Electric Vehicle Charging Station Installation Best Practices:

A Guide for San Diego Region Local Governments and Contractors

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Submitted by
Center for Sustainable Energy

SANDAG Center for Sustainable Energy

Summary of Acronyms

AHJ: authority having jurisdiction

BEV: battery electric vehicle

CSE: Center for Sustainable Energy

EVSE: electric vehicle supply equipment

EVCS: electric vehicle charging station

GHG: greenhouse gas

NRTL: Nationally Recognized Testing Laboratory

PEV: plug-in electric vehicle

PHEV: plug-in hybrid electric vehicle

SANDAG: San Diego Association of Governments

SAE: Society of Automotive Engineers

ZEV: zero-emission vehicle

Executive Summary

As adoption of plug-in electric vehicles (PEVs) grows in the San Diego region and statewide, there is a greater demand for residential, workplace and commercial electric vehicle charging stations (EVCS). Although the region has made great strides in facilitating the adoption of vehicles and infrastructure, more work is necessary. Through funding from the California Energy Commission, the San Diego Association of Governments (SANDAG) and the Center for Sustainable Energy (CSE) have partnered to implement the EVCS best practice recommendations from the 2014 San Diego Regional PEV Readiness Plan (Readiness Plan) that was developed through the San Diego Regional Electric Vehicle Infrastructure (REVI) Working Group.[i] This implementation program is known as **Plug-in SD**.

In July 2015, SANDAG and CSE launched Plug-in SD to promote regionally consistent and streamlined residential and commercial EVCS permitting, inspection and installation best practice resources for local governments and installers. This report serves as one of these resources and includes:

- A review of codes and standards relating to EVCS installations
- An overview of common installation challenges in different scenarios
- Best practices to assist local building departments and electrical contractors to prepare for the anticipated increase of EVCS installations

EVCS installation best practices presented in this report derive from those currently in place through San Diego region local governments, the Readiness Plan and the Governor's Office of Planning and Research Zero-Emission Vehicle Guidebook (ZEV Guidebook).[ii] These best practices include:

- Standardization of EVCS building codes and installation requirements
- Training for electrical contractors
- Electric vehicle charging station installation guides and checklists
- Electric vehicle charging station encouragement programs

Plug-in SD provides technical assistance to municipalities to facilitate the adoption and implementation of this project's best practices and resources. Consultations with technical staff, or "EV experts," are available via in-person or remote (email and phone) meetings. EV experts can be contacted by email at evexpert@energycenter.org or by phone at (866) 967-5816. Resources and information will be hosted at http://energycenter.org/pluginsd.

This report does not discuss local permitting authority requirements in depth. For more information on the local government EVCS permitting and inspection process, see Plug-in SD's *Electric Vehicle Charging Station Permitting and Inspection Best Practices: A Guide for Local Governments.*[iii]

I. Introduction

As adoption of plug-in electric vehicles (PEVs) grows in the San Diego region and statewide, there is a greater demand for residential, workplace and commercial electric vehicle charging stations (EVCS), also known as, electric vehicle supply equipment (EVSE). More than 150,000 PEVs[iv] have been deployed statewide, and nearly 13,000 of those vehicle owners reside in San Diego County. Charging infrastructure not only needs to be installed for existing electric vehicles, but also

to accommodate up to 1 million zero-emission vehicles (ZEVs) by 2020 and 1.5 million ZEVs on California roadways by 2025 per Governor Brown's Executive Order.[v] In order to accommodate the expected increase of PEVs, the Executive Order requires that the state's major metropolitan areas, including the San Diego region, have adequate infrastructure plans to be "ZEV-ready" by 2015. According to the Alternative Fuels Data Center, the San Diego region currently has 687 charging stations open to the public.[vi] The state has estimated the San Diego region needs to deploy approximately 75,000 residential charging ports and 12,000 workplace charging ports to support this growth.[vii] EVCS installers and local governments play a key role in PEV adoption and deployment of charging infrastructure.

II. Electric Vehicle Charging Technology

Table 1 displays the three levels of PEV charging. The majority of PEVs come with a 120-volt charging cord that enables owners to charge their vehicle with a conventional three-prong outlet. This is classified as Level 1 charging. Level 2 charging stations use 240 volts and offer two to three times the charging speed compared with 120-volt charging. Level 2 charging stations are commonly installed in residential as well as commercial settings. DC fast charging has high power requirements only suited to commercial settings; not all PEVs are capable of DC fast charging.

Table 1: Levels of Charging and Miles of Range[viii]

Type of Charging	Power Levels (installed circuit rating)	Miles of Range per Hour of Charge*	Where to Charge
Level 1	110/120VAC at 15 or 20 Amps	~4-6 miles/hour	At home or workplace
Level 2 **3.3kW (low)** **6.6kW (medium)** **9.6kW (high)** **19.2kW (highest)**	 208/240 VAC at 20 Amps 208/240 VAC at 40 Amps 208/240 VAC at 50 Amps 208/240 VAC at 100 Amps	 8-12 miles/hour 16-24 miles/hour 32-48 miles/hour >60 miles/hour	At home, workplace or public charging station
DC Fast Charging	440 or 480 VAC	~80% in <30 minutes	Public or commercial

***Refer to vehicle specifications for exact ratings.**

III. Common EVCS Installation Barriers

During previous PEV readiness planning efforts, the San Diego Regional Electric Vehicle Infrastructure (REVI) Working Group identified several common EVCS installation barriers. These barriers are summarized in Table 2. The best practices discussed in Section V of this report address the identified EVCS installation barriers specific to contractor education, technical installation guides and the use of building codes that support dedicated EVCS infrastructure.

Table 2: Regional Barriers to PEV Infrastructure

Barrier	Description
Permitting/Inspection	Lack of streamlined permitting and inspection processes and inconsistent (high) costs across jurisdictions.
Building Codes	Lack of standard building codes that accommodate charging infrastructure or dedicate circuits for charging infrastructure in new construction and major renovations.
Zoning and Parking Rules	Lack of standard regional ordinances that facilitate the installation and access to publicly available charging infrastructure.
Training and Education for Municipal Staff and Electrical Contractors	Lack of knowledge about PEVs and EVCS.
Consumer Awareness of PEV and EVCS Availability	Consumer lack of understanding of the electric vehicle types and EVCS equipment availability.
EVCS at Multi-Unit Dwellings	Building managers, building owners and homeowner associations lack understanding of unique challenges associated with EVCS installations at multi-unit dwellings.
Commercial and Workplace Charging	Businesses lack of understanding regarding benefits of and approaches to implementing successful workplace charging programs.

As identified in the Readiness Plan,[ix] EVCS installations face common barriers of permit application delays, inconsistent permit fees and inspection corrections. Installation delays result from electrical contractor unfamiliarity with charging infrastructure and applicable codes and standards specific to EVCS. The following information serves as a reference for installers and local governments on relevant codes and standards.

EVCS Codes and Standards

The California Green Building Standards Code (CALGreen),[x] known as Title 24, Part 11, was the first state-adopted green building code in the nation. CALGreen includes both mandatory and voluntary measures that ensure residential and commercial new construction projects are ready for EV infrastructure. Local jurisdictions have authority to adopt their own PEV-readiness building codes standards beyond CALGreen's mandatory requirements. Cities can adopt the voluntary measures in CALGreen or adapt them to reflect local priorities.

CALGreen requirements include prewiring of the site to allow for the future installation of a charging circuit and electrical retrofits to support EVCS. The specific requirements for residential and nonresidential buildings are described in Tables 3 and 4.

Table 3: CALGreen Residential EVCS Requirements

Multifamily Residential	
Mandatory Requirements	**Voluntary Requirements**
PEV "readiness" (i.e., electrical system capacity, building plans and any underground conduits) for at least 3% of total parking spaces	Multifamily PEV "readiness" applies to at least 5% of total parking spaces
All developments under 17 units exempt	All developments under 17 units exempt
Single-family Residential	
Mandatory Requirements	**Voluntary Requirements**
Raceway (such as conduit) and electrical panel capacity to support 40-amp capacity electric circuit	Install complete 40-amp electrical circuit
Does not include pulling wire nor installing receptacle	

Table 4: CALGreen Nonresidential EVCS Requirements

Nonresidential	
Current Mandatory Requirements	**Current Voluntary Requirements**
PEV "readiness" which includes raceway (such as conduit) and electrical panel capacity to support 40-amp PEV charging capacity	At least 4% (Tier 1) or 6% (Tier 2) of parking spaces must be PEV ready
If there are more than 50 parking spaces, at least 3% must be PEV-ready	No minimum parking space threshold
Proposed New Mandatory Requirements	**Proposed New Voluntary Requirements**
If there are more than 10 parking spaces, at least 6% or more must be PEV-ready (Raceway (such as conduit) and electrical panel capacity to support 40-amp PEV charging capacity)	At least 8% (Tier 1) or 10% (Tier 2) of parking spaces must be PEV ready

The 2013 CALGreen Code became effective on January 1, 2014, after adoption by the California Building Standards Commission. The PEV readiness requirements were included in supplementary changes adopted and approved in the 2013 Intervening Code Adoption Cycle, which became effective on July 1, 2015. Proposed changes and possible amendments for the 2016 CALGreen Code are currently in process and will go into effect January 1, 2017. These changes to the code include enhanced statewide mandatory requirements for EVCS readiness and expanded voluntary "reach" codes for new construction. The current proposed change in the Code Adoption Cycle of CALGreen is to increase the

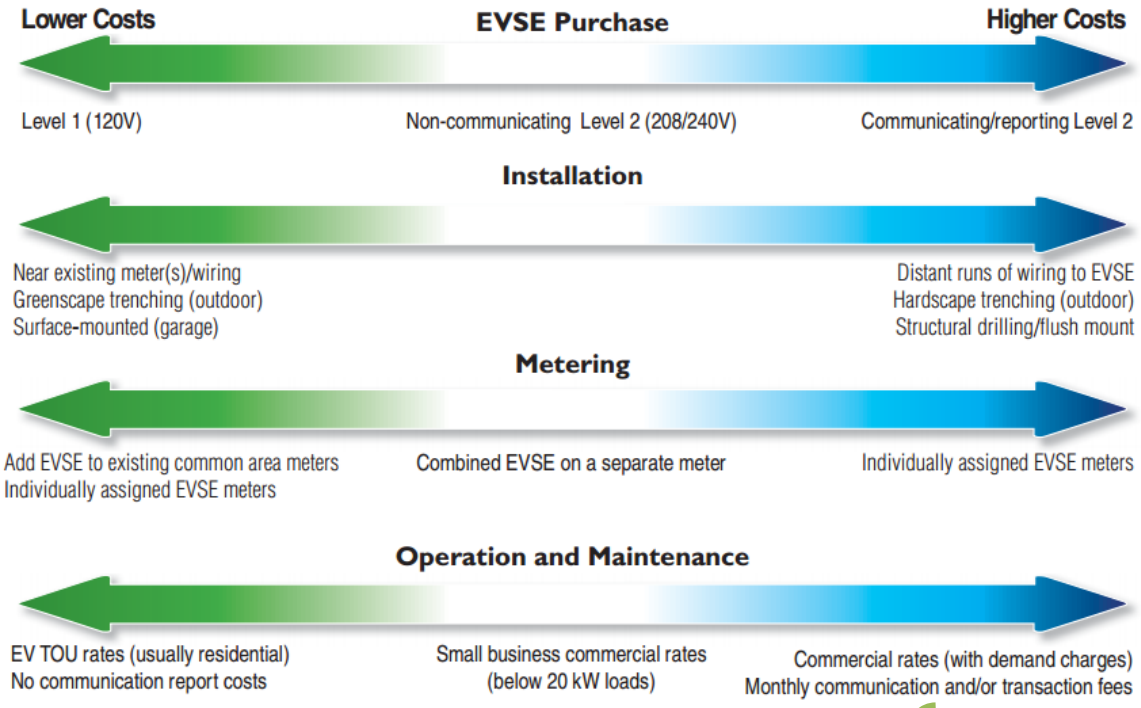
threshold for non-residential parking lots from 3% of lots with 51 or more parking spaces to 6% of lots with 10 or more parking spaces.

As a local jurisdiction that adopted the 2013 CALGreen Code, the County of San Diego is working toward streamlining enforcement of the California Green Building Code requirements. The County's Building Division of the Planning and Development Services Department encourages constituents to be aware of the CALGreen Code and familiarize themselves with the regulations. The County enforces mandatory energy efficiency requirements and offers a Green Building Incentive Program for projects that go beyond the minimum requirements.

Installation Costs

Varying and unpredictable installation costs present a barrier to EVCS deployment. Figure 1 provides insight on the range of costs for various scenarios as a guide for consumers and contractors. While not included in this figure, permitting costs can add to the overall EVCS installation cost.

Figure 1: PEV Collaborative EVCS Cost Spectrum[xi]



The EV Project examined the installation costs associated with residential EVCS in 10 metropolitan areas across the United States. Installation costs include materials, labor, permit fees, administration and the unit itself. Costs also include installation of conduit, wiring and trenching depending on the location and capacity of the existing power supply. The EV Project identified the San Diego region as having the highest fees associated with obtaining a permit for residential Level 2 charging installation.[xii]

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Electrical service panel upgrades were a significant cost driver in EV Project's installations. There are various methods to power EVCS that can involve coordinating with the utility to complete a panel upgrade or a new service drop. To accommodate the circuit for a Level 2 charger, individuals with older homes typically require an upgrade of their electrical service panel that adds significant cost to an EVCS installation project.

IV. Existing EVCS Installation Processes

This section begins with the general installation processes and standards, from pre-installation to final inspection, that exist across residential and nonresidential EVCS installations. Residential project types include single-family homes; nonresidential project types include multi-unit family or dwelling buildings with more than two units, workplaces, commercial retail centers and public locations. This section also addresses the unique installation challenges of both multifamily and commercial projects and provides resources to help installers avoid project delays.

Installation Standards for Residential and Nonresidential EVCS

The general EVCS installation standards described relate to electrical code and workmanship requirements, equipment, determining proper electrical load, physical installation, post-installation equipment use and maintenance, and communications.

Electrical Code and Workmanship Requirements

The National Electrical Contractors Association (NECA) publishes the National Electrical Installation Standards (NEIS) to define a minimum baseline of quality and workmanship for installing electrical products and systems. The NEIS for EVCS is NECA 413-2012, *Standard for Installing and Maintaining Electric Vehicle Supply Equipment*.[xiii] NECA 413 includes guidance on the electrical supply equipment itself, the installation process, ongoing maintenance, and communications. Additionally, NECA 413 recommends that all work should be performed in accordance with established requirements for electrical safety. In California, those requirements are in the California Electrical Code, Title 24, Part 3, Article 625 *Electric Vehicle Charging System*.[xiv] Article 625 specifies required methods for wiring, equipment construction and safety [shock] protection systems and overcurrent control and protection as well as proper equipment marking, placement, orientation and location. Table 6 highlights requirements for the EVCS as listed in the National Electric Code.

Table 6: EVCS Code Requirements and Standards[xv]

Applicable Code	Description
NEC 110.28	The enclosure must be NEMA-rated
NEC 625.17	Cord length will reach vehicle's inlet without excessive slack and must be no more than 25' in length
NEC 625.29	Connector must be mounted at a height between 36" and 48" from the ground unless otherwise indicated by the manufacturer
NEC 110.26	The recommended space around electrical equipment is 30" wide, 3' deep and 6'6" high
NEC 110.27	Equipment operating above 50 volts must be protected against physical damage
NEC 625.23	For EVCS greater than 60 amperes, a separate disconnect is required and should be installed concurrently with conduit and visible from EVCS
NEC 625.21	Conductors should be sized to support 125% of the rated equipment load

Equipment

- Equipment should be certified by a Nationally Recognized Testing Laboratory (NRTL) and listed for electric vehicle use.
- Society of Automotive Engineers (SAE) J1772-2009 standard includes a number of safety features between the charging station and the electric vehicle, such as ground fault current interrupter, proximity detection and signaling. Power is only supplied after a connection is made.
- Equipment should be located away from potential hazards to be protected from physical damage. Bollards, wheel stops or other devices can be used to ensure appropriate setbacks between vehicle and equipment.
- Equipment should be positioned to minimize tripping hazard from cords or include cord management devices, such as self-retracting reels.

Determining Proper Electrical Load

- EV charging is a continuous load. Required wiring size and overcurrent protection for EVCS must be 125 percent of the EVCS nameplate continuous output rating.
- Load calculations or a load study may be required to ensure there is sufficient electrical capacity to support EVCS. Load control strategies may be employed to fit charging within existing capacity.

Physical Installation

- Before beginning work, the intended EVCS electrical circuit must be properly de-energized via industry standard lockout/tagout procedures. The vehicle should not be connected to the equipment during installation or service.
- Use personal protective equipment and treat all conductors as energized until confirmed to be de-energized.
- Ensure installation follows manufactures specifications and approved design plans. Note any deviations or corrections to the plans, or stop and inform permitting authority.

- The U.S. DOE *Clean Cities Electric Vehicle Handbook*[xvi] includes detailed information on the phases of an EVCS installation, as well as associated topics of maintenance and technical requirements. An EVCS installation example is highlighted in the handbook along with lessons learned for the general installation and inspection process.

Post-installation equipment use and maintenance

- An EVCS requires little ongoing maintenance; however maintenance should be performed in accordance with manufacturer recommendations.
- Units may be cleaned with a damp cloth and mild detergent.
- Connectors and wiring should be regularly inspected for damage.
- It is good practice to shut off, discontinue use and/or replace EVCS couplers or plugs if observed to be damaged, discolored, disfigured, modified, hot, sparking, popping or otherwise suspect.
- Always ensure equipment is de-energized before performing service on electrical components.

The largest volume of PEV charging is performed by single-family homeowners.

Communications

Many commercial EVCS require a communications connection to manage access control, billing, power metering or other features. Contractors should be aware of communications requirements of EVCS equipment they are installing. There are three types of communication methods:

- Cell-based communication
- Wi-Fi based communication
- Hard-wired communication

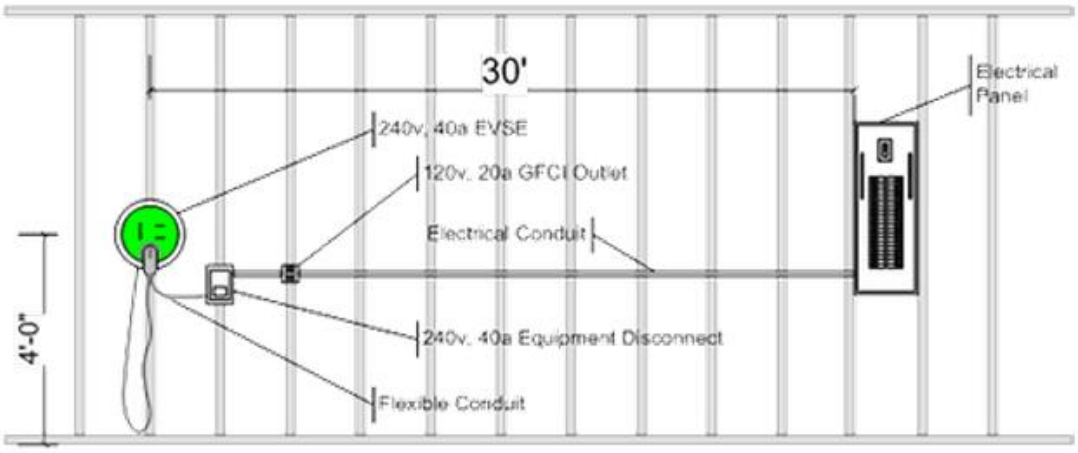
Communications protocols depend on vendors, and the method of communication may depend on the installation site. For example cell-based communications will generally not function in subterranean parking structures. Communications should be considered as part of project planning to support a successful installation. Communicating residential units most commonly use Wi-Fi.

Residential-Specific EVCS Installation Considerations

As mentioned in OPR's *ZEV Guidebook*,[xvii] the largest volume of PEV charging is performed by single-family homeowners. A majority of PEV drivers install Level 1 or Level 2 charging at their single-family home. For single-family homes, the electrical contractor will examine the customers' home panel to determine wiring needs and potential load capacity. During the site assessment, the contractor determines what process is needed for the panel to accommodate the load of installing EVCS and provides a quote to the homeowner. Some contractors may perform an initial assessment remotely using pictures of the electrical panel and proposed installation site. Following this assessment, the installer must obtain a building or electrical permit for the installation and coordinate with the local utility (i.e., San Diego Gas & Electric) if an electrical service upgrade is needed.[xviii] The installation commences once a building permit is issued and utility service approval (if needed) is granted. The contractor will pull the necessary wiring and mount the EVCS in the permitted location. For residential installations, wire can run through the attic, crawlspace or exterior and surface mount conduits.

A typical EVCS is mounted indoors in the garage or outdoors on a solid wall that can be drywall, concrete block or brick as well as other standard wall materials. A helpful example depicting a standard residential EVCS installation is shown in Figure 2 as described in AeroVironment (AV) Inc.'s Cal Electric: Residential EVCS Deployment program.

Figure 2: AV Cal Electric's standard installation route to EVCS location[xix]



AV defined the typical installation for their program as a 30 linear feet electrical run from the electrical panel that has sufficient space and capacity (additional 40-ampere circuit breaker and load of 200 amperes) to the EVCS location. A 30-foot run would accommodate charging in many residential houses.

Nonresidential-Specific EVCS Installation Considerations

Nonresidential installations include multi-unit dwelling (MUD) communities, commercial and retail centers, public locations and workplace charging stations. These types of installations are more complex than single-family installations. Common considerations are described, as well as challenges that are unique to multifamily and workplace installs.

Permitting

Nonresidential installations require a more comprehensive review by local building, fire, environmental and electrical permitting authorities. In order to obtain a permit, proposed EVCS installations must comply with codes and regulations set forth locally, statewide and nationally.

During the pre-installation process, the scope design requires planning for site layout, number of chargers, parking availability and existing electrical panel capacity. Parking considerations such as parking stall size, orientation and minimum number of required parking stalls for the site are important variables that need to be evaluated prior to EVCS installations.

Utility Coordination

Additional site assessment includes determining the current electrical service capability and potential upgrade requirements to support an EVCS installation. These assessments will involve the utility provider as well as the local permitting authority. Utility considerations can complicate nonresidential installations in total load management and rate structures for the EVCS. More detailed planning is required and the electrical contractor must check with the electrical services utility prior to modifying an existing electrical system. A contractor with proper expertise and training

should notify the local utility of proposed charging infrastructure so that there can be proper planning for local increases in electricity demand.

Installation and Inspection

To complete the installation, preparation and scheduling of contractor and utility work must be coordinated in detail as the EVCS installation can require shutoff of the main power supply at a nonresidential building. Cooperating with local utility requirements and organizing the scheduling of when electrical work can be completed are vital to providing power to the EVCS. In addition, the EVCS installation requires permit approval and issuance from the local building department. Following installation, the local building inspector will verify that the equipment is installed per the manufacturer's specifications and instructions. EVCS installations must comply with applicable electrical codes and safety requirements, as noted earlier.

Parking and Accessibility

While single-family residential installations do not have complex parking requirements, nonresidential and MUD installations have additional parking considerations that include Americans with Disabilities Act (ADA) accessible EVCS spaces and meeting the minimum requirements for spaces in parking lots and facilities. EVCS site hosts often experience challenges in providing ADA accessible EVCS spaces in addition to standard EVCS spaces while maintaining the minimum requirements for parking. Consideration of the available parking is important for residents as well as employers. Installing charging in unassigned spaces or common areas for availability to all residents at MUDs requires compliance with ADA accessibility regulations.

Statewide EVCS accessibility standards have been approved for the 2016 California Building Standards Code and go into effect January 2017.

The California Building Standards Commission (CBSC) approved proposed amendments by the Division of the State Architect (DSA) for the 2016 California Building Standards Code, Title 24, Part 2, Chapter 11B at CBSC's January 19-20, 2016 public meeting. Prior to approval of these access regulations, there has been no single, comprehensive guidance on what is needed to ensure that charging infrastructure is accessible to all users. The approved EVCS regulations that apply to both new construction as well as alterations to existing buildings and facilities for the 2016 CBC in sections 11B-812, 11B-206, 11B-228 and 11B-309 will be effective January 1, 2017. These proposed changes to the accessibility standards for EVCS can be viewed in detail on DSA's 2016 Access web reference of Final Express Terms.[xx]

The 2016 edition of the California Building Code includes requirements for accessible EVCS. Accessibility requirements define a minimum number of accessible EVCS per the total number of EVCS at a facility based on type of EVCS. Where four or fewer total EVCS are provided, identification with an International Symbol of Accessibility (ISA) shall not be required. Where more than four total EVCS are provided, the van accessible space will be identified with an ISA and is reserved for the use of persons with disabilities. Newly constructed parking facilities, and existing parking facilities that undergo alteration, must meet requirements for accessibility unless otherwise exempted.

The number of EVCS spaces is determined by the number of vehicles that can be charged, not by the number of service pedestals that are installed. Installing accessible electric vehicle charging equipment includes requirements for accessible routes, path of travel, operable parts, and reach ranges. An accessible route must be provided between the vehicle space and the EV charger that serves it. EV chargers and vehicle spaces that serve a particular building or facility must be located on an accessible route to an entrance. Where EV chargers and vehicle spaces serve more than one

accessible entrance, EV chargers and vehicle spaces must be dispersed and located on an accessible route to the accessible entrances. Where EV chargers and vehicle spaces do not serve a particular building or facility, EV chargers and vehicle spaces must be located on an accessible route to an accessible pedestrian entrance of the EVCS. For new construction or alterations, accessible charging stations must be provided when EVCS are installed. According to Title 24, Part 2, Chapter 11B, all building entrances and path of travel to building facilities must provide an accessible path of travel for the disabled; this includes access to EVCS parking stalls and equipment. EVCS must be located so that ADA routes maintain a pathway of 36" at all times.

While accessibility standards for EVCS were being developed by the DSA, a majority of local San Diego jurisdictions look to the City of San Diego for guidance on the topic of accessibility for EVCS. The City of San Diego's Development Services created Technical Policy 11B-1[xxi] in April 2012 to address accessibility to EVCS in both new and existing construction. The policy requires EVCS installations in public areas to be made accessible to persons with disabilities. The policy is consistent with the 2010 California Building Code requirements for accessible parking, public accommodations and services and includes specifications for the number of accessible EVCS required as well as the dimensions, identification and disabled access to accessible EVCS. The City of San Diego is currently making updates to their Technical Policy 11B-1 to align with DSA's approved accessibility standards.

Architects, developers and installers should work with the local permitting authority to determine a site's EVCS accessible parking needs during the project design phase. Installers can reference Advanced Energy's Charging Station Installation Handbook for Electrical Contractors and Inspectors[xxii]. This includes information on parking design and accessibility installation examples and codes that provide information to contractors on disabled access charging stations.

Challenges Unique to Multi-Unit Dwellings

Multi-unit dwelling communities face challenges with EVCS station ownership, siting in parking areas, electrical supply and billing. Solutions to these issues vary depending on community type (e.g., high-rise condominium, rental apartments, homeowner association-controlled townhome development). The California Plug-in Electric Vehicle Collaborative *Plug-in Electric Vehicle Charging Infrastructure Guidelines for Multi-unit Dwellings*[xxiii] provides extensive guidance on these subjects.

Installer should work with building owners and community members to make sure the following issues are considered:

- How many residents will want charging, should stations be dedicated or shared?
- Will the EVCS be installed in assigned parking spaces or in common areas?
- Will the power be supplied from existing common areas meters, individual units or on a new meter?
- Assigning construction and operation costs.
- Equipment or building insurance.

Case Study: CityFront Terrace[xxiv]
CityFront Terrace is a 320-unit condominium community located in downtown San Diego. When a few residents expressed interest in getting electric vehicles, the property managers decided to look for a flexible installation that could serve current and future needs. The homeowner association (HOA) installed 20 individual meters on different floors of the parking structure. Otherwise, residents who want to install EVCS in their assigned space are responsible for the costs

of purchasing their own equipment and completing the wiring. Residents then establish their own service directly with the utility and are able to benefit from PEV specific time of use rates. Although doing this means the initial installation is costly, this approach allows residents full responsibility for their own charging equipment and costs, rather than having ongoing involvement of the property management or HOA.

Challenges Unique to Commercial and Workplace Charging

Charging at commercial and workplace sites is a benefit to visitors and employees. CALSART's *Best Practices for Workplace Charging*[xxv] provides details and solutions for many of the challenges faced when installing EVCS at commercial and workplace sites, including:

- Scalability of charging solution
- Operational costs including energy and demand charges
- Billing policies and network costs
- Employee charging guidelines and managing etiquette

Case Study: Scripps Memorial Hospital Encinitas
Scripps Encinitas originally installed two EVCS that were available free to staff and the public. Some staff members would regularly leave their car plugged into the stations all day, which limited their utility to other users. To expand access, the hospital replaced these units with networked ones that included a fee for charging with an additional fee for remaining plugged in after charging. This encourages users to move their vehicles after they are finished charging and frees up the units for other users.

V. Best Practice Recommendations

The following best practices offer potential opportunities for jurisdictions and PEV stakeholders to improve the installation process and encourage greater adoption of EVCS. The Plug-in SD program will provide assistance to jurisdictions to adopt best practices. This includes the development of resources and technical assistant from an "EV expert."

Best Practice: Standardization of EVCS Building Codes and Installation Requirements
Standardization of EVCS requirements across jurisdictions during planning, design and installation helps installers understand local requirements and deploy EVCS in a more streamlined fashion. Adoption of a streamlined permitting process may become a requirement for California jurisdictions over the next two years if Assembly Bill 1236[xxvi] is signed into law.

To facilitate EVCS installations, local building departments can establish guidelines highlighting model installation scenarios at residential and nonresidential buildings. The OPR *ZEV Guidebook* has recommendations for standardized permitting and installation processes that local jurisdictions can adopt. For example, the guidebook recommends local governments to include language about ZEV readiness in their general plans and to prioritize different types of charging as part of a general land use or zoning ordinance update.

Best Practice: Adopt Voluntary CALGreen Codes

Local governments can consider adopting CALGreen voluntary codes that require a higher number of parking spaces to be capable of supporting PEV charging, including sufficient panel capacity and conduit. By adopting CALGreen voluntary standards, local governments can advance PEV adoption to reach near-term and long-term state goals for zero-emission vehicles while avoiding retrofit costs per charging space by prewiring spaces for EV charging infrastructure.

The California Air Resources Board (ARB) has prepared suggested code changes as documented in a Technical and Cost Analysis[xxvii] for Nonresidential Buildings for EV Charging Provisions in the CALGreen Code. ARB's suggested code changes for nonresidential buildings recognize that the latest CALGreen Code, effective July 1, 2015, for EV-capable building are a good first step that provide EV charging infrastructure in new construction. In order to adequately meet future demand for EV charging, the ARB recommends that CALGreen Code be strengthened to require more EV charging infrastructure during the 2016 code cycle and be adopted by local governments. Jurisdictions who adopt CALGreen can provide cost savings for PEV owners and EVCS installers as shown in ARB's Technical and Cost Analysis.

Jurisdictions can encourage EVCS installations by offering reduced permit fees.

Best Practice: Training for Electrical Contractors

To meet the demand for additional infrastructure, there is a need for local electrical contractors who are trained and knowledgeable about PEVs and EVCS. It is important to the PEV industry and local governments to ensure that contractors are completing safe and reliable installations for their customers and constituents. EVCS installations should be completed by a licensed electrical contractor. The Contractor State License Board (CSLB) classifies the licensed electrical contractor as a C-10 Electrical Contractor.[xxviii] A C-10 Electrical Contractor will need to be familiar with National Electric Code (NEC) Article 625 specific to EVCS. The California Building Standards Commission bases the California Electrical Code Title 24, Part 3, Article 625 on the NEC standards.

NEC considers EVCS a continuous load, which impacts how wiring must be sized. Electricians who do not have familiarity with EV charging may not be aware of this and install the incorrect size of wire or circuit breaker. Load monitoring and completing accurate load calculations is crucial in the site assessment phase. Incorrect load calculations can delay permit processing and approval. Electrical load calculations and examining the existing electrical panel are imperative to determining if a panel upgrade is necessary, which significantly impacts the overall costs and timeline of the installation.

Training programs on regulations, standards and code provisions facilitates the development of a skilled workforce to support the large-scale deployment of PEV infrastructure. The Electric Vehicle Infrastructure Training Program (EVITP)[xxix] provides training for EVCS installation in commercial and residential markets. EVITP facilitates training and certification for installations addressing technical, safety and performance requirements. Additional training is available at training centers in the San Diego region as described in *Plug-in Electric Vehicles: Resources for Electrical Contractors.*[xxx] EVCS training for all licensed contractors is an important component of providing safe, high-quality and efficient installations. Local governments could work with community colleges or NECA/IBEW instructors to set up training in their jurisdictions.

Best Practice: EVCS Incentives and Financing Programs

EVCS Installation Incentives

Various federal, state and local programs have provided incentives for EVCS installation. Although many of these programs are no longer active, the ARB's Drive Clean website[xxxi] maintains a listing of current incentives.

Jurisdictions can encourage proper EVCS installations by offering EVCS incentive programs that reduce the cost of installations to be performed by qualified, licensed EVCS contractors and demonstrate closure of building permits. The City of Encinitas provides an "energy efficiency permit waiver" that foregoes the fee for residential EVCS applications. A permit fee waiver incentivizes contractors and customers to obtain a permit and ensures that the installation will receive a final inspection. This best practice also saves installation costs for applicants, incentivizes permit pulling and allows a jurisdiction to track EVCS installation in its community.

San Diego Gas & Electric has proposed a vehicle-grid integrated charging program that would include utility-funded installation of EVCS at multi-unit and workplace sites. SDG&E would use price signals to encouraging charging at times when there is sufficient grid capacity and discharge charging at times the grid is under strain. This program is currently under review by the California Public Utilities Commission, but would likely result in increased local installations if approved.

Financing for EVCS

For potential EVCS hosts, the upfront cost of installation can be a deterrent; however, there are financing programs available that contractors can promote to customers.[xxxii] PACE financing allows property owners to fund energy efficiency and renewable energy projects for residential or commercial properties with little or no upfront costs. Currently, all 19 jurisdictions in the San Diego region offer PACE financing. Coupling EVCS with the installation of solar photovoltaic (PV) systems is also an option when applying to for financing through PACE. The installation cost can also be lower when combined with a larger project.

Lastly, the California Energy Commission has allocated $2 million to the CalCap Electric Vehicle Charging Station (EVCS) Pilot Financing Program[xxxiii] launched in June 2015. The CalCap program encourages small businesses to install EVCS through a combination of low-interest financing combined with a rebate. Small businesses work directly with the lender to apply for a loan and are eligible for a 10-15% rebate when the load is repaid. Participating lenders are identified on the CalCap website.

Best Practice: EVCS Guidelines and Installation Checklists

The City of Oceanside's Building and Division provides Residential Electric Vehicle (EV) Charger Guidelines[xxxiv] to assist permit applicants in the permitting, installation and inspection process. The guidelines provide tools to assist in service load calculations, as well as general installation guidelines for Level 2 residential chargers and type and size of wire and conduit for EVCS circuits.

To streamline the permitting process and assist municipal staff and contractors with completing installations more smoothly, Plug-in SD will create an installation checklist and provide subregional workshops for training. (See Appendix A.)

An installation checklist will guide both contractors and inspectors in completing the installation properly and efficiently. The checklist will including all the steps to plan and execute a successful EVCS installation project including equipment and site considerations, permitting, electrical connections and commissioning.

VI. Conclusion

As the State of California seeks to achieve its ambitious energy and climate goals, the adoption of plug-in electric vehicles is expected to greatly increase.

Improving the installation process for EVCS will aid the growth of infrastructure and, in turn, continue to encourage the deployment of PEVs throughout the San Diego region. This report offers several recommendations to improve the existing installation processes in the region. EVCS installations should be a routine task performed by electrical contractors and supported by building department staff. The Plug-in SD program will help to support jurisdictions and contractors that want to institute best practices for EVCS installation

A separate Plug-in SD report, *Electric Vehicle Charging Station Permitting and Inspection Best Practices: A Guide for Local Governments*,[xxxv] offers more information on the local government EVCS permitting and inspection process. In addition, the "EV expert" offers assistance and serves as a one-stop shop for jurisdictions looking for more resources to support permitting and installation and encourage EVCS deployment. Through sustained efforts, the San Diego region can foster widespread and accessible PEV infrastructure that meets the needs of current and future PEV drivers.

Appendix A: Installation Checklists

INSTALLATION CHECKLIST FOR MULTI-UNIT DWELLING ELECTRIC VEHICLE CHARGING STATION (EVCS)

Installations must be completed by a licensed electrical contractor (C-10). (Local Regulations, California Electrical Code CEC Article 625) Plans must show conformance with the California Electrical Code Title 24, Part 3, the California Building Code (Volume 1 and 2), Title 24, Part 2, and other applicable local municipal codes.

Submittal Documents required*

- ☐ **Permit Application**
  - **i.** Include job address (a unique address for the EVCS installation that is used for billing), parcel number, existing use, description of work, name, address, and contact information of the applicant and the owner.
- ☐ **Plan Sets (#, size of plans)**
  - **a. Site/Plot Plan**
    - **i.** Show full property extent (property lines, parking areas, structures, etc.).
    - **ii.** List relevant property information, such as existing parking counts and ratios.
    - **iii.** Provide a detailed site plan showing where the charging unit is located within the parking garage or lot, and any necessary accessibility improvements
    - **iv.** As required by type of EVCS, installation mounting method, and local jurisdiction requirements provide necessary structural details.
  - **b. Electrical Plan**
    - **i.** Provide a complete electrical single line drawing showing the main service, sub panels and disconnecting means as applicable, and proposed EV charging unit, include; size of overcurrent protection devices (in amperes) for main service, sub panels, disconnects and EV charger circuit supply, show conduit sizes and types, and conductor sizes and types.
    - **ii.** Provide a trenching detail and call out trench work in the scope of work on the plan if trenching is required. Trenching may result in a structural plan review if conduit trenches undermine foundations.
    - **iii.** Note electrical feeder requirements when trenching structure to structure (CEC 225). The feeder from structure to structure should be noted in the scope of work. Verify that trenching is in compliance of minimum cover requirements for wiring methods or circuits (18” for direct burial per CEC 300).
    - **iv.** Provide EVSE manufacturer's specification sheets showing Nationally Recognized Testing Laboratory (NRTL) approved listing mark for indoor or outdoor (UL 2202/UL 2200).
- ☐ **Electrical Load Calculation Worksheet**
  - **i.** Include existing and proposed load to estimate if existing electrical service will handle the new load from EVCS and wiring methods. Note: Unless electrical service equipment is 100% rated, the calculated load demand on the main

service shall not exceed 80% of the nameplate rating of the main service over-current protection device (OCPD).

***All plans and documents listed above must be provided for multi-unit dwelling electric vehicle charging stations at time of permit submittal prior to issuance.**

Pre-Installation Work

1. Determine units to be installed. Follow all manufacturer specifications for installation. Must be NRTL listed and suitable for the location, indoor or outdoor.

2. Conduct site assessment and submit quote to customer for approval of work and utility upgrades or new service if applicable. Assess the site for:
    a. All electrical system elements (main service, sub-panels, disconnecting means, etc.)
    b. Current electrical code deficiencies
    c. Existing electrical load
    d. Wet and dry utility locations (affecting trench paths for electrical)
    e. Presence of corrosive conditions (e.g. salt air, etc.) affecting recommended equipment
    f. Water drainage (to avoid locating EVCS in areas with possible standing water)
    g. Site accessible parking, and / or accessibility of proposed EVCS
        i. Site slope at proposed EVCS location
        ii. Surface conditions
        iii. Access path(s) connectivity to on-site uses
    h. Visibility of proposed EVCS from uses on site, and/or from public rights-of-way (safety)
    i. Site lighting for use of EVCS and general safety
    j. Placement of EVCS to serve only one versus multiple parking stalls (dependent on hosts intended use of the EVCS)
    k. EVCS protection from vehicle damage through proper placement, and then physical protection (e.g. wheel stops, bollards)
    l. EVCS orientation
        i. Facilitating ease of human interface
        ii. Minimizing sun exposure on digital screens
        iii. Facilitating ease of cable management
    m. Placement and/or screening of electrical support equipment (e.g. transformers, meter pedestals/cabinets, etc.) as it relates to site aesthetics
    n. Need for signage and / or stenciling at the EVCS location(s), and / or as directional signage on large sites

3. Complete permit application from local jurisdiction and electrical load calculation for proposed stations (Include load calculations for EVCS):
    a. Mandatory requirements for new construction in new multifamily dwellings of 17 or more units to be EV Capable. 3% of the total parking spaces, but not less than one, shall be capable for supporting future EVCS. (CALGreen Code Section 4.106.4.2)

4. Contact SDG&E for service work order for utility upgrades/notification of new service. File Service and Meter Request Form (http://www.sdge.com/service-and-meter-request-form).
    a. Ensure SDG&E work order is approved. Any work on the utility side of the electric service requires a work order and disconnect/re-connect.

b. Following SDG&E approval, permit is approved, issued and appropriately posted.

5. Construction plans indicate how requirements for types of wiring and installation siting. Show compliance with requirements of NFPA 70, CEC Article 625.

6. Construction plans show compliance with the California Building Code Title 24, Part 2, Section 11B-812 and Section 11B-228.

    a. Signage for EVCS (International Symbol of Accessibility (ISA) signage for ADA accessible spots be provided in compliance with Section 11B-812.8).
    b. For a facility for public and common use, minimum number of EVCS required to comply with Section 11B-812.

Equipment and Scheduling

7. Schedule all necessary contract work for installation of new service (if applicable), and pulling wires from electric panel(s) / meter pedestals to parking structure(s) or lot(s):
    a. Boring, trenching, concrete and/or paving restoration if these operations are included in project scope
    b. Indoor-rated EVCS can be installed in a garage (CEC 625.29)
    c. Outdoor installations require outdoor-rated EVCS (CEC 625.30)
    d. Coordinate with property manager, Homeowners Association, property owner(s), and/or tenants for scheduling installation

8. Coordinate with the utility for markings of existing power lines, gas lines or other infrastructure is completed and utilize “call before you dig” services (811), service upgrade, new service/meter pull.

Installation

9. Secure the construction area appropriately (e.g. temporary fencing, barriers and signage) for safe working conditions. Prepare mounting surface prior to installation.

10. Remove material to run conduit and/or wiring (i.e., drywall, insulation, pavers, concrete, pavement, earth, etc.).

11. Install rough electrical conduit, boxes and fittings, subpanels etc. in walls, ceilings, floors and trenches to be covered.

12. Request a rough inspection from the building inspection office prior to covering any rough electrical installations.

13. Install charging unit(s) per manufacturer instructions and permitted construction plans. (CEC 110.3)

    a. Install circuit conductors of appropriate size to comply with rating of the overcurrent protection. Securely fasten wiring to the structure. (CEC 300.11, CEC 210.19, CEC 215.2(A), CEC 110.3(B); CEC 310.15(B))

b. Identify and install properly sized equipment grounding conductor with the branch circuit. Connect at the EVCS and panelboard or service. (CEC 250.110, 112, 114, 119, 120, 122; CEC 300.3(B))

c. Bring grounded conductor to the service disconnect and bond to the enclosure. (CEC 250.24 (C))
d. Install overcurrent protection for any newly installed service equipment and conductors. (CEC 230.90, 91)

e. Install disconnect in proper readily accessible location for EVCS that is rated more than 60 amperes or more than 150 Volts to ground (CEC 625.23) If additional service disconnects are installed, verify that they are grouped and do not exceed the maximum number of service disconnects. (CEC 230.71, 72)

f. Identify branch circuit device and disconnects. (CEC 408.4 (A); CEC 110.22(A))

g. Install properly sized supply-side bonding jumpers. (CEC 250.50, 104(A) and (B))

14. Install wheel blocks/safety bollards as needed, and per approved plans. (CEC 110.27(B))

15. Perform finish work to repair existing surfaces, infrastructure, and landscaping, and parking lot striping (if applicable).

16. Make electrical connection and schedule for inspection with local jurisdiction Building Inspector

INSTALLATION CHECKLIST FOR NON-RESIDENTIAL ELECTRIC VEHICLE CHARGING STATION (EVCS)

Installations must be completed by a licensed electrical contractor (C-10). (Local Regulations, California Electrical Code CEC Article 625) Plans must show conformance with the California Electrical Code Title 24, Part 3, the California Building Code (Volume 1 and 2), Title 24, Part 2, and other applicable local municipal codes.

Submittal Documents required*

- ☐ **Permit Application**
  - **a.** Include job address (a unique address for the EVCS installation that is used for billing), parcel number, existing use, description of work, name, address, and contact information of the applicant and the owner.
- ☐ **Plan Sets (#, size of plans)**
  - **a. Site/Plot Plan**
    - **i.** Show full property extent (property lines, parking areas, structures, etc.).
    - **ii.** List relevant property information, such as existing parking counts and ratios.
    - **iii.** Provide a detailed site plan showing where the charging unit is located within the parking garage or lot, and any necessary accessibility improvements
    - **iv.** As required by type of EVCS, installation mounting method, and local jurisdiction requirements provide necessary structural details.
  - **b. Electrical Plan**
    - **i.** Provide a complete electrical single line drawing showing the main service, sub panels and disconnecting means as applicable, and proposed EV charging unit, include; size of overcurrent protection devices (in amperes) for main service, sub panels, disconnects and EV charger circuit supply, show conduit sizes and types, and conductor sizes and types.
    - **ii.** Provide a trenching detail and call out trench work in the scope of work on the plan if trenching is required. Trenching may result in a structural plan review if conduit trenches undermine foundations.
    - **iii.** Note electrical feeder requirements when trenching structure to structure (CEC 225). The feeder from structure to structure should be noted in the scope of work. Verify that trenching is in compliance of minimum cover requirements for wiring methods or circuits (18” for direct burial per CEC 300).

iv. Provide EVSE manufacturer's specification sheets showing Nationally Recognized Testing Laboratory (NRTL) approved listing mark for indoor or outdoor (UL 2202/UL 2200).

- **Electrical Load Calculation Worksheet**
  - **a.** Include existing and proposed load to estimate if existing electrical service will handle the new load from EVCS and wiring methods Note: Unless electrical service equipment is 100% rated, the calculated load demand on the main service shall not exceed 80% of the nameplate rating of the main service over-current protection device (OCPD).

***All plans and documents listed above must be provided for non-residential electric vehicle charging stations at time of permit submittal prior to issuance.**

Pre-Installation Work

1. Determine unit to be installed. Follow all manufacturer specifications for installation. Must be NRTL listed and suitable for the location, indoor or outdoor.

2. Conduct site assessment and submit quote to customer for approval of work and utility upgrades or new service if applicable. Assess the site for:

    a. All electrical system elements (main service, sub-panels, disconnecting means, etc.)
    b. Current electrical code deficiencies
    c. Existing electrical load
    d. Wet and dry utility locations (affecting trench paths for electrical)
    e. Presence of corrosive conditions (e.g. salt air, etc.) affecting recommended equipment
    f. Water drainage (to avoid locating EVCS in areas with possible standing water)
    g. Site accessible parking, and / or accessibility of proposed EVCS
        i. Site slope at proposed EVCS location
        ii. Surface conditions
        iii. Access path(s) connectivity to on-site uses
    h. Visibility of proposed EVCS from uses on site, and/or from public rights-of-way (safety)
    i. Site lighting for use of EVCS and general safety
    j. Placement of EVCS to serve only one versus multiple parking stalls (dependent on hosts intended use of the EVCS)
    k. EVCS protection from vehicle damage through proper placement, and then physical protection (e.g. wheel stops, bollards)
    l. EVCS orientation
        i. Facilitating ease of human interface
        ii. Minimizing sun exposure on digital screens
        iii. Facilitating ease of cable management
    m. Placement and/or screening of electrical support equipment (e.g. transformers, meter pedestals/cabinets, etc.) as it relates to site aesthetics

n. Need for signage and/or stenciling at the EVCS location(s), and / or as directional signage on large sites

3. Complete permit application from local jurisdiction and electrical load calculation for proposed stations:
    a. Mandatory requirements for new construction to be EV Capable. 3% of spaces in lots of 51+ spaces must be capable of supporting future charging. (CALGreen Code Section 4.106.4 and 5.106.5.3)
    b. Comply with zoning setbacks and easements. (Local Regulations)

4. Contact SDG&E for service work order for utility upgrades/notification of new service. File Service and Meter Request Form (http://www.sdge.com/service-and-meter-request-form).
    a. Ensure SDG&E work order is approved. Any work on the utility side of the electric service requires a work order and disconnect/re-connect.
    b. Following SDG&E approval, permit is approved, issued and appropriately posted.

5. Construction plans show compliance with the California Building Code Title 24, Part 2, Section 11B-812 and Section 11B-228:
    a. Signage for EVCS (International Symbol of Accessibility (ISA) signage for accessible spots be provided in compliance with Section 11B-812.8)
    b. For a facility for public and common use, minimum number of EVCS required to comply with Section 11B-812.

6. Construction plans must show compliance with requirements of NFPA 70, CEC Article 625.

Equipment and Scheduling

7. Schedule all necessary contract work for installation of new service (if applicable), and pulling wires from electric panel/meter pedestal to parking structure or lot:
    a. Boring, trenching, concrete and/or paving restoration
    b. Coordinate with building managers, tenants and/or property owner(s) for scheduling installation, including site cleanup/closeout

8. Coordinate with the utility for markings of existing power lines, gas lines or other infrastructure is completed and utilize “call before you dig” services (811), service upgrade, new service/meter pull.

Installation

9. Secure the construction area appropriately (e.g. temporary fencing, barriers and signage) for safe working conditions. Prepare mounting surface prior to installation.

10. Remove material to run conduit and/or wiring (i.e., drywall, insulation, pavers, concrete, pavement, earth, etc.).

11. Install rough electrical conduit, boxes and fittings, subpanels etc. in walls, ceilings, floors and trenches to be covered.

12. Request a rough inspection from the building inspection office prior to covering any rough electrical installations.

13. Install charging unit(s) per manufacturer instructions and permitted construction plans. (CEC 110.3)

    a. Install circuit conductors and wiring of appropriate size to comply with rating of the overcurrent protection. Securely fasten wiring to the structure. (CEC 300.11, CEC 210.19, CEC 215.2(A), CEC 110.3(B); CEC 310.15(B))

    b. Identify and install properly sized equipment grounding conductor with the branch circuit. Connect at the EVCS and panelboard or service. (CEC 250.110, 112, 114, 119, 120, 122; CEC 300.3(B))

    c. Bring grounded conductor to the service disconnect and bond to the enclosure. (CEC 250.24 (C))

    d. Install overcurrent protection for any newly installed service equipment and conductors. (CEC 230.90, 91)

    e. Install disconnect in proper readily accessible location for EVCS that is rated more than 60 amperes or more than 150 Volts to ground (CEC 625.23) If additional service disconnects are installed, verify that they are grouped and do not exceed the maximum number of service disconnects. (CEC 230.71, 72)

    f. Identify branch circuit device and disconnects. (CEC 408.4 (A); CEC 110.22(A))

    g. Install properly sized supply-side bonding jumpers. (CEC 250.50, 104(A) and (B))

14. Install wheel blocks/safety bollards as needed, and per approved plans. (CEC 110.27(B))

15. Perform finish work to repair existing surfaces, infrastructure, and landscaping, and parking lot striping (if applicable).

16. Make electrical connection and schedule for inspection with local jurisdiction Building Inspector.

Endnotes

[i] During 2012-13, REVI identified major barriers to EVCS deployment and PEV adoption through collaboration with local jurisdictions, regional public agencies, San Diego Gas & Electric, local universities and community colleges, IBEW Local 569, the National Electric Contractors Association and the local San Diego business community. The outcome of REVI was the San Diego Regional PEV Readiness Plan that identifies and resolves barriers to the widespread deployment of private and public PEV charging infrastructure, http://www.sandag.org/index.asp?projectid=413&fuseaction=projects.detail.

[ii] *Zero-Emission Vehicles in California: Community Readiness Guidebook* (2013), Governor's Office of Planning and Research, http://opr.ca.gov/docs/ZEV_Guidebook.pdf.

[iii] See *Plug-in SD's EVCS Permitting and Inspection Best Practices: A Guide for Local Governments*, 2016, http://www.sandag.org/uploads/projectid/projectid_511_19814.pdf.

[iv] PEVs include battery electric vehicles and plug-in hybrid electric vehicles. Center for Sustainable Energy (2016). California Air Resources Board Clean Vehicle Rebate Project, Rebate Statistics. Data last updated June 6, 2016. Retrieved June 16, 2016 from https://cleanvehiclerebate.org/eng/rebate-statistics

[v] Governor Brown's Zero-Emission Vehicle Executive Order, March 23, 2012, https://www.gov.ca.gov/news.php?id=17463.

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[viii] *San Diego Regional Plug-In Electric Vehicle Readiness Plan* (2014), p. 13, http://www.sandag.org/uploads/publicationid/publicationid_1817_17061.pdf.

[ix] Ibid. p. 8-9.

[x] CALGreen, 2013, http://hcd.ca.gov/codes/state-housing-law/calgreen_guide_rev_12-13.pdf.

[xi] PEV Collaborative MUD Guidelines, figure 5.1, page 13, http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/reports/MUD_Guidelines4web.pdf.

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[xiii] NEIS® ANSI standard for EVCS, http://www.necanet.org//store/product/neca-413-2012-standard-for-installing-and-maintaining-electric-vehicle-supply-equipment-(EVCS)-Standard.

[xiv] California Electrical Code, Title 24, Part 6, Article 625, http://www.nfpa.org/codes-and-standards/document-information-pages/free-access?mode=view.

[xv] OPR Zero-Emission Vehicles in California: Community Readiness Guidebook Permitting Checklist, p. 112-115.

[xvi] Clean Cities, *Plug-in Electric Vehicle Handbook for Electrical Contractors*, http://www.afdc.energy.gov/pdfs/51228.pdf.

[xvii] *Zero-Emission Vehicles in California: Community Readiness Guidebook*, 2013, http://opr.ca.gov/docs/ZEV_Guidebook.pdf.

[xviii] *Plug-in SD's EVCS Permitting and Inspection Best Practices: A Guide for Local Governments*, 2016, http://www.sandag.org/uploads/projectid/projectid_511_19814.pdf.

[xix] The Cal Electric Residential EVCS Program, 2015, http://www.energycentral.com/enduse/electricvehicles/articles/3203/The-Cal-Electric-Residential-EVCS-Program.

[xx]DSA's 2016 access web reference, Final Express Terms for Proposed Building Standards of the Division of the State Architect (DSA-AC), pages 74-90, http://www.documents.dgs.ca.gov/dsa/access/2016-Pt2_Final-Express-Terms_12-22-15.pdf.

[xxi] City of San Diego Technical Policy 11B-1, http://www.sandiego.gov/development-services/pdf/industry/tpolicy11b1.pdf.

[xxii] Advanced Energy, 2014, Charging Station Installation Handbook for Electrical Contractors and Inspectors, http://www.advancedenergy.org/portal/ncpev/resources/ESVEHandbook.pdf.

[xxiii] PEV Collaborative, *Plug-In Electric Vehicle Charging Infrastructure Guidelines for Multi-Unit Dwellings*, *http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/MUD_Guidelines4web.pdf.*

[xxiv] *Plug-In Electric Vehicle Charging Infrastructure Guidelines for Multi-Unit Dwellings*, Ibid., p. 24-25, http://www.pevcollaborative.org/sites/all/themes/pev/files/cityfront%20copy.pdf.

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[xxvi] AB 1236 local ordinances: electric vehicle charging stations, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB1236, enrolled September 11, 2015.

[xxvii] California Air Resources Board, 2015, Electric Vehicle Charging Infrastructure Provisions, http://www.documents.dgs.ca.gov/bsc/2015TriCycle/CAC/GREEN/Exhibit-B-CARB-Cost-Analysis-and-Technical-Report.pdf.

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[xxix] EVITP Training Program, http://www.evitp.org/training-programs/.

[xxx] Plug-in Electric Vehicles: Resources for Electrical Contractors, https://energycenter.org/sites/default/files/docs/nav/programs/pev-planning/san-diego/fact-sheets/Electrical%20Contractor%20Fact%20Sheet.pdf.

[xxxi] California Air Resources Board, DriveClean.ca.gov, http://www.driveclean.ca.gov/.

[xxxii] Property assessed clean energy (PACE), http://energycenter.org/policy/property-assessed-clean-energy-pace.

[xxxiii] CalCap EVCS Financing Program, http://www.treasurer.ca.gov/cpcfa/calcap/evcs/.

[xxxiv] City of Oceanside Residential Electric Vehicle (EV) Charger Guidelines, 2012 http://www.ci.oceanside.ca.us/civicax/filebank/blobdload.aspx?blobid=30053.

[xxxv] *Plug-In SD's EVCS Permitting and Inspection Best Practices: A Guide for Local Governments*, 2016, http://www.sandag.org/uploads/projectid/projectid_511_19814.pdf