California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Department of Housing and Community Development Electrical Vehicle Readiness Study

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued contract 600-12-003 to create an information resource of the current building codes, existing research, and current market data related to the requirements and costs of electric vehicle readiness in new construction single-family and multi-family dwellings. The CEC issued contract 600-12-003 on January 31, 2013.

ABSTRACT

This report is intended to be an information resource of the current building codes, existing research, and current market data related to the requirements and costs of electric vehicle readiness in new construction single-family and multi-family dwellings.

Research included identification and review of industry stakeholders, current reports, and building standards related to current and future electric vehicle charging for single-family and multi-family dwellings.

For each residential parking arrangement the technical analysis encompassed several areas including determination of appropriate voltage and amperage needs for electric vehicle charging, the effect of solar photovoltaic (PV) systems installed in conjunction with electric vehicle charging loads, the estimate of the added cost to housing construction and subdivision infrastructure, current ventilation requirements, and the types of housing where electric vehicle charging may be impractical.

Existing building codes, builder awareness and public and private sector stakeholder involvement appears to have created a market for the feasibility of electric vehicle readiness. Supporting the feasibility of installing electric vehicle chargers, several developers are offering and have offered electric vehicle-ready homes. Utilities have also offered assistance as well as incentives to promote the purchase of electric vehicles.

The cost of electric vehicle-ready homes does not appear to be a barrier to the implementation of electric vehicle chargers and the required infrastructure. Most builders do not see this as a significant cost increase in building a residential dwelling unit or multi-family unit. The cost for electric vehicle readiness ranges from under $50 for a simple receptacle level 1 installation to under $300 per unit for a Level 2 installation prewired with circuit breakers including labor but without the cost of the charger. Most Investor Owned Utilities agree that if the Level 2 charging requirements are kept at or less than 240 volt, 40-amp within a 200-amp panel there would be little impact on the utility grid infrastructure.

Keywords: Level 1 charger, Level 2 charger, PEV charging station, electric vehicle charging, PEV charger installation

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report is intended to be an information resource that supports the Governor's Action Plan and the expansion of Zero Emission Vehicles through the new construction development of electric vehicle ready single-family and multi-family dwellings. It is also intended as an information resource of the current building codes, existing research, and current market data related to the requirements and costs of electric vehicle readiness in new construction of single-family and multi-family dwellings.

Research for this report included identification and review of industry stakeholders, current reports, and building standards related to current and future electric vehicle charging for single-family and multi-family dwellings. The research covered four residential structures with distinctive parking arrangements.

- Single-family Residential
- Multi-family #1 Parking Below
- Multi-family #2 Parking Adjacent
- Multi-family #3 Open-space, grade-level parking located next to the building

For each residential parking arrangement the technical analysis encompassed several areas including determination of appropriate voltage and amperage needs for electric vehicle charging, the effect of solar photovoltaic systems installed in conjunction with electric vehicle charging loads, the estimate of the added cost to housing construction and subdivision infrastructure, current ventilation requirements, and the types of housing where electric vehicle charging may be impractical. While the focus of the analysis was on residential new construction single-family and multi-family dwellings, the analysis also assessed the appropriate percentage of electric vehicle charging spaces necessary to serve the Governor's Action Plan which predicts 1.5 million electric vehicles on California's roads by 2025.

General Findings

Electric vehicle and relevant stakeholder groups were consulted, including a thorough review of extensive online information and electric vehicle industry news, resources and tools. Input on the research topics was solicited from industry experts. Their findings are reported by research topic and key studies are included in the appendices. For the most part, stakeholders were engaged and had a good understanding of the electric vehicle challenges and barriers to electric vehicle readiness. Most embraced the need to be electric vehicle-ready.

Codes have significant language that addresses the requirements for electric vehicle readiness. The codes that have the greatest impact on electric vehicle readiness are the 2013 California Electric Code and the 2013 California Green Building Standards Code. The 2013 California Energy Code also impacts electric vehicle readiness in terms of photovoltaic solar readiness requirements that specify a 200-amp electrical service panel. The recently adopted 2013 codes that become effective on January 1, 2014, slightly expand on code requirements that impact electric vehicle readiness.

The voltage and amperage to use for Level 2 electric vehicle charging is 240 volts, 40-amp breaker which requires two panel spaces or slots. Level 2 will provide a reasonable charge time and will ensure a full charge when an automobile is charged overnight. The impact to the local utility is minimal since the electrical service line size and transformer diversity will compensate for this load with little to no impact to the utility infrastructure. Due to consumer desire to drive longer distances with minimal time spent charging, the Level 2 charger has become the charger of choice for electric vehicle owners.

Concern for ventilation requirements for electric vehicle supply equipment does not appear to be well founded. Current and proposed code references adequately address the issue of when ventilation is required. Battery packs used in electric vehicles do not require ventilation. If electric vehicle supply equipment is marked to be used without ventilation, then no ventilation is required by the code. Additionally, manufacturers' standards for electric vehicle supply equipment adequately address the issue of when ventilation is required.

The subject of the impracticality of providing electric vehicle charging in residential new construction applications did not seem to be widespread. With good engineering, planning and forethought electric vehicle charging may be practical in most residential dwelling units, although multi-family units with distant carport and unassigned parking can be challenging, due to the cost of providing the infrastructure. The main challenge may be due to limitations in the utilities' electrical service infrastructure, resulting from inadequate service mains, transformers or substations to provide for large multi-family complexes.

Overall, the industry appears to be ready and receptive to providing residential single-family dwellings and multi-family dwelling units with electric vehicle readiness. Momentum appears to be increasing, local jurisdictions are adopting regulations and permitting processes that facilitate electric vehicle installations, manufacturers are decreasing their price to promote consumer buy in, and the governments and utilities are providing incentives to promote purchase of electric vehicles.

The Governor's electric vehicle Action Plan goal calls for 1.5 million electric vehicles in California by 2025. Assuming an electric vehicle charging ready code requirement for all single-family and 5 percent multi-family dwelling units in July 2015 there will be 1,025,000 electric vehicle-ready charging locations from new construction by 2025. Additionally, if electric vehicle car sales increase 18 percent per year (current growth 24 percent) approximately 1,500,000 electric vehicles will have been sold in California by 2025. These electric vehicles will also have home-based chargers; the vast majority of which will not be in newly constructed homes. Table 1 below provides a summary of the infrastructure costs and associated findings for both single-family and multi-family which are detailed further in Chapter 3 of this report.

Single-family Findings

Due to the 2013 California Energy Code requiring more efficient homes by as much as 30 percent and the continued decrease in energy consumption and eventual goal of net zero homes by 2020, it is believed that a 200-amp panel would be adequate to serve the electric vehicle loads. This will minimize impact on the utilities and reduce cost to the builder and the consumer.

In addition, based on cost studies reviewed for this report, as well as conversations with utility stakeholders, suggests that there may be no cost impact to the investor owned utilities infrastructure if the panel size is kept at 200-amp.

Adding Level 1 or 2 chargers to single-family residential dwellings with dedicated parking did not seem to pose a significant challenge. An electric vehicle option is already being offered by a few builders. Based on interviews with those large California builders who offer an electric vehicle option, it is of interest to note that very few new home buyers (less than 0.2 percent) of 2012 single-family new construction starts (27,523)[1] purchased the electric vehicle option.

The 2013 California Energy Code requires a 200-amp panel for single-family residences to be solar ready. In larger homes (greater than 4,000 square feet) with significant amenities providing reserved space for future circuit breakers to accommodate future solar electric and electric vehicle installations may require an increase to a 400-amp panel. If a subdivision of large homes is added at the end of a service line or on a line that is near capacity, then significant cost impacts to the utility infrastructure may occur. Based on interviews with local utilities, an increase in the existing line extension infrastructure should not be needed for typical electric vehicle installations.

Multi-family Findings

Multi-family parking space requirements are typically determined by local jurisdictions. An electric vehicle ready code requirement of 5 percent multi-family dwelling units or parking spaces, whichever is less, will accommodate for electric vehicle use in multi-family dwellings over the various parking space calculation methods.

The greatest challenge facing electric vehicle chargers is where to place them in multi-family units where parking was not available below the units or in an adjacent parking garage. Multi-family units with carports with unassigned parking also pose large challenges. For some of these locations local jurisdiction could deem an electric vehicle ready requirement impractical.

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[1] Construction Industry Research Board/California Homebuilding Foundation; December 2012 report dated March 1, 2013

Table 1: Summary of Infrastructure Costs and Associated Findings

Electric Vehicle Readiness Types	Housing Type	Cost	Conduit	Jbox	Breaker	Receptacle	Charger	Labor	Conditions
No installation at time of original construction. Include samples of retroactive installation costs, e.g., increasing electrical service, modifying panels or adding subpanels, installing conduit and conductors, etc.	Single-family	$0 to $8,000 plus Typical Level 1=$0 Typical Level 2=$3,500	√	√	√	√	√	√	Depends on if they only use Level 1 could be as low as $0 cost. If level 2 depends on existing electrical infrastructure
	Multi-family	$0 to $8,000 plus Typical Level 2=$3,500	√	√	√	√	√	√	Depends on if they only use Level 1 could be as low as $0 cost. If level 2 depends on existing electrical infrastructure
Installation of dedicated 120-volt GFCI wall receptacle for Level 1 charging only.	Single-family	$100	√	√	√	√	N/A	√	No infrastructure cost.
	Multi-family	$100	√	√	√	√	N/A	√	Cost is per installation not per dwelling. Cost per dwelling unit would be significantly less expensive.

Electric Vehicle Readiness Types	Housing Type	Cost	Conduit	Jbox	Breaker	Receptacle	Charger	Labor	Conditions
Installation of conduit or raceway for dedicated branch circuit in compliance with CAL Green Section A4.106.6 (2013 CAL Green Section A4.106.8) which requires at least a Trade Size 1 (nominal 1-inch inner diameter) raceway for a dedicated branch circuit and related requirements.	Single-family	$50	√	√	N/A	N/A	N/A	√	Alternative electrical installation than proposed in CAL Green may decrease cost
	Multi-family	$110	√	√	N/A	N/A	N/A	√	Cost is per installation not per dwelling. Depending on the number of EV readiness installations a dedicated panel may be required.
Installation of 30 and 40-amp 240 volt dedicated	Single-family	$300	√	√	√	√	N/A	√	Includes $100 in infrastructure cost.

Electric Vehicle Readiness Types	Housing Type	Cost	Conduit	Jbox	Breaker	Receptacle	Charger	Labor	Conditions
branch circuit with receptacle.	Multi-family	$300	√	√	√	√	N/A	√	Includes $100 in infrastructure cost. Installation cost can vary significantly if parking is not above or below or is not assigned. If parking is distance in carports underground trenching, conductors, and wiring costs will be significant. Number of electric vehicle installations will affect size and cost of electrical panel if required.
Installation of 30 and 40-amp 240-volt branch circuit plus electric vehicle supply equipment in new single-family and multi-family dwellings.	Single-family	$280	√	√	√	N/A	√	√	Includes $100 in infrastructure cost. Cost of charger that can vary from $399 to $1500 is not included

Electric Vehicle Readiness Types	Housing Type	Cost	Conduit	Jbox	Breaker	Receptacle	Charger	Labor	Conditions
	Multi-family	$280	√	√	√	N/A	√	√	Includes $100 in infrastructure cost. The cost of charger, which can vary from $399 to $1500, is not included. Installation cost can vary significantly if parking is not above or below or is not assigned. If parking is distance in carports underground trenching, conductors, and wiring costs will be significant.
Assumptions: Cost of the 200-amp panel is not included since a 200-amp panel may be required and has adequate breaker spaces.									

Source: ConSol

INTRODUCTION

This report addresses Plug-In Electric Vehicles, which include both pure battery electric vehicles and Plug-In Hybrid Electric Vehicles. The focus of this report is the expansion of Plug-In Electric Vehicle Readiness in the form of Level 1 (120V) and Level 2 (240V) charging capability for residential new construction, including single-family and multi-family dwellings. The terms Plug-In Electric Vehicles and Electric Vehicle may be used interchangeably throughout this report. Additionally, the term charger, while technically a component within a Plug-In Electric Vehicles, will follow the general meaning of charging equipment throughout this report.

Chapter 1 is an overview of certain Plug-In Electric Vehicles charging stakeholders, groups and other related information including utilities, home builders, building departments, Plug-In Electric Vehicle manufacturers, Plug-In Electric Vehicle charging station manufactures, and Plug-In Electric Vehicle battery manufacturers. Chapter 2 provides an overview of building codes and other items impacting Plug-In Electric Vehicle charging. Chapter 3 contains a technical analysis of Plug-In Electric Vehicle charging readiness as it relates to single-family and multi-family dwellings, including voltage and amperage needs, the effect of solar photovoltaic systems on Plug-In Electric Vehicle charging, the added new construction infrastructure costs, ventilation requirements, and the number of Plug-In Electric Vehicle charging stations needed to serve 1.5 million electric vehicles.

CHAPTER 1: EV Charging Stakeholders

EV – Stakeholders, Groups and Other Information

There are many organized electric vehicle (EV) groups that have an extensive online presence providing consumers with EV industry news, resources and tools. Utilities are very engaged due to the impact EVs have on their infrastructure, peak load demands and economics. Other stakeholders have a direct interest in the development of codes and standards that will impact their constituencies. Below is a summary of those EV groups and stakeholders that were identified and reviewed as part of this research report.

California Building Industry Association

California Building Industry Association is the California home builders' trade association based in Sacramento representing over 3,000 member companies including homebuilders, trade contractors, architects, engineers, designers, suppliers and other industry professionals. California Building Industry Association members build over 80 percent of the new California housing (single-family and multi-family) annually.[2] California Building Industry Association members will be directly impacted by EV charging codes and mandates. The California Building Industry Association (http://www.cbia.org/go/cbia/).

California Building Officials

California Building Officials is the California building officials' trade association dedicated to promoting public health and safety in building construction through responsible legislation, education and building code development. California Building Officials provides a host of valuable services, including continuing education and training, to its over 500 members. The California Building Officials (https://www.calbo.org/).

The California Plug-In Electric Vehicle (PEV) Collaborative

The California PEV Collaborative is a multi-stakeholder public-private partnership, working to ensure a strong and enduring transition to a PEV market in California. The Collaborative embodies all key California PEV stakeholders including elected and appointed officials, automakers, utilities, infrastructure providers, environmental organizations, research institutions and others. Their mission, under the guidance of a multi-stakeholder executive membership, is to facilitate the deployment of PEVs in California to meet economic, energy and environmental goals.

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[2] CBIA Technical Director, testimony at CEC Draft Action Plan for the Comprehensive Energy Efficiency Program for Existing Buildings, Fresno Workshop, June 25, 2013

DriveClean

DriveClean is a consumer-focused website developed by the California Air Resources Board as a resource for car buyers to find clean technology vehicles. The website helps consumers compare their options to take the next steps into PEV ownership. The California Air Resources Board is part of the California Environmental Protection Agency with a mission to promote and protect public health, welfare and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state. DriveClean (https://driveclean.ca.gov/).

Electric Auto Association

The Electric Auto Association is a non-profit educational organization that promotes the advancement and widespread adoption of EVs. The Electric Auto Association acts as a public source of information to communicate developments in EV technology, to encourage experimentation in the building of EVs, and to organize public exhibits and events of EVs, and to educate the public on the progress and benefits of EV technology. The Electric Auto Association (www.electricauto.org).

Electric Power Research Institute

The Electric Power Research Institute, Inc. conducts research, development and demonstration (RD&D) relating to the generation, delivery and use of electricity for the benefit of the public. As an independent, nonprofit organization, they bring together scientists and engineers as well as experts from academia and the industry to help address challenges in electricity. The Electric Power Research Institute (http://www.epri.com/Pages/Default.aspx).

FuelEconomy

FuelEconomy is an Internet resource that helps consumers make informed fuel economy choices when purchasing a vehicle and achieve the best fuel economy possible from the cars they own. The website is maintained by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy with data provided by the U.S. Environmental Protection Agency. The site helps fulfill U.S. Department of Energy and U.S. Environmental Protection Agency's responsibility under the Energy Policy Act of 1992 to provide accurate miles per gallon information to consumers. FuelEconomy (http://www.fueleconomy.gov/).

The GoElectricDrive Foundation

The GoElectricDrive Foundation is an independent nonprofit entity dedicated to consumer education, outreach and awareness around electric drive technology. Their aim is to highlight the positive impacts of EV for consumers. The GoElectricDrive Foundation is comprised of a consortium of critical and diverse stakeholders from utilities to manufacturers, car enthusiasts to environmental nonprofits, non-EV industry business and community leaders to government opinion leaders. The Mission of The GoElectricDrive Foundation is to enable and accelerate mass-market adoption of EVs by the American public. The GoElectricDrive Foundation (http://www.goelectricdrive.com/).

TakeCharge

TakeCharge is the one-stop website for current and prospective PEV drivers in the counties of El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba. As PEVs become more integrated into transportation networks, TakeCharge helps communities to become "PEV-ready" with the necessary knowledge and infrastructure. TakeCharge (http://www.takechargesac.org/).

EV Owners

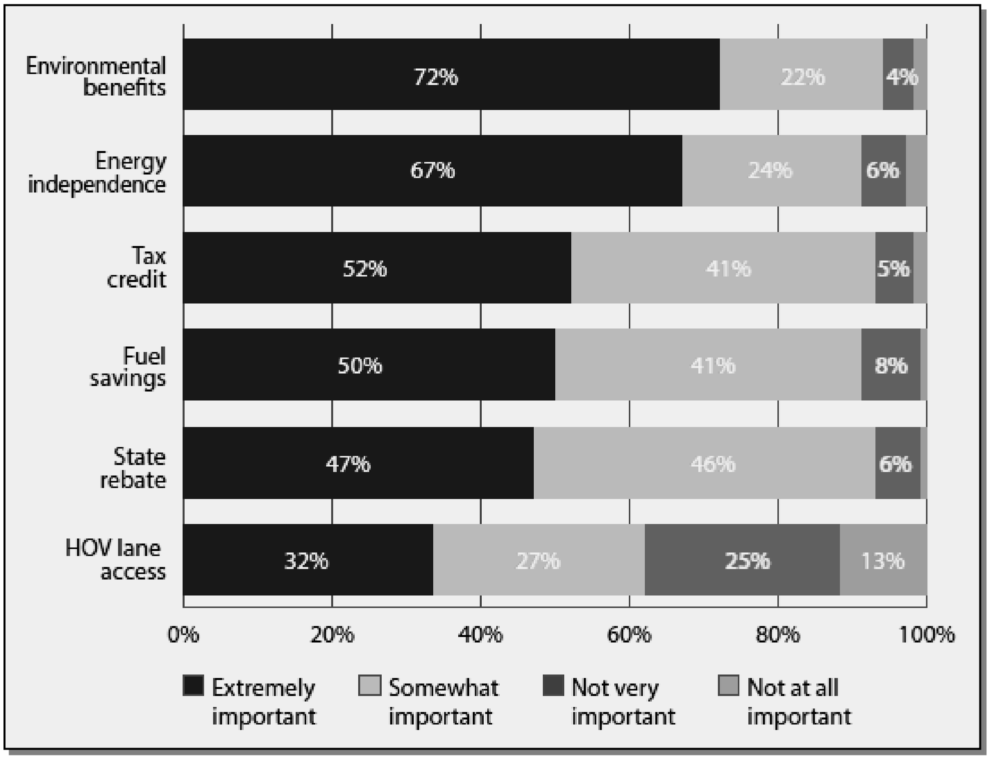
The United States plug-in electric vehicle market experienced remarkable growth in 2012, with sales tripling that of 2011. This rapid expansion was driven in large part by California, which had more than 22,000 plug-in vehicles (roughly 35 percent of the United States market) on its roads by the end of 2012. This strong market growth was highlighted by the fact that roughly one of every 40 new cars bought or leased in California during the last three months of 2012 was a plug-in electric vehicle. As a result, Californians are now driving more than 15 million electric-fueled miles every month.

The California Center for Sustainable Energy in coordination with the California Air Resources Board is conducting a longitudinal study of EV owners that explores vehicle satisfaction, driving behavior, use of charging infrastructure, motivations for vehicle purchase and household demographics. Since early 2012, The California Center for Sustainable Energy has collected information from 2,039 individual California plug-in vehicle owners and drivers. Overall, these surveys represent the largest and most detailed surveys of plug-in electric vehicle drivers in the nation.

In the survey, respondents were asked to rate the importance of various factors in their decision to purchase a PEV. A summary of the survey responses is provided in Figure 1. Environmental benefits were rated as the most important motivation for purchasing a PEV, with 72 of respondents describing it as "extremely important."[3]

[3] California Plug-in Electric Vehicle Driver Survey Results, Center for Sustainable Energy, May 2013

Figure 1: Importance of Motivation on EV Purchasing Decision



Source: California Plug-in Electric Vehicle Driver Survey Results, Center for Sustainable Energy, May 2013

Investor Owned Utilities (IOUs)

The IOUs, Pacific Gas & Electric Company (PG&E), San Diego Gas &Electric (SDG&E), and Southern California Edison (SCE) have informative websites that provide their customers with the tools to determine EV charging options, installation options, the most advantageous rate schedules and incentives available. These websites help consumers who wish to purchase an EV or who have already made the purchase and want to add an EV charger to their home.

Key factors determining the installation and operating costs of an EV charger include the amount of electricity currently used and the time required for recharging the EV batteries. Each IOU provides time of use (TOU) rates which encourage customers to limit daytime use of electricity, when demand and cost for electricity is highest. The lowest cost to charge is during a time period that the IOUs call "super" off-peak which lasts typically 5–6 hours (e.g., midnight to 6 AM). While the electric rates are at their lowest, the 5–6 hour timeframe does not provide enough time for an alternating current (AC) Level 1 charger to completely recharge most EV batteries from empty to full. A full charge can take approximately 7–17 hours depending on whether it's a plug-in hybrid electric vehicle (PHEV) or battery electric vehicle (BEV). Seventy-eight percent of EV drivers drive an average of 15 to 45 miles per day.[4] For the consumer who drives more than 45 miles per day, a 3.3kW AC Level 2 charging station would provide the necessary charging power to charge a battery from empty to full in approximately 3 to 8 hours depending on whether the battery was for a PHEV or BEV respectively.

The IOUs found that customers on TOU rates refueled their vehicles during the off-peak periods during the weekdays. Although PEV customers generally have higher usage and higher demand on the system than non PEV customers, peak times for PEV Demands have typically been in the early morning hours compared to evenings for typical residential customers.

The IOUs tracked monthly EV consumption in their recently published Joint IOU Electric Vehicle Research Final Report (dated December 28, 2012). In general, EV customers have higher usage and demand on the electrical system than non-EV customers (approximately 300–600-kwh per month depending on the IOU service territory). A key finding of the Joint IOU EV Research Final Report was that added load from EV charging at peak times is about equivalent to the load from summertime air conditioning demand. However, peak usage time for EV customers was typically in the early morning hours compared to evenings for residential customers.[5] The use of electricity during the off-peak times was attributed to pricing signals from TOU rates.[6]

In addition to TOU electric rates, the IOU may require the installation of a separate EV meter. The cost of the second meter, the permit(s) and the installation costs are typically born by the customer. The need for utility infrastructure upgrades is not prominently discussed on the IOUs websites, however, the installation instructions typically request a load survey (determination of panel capacity and space availability) by a qualified electrician and that the IOUs are contacted to assess transformer and service capacity for the home. The IOUs have completed more than 6,300 residential infrastructure checks for EV installations through October 2012 and only 22 homes (0.3 percent) required upgrades.[7] Table 2 below from PG&E also implies no system (infrastructure) upgrades required for EV Level 1 or 2 chargers.

The costs can vary depending on whether the existing electrical service has the capacity for the desired charging level and whether a second meter is required. For illustrative purposes, below in Table 2 are installation construction requirements for level 1 and 2 chargers as well as some of the cost considerations for just one of the IOUs.

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[4] California Plug-in Electric Vehicle Driver Survey Results, Center for Sustainable Energy, May 2013
[5] Joint IOU Electric Vehicle Load Research Final Report, Page 4, December 28, 2012
[6] Joint IOU Electric Vehicle Load Research Final Report, Page 19, December 28, 2012
[7] Joint IOU Electric Vehicle Load Research Final Report, Page 10, December 28, 2012

- **Rate:** Residential customers who charge their electric vehicles at home have multiple rate options depending on their utility including flat, tiered, time-of-use, single meter and dual meter.
- **Panel Upgrade:** AC Level 2 charging requires a dedicated circuit, which may result in an electrical panel upgrade. An electrician will determine whether the current electrical panel has capacity. If an upgrade is required, the electrician will arrange an inspection and obtain a permit from the city/county.
- **Second Meter and Panel:** Customers could opt to replace an existing panel with a dual meter panel, although this is generally more costly. The electrician will arrange an inspection and obtain a permit from the city and/or county. Additional costs include the electrician's installation costs for the second panel and $250 for the second meter (PG&E territory).
- **Service Upgrades:** If the existing panel requires upgrading or addition of a second panel, a service upgrade may be required. Service upgrades are necessary when the service wire to the home has inadequate capacity to meet the needs of the panel.

If a service upgrade is required, customers are responsible for costs that exceed the $1,918.00 allowance that PG&E provides. Generally, overhead service upgrade costs are covered entirely by the allowance. Underground service upgrades will likely exceed the allowance costs because of the additional trenching and labor required.

- **System Upgrades:** Charging a vehicle at AC Level 2 can add considerable load to the infrastructure. PG&E may need to upgrade the distribution infrastructure at PG&E's expense. Until the upgrades are complete, PG&E may request customers to charge their PEV during off-peak hours (12 a.m. – 7 a.m.) in order to prevent electrical service disruption.

The following are the EV website locations for the three IOUs.

- PG&E – (http://www.pge.com/electricvehicles/)
- SDG&E – (http://www.sdge.com/electric-vehicles)
- SCE – (https://www.sce.com/wps/portal/home/residential/electric-cars/)

Table 2: PG&E Installation Requirements in Existing Dwellings

Charging	Rate	Panel Upgrade	Second Meter & Panel	Permits	Service Upgrade	System Upgrade
AC Level 1	E-1, E-6, E-9A, EV-A	No	No	No	No	No
	E-9B, EV-B	No	Yes	Yes	Yes	No
AC Level 2	E-1, E-6, E-9A, EV-A	Yes	No	Yes	Yes	No
	E-9B, EV-B	No	Yes	Yes	Yes	No

Source: Instructions for installing level 2 charging station at home (http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/installationprocess)

ConSol surveyed the IOUs about the effects installing Level 2 EV chargers in new construction would have on house panel size and infrastructure requirements. The following is a summary of the feedback received.

PG&E

200-amp vs. 400-amp Main Panel – Level 2 Charger plus Solar photovoltaic System

PG&E believes in most cases a 200A panel will be large enough to accommodate a Level 2 electric vehicle charging station, solar, as well as the energy consumption of a typical household. In very rare cases, a home will need to upgrade to a higher level of service (400A or two parallel 200A panels). However, the homes in these cases are significantly larger and consume much more energy than typical homes.

Infrastructure Requirements

PG&E states a proposed EV ready code will not require any additional utility infrastructure improvements that will need to be made to accommodate EV charging stations in new construction. It is standard practice for PG&E to build utility infrastructure to serve the expected energy demand for each new development. In cases where homes are built in older developments, customers are required to notify PG&E for any load increases. In these cases, PG&E will make any necessary utility infrastructure improvements to ensure safe and reliable power to all customers on that distribution circuit.

Level 2 Charger plus Solar PV System

PG&E believes that the 2013 Energy Code solar ready requirement does not directly impact utility infrastructure improvements associated with solar. All customers interested in installing solar at their home or work are required to enter into an Interconnection Agreement with PG&E. This agreement allows PG&E to identify and perform necessary infrastructure improvements associated with each solar installation on a case by case basis. The Interconnection Agreement will continue to be required and supersedes the Energy Code.

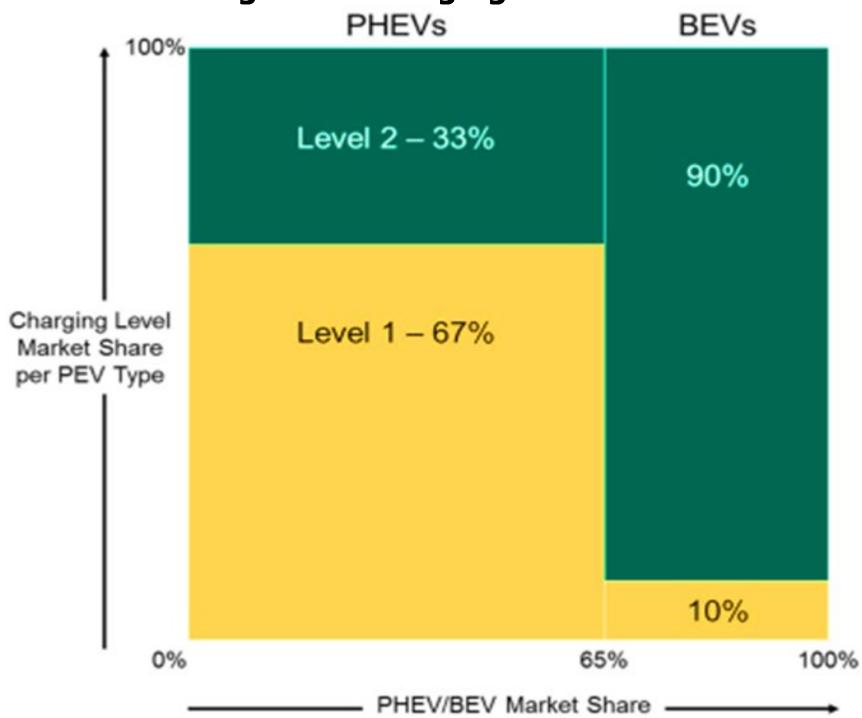
Existing vs. New Construction

PG&E strives to provide their customers with safe and reliable power. At this stage in the market, PG&E believes that EVs have not impacted grid stability. However, they believe this may change as the market develops. PG&E is currently gathering data in order to determine what next steps need to be taken to accommodate higher adoption. As part of their ongoing efforts to provide safe and reliable service to customers, PG&E performs and tracks information related to service upgrades to better understand the support necessary for the EV market.[8]

SCE

Figure 2 provides a visual representation of the Residential PEV Customer Profile in SCE Service Territory. Based on industry insights and customer data, SCE estimated the charging levels being utilized by customer who contacted SCE. Most customers charge their PEVs with Level 2 chargers.

Figure 2: Charging Levels



Source: PEV Market Update, Bob Graham, Transportation Electrification, Southern California Edison, July 24, 2013

[8] Emails with David Almeida and Ulric Kwan, PG&E electric vehicle programs, August 2013

SDG&E

200-amp vs. 400-amp Main Panel – Level 2 Charger plus Solar PV System

SDG&E believes a 200-amp main panel will work in many cases for homes with a Level 2 charger and a solar PV system. Each home is unique depending on the existing load connected to the panel and the proposed additional load. A qualified engineer will need to perform load calculations with the existing load and then incorporate the new proposed load into the calculations to determine the appropriate panel size. New EVs on the market, such as Tesla, have the ability to charge at 240 volts / 80-amp (19.2 kW). Level 2 charging no longer means just 3.3 kW or 6.6 kW. In addition, most new EVs coming to market have the ability to charge at a rate of 7.7 kW from an outlet connection. Regarding 400-amp panels, there are definitely installation impacts to keep in mind. For a 200-amp panel installation, 2-inch conduit is required from the pad-mounted transformer to the main panel. However, for a 400-amp panel, 3-inch conduit is required. Since the customer is responsible for the trenching and conduit costs, that would influence the cost of installation. An SDG&E Planner will look at the existing infrastructure and transformer requirements for each project on an individual case basis.

Level 2 Charger plus Solar PV System

SDG&E is not yet aware of any additional infrastructure requirements that may be needed for compliance with the current 2013 Energy Code requirement for new solar ready homes in conjunction with a possible EV charging readiness requirement. SDG&E believes that any new home code improvements would require additional load calculation for each new home or subdivision. As a caveat, solar PV systems may help reduce peak loading at each new home (depending on the configuration and consumption), so it may be difficult to determine without more inputs to the load calculation.

Existing vs. New Construction

For existing construction, electric vehicle charging installations are really just additional load, which is added by homeowners all the time (air conditioning, spas, etc.). We have arranged with the City of San Diego to be notified when permits are inspected and approved for new vehicle chargers. Those notifications are looked at within our Distribution Engineering group to see if there are any circuit issues that may develop with the installation. With new construction, the additional load from a vehicle charging station would be treated like any other load in the residence (and aggregated in the community) and looked at by the Planner that is assigned to the job for utility infrastructure purposes. An entire community of EVSEs would get some attention, as we are very interested in the clustering effect from dense installations of EV chargers.[9]

[9] Emails with Randy Schimka and Greg Haddow, SDG&E electric vehicle programs, July 2013

Municipal Utilities

Large and small municipal utilities website were reviewed for EV content. In general, the investor owned and large municipal utilities offer detailed consumer and installation instructions.

The Anaheim Public Utilities

provides customers with an online EV Readiness Guide which walks the consumer through the main decision-making process including the additional steps to consider for installation of a Level 2 charger.

- Are you considering a plug-in hybrid electric vehicle (PHEV) or a battery electric vehicle (BEV)?
- Will you be using a Level 1 or Level 2 charger?
- Does your home have sufficient electrical capacity to charge the battery?
- How will an EV impact your electricity bill?

The Los Angeles Department of Water and Power

"CHARGE UP L.A.!" website provides customers with detailed fact sheet information on their EV program which includes a seven-day permit-to-plug promise. The Los Angeles Department of Water and Power, through a partnership with the Department of Building and Safety, has streamlined basic EV charger installations to be completed within seven days. Customers are encouraged to schedule a preliminary check to identify any potential issues prior to installation. Besides time of use (TOU) rates, The Los Angeles Department of Water and Power additionally provides customers four-meter level choices. The fact sheet includes pros, cons, installation time estimates and other information on each meter choice, ensuring their customer is informed and is part of the decision-making process. The four-meter choices include standard meter; whole house TOU; non-billed submeter; and separate TOU meter.

The Sacramento Municipal Utility District

has been actively installing EV chargers since 1991. They began working with electrical vehicle infrastructure in 1992 on conductive chargers. The Sacramento Municipal Utility District's extensive experience in utility infrastructure for EV has led them to document their findings. They are currently working on a white paper on the impact of EV Level 2 chargers on their grid. The white paper was not available at the time of this report. However, the findings support that Level 2 chargers at 240 volts, 40-amp do not significantly affect the utility infrastructure.

The following are the EV website locations for the municipal utilities mentioned.

- Anaheim Public Utilities – (http://www.anaheim.net/articlenew2222.asp?id=4501)
- LA DWP – (https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=12gpm6ra56_63&_afrLoop=126567111685000)

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

Home Builders

To understand the market status of EVSEs in residential new construction, the top ten builders of California's five largest metropolitan statistical areas were surveyed for their marketing efforts and installation rates of EVSE. These five markets (Los Angeles, Riverside, San Francisco, San Diego and Sacramento) represented 70 percent of the single-family housing starts in 2012.[10] The top ten builders in these five metropolitan statistical areas consisted of thirty-one home building companies. These builders built 44 percent of single-family homes in California in 2012.[11] Only one of the builders, Shea Homes-Northern California, offered EVSEs as a standard feature in their Landsdowne 93 unit townhouse community in San Mateo, California. Two builders, KB Home who offers the ZeroHouse option, and Pardee who offers Living Smart options, marketed EVSEs as a home buyer option in multiple communities. Both builders who reported offering EVSEs as an option installed fewer than five (5) EVSEs statewide in 2012. The total EVSEs installed in the 2012 residential single-family market represented by these builders was fewer than 100 units statewide. EVSEs were installed in less than 0.2 percent of new home starts in 2012. Those builders with experience installing EVSEs reported the following items that builders should consider when offering EV charging as a new construction option:

- Design costs for fully engineered electrical system
- Construction costs
    - Increased capacity of meter/distribution panel.
    - Dedicated 220V 30–40amp circuit.
    - Additional primary trench and conductors.
    - Additional meter or submeter.
    - Increase in infrastructure (additional or larger transformers).
    - Increased size of panel or additional subpanel.
    - Conduit to EV charger.
    - EV charger (usually supplied by homeowner).

[10] CIRB Monthly Report, December 2012

[11] Builder Magazine, 2012 Local Leaders, May 2013

- Time for
    - Utility review of plans.
    - Plan check for EV charger construction components.
    - Education of building departments about EV chargers.

Builders expressed concerns about panel size and capacity in the view of the 2013 Energy Code, which requires the main electrical service panel have a reserved space to allow for the installation of a double pole circuit breaker for a future solar electric installation. Builders also reported concerns regarding the potential impact the combination of an EV charger and PVE system would have to the utility infrastructure.

Building Departments

With regards to EV policies and guidelines in local jurisdictions, they range from adopted Green Building Codes to guidelines on permit issuance to none at all. In California, the cities of Davis, Los Angeles and Sunnyvale are good examples of jurisdictions that have EV policies set guidelines for new construction readiness. In addition, the cities of Santa Clara, Hayward and San Leandro were contacted regarding their EV policies and guidelines. Excerpts from those conversations are provided below.

In December 2010, the City of Los Angeles adopted a Green Building Code, which is set out in section 99.04.106.6 of the City Code (LA Green Code).

Sheila Lee, Building Official for City of Santa Clara and chair of the Tri-Chapter Uniform Code Committee EV Policies, stated that the policies are focused on providing guidelines for permit issuance and accessibility concerns on commercial projects.

According to Gary Lepori, Building Official for the City of Hayward, his lesson learned with any policy is that it must be clear and it must be distributed to contractors and developers prior to permit issuance.

William Shock, Building Official for the City of San Leandro, stated that his jurisdiction does not have policies in place for EV readiness today, but they will likely use whatever is in CALGreen.

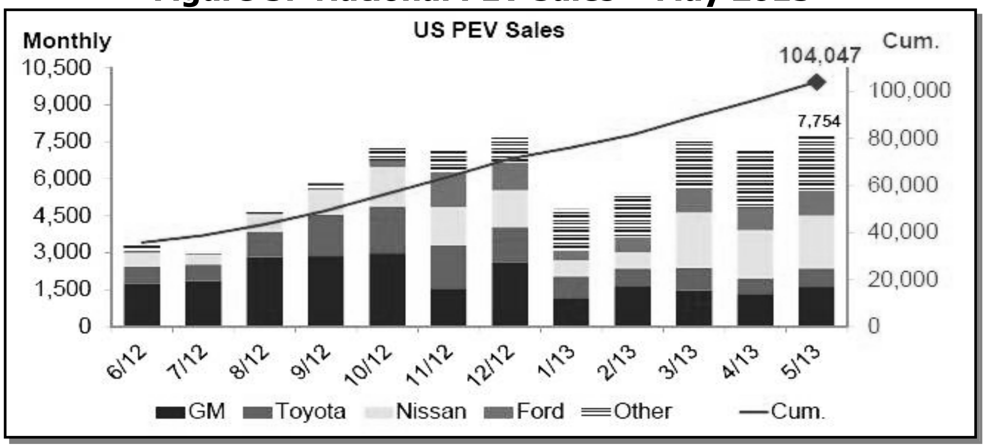
PEV Car Manufacturers

In the last two years, approximately 40 percent of plug-in electric car sales in the country took place in California, while the state represents about 10 percent of the new car sales nationally.[12] California's EV leadership arises from being the most populous state, having the largest U.S car market, having significantly congested freeways, and

[12] California Energy Commission news release; Energy Commission Awards $4.5 Million for Clean Vehicle Rebates, February 28, 2013

PEVs access to carpool lanes.[13] The leading EV markets in California are San Francisco, Los Angeles and San Diego. These markets have high traffic congestion and allow free access to high-occupancy lanes for solo PEV drivers. Anecdotal reports estimate that carpool lanes were the "primary deciding factor" for nine in ten Volt buyers.[14] As of June 30, 2013, more than 100,000 plug-in electric cars have been sold worldwide since December 2008.[15] In the United States the leading PEV manufacturers with vehicles sold by June 30, 2013 are the Toyota Prius Plug-In (16,964), Nissan Leaf (9,839), Chevrolet Volt (9,855), and the Tesla Model S (8,939).[16] Figure 3 illustrates the concentration of PEV sales for the top manufacturers. The bar chart stack ranks the car manufacturers, as listed left to right in the legend, from the bottom up.

Figure 3: National PEV Sales – May 2013



Source: Automotive News (PEV Market Update, Southern California Edison, July 24, 2013)

Current PEV sales are provided in the following Table 3 below:

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[13] Natham Bomey; Detroit Free Press (June 5, 2012: California can't get enough of the Chevy Volt as sales surge)

[14] Natham Bomey; Detroit Free Press (June 5, 2012: California can't get enough of the Chevy Volt as sales surge)

[15] Plug-in Hybrid, July 7, 2013

[16] Automotive News/Green Cars: Ford, Tesla drive healthy volume gains for battery cars in first half, July 6, 2013

Table 3: PEV Sales Summary by Car Manufacturer – Jun 2013

Electric Vehicles	**Market launch**	**Sales to Date**	**Charger Level**	**Charger Power**
BMW ActiveE	January 2012	673	2	Active E; 240 V
Honda Fit EV	July 2012	384	1	120V, 20-amp
Fisker*discontinued	November 2011	1,550		120V or 240V
Mitsubishi i-MiEV	December 2011	1,550	1	120 V; 20-amp
Nissan Leaf	December 2012	29,351	2	240V; 6.6 kW
Tesla Model S	June 2012	12,000	2	240V; 10 kW; 80-amp
Toyota RAV4 EV	September 2012	600	2	Leviton 240V; 40-amp
Ford Focus Electric	December 2012	1,593	1	120 V; 20-amp
Chevrolet Spark EV	June 2013	27	1	120V
Smart Fortwo ED	January 2011	645	1	120 V; 20-amp
Plug-In Hybrids				
Chevrolet Volt	December 2012	41,313	1	120 V; 20-amp
Ford CMax Energi	October 2012	4,856	1	120 V; 20-amp
Ford Fusion Energi	February 2012	1,585	1	120 V; 20-amp
Honda Accord Plug-In	January 2012	200	1	120V; 20-amp
Toyota Prius Plug-In	February 2012	16,964	1	120V; 15 amp
United States PEV sales		**113,291**		

Source: Consol

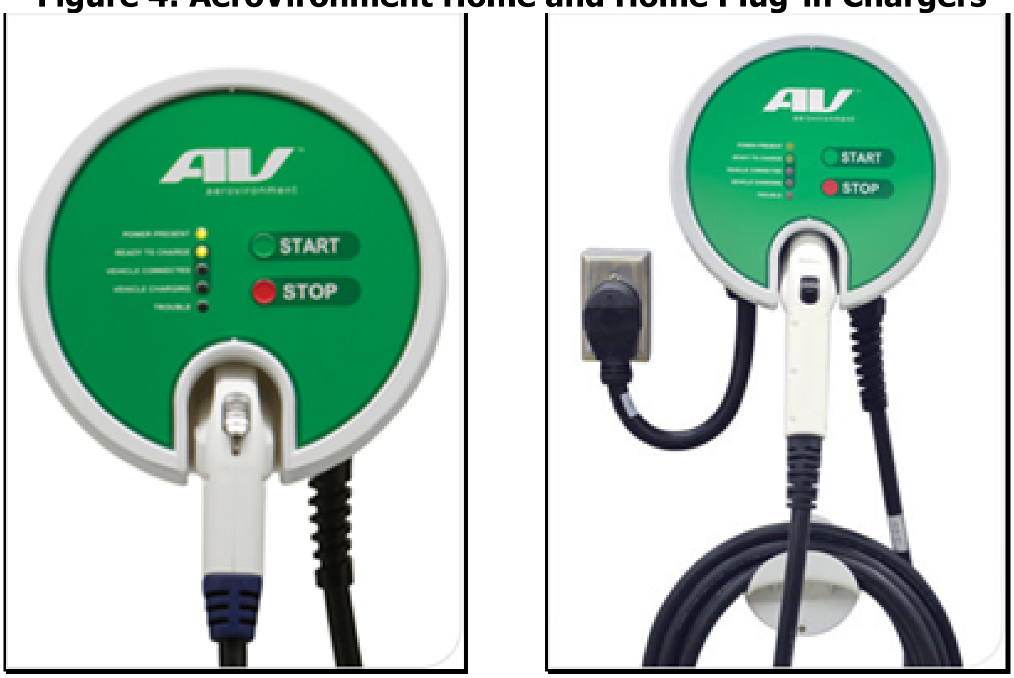
PEV Charging Station Manufacturers

According to the *California Plug-in Electric Vehicle Driver Survey Results May 2013,* approximately 90 percent of respondents who purchased EVs reported having a dedicated Level 2 (240V) charger.[17] The following section includes information about the top PEV charging manufacturers[18] and the type of chargers manufactured for residential use. The following is just a sampling of available PEV charger manufacturers. Additional information on other types of Level 1 and Level 2 chargers including amperage, volts and other product details can be found at the plug in America website (https://s3-uswest1.amazonaws.com/zappyassets/img/custom/plugstar/PIA_EV_Charging_101_Final.pdf)

AeroVironment

AeroVironment is a leading supplier of high-power test systems used by automakers and advanced battery manufacturers to develop the next generation of EVs and EV chargers. AeroVironment's line of charging products includes Home EV chargers, Multi-Unit Homes Charging, Public Charging, Fleet Charging, Retail and Commercial Charging and Workplace Charging. Their Home EV chargers are Level 2 (240V) and include both hard-wired and plug-in options. Figure 4 provides an example a Level 2 EV charger.

Figure 4: AeroVironment Home and Home Plug-in Chargers



Source: EV Solutions, Webasto Charging Systems inc.
(http://evsolutions.avinc.com/products/at_home)

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[17] California Plug-in Electric Vehicle Driver Survey Results, Center for Sustainable Energy, May 2013

[18] Top 10 Electric Vehicle Charging Companies, Jeff Siegel, Energy and Capital, May 23, 2011 (http://www.energyandcapital.com/articles/top-10-electric-vehicle-charging-companies/1529)

ClipperCreek

ClipperCreek, Inc. is a manufacturer of EV chargers for the last 18 years. ClipperCreek offers a wide variety of EV chargers. Besides the home options provided below they also offer At the Parking Lot CS - 7.2KW–240VAC, At Work ACS-2.4KW–120VAC, Fast Charge, High Power- 18KW–240VAC and International 3.7kW–230VAC EV chargers. Figure 5 and Figure 6 provide examples of an On the Road and Garage charger.

Figure 5: On the Road - 1.4KW–120VAC

Source: [Clipper Creek, Inc products page](http://www.clippercreek.com/products.html)
(http://www.clippercreek.com/products.html)

Figure 6: In the Garage LCS - 4.8KW - 240VAC

Source: [Clipper Creek, Inc products page](http://www.clippercreek.com/products.html)
(http://www.clippercreek.com/products.html)

Coulomb Technologies

Coulomb Technologies, ChargePoint, has the largest network of independently owned charging stations in the world with more than 1,900 organizations provide charging via ChargePoint and more than 12,725 charging spots worldwide. ChargePoint has built the world's largest online network of charging stations, operating in more than a dozen countries. ChargePoint stations currently dispense more than 1,243 megawatt-hours of electric fuel each month. The annual equivalent of 3,000,000 gallons of gas avoided is equivalent to 59.8 million pounds of carbon dioxide emissions prevented.[19] For charging station owners, their hardware or hardware from other manufacturers is connected to their cloud-based software giving EV Station Operators the control and data needed to optimize charging operations. For drivers, their mobile apps let one locate a charging station, check for availability, and provide real-time status.[20]

ECOtality

ECOtality, Inc. provides clean, electric transportation technologies. ECOtality has three distinct lines of business:

- Blink - EV charging solution for consumers and businesses.
- Minit Charger - EV charging solution for industrial applications.
- ETEC LABS - Research, testing, and consulting division dedicated to analyzing and delivering proven results for advanced vehicle and battery technology.

Over 12,000 Blink Level 2 and DC Fast Chargers have been installed across the country in homes and commercial locations in support of The EV Project, including over 8,000 smart residential Level 2 chargers, more than 3,000 smart Level 2 commercial chargers, and over 160 charge ports for DC Fast Chargers nationwide. California locations include San Francisco, Los Angeles and San Diego. As of August 2013, 323 public chargers have been installed in Northern California and 778 in Southern California.[21]

On Monday, September 16, 2013, ECOtality and five affiliates filed for Chapter 11 protection on with the United States bankruptcy court in Phoenix.[22] The EV Project and ECOtality's Blink network of charging stations were acquired in October 2013 by the Miami Beach-based Car Charging Group. Car Charging is in discussions with the U.S.

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[19] U.S. EPA Energy and the Environment (http://www.epa.gov/cleanenergy/energy-resources/calculator.html)

[20] Charge Point, Inc. Diver Resources (https://www.chargepoint.com/resources/)

[21] Ecotality website (http://www.ecotality.com)

[22] ECOtality, an electric car charger maker, files for bankruptcy, Jonathan Stempel, Reuters, September 17, 2013 (http://www.reuters.com/article/2013/09/17/us-ecotality-bankruptcy-idUSBRE98G1E720130917)

Department of Energy about resuming the EV Project, according to company spokeswoman Suzanne Tamargo.[23]

Elektromotive

Elektromotive designs, manufactures, sells, installs, operates and maintains a range of ElektroBay® charging stations for Residential, Commercial and On-Street charging.

- ElektroBay 250 provides Level 2 charging for the home. The unit can be installed on an internal wall, external wall or pole mounted. It utilizes a 32 amp, 240V power supply with a 3kW charging capacity.
- ElektroBay 305 and ElektroBay 305 Compact provide Level 2 charging for EVs with limited parking space. The ElektroBay 305 is made of marine grade steel, ground mounted for single and dual units. The ElektroBay 305 Compact unit is high wall mounted and available for Residential, or Commercial use.

General Electic

General Electic's EV Charging solutions offer non-networked and networked charging options for EV owners and communities.

The WattStation Wall Mount provides EV charging in public or private parking garages. The WattStation Wall Mount is NEMA 3R rated, so it may be installed outdoors. A power button on the front ensures zero energy consumption when the unit is not in use.

Figure 7 is an example of a wall mount charger that delivers a full-cycle charge to a 24-kwh battery (4–8 hours) and Figure 8 is an example of a self-standing charger similar to existing gas pumps with a charge time of 4–8 hours at 208–240 VAC.

[23] Audit revisits ECOtality bankruptcy, Morgan Lee, UT San Diego, November 8, 2013 (http://www.utsandiego.com/news/2013/Nov/08/audit-ecotality-faulted/)

Figure 7: WattStation™ Wall Mount

Source: [ABB Electrification Business](http://www.geindustrial.com/cwc/Dispatcher?REQUEST=PRODUCTS&pnlid=8&famid=9404&catid=6062&id=WS-WallMount)
(http://www.geindustrial.com/cwc/Dispatcher?REQUEST=PRODUCTS&pnlid=8&famid=9404&catid=6062&id=WS-WallMount)

Figure 8: General Electric's DuraStation

Source: ABB Electrification Business
(http://www.geindustrial.com/cwc/Dispatcher?REQUEST=PRODUCTS&pnlid=8&famid=9404&catid=6062&id=WS-Wall Mount)

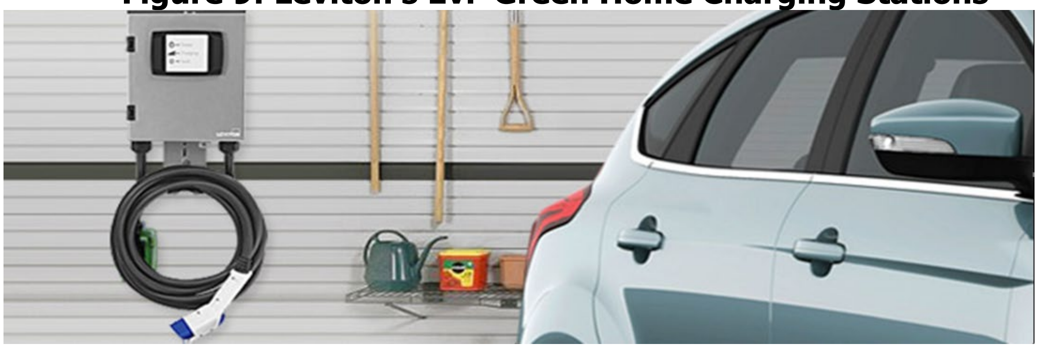
Leviton

Leviton offers PEV charging for residential, commercial and public. Their Evr-Green™ line of EV charging products is compliant with all industry standards and compatible with all major auto manufacturers' electric vehicles (SAE J1772 compliant).

Residential

Leviton's Evr-Green Home Charging Stations, as shown in Figure 9, enable quick charging of any SAE J1772™ compatible PEV. The intuitive user interface and automatic features make the charging process extremely simple. The small footprint of these stations requires a minimum amount of valuable wall space for mounting. Leviton's patent pending mounting system allows for a do-it-yourself installation (when using cord-connected stations in conjunction with the Evr-Green Pre-Wire Kit). Level 2 chargers at 240V 3.8kW or 7.7kW options are available.

Figure 9: Leviton's Evr-Green Home Charging Stations



Source: Leviton Manufacturing Co. Inc. website
(http://www.leviton.com/OA_HTML/SectionDisplay.jsp?section=49065&minisite=10251)

PEP Stations

PEP Stations is an EV charger company based in Detroit. PEP's electric car chargers are commercial, dual Level 2 EV chargers, see Figure 10, with an architectural design and a flexible operating model that require no subscriptions for EV charging. PEP's PS2000 is a credit card capable charger with monitoring and reporting features.

Figure 10: PEP Stations PS2000

Source: PEP stations website (http://www.pepstations.com/)

Schneider Electric

Schneider Electric offers the EVlink line of EV chargers for Residential, Secured Parking and Fast Charge. The EVlink Residential Charging Station, as shown in Figure 11, transmits power between the electrical network and the vehicle. The station evaluates the energy required for charging the battery. The EVlink charging station can be installed with a load shedding function in order to avoid exceeding the threshold provided by an energy supplier, and it allows the charge to be programmed for a time when the energy costs are less (i.e., off-peak times).

- Frequency: 50/60 Hz
- Power: 3 to 11 kW
- Charging mode: mode 3 as per IEC 61851
- Charging socket-outlet: type 3 and type2
- Mechanical protection by sliding shutter

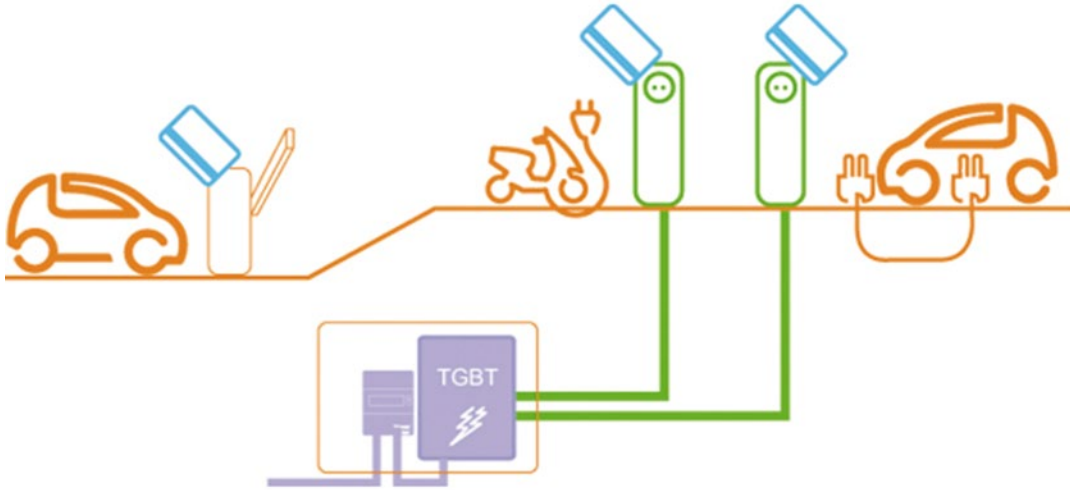
Figure 11: EVlink Residential Charging Station

Source: Electrical Car Charging Products (https://www.se.com/ww/en/product-category/1800-electrical-car-charging/)

EVlink Parking, as illustrated in Figure 12, provides EV charging for secured parking market including vehicle fleet car park, private company car parking, shopping center car park, and residential car parking. EVlink Parking is available in Floor Standing and Wall-Mounted.

- Power : 7kW or 22KW
- Number of socket: 1 or 2 plugs per charger
- Type of charging socket-outlet : Type 2 or Type 3
- Degree of protection : IP54
- External mechanical impact resistance : IK10
- Cable management ; cable entrance on the bottom
- Color: caps in white, enclosure in green, base in black
- Flood proof (height from the ground) : >50cm
- Certifications : LCIE certificate, CB certification, declaration EC conformity

Figure 12: EVlink Secured Parking



Source: EVlink parking charging solutions (http://www.schneider-electric.com/products/ww/en/1800-evlink-charging-solutions-for-electric-vehicles/1820-evlink-parking/60850-evlink-parking/)

EVlink Fast Charge, pictured in Figure 13, provides EV owners the ability to charge their EV car battery to approximately 80 percent in less than 20 minutes.

- DC output 500 V DC - 120 A
- Output power 50kW
- Charging mode 4 as per IEC 61851
- CHAdeMO protocol compliant
- Vehicle connector: Yazaki 125 A
- Outdoor, IP54, IK10, humidity up to 95 percent
- Temperature ranges: -30°C/ +50°C
- Touch Screen HMI
- AC 400V 3 phases 63 A (43 kW) as per IEC 61851, vehicle connector Type 2
- RFID (identification)

Figure 13: EVlink Fast Charge Station

Source: EVlink fast charge solution (http://www.schneider-electric.com/products/ww/en/1800-evlink-charging-solutions-for-electric-vehicles/1830-evlink-fast-charge/60852-evlink-fast-charge/)

PEV Battery Manufacturers

The following section includes information about the top PEV battery manufacturers[24] and the type of batteries manufactured for PEV use.

Toyota, the current market leader, sells mostly nickel-metal hydride battery packs. But many of the newest plug-in hybrid and pure electric cars are powered by lithium-ion batteries, currently considered the best battery technology for range, power, and recharging time.[25]

A switch from nickel-metal hydride to Lithium-ion (Li ion) batteries has begun. Nickel-metal hydride has limitations in meeting the power, energy and life demands of many

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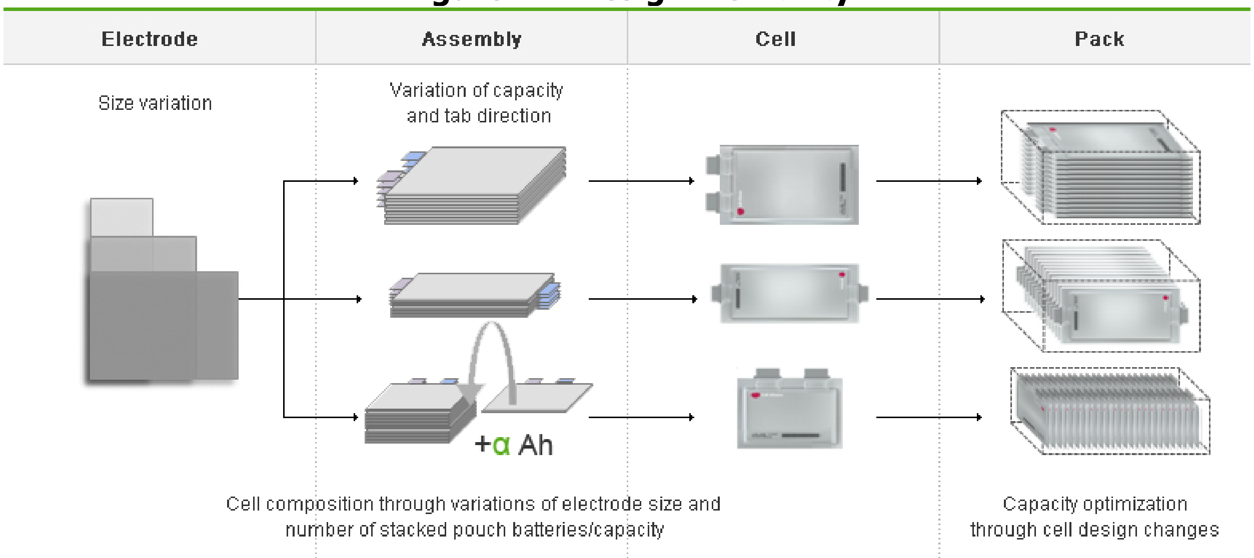
[24] Asian supplier lead EV battery race, David Sedgwick, Automotive News, March 13, 2012 (http://www.autonews.com/article/20120313/OEM06/120319981)

[25] 8 Potential EV and Hybrid Battery Breakthroughs Phil Berg, Popular Mechanics, (http://www.popularmechanics.com/cars/news/fuel-economy/8-potential-ev-and-hybrid-battery-breakthroughs#slide-1)

applications. Lithium-ion batteries are providing equivalent energy for longer periods of time at a smaller size and half the weight of nickel-metal hydride.

Realization of capacity optimization through design flexibility is crucial for automotive batteries since the location and size fit in can vary by different models and partners accordingly as illustrated in Figure 14.

Figure 14: Design Flexibility



Source: LG Chem Automotive Battery page

While Li ion batteries are smaller, lighter and have a longer battery life, there are still some concerns over recent overheating incidents. Inspired by these recent incidents, Underwriters Laboratories Inc. (UL) has developed a new testing methodology, along with guidelines and standards aimed at making Li ion battery applications safer. Since March 2012, the Consumer Product Safety Commission documented 467 reported incidents that identified Li ion cells as the battery type involved, with 353 of those being incidents involving fire/burn hazards. In 2013 there were two reported incidents related to Li ion batteries employed in the Boeing 787 aircraft in which flames were seen coming from an auxiliary power unit battery and/or odd smells were detected in the cockpit and cabin. As was the case with the Boeing batteries, many of the incidents have been linked to internal short circuits. According to John Drengenberg, Consumer safety Director at UL, "It's mainly the quality control of the separator that gets implicated in many of these incidents."

To help engineers deal with the challenges of the chemistry, UL teamed with the National Aeronautics and Space Administration and Oak Ridge Laboratories to develop new tests, including an indentation test that induces an internal short circuit. In the test set-up, the cell is placed in a holder then pressed from above by an "indenter." As the indenter pushes against the battery casing, layers of the separator, anode, and cathode are deformed, potentially causing separator failure and overheating. According to UL, some cells experienced a rapid increase in temperature as high as 700°C just seconds after a measured drop in open circuit voltage, which resulted in an explosive release of gases and generation of flames. This test will help battery engineers know whether the construction of their Li ion batteries, whether cylindrical or prismatic, are safe from overheating caused by separator failure.

UL has provided certification for smaller Li ion batteries in applications, such as cell phones and laptops, but monolithic batteries, such as those used in autos and aircraft have been less likely to have UL certification. According to Drengenberg, "Consumers are demanding more and more power in smaller packages. That's easy to say, but for engineers, it's very difficult to do."[26]

A123

A123 Systems, LLC develops and manufactures advanced nanophosphate® lithium ion phosphate batteries and energy storage systems that deliver high power and energy density, long life, and safety performance. The company's innovative technology enables customers to commercialize innovative products for the transportation, electric grid, commercial and government markets.

AMP20 Lithium Ion Prismatic Cell

Nanophosphate® AMP20M1HD-A–A123's AMP20 prismatic pouch cell, as pictured in Figure 15, is built to deliver high energy and power density combined. The AMP20 prismatic cell demonstrates tolerance coupled with excellent life performance under the most rigorous duty cycles. The AMP20 delivers high usable energy over a wide state of charge range to minimize pack oversizing and offer very low cost per watt-hour.

Prismatic Cell Primary Applications:

- Passenger and commercial plug-in hybrid electric vehicles (PHEVs)
- Passenger and commercial battery electric vehicles (BEVs)
- Mild and micro hybrid vehicles
- Long-Duration grid energy storage systems.

[26] UL Targets Lithium-ion Battery Fires, Charles Murray, Design News, August 8, 2013, (http://www.designnews.com/author.asp?section_id=1395&doc_id=265934&dfpPParams=ind_184,industry_auto,industry_consumer,industry_medical,bid_22,aid_265934&dfpLayout=blog)

Figure 15: Nanophosphate® AMP20M1HD-A

Source: A123 systems website (http://www.a123systems.com/)

AHR32113 Power Modules

As provided in Figure 16, the Nanophosphate® AHR32113 Power Modules—With modular design flexibility for passenger and commercial hybrid powertrains the high power modules are easily configurable for rapid deployment and validation into vehicle platforms. Each module comes equipped with battery management electronics for cell balancing, voltage, temperature and state of charge measurement, and stores data over time for diagnostic history. Radsok® high voltage connectors enable safe module connections and quick swapping in the field for easy servicing.

Figure 16: Nanophosphate® AHR32113 Power Modules

Source: A123 systems websites (http://www.a123systems.com/)

Energy Core Pack (23kWh)

Nanophosphate® Energy Core Pack (23kWh) - Designed for plug-in hybrid and electric vehicle applications. As seen in Figure 17, the Energy Core Packs are designed as ready-to-use sample packs for rapid deployment into powertrains for testing and development purposes. Each pack comes equipped with battery management electronics, thermal management, and standard vehicle communication and control interface.

Figure 17: Nanophosphate® Energy Core Pack (23kWh)

Source: A123 systems website (http://www.a123systems.com/)

EnerDel

EnerDel designs, builds and manufactures lithium-ion energy storage solutions and battery systems with a focus on heavy duty transportation, on- and off-grid electrical, mass transit and task-oriented applications. EnerDel's *Vigor+* lithium-ion battery packs are "road-tested" with demonstrated durability, safety and reliability for hybrid, plug-in hybrid or all-electric applications, including trains, commercial trucks and other heavy-duty vehicles.[27]

LG Chem

LGCPI is a North American subsidiary of LG Chem Ltd., one of the world's largest producers of lithium-ion batteries for automotive (Hybrid Electric Vehicles) and non-automotive (commercial, military, conversion, and portable equipment) applications. An example of an LG lithium-ion battery cell is provided in Figure 18.

Figure 18: LG Lithium Ion Battery Cells

Source: [LG Chem website](http://www.lgchem.cn/main/index)
(http://www.lgchem.cn/main/index)

Panasonic

Panasonic Corporation is one of the largest electronic product manufacturers in the world, comprised of over 634 companies. The company is already supplying nickel-metal hydride (Ni-MH) batteries for hybrid electric vehicles to a growing number of automotive manufacturers around the world, as well as lithium-ion batteries for hybrids, plug-in hybrids and electric vehicles.

- Panasonic supplies lithium-ion batteries to Toyota's Prius Plug-in Hybrid and Prius hybrid. The supply agreement with Toyota expanded in 2012 to all-electric vehicle models as well as hybrid and plug-in hybrid models.[28]

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[27] Enerdel Transportation page (http://www.enerdel.com/transportation/)

[28] Panasonic (http://news.panasonic.net/archives/2012/0924_13479.html)

- Panasonic Corporation announced that it will supply nickel metal hydride (Ni-MH) battery systems for Fuji Heavy Industries Ltd.'s first-ever hybrid electric vehicle. The Subaru XV Crosstrek Hybrid designed for sale in the United States was unveiled at the 2013 New York International Auto Show (Press Days: March 27 and 28; Public Days: March 29 through April 7, 2013). The car will go on sale in the United States in autumn this year.[29]
- Panasonic Corporation announced that shipments of its automotive-grade lithium-ion battery cells for Tesla Motors' premium, all-electric Model S sedan will surpass 100 million units by the end of this month[30] (each lithium-ion battery consists of 7,000 cells, which equates to approximately 14,000 batteries).[31] Delivery of the Model S started in 2012 in the United States. The electric-powered car has been praised for its innovative and luxurious design and outstanding performance, including long driving range, and sales of the vehicle are projected to top 20,000 units in 2013.

Sanyo

SANYO Electric Co., Ltd. (Panasonic) announced that Mira EV powered by SANYO lithium-ion battery systems achieved a travel distance of 1,000 km, breaking its own Guinness World Record for the longest journey without recharging.

The trial run was provided by Japan Electric Vehicle Club (Japan EV Club), and implemented at a training school for auto racers in Ibaraki, Japan during May 22 to 23, 2010. The Mira EV has already achieved a 555.6km run without recharging from Tokyo to Osaka, Japan on November 17, 2009, with this travel distance of 555.6km having been officially recognized as the Guinness World Record this past April.

The SANYO lithium-ion battery systems employed in the Mira EV were designed by assembling 8320 cylindrical lithium-ion batteries (18650-type) which are normally used in laptops etc., similar to the configuration used in the April record. Table 4 details the battery information of the Mira EV.

SANYO continues to improve its lithium-ion battery technology as it contributes to realizing a low carbon society.

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[29] Panasonic (http://news.panasonic.net/archives/2013/0402_21676.html)

[30] Panasonic (http://news.panasonic.net/archives/2013/0612_22989.html)

[31] Tesla motors forum (http://www.teslamotors.com/forum/forums/why-tesla-model-s-has-so-many-battery-cells)

Table 4: SANYO lithium-ion battery systems housed in Mira EV

Number of batteries:	8320 cylindrical lithium-ion batteries (18650-type)
Rating:	240.5V–294Ah
Total energy:	Approx. 50kWh (Max: Approx. 74kWh)

Source: Panasonic (http://panasonic.net/sanyo/corporate/message/topics/100524.html)

Findings

Electric vehicle groups and relevant stakeholder groups were consulted, and a thorough review was done of their extensive online information providing consumers with EV industry news, resources and tools. Input on the particular topic was solicited and documented where it pertained to the task being addressed. For the most part, all stakeholders were engaged and had a good understanding of the EV challenges and barriers to EV readiness. Most embrace the need to be EV-ready.

Some home builders are proactively offering an EV option on new construction homes for as little as $250 per unit. This likely brings the wiring out to a junction box. Homeowners will still have to add a charging station.

Building departments are also reviewing and streamlining their permitting process to make EV readiness easier for the contractor and consumer. Current codes have significant language that addresses the requirements for EV readiness. Some jurisdictions have adopted these as local requirements. Some have actually exceeded minimum code requirements by amending state codes. The City of Los Angeles adopting and modifying the 2010 California Green Building Standards Code along with the July 1, 2012 supplement is an example of this.

EV manufacturers continue to improve their EV offerings on a regular basis. The EV industry currently provides numerous EV charging equipment stations with many options for customers. New battery technology is also available, and many manufacturers are continuing to research and develop longer lasting and more powerful battery packs. As higher capacity battery packs become available higher amperage chargers may be needed to charge these larger battery packs in acceptable or reduced time periods. Codes and cost effectiveness will need to be evaluated to address these potential future market changes.

CHAPTER 2: Building Codes and Other Items Impacting EV Charging

Current Building Codes

California Code of Regulations, Title 24

The California Building Standards Code in the California Code of Regulations (CCR) Title 24 is published by the California Building Standards Commission and it applies to all building occupancies throughout the State of California. Title 24 is the 24th of 28 titles within the CCR. CCR Title 24 is reserved for state regulations that govern the design and construction of buildings, associated facilities and equipment. These regulations are also known as building standards. Title 24 applies to all building occupancies, and related features and equipment throughout the state.

CCR Title 24 Organization

The provisions of adopted CCR Title 24 (2013 edition) include requirements for the structural, plumbing, electrical and mechanical systems of buildings, and for fire and life safety, energy conservation, green design and accessibility in and about buildings. The CCR Title 24 is organized into separate parts. Each part is given a separate name reflecting its subject. Many CCR Title 24 Parts are based on national model codes.

The current edition of CCR Title 24 has twelve (12) Parts. The 2013 codes have recently been adopted and become effective in January 1, 2014. The Parts are listed below in addition to the relevant code sections that impact EV readiness:

- Part 1 - Named the 2013 California Building Standards Administrative Code
- Part 2 - Volume 1 and 2, named the 2013 California Building Code
    - Based on the 2012 international Building Code
- Part 2.5 - Named the 2013 California Residential Code
    - Based on the 2012 International Residential Code
- Part 3 - Named the 2013 California Electrical Code

This code is the most significant reference for electric vehicle charging, specifically Article 625, it provides the installation requirements and highlights the listing or independent certification by a National Recognized Testing Laboratory (NRTL) such as Underwriters Laboratories (UL). These listings are one way to confirm that a piece of equipment meets the necessary requirements of the building code and helps to ensure safe EV charging.

- Based on the 2011 National Electrical Code

- Chapter 2 Wiring and Protection specifically Article 200 – Grounding and Bonding
- Chapter 4: Equipment for General Use, specifically Article 400 – Flexible Cords and Cables
- Chapter 6: Special Equipment, specifically Article 625 Electric Vehicle Charging System

Two definitions that are critical in the review of EV charging systems are found in Article 625.2

- ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, electric motorcycles and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current. Plug-in hybrid electric vehicles (PHEV) are considered electric vehicles. For purposes of the California Electrical Code, off-road, self-propelled electric vehicles, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats, and the like, are not included.
- ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). 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 transferring energy between the premises wiring and the electric vehicle.

On July 1, 2013, an information bulletin was sent by the California Building Standards Commission to the local building departments, state agencies and interested parties. The bulletin, in part, is included herein:

The purpose of this information bulletin is to advise of Tentative Interim Amendments (TIA) #11-2 and #11-3 issued by the National Fire Protection Association (NFPA) applying to the 2011 National Electrical Code (NEC) Sections 625.13 and 625.14 regarding electric vehicle supply equipment.

The 2011 NEC is the base model code for the 2013 California Electrical Code, which is Part 3, of the California Building Standards Code in Title 24, California Code of Regulations. The 2013 California Electrical Code and the balance of the 13-part California Building Standards Code will be effective on January 1, 2014.

The provisions of the NFPA, TIA #11-2 and #11-3 are not included in the 2013 California Electrical Code. The TIA provisions may be considered for adoption into the 2013 California Electrical Code during the 2013 Intervening Code Adoption Cycle. For local government to enforce the provisions of TIA #11-2 and #11-3 before it is adopted into the 2013 California Electrical Code, it is necessary to enact a local ordinance and make a filing pursuant to Health and Safety Code Sections 17958.7 and 18941.5. Please refer to our Building Standards Bulletins 10-03, dated December 22, 2010, and 11-01, dated June 8, 2011. Both bulletins are available at the *California Building Standards Commission* website (www.bsc.ca.gov) under the "Publications" tab and contain helpful information on local amendment and filing requirements.

TIA #11-2 amends NEC Section 625.13 regarding the use of plug and cord connected electric vehicle supply equipment of 250-volts. TIA #11-3 amends Section 625.14 regarding electric vehicle supply equipment ratings. Each TIA may be accessed at the *National Fire Protection Association* website (http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=70)

The revised sections 625.13 and 625.14 are as follows:

- **625.13 Electric Vehicle Supply Equipment Connection.** Electric vehicle supply equipment shall be permitted to be cord and plug connected to the premises wiring system in accordance with one of the following:

(A) Electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20-amperes.

(B) Electric vehicle supply equipment that is rated 250 volts maximum and complies with all of the following:

(1) It is part of a listed system meeting the requirements of 625.18, 625.19, and 625.29.

(2) It is intended for connection to receptacle outlets rated no more than 50-amperes.

(3) It is installed to facilitate any of the following:

a. Ready removal for interchange

b. Facilitate maintenance and repair

c. Repositioning of Portable, movable, or EVSE fastened in place

(4) Power supply cord length for electric vehicle supply equipment fastened in place is limited to 6 ft. (1.8 m).

(5) Receptacles are located to avoid physical damage to the flexible cord.

All other electric vehicle supply equipment shall be permanently connected to the premises wiring system. The electric vehicle supply equipment shall have no exposed live parts.

- **625.14 Rating.** Electric vehicle supply equipment shall have sufficient rating to supply the load served. Electric vehicle charging loads shall be considered to be continuous loads for the purposes of this article.

Where an automatic load management system is used, the maximum electric vehicle supply equipment load on a service or feeder shall be the maximum load permitted by the automatic load management system.

- Part 4 - Named the 2013 California Mechanical Code
  - based on the 2012 Uniform Mechanical Code
- Part 5 - Named the 2013 California Plumbing Code
  - based on the 2012 Uniform Plumbing Code
- Part 6 - Named the 2013 California Energy Code

The 2013 California Energy Code in mandating PV Solar readiness may affect the physical size and rating of the panel as well as the specified 200-amp minimum service panel size for single-family residences. This will have some impact on the EV readiness infrastructure. Section 110 for solar ready buildings has a number of exceptions and should be reviewed carefully for its applicability. Pertinent sections are quoted below:

- 2013 Building Energy Efficiency Standards; effective January 1, 2014
- SECTION 110.10 – MANDATORY REQUIREMENTS FOR SOLAR READY BUILDINGS

(a) **Covered Occupancies.**

1. **Single-family Residences.** Single-family residences located in subdivisions with ten or more single-family residences and where the application for a tentative subdivision map for the residences has been deemed complete, by the authority having jurisdiction, on or after January 1, 2014, shall comply with the requirements of Section 110.10(b) through 110.10(e).

2. **Low-rise Multi-family Buildings**. Low-rise multi-family buildings shall comply with the requirements of Section 110.10(b) through 110.10(d).

(e) **Main Electrical Service Panel.**

1. The main electrical service panel shall have a minimum busbar rating of 200-amp.

2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future solar electric installation.

A. **Location.** The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

B. **Marking.** The reserved space shall be permanently marked as "For Future Solar Electric".

- SECTION 130.5 –ELECTRICAL POWER DISTRIBUTION SYSTEMS

Service metering for high-rise residential and hotel/motel occupancies.

(a) **Service Metering.** Each electrical service shall have permanently installed user-accessible metering of total electrical energy use per TABLE 130.5-A MINIMUM REQUIREMENTS FOR METERING OF ELECTRIC LOAD

- Part 7 - Currently vacant
- Part 8 - Named the 2013 State Historical Building Code
- Part 9 - Named the 2013 California Fire Code
    - Based on the 2012 International Fire Code
- Part 10 - Named the 2013 California Existing Building Code
    - Based the 2012 International Existing Building Code
- Part 11 - Named the 2013 California Green Building Standards Code (2013 CALGreen Code)

The 2013 California Green Building Standards in regard to voluntary EV charging has essentially incorporated the July 1, 2012 Supplement to the 2013 California Green Building Standards Code with two minor adjustments. Numbering was revised and clarification of the trade size 1 was added. The following is section A4.106.8 in its entirety:

- **A4.106.8 Electric vehicle (EV) charging.** Dwellings shall comply with the following requirements for the future installation of electric vehicle supply equipment (EVSE).
- **A4.106.8.1 One-and two-family dwellings.** Install a listed raceway to accommodate a dedicated branch circuit. The raceway shall not be less than trade size 1 (nominal l-inch inside diameter). The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure. Raceways are required to be continuous at enclosed or concealed areas and spaces. A raceway may terminate in an attic or other approved location when it can be demonstrated that the area is accessible, and no removal of materials is necessary to complete the final installation.
    - Exception: Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 2 EVSE.
    - Note: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation and should be consulted during the project design and installation.

- **A4.106.8.1.1 Labeling requirement.** A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and next to the raceway termination point.
- **A4.106.8.2 Multi-family dwellings.** At least 3 percent of the total parking spaces, but not less than one, shall be capable of supporting future electric vehicle supply equipment (EVSE).
- **A4.106.8.2.1 Single charging space required.** When only a single charging space is required, install a listed raceway capable of accommodating a dedicated branch circuit. The raceway shall not be less than trade size 1 (nominal l-inch inside diameter). The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure.
  - Exception: Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 2 EVSE.
- **A4.106.8.2.2 Multiple charging spaces required.** When multiple charging spaces are required, plans shall include the location(s) and type of the EVSE, raceway method(s), wiring schematics and electrical calculations to verify that the electrical system has sufficient capacity to simultaneously charge all the electrical vehicles at all designated EV charging spaces at their full rated amperage. Plan design shall be based upon Level 2 EVSE at its maximum operating ampacity. Only underground race- ways and related underground equipment are required to be installed at the time of construction.
  - Note: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation, and should be consulted during the project design and installation.
- **A4.106.8.2.3 Labeling requirement.** A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and the EV charging space.

- Part 12 - Named the 2013 California Reference Standards Code

Draft Building Codes

NFPA 70: 2014 National Electric Code (NEC)

The 2013 California Electrical Code has been adopted and will come into effect in 2014. The 2013 California Electrical Code is based on the 2011 edition of the National Electrical Code (NEC). The NEC will be updated in 2014. A draft of the 2014 edition of the NEC is available which includes proposed code changes from the 2011 NEC. There are some proposed changes to Article 625, which contain code that regulates EV charging systems. There does not appear to be language in the 2014 draft which specifically addresses installation of DC charging or induction charging systems. However, there is language which clarifies the general applicability of the code to both conductive and inductive charging systems and similarly, AC and DC charging systems.

Inductive Charging

In the 2011 NEC, Article 625.2 Definitions, Electric Vehicle Connector is defined:

- **Electric Vehicle Connector.** A device that, by insertion into an electric vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of power transfer and information exchange. This device is part of the electric vehicle coupler.

The language used in the definition is limited to conductive charging, i.e., a physical plug from the EVSE to the EV charger. In inductive charging, also known as wireless charging, there is no physical connection between the connector and vehicle inlet. The EV is charged via current induced from an electromagnetic field.

In the 2014 NEC, Article 625.2, the definition has been broadened to explicitly reference conductive charging and inductive charging:

- **Electric Vehicle Connector.** A device that, when electrically coupled (conductive or inductive) to an electric vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of power transfer and information exchange. This device is part of the electric vehicle coupler.

Similarly, the 2011 NEC definition for Electric Vehicle Inlet was specific to a physical coupling between the inlet and connector:

- **Electric Vehicle Inlet.** The device on the electric vehicle into which the electric vehicle connector is inserted for power transfer and information exchange. This device is part of the electric vehicle coupler. For the purposes of this Code, the electric vehicle inlet is considered to be part of the electric vehicle and not part of the electric vehicle supply equipment.

It has been updated in the 2014 NEC to address coupling for inductive charging.

Under the draft 2014 NEC, Article 625.2 Definitions, a proposed change has been made to the definition for Electric Vehicle Inlet. The language has been changed to specifically reference induction charging.

- **Electric Vehicle Inlet.** The device on the electric vehicle into which the electric vehicle connector is electrically coupled (conductive or inductive) for power transfer and information exchange. This device is part of the electric vehicle coupler. For the purposes of this Code, the electric vehicle inlet is considered to be part of the electric vehicle and not part of the electric vehicle supply equipment.

DC Charging

Article 625.4 in the 2011 NEC references AC supply voltages only for use with EV equipment. The proposed Article 625.4 in the draft 2014 NEC now explicitly references DC system supply voltages up to 600 V. This would account for DC supplies such as direct charging with PV and DC fast charging.

Under the 2014 NEC, Article 625.4 Voltages, the information has been updated to include DC charging supply voltages.

- **625.4 Voltages.** Unless other voltages are specified, the nominal ac system voltages of 120, 120/240, 208Y/120, 240, 480Y/277, 480, 600Y/347, and 600 volts and dc system voltages of up to 600 volts shall be used to supply equipment covered by this article.

Under the proposed 2014 NEC, Article 625.52 Ventilation, the ventilation equations for single phase supply now explicitly references applicability to direct current.

Provisions have also been made for Systems under 50 volts DC.

- The existing 2011 NEC Article 625.18 Interlock states:

Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connecter and its cable whenever the electrical connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20-amp.

- The proposed 2014 NEC Article 625.18 Interlock states:

Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connecter whenever the electrical connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connections to receptacle outlets rated at 125 volts, single phase, 15 and 20-amp. An interlock shall not be required for DC supplies less than 50 volts DC.

Induction chargers do not have connector cables. The reference to the connector cable is no longer included in the article. The 2011 NEC, Article 625.29 Indoor Sites Location, states:

- Location: The electric vehicle supply equipment shall be located to permit direct connection to the electric vehicle.

In inductive charging systems, there is no "direct connection" between the EV connector and EV inlet. The 2014 NEC proposed Article 625.50 has been modified to account for inductive charging:

- Location: The electric vehicle supply equipment shall be located for direct electrical coupling of the EV connector (conductive or inductive) to the electric vehicle…

Standards Referenced by Codes

Relevant Standards

UL 2595 Electric Vehicle Supply Equipment

This standard applies to battery operated appliances. This standard applies to appliances incorporating detachable, integral and separable battery packs. The maximum rated voltage for appliances and battery packs is 75 V DC. This standard also applies to battery-powered appliances that are also operated and/or charged directly from the mains or a non-isolated source, including appliances provided with integral battery chargers. The additional considerations for these constructions are contained in Additional Requirements for Battery Operated Appliances with a Connection to Mains or a Non-isolated Source, Section 22. These requirements are structured so as to be used in conjunction with an end product standard. These requirements are not intended to provide comprehensive evaluation of a battery operated appliance independent of an end-product standard. These requirements only address the potential risks unique to the utilization of a battery supply in a product. With the exception of appliances that also have a mains or non-isolated source, these requirements replace or modify the requirements associated with risk of fire and electric shock for mains powered versions of the appliance in the end product standard.

UL 2251 Plugs, Receptacles and Couplers for Electric Vehicles

These requirements cover plugs, receptacles, vehicle inlets, vehicle connectors, and breakaway couplings, rated up to 800-amperes and up to 600 volts AC or DC, intended for conductive connection systems, for use with electric vehicles. These devices are for use in either indoor or outdoor nonhazardous locations.

UL 1998 Firmware Operation – Software in Programmable Components

These requirements apply to non-networked embedded microprocessor software whose failure is capable of resulting in a risk of fire, electric shock, or injury to persons. This is a reference standard in which the requirements are to be applied when specifically referenced by other standards or product safety requirements. These requirements address the risks unique to product hardware controlled by software in programmable components. These requirements are intended to supplement applicable product or component standards and requirements and are not intended to serve as the sole basis for investigating the risk of fire, electric shock, or injury to persons. These requirements are intended to address risks that occur in the software or in the process used to develop and maintain the software in the various areas described in the document.

SAE J1772 SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler

The SAE J1772 standard defines the charging level ratings and the connector architecture. In addition, SAE defines the architecture of the coupler and its functions. Each coupler utilizes five pins – two power pins, a ground pin, a proximity pin, and a control pilot pin. The ground pin is the first to engage and the last to disengage. The proximity pin prevents the vehicle from moving while it is charging. The control pilot pin is the last to engage and the first to disengage. It communicates the available charge rate so the accurate current (amperes) can be determined for the vehicle being charged.

FCC Part 15 EMI / RFI Subpart B Compliant

The Federal Code of Regulation (CFR) FCC Part 15 is a common testing standard for most electronic equipment. FCC Part 15 covers the regulations under which an intentional, unintentional, or incidental radiator can be operated without an individual license. FCC Part 15 covers as well the technical specifications, administrative requirements and other conditions relating to the marketing of FCC Part 15 devices. Depending on the type of the equipment, verification, declaration of conformity, or certification is the process for FCC Part 15 compliance.

Safety Standards

The following safety standards are applicable for EV charging:

NEC Article 625 Electric Vehicle Supply Equipment

Article 625 of the National Electric Code is discussed on pages 46 and 47.

UL 2231-1 & -2 Personal Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements

These requirements cover devices and systems intended for use in accordance with annex a, Ref. No. 1, to reduce the risk of electric shock to the user from accessible parts, in grounded or isolated circuits for charging electric vehicles. These circuits are external to or on board the vehicle. The devices and systems covered by these requirements are compatible with the designs of charging systems and vehicles where use is intended and are rated accordingly. To assure compatibility, the charging system, the vehicle, or both, are in accordance with the features contained herein. The type of vehicle covered by these requirements, is described in the standard.

UL 62 Standard for Safety of Flexible Cord

This standard specifies the requirements for flexible cords, elevator cables, and hoistway cables rated 600 V maximum and intended for use in accordance with CSA C22.1, Canadian Electrical Code, Part I and CAN/CSA-C22.2 No. 0, General Requirements - Canadian Electrical Code, Part II, in Canada, NOM-001-SEDE, La Norma de Instalaciones Electricas (Mexican Electrical Code), in Mexico, and NFPA 70, National Electrical Code (NEC), in the United States.

UL 2202 Electric Vehicle Charging System Equipment

These requirements cover conductive charging system equipment intended to be supplied by a branch circuit of 600 volts or less for recharging the storage batteries in over-the-road electric vehicles (EV). The equipment includes off board and on board chargers. Off-board equipment may be considered for indoor use only or indoor/outdoor use. On board equipment is always considered outdoor use. Off board equipment is intended to be installed in accordance with the National Electrical Code, NFPA 70. The Standard was revised in October 5, 2012 as follows:

For the purposes of this standard, the term "electric vehicle", designated throughout by the initials "EV", is considered to cover electric vehicles, hybrid electric vehicles, and plug-in versions of these vehicles. Electric vehicle charging system equipment that is not a complete assembly and depends upon installation in an end product for compliance with the requirements in this standard is investigated under the requirements of this standard and the standard for the end product. On board chargers that rely upon specific installation requirements within an EV for compliance with the requirements in this standard, are to be evaluated based on those installation requirements and equipment.

Local Jurisdiction

In comparing the NEC (EV) code to local EV policies, it appears that many jurisdictions that have EV policies set guidelines for new construction readiness and then reference NEC provisions within those guidelines.

In California, the cities of Davis, Los Angeles and Sunnyvale are good examples of this practice. Additionally, Los Angeles and Sunnyvale are also good examples of placing their EV Readiness guidelines and policies in their local Green Building Codes, which makes them relevant templates for other jurisdictions.

City of Davis

In the 2010 city of Davis ordinance, all newly constructed one (1) and two (2) family dwellings must have provision for future electric vehicle charging facility.

City of Davis Municipal Code §8.01.040 Amendments, deletions and additions to the National Electric Code.

The National Electric Code adopted herein by reference is hereby amended by the following additions, deletions and amendments set forth in this section. The section numbers herein reference said National Electric Code.

- (b) Article 210.52 (G) is hereby amended to add item #3 as follows based upon expressed finding of necessity # 1 set forth in Section 2 of the ordinance codified in this article:

For all new single- and two-family residential buildings a three-quarters inch (3/4") raceway shall be installed, with an insulated pull wire or a one-quarter inch (1/4") rope, from the service to a surface mounted junction box located on the wall in front of a parking stall. The service shall be sized to provide space for a two-pole circuit breaker (220 V circuit).

City of Los Angeles

In December 2010, the city of Los Angeles adopted a Green Building Code, mandating that all new single-family and multi-family construction be equipped with the necessary electrical infrastructure and designated parking spaces (only for new high-rise residential construction) to accommodate electric vehicles.[32] The City of Los Angeles policies are set out in section 99.04.106.6 of the City Code (LA Green Code).

With the adoption of the Los Angeles Green Building Code, all new residential structures, both single-family and multi-family will have to be EV-ready. Time and money costs for installing EV infrastructure are expected to be minimal in new construction. New residential construction in the City of Los Angeles will be one of the primary sources of EV-ready buildings due to the construction mandates in the city's Green Building Code.

The City of Los Angeles Green Building Code (Chapter IX, Article 9, of the Los Angeles Municipal Code), adopted on December 14, 2010, mandates newly constructed "low-rise" (single-family residences, duplexes, and townhouses) and "high-rise" residential buildings to be charging station-ready. For low-rise buildings with private parking, either a 208/240 Volt 40-amp outlet must be installed for each unit, or panel capacity and conduits for future installation of a 208/240 Volt 40-amp outlet. All outlets must be located "adjacent to the parking area."

For low-rise buildings with common parking, the following options are available:

- A minimum number of 208/240 of Volt 40-amp outlets, equal to 5 percent of the total number of parking spaces, to be located within the parking area; or
- Panel capacity for the future installation of 208/240 Volt 40-amp outlets, equal to a minimum of 5 percent of the total number of parking spaces, with a conduit terminating in the parking area; or
- Additional service capacity, space for future meters, and conduit for future installation of electrical outlets, equal to 5 percent of the total number of parking spaces, with the conduits terminating in the parking area.

High-rise buildings are required to provide 208/240 Volt 40-amp outlets equal to 5 percent of the total number of parking spaces, with the outlets located in the parking area. The Code also mandates high-rise buildings to provide designated parking for "low-emitting, fuel-efficient, and carpool/van pool vehicles according to a fixed schedule".

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[32] Addressing Challenges to Electric Vehicle Charging in Multifamily Residential Buildings, Luskin Center, June 2011

The Green Building Code's EV-ready specifications only apply to new construction, and not to building remodels. Peter Suterko, Fleet Services Manager at the Los Angeles Department of Water and Power, is developing a proposal to mandate that remodels require a certain percentage of electricity to be set aside for electric transportation, but this is yet to be formalized.

City of Sunnyvale

The city of Sunnyvale Electrical Vehicle Charging guidelines include readiness policies as well as permit requirements and NEC code references. The City guidelines also require readiness for industrial and office use where people stay for an extended time but not commercial use where customers typically stay only for a short time.

Pre-Wiring in New Construction

The July 1, 2012 Sunnyvale Municipal Code requires that new construction provide pre-wiring for electric vehicle chargers as described below. Pre-wiring shall include the installation of conduit, appropriately sized conductors, and adequate electrical capacity to serve the chargers.

- Residential garages/carports attached to individual dwelling units (typically single-family detached and townhouses) shall be pre-wired for a Level 2 electric vehicle charger.
- Residential shared parking facilities (typically condominiums and apartments) shall have 12.5 percent of the required spaces pre-wired for Level 2 electric vehicle chargers.
- Industrial, research and development, and office buildings that have 100 parking spaces or more shall have 3 percent of the required spaces pre-wired for Level 2 electric vehicle chargers.

Other National and State Policies and Legislations Influencing EVs

EV Everywhere Grand Challenge Blueprint

In March 2012, President Obama announced the EV Everywhere Grand Challenge, which focuses on the United States becoming the first nation in the world to produce PEVs by 2020 that are as affordable for the average American family as today's gasoline –powered vehicles.[33]

The strategic investments to meet these goals are:

- Improve the competitive position of United States industry and create jobs through American innovation.

[33] U.S. Department of Energy, Vehicle Technologies Office, (http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/index.html)

- Enhance energy security by reducing our dependence on foreign oil.
- Save money by cutting fuel costs for American families and businesses.
- Protect our health and safety by mitigating the impact of energy production and use on climate change.[34]

Today, half the vehicles in the United States park overnight at locations with access to electric plugs. However, workplace and public parking lots are only beginning to offer access to chargers. Widespread PEV charging infrastructure will help promote rapid scale-up of PEVs in the years ahead.[35]

Codes

A comprehensive set of codes and standards addressing the interface between PEVs and charging infrastructure is essential. These include physical interfaces, power flow, communications, test procedures, and installation/permitting processes. Although some standards already exist, further progress is needed on standards to address current issues around DC fast charging to ensure that all consumers have safe, seamless access to this important charging capability.

Permitting

Permitting for PEV charging station installation varies significantly by region, and costs and delays associated with permits continue to be a barrier to PEV charging station deployment. Developing efficient permitting and inspecting procedures will reduce time and costs for PEV charging station installation.

2013 ZEV Action Plan

The Office of California Governor Edmund G. Brown published its 2013 Zero Emissions Vehicle (ZEV) Action Plan in February 2013. The plan includes a long-term target of putting 1.5 million ZEVs on California roads by 2025. The development and success of ZEVs is to protect the environment, stimulate economic growth and improve the quality of life in the State of California.

Broad Goals for ZEV Advancement

- Complete needed infrastructure and planning.
- Expand consumer awareness and demand.
- Transform fleets.
- Grow jobs and investment in the private sector. [36]

Executive Order Milestones Related to Infrastructure and Planning

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[34] EV Everywhere Grand Challenge: U.S. Department of Energy's 10-Year Vision for Plug-in Electric Vehicles (http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/10_year_goal.html)

[35] EV Everywhere Grand Challenge Blueprint

[36] 2013 ZEV Action Plan: A Roadmap toward 1.5 million Zero-emission Vehicles on California Roadways

- By 2015 the state's major metropolitan areas will be able to accommodate zero-emission vehicles, each with infrastructure plans and streamlined permitting.
- By 2020 the state's zero-emission vehicle infrastructure will be able to support up to one million vehicles.
- By 2020 electric vehicle charging will be integrated into the electricity grid.
- By 2020 there will be widespread use of zero-emission vehicles for public transportation and freight transport.
- By 2020 transportation sector greenhouse gas emissions will be falling as a result of the switch to zero-emission vehicles. [37]

Specific Strategies and Actions to Complete Needed Infrastructure and Planning for the Department of Housing and Community Development

- Consider amendments to the California State Building Standards Code to ensure that new buildings are ZEV-ready, including criteria such as pre-wiring and electric panel capacity requirements.
- Consider requiring multi-unit buildings to dedicate a portion of their parking spots to PEV charging. [38]

Davis-Stirling Act

Common interest developments were first regulated in California in 1963 with the passage of the California Condominium Act. However, the laws affecting homeowners' associations were scattered throughout the Corporations Code and the Civil Code and did not adequately address the unique issues posed by community associations. Through the efforts of Assemblyman Lawrence W. Stirling and law professor Katherine Rosenberry, a comprehensive body of law governing common interest developments was drafted in 1985 and became known as the Davis-Stirling Common Interest Development Act. The Act went into effect January 1, 1986 as Civil Code §§1350-1378. In 2012, the Davis-Stirling Act was rewritten to simplify, reorganize and renumber the Act into Civil Code §§4000-6150. The rewrite goes into effect January 1, 2014. The Davis-Stirling Act applies to all common interest developments in California, including those in existence prior to the Act.[39]

EV Charging Stations in Multi-Family Parking

The basic purpose of this law is to ensure that PEV drivers are not unreasonably prohibited from installing a charging station, either in their deeded or designated parking spaces or in common areas. Homeowners Associations must allow charging in

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[37] 2013 ZEV Action Plan: A Roadmap toward 1.5 million Zero-emission Vehicles on California Roadways
[38] 2013 ZEV Action Plan: A Roadmap toward 1.5 million Zero-emission Vehicles on California Roadways
[39] Adams Stirling Professional Law Corporation (http://www.davis-stirling.com/MainIndex/DavisStirlingAct/tabid/427/Default.aspx#axzz2WWKHKHB9)

common areas only if installation in the PEV owner's deeded or designated space is impossible or unreasonably expensive. If a driver has exclusive use of a charging station in a common area, Homeowners Associations must then enter a license agreement with the PEV driver, who must meet the following conditions:

- The charging station meets all applicable health and safety standards as well as all other applicable zoning, land use or other ordinances, or land use permits.
- The charging station meets all applicable measurement standards pursuant to the Business and Professions Code, Division.[5]
- The charging station complies with the association's architectural standards for the installation of the charging station.
- A licensed contractor is engaged to install the charging station.
- Within 14 days of approval, provide a certificate of insurance that names the association as an additional insured party under the owner's homeowner liability coverage policy in the amount of $1,000,000 (except when existing wall outlets are used).
- The PEV driver pays for the electricity usage associated with the charging station.

The Homeowners Association can also compel current and future owners of the charging station to pay for maintenance, repair or removal of the charging station and for any resulting damage to the station, common area, or exclusive use common area. The law allows, without a full Homeowners Association member vote, a portion of the common area to be used for utility lines or meters to support charging in a deeded or designated parking space. The provisions of this bill can be found currently in sections 1353.9 and 1363.07 of the Civil Code. As part of the rewrite, section 1353.9 will be renumbered as Civil Code §4745. Electric Vehicle Charging Stations.[40]

[40] Office of Planning and Research, ZEV Readiness Guide

Findings
Current codes and standards have significant language that addresses the requirements for EV readiness. Local jurisdictions have adopted additional requirements that make EV charging possible in their communities. Some municipalities have adopted the 2010 California Green Building Standards Code along with its voluntary measures as local requirements.

Other national and state policies and legislative acts have also mandated EV Readiness in the foreseeable future. Given all these provisions the foundation for EV readiness appears to exist.

CHAPTER 3: EV Charging Readiness Technical Analysis

EV Readiness Defined

Charging stations are the point of power for electric vehicles, ranging in style and charging levels and are subject to standards and codes. It is important to note that while EVSE is most commonly referred to as a charging station, they are not battery chargers. The main purpose of a charging station is to establish communication with the vehicle and to transfer power to the PEV while providing proper grounding, shock protection, overload protection and general safety.[41]

Level 1 Charging Defined

Level 1 charging uses a standard 120-volt plug. This charging level is equivalent to plugging your PEV into a standard wall outlet. No upgrades to the current electrical service are required. Every new PEV comes with portable charging equipment that allows them to plug in to any 120-volt outlet. Level 1 charging is ideal for Plug-in Electric Vehicles that have a smaller battery and travel less than 45 miles a day (78 percent of EV drivers' drive an average of 15 to 45 miles per day.[42]) Level 1 is not for EVs that need full battery charging over night or full battery electric vehicles. [43] [44]

Level 2 Charging Defined

A Level 2 charger requires either a 240-volt plug (similar to an electric clothes dryer) or permanently hard wired. This charging level requires charging equipment to be purchased and installed by a qualified electrician. From empty, a full size battery EV takes about 4-7 hours to recharge.[45]

- Speed: AC Level 2 charges at least 4 times faster than plugging into a wall socket. [46]

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[41] Residential Charging Station Installation Handbook for Single-Family and Multi-Family Homeowners and Renters, Version 1.0, Advanced Energy
[42] California Plug-in Electric Vehicle Driver Survey Results, Center for Sustainable Energy, May 2013
[43] Pacific Gas & Electric (PG&E) Charging at Home, (http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/charginglevel/)
[44] DriveClean (http://www.driveclean.ca.gov/pev/Charging.php)
[45] DriveClean (http://www.driveclean.ca.gov/pev/Charging.php)
[46] Pacific Gas & Electric (PG&E) Charging at Home, (http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/charginglevel/)

- Equipment: AC Level 2 requires charging equipment known as EV chargers. The type of EV charger and the amount of charge it can deliver is specific to the PEV. [47]
- Level 2 charging by definition can go up to 80-amp and offers significantly faster charging time than Level 1. As provided in Table 6, a 3.3 kW or 6.6kw, 40-amp Level 2 charger significantly reduces the time required to charge an EV by approximately 50%-80% compared to Level 1. An 80-amp Level 2 charger, while considered "fast charging" within the Level 2 range, would expend approximately 20kW and installing this in a residential home may be very cost prohibitive. The increase in electrical service panel rating, electrical house infrastructure, and potential impact to the utility grid would currently make this option unpractical and not cost effective. An amperage load of 20kW would significantly affect the size of the electric service panel and potentially require an increase of the electric service panel to a 400-amp panel. Currently, EV manufacturers and battery suppliers are not recommending this as a standard since it can significantly reduce the life of the battery packs. Potential Service Upgrade: Charging at 240 volts is similar to adding an additional appliance such as an electric oven, washer/dryer, resulting in a greater electrical load and potentially requiring upgrades to the electrical service.[48]

Direct Current (DC) Fast Charging Defined

For DC fast charging, a permanently installed charging station converts three-phase AC electricity to direct current (DC) off-board of the PEV, delivering up to 250 kW directly to the PEV battery. DC charging is often referred to as fast charging. Near-term demonstration programs and some production PEVs incorporate this capability at a rate sufficient to charge a 24-kWh battery to about 80 percent capacity in approximately 30 minutes.

For DC fast charging there are currently two competing DC fast charging options for EV owners. The Japanese-developed standard CHAdeMO which is an abbreviation of "CHArge de MOve", equivalent to "charge for moving", and the Society of Automotive Engineers' (SAE) International J1772 Combo standard. Both are direct-current quick-charging systems designed to charge the battery of an EV to 80 percent in about 20 minutes, but these two systems are not compatible. As of July 1, 2013, there were 283 publicly available CHAdeMO chargers installed in the United States. The SAE Combo standard chargers are not yet commercially available. The first SAE Combo-compatible car, the Chevrolet Spark, is now available in the United States.

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[47] Pacific Gas & Electric (PG&E) Charging at Home,
(http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/charginglevel/)
[48] Pacific Gas & Electric (PG&E) Charging at Home,
(http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/charginglevel/)

At a California hearing last year, a call was made to boycott the CHAdeMO chargers. CHAdeMO supporters, in turn, have called the SAE Combo charger "the plug without cars". Experts warn the feud could kill the momentum of the electric vehicle market. This standards war is similar to the VHS versus Betamax battle of years past, but with greater financial stakes.

One proposed solution is to offer dual EV chargers. This would be akin to gas stations in the sense that they offer both CHAdeMO and Combo chargers, just like a gas station offers both gasoline and diesel.

Public Charging

ECOtality is deploying chargers in major cities and metropolitan areas across the United States. The EV Project collects and analyzes data to characterize vehicle use in diverse topographic and climatic conditions, evaluates the effectiveness of charge infrastructure, and conducts trials of various revenue systems for commercial and public charge infrastructures. The ultimate goal of The EV Project is to take the lessons learned from the deployment of the first thousands of EVs, and the charging infrastructure supporting them, to enable the streamlined deployment of the next generation of EVs. Public chargers will be installed in 21 major cities and metropolitan areas in nine states and the District of Columbia. Over 12,000 Blink Level 2 and DC Fast chargers have been installed across the country in homes and commercial locations in support of The EV Project, including over 8,000 smart residential Level 2 chargers, more than 3,000 smart Level 2 commercial chargers, and over 160 charge ports for DC Fast Chargers nationwide. California locations include San Francisco, Los Angeles and San Diego. As of August 2013, 323 public chargers have been installed in northern California and 778 in southern California.

On Monday, September 16, 2013, ECOtality and five affiliates filed for Chapter 11 protection on with the United States bankruptcy court in Phoenix.[49] The EV Project and ECOtality's Blink network of charging stations were acquired in October 2013 by the Miami Beach-based Car Charging Group. Car Charging is in discussions with the U.S. Department of Energy about resuming the EV Project, according to company spokeswoman Suzanne Tamargo.[50]

EV Readiness for Residential New Construction Structure Types Including Voltage and Amperage Needs

Original Construction without EV Readiness

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[49] ECOtality, an electric car charger maker, files for bankruptcy, Jonathan Stempel, Reuters, September 17, 2013 (http://www.reuters.com/article/2013/09/17/us-ecotality-bankruptcy-idUSBRE98G1E720130917)
[50] Audit revisits ECOtality bankruptcy, Morgan Lee, UT San Diego, November 8, 2013 (http://www.utsandiego.com/news/2013/Nov/08/audit-ecotality-faulted/)

The EV industry has essentially standardized two types of charging levels, Level 1 and Level 2. There is also a third charging level, DC Fast Charging. The ability to provide Level 1 charging is essentially what already exists in most home garage receptacles. Most EVs are provided with a Level 1 charging cord and connector from the car manufacturer. In a Level 1 charging system, an EV can be connected to a normal 20-amp, 120 volt receptacle with the provided cord to charge the EV battery pack.

As of October 31, 2012, the IOUs estimate there are over 17,000 new light duty PEVs within the three service territories. Through monitoring service upgrade costs due to new PEV load, the IOUs have determined the costs are currently insignificant. The IOUs have completed more than 6,000 residential infrastructure checks and only 22 upgrades (0.4 percent) have been identified and completed. In all but five instances in the PG&E territory, the existing allowance was sufficient to cover the customer portion on the upgrade. A summary of these upgrade costs by IOU are provided in Table 5.

Table 5: IOU Summary of Cost Tracking Data

Residential	PG&E	SCE	SDG&E
Estimated PEV customers through October 31, 2012	6,969	7,976	2,125
Number of Infrastructure Checks completed	3,066	2,600	640
PEV customers requiring service facility upgrades – Rule 15 & 16	9	8	5
Total Costs Incurred	$41,834	$28,097	$9,592
Range of Costs	$656-$8,265	$274-$10,384	$666-$4,007
Average Cost	$4,648	$3,512	$1,590
Number of Foregone Rule 16 Billings	$1,918	$2,506	$2,578
Existing Residential Allowance	$9,226	$0	$0
Amount of Foregone Billings – Rule 16	3,066	2,600	640

Source: Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric Sempra Energy Utility, December 28, 2012, Joint IOU Electric Vehicle Load Research Final Report, Electric Vehicle Load Research & Cost Studies, R.09-08-009, AFV OIR, Ordered in D.11-07-029

Level 2 charging has a wide range of charging capabilities, but charging is limited by the EV manufacturer’s recommendations. Most EV manufacturers do not recommend going beyond 6.6 kW. Going beyond the manufacturer’s recommendation may damage or decrease the life of the battery pack. Additionally, most current EVs do not have the capability to charge at this high rate. For the purpose of this study, Level 2 charging is considered to be, approximately 6.6 kW or 40-amp at 240 volts single phase current.

As part of the SDG&E's First Year Evaluation of their Electric Vehicle Pilot all customers purchasing a LEAF were offered no-cost electric vehicle supply equipment (EVSE) for home installation (approximate value $1,499.00), up to $1,200 credit towards the installation of the equipment and a DC Fast Charge port on the car at no charge (approximate value $700.00).[51]

There is currently no North American standard for uniform DC charging, although one is being developed.[52] DC Fast Charging is mainly applicable to commercial buildings since the required higher voltage, three phase current, and energy consumption are beyond what is normally provided in residential dwellings. While not appropriate in most residential settings, property managers may offer DC fast charging through a valet parking service as a perk to attract or retain tenants.[53] Table 6 summarizes the levels of EV charging including the time required to charge. It is apparent from the table why Level 2 charging would be preferred over Level 1 charging. The time required for Level 2 charging is significantly less than the charge time for Level 1 charging.

Table 6: Summary of EV Charging Types

		On-Board Chargers	**Charging Times from empty to full***	
Charging Level	**Power Supply**	**Charger Power**	**BEV**	**PHEV**
Level 1	120VAC/16 amp Single Phase	1.4 kW @ 12 amp	~17 Hours	~7 Hours
Level 2	208-240VAC up to 80-amp Single Phase	3.3 kW	~ 8-10 Hours	~ 3 Hours
		6.6 kW	~ 3.5 Hours	~ 1.4 Hours
DC Fast Charge	200-450VDC @ 200-amp	45 kW	~30-45 Minutes	~10 Minutes

[51] Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric Sempra Energy Utility, December 28, 2012, Joint IOU Electric Vehicle Load Research Final Report, Electric Vehicle Load Research & Cost Studies, R.09-08-009, AFV OIR, Ordered in D.11-07-029, Appendix A -: Other Research, SDG&E, December 2012, First Year Evaluation for San Diego Gas & Electric's Electric Vehicle Pilot

[52] TAKING CHARGE ESTABLISHING CALIFORNIA LEADERSHIP IN THE PLUG-IN ELECTRIC VEHICLE MARKETPLACE, California Plug-In Electric Vehicle Collaborative

[53] Residential Charging Station Installation Handbook for Single-Family and Multi-Family Homeowners and Renters, Version 1.0, Advanced Energy

		On-Board Chargers	Charging Times from empty to full*	
Charging Level	**Power Supply**	**Charger Power**	**BEV**	**PHEV**
	3-Phase			

*SAE "Charging Configurations and Rating Terminology", Society of Automotive Engineers Hybrid Committee, version 031611, 2011, SAE Assumptions: BEV = 25-kwh usable battery; PHEV = 8-kwh usable battery; Calculations reviewed and edited by The Electric Power Research Institute.

Source: Plug-in Electric Vehicle Resource Center, DriveClean ca.gov, (http://driveclean.ca.gov/pev/Charging.php)

Code – New Construction in Compliance with CALGreen, Section A4.106.8

The 2013 California Green Building Standards Code (CALGreen), Section A4.106.8, includes requirements for the EV electrical infrastructure in Appendix A4 Residential Voluntary Measures. The CALGreen Appendices are voluntary and may be adopted by local jurisdictions who want to exceed the current version of CALGreen.

- **A4.106.8 Electric vehicle (EV) charging.** Dwellings shall comply with the following requirements for the future installation of electric vehicle supply equipment (EVSE).
- **A4.106.8.1 One-and two-family dwellings.** Install a listed raceway to accommodate a dedicated branch circuit. The raceway shall not be less than trade size 1 (nominal l-inch inside diameter). The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure. Raceways are required to be continuous at enclosed or concealed areas and spaces. A raceway may terminate in an attic or other approved location when it can be demonstrated that the area is accessible, and no removal of materials is necessary to complete the final installation.
    - Exception: Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 2 EVSE.
    - Note: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation and should be consulted during the project design and installation.
- **A4.106.8.1.1 Labeling requirement.** A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and next to the raceway termination point.

- **A4.106.8.2 Multi-family dwellings.** At least 3 percent of the total parking spaces, but not less than one, shall be capable of supporting future electric vehicle supply equipment (EVSE).
- **A4.106.8.2.1 Single charging space required.** When only a single charging space is required, install a listed raceway capable of accommodating a dedicated branch circuit. The raceway shall not be less than trade size 1 (nominal l-inch inside diameter). The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure.
  - Exception: Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 2 EVSE.
- **A4.106.8.2.2 Multiple charging spaces required.** When multiple charging spaces are required, plans shall include the location(s) and type of the EVSE, raceway method(s), wiring schematics and electrical calculations to verify that the electrical system has sufficient capacity to simultaneously charge all the electrical vehicles at all designated EV charging spaces at their full rated amperage. Plan design shall be based upon Level 2 EVSE at its maximum operating capacity. Only underground race-ways and related underground equipment are required to be installed at the time of construction.
  - Note: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation and should be consulted during the project design and installation.
- **A4.106.8.2.3 Labeling requirement.** A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and the EV charging space.

The current voluntary measure option for EV electrical infrastructure in the 2013 California Green Building Standards Code to install a 1-inch conduit would cost under $50.00[54] for the conduit, connectors if required, junction box and cover, labeling and labor to install. The use of non-metallic wiring may significantly reduce the cost of the EV installation if equipment is installed in conjunction with the new construction. Non-metallic wiring is flexible and does not require the conduit, numerous fittings, connectors, and additional labor to install.

[54] Home Depot Building Materials – (http://www.homedepot.com/b/Building-Materials/N-5yc1vZaqns?cm_mmc=SEM|G|BT2), see Appendix B for details.

Level 1 Charging - New Construction Readiness

Current codes and home construction industry practices provide for the installation of 15 or 20-amp, 120-volt receptacles in the garage space. The 2013 California Electric Code in Article 210.8 (A) (2) requires ground-fault circuit-interruption for garage receptacles installed in dwelling units. Car manufacturers provide Level 1 charging electrical cords with the EV purchase. These Level 1 cords can connect directly to the receptacles provided in new construction with no special receptacle or modifications required. No modifications to the electrical infrastructure should be needed. The Level 1 chargers are rated at 15-amps, 120 volts of load. The breakers serving the garage receptacles are rated at 15-amps, 120 volts at normal load.

By definition these receptacles, if used for an electric vehicle, need to comply with the 2013 California Electrical Code Chapter 2 Wiring and Protection Article 210 Branch Circuits and Chapter 6 Article 625 Electric Vehicle Charging System.

Article 625.2 Definitions, states:

Electric Vehicle Supply Equipment

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 transferring energy between the premises wiring and the electric vehicle.

Therefore, by definition from Article 625.2, the Level 1 chargers are required to comply with the California Electrical Code specifically, Chapter 2 Article 210, Chapter 6 Article 625.13 Electric Vehicle Supply Equipment and referenced sections 625.18, 625.19 and 625.21, except as noted in these chapters for outlets rated at 125 volts.

The 2013 California Electrical Code also requires the load be calculated as a continuous load per Article 625.14 Rating.

To comply with the California Electrical Code, the following items addressing garage outlets need to be addressed:

- The receptacles in the garage are not dedicated EV charging receptacles.
- Quantity of receptacles may not be adequate.
- Location of receptacles may not be suited for EV charging.
- The breakers are not rated for continuous use.

Although the receptacles can currently be used with no modifications, they are technically not code compliant. An option would be to provide EV receptacles rated for EV use in every single-family dwelling with a dedicated parking garage. The following option is presented in terms of addressing quantity, sizing, and potential safety issues.

Option 1

- Provide dedicated 20-amp EV receptacle, the 20-amp breaker will comply with the continuous rated requirement.
- Provide GFCI breaker rated for continuous use for EV charging.

Pros and Cons of Option 1

Pros

- Provides dedicated GFCI receptacle.
- Addresses the location of dedicated GFCI receptacle.
- Provides a greater level of safety and protection by having dedicated GFCI receptacles properly located.
- Provides Level 1 EV readiness for all homes with minimal cost.
- Will be adequate for most PHEVs.
- Awareness of portions of the cost to implement EV infrastructure is well understood and offered as an option by a few builders, which is mainly due to current codes addressing these.

Cons

- Increases the amount of breakers required in the panel for EVSE by one (1).
- Increases the electrical infrastructure cost for additional conduit, wiring, GFCI, and continuously rated breaker.

Anticipated cost is approximately $50.00 to $100.00[55] which includes the cost of the conduit, wiring, dedicated GFCI receptacle, dedicated breaker, and labor to install.

Level 2 Charging - New Construction with Installation of 240-volt Dedicated Branch Circuit with Receptacle Plus EVSE

Level 2 charging provides a reasonable charge time and will ensure a full charge by the morning when the automobile is charged overnight. For customers on a time-of-use (TOU) electrical rate, it allows the vehicle to be charged during off-peak time at lower rates. Additionally, the impact to the local utility is minimized since the load is less likely to occur during the heavier usage periods. Due to consumer desire to drive longer distances with less time spent charging, the Level 2 charger is becoming the de facto charger of choice for electric vehicle owners.

The option to use a standard NEMA 30R or 40R receptacle similar to an electric stove or an electric dryer would not be code compliant under the California Electrical Code. Additionally, due to the frequency of connecting and disconnecting from the receptacle,

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[55] Home Depot Building Materials – (http://www.homedepot.com/b/Building-Materials/N-5yc1vZaqns?cm_mmc=SEM|G|BT2), see Appendix B for details.

the potential for electric shock is significantly increased. Most electric stoves and dryers are rarely disconnected once installed.

Option 2

- Provide 200-amp panel, Electrical load calculations should verify a 200-amp panel will accommodate future 40-amp continuous EV load and 40-amp PV electrical load, otherwise a 400-amp panel may be required.
- Provide spare space in the 200- or 400-amp panels to accommodate a dedicated 50-amp breakers to serve the EV charging unit.
- Provide duplex box with cover for future EVSE charging unit.
- Provide space to accommodate the PV electrical supply breaker rated at 50-amp.

The 2013 California Electrical Code provides language for the installation of Level 2 EVSE, but no direction is provided as to the size of the breakers serving the EVSE or the size of the electrical panels.

Pros and Cons of Option 2

Pros

- Provides size of breakers required for current and future EVSE installation.
- Provides number of breakers required.
- Provides direction on size of electrical panel serving the home.
- Allows sizing of conduit to serve the future EVSE.
- Provides EV readiness for new home construction.

Cons

- Increases the amount of breakers required in the panel for EVSE by two (2).
- May increase the size of the main electrical panel.
- Increased panel size may require an increase in electrical service feeding the home
- Increased electrical service may require an increase in the size or quantity of electrical transformers feeding the homes or subdivision. Note: Most electrical utilities do not believe this will affect the existing electrical grid.
- Increases the cost of electrical infrastructure due to some additional conduit and breakers.

- Anticipated cost is approximately $200.00 to $300.00[56] per home, including the conduit, 240-volt wiring, junction box, connection, 50-amp breakers and labor to install but does not include the charging unit.
  - For example, California-based home builder KB Home announced as early as 2010, an option to pre-wire new homes for Level 2 EV charging, at a reported cost of around $250.00.[57]
  - Some manufactures are now including the charging unit with the purchase of the car the charging unit varies in cost from $399.00 to $1,500.00.

DC Fast Charging

Most DC Fast Charging units require 208 or 480 volt, three-phase current. This is not usually available to residential customers and it is very expensive, therefore it is not applicable to single-family dwelling units or smaller multi-family units. Although DC fast charge units can be provided at 240 volt single-phase the high amperage draw makes them cost prohibitive for residential installations. The high 80-amp or above amperage draw would require significant modifications to the electrical infrastructure on both sides of the electrical meter. Currently, there are no clear standards for 80-amp or above.

Additionally, DC Fast chargers are expensive and currently cost in the range of $40,000 to $50,000.[58] Although multi-family/multi-unit housing projects would have the required electrical service, DC Fast chargers are currently cost prohibitive, which may prevent DC Fast chargers from being installed in most of these types of multi-family residential units.

Option 3

There are no provisions for DC Fast Charging electrical infrastructure for residential or multi-family units.

Findings

Costs for Level 1 or Level 2 readiness are not significant. Where appropriate, Level 1-ready would be a dedicated circuit and Level 2 ready would be a prewired dwelling.

The efficacy of using Level 1 or Level 2 charging in the single-family residential, multi-family high-rise and low-rise located above parking facilities, multi-family adjacent to parking facilities (parking lot, parking garage), and multi-family above pedestals,

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[56] Home Depot Building Materials – (http://www.homedepot.com/b/Building-Materials/N-5yc1vZaqns?cm_mmc=SEM|G|BT2), see Appendix B for details.

[57] Green Autoblog article (http://green.autoblog.com/2010/03/10/california-homebuilder-offers-to-pre-wire-homes-for-electric-veh/)

[58] Addressing Challenges to Electric Vehicle Charging in Multifamily Residential Buildings, Luskin Center, June 2011

individual garages (carriage units) is considered in the following illustrative residential categories.

Level 1 or level 2 as discussed in this section would be appropriate for single-family dwellings as illustrated in the following images and figures.

Single-Family Residential

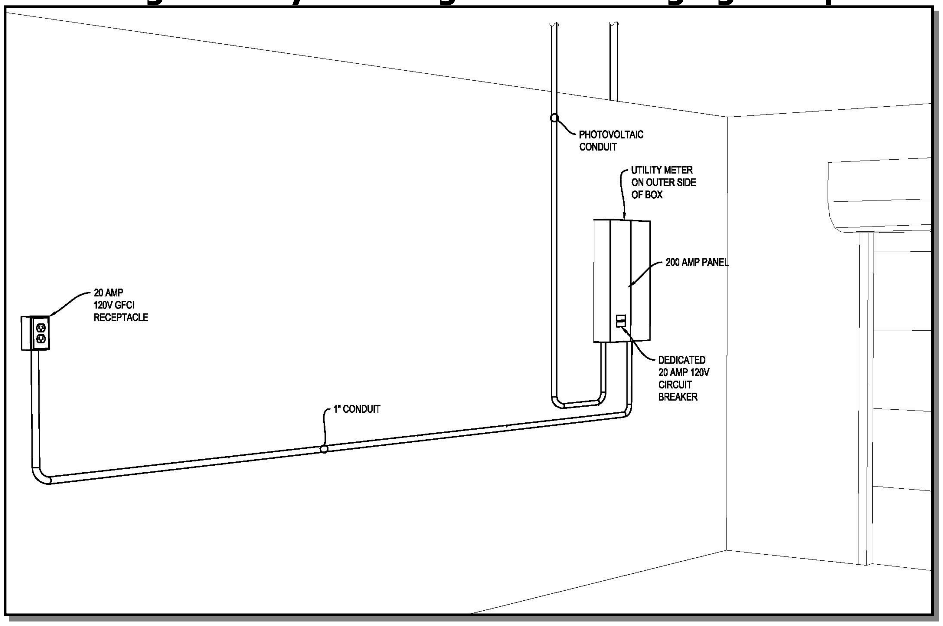
Single-family residential buildings may include single-family detached homes, as shown in Figure 19 and single-family attached homes, such as duplexes, triplexes and condominiums.

Figure 19: Single-family House

Source: SummerHill Homes, Roubion – Bay Area

Figure 20 illustrates a completed wired and ready to use code compliant EV-ready charging receptacle.

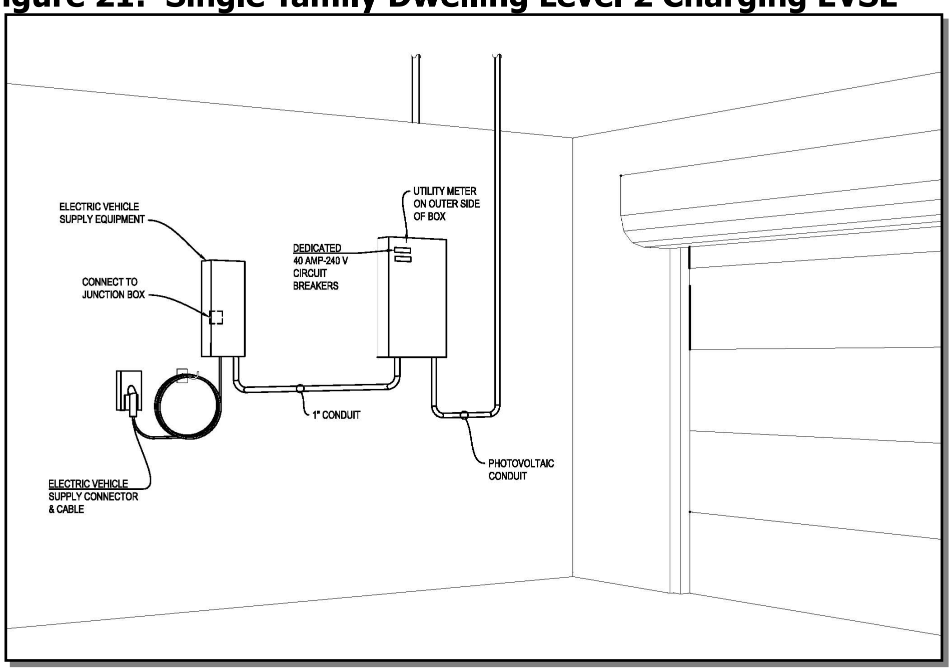
Figure 20: Single-family Dwelling Level 1 Charging Receptacles



Source: ConSol

Figure 21 illustrates the EV-ready infrastructure, only the 1" conduit; pull wire, duplex junction box, and spaces in the panel would be required. The EVSE is shown for illustrated purposes.

Figure 21: Single-family Dwelling Level 2 Charging EVSE



Source: ConSol

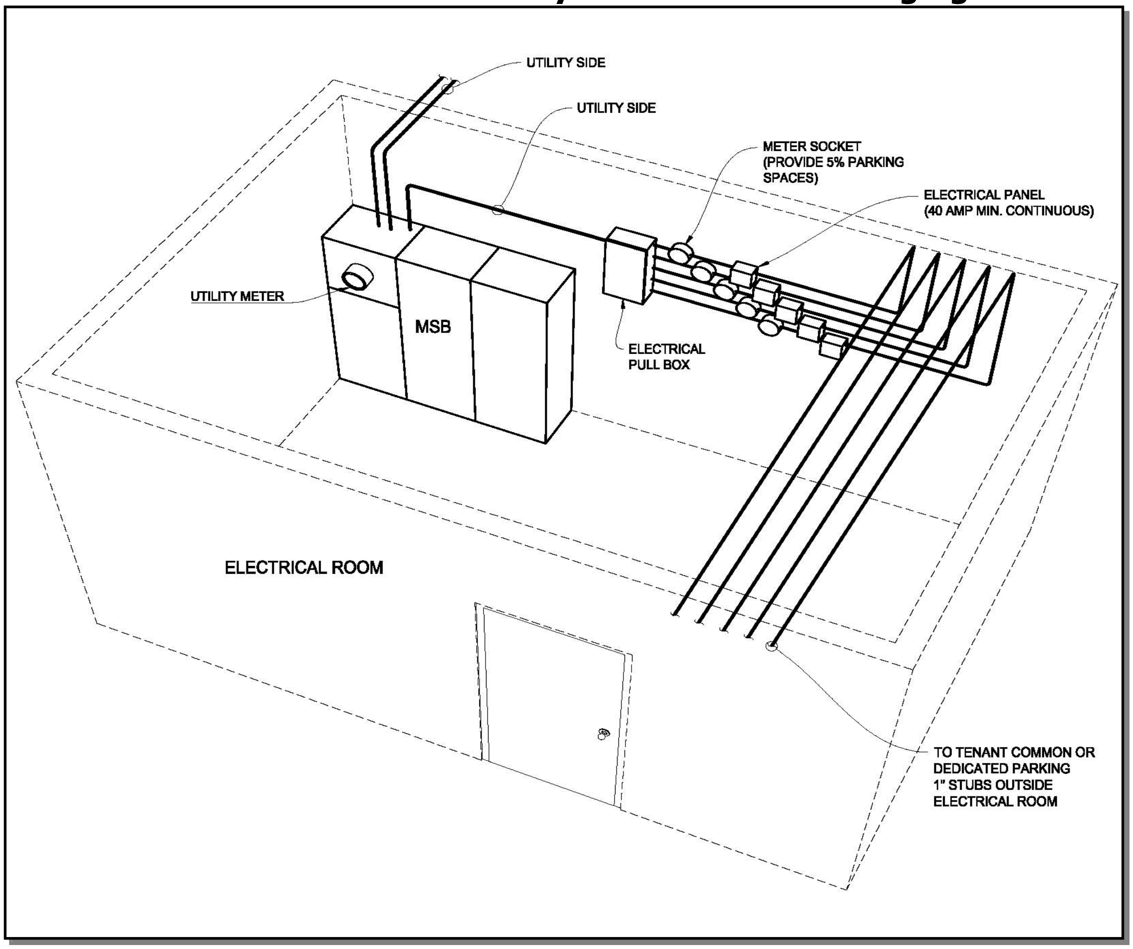
Multi-family High-Rise and Low-Rise Located Above Parking Facilities
Multi-unit dwellings (also known as multi-family residences) are a classification of residential housing where multiple housing units are contained within one building or several buildings within a complex. Some multi-unit residences are owned as condominiums, where one or more units are owned individually rather than leased from a single building owner. Some common types of multi-unit dwellings are duplexes, townhomes and apartments, mobile homes and manufactured homes. All are similar to single-family housing in terms of time-of-day charging and general power requirements, but installation requirements may be more similar to commercial parking lots and decks.

Construction of multi-family high-rise and low-rise buildings located on top of the tenant parking facility typically appears in urban infill projects where space is limited. The parking facility is generally located below grade or at grade level with high-rise or low-rise apartment building located above.

Level 1 or Level 2 as discussed in this section would be appropriate for multi-family units as illustrated in Figures 22-25. However, Level 2 would be a more practical and cost-effective alternative in these scenarios.

Figure 22 illustrates an option of single level parking with 5 percent of the spaces being allocated to EV Readiness. The assumption is that the multi-family unit consists of 100 units. The charging station would be supplied with a pull-box on the utility side, dedicated meter sockets, small panel boxes (cans) for future panels, and 1" conduit with a pull wiring extended to the outside of the electrical room.

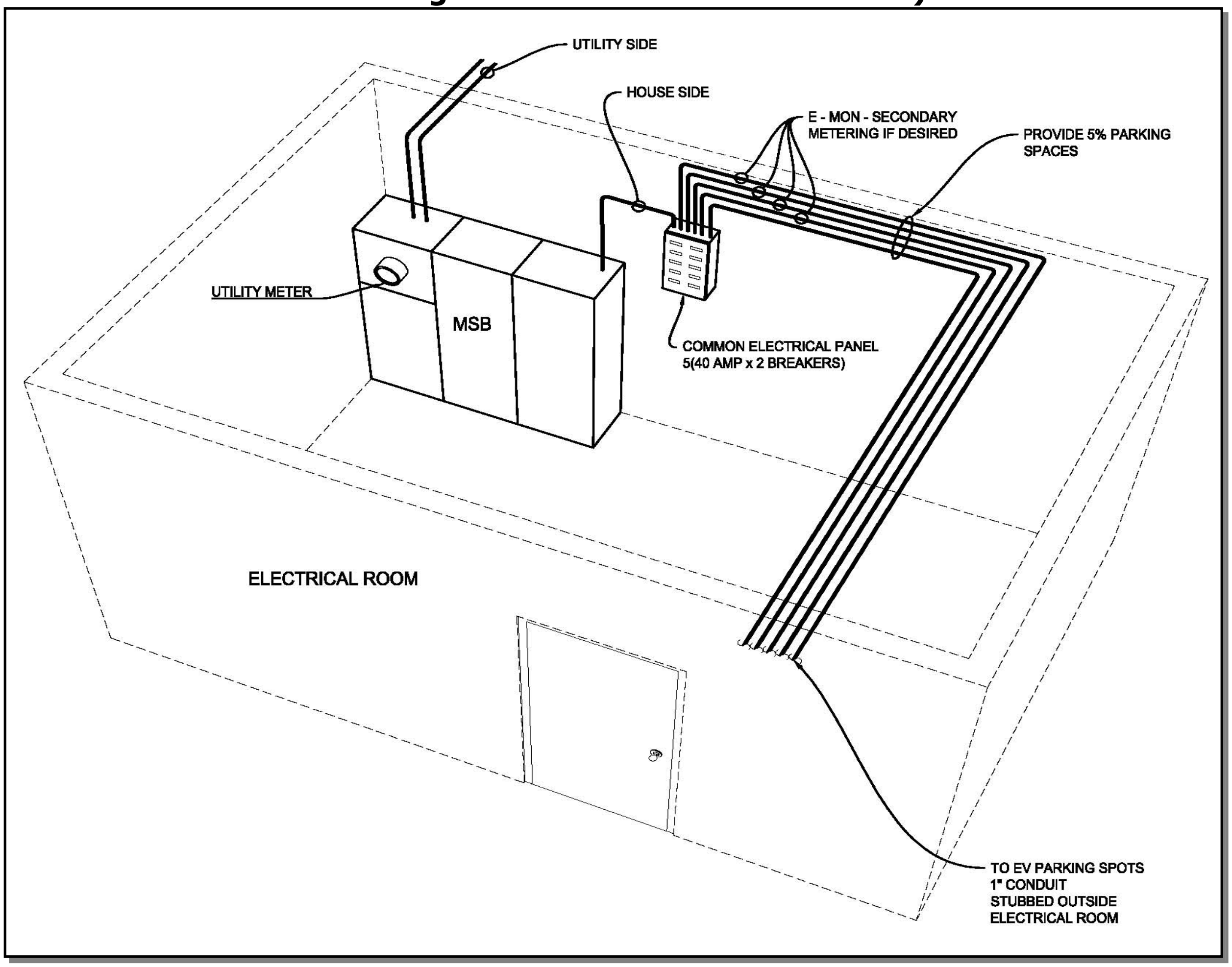
Figure 22: Multi-family Single Level Parking – 5 percent of Total Parking Reserved for EV Dedicated Utility Meter for each Charging Station



Source: ConSol

Figure 23 illustrates an option of single level parking with 5 percent of the spaces being allocated to EV Readiness. The assumption is that the multi-family unit consists of 100 units. The charging station would be supplied from the common "house" meter served by a future electrical service panel, and 1" conduit with a pull wiring extended to the outside of the electrical room. The figure also shows alternate E-Mon sub-metering if desired. This arrangement allows for taking advantage of PV solar if installed, use of revenue EVSE equipment, and marketing EV readiness.

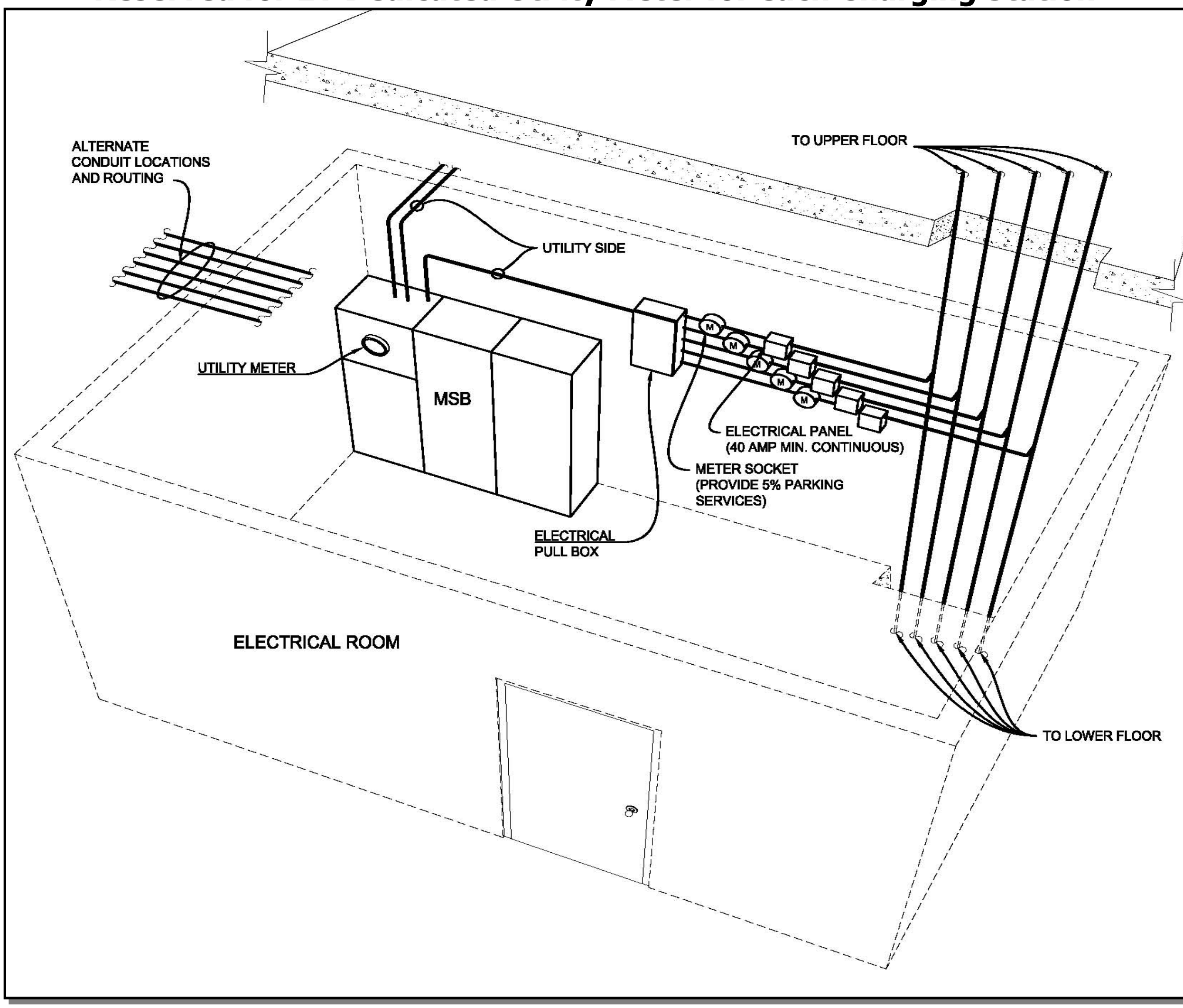
Figure 23: Multi-family Single Level Parking – 5 percent of Total Parking Reserved for Charging Stations off Common or House Meter - (Take advantage of PV or Revenue EV Meters)



Source: ConSol

Figure 24 illustrates an option of multiple level parking with 5 percent of the spaces being allocated to EV Readiness. The assumption is that the multi-family unit consists of 100 units. The charging stations would be supplied with a pull-box on the utility side, dedicated meter sockets, small panel boxes (cans) for future panels, and 1" conduit with a pull wiring extended to the outside of the electrical room. The figure also shows alternate routing of the conduit.

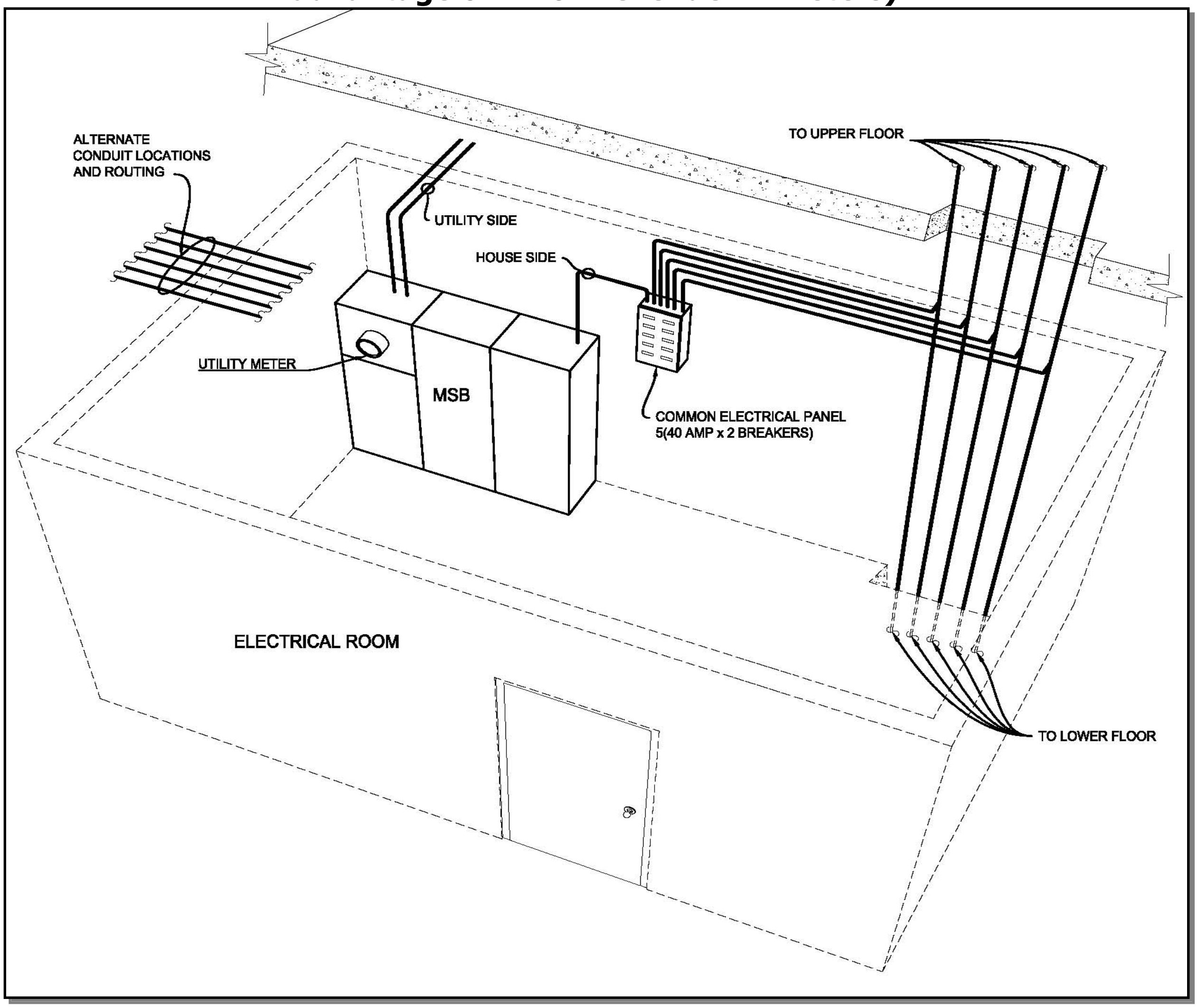
Figure 24: Multi-family Multiple Level Parking – 5 percent of Total Parking Reserved for EV Dedicated Utility Meter for each Charging Station



Source: ConSol

Figure 25 illustrates an option of multiple level parking with 5 percent of the spaces being allocated to EV Readiness. The assumption is that the multi-family unit consists of 100 units. The charging stations would be supplied from the common "house" meter served by a future electrical service panel, and 1" conduit with a pull wiring extended to the outside of the electrical room. The figure also shows alternate E-Mon submetering if desired. This arrangement allows for taking advantage of PV solar if installed, use of revenue EVSE equipment, and marketing EV readiness. The figure also shows alternate routing of the conduit for adjacent minimal conduit runs to revenue EVSE.

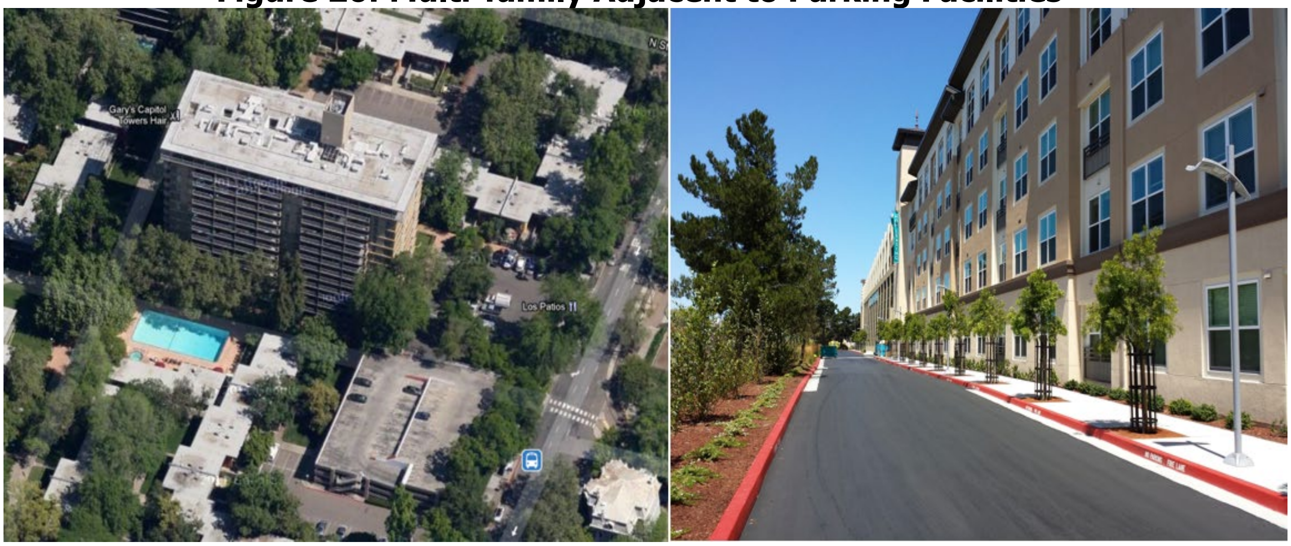
Figure 25: Multi-family Multiple Level Parking – 5 percent of Total Parking Reserved for Charging Stations off Common or House Meter - (Take advantage of PV or Revenue EV Meters)



Source: ConSol

Multi-family Adjacent To Parking Facilities (Parking Lot, Parking Garage)
Figure 26 provides examples of large 2 to 3 story apartment complexes generally surrounded by open parking lots or open parking structures located adjacent to the apartment buildings.

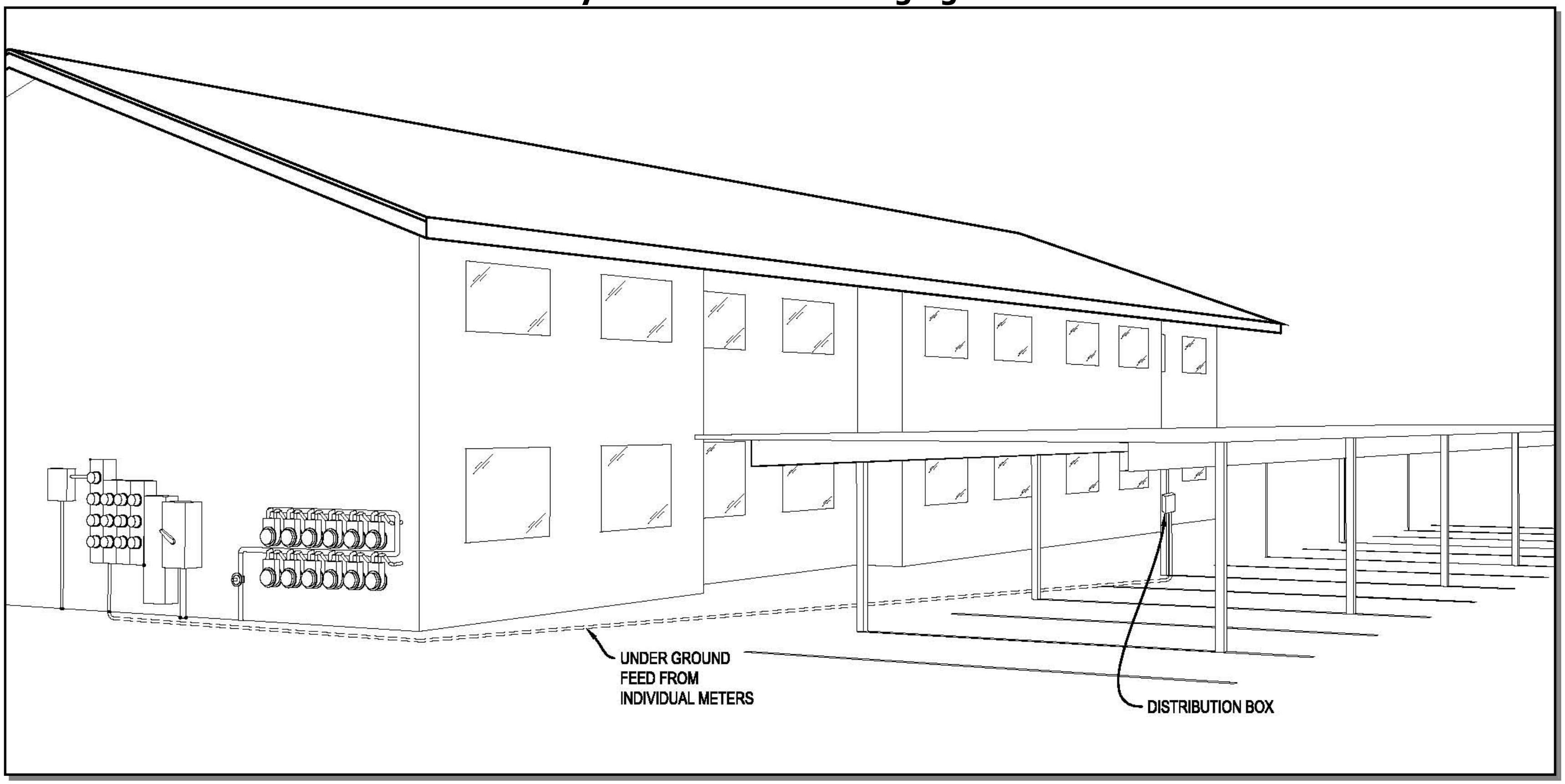
Figure 26: Multi-family Adjacent to Parking Facilities



Source: Google Earth (Left)   Source: ConSol(Right)

Figure 27 illustrates an option of spaces being allocated to EV Readiness. The charging stations would be supplied from the dedicated tenant utility meters. Underground conduit and pull wire would be extended to a common distribution or pull-box. The individual EVSE would be fed from this distribution box.

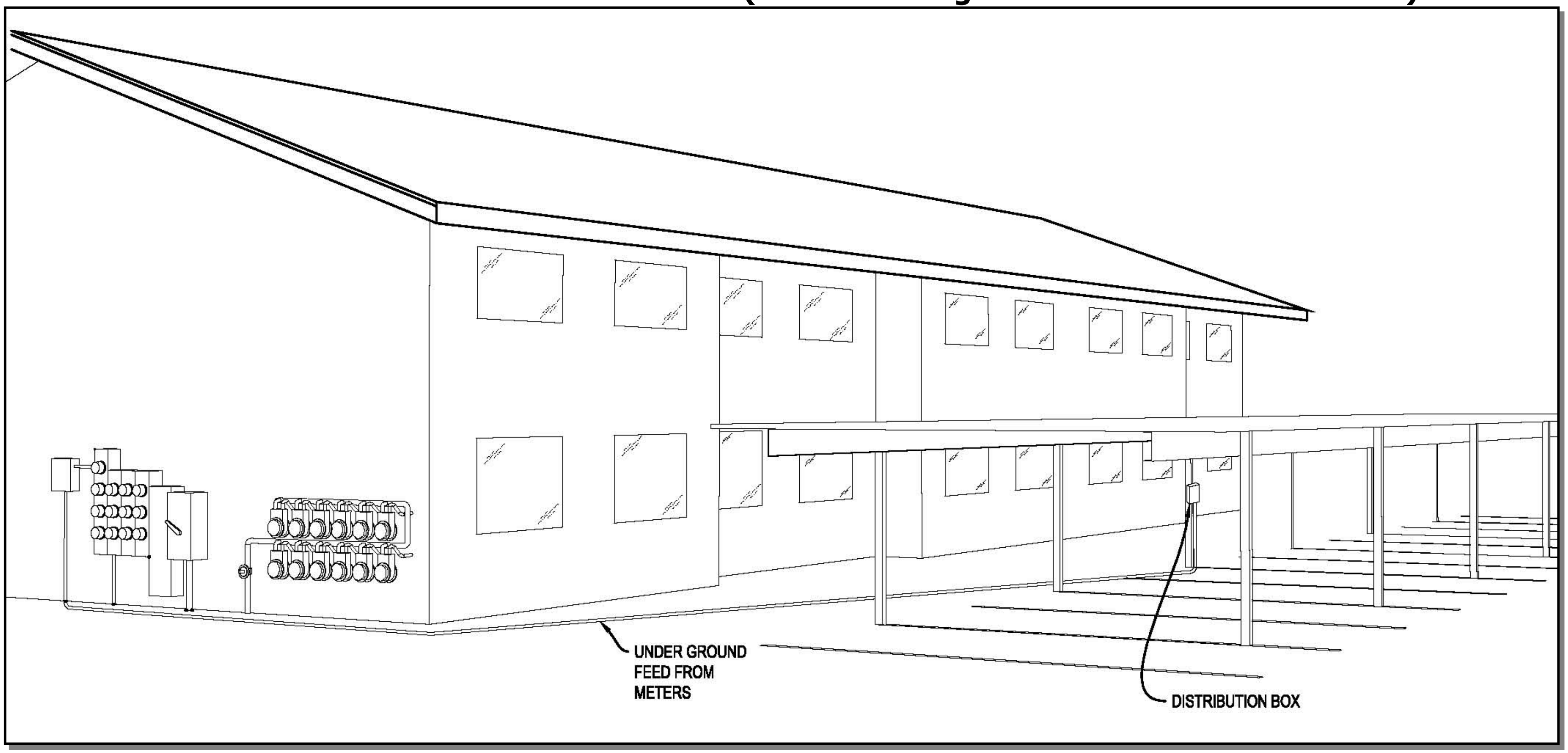
Figure 27: Multi-family Adjacent Carport Parking – 5 percent of Total Parking Reserved for EV Dedicated Utility Meter for each Charging Station



Source: ConSol

Figure 28 illustrates an option of spaces being allocated to EV Readiness. The charging stations would be supplied from the common or "house" meter. Underground conduit and pull wire would be extended to a common distribution or pull box. The individual EVSE would be fed from this distribution box.

Figure 28: Multi-family Adjacent Carport Parking – 5 percent of Total Parking Reserved for Charging Stations off Common or House Meter – (Take advantage of PV or Revenue EV Meters)



Source: ConSol

Multi-family Above Pedestals, Individual Garages (Carriage Units)

Multi-family above pedestal buildings are typically low density and feature single level dwelling units located above a garage structure or open parking space. Examples of a Carriage House and Townhouse/Pedestal are provided in Figures 29 and 30.

Figure 29: Carriage House

Source: Google Street View

Figure 30: Townhouse/Pedestal House

Source: Google Street View

Additional Considerations

Consideration should be given to EVSE's cords being located above head height for the following reasons:

- Safety: avoid potential cord tripping hazard from cord, can use a retractable coil.

- Durability: minimize or eliminate potential damage from driving over the cord and damaging the cord or the equipment, such as the connector or charging station.

Effect of Solar Photovoltaic Systems on EV Charging Load

On September 18, 2008, the California Public Utilities Commission adopted the state's first Long Term Energy Efficiency Strategic Plan, presenting a single roadmap to achieve maximum energy savings across all major groups and sectors in California. This comprehensive Plan was created for the 2009 to 2020 timeframe and is the state's first integrated framework of goals and strategies for saving energy, covering government, utility, and private sector actions, and holds energy efficiency to its role as the highest priority resource in meeting California's energy needs. This Plan proposes four "Big Bold Energy Efficiency Strategies,"[59] one of which is that all new residential construction will be zero net energy by 2020. On January 1, 2014 when the 2013 California Energy Code goes into effect, providing PV infrastructure will be a mandatory requirement for new residential construction. Recently, the Office of the California Governor Edmund G. Brown has published its 2013 Zero Emissions Vehicle (ZEV) Action Plan, which includes a roadmap towards putting 1.5 million ZEVs on California roads by 2025. The mandatory PV ready requirement highlights the likelihood that new residential construction will be solar PV ready before they are EV-ready.

When a photovoltaic system is installed in conjunction with an EV charger in residential new construction it will impact the residential electric service in two areas:

1) The rating or load capacity of the panel may be affected, and;
2) The number of spaces required within the panel may also be impacted.

The 2013 California Energy Code Title 24, Part 6 will require the electrical service panel to be rated at a minimum of 200-amp for single-family homes and be PV ready. There are numerous exceptions to this requirement. The section 110.10(e) 200-amp panel requirement is not applicable to multi-family buildings. Title 24 section 110.10 in part states:

- 110.10 Mandatory Requirements for Solar Ready Buildings:

  (a) Covered Occupancies.

    1. Single-family Residences. Single-family residences located in subdivisions with ten or more single-family residences and where the application for a tentative subdivision map for the residences has been deemed complete, by the enforcement agency, on or after January 1,

[59] 2013 ZEV Action Plan: A Roadmap toward 1.5 million Zero-emission Vehicles on California Roadways

2014, shall comply with the requirements of Section 110.10(b) through 110.10(e).

2. Low-rise Multi-family Buildings. Low-rise multi-family buildings shall comply with the requirements of Section 110.10(b) through 110.10(d).
3. Hotel/Motel Occupancies and High-rise Multi-family Buildings. Hotel/motel occupancies and high-rise multi-family buildings with ten stories or fewer shall comply with the requirements of Section 110.10(b) through 110.10(d).
4. All Other Nonresidential Buildings. All other nonresidential buildings with three stories or fewer shall comply with the requirements of Section 110.10(b) through 110.10(d).

(c) Interconnection Pathways.

1. The construction documents shall indicate a location for inverters and metering equipment and a pathway for routing of conduit from the solar zone to the point of interconnection with the electrical service. For single-family residences the point of interconnection will be the main service panel.

2. The construction documents shall indicate a pathway for routing of plumbing from the solar zone to the water heating system.

(d) Documentation. A copy of the construction documents or a comparable document indicating the information from Section 110.10(b) through Section 110.10(c) shall be provided to the occupant.

(e) Main Electrical Service Panel.

1. The main electrical service panel shall have a minimum busbar rating of 200-amp.

2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future solar electric installation.

A. Location. The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

B. Marking. The reserved space shall be permanently marked as "For Future Solar Electric".

The required minimum 200-amp service panel will need to accommodate the rating of a double pole circuit breaker for a future photovoltaic system installation. However, the size of the breaker is not stipulated. Only the space requirement is specified. Assuming a typical residential PV system array size ranges from 3 to 10 kW, a 20 to 50-amp circuit breaker would be required. The Renewable Energy Ready Homes guidelines, which were developed by the United States Environmental Protection Agency, recommend a 70-amp breaker be allocated for future PV systems. Per the 2013 California Electric Code the breakers have to be rated for a continuous load. The option or recommendation of using a double pole 50-amp breaker for the electric vehicle charger also would require the breakers be rated for continuous load as stated in the 2013 California Electric Code, Article 625.21. This would require the breaker to be sized to the 125 percent continuous load or the installation of a 100 percent rated circuit breaker, but these are about 20 percent more expensive and have additional code requirements for the electric service panel they are installed in. Therefore, a 50-amp standard breaker would meet the continuous rating requirements of a 40-amp load.

The 2013 California Electric Code

210.20 Overcurrent Protection. Branch-circuit conductors and equipment shall be protected by overcurrent protective devices that have a rating or setting that complies with 210.20(A) through (D).

(A) Continuous and Non-continuous Loads. Where a branch circuit supplies continuous loads or any combination of continuous and non-continuous loads, the rating of the overcurrent device shall not be less than the non-continuous load plus 125 percent of the continuous load.

Exception: Where the assembly, including the overcurrent devices protecting the branch circuit(s), is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent device shall be permitted to be not less than the sum of the continuous load plus the non-continuous load.

The combination of the 20 to 50-amp PV system breakers and the 50-amp electric vehicle charging system breakers could create almost 100-amp of continuous load. Depending on the other electrical loads within the residence, the panel may need to be upsized to a larger load rated panel of 400-amp. Regarding the number of spaces available, the 200-amp panel will need to accommodate a double pole circuit breaker for the PV solar. These two spaces will need to be reserved and labeled on the panel for a future PV system. The option or recommendation of using a double pole breaker for the electric vehicle charger will require two additional spaces. These two items require that the panel have four spaces reserved for these future systems.

An independent, random survey of new construction homes conducted by ConSol indicates that new construction builders of single-family residences in California are utilizing a 200-amp panel and most of the panels have adequate spaces to accommodate future breakers. The panels that do not have spare breaker spaces are partly the result of the configuration of the panel in terms of total spaces. Surprisingly the industry has managed to make these smaller panels work. The 200-amp panels can be purchased with a total of 20, 30, 40, and even 42 spaces. The smaller 200-amp 20 space panels would tend to have no spare breaker spaces available. The existing electrical load rating of the panel was not available, so no subsequent information was gathered as to whether the panel had any additional electrical load capacity.

The survey covered fourteen (14) single-family new construction subdivisions for seven (7) builders from the Bay Area to San Diego. Table 7 below summarizes the survey areas. Additionally, the graphs in Figures 31 – 33 provide a graphical summary of the spaces available within the different areas based on three levels (entry, mid, and high). Whether a house is categorized as an entry, mid or high level is a factor of the various upgrades that contribute to the electrical load of the house and the overall price of the house.

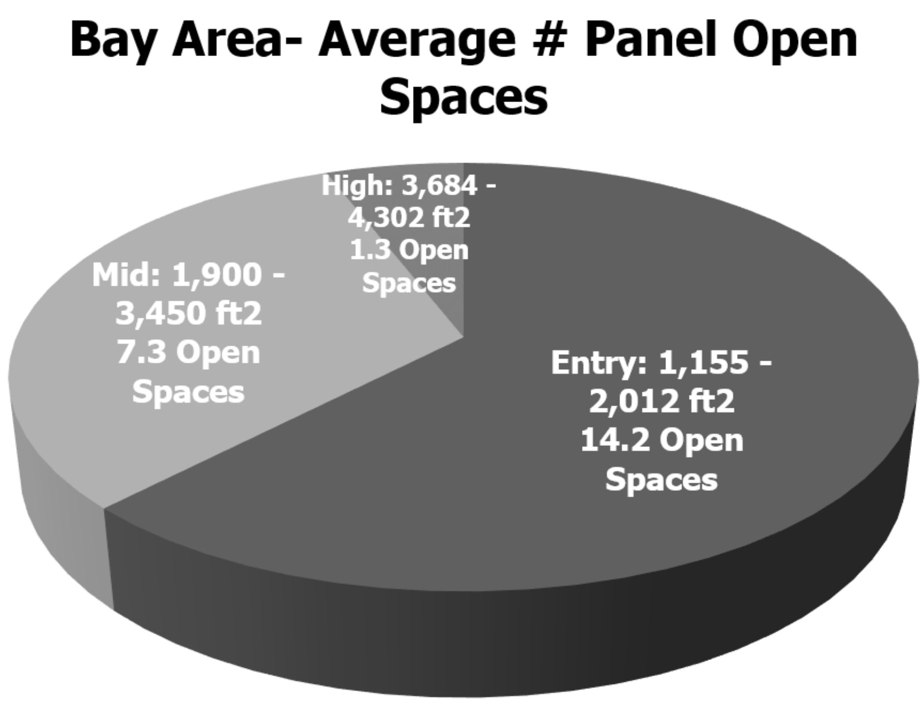
Table 7: Survey of Subdivisions to Evaluate Electrical Panel "Spare Space" Capacity

Builder	Subdivision	Location	Home Styles Observed	Number of Home Styles	Number of Homes in Subdivision
D.R. Horton	Iris at Spencer's Crossing	Murrieta, CA	3	4	300+
Pardee Homes	Living Smart at Canyon Hills	Lake Elsinore, CA	0	8	183
Pardee Homes	Sundance	Beaumont, CA	2	4	71
Pardee Homes	Living Smart at Hillside	Lake Elsinore, CA	3	4	197
Pardee Homes	Meadow Ridge	Lake Elsinore, CA	3	7	104
Pardee Homes	Watermark	San Diego, CA	3	4	160
Pardee Homes	Alta Del Mar	San Diego, CA	3	3	136
Richmond American	Acacia at Sundance	Beaumont, CA	1	4	110
Richmond American	Kensington II at Tournament Hills	Beaumont, CA	2	6	122
Shea Homes	Portico at Montage	Livermore, CA	3	6	248

Builder	Subdivision	Location	Home Styles Observed	Number of Home Styles	Number of Homes in Subdivision
Shea Homes	The Ivy at Montage	Livermore, CA	3	3	161
Summerhill	Renaissance at Roubion	San Ramon, CA	3	4	42
Taylor Morrison	La Solara	Pleasanton, CA	4	6	112
Woodside Homes	Altura at Spencer's Crossing	Murrieta, CA	3	3	69
		Total	36	66	2,015

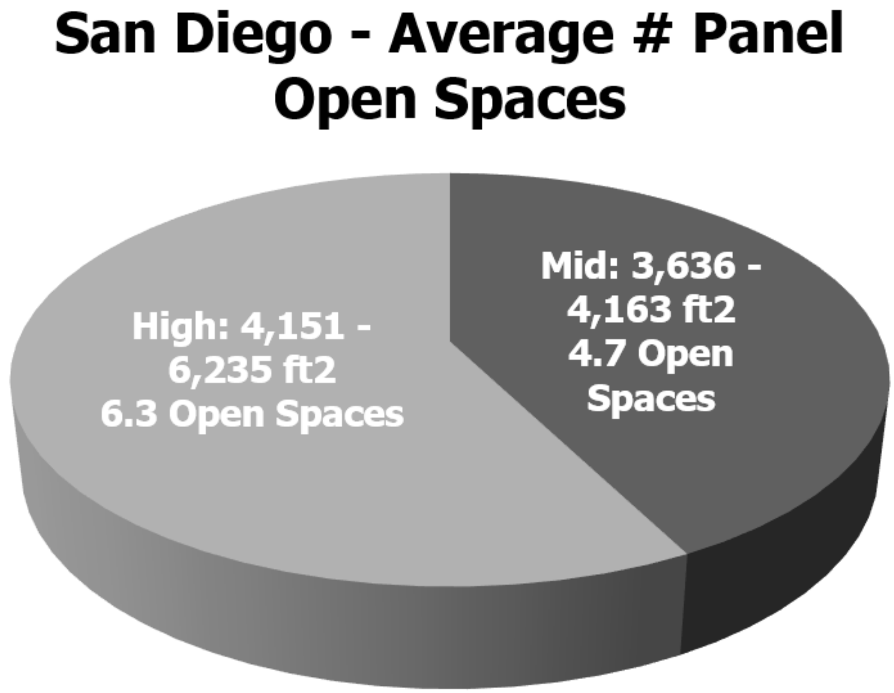
Source: Consol

Figure 31: Space Types Relative to Type of Bay Area Residence



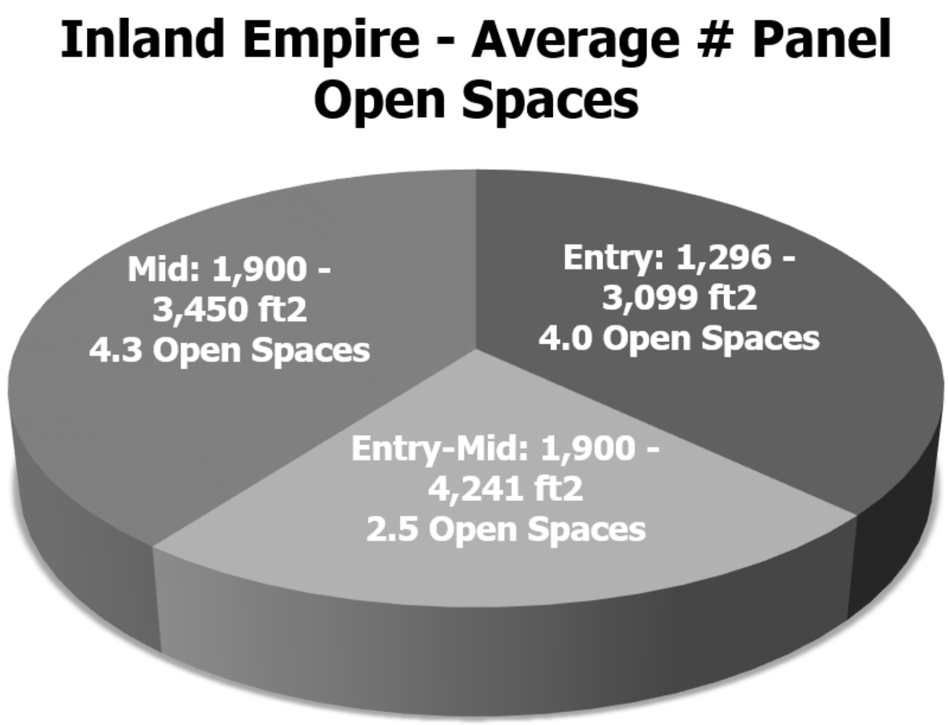
Source: ConSol

Figure 32: Space Types Relative to Type of San Diego Residence



Source: ConSol

Figure 33: Space Types Relative to Type of Inland Empire Residence



Source: ConSol

Currently there are spaces available in most new homes for EV designated breakers. However, as the price of solar panels continues to drop, an increasing number of new homebuilders are building with PV systems pre-installed. In 2012, 1,912 solar systems received rebates from the New Solar Home Partnership.[60] A solar expert testified at the CEC Solar Workshop that the solar market share will increase significantly to over 15 percent in the next few years.[61] Some are building "Solar Ready Homes" or homes which have the PV system infrastructure pre-installed. On January 1, 2014 when the 2013 California Energy Code goes into effect, providing PV infrastructure will be a mandatory requirement and two slots in the panel will be reserved for future solar systems. Careful planning of the electrical load will be required to ensure adequate breaker slots for EV and solar ready homes.

As homes add more electric load through solar, EV or additional electric loads the electric service panel may be limited in available breaker spaces. The following images taken during the survey found new construction single-family homes with some fully loaded or near fully loaded panels as well as homes with adequate space for future expansion.

The survey results show that a large majority of the new homes already have 200-amp panels. The number or spaces in the 200-amp panels vary from 20 spaces, to 26 spaces to 30 spaces. For many of the houses with fully loaded or nearly fully loaded 200-amp panels with 20 spaces, a larger 30 space panel may provide the necessary space for future expansion. Alternatively, the addition of a subpanel would provide a similar solution.

Figure 34 shows a 200-amp electrical service panel with plenty of spare breakers spaces which was typical of our findings.

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[60] Le-Quyen Nguyen Renewable Energy Office California Energy Commission, email to Mike Hodgson of ConSol, July 23, 2013

[61] Matt Brost, Sun Power, testimony at CEC's Solar ion New Residential Construction workshop, Dec. 5, 2012

Figure 34: 200-amp Panels with Open Spaces

(left) Source: Shea Homes (right) Source: SummerHill Homes

Figure 35 shows a 200-amp electrical service panel with no spare breakers spaces and breakers for PV solar. The panel has 26 breaker spaces.

Figure 35: Fully Loaded 200-amp Panel with PV System

Source: Pardee Homes

Figure 36 shows a 200-amp electrical service panel with no spare breakers spaces and breakers for EV solar. The panel has 20 breaker spaces.

Figure 36: Fully Loaded 200-amp Panel with EV Charger

Source: SummerHill Homes

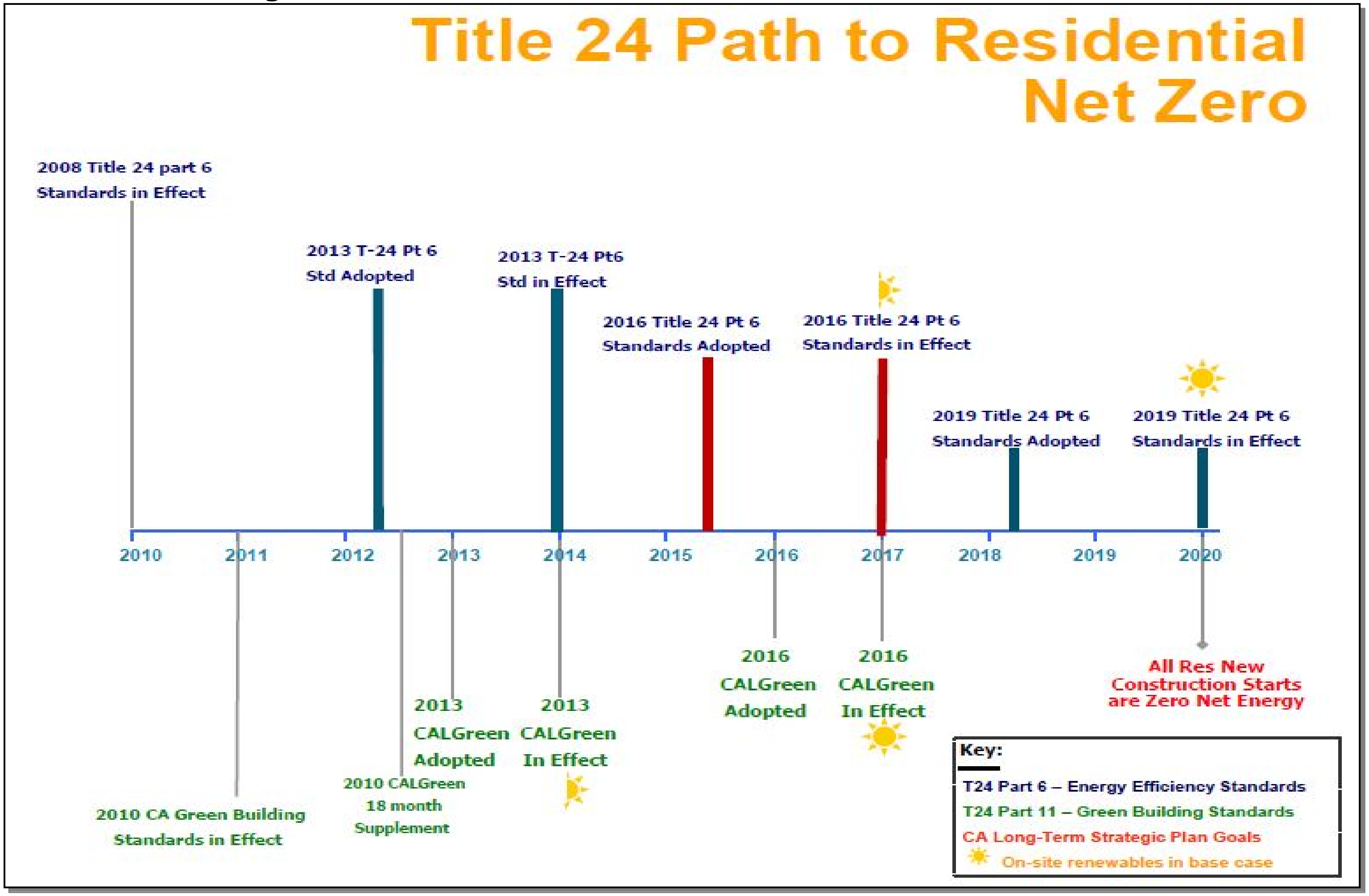
Additional Loads

In addition to a PV system and an EV charger, the homeowner may choose to install additional amenities in the future which require dedicated circuits, such as a spa, sunroom, wine cooler, freezer, security system, etc. Depending on the existing loads and taking into account the physical space taken by a PV system and EV charging system, there may not be enough physical space or electrical capacity within a 200-amp panel. It may require the need to upgrade the existing electrical service and/or install a subpanel. Larger homes with more amenities may require 400-amp panels. A subdivision of large homes added at the end of a service line or on a line that is near capacity may require additional utility infrastructure. In most instances installing a 200-amp panel with more physical space and/or increased capacity during construction should mitigate the additional loads.

Energy Code Reducing Loads

The California Long Term Strategic Plan proposes a goal of zero net energy in all new residential construction by 2020. The California Energy Commission has proposed to achieve zero net energy homes (homes that generate as much Time-Dependent Value (TDV) energy as they consume) over the next two triennial code cycles scheduled for 2016 and 2019. Figure 37 below outlines the Commission's timeline to achieve zero. The current energy code regulates space cooling, space heating, water heating and lighting. This represents approximately 50 percent of the total energy consumption in a home. As the code moves toward zero all energy uses will need to be evaluated in these codes. As loads are reduced by energy mandates it is anticipated that total loads for new homes will significantly decrease.

Figure 37: CEC/ZNE - Path to Net Zero for Residential

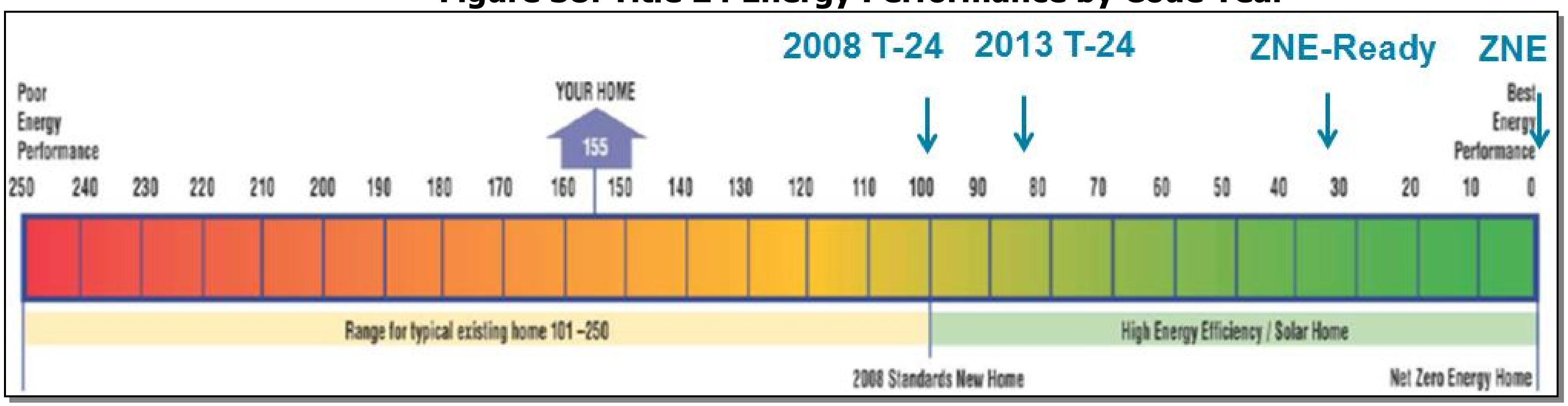


Source: [California Energy Commission](http://www.energy.ca.gov/2011_energypolicy/documents/2011-07-20_workshop/presentations/Revised_Zero_Net_Energy_Definition.pdf) (http://www.energy.ca.gov/2011_energypolicy/documents/2011-07-20_workshop/presentations/Revised_Zero_Net_Energy_Definition.pdf), PG&E

The California HERS Index is the ratio of the TDV energy of the rated home to the TDV energy of the reference home. The HERS Program was initially implemented to address construction defects and equipment installations that had historically not been done correctly. These HERS measures cover HVAC system and insulation installation. In an update to the HERS Regulations, the rating of a home as a system (known as Whole House Home Energy Rating) was implemented, where a home is rated on a scale from 0 to 250 to show its efficiency relative to a reference home built to just meet the Title 24 Building Energy Efficiency Standards' prescriptive requirements.[62]

Figure 38 outlines the CEC's assumption on how energy use will be reduced over these two code cycles resulting in zero energy homes (zero on the Home Energy Rating or HERS Index). One assumption is that by 2016 homes will be ZNE ready. ZNE ready means the maximum energy efficiency of homes has been reached and the remaining energy needed to achieve "zero" is derived from generation (solar). Note that a home built to the 2016 T-24 code will be a 32 on the HERS scale while a new home built today is an 82. The represents a 50 percent reduction in total energy use for homes in the next code cycle. Assuming the energy code is significantly more stringent as homes approach zero energy or near zero homes the house electric loads will be significantly reduced. These reduced loads should result in the 200-amp panel having adequate spaces and service load for future new homes.

Figure 38: Title 24 Energy Performance by Code Year



Source: Path to Zero Net Energy: Residential New Construction Redesign, PG&E, July 16, 2013

[62] Home Energy Rating System Program (http://www.energy.ca.gov/HERS/)

Single Meter Configuration
Providing a PV system and EV charging system on one electrical service panel could potentially introduce space issues in the service panel. A typical residential 200-amp service panel has limited space in the range of 20 to 30 spaces. The PV system breakers and the proposed 50-amp breakers for EV charging take a total of 4 spaces. In larger homes, which may have more loads and thus more circuits, there may not be enough space in the service panel to accommodate the extra breakers. To avoid space limitations, adding a smaller subpanel may be a viable option to address the issue. This option, however, does not address the fact that a 200-amp panel rating may not be adequate to accommodate the extra 40-amp continuous load of an EV charger.

Multiple Meter Configurations
Some utilities offer a dedicated meter for an EV charger with a separate EV charging rate schedule. A second meter with its own service panel would likely minimize the space issue of using a single meter and service panel. This may not be an attractive option to homeowners with a PV system and EV charger. In the multiple meter configurations, the PV system would not offset the consumption from the EV charger. Net metering would only apply to the electric meter that is connected to the PV system. This may not be an issue if the energy generated by the PV system is less than the house meter consumption or if the utility could apply the EV charging electric usage to the net metering bill. From the first year of SDG&E's multi-year EV Rate Experiment, PV systems were present in 204 (38 percent) of participant households who had interval data. This is important because these customers face quite different incentives regarding their charging behavior. Specifically, they may be more apt to charge their vehicles during the day using the energy from their PV system, which they would otherwise get a credit for by providing electricity to the grid. Virtually all customers in the EV Rate Experiment who opt-out of the EV rates have PV systems (94 percent). The fact that almost all EV customers on non-TOU standard rates have PV systems suggests that EV customers with PV systems make different decisions about rates, most likely to maximize economic benefits from their PV systems.[63]

Size of Home vs. Electrical Panel Rating
ConSol's electrical service panel survey and analysis of data collected such as rating of panel, number of breakers, number of empty spaces, and equipment protected by the breakers did not show a significant correlation between the square footage of a median sized home in the western region of the United States (i.e. 2,149)[64] and the rated panel size 200 or 400-amp. This excludes higher end houses over 4,000 square feet. Larger homes had more amenities such as breakers for wine coolers, dual heat stoves, spas, pools, etc. These homes would require a 400-amp panel and would not be affected by

[63] *First Year Evaluation for San Diego Gas & Electric's Electric Vehicle Pilot*, December 21, 2012, Freeman, Sullivan & Co.
[64] New single family home square footage (http://www.census.gov/const/C25Ann/sftotalmedavgsqft.pdf)

the addition of a PEV. Since these types of homes would already have at least a 400-amp service panel and potentially additional sub panels to accommodate the addition of a PEV. The increase in panel rating is not driven by PEV but by the type of home and associated amenities. The correlation in panel sizes was a result of the type of home, entry level, mid-level or luxury.

Findings

In a PV and EV-ready single-family new construction project, the panel sizing issue should be addressed during the electrical design phase of the home. The panel specified should be able to accommodate the normal house circuits' electrical loads as well as provide enough capacity for a PV system with 20 to 50-amp breakers and an EV charger with 50-amp breakers. The electrical loads should be calculated assuming continuous loads for both a PV system and an EV charger. In selecting the electrical service panel's physical size, the panels should have adequate spaces available to accommodate PV, EV, and future electrical breaker requirements. This will ensure that the supply side service is adequately sized to meet all loads if a PV system and EV charger are installed in the future. In some cases, and for some larger homes, the installation of a 400-amp panel may be required. However, more stringent energy code requirements and the evolving trend of using smart load management strategies will continue to reduce electrical loads. In most cases a 200-amp panel should be adequate for both PV and EV requirements.

New Housing Construction and Subdivision Infrastructure Added Costs

The overall cost to provide Level 1 and/or Level 2 charging readiness in residential new construction does not appear to be significant. The actual cost to construct the infrastructure on the demand or house side of the meter is minimal. The cost on the demand side would include meter socket, electrical panel cost if increased from 200-amp to 400-amp, conduit and duplex box. The cost range is between $100 and $300[65] per dwelling unit for electrical infrastructure installation on both sides of the meter.

On the supply or upstream side of the meter the cost varies considerably, depending on the electrical utility company. SCE for example indicates little to no cost to the utility infrastructure while PG&E is careful to commit to actual impact and cost. Most utilities agree that nominally sized Level 2 chargers in the range of 6.6 kW or approximately 40-amp at 240 volts would not significantly impact their grid. This mainly stems from the considerable impact that air conditioning loads have on sizing the utility infrastructure. Due to the impact of unpredictable air conditioning loads on the service, transformers are often sized with considerable diversity and capacity.

[65] Home Depot Building Materials – (http://www.homedepot.com/b/Building-Materials/N-5yc1vZaqns?cm_mmc=SEM|G|BT2), see Appendix B for details.

Additionally, the impact of the California Energy Code requiring more efficient air conditioning equipment causes a decrease in air conditioning load on the utility transformer and increase in available capacity.

ConSol obtained opinions of costs from a number of consultants to derive potential infrastructure upgrade costs to accommodate Level 1 and Level 2 EV charging in residential new construction subdivisions. Since Level 1 is well defined and can currently be provided without upgrading utility infrastructure, the focus was on Level 2 charging and the impact this would have on the utility grid. Below is a summary of the potential cost studies for the implementation of Level 2 infrastructure.

Eight Different Subdivision Study

A study performed by Giacalone Design Services, Inc., a company specializing in comprehensive Joint Trench Consulting services, provided cost studies for eight (8) projects to determine the impact of 6.7 kVA EV car chargers for each "living unit". They reviewed four different "Single-Family Homes" subdivision projects (from 4 lots to 59 lots) and four different "multi-family row-homes" (from 55 units to 240 units) subdivision projects. The focus was to analyze the impact of the additional EV charging load with regard to voltage drop/flicker calculations, and transformer and cable loading. Table 8 summarizes the estimated utility infrastructure cost impact on Level 2 charging. The study did not review the impact of multiple projects to the utility grid, or any impact to utility substations.

The consultants did not study the impact to large multi-family "podium style projects" because their experience indicated that dedicating 5 percent of parking spaces for EV charging compared to the current practice of dedicating 2-3 percent would have minimal impact on a large multi-family "house panel" (1200A or greater). The 5 percent target number was a request ConSol made to evaluate what impact this higher percentage of electric vehicle chargers would have on infrastructure costs.

To derive a more comprehensive study showing the effect of EVs on utility infrastructure the consultant recommended a larger sample size to study. Nonetheless, their preliminary observations were:

1. Impact to the smallest project studied (4 lots) was the greatest.
2. If Level 2 chargers can be added without impact to the electric service size, there is minimal impact to secondary conduits and cable sizing.
3. The largest per unit cost impact is due to the cost of additional transformers (sub-surface transformers impact is approximately twice the impact of pad mount transformers).
4. In the one large project studied that utilized three-phase transformers, the per-unit cost impact was approximately 10 percent of the impact of the smaller projects that utilized single-phase transformers.

Table 8: Electric Vehicle Level 2 Charger Impact to Builder on Utility Costs Analysis

Sub-division	Description of Project	# Units	Description of Impact	Secondary Conduit impact per unit	Secondary Cable cost impact per unit	Transformer cost impact per unit	Total cost impact
1	Single-family Homes -4 lots, 4200SF ea., 400A (120/240V)	4	Existing 50kVA transformer needs to be upgraded to 100kVA by utility company.	$ -	$ -	$6,250	**$6,250**
2	Single-family Homes -12 lots, 2000SF ea., 200A (120/240V)	12	Upgrade 165' of Secondary cable.	$ -	$83	$ -	**$83**
3	Single-family Homes -36 lots, 1800SF ea., assumed panels increased from 125 to 200A (120/240V)	36	Addition of single-phase sub-surface transformer and upgrade 550' of conduit and cable.	$10	$60	$500	**$570**
4	Single-family Homes -59 lots, 3500SF ea., 200A (120/240V)	59	Addition of three single-phase sub-surface transformers.	$ -	$ -	$763	**$763**

Sub-division	Description of Project	# Units	Description of Impact	Secondary Conduit impact per unit	Secondary Cable cost impact per unit	Transformer cost impact per unit	Total cost impact
5	Multi-Family Row homes mixed with Single-townhomes -75 units total (120/240V)	75	Addition of two sub-surface single-phase transformers.	$ -	$ -	$250	**$250**
6	Multi-Family Row Homes, 80 units, 4 to 7 units per building, assumed panels increased from 200A to 400A or 400A to 600A (120/240V)	80	Addition of one pad mount single-phase transformer and upgrade one single-phase transformer. Increase 1900 Secondary conduit.	66	$ -	$238	**$304**
7	Multi-Family Row Homes, 93 units, 4 to 10 units per building, assumed panels increased from 400A to 600A or 600A to 800A (120/240V)	93	Addition of two pad mount single-phase transformers and 200' of secondary conduits/cable.	$10	$10	$322	**$342**

Sub-division	Description of Project	# Units	Description of Impact	Secondary Conduit impact per unit	Secondary Cable cost impact per unit	Transformer cost impact per unit	Total cost impact
8	Multi-Family Row Homes, 240 units, 4 to 8 units per building, assumed panels increased from 400A to 600A or 800A to 1000A(120/208V - Three Phase)	240	Upgrade four three-phase pad mount transformers and add 3800' of secondary conduits.	$75	$ -	$ 33	**$108**

Source: ConSol

Shea Builder Townhome Study

A study performed on a 93-unit townhouse community by the master builder Shea was also reviewed. The subdivision Landsdowne at Bay Meadows in San Mateo focused on sustainability and a reduced environmental footprint with a unique buyer profile of higher income and a shorter commute pattern. The study evaluated the effect on the utility infrastructure if all 93 townhomes were provided with Level 1 or Level 2 chargers. This study is unique in that it assumes 100 percent of the townhome will be fully equipped with EVSEs.

The study assumed the following charger characteristics:

- Level 1 (8-hour charge)
  - 110 V Power Supply
  - 20A Dedicated Circuit
  - Standard NEMA Receptacle-15A continuous
- Level *2* (3–4 hour charge)
  - 220V Power Supply
  - 30–40-amp Dedicated Circuit
  - NEMA 6–30 or 6–50 Receptacle (Station Dependent)
- Level 3 (Commercial/Industrial) Quick Charge

The infrastructure assumptions were:

- Level l (1.4 kVA each) - 409 kVA Total Demand = 4 Transformers
- Level 2 (6 kVA each) - 715 kVA Total Demand = 6 Transformers
- Load Factors are Critical
  - 50 percent ON = 6 Transformers
  - 100 percent ON = 12 Transformers

Two (2) additional transformers were added to the project as a result of the potential Level 2 EV charging. This was an increase of 50 percent over the number of transformers required if the town homes were not Level 2 EV-ready. The load diversity factors were critical in determining the number of transformers required since a diversity factor of 100 percent, in essence no diversity, would result in doubling the number of transformers required for electric vehicle chargers. A diversity factor of 50 percent was agreed upon with the utility company.

The EV readiness resulted in additional cost to the building distribution system as a result of:

- Design costs

- Additional construction costs due to:
    - An increased capacity of the meter distribution panel.
    - Increased capacity of the Sub-panels.
    - Additional 220 volt and 30 to 40-amp circuit.
    - Addition of electric vehicle supply equipment.

Table 9 below summarizes the installed cost to be under $300 per unit.

Table 9: Cost to Implement EVSE

Item	**Description**	**QTY**	**Cost**	**Total**
Infrastructure				
	Additional Transformers	2 each	$ 6,215	$ 12,430
	Additional Primary Trench and Conductors	2 each	$ 750	$ 1,500
Buildings				
	Higher Capacity Meter Panels/Distribution	12 each	$ 250	$ 3,000
	Higher Capacity Sub Panels and Unit Feeds	93 each	$ 50	$ 4,650
Individual Units				
	Dedicated Circuit	93 each	$ 50	$ 4,650
	EV Supply Equipment (Option w/revenue offset)	93 each	$ 1,400	$ 130,200
Total Cost				**$26,230**
Total Cost per Unit				**$ 282**

Source: ConSol

Utility Specialist Study

A study performed by Utility Specialist, a company specializing in investor owned utility infrastructures, was commissioned to evaluate the impact of adding Level 2 EV chargers to the utility's infrastructure and the cost impact to housing construction.

Utility Specialist evaluated the probable impact of EV charging on builders/developers that provide electric infrastructure for residential single-family and residential multi-family homes in IOU service territories. The California investor owned utilities evaluated were PG&E, SCE and SDG&E companies.

To perform the study the following assumptions were made:

- Contractors understand IOU electric distribution infrastructure standards and guidelines.
- Opinions of cost criteria; 100 percent of new residential single-family units and 5 percent of residential multi-family dwellings will accommodate EV charging.
- To accommodate residential single-family EV charging, typical 200A electric metering equipment will require upgrading to 400A.
- residential multi-family EV charging capability will be provided by designated location with separate electric metering as a construction practicality. This report covers only IOU meter charges, excluding all metering equipment and labor costs.
- EV charging electric demand is estimated at 6.6kW per charger.

Impact to infrastructure findings:
Current IOU electric infrastructure design guidelines and standards are driven by air conditioning loads. Accordingly, the IOUs have made recent changes to these guidelines and standards to increase the demand capacity of their infrastructure systems. Based on discussions with IOU engineering and design representatives during the implementation of recent infrastructure design changes, it is our understanding that additional EV charging at a nominal 6.6kw per charger can be accommodated without material change to new electric infrastructure nominal 6.6kw requirements.

Impact to panels and metering findings:
In the event of an increase in residential single-family electric service main switch from 200 to 400-amperes, special metering will be necessary. Our opinion of the additional IOU charges for 400-ampere SFR meters is estimated at $122 per unit. For residential multi-family dwellings our opinion of the additional IOU electric meters is estimated at $11 per dwelling unit.

IOU electric companies are not responsible for meter bases and supporting equipment; accordingly, these opinions of cost exclude any and all metering, switchgear infrastructure, and associated labor of installation.

KB Home
In 2010, KB Home announced an option for their homes to be pre-wired for Level 2 EV charging for $250.

The website states the following:

A California-based home builder, KB Home, is angling to take advantage of what could be a strong demand for home chargers by offering a new entry on its options list.

People who buy from KB will now be able to check a box that will see their homes pre-wired for electric vehicle charging. Running the wiring will only cost buyers an extra $250, but this likely only brings the circuit out to a junction box. Homeowners will probably still have to add a charging box of some kind.[66]

Findings

Based on these studies, previous studies and presentations, reports, and conversations with IOUs and localized municipal utilities, the addition of Level 2 chargers as defined in this readiness study will have minimal cost impact to the utility infrastructure. The main cost increase would be attributed to increasing the size of the electrical service from 200-amp to 400-amp which should not be necessary. Table 10 summarizes the estimated costs across the six (6) cost studies.

Table 10: Summary of Costs

Household Type	Readiness	Units	Demand or House Side	Utility Infrastructure
Single-family	**100% EV Ready**			
	2,000 Single-family, small subdivision	12	$65	$83
	1,800 Single-family, medium subdivision	36	$59	$570
	3,500 Single-family, medium subdivision	59	$54	$763
	1,800 Single-family entry level, large subdivision	280	$36	$ -
	2,200 Single-family move-up large subdivision	165	$45	$ -
	2,800 SF move-up, large subdivision	80	$56	$ -
	Average Cost	=	**$44**	**$105**

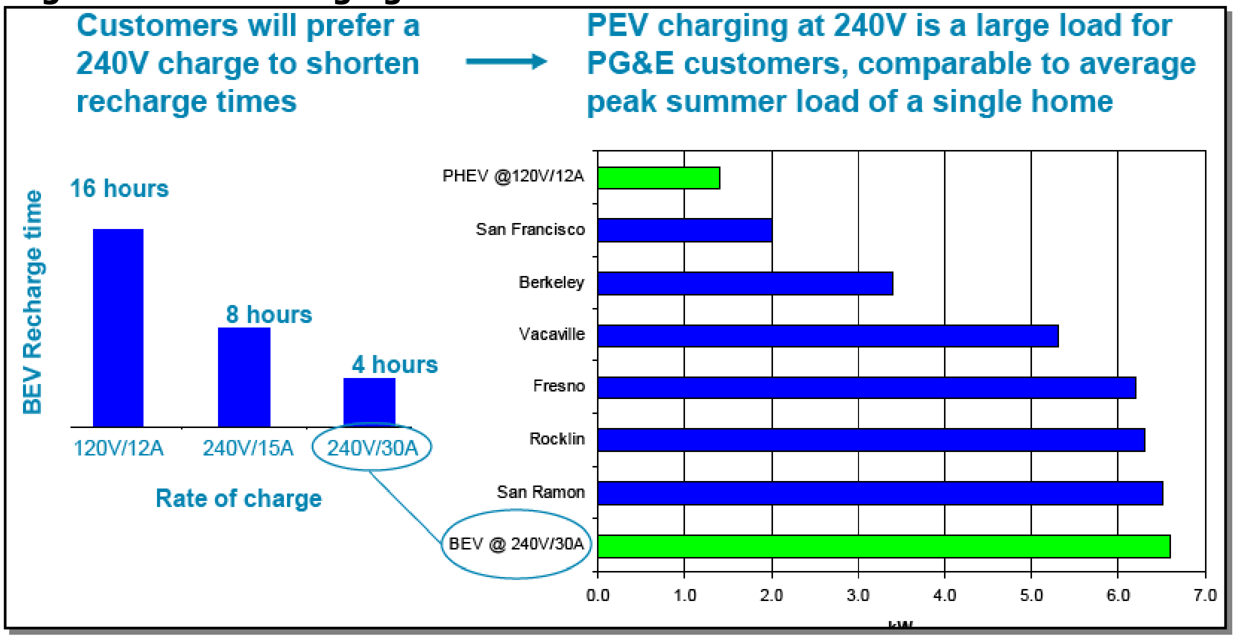
[66] Green auto blog article (http://green.autoblog.com/2010/03/10/california-homebuilder-offers-to-pre-wire-homes-for-electric-veh/)

Household Type	Readiness	Units	Demand or House Side	Utility Infrastructure
Multi-family	**5% EV Ready**			
	Townhomes	75	$7	$250
	Multi-family, row homes	80	$6	$304
	Multi-family, row homes	93	$27	$342
	Multi-family, row homes	240	$4	$108
	Townhouse 100%	93	$50	$232
	Apartments	240	$15	$ -
	Apartments	164	$8	$ -
	Average Cost	**=**	**$14**	**$124**

Source: ConSol

There are concerns related to EV charging which may impact utility infrastructure and thus the cost of implementation. Figure 39 illustrates the electrical load of typical Level 1 and Level 2, 30-amp EV chargers relative to the average peak summer electrical load of a single home in various cities throughout California. The figure indicates that while the typical Level 1 EV charger (1.5 kW) draws less than 50 percent of the average power of a Berkeley customer, a Level 2, 30-amp EV charger (6.5 kW) draws about the same amount of power as the average customer in Fresno.

Figure 39: PEV Charging and Increase in Electrical Load for PG&E Customers



Source: Electrical Vehicle Charging and NFPA Electrical Safety Codes and Standards, Fire Protection Research Foundation, October 2011

EVs localized in geographical clusters with low average electrical loads may have a greater impact to utility infrastructure than EVs localized in geographical clusters with high average electrical loads. The impact to the electrical grid would be compounded if two or more EVs are charged simultaneously per home. The impact of simultaneous charging at various levels (Level 1 or Level 2) will need to be evaluated.

While the potential exists for EV charging to impact utility infrastructure, leading to an increase in the cost of implementation, consensus suggests that Level 2 charging at 40-amp and 240 volts will not have a significant impact in the near future.

Ventilation Requirements

It is important to differentiate between the various battery chemistries currently available in the industry. Neighborhood EVs use lead acid batteries (which potentially vent toxic vapor). On-road EVs utilize lithium cobalt, lithium nickel manganese cobalt, and lithium phosphate batteries. These have pros and cons as to where and why they are used. The battery chemistries are listed in order from most toxic to least toxic. Lithium phosphate is often used for its inherent safety attributes. Typically, all lithium batteries are sealed and do not vent or off-gas unless there is a thermal event, as illustrated recently with lithium-ion batteries overheating in vehicles under test conditions.[67]

[67] Lithium-Ion batteries overheated in Mitsubishi vehicles, Charles Murray, Senior Technical Editor, Electronics & Test, 3/28/2013, (http://www.eetimes.com/document.asp?doc_id=1263138)

Currently most major car companies utilize nickel-metal-hydride or various lithium-based technologies for their EVs. Lithium provides four times the energy of lead-acid and two times that of nickel-metal-hydride. The materials for lithium-based batteries are generally considered abundant, non-hazardous, and lower cost than nickel-based technologies. The current challenge with lithium-based technologies is increasing battery capacity while maintaining quality and cycle life and lowering production costs. It is important to consider that as battery costs are driven down over time, auto manufacturers will increase the size of the lithium-based battery packs, and thus extend the range of electric vehicles.

Although lead-acid technology serves many EV applications like forklifts and airport ground support equipment very cost-effectively, the limitations on energy density and repeated cycles of charging and discharging make its application to on-road highway speed EVs less practical.

Essentially all new PEVs produced by major automakers use sealed battery packs that greatly reduce the possibility of gaseous release during charging. These vehicles are considered exempt from ventilation requirements when properly marked for such use. Most major automakers and EVSE providers label these battery packs and equipment as exempt from requiring ventilation.

In instances where local inspectors have evoked the application of the code reference for Indoor Sites (NEC 625.29) involving the venting requirements for batteries, General Motors' Volt Program offered the following response to inspector concerns and questions.

The Chevrolet Volt's lithium ion battery cells do not off-gas during charge and therefore do not require ventilation. The Volt's Li-ion battery cells are hermetically sealed, and because of their organic solvent-based electrolytes, do not generate (nor emit) gases during charging. Venting during charging is usually associated with the electrolyte systems in lead acid or nickel metal-hydride batteries. Furthermore, in accordance with National Electrical Code (Article 625), the Volt can be charged using an EVSE labeled "Ventilation Not Required." Alternatively, an EVSE labeled "Ventilation Not Required" does not have the proper interlock to charge an electric vehicle that requires ventilation. That is, an EVSE labeled "Ventilation Not Required" will not charge a PEV whose batteries off-gas during charge. Furthermore, a vehicle that requires ventilation will not charge with an EVSE not capable of supplying ventilation.

The NEC ensures that the proper ventilation equipment is available since it requires specific engineering controls that prevent different types of batteries from using EV chargers interchangeably.

Codes

The existing 2010 California Electrical Code and by reference from the California Electrical Code the California Mechanical Code have requirements for mechanical ventilation when batteries require it.

The 2010 California Electrical Code stipulates:

- **625.15 Markings.** The electric vehicle supply equipment shall comply with 625.15(A) through (C).
  A. **General.** All electric vehicle supply equipment shall be marked by the manufacturer as follows:

     FOR USE WITH ELECTRIC VEHICLES

  B. **Ventilation Not Required.** Where marking is required by 625.29(C), the electric vehicle supply equipment shall be clearly marked by the manufacturer as follows:

     VENTILATION NOT REQUIRED

     The marking shall be located so as to be clearly visible after installation.

  C. **Ventilation Required.** Where marking is required by 625.29(D), the electric vehicle supply equipment shall be clearly marked by the manufacturer, "Ventilation Required." The marking shall be located so as to be clearly visible after installation.
- **625.29 Indoor Sites.** Indoor sites shall include, but not be limited to, integral, attached, and detached residential garages; enclosed and underground parking structures; repair and non-repair commercial garages; and agricultural buildings.

  C. **Ventilation Not Required.** Where electric vehicle non-vented storage batteries are used or where the electric vehicle supply equipment is listed or labeled as suitable for charging electric vehicles indoors without ventilation and marked in accordance with 625.15(B), mechanical ventilation shall not be required.

The 2013 California Electrical Code will have the following amendment with regard to EV ventilation from the 2011 NEC which stipulates:

- Chapter 6 Special Equipment - ARTICLES 600–695

625.29 (E) Ventilation Required. [SFM] Where the electric vehicle supply equipment listed or labeled as suitable for charging electric vehicles that require ventilation for indoor charging and marked in accordance with Section 625.15(C), mechanical ventilation, such as fans, shall be provided as specified in the California Building Code.

Department of Housing and Community Development proposes to adopt the 2011 NEC and specifically Article 625 dealing with ventilation:

- Chapter 6 Special Equipment - ARTICLES 600-694

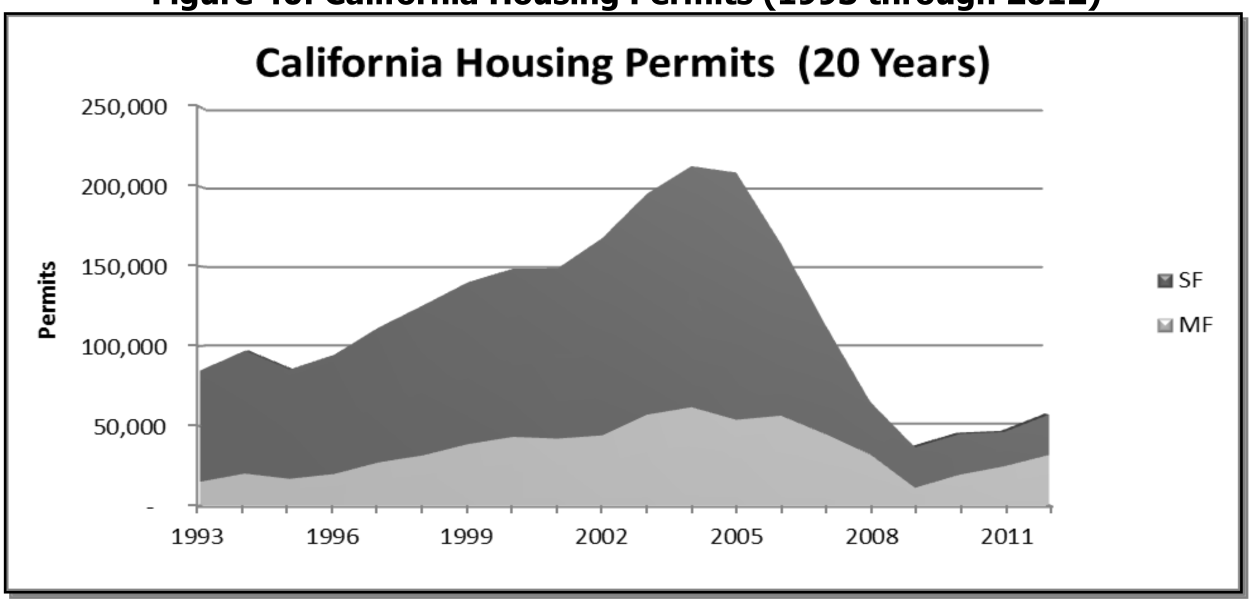
10. Department of Housing and Community Development proposes the adoption of Chapter 6, Articles 600, 620, 625, 626, 680, 682, 690, 692 and 694, from the 2011 National Electrical Code into the 2013 California Electrical Code without amendment.

Findings
It is apparent from the above code references that if EV chargers are marked to be used without ventilation then no ventilation is required by the code.

Current codes and manufacturer's standards adequately address the issue of when ventilation is required.

EV Charging Stations Needed to Serve 1.5 million Vehicles by 2025
To determine the impact of mandating EV readiness in new construction it was necessary to estimate the market projections for dwelling units through 2025. The Construction Industry Research Board historically has reported housing permits since the late 1970s. A normal California housing market is approximately 150,000 dwelling units per year. The average number of permits for the last 10 years was 75,000 for single-family and 39,000 for multi-family, which is a 66 percent to 34 percent split. Figure 40 reflects the number of California housing permits for the last twenty years.

Figure 40: California Housing Permits (1993 through 2012)



Source: ConSol

The California Energy Commission's Medium Housing Demand forecast as well as the California Department of Finance Economic Research Unit,[68] predict the housing market to return to 150,000 starts per year in 2016. Both predict that housing growth will continue at that level through 2020. After that their forecasts diverge. The earliest a

[68] Bill Schooling email July 12, 2013; Housing Forecast from ER

code requirement could impact the housing market is July 2015 which translates into homes being completed in the end of 2015 through early 2016. Utilizing the most recent 10 year average permit data ratio of single-family and multi-family, and Economic Research and Demand Forecast housing forecasts,[69]

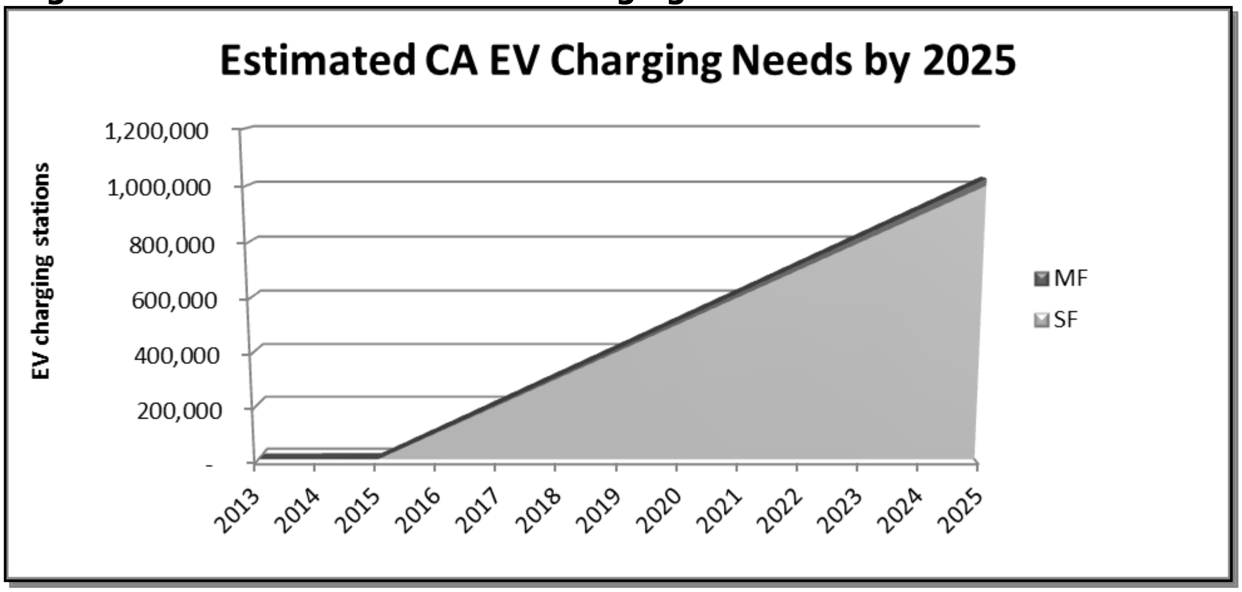
ConSol ramped up the number of single-family and multi-family dwelling units to 150,000 in 2016 and leveled the housing forecast at 150,000 through 2025. For this forecast ConSol assumed 67% of the dwelling units would be single family and 33% would be multi-family. All single-family units after completed after 2016 were assumed to be EV ready.

To determine the contribution of multi-family dwelling units one can require some percentage of dwelling units or parking spaces to be EV ready. Multi-family units are not linearly associated with parking spaces. Parking requirements vary due to type of occupancy, zoning, general plan, type of building (high-rise), urban influences and association with mixed uses. Typically parking spaces are proportional to bedrooms; however, many urban settings have limited parking spaces. The Construction Industry Research Board managed by the California Homebuilding Foundation produces the most comprehensive permit data for California. The Construction Industry Research Board does not distinguish multi-family dwelling units between garden apartments (3 stories or less), high-rise apartment (greater than 6 stories) and condominiums. Thus, it is difficult to determine the number of parking spaces available for EV readiness. Los Angeles County's Green Building Code mandates 5% of the total parking spaces have AC outlets for EV charging.

To estimate the number of multi-family charging stations by 2025 ConSol used dwelling units because it is the most reliable data available. The multi-family contribution to charging stations is approximately 2.5% of the total using dwelling units. Assuming EV-ready dwelling units are required for all single-family homes and 5 percent of multi-family dwelling units starting in 2016, there will be 1,025,000 charging stations in new single-family homes and multi-family communities by 2025. The cumulative total of charging stations from code mandated EV-ready dwelling units and from EV sales is estimated and shown in Figure 41.

[69] California Energy Commission (http://www.energy.ca.gov/2013_energypolicy/documents/2013-05-30_workshop/spreadsheets/Mid/)

Figure 41: Number of Estimated Charging Stations to Serve 1.5 Million PEVs



Source: ConSol

A low percentage of electric vehicle purchasers will also be new home buyers. Currently the new construction market reports less than 0.2 percent of new home buyers have requested charging stations to be installed. However, EV car sales are a rapidly growing market. The market share of EV among all passenger cars has increased from 0.14 percent in 2011 to 0.53 percent in the first six months of 2013.[70] Pike Research projected that annual sales of plug-in electric vehicles in the US will exceed 400,000 units by 2020.[71] Figure 42 from Southern California Edison iterates this PEV ramp up estimate. California is predicted to have 25 percent of the PEV sales in the United States through 2020. These sales predictions would generate over 1,500,000 EVs in California by 2025. The California Air Resources Board estimates by 2025 there will be over 1,400,000 electric vehicles in California with 15.4% of California car sales in 2025 being electric.[72] Total EV sales may be influenced by the continuation or expiration of financial incentives. The current EV market is provided significant financial incentives which expire over the next few years. Ultimately the consumer will determine whether California's 2025 EV goal is met. By having EV ready dwelling units California facilitates the consumer and reduces an impediment to that goal.

Figure 42: Revised SCE Forecast: One-Year Shift in PEV Adoption Curve

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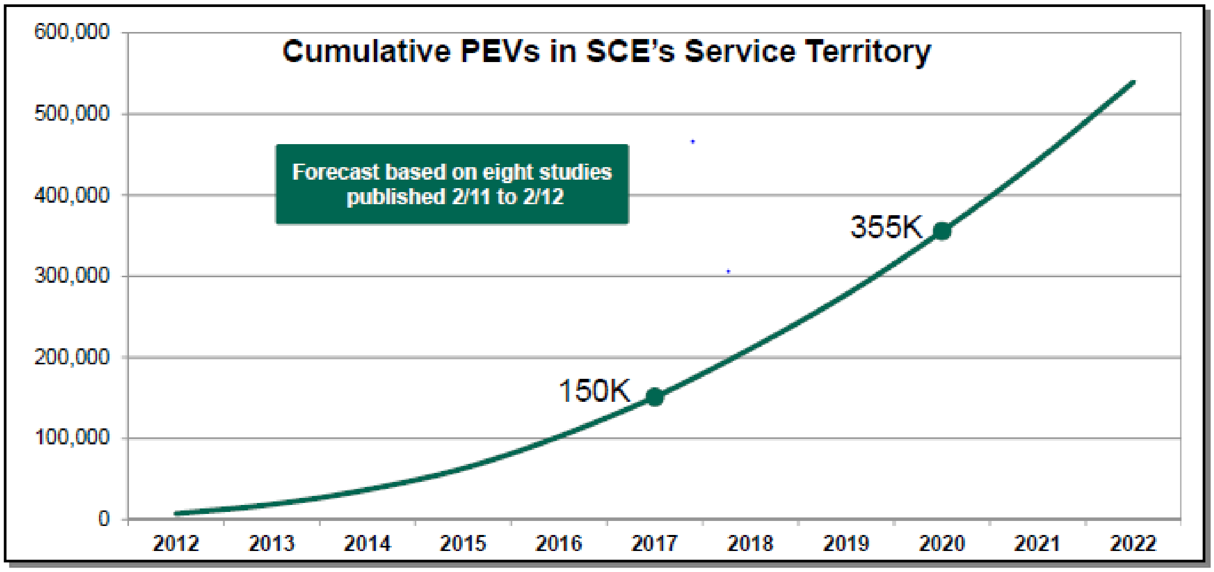
[70] Jay Cole, June 2013 Plug-In Electric Vehicle Sales Report Card, July 3, 2013; John Voelcker, Plug-In Electric Car Sales Triple in 2012 as Buyers, Models Increase, January 3, 2013
[71] Wikipedia, US Electric Car Sales, July 25, 2013
[72] California Environmental Protection Agency Air Resources Board Staff Report: Initial Statement of Reasons, Advanced Clean Cars, 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations, December 7, 2011.



Source: PEV Market Update, Bob Graham, Transportation Electrification, Southern California Edison, July 24, 2013

Findings

Assuming an EV charging ready code requirement for all single-family and 5 percent multi-family dwelling units or parking spaces, whichever is less, in July 2015 there will be 1,025,000 EV-ready charging locations from new construction by 2025.

EV sales will generate an additional 1,500,000 charging stations in California by 2025.

Type of Housing Where PEV Charging Unnecessary or Impractical

EV charging may be practical in many residential new construction applications with good engineering and planning forethought. However, retrofitting existing residential buildings to provide EV charging may be impractical and cost prohibitive in many of these types of buildings.

Nevertheless, there are areas even in residential new construction where requiring EV charging may not be practical or cost effective.

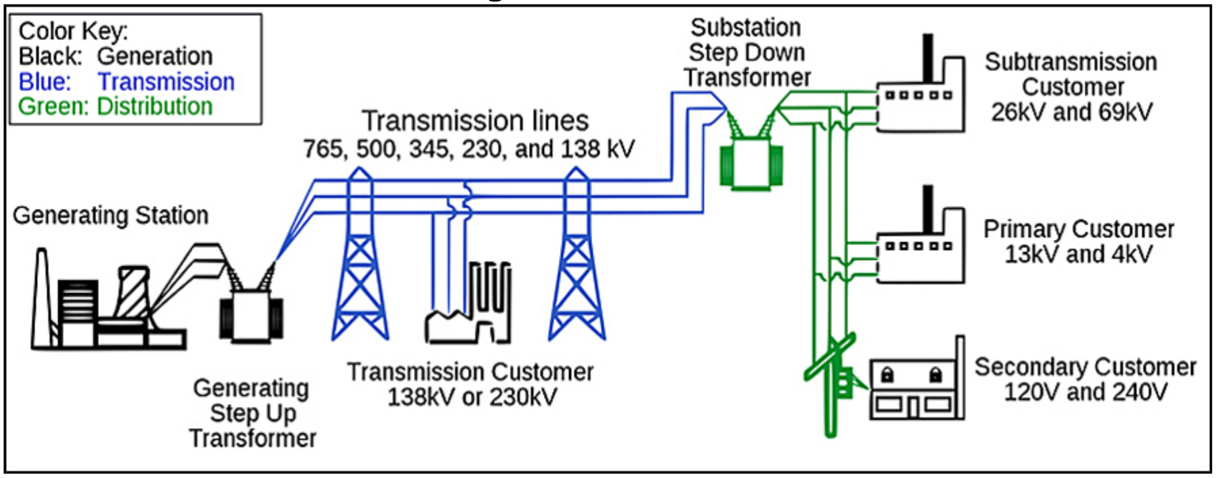
Single-Family Residential

Single-family residential buildings may include single-family detached homes and single-family attached homes, such as duplexes, triplexes and condominiums.

As illustrated in Figure 43, new subdivisions or 120V and 240V secondary customers located at the end of the electrical service main may require extension of the electrical service and upgrade of the utility infrastructure. This may be cost prohibitive, since the cost of the electrical infrastructure, conduit, wiring, transformers, and other items may be very expensive and not practical to implement.

New subdivisions located at the end of substation electrical lines served by a dedicated substation may not have sufficient capacity to accommodate a large increase in load due to Level 2 chargers. Increasing the capacity or building a new substation would be very costly. If utility infrastructure, such as a substation or transformer cannot handle the additional EV charging load, it may not be practical to install EV chargers, due to the cost of upgrading the infrastructure.

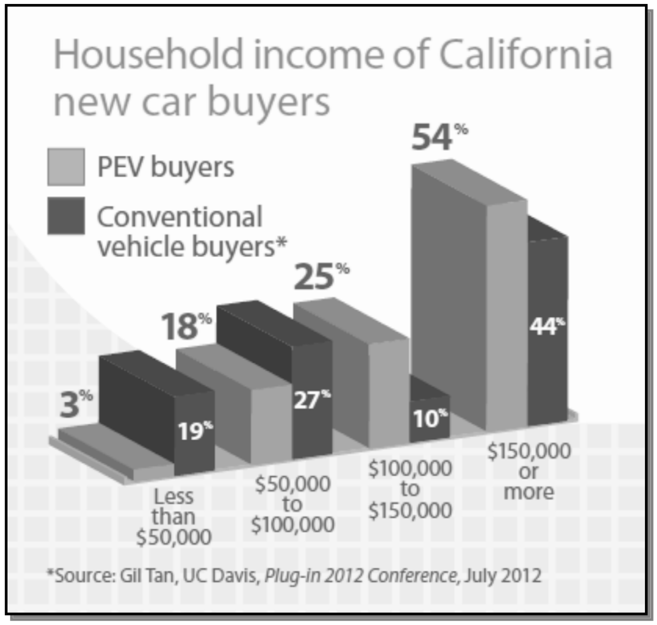
Figure 43: The Grid



Source: [Electric power transmission Wikipedia page](http://en.wikipedia.org/wiki/Electric_power_transmission)
(http://en.wikipedia.org/wiki/Electric_power_transmission)

Additionally, EV charging may not be practical in housing developments provided for lower income ownership or rental where smaller more cost-effective housing is being provided. The smaller house would be designed with smaller electrical panels to keep the cost of the home down. The panel would probably not have the capacity to accommodate the extra 40-amp Level 2 chargers, nor does it seem likely that this type of ownership would have the required income to afford the high cost of an EV. This would also apply to Section 8 housing. As illustrated in Figure 44, The California Plug-in Electric Vehicle Owner Survey showed that electric vehicle owners had a significantly higher income than conventional vehicle buyers.

Figure 44: Household Income of California Car Buyers



Source: ConSol

Multi-Family

New construction of multi-family high-rise and low-rise buildings that are located on top of the tenant parking facility typically appear in urban infill projects where space is limited. The parking facility is generally located below grade or at grade level with high-rise or low-rise apartment building located above.

Large two to three story apartment complexes are generally surrounded by open parking lots or open parking structures located adjacent to the apartment buildings.

Multi-family above pedestal buildings are typically low density and feature single level dwelling units located above a garage structure or open parking space.

There are a number of challenges that may make EV charging impractical for these types of multi-family parking arrangements. For example:

- New subdivisions located at the end of the electrical service main. Extension of the electrical infrastructure may be cost prohibitive.
- New multi-family developments located at the end of substation electrical lines served by a substation. The substation may not have sufficient capacity to accommodate a large increase in load due to Level 2 EV chargers. This also may be the case in urban areas where the building density has maximized the electrical service infrastructure.
- Multi-family facilities where the electrical infrastructure, such as the main switch board or the incoming service, is located in such a manner that it would be very

difficult or cost prohibitive to tap in to the utility side of the service to provide dedicated metered spaces to the tenants due to extreme space constraints.

- If the physical size of the parking structure is large and spread out, it would be very expensive to provide the required electrical service to the EV charger at the location of the tenant's parking space(s).
- Parking facilities that do not have assigned spaces would make it extremely difficult to allocate parking spaces with EV chargers, since the developer would not know where to locate them or control the use of the spaces.
- In multi housing units where the utility deems it not cost effective to provide dedicated meters for the charging stations.
- The location of the covered parking spaces may be so spread out that it would be very expensive to provide the required electrical service to the charging stations at the location of the tenant's parking space(s).

Findings

The question of where it may not be practical to provide EV charging in residential new construction applications did not seem to be widespread. With good engineering, planning and forethought, EV charging may be practical in most residential dwelling units. Although multi-family units with distant carport and unassigned parking can be challenging in that the cost of providing the infrastructure may be costly, the main challenge may be due to limitations in the utilities' electrical service infrastructure resulting from inadequate service mains, transformers or substations to provide for large multi-family complexes.

Summary Conclusions

The voltage and amperage to use for Level 2 EV charging is 240 volts, 40-amp fed by two breakers or spaces allowed for these. This will provide a reasonable charge time and will ensure a full charge when an automobile is charged overnight. The impact to the local utility is minimal since service line and transformer diversity will accommodate for this load with little to no impact to the utility infrastructure. Due to consumer desire to drive longer distances with less time spent charging, the Level 2 charger is becoming the de facto charger of choice for electric vehicle owners.

Adding Level 1 or Level 2 Electric Vehicle Supply Equipment to single-family residential dwellings with dedicated parking did not seem to pose a significant challenge. It is already being offered by a few builders. It is of interest to note that very few home buyers (less than 0.2 percent) have opted to have EV-ready homes when they have been offered.

The greatest challenge facing EV chargers is where to place them in multi-family units where parking was not available below the units or in an adjacent parking garage. Multi-family units with carports with unassigned parking also pose large challenges.

The largest potential impact to the cost of implementing Level 2 chargers is the potential increase of the single-family residential electrical service panel, per the 2013 California Electrical Code, from the soon to be required 200-amp panel to a 400-amp panel. This may have significant cost impacts to the utility infrastructure. One study reviewed for this report, as well as conversations with utility stakeholders, suggests that there may be no cost impact to the IOUs' infrastructure cost if the panel size is kept at 200-amp. Due to the 2013 California Energy Code requiring more efficient homes by as much as 30 percent and the continued decrease in energy consumption and eventual goal of net zero homes by 2020, it is believed that a 200-amp panel would be adequate to serve the EV loads. This will minimize impact on the utilities and reduce cost to the builder and the consumer.

Based on commissioned studies, previous studies, presentations, reports, and conversations with the IOUs and localized municipal utilities, the addition of Level 2 chargers as defined in this readiness study will have minimal cost impact to the utility infrastructure. The cost should be under $300 per dwelling unit. This number will decrease if a 400-amp panel is not required.

Concern for ventilation requirements for EV chargers does not appear to be well founded. Current and proposed code references adequately address the issue of when ventilation is required. Battery packs used in EV do not require ventilation. If EV charger is marked to be used without ventilation, then no ventilation is required by the code. Additionally, manufacturer's standards for EV chargers adequately address the issue of when ventilation is required.

The subject of the impracticality of providing EV charging in residential new construction applications did not seem to be widespread. With good engineering, planning and forethought EV charging may be practical in most residential dwelling units, although multi-family units with distant carport and unassigned parking can be challenging, due to the cost of providing the infrastructure. The main challenge may be due to limitations in the utilities' electrical service infrastructure, resulting from inadequate service mains, transformers or substations to provide for large multi-family complexes.

GLOSSARY

ALTERNATING CURRENT (AC) – Flow of electricity that constantly changes direction between positive and negative sides. Almost all power produced by electric utilities in the United States moves in current that shifts direction at a rate of 60 times per second.

BATTERY ELECTRIC VEHICLE (BEV) – Also known as an "All-electric" vehicle (AEV), BEVs utilize energy that is stored in rechargeable battery packs. BEVs sustain their power through the batteries and therefore must be plugged into an external electricity source in order to recharge.

CALIFORNIA CODE OF REGULATIONS (CCR) – The official compilation and publication of the regulations adopted, amended, or repealed by state agencies pursuant to the Administrative Procedure Act (APA). Properly adopted regulations that have been filed with the Secretary of State have the force of law. The CCR is compiled into Titles and organized into Divisions containing the regulations of state agencies.[73]

CALIFORNIA ENERGY COMMISSION (CEC) – The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The CEC's five major areas of responsibilities are:

1. Forecasting future statewide energy needs.
2. Licensing power plants sufficient to meet those needs.
3. Promoting energy conservation and efficiency measures.
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels.
5. Planning for and directing state response to energy emergencies.

Funding for the CEC's activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, and other sources.

DIRECT CURRENT (DC) – A charge of electricity that flows in one direction and is the type of power that comes from a battery.

ELECTRIC VEHICLE (EV) – A broad category that includes all vehicles that are fully powered by electricity or an electric motor.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE) – Infrastructure designed to supply power to EVs. EVSE can charge a wide variety of EVs, including BEVs and PHEVs.

INVESTOR-OWNED UTILITIES (IOU) – A private company that provides a utility, such as water, natural gas or electricity, to a specific service area. The investor-owned utility

[73] California Office of Administrative Law (https://oal.ca.gov/)

is regulated by the California Public Utilities Commission. In California the investor owned utilities supplying energy are:

- Canadian Pacific National Corporation
- Pacific Gas and Electric Company
- Pacific Power and Light Company
- San Diego Gas & Electric
- Sierra Pacific Power Company
- Southern California Edison Company
- Southern California Gas Company (The Gas Company)
- Southwest Gas Corporation

LITHIUM-ION (Li-Ion) BATTERY – A type of rechargeable battery. In the batteries lithium ions move from the negative electrode to the positive electrode during discharge and back when charging.

NATIONAL ELECTRICAL CODE (NEC) – The NEC (the National Fire Protection Association's *NFPA 70*) is a widely-adopted model code for the installation of electrical components and systems. Its purpose is to safeguard persons and property from hazards arising from the use of electricity (*NEC* 90.1(A)).[74]

PACIFIC GAS AND ELECTRIC (PG&E) -- The acronym for Pacific Gas and Electric Company an electric and natural gas utility serving the central and northern California region.

PHOTOVOLTAIC (PV) – Photovoltaics (often shortened as PV) gets its name from the process of converting light (photons) to electricity (voltage), which is called the *photovoltaic effect.*[75]

PLUG-IN ELECTRIC VEHICLE (PEV) – A general term for any car that runs at least partially on battery power and is recharged from the electricity grid. There are two different types of PEVs to choose from—pure battery electric and plug-in hybrid vehicles.

PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV) – PHEVs are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. The vehicle can be plugged in to an electric power source to charge the battery. Some can

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[74] U.S. Consumer Product Safety Commission website (https://www.cpsc.gov/Regulations-Laws--Standards/Voluntary-Standards/Topics/National-Electrical-Code/)
[75] The National Renewable Energy Laboratory (https://www.nrel.gov/research/re-photovoltaics.html)

travel nearly 100 miles on electricity alone, and all can operate solely on gasoline (similar to a conventional hybrid).

SAN DIEGO GAS AND ELECTRIC (SDG&E) -- The acronym for San Diego Gas & Electric an electric and natural gas utility serving the San Diego, California, region.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) – A global association of more than 128,000 engineers and related technical experts in the aerospace, automotive, and commercial-vehicle industries. The leader in connecting and educating mobility professionals to enable safe, clean, and accessible mobility solutions.[76]

SOUTHERN CALIFORNIA EDISON (SCE) – One of the nation's largest electric utilities, which delivers power to 15 million people in 50,000 square miles across central, coastal, and Southern California, excluding the City of Los Angeles and some other cities.

TIME-OF-USE (TOU) – PG&E rate plans that can reduce expenses by shifting energy use to partial-peak or off-peak hours of the day. Rates during partial-peak and off-peak hours are lower than rates during peak hours.

UNDERWRITERS LABORATORIES INC (UL) – Underwriters Laboratories is a nonprofit organization dedicated to advancing the UL Mission through the discovery and application of scientific knowledge.[77]

ZERO EMISSION VEHICLE (ZEV) – Vehicles that produce no emissions from the on-board source of power (e.g., an electric vehicle).

[76] Society of Automotive Engineers (https://www.sae.org/about/)
[77] Underwriters Laboratories Homepage (https://ul.org/)

APPENDIX A: References

The following is a list of reports and websites that were reviewed as part of the Electric Vehicle Readiness Study research. Some but not all are cited within the report itself. The numbering is chronological for counting purposes and does not correlate to any footnote numbering within the report.

REPORTS

1. Association of Bay Area Governments, Bay Area Climate Collaborative, Clean Fuel Connection, EV Communities Alliance, LightMoves Consulting, November 2011, ***Ready Set Charge California: A Guide to EV-Ready Communities***
2. Bellino, George, General Motors, May 3, 2011, ***Plug-in Electric Vehicles Home Charging Installation–Electrical Contractor & Inspector Outreach Presentation Texas***
3. California Energy Commission, May 2013, ***California Energy Demand 2014-2024 Preliminary Forecast–Volume 2: Electricity Demand by Utility Planning Area***, Draft Staff Report, CEC-200-2013-004-SD-V2
4. California Energy Commission, December 2009, ***California Energy Demand 2010–2020 Adopted Forecast***, Commission Report, CEC-200-2009-012-CMF
5. California Environmental Protection Agency Air Resources Board, December 7, 2011, ***Staff Report: Initial Statement of Reasons-Advanced Clean Cars-2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations***
6. California Plug-In Electric Vehicle Collaborative, July 2012, ***Streamlining the Permitting and Inspection Process for Plug-In Electric Vehicle Home Charger Installations***, Report and Recommendations, Version 2
7. California Plug-In Electric Vehicle Collaborative, December 2010, ***Taking Charge––Establishing California Leadership in the Plug-In Electric Vehicle Marketplace***
8. Center for Sustainable Energy California, California Environmental Protection Agency-Air Resources Board, 2012, ***California Plug-in Electric Vehicle Owner Survey***
9. Center for Sustainable Energy California, California Environmental Protection Agency-Air Resources Board, 2013, ***California Plug-in Electric Vehicle Driver Survey Results May 2013***
10. County of Sonoma, General Services Department, July 2011, ***County of Sonoma Electric Vehicle Charging Station Program and Installation Guidelines***
11. Department of Commerce, Puget Sound Regional Council, July 2010, ***Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State Model***

Ordinance, Model Development Regulations, and Guidance Related to Electric Vehicle Infrastructure and Batteries per RCW 47.80.090 and 43.31.970

12. Electric Transportation Engineering Corporation An ECOtality Company, April 2010, ***Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene***, Final Version 3.1
13. Elkind, Ethan, Bank of America, Berkeley Law, UCLA Law, September 2012, ***Electric Drive By '25: How California Can Catalyze Mass Adoption of Electric Vehicles by 2025***
14. Florida Public Service Commission, December 2012, ***Report On Electric Vehicle Charging***, Submitted to the Governor, the President of the Senate, and the Speaker of the House of Representatives To Fulfill the Requirements of Section 366.94, Florida Statutes
15. Governor Edmund G. Brown Jr., Governor's Interagency Working Group on Zero-emission Vehicles, February 2013, ***2013 ZEV Action Plan: A roadmap toward 1.5 million zero-emission vehicles on California roadways by 2025***
16. Graham, Bob, Transportation Electrification, Southern California Edison, July 24, 2013, ***PEV Market Update July 2013***
17. Grant PE, Casey C., Fire Protection Research Foundation, Co-Hosted by SAE and NFPA, November 2010, ***U.S. National Electric Vehicle Safety Standards Summit: Summary Report***
18. McHugh Energy Consultants, IEPR Workshop California Energy Commission, July 20, 2011, ***Revised Zero Net Energy (ZNE) Definition***
19. National Renewable Energy Laboratory, Revised February 2011, ***Electric Vehicle and Infrastructure Codes and Standards Chart***
20. Nemry, Francoise, Leduc, Guillaume, Munoz, Almundena, JRC European Commission, Institute for Prospective Technical Studies, ***Plug-in Hybrid and Battery-Electric Vehicles: State of the research and development and comparative analysis of energy and cost efficiency***
21. Nicholas, Michael, Tal, Gil, Woodjack, Justin, Turrentine, Thomas, University California Davis, ***Statewide Fast Charging Scenarios***
22. North Carolina Advanced Energy Corporation, 2012, ***Residential Charging Station Installation Handbook for Single- and Multi-Family Homeowners and Renters Version 1.0***
23. North Carolina Advanced Energy Corporation, 2011, ***Charging Station Installation Handbook for Electrical Contractors and Inspectors***
24. Oak Ridge National Laboratory, U.S. Department of Energy Vehicle Technologies Program, U.S. Department of Energy Office of Electricity Delivery & Energy Reliability, July 2010, ***Plug-In Hybrid Electric Vehicle Value Proposition Study Final Report***

25. Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric - Sempra Energy Utility, July 16, 2013, *Path to Zero Net Energy: Residential New Construction Redesign*

26. Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric Sempra Energy Utility, December 28, 2012, *Joint IOU Electric Vehicle Load Research Final Report*, Electric Vehicle Load Research & Cost Studies, R.09-08-009, AFV OIR, Ordered in D.11-07-029

27. Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric Sempra Energy Utility, January 3, 2012, *Submetering Protocol Roadmap Report*, As Directed by Alternative-Vehicle Proceeding R.09-08-009, Decision 11-07-029 Ordering Investor-Owned Utilities To Develop Protocols Supporting The Use of Customer-Owned Submeters For Use In Billing EV Load

28. Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric Sempra Energy Utility, December 23, 2011, *Joint-IOU Assessment Report For PEV Notification*, R.09-08-009 (AFV OIR) Ordered in D.11-07-029

29. Pacific Gas & Electric Company, Southern California Edison, San Diego Gas & Electric Sempra Energy Utility, October 27, 2011, *California Public Utilities Commission Sub-Metering Protocol Workshop*, As Directed by Alternative-Fueled Vehicle Proceeding R.09-08-009, Decision 11-07-029 Ordering Investor-Owned Utilities to Develop Protocols to Support the Use of Customer-Owned Submeters for Use in Billing EV Load

30. Peterson, David, UCLA Luskin School of Public Affairs, Luskin Center for Innovation, June 2011, *Addressing Challenges to Electric Vehicle Charging in Multifamily Residential Buildings*

31. Rawson, Mark, Kateley, Sue, California Energy Commission, August 31, 1998, *Electric Vehicle Charging Equipment Design and Health and Safety Codes*

32. Rubin, Ben, Office of Planning and Research, fall 2013, *Zero-Emission Vehicles in California: Community Readiness Guidebook*

33. Simonian PE, Larry, Korman PE, Dr. Thomas, Mowrer, Dr. Fredrick W., Philips, David, California Polytechnic State University, The Fire Protection Research Foundation, October 2011, *Electric Vehicle Charging and NFPA Electrical Safety Codes and Standards - Technology Review and Safety Assessment - Standards Review and Gap Assessment*

34. Tal, Gil, Nicholas, Michael A., Woodjack, Justin, Scrivano, Daniel, Institute of Transportation Studies University of California Davis, August 1, 2012, *Who is Buying Electric Cars in California? Exploring Household and Fleet Characteristics of New Plug-In Vehicle Owners*

35. U.S. Department of Energy, January 31, 2013, *EV Everywhere: grand challenge blueprint*

WEBSITES

A123 Systems:

- (http://www.a123systems.com/Collateral/Images/English-US/AMP20.jpg)
- (http://www.a123systems.com/Collateral/Images/English-US/AHR32113%20Power%20Module.jpg)
- (http://www.a123systems.com/Collateral/Images/English-US/Energy%20Pack.jpg)

AeroVironment (AV):

- (http://evsolutions.avinc.com/products/at_home)

Anaheim Public Utilities:

- (http://www.anaheim.net/articlenew2222.asp?id=4501)

Autobloggreen:

- (http://green.autoblog.com/2010/03/10/california-homebuilder-offers-to-pre-wire-homes-for-electric-veh/)

California Building Industry Association:

- (http://www.cbia.org/go/cbia/)

California Building Officials:

- (http://www.calbo.org/)

California Energy Commission:

- (http://www.energy.ca.gov/HERS/)
- (http://www.energy.ca.gov/2013_energypolicy/documents/2013-05-30_workshop/spreadsheets/Mid/)

California Plug-In Electric Vehicle (PEV) Collaborative:

- (http://www.pevcollaborative.org/)

Census:

- (http://www.census.gov/const/C25Ann/sftotalmedavgsqft.pdf)

ChargePoint OnRamp Program:

- (http://www.chargepoint.com/ecosystem.php)

ClipperCreek:

- (http://www.clippercreek.com/products.html)

Davis-Stirling:

- (http://www.davis-stirling.com/MainIndex/DavisStirlingAct/tabid/427/Default.aspx#axzz2WWKHKHB9)

DriveClean:

- (http://www.driveclean.ca.gov/)

ECOtality:

- (http://www.ecotality.com)

EE Times:

- (http://www.eetimes.com/document.asp?doc_id=1263138)

Electric Auto Association:

- (www.electricauto.org)

EnerDel:

- (http://www.enerdel.com/transportation/)

Environmental Protection Agency:

- (http://www.epa.gov/cleanenergy/energy-resources/calculator.html)

FuelEconomy:

- (http://www.fueleconomy.gov/)

General Electric (GE):

- (http://www.geindustrial.com/cwc/Dispatcher?REQUEST=PRODUCTS&pnlid=8&famid=9404&catid=6062&id=WS-WallMount)
- (http://www.geindustrial.com/cwc/Dispatcher?REQUEST=PRODUCTS&pnlid=8&famid=9404&catid=6062&id=Elec-evcs)

GoElectricDrive Foundation:

- (http://www.goelectricdrive.com/)

LG Chem Power Inc.:

- (http://www.lgchem.com/global/vehicle-battery/car-batteries)

Leviton:

- (http://www.leviton.com/OA_HTML/SectionDisplay.jsp?section=49065&minisite=10251)

Los Angeles Department of Water and Power (LA DWP):

- (https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=12gpm6ra56_63&_afrLoop=126567111685000)

Pacific Gas & Electric (PG&E):

- (http://www.pge.com/electricvehicles/)
- (http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/installationprocess)
- (http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/charginglevel/)

Panasonic:

- (http://news.panasonic.net/archives/2012/0924_13479.html)
- (http://news.panasonic.net/archives/2013/0402_21676.html)
- (http://news.panasonic.net/archives/2013/0612_22989.html)
- (http://panasonic.net/sanyo/corporate/message/topics/100524.html)

PEP Stations:

- (http://www.pepstations.com/)

Plug In America:

- (http://www.pluginamerica.org/accessory-tracker?type=All&level=All&nrtl=All)

Sacramento Municipal Utility District:

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

San Diego Gas & Electric (SDG&E):

- (http://www.sdge.com/electric-vehicles)

Schneider Electric:

- (http://www.schneider-electric.com/sites/corporate/en/products-services/product-launch/electric-vehicle/evlink-residential-charging-station.page)
- (http://www.schneider-electric.com/products/ww/en/1800-evlink-charging-solutions-for-electric-vehicles/1820-evlink-parking/60850-evlink-parking/)
- (http://www.schneider-electric.com/products/ww/en/1800-evlink-charging-solutions-for-electric-vehicles/1830-evlink-fast-charge/60852-evlink-fast-charge/)

Southern California Edison (SCE):

- (https://www.sce.com/wps/portal/home/residential/electric-cars/)

TakeCharge:

- (http://www.takechargesac.org/)

Tesla Motors:

- (http://www.teslamotors.com/forum/forums/why-tesla-model-s-has-so-many-battery-cells)

U.S. Department of Energy, Vehicle Technologies Office:

- (http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/index.html)
- (http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/10_year_goal.html)

APPENDIX B: Electrical Component Costs

Table 11: Electrical equipment costs

Tag	Description	1" Conduit	Level 1	Level 2 w/Recep	Level 2 w/Charger	Level 2 w/Charger and 80-amp load	Comments
1	1" conduit 10 ft. long	$6.77	$6.77	$6.77	$6.77	$6.77	1st section of conduit
2	1" conduit 10 ft. long	$6.77	$6.77	$6.77	$6.77	$6.77	2nd section of conduit
3	1" set screw, pack 10 $4.23 per box	$0.43	$0.43	$0.43	$0.43	$0.43	Connects 1st and 2nd sections listed
4	2-1/8 deep, 4-11/16 in. sq. steel box, pack 25, $91.25 per box, $3.65 each	$3.65	$3.65	$3.65	$3.65	$3.65	
5	1" Threadless Compression Conduit Connector	$6.60	$6.60	$6.60	$6.60	$6.60	
6	1" Threadless Compression Conduit Connector	$6.60	$6.60	$6.60	$6.60	$6.60	
7	4" Box cover plate / 50-amp plate	$1.20	NA	$2.20	NA	NA	

Tag	Description	1" Conduit	Level 1	Level 2 w/Recep	Level 2 w/Charger	Level 2 w/Charger and 80-amp load	Comments
8	12 AWG THHN wire, 30 ft., 3 wires, $0.16 per Linear ft.	NA	$14.40	NA	NA	NA	Builders would probably use 12-3 NM wiring (Romex)
9	8 AWG THHN wire, 30 ft., 4 wires, $0.34 per Linear ft.	NA	NA	$40.80	$40.80	NA	
10	6 AWG THHN wire, 30 ft., 4 wires, $0.51 per Linear ft.	NA	NA	NA	NA	$61.20	Increased wire size due to higher amperage
11	20-amp GFCI Duplex Outlet, 120 V	NA	$15.98	NA	NA	NA	
12	NEMA 14-50R, 50-amp outlet, 3P, 4W, flush mount receptacle straight blade, industrial grade, grounding, 240 V	NA	NA	$13.46	NA	NA	
13	Double-pole 50-amp, 2-pole, plug-on circuit breaker, 240 V	NA	NA	$11.45	$11.45	NA	50-amp breaker would meet code of 125% continuous load

Tag	Description	1" Conduit	Level 1	Level 2 w/Recep	Level 2 w/Charger	Level 2 w/Charger and 80-amp load	Comments
14	Double-pole 100-amp, 2-pole, plug-on circuit breaker, 240 V	NA	NA	NA	NA	$130.00	Circuit breaker rated for continuous use, 80-amp load
15	200-amp panel	NA	NA	$238.00	$238.00	NA	Base Panel cost is $218.00
16	400-amp panel[78]	NA	NA	NA	NA	$775.00	Panel increased due to higher amperage
17	Labor -Mount J-box and Run Conduit, 1/4 hour @ $73.00 per hour	$18.25	NA	NA	NA	$18.25	DEER Measure Cost Labor - 1) Base Wage Rate: $67.88 2) Average Climate Multiplier: 1.085 ***See Section 2.2 and 2.3 in Measure Cost Documentation
18	Labor - Run Conduit, cable and connect to breaker & receptacle, 1/2 hour @ $73.00 per hour, 1 hour for Level 2	NA	$36.50	$73.00	$73.00	NA	

[78] Cost of large electrical equipment such as the 400-amp panel is highly dependent on manufacture, supply house, contractor discount, and contractor volume. Average cost based on quotes from electrical supply companies such as Platt Electrical and Grainger.

Tag	Description	1" Conduit	Level 1	Level 2 w/Recep	Level 2 w/Charger	Level 2 w/Charger and 80-amp load	Comments
19	Labor – Install panel, conduit, cable and connect to breaker, 4 hour @ $73.00 per hour	NA	NA	NA	NA	$584.00	Due to the larger size and weight of a 400-amp panel will require a two man installation
	Labor	$18.25	$36.50	$73.00	$73.00	$602.25	
	Materials	$32.02	$61.20	$336.73	$321.07	$997.02	
	Taxes 9 % (materials)	$2.88	$5.51	$30.31	$28.90	$89.73	
	Sub-total	**$53.15**	**$103.21**	**$440.04**	**$422.97**	**$1,689.00**	Labor, materials and taxes
	EV Charger	NA	NA	NA	$1,500.00	$1,500.00	Cost of charger can vary from $0 if included with car to $399 to $1,500.
	Grand Total Demand Side	**$53.15**	**$103.21**	**$440.04**	**$1,922.97**	**$3,189.00**	House side of the meter cost including panel

Tag	Description	1" Conduit	Level 1	Level 2 w/Recep	Level 2 w/Charger	Level 2 w/Charger and 80-amp load	Comments
	Infrastructure Costs	$0.00	$0.00	$96.00	$96.00	$10,000.00	For Level 2 w/Charger and 80-amp load the cost can be very high and is dependent on existing infrastructure and size of development
	Grand Total	**$53.15**	**$103.21**	**$536.04**	**$2,018.97**	**$13,189.00**	$411.12 w/o level 2 charger
Assumptions: *Pricing based on consumer purchasing items from Home Depot Building Materials – (http://www.homedepot.com/b/Building-Materials/N-5yc1vZaqns?cm_mmc=SEM|G|BT2)* *Builder mass volume purchasing power and large quantity purchases would significantly lower the cost.*							

Source: ConSol

APPENDIX C: 1 inch Conduit Price Break Down

Figures 45 through 49 indicates the part specifications and price for various electrical items used on this project.

Figure 45: Allied Tube & Conduit 1 in. x 10 ft. Electric Metallic Tube Conduit

Source: The Home Depot

Model # 101568 $6.77/each

Figure 46: Halex 1 in. Electrical Metallic Tube (EMT) Set Screw Coupling Steel (10-Pack)

Source: The Home Depot

Model # 62811B $4.23 /box ($0.43 each)

Figure 47: Raco 2-1/8 in. Deep 42 cu. in. 4-11/16 in. Square Box (Pack-25)

Source: The Home Depot

Model #259 $91.25 /carton ($3.65 each)

Figure 48: Halex 1 in. Threadless Compression Conduit Connector

Source: The Home Depot

$6.60 each

The majority of THHN wire carries a dual rating on the cable marked THHN / THWN for both the wet and dry temperature rating.

Figure 49: THHN, Stranded, Copper

Source: The Home Depot

Item sold by the foot unless noted otherwise. Items 12 AWG THHN, 500ft, 1000ft, or 2500ft spool, 0.128 inches, 20 amps, $0.16/ft. Item 8 AWG THHN, 0.213 inches, 55 amps, $0.34/ft.

APPENDIX D: IOU Emails on Infrastructure

Figure 50: PG&E email communication

Mike Hodgson

From:	Almeida, David B <DBA9@pge.com>
Sent:	Friday, August 30, 2013 11:39 AM
To:	Mike Hodgson
Cc:	Kwan, Ulric
Subject:	RE: PG&E electric vehicle contact

Hi Mike,

I have included our responses to your questions below. That said, feel free to reach out if you need clarification or additional information.

1. ***Is the 200 AMP panel typically installed in new construction large enough for a Level 2 electric vehicle charging station and a possible PV solar system (as we move toward zero energy homes). If not, does a 400 amp panel cause any concerns for the utility?***

   In most cases, a 200A panel will be large enough to accommodate a Level 2 electric vehicle charging station, solar, as well as the energy consumption of a typical household. In very rare cases, a home will need to upgrade to a higher level of service (400A or two parallel 200A panels). However, the homes in these cases are significantly larger and consume much more energy than typical homes.

2. ***What utility infrastructure improvements (e.g.; transformers, switches, cabling), if any, need to be made to accommodate the current 2013 Energy Code requirement for new homes to be solar ready in conjunction with a possible EV charging station ready code requirement that may be proposed as early 2015?***

   The 2013 Energy Code requirement does not directly impact utility infrastructure improvements associated with solar. All customers interested in installing solar at their home or work are required to enter into an Interconnection Agreement with PG&E. This agreement allows PG&E to identify and perform necessary infrastructure improvements associated with each solar installation on a case by case basis. The Interconnection Agreement will continue to be required and supersedes the Energy Code.

   With respect to a proposed EV ready code; there are not any additional utility infrastructure improvements that will need to be made to accommodate EV charging stations in new construction. It is standard practice for PG&E to build utility infrastructure to serve the expected energy demand for each new development. In cases where homes are built in older developments, customers are required to notify PG&E for any load increases. In these cases, PG&E will make any necessary utility infrastructure improvements to ensure safe and reliable power to all customers on that distribution circuit.

3. ***What, if any, utility issues do we need to understand as electric vehicle charging stations are installed in primarily in new, but also existing, construction.***

   PG&E strives to provide our customers with safe and reliable power. At this stage in the market, EVs have not impacted grid stability. However, this may change as the market develops. PG&E is currently gathering data in order to determine what next steps need to be taken to accommodate higher adoption. As part of our ongoing efforts to provide safe and reliable service to customers, PG&E performs and tracks information related to service upgrades to better understand the support necessary for the EV market.

Source: ConSol

Figure 51: PG&E email Communication 2

Again, feel free to reach out if you need to follow up.

Best,

David Almeida | Sr. Program Manager, Electric Vehicles
Pacific Gas and Electric Company
DBA9@pge.com | (415) 973-1769

From: Kwan, Ulric
Sent: Thursday, August 29, 2013 5:30 PM
To: Mike Hodgson
Cc: Almeida, David B
Subject: RE: PG&E electric vehicle contact

Hi Mike,

David Almeida from my group has been working up the response to your questions. For your specific question, I believe that there will be minimal impact on the electricity infrastructure in new construction. David will provide feedback on the rest of your questions today or tomorrow.

Best,
Ulric

Source: ConSol

Figure 52: SDG&E (Sempra) email communication

Mike Hodgson

From:	Schimka, Randy <RSchimka@semprautilities.com>
Sent:	Thursday, July 11, 2013 10:54 AM
To:	Haddow, Greg; Mike Hodgson
Cc:	Fox, Chip
Subject:	RE: SDG&E electric vehicle contact

Good morning Gentlemen....Let me take a stab at answering Mike's questions, and then we can chat more about them if additional questions come up....

1. Is the 200 AMP panel typically installed in new construction large enough for a Level 2 electric vehicle charging station and a possible PV solar system (as we move toward zero energy homes). If not, does a 400 amp panel cause any concerns for the utility?

While a 200 amp main panel tends to work in many cases for homes with Level 2 charging and PV systems, the answer really depends on the existing load connected to the panel and the proposed addition(s). A qualified engineer will need to perform load calculations with the existing load and then incorporate the new proposed load into the calcs to see what size panel would work for the installation. There are now electric cars on the market (Tesla) that have the ability to charge at 240 volts / 80 amps (19.2 kW), so Level 2 charging no longer means just 3.7 kW additional loads any longer. As a point of reference, most of the newer electric vehicles coming to market have the ability to charge at a rate of 7.7 kW from the wall.

Regarding 400 amp panels, there are definitely impacts to the installation to keep in mind. For a 200 amp panel installation, 2" conduit is required from the pad-mounted transformer to the main panel. However, for a 400 amp panel, 3" conduit is required. Since the customer is responsible for the trenching and conduit costs, that would influence the cost of installation. The SDG&E Planner for the job can also help look at existing infrastructure and transformer requirements.

2. What utility infrastructure improvements (e.g.; transformers, switches, cabling), if any, need to be made to accommodate the current 2013 Energy Code requirement for new homes to be solar ready in conjunction with a possible EV charging station ready code requirement that may be proposed as early 2015?

I am not yet aware of additional infrastructure requirements that would be needed for new homes to be in compliance. I would think that any improvements would still boil down to the additional load requirements from each residence. Of course, solar PV systems could actually reduce peak loading at the residence (depending on the configuration and consumption), so it may be a difficult question to answer without more inputs to the equation as far as what specifically will be added.

3. What, if any, utility issues do we need to understand as electric vehicle charging stations are installed in primarily in new, but also existing, construction.

For existing construction, electric vehicle charging installations are really just additional load, which is added by homeowners all the time (air conditioning, spas, etc.). We are set up with the City of San Diego to get notification of when permits are inspected and approved for new vehicle charging stations. Those notifications are looked at within our Distribution Engineering group to see if there are any circuit issues that may develop with the installation. With new construction, the additional load from a vehicle charging station would be treated like any other load in the residence (and aggregated in the community) and looked at by the Planner that is assigned to the job for utility

1

Source: ConSol