Bay Area and Monterey Bay Regions PEV Planning Concepts Document

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Prepared for the:

Bay Area Air Quality Management District

In Partnership with:

Association of Bay Area Governments

Metropolitan Transportation Commission

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Executive Summary

The Bay Area Air Quality Management District (BAAQMD) in partnership with the Metropolitan Transportation Commission (MTC), Association of Bay Area Governments (ABAG) and other stakeholders is developing a Plug-in Electric Vehicle (PEV) Readiness Plan (the Plan) as part of a grant awarded by the United States Department of Energy (DOE) under a solicitation released in 2011 (DE-FOA-0000451). BAAQMD is also administering two (2) grants awarded by the California Energy Commission (CEC) for regional PEV readiness (PON-10-602); one for the Bay Area and the other for the Monterey Bay area.

This document is one of two highlighting the results of the first phase of PEV readiness planning for the Bay Area and Monterey Bay Region (the Region) – the other is a Best Practices Document provided to local governments. This document provides an introduction to the PEV ecosystem, with a goal of identifying the key planning elements that require further research, analysis, and planning to help the Region achieve the goal of being PEV Ready.

Although there is some overlap in the efforts required by each of the grants received, there are distinct elements for each award. For instance, this document and the aforementioned Best Practices Document have been produced to fulfill obligations associated with the DOE grant. While the approach taken here will ultimately yield a comprehensive Bay Area and Monterey Bay PEV Readiness Plan, this document only identifies gaps and deficiencies that need to be addressed in the Region as defined by the DOE. Therefore, this document, in its approach, options, and methodologies is geared to address gaps and deficiencies in that context. It is anticipated that significant additional work on other elements of readiness will occur as part the CEC readiness planning process in 2013. For reference and comparison, a sample plan outlining the elements of readiness from the original DOE solicitation has been included as an appendix for readers to familiarize themselves with the scope of this initial effort.

This document, and the Plan that it informs, focuses on actionable steps for local and regional governments to help them move towards PEV readiness. These include identifying key locations for siting public PEV charging infrastructure; creating guidelines for installing chargers at challenging locations such as parking garages and multi-unit dwellings; and changing permitting processes, zoning ordinances, and building codes in order to remove key barriers to PEV deployment.

This document and others produced as part of the Region's initial planning efforts are not focused on aspects of PEV adoption and deployment which are largely outside of the control of local and regional agencies. The most prominent example of this is vehicle price: The upfront cost (i.e., the purchase price) of PEVs is higher than conventional vehicles. Although this is perhaps the most significant barrier to mass adoption of PEVs, it is not the focus of readiness planning efforts because local and regional agencies have limited capacity to affect significant change. This document provides background on this and other key market-related issues, but neither it nor the Plan which it informs focuses on identifying solutions to these issues.

This document is presented with three parts and 12 sections that align to a large extent with the segments that will constitute the final Bay Area and Monterey Bay Region PEV Readiness Plan.

Each section identifies the most significant gaps and deficiencies in the Region with respect to key issues, as well as the proposed solutions to close the gaps and correct the deficiencies. Part A provides an overview of the current PEV market in the U.S., including available technologies and key barriers to deployment, and examines current and upcoming regional efforts in the Bay Area and Monterey Bay Region to collect improved data on PEV ownership and to create plans for siting charging infrastructure in these regions. Part B discusses key issues for local governments related to permitting processes, zoning ordinances, parking regulations, and building codes. The proposed solutions for local and regional governments to address the gaps identified in Parts A and B make up the key elements that will be addressed in the Plan. Part C discusses key gaps in training, education, and minimizing impacts on utilities.

In each area examined in this document (Section 5 through Section 12), best practices and mechanisms for their adoption need to be transferred between local governments. In certain jurisdictions this is projected to require funding, however, firm costs and funding mechanisms for these efforts have not been identified at the time of the drafting of this document. As part of the final Plan, these issues, sources of funding and other strategies to ensure best practices adoption will be discussed in detail for each individual segment of the plan.

The responsibility for implementing the solutions to many of the issues identified in this document is outside the jurisdiction of local and regional governments, so this document focuses on creating informational resources and on identifying solutions that may be addressed through the CEC grant or in collaborations with utilities and other stakeholders. Specifically, as part of the review process for this document, a number of issues were raised by various reviewers that will require further investigation, including:

- Integrating PEV readiness into the Sustainable Community Strategies (per Senate Bill 375) for the Region;
- Accelerating PEV adoption in the Region, particularly in fleets (private and public);
- Attracting PEV manufacturing, production, infrastructure, and services;
- Other infrastructure issues such as mapping and reservations and accessibility to all EVSE; and,
- Other vehicle issues such as reducing upfront costs (e.g., via battery leasing).

These issues will be examined in terms of the scope of work required by the CEC grant and where possible addressed within that framework. Issues lying outside of that process will be flagged and appropriate actions recommended to address these additional items provided where possible.

The following table identifies the area of focus required by the DOE, issues believed to be addressed for the Region and gaps and deficiencies requiring additional planning:

Part A: Introduction and Overview of Deployment

Section	Area of Focus	Issues addressed	Gaps and deficiencies	Planning Concepts & Proposed Solutions
1	Stakeholders and Partnerships	Placeholder to be included in final plan	N/A	
2	Need for PEV Readiness Plan	Placeholder to be included in final plan	N/A	
3	Key Technical Characteristics of PEV and Infrastructure	Review of technical characteristics of vehicles and infrastructure; serves as a primer for general audience	N/A	
4	PEV Ownership and Barriers	Review of the current state-of-knowledge regarding PEV ownership and identifies the barriers to more significant deployment of PEVs.	N/A	
5	Current Deployment of PEVs in the Region	• Current demand for PEVs in the Region is strong based on industry-reported data and CVRP • First draft of light-duty vehicle projections out to 2025 presented. • Significant amount of data available from BAAQMD (via ECOtality) regarding charging and driving behavior. • Data is available from BAAQMD to estimate deployment of vehicles in private & public fleets.	• Limited information available on location, socioeconomic characteristics, driving and charging behavior of early PEV adopters • Need to develop usage patterns to improve understanding of driver behavior in the region. • Most data available are BEVs; limited PHEV data in the Region.	• Work with stakeholders to collect information on PEVs in the Region, including the location, socioeconomic characteristics, and driving and charging behavior of early adopters of PEVs. • Develop usage patterns for PEVs in the Region using available data. • Expand, improve, and refine estimates of PEV adoption in the Region.
6	Siting, Locating and Maintaining Infrastructure in the Region	• The Region has several active projects to deploy EVSE – at least 5,000 residential and non-residential Level 2 EVSE and 90+ DC fast chargers are estimated to be deployed over the next several years • It will be important to focus on multi-unit dwellings in the Region because of high population density. • Environmental justice considerations will need attention to ensure equitable& ubiquitous access to EVSE for potential PEV drivers in the Region • Clear guidance and "best practices" available for standard EVSE installations in single-family homes.	• A siting analysis has not been performed for the Region. • Parking garages are a good place for EVSE, but, limited electrical capacity and potential demand charges present significant challenges. • There is potential for EVSE saturation in the Region, which would increase the risk of stranded assets. • With a focus on deploying EVSE, a more substantive focus on networking EVSE and integrating EVSE with smart grid technologies is needed.	• Develop reporting protocol for publicly funded chargers that require grantees to report usage data in a consistent format. • Compile best practices on EVSE deployment at multi-unit dwellings. • Conduct a siting analysis to identify areas of focus for EVSE deployment. • Explore solutions to manage electricity demand from EVSE at public parking garages. • Explore potential for Level 1 charging.

Part B. Guidelines for Local Governments: EVSE Deployment in the Bay Area and Monterey Bay Region

Section	Area of Focus	Issues addressed	Gaps and deficiencies	Planning Concepts & Proposed Solutions
7	Building Codes	• Example building codes and "best practices are available.	• Limited information available from agencies regarding readiness in this area. For the data that we do have, most agencies have not started or have only just started to consider how to adapt building code requirements for EVSE. • No agencies have adopted unique building code requirements for new construction.	• Update building codes to encourage EVSE. Currently, building codes vary widely in their approach to EVSE, which creates uncertainty for potential PEV owners.
8	Construction, Permitting, and Inspection Procedures for Infrastructure	• A significant percentage of jurisdictions in the Region can provide permits with several days (~48 hours). • A significant percentage of jurisdictions can provide permits for less than $250.	• Current costs and turnaround times for EVSE installation permits vary widely between local governments. • There are limited guidelines available to agencies outside of residential charging • Lack of clarity regarding the specific steps and costs associated with streamlining the process for construction, permitting, and inspection.	• Streamline permitting procedures for EVSE. For standard installations, charging permit fees between $100 to $250 and issuing permits within 24 to 48 hours is considered to be a best practice. • Coordinate effort to get dealer, customer, utility provider, and local jurisdictions on the same page regarding procedures. • Outline plan to educate local officials and other stakeholders, overlap with Section 10 of the Plan.
9	Zoning, Parking, and Local Ordinances	• There are model ordinances within the Region and from other regions that have been developed to facilitate publicly available charging infrastructure installation, access, and ADA compliance.	• Local agencies need to identify potentially onerous zoning ordinances or inconsistent parking requirements that make it more difficult to install EVSE in certain places. • Little available data regarding readiness from local agencies regarding this aspect of the PEV ecosystem. Of the agencies from which we have data, about 1/5 are involved in creating zoning and parking ordinances, while 79% are not.	• Develop guidance on how PEV charging stations count toward parking requirements. • Develop separate parking requirements for PEV charging stations that require developers to set aside parking spaces for EVs or to provide infrastructure to support a minimum number of charging stations. • Normalize parking and zoning ordinances across the Region • Develop model ordinance for new construction

Part C: Other Areas Requiring Planning for EVSE Deployment

Section	Area of Focus	Issues addressed	Gaps and deficiencies	Planning Concepts & Proposed Solutions
10	Stakeholder Training and Education	• Stakeholders such as electricians, permitting agencies, building inspectors, and first responders need to receive training & education required to ensure public safety and minimize barriers to widespread adoption of PEVs. • Training and education are low-cost, high-reward investments that local and regional agencies can make to help support the deployment of PEVs and EVSE.	• Anecdotal evidence suggests that some initial PEV deployments, and associated EVSE installations, are being performed without the assistance of an electrician and without the required permit. • As more local and regional agencies seek to educate themselves about the PEV ecosystem, a more coordinated effort will be required by prioritizing the most likely early- and mid-adopter regions.	• Develop a schedule for PEV-related stakeholder training and outreach that combines information on workshops and technical training courses offered by organizations throughout the Region. • Conduct outreach to dealers to understand how they are informing new buyers of the processes regarding EVSE acquisition. • Identify sources of funding for increased PEV education and training.
11	Consumer Education for PEV	• There are many incentives available for PEVs and EVSE deployment. Local and regional agencies need work together with the private sector to communicate the benefits of PEVs	• The sheer volume of stakeholders has led to a lack of centralized resource for consumers and stakeholders. • There is an opportunity to communicate the lessons learned from existing regional efforts.	• Create a centralized resource for information on PEVs that summarizes information from a variety of sources on purchasing PEVs, installing EVSE, and locating public charging stations.
12	Minimizing Grid and Utility Impacts	• The economic and environmental benefits of using electricity to displace gasoline in the transportation sector are dependent on a reliable and clean electrical grid. • The adoption of PEVs may cause challenges in some areas and will require careful planning by utilities. However, current estimates indicate that the existing infrastructure is sufficient to support the near-term deployment of PEVs. • Many utilities, including PG&E in the Region, are offering attractive vehicle charging pricing and incentives for PEV buyers. • There is an opportunity to integrate renewable energy with PEV charging infrastructure and reduce the environmental impact of driving.	• There is a risk of clustered PEV charging, which is highly dependent on local conditions, beyond those addressed by macro-level transmission and load impact assessments. • The risks for congestion and capacity constraints are very small in the near-term; however, as PEV adoption increases in the Region, these issues will require ongoing consideration. • Utility notification is a salient issue that requires careful consideration.	• Create standard, mandatory utility notification protocols to enable utilities to plan for distribution infrastructure upgrades & repairs. • Identify effective pricing structures for PEV charging to discourage PEV owners from charging during hours of peak demand. • Analyze PEV impacts when upgrading electric distribution infrastructure to ensure that new infrastructure is adequate to handle anticipated levels of demand. • Implement smart grid technology that automatically manages demand from EVSE • Ensure that electricity consumers are well informed about PEV facts, electricity rates, and incentives.

Part A: Introduction and Overview of Deployment

1. Stakeholders and Partnerships in the Bay Area and Monterey Bay Region

This section of the Plan will:

- Document a substantial partnership with relevant stakeholders;
- Give a clear description of the role and responsibilities of each stakeholder; and,
- Outline a plan for continuing the engagement and participation of the stakeholders, as appropriate, throughout the implementation of the Plan.

2. PEV Regional Planning: Filling a Need

This section will document the need for the Plan based on ongoing efforts in the Region and will include an analysis of barriers to the implementation of PEVs and infrastructure in the Region and a discussion of steps to reduce or eliminate the identified barriers. This section will also include the gaps, deficiencies and barriers identified in the planning process funded by the DOE grant (i.e., the contents of this document), and those that will be addressed in more detail as part of the planning process funded by the CEC grant.

3. Key Technical Characteristics of PEVs and Infrastructure

3.1. Vehicles

Electricity is used as transportation fuel in three types of vehicles: hybrid electric vehicles (HEV), which are powered by both an internal combustion engine (ICE) and an electric motor; plug-in hybrid electric vehicles (PHEV), which have larger battery packs than HEVs and are designed to plug into the electrical grid to charge the vehicle; and battery electric vehicles (BEV) , which are powered solely by energy from the battery. In the context of this report, we refer to vehicles that use electricity from the grid as plug-in electric vehicles (PEV), a term that includes both PHEVs and BEVs.[1]

The battery technology used in PEVs has been in development for over a decade; however, limitations on stability, energy capacity, energy density, and the cost of producing the battery have been barriers to widespread deployment in vehicles. Despite the latest advances in rechargeable battery technology, most recently using lithium-ion technology, the energy densities of batteries are still about two orders of magnitude less when compared to common liquid fuels used in ICEs.

Prior to 2012, PEVs were limited to niche markets, introduced in demonstration programs, converted by aftermarket companies, or legacy PEVs from the deployment in the 1990s. More recently, the number of vehicle offerings is steadily increasing. For instance, both the Nissan LEAF (BEV) and the Chevrolet Volt (PHEV) have been available since early 2011 and in 2012 new entrants into the vehicle marketplace included the Toyota Plug-In Prius (PHEV), Tesla Model S (BEV), and Ford Focus Electric (BEV).[2]

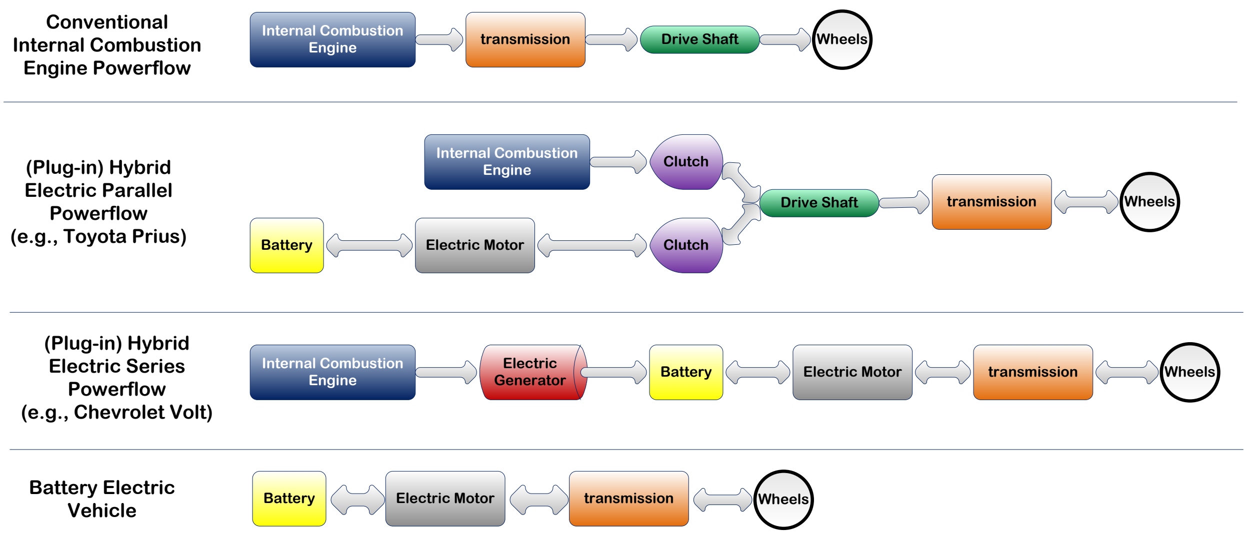
Review of PEV Drivetrain Architecture

Most PHEVs are designed to provide an all-electric driving range of 10 to 40 miles. When the battery state of charge falls to a predetermined limit, the system automatically switches to the ICE. Battery-related costs tend to be lower for PHEVs as compared to BEVs because of the smaller battery size, but this is partially offset by the additional expense of outfitting a vehicle with two powertrains (electric and ICE). PHEVs can have two types of drivetrain architectures, characterized as series or parallel configurations. The series PHEV is designed for electric motor propulsion only, with the ICE acting as a backup generator. Currently, the only series PHEV on the market is the Chevrolet Volt. The parallel PHEV is based on a conventional HEV architecture and has two powertrains, one with the electric motor and one with the ICE. The parallel PHEV is equipped with additional battery capacity and a higher power electric system to extend the electric motor propulsion system range. Parallel PHEV models based on aftermarket conversions of the Prius have been available, but most original equipment manufacturers (OEM) models in the near future are expected to produce parallel PHEVs as well.

[1] The general term PEV also includes low-speed vehicles or neighborhood electric vehicles (NEVs), which are small, lightweight vehicles limited to roads with posted speed limits of 25 miles per hour or less. However, they are not discussed in this report.
[2] The Renault Fluence ZE entered in the global PEV market in 2012, however, it is not available in the U.S.

BEVs operate solely on an electric powertrain and therefore are equipped with more batteries to extend the operating range. This is a very simple architecture where the battery drives the electric motor to propel the vehicle. This simplified architecture may make BEVs less expensive than the comparable PHEVs in some cases, but given the greater need for electricity, BEVs also typically have a heavier reliance on infrastructure with faster charging times. Figure 1 below illustrates the variations between PEVs as compared to conventional ICEs.

Figure 1. Simplified explanation of power flows for different vehicle types[3]



Most new PEVs use lithium-ion batteries, the same chemistry used in cell phone and laptop batteries. Lithium-ion batteries are rechargeable, relatively lightweight, and have high energy content. Other battery chemistries used in vehicles include lead acid and nickel-metal-hydride.

Battery Technology

As noted previously, the cost of batteries is a major factor in the higher price of PEVs as compared to conventional vehicles, creating a significant barrier to deployment. Advances in battery technology are commonly cited as a prerequisite for widespread adoption of PEVs to help improve vehicle range, decrease cost (and potentially price), and ensure reliability.

In a study for the European Commission, ICF assessed the current status of battery technology.[4] Based on ICF estimates, the current unsubsidized PEV battery cell cost is approximately $550/kWh, a figure widely acknowledged by OEMs. Due to better economies of scale in 2012, cell costs are predicted to decline to $450-500/kWh, resulting in total battery costs in the $700-750/kWh range. The cost of the total battery includes raw materials and components that are around $250/kWh and these costs will fluctuate as a function of lithium supply and demand moving forward.

[3] Monica Ralston and Nick Nigro, "Plug-In Electric Vehicles: Literature Review," *Center for Climate and Energy Solutions*, July 2011, http://www.c2es.org/docUploads/PEV-Literature-Review.pdf.
[4] Duleep, KG et al. Impacts of Electric Vehicle, Deliverable 2: Assessment of electric vehicle and battery technology, April 2011. Available online at: http://ec.europa.eu/clima/policies/transport/vehicles/docs/d2_en.pdf

Over time, battery costs will decrease as a result of technology advancements and greater demand for the product. The use of lithium-sulfur chemistry in next generation batteries, for example, may increase the energy density of the battery pack. Costs of second generation batteries are likely to fall to around $300/kWh by 2025 as knowledge, scale of production, and the market increases. These reductions in cost are essential to realize a sustainable future for PEVs, as battery technology is regarded as the key cost-driver for the mass adoption of PEVs. Battery technology advancements will also help address the range limitations of current generation PEVs as well as potential safety hazards (e.g., fire hazards).

A wide variety of new concepts are being explored with the potential to double or triple battery energy density. While many problems and issues remain before successful commercialization, lithium-sulfur systems, solid-state batteries, and the use of silicon anodes in lithium batteries may emerge over as solutions to power PEV the next decade. Some examples of current research include:

- BASF Battery Solutions and Sion Power are collaborating to increase energy density and battery life of lithium-sulfur systems. The consortium has been awarded a DOE Defense Advanced Research Projects Agency (DARPA) grant to develop a commercial battery by 2016.[5]
- Panasonic is working with Tesla to develop a new generation of silicon anode-based batteries. First generation systems may become available in 2017 that improve energy density by 30% relative to current cells.
- Toyota demonstrated a prototype solid-state battery in 2010 and may introduce this technology into a vehicle by 2020.[6] The chemistry of solid-state batteries can be similar to lithium-ion but with a solid electrolyte instead of a liquid, meaning a smaller and lighter battery.

These improvements are expected to lead to increased ranges for PEV in the long-term that should be considered in the long-term planning for PEV deployment.

3.2. Charging Infrastructure

Charging Technology Overview

Electric Vehicle Supply Equipment (EVSE) standards are set by the Society of Automotive Engineers (SAE) and are differentiated by the maximum amount of power provided to a PEV battery. Two primary types of EVSE provide either alternating current (AC) or direct current (DC) electricity to PEVs. Current SAE standards are as follows:

- **Level 1 AC –** These chargers use standard 120 volt (V), single phase service with a three prong electrical outlet at 15-20 amperage (A). At this standard, the National Electric Code

5 Sion Power, "Sion Power Receives DOE grant to Enhance Lithium Sulfur Batteries," November 2009, http://sionpower.com/pdf/articles/Sion%20Power%20DOE%20Press%20Release_11-10-09.pdf.
6 Nikkei Electronics, "Toyota Announces 4-layer All-solid-state Battery," accessed on April 20, 2012, http://techon.nikkeibp.co.jp/english/NEWS_EN/20101122/187553/.

(NEC) allows cord-and-plug connections to be up to 25 meters in length; however, more stringent local codes may also apply. Level 1 charging outlets should have ground fault interrupters installed and a 15 A minimum branch circuit protection. Level 1 charging requires no new electrical service for a building operating on an existing circuit. The main drawback of Level 1 charging is the time required to recharge the PEV. At 15 A and 85% electrical transfer efficiency, the power delivered is 1.4kW this leads to longer charging times (up to 20 hours for certain BEVs).

- **Level 2 AC** – These chargers are used specifically for PEV charging and are rated at less than or equal to 240 V AC, and less than or equal to 80 A. Level 2 EVSE requires additional grounding, personal protection system features, a no-load make/break interlock connection, and a safety breakaway for the cable and connector. If 240 V service is not already installed at the charging site, a new service drop will be required from the utility. With a 40 A, 240 V service power can be delivered at 7.5 kW which shortens charging time considerably for PEV. These chargers use a standard SAE approved J1772 connector, as shown in Figure 3 below.
- **Level 1 & 2 DC** – Level 1 & 2 DC chargers, also known as DC fast chargers, provide power much faster than the AC counterparts. However, DC fast chargers are more expensive to build and operate due to the equipment and electrical upgrades necessary to operate them. Thus, they are less common than Level 2 AC chargers, and will not likely be used for residential applications. Few PEVs are currently equipped with compatible hardware for DC charging, but certain models such as the Nissan LEAF and Mitsubishi iMiEV do come with "fast charging" as an option (see below). At the time of this publication, SAE has not approved the DC charging standard for the Level 1 & 2 DC coupler and connector. Most analysts assumed the CHAdeMO protocol, developed by the Tokyo Electric Power Company (TEPCO) and promoted by its partners in the CHAdeMO Association (includes Nissan, Mitsubishi, Subaru, and Toyota) would also be adopted by the SAE for DC fast charging. However, in October 2011 other major OEMs, including Ford, GM, BMW, Daimler AG, and Volkswagen, announced their support for the HomePlug GreenPHY protocol for fast charging. Pictures of both connector prototypes are included in Figure 3.

  Manufacturers may include a DC fast charge connection in addition to Level 1 or Level 2 AC charging connections on PEVs, giving owners the option of quickly recharging their vehicles.[7] In addition, some EVSE units are equipped with a combination of these types to accommodate different vehicles and consumer needs.

- **Proposed Level 3** - A Level 3 AC and DC standard for much higher-power charging applications is also under development by the SAE.
- **Battery Switching**: Another charging strategy that warrants consideration is battery switching. Rather than relying solely on charging a battery using the various levels of EVSE described above, a consumer would also have option of switching the battery out of the vehicle via a network of automated stations. In this scenario, the ownership of the battery

[7] S Chhaya and M. Alexander, "Plug-In Electric Vehicle Infrastructure Installation Guidelines Volume 1: Multi-Family Dwellings," *EPRI 1017682*, September 2009.

and vehicle is typically separated. For instance, the consumer may own the vehicle and lease the battery. This may be attractive economically because it can reduce the upfront costs associated with PEVs and still maintain price competitiveness through a lease price that is comparable to the cost of gasoline. The main barrier to battery switching is vehicle design: in order for battery switching to be successful, there must be some level of standardization regarding the placement of the battery and ensuring switch-capabilities. Better Place (a Palo Alto-based company) is currently the only vendor proposing a battery switching strategy in the United States. Although their focus to date has been outside of the United States e.g., Israel, Denmark, and Japan, they are actively involved in the Bay Area on a demonstration project for battery switch capable PEVs in the regions taxi fleet, as described in more detail below.

Figure 2. (L to R): J1772 standard connector for Level 2 AC,[8] CHAdeMO plug for DC fast charging,[9] and the HomePlug GreenPHY plug for DC fast charging[10]

Charging Times

One of the common questions asked about PEVs is: How long do they take to charge? The simple answer is: It depends. One of the key aspects to understand about PEVs is the battery pack: The battery capacity is the amount of electrical charge a battery can store. Maximum capacity can only be reached, however, under optimal discharge conditions that account for the magnitude of the current, the allowable terminal voltage of the battery, and other external conditions such as temperature. PEV manufacturers have optimized battery packs to provide maximum capacity through devices such as battery thermal management systems. Thermal management systems maintain a constant temperature around the battery pack to prevent potential impacts from extreme hot or cold temperatures. PEV charging times are also impacted by extremely hot temperatures. For example, with an external temperature of 120-130°F, DC fast charging will take longer than the average 30 minutes.[11]

In addition to temperature, vehicle charging time is heavily dependent on the current type (AC or DC), electric potential difference (V), current (A), maximum power (kW), and the on-board

[8] Wikipedia, "SAE J1772," accessed on April 20, 2012, http://en.wikipedia.org/wiki/J1772. Additional information is available online at http://standards.sae.org/j1772_201202/

[9] Yazaki, "Connector on the side of a DC charging stand for EV (conforming to CHAdeMO specifications)," accessed on April 20, 2012, http://charge.yazaki-group.com/english/product/quick_outlet.html.

[10] Eurocarblog.com, "Audi, BMW, Daimler, Ford, GM, Porsche and Volkswagen to unveil combined charging system," accessed on April 20, 2012, http://www.eurocarblog.com/tag/homeplug+green+phy.

[11] Interview with David Peterson, Nissan North America, Inc., March 2012.

charging capabilities of the vehicle. The most important determination of charging time is generally the charging capabilities of the vehicle. For example, the Chevy Volt and Nissan LEAF both include a 3.3 kW on-board charger. This means that even with a Level 2 AC charger capable of delivering power at 6 or 7 kW, the on-board system will limit power to the battery at 3.3 kW. The Tesla charging system has a capacity of 10 to 20 kW. According to Nissan, the 2013 LEAF will include a 6.6 kW charger, which will reduce the charging time by half.[12]

The times needed to replenish a battery halfway and fully for the Toyota Prius Plug-in, Chevy Volt, Nissan LEAF, and Tesla Roadster are shown in Table 1 below. Charging times on Level 1 EVSE are primarily suitable for small battery vehicles, such as the Volt, which require over 7 hours to fully charge. Estimated charge times using DC fast charging for the Volt, LEAF, and Roadster are included, despite not being equipped with the appropriate hardware, and are meant for demonstrative purposes only. For DC fast charging, calculations assume the battery is only charged to 80% and the remaining 20% is completed by charging at a slower rate. If left connected at high power, the time to fully charge the battery will increase above an hour due to the nature of direct DC fast charging. Furthermore, some industry observers have voiced concerns about the effects of fast charging on battery life due to potential over-heating and over-voltage; however, Nissan reports that proper cooling and voltage can allay these effects.[13] Idaho National Laboratory (INL) is conducting research into DC fast charging; they have started a fast charging demonstration, with one Nissan LEAF charging on Level 2 EVSE and one LEAF recharging using a DC fast charger. The results of this research are anticipated for publication in approximately one year.[14]

Table 1. Estimated charging times using various EVSE (hours:minutes)

Charger Type	Charge	Vehicle			
		Prius	Volt	LEAF	Roadster
		4.4 kWh	16 kWh	24 kWh	53 kWh
Usable		3.5 kWh	10.4 kWh	21.6 kWh	42.4 kWh
Level 1 1.4 kW	Half	1:34	3:42	7:42	15:08
	Full	3:08	7:25	15:25	30:17
Level 2 7.5 kW	Half	0:40	1:34	3:16	2:49
	Full	1:20	3:09	6:32	5:39
DC Fast 50 kW	Half	*0:02*	*0:06*	*0:12*	*0:25*
	Full	*0:05*	*0:47*	*1:39*	*1:08*
DC Fast 150 kW	Half	*0:01*	*0:02*	*0:04*	*0:08*
	Full	*0:02*	*0:41*	*1:25*	*0:41*

Note: For the sake of comparison, the estimated time for a battery switch is less than 5 minutes.

12 Interview with David Peterson, Nissan North America, Inc., March 2012.
13 Mark Perry, Nissan, EVS26, May 6-9, 2012. Los Angeles, CA.
14 Sheehy, P. and Myers, E. Personal communication with Jim Francfort at INL, May 2012.

4. PEV Ownership and Barriers

4.1. PEV Ownership Costs

Consumers' willingness to pay for new technology, as well as the extent to which they value their convenience will play a large role in PEV deployment. Consumer surveys indicate the manufacturer's suggested retail price (MSRP) of a PEV is of paramount importance, with nearly 70% claiming it is the most important factor in deciding their purchase.[15] Additionally, consumers expect PEVs to be cost-competitive with similar ICE vehicle models, with a majority desiring a sticker price under $30,000.[16] While consumers do acknowledge the higher cost of PEVs and are willing to pay more, the price differential between a PEV and a conventional vehicle or even a HEV remains too high. Incentives for PEV purchases are one policy mechanism to counter the current price gap.

The difference between the MSRP for a PEV and that of a comparable (i.e., similarly equipped) conventional vehicle is typically referred to as the incremental cost. While most PEVs do not have perfectly analogous comparison vehicles, Table 2 shows a general comparison between similar vehicles.

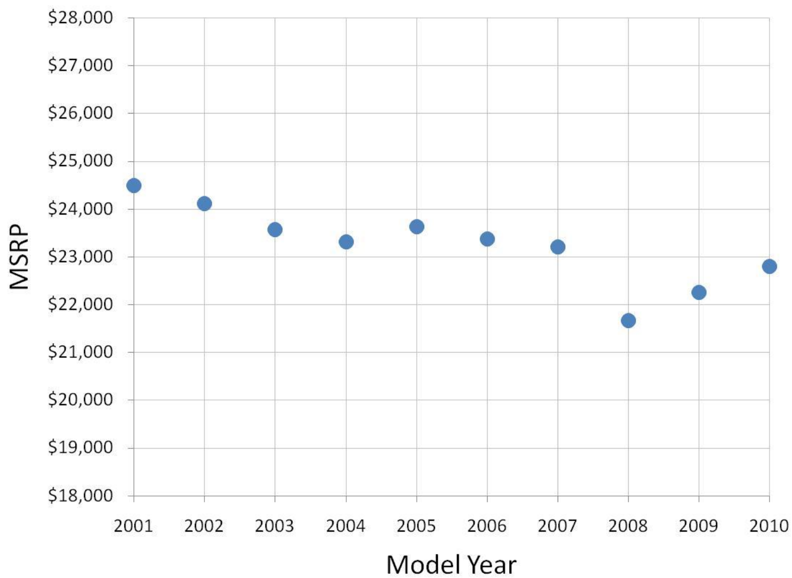
Table 2. MSRP Comparisons: PEVs vs. Conventional Vehicles

PEVs		Conventional Vehicles		Price Difference	Tax Credit		Price Difference after credits
Make/Model	MSRP	Make/Model	MSRP		Fed	State	
Nissan LEAF SV	$35,200	Nissan Versa SL	$18,490	$16,710	$7,500	$2,500	$6,710
Chevrolet Volt	$39,145	Chevrolet Cruze ECO	$19,325	$19,820	$7,500	$1,500	$10,820
Toyota Prius Plug-In	$32,000	Toyota Prius HEV	$24,000	$8,000	$2,500	$1,500	$4,000

Industry observers generally agree the incremental *cost* of PEVs is expected to decrease over time, but there is considerable disagreement as to how much the *pricing* will change. Most discussions of vehicle costs focus on the expected decrease in battery costs, explained above. The focus on battery costs obscures the point regarding vehicle pricing: the retail price of the vehicles, especially in the earlier models, is not necessarily correlated with the manufacturer's cost to produce the vehicle. In other words, it is possible that both Nissan and Chevrolet are selling the LEAF and Volt as loss leaders to gain market share for their respective PEVs, which in turn would yield increased production and decreased manufacturing costs. In this scenario, OEMs would hope to recoup initial losses in later years without changing the price of the vehicle. For instance, the price of the Toyota Prius HEV has been essentially flat in the last decade (Figure 3), with a range of less than $3,000 when adjusted for inflation, despite declining battery costs.

[15] Deloitte Touche Tohmatsu Ltd, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 2010.
[16] Deloitte Touche Tohmatsu Ltd, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 2010.

Figure 3. MSRP for Toyota Prius ($2010)



There are many factors that will affect pricing for PEVs beyond battery costs. It is likely that conventional vehicles will become more expensive as manufacturers develop offerings to comply with more stringent fuel economy and emissions standards. Although the price increase for conventional vehicles will decrease the comparable upfront cost for PEV ownership, the increased fuel economy of new vehicles may reduce the long-term cost savings realized from PEV operation. Another source of savings could be in reduced maintenance costs. Due to PEV use of regenerative braking, brakes may never need to be replaced and if the PEV does not have an ICE, oil changes are not required. Based on an interview with Ford, PEV owners may save approximately $200-$300 dollars per year in reduced and avoided maintenance costs.[17]

The potential fuel cost savings resulting from substituting electricity for gasoline are also significant but depend on the utility rate structures in a given region. For example, studies estimate PEV operational cost based on fixed prices of electricity (e.g., $0.10-$0.12/kWh). This methodology assumes consumers will either not be subject to additional charges as a result of increasing their residential load or that charging infrastructure will be sufficiently "smart" to avoid charging at peak times when electricity rates are highest. Conversely, the use of electricity as a transportation fuel reduces consumer exposure to volatility in the gasoline or diesel markets. Generally, analysts forecast a lower rate of price increase for electricity than for gasoline in the near-, mid-, and long-term.[18]

Tax credits, rebates, and other incentives can reduce the initial purchase cost of PEVs. Incentives available at the national, state, corporate and local level, can also help to reduce the upfront costs. DOE's Alternative Fuels and Advanced Vehicles Data Center's Laws and

[17] Interview with Stephanie Janczak, Barbara Rogers, and Mike Tinsky, Ford Motor Company, April 2012.
[18] U.S. Energy Information Administration, "Annual Energy Outlook 2011: Table 3," accessed April 24, 2012, http://www.eia.gov/forecasts/aeo/data.cfm#enprisec.

Incentives website provides current information[19] as does the California Air Resources Board's (ARB) Drive Clean site.[20]

4.2. PEV Consumer Demographics

Public surveys generally reinforce the notion that nationwide, public support exists for PEVs; however, this support has not translated into definitive market success yet. Surveys by Pike Research indicate the appeal of PEVs cuts across various demographic segments, with consumers under 30 years old or with higher education levels demonstrating higher tendencies for early adoption.[21] The results of a Deloitte survey portrayed the majority of PEV buyers as male with above average income and living in urban or suburban settings.[22] Another indicator is previous HEV ownership. In an Electric Power Research Institute (EPRI) survey, HEV owners are more than twice as likely to say they "definitely" intend to purchase or lease a PEV vehicle. [23] Survey results obtained through Pacific Gas & Electric's (PG&E) Consumer EV Billing Program in California concluded that PEV consumers in early adopter regions are defined by smaller household sizes, an above average number of vehicles per household, above average median income, home ownership, and an increased likelihood of driving to work.[24]

These survey data are bolstered by data gleaned from interviews conducted by ICF with GM, Nissan, and Ford:

- GM characterized Chevrolet Volt buyers in two major categories. The first are 50+ year old, technology savvy, above average median household income and image conscious. GM noted that buyers are less concerned about environmental issues and more interested in the technology. The second group includes 30-40+ year old males that are more environmentally- conscious and image-conscious. For both groups, GM indicated approximately 90% of the consumers are male. Based on a variety of vehicle survey data, women do not tend to be early adopters and are more concerned with the reliability and dependability of vehicles.[25]
- Nissan characterized the average consumer of the Nissan LEAF to have an above average median income, well-educated, and male, with an average age of 49-55. Nissan expects this demographic to change over time.[26]
- The primary consumer of the Ford Focus BEV has an annual household income between $120,000 and $140,000, is environmentally-conscious, is interested in reducing operating costs, and has a desire to access to HOV lanes (where available).[27]

[19] Alternative Fuels & Advanced Vehicles Data Center, "Federal & State Incentives and Laws: State of Pennsylvania," U.S. Department of Energy, accessed on April 20, 2012, http://www.afdc.energy.gov/afdc/laws/.
[20] DriveClean, A buying guide for clean and efficient vehicles, CARB. http://www.driveclean.ca.gov.
[21] Charul Vyas and Clint Wheelock, "Energy & Environment Consumer Survey: Consumer Attitudes and Awareness about 13 Clean Energy Concepts," *Pike Research*, 2012, 2.
[22] Deloitte Touche Tohmatsu Ltd, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 2010, 6.
[23] Electric Power Research Institute and Southern California Edison, "Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results," May 2010, 3-2.
[24] Pacific Gas & Electric Company, "Electric Vehicle Penetration Study Using Linear Discriminant Analysis," June 2011, 4.
[25] Interview with Britta Gross, General Motors Company (GM), March 2012.
[26] Interview with David Peterson, Nissan North America, Inc., March 2012.
[27] Interview with Stephanie Janczak, Barbara Rogers, and Mike Tinsky, Ford Motor Company, April 2012.

Although the demographics of early adopters are well-known, in the mid- to long-term PEVs should become more appealing to a broad range of consumers. PEV education efforts, such as “ride-and-drive” events, will provide significant benefits as the general public becomes more knowledgeable about the technology. Additionally, the Metropolitan Transportation Commission (MTC) and the Bay Area Air Quality Management District (BAAQMD) are in the early stages of launching a regional Go EV Campaign, which is designed to provide outreach and education regarding the benefits of PEVs – this campaign is discussed in more detail in Section 11.

4.3. PEV Consumer Behavioral Characteristics

Vehicles

Among the key decisions and considerations of potential PEV consumers are vehicle financing and convenience. Regarding convenience, some PEVs may require drivers to adjust travel patterns or commuting behaviors compared to conventional vehicles, such as travel distance and driving behavior modifications to increase battery life. Researchers have noted a significant difference between PEV drivers and non-PEV drivers - PEV drivers tend to commute shorter distances and integrate regular charging and limited vehicle range into their routine driving pattern.[28]

One concern which is widely believed to influence consumer behavior and willingness to use PEVs is known in the PEV industry as “range anxiety.” Range anxiety describes a condition in which the consumer is hesitant to adopt a PEV due to concerns about being stranded without access to charging infrastructure or being unable to complete a trip given the constraints of the vehicle. This concern has been addressed to some extent with the introduction of PHEVs, such as the Chevrolet Volt and the Toyota Prius Plug-In, which have an engine fueled by gasoline to supplement the electric motor. To some extent, range anxiety is a phenomenon primarily associated with consumers with limited exposure to PEVs. Many studies, including initial results from the United States Department of Energy’s (DOE) The EV Project, have shown PEV drivers are more comfortable and likely to drive further before charging after an initial driving period following first owning an electric vehicle. Apart from general familiarity gained by driving the vehicles, other ways to reduce or eliminate range anxiety may include increased availability of charging infrastructure, particularly in public places or with fast charging capabilities, and increased vehicle range through improved battery technology.

In a University of California Davis trial study, the BMW MINI E, a plug-in electric version of the Mini Cooper, was leased to consumers in New York City and Los Angeles. Researchers tracked how consumers responded to and adjusted to the vehicle’s range. The research revealed participant adjustments which included using a conventional vehicle for longer trips, trip chaining, avoiding unnecessary trips, using GPS tools to track vehicle distance, and turning off

[28] Deloitte Touche Tohmatsu Ltd, “Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market,” 2010.

in-car climate controls to increase range.[29] The most frequent adaptation was to simply use a second, conventional vehicle, as cited by 94% of the MINI E users.[30]

Charging

It is unclear which level charging consumers will ultimately prefer. Level 1 charging is readily available and inexpensive, but may not be practical, particularly for BEVs where vehicles are not parked for extended periods of time. A Level 2 EVSE could potentially charge a vehicle in half the time of a Level 1 charger, but requires a dedicated space to install the EVSE and is more expensive. Each type of PEV has different needs. For example, the Toyota Prius Plug-in and Chevrolet Volt would not require a Level 2 EVSE to complete a charge overnight. However, the Nissan LEAF would need a Level 2 charger to completely charge a depleted battery within seven hours.

The University of California Davis MINI E Consumer Study supplied a residential Level 2 charger and a Level 1 "convenience charger" for use outside of the home. The Level 2 charger completed the charge in approximately three to five hours, while the convenience charger required nearly 26.5 hours to fully charge a depleted battery. The study concluded PEV consumers were content with the Level 2 charging speed and preferred a fully charged vehicle by the morning. One criticism among drivers was the inconvenience of "topping-off" the battery between activities using public infrastructure.[31] Wider implementation of public DC fast charging or even Level 2 charging availability is likely to have an influence on PEV adoption, as two in five HEV owners and one in three ICE vehicle owners say the capability will "definitely" influence their PEV acquisition decision.[32]

Consumer willingness to purchase EVSE depends in large part on the price of the infrastructure. As charger speed and "intelligence" increase, the expense of the installation rises commensurately. Currently, a residential Level 2 EVSE is estimated to cost approximately $2,000, including installation, however, survey results show only 28% of respondents would pay over $500 for the capability, with the average respondent willing to pay up to $400.[33] Consumer willingness to add additional expense to the purchase of the vehicle presents a significant barrier to the mass deployment of Level 2 EVSE.

Tony Posawatz, formerly the Vehicle Line Director for the Volt and Global Electric Vehicle Development at GM (now the CEO of Fisker Automotive), indicated in a presentation that GM has been surprised that "most" Volt drivers have opted for Level 1 charging over Level 2 charging at home. He noted that it takes longer to charge, but that consumers believe the chargers work "well enough" and "suffice for overnight charging".[34]

[29] Tom Turrentine, Dahlia Garas, Andy Lentz, and Justin Woodjack, "The UC Davis MINI E Consumer Study," *UC Davis Plug-In Hybrid & Electric Vehicle Research Center*, May 2011.
[30] *Ibid*.
[31] *Ibid*.
[32] EPRI and SCE, "Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results," May 2010/
[33] Charul Vyas et al., "Executive Summary: Electric Vehicle Consumer Survey," *Pike Research*, 2012.
[34] Ernst & Young, *Cleantech matters: moment of truth for transportation electrification*, 2011 Global Ignition Sessions Report, 2011.

Nissan Leafs have been deployed in greater numbers than the Chevrolet Volt in the Bay Area; however, with more competitive PHEV offerings likely available in the near-term e.g., the Toyota Prius Plug-In, the role of Level 1 charging – for both residential applications and public applications – will become clearer over time.

4.4. Potential Consumer Barriers to Expanded PEV Adoption

Despite a recent survey by Accenture finding that 57% of Americans would consider purchasing a PEV for their next vehicle,[35] consumers' expectations regarding price, range, and charging time are in many cases not met by PEVs available today.[36] These barriers make converting potential consumers into actual purchasers a significant challenge. As discussed in more detail previously, vehicle price is the primary barrier to widespread PEV adoption in the near-term. Even with incentives, the initial cost of PEVs remains considerably higher than HEVs and ICE vehicles. In the 2011 Los Angeles EV market survey, for example, over 80% of respondents said price is an important factor in the decision to purchase a PEV, and 71% believe that "EVs cost too much for what they offer."[37]

Consumers' unwillingness or hesitancy to pay for the additional upfront cost of PEVs is coupled with an undervaluation of fuel savings. Ideally, consumers would have an idea of the payback period – the period of time required for the consumer to recoup their investment – for the purchase of a PEV or understand the total cost of ownership. These values are dependent on variables such as the price of gasoline, the price of electricity, the price of the vehicle, and the availability of purchasing incentives. The calculation of the payback period or total cost of ownership can be relatively straightforward; however, most consumers are not going to conduct this type of analysis when purchasing a vehicle. Rather, research has shown consumers generally under-value future fuel savings and only capture the potential benefits of more fuel efficient vehicles over a period of two to four years, when actual ownership is two to three times longer than that.[38] In other words, even if the present value of fuel savings over a vehicle's lifetime outweighs the difference in initial cost, it may not be enough to convince consumers to pay more upfront.[39]

Apart from pricing, the other main barriers to PEV deployment are vehicle range and charging logistics, which are more salient issues in the context of BEV deployment. Consumers concerns about vehicle range vary, but include issues such as "range anxiety" (i.e., the fear of being stranded due to a depleted battery), uncertainty with respect to the time necessary to charge PEVs, and EVSE accessibility. According to the Los Angeles EV market survey, 56% of consumers in the area reported that they would not buy a PEV if they could not charge at night.[40] Data from Nissan indicates that the average LEAF owner typically charges his/her vehicle at home overnight during a once-daily charging session. Most stakeholders put an emphasis on residential charging for access to EVSE, with special attention to MUDs where

[35] Accenture, "Plug-in electric vehicles: Changing perceptions, hedging bets," 2011.
[36] Deloitte, "Gaining Traction: Will Consumers ride the electric vehicle wave?" *Deloitte Global Services Ltd*., 2011.
[37] Dr. Jeffrey Dubin, et.al, "Realizing the Potential of the LA EV Market," *University of California Los Angeles Luskin Center for Innovation*, May 2011.
[38] D. Greene and S. Plotkin, "Reducing Greenhouse Gas Emissions from U.S. Transportation," *Pew Center on Global Climate Change*, 2011.
[39] Indiana University, "Plug-in Electric Vehicles: A Practical Plan for Progress," *Indiana University*, 2011.
[40] Dr. Jeffrey Dubin, et.al., "Realizing the Potential of the LA EV Market," *University of California Los Angeles Luskin Center for Innovation*, May 2011.

PEV users may face additional challenges, followed by the development of workplace charging.[41] As the market for PEVs grows, the placement and quantity of EVSE both influences and is influenced by PEV growth.

Recent research from Ford Motor Company [42] and the University of Delaware[43] highlight some of the barriers PEVs, particularly BEVs, will face. Researchers initially sought to answer what percentage of trips or vehicle miles traveled (VMT) could be electrified, and then changed the question to "how many days per year would a driver be inconvenienced by the limitations of a PEV?" Although similar, these questions are fundamentally different. The first question can be addressed by examining national statistic ensembles; however, the second question requires more detailed data on a per driver basis. Ultimately, both research studies highlighted how driver behavior would impact the right PEV technology for each consumer. For instance, the researchers at Ford estimated the cost of batteries as a function of customers' demand cost and high functionality of vehicles. In other words, if there were no restrictions on battery technology, then meeting consumer demand with battery technology would require an estimated cost of around $100/kWh, a value Ford describes as "impossibly low". Both studies highlight the potential of PHEVs to satisfy individual consumers' demands and the challenges that BEVs might face with the average consumer.

A variety of strategies can be employed to overcome pricing, range concerns, and the availability of EVSE. For vehicle pricing, the most common strategy to overcome high initial costs of PEVs is to provide consumers with purchasing incentives. As noted previously, there is a federal incentive for qualified vehicle purchases, and there are many states and other entities that provide additional incentives. These credits and rebates help defray the additional cost of the vehicle, and also have a secondary benefit of improving the consumer's consideration of potential savings through total cost of ownership or payback period estimates. These incentives are often a key aspect of vehicle purchasing; for example, Nissan has observed higher sales in states with more aggressive incentives.[44] As incentives are developed, the structure of policy should be informed by the needs of the individual region. The Ford and University of Delaware studies may help policies be more effective and useful for regional agencies, such as BAAQMD and MTC, by understanding the demand for PHEVs or BEVs in a given region, rather than estimating demand strictly from an average origin-destination trip activity.

Technological advances in batteries may also help reduce vehicle pricing, improve vehicle range, and reduce the time it takes to charge vehicles; however, this should be considered a long-term strategy. Battery technology currently in development cannot provide PEVs with the attributes that satisfy all driver behavior (e.g., range and power) at an affordable price.[45] Although a breakthrough in battery technology is conceivable, the more likely scenario is a gradual improvement of battery technology in the near-term, yielding small improvements in battery characteristics (e.g., performance, lifetime, and cost). For instance, the average cost of

[41] Interview with David Peterson, Nissan North America, Inc., March 2012.
[42] Mike Tamor, et al. "An Analytic Method for Estimation of Electric Vehicle Range Requirements, Electrification Potential and Prospective Market Size"
[43] Nathaniel Pearre, et al. "Electric vehicles: How much range is required for a day's driving?", Transportation Research Part C, 19, 1171-1184, 2011.
[44] Interview with David Peterson, Nissan North America, Inc., March 2012.
[45] Interview with Britta Gross, General Motors Company (GM), March 2012.

batteries has decreased from an estimate of about $1,000/kWh in 2008 to an estimated $750/kWh in 2012. Ultimately, regional agencies should make near-term plans assuming gradual changes rather than deploying resources that are dependent on disruptive technological change.

Given the status of battery and PEV technology that is readily available, strategically located charging infrastructure will play a central role in alleviating range anxiety and uncertainty about EVSE accessibility. Careful planning for the location of that equipment may successfully encourage PEV sales. An important role for regional agencies in the Bay Area and Monterey Bay Region will be to assess how best to provide charging for PEV drivers without dedicated, off-street parking. The recommendations generated from the Readiness Plan will provide an excellent foundation for which to develop the publicly-accessible EVSE strategy for the Bay Area and Monterey Bay Region.

Another strategy that has been employed in other regions (i.e., outside of the United States) is financial separation of the battery from the vehicle. For instance, the consumer might purchase the vehicle and lease the battery on a monthly basis. This strategy helps reduce the upfront cost of the vehicle and makes the price competitive with comparable conventional vehicles.

Range anxiety and unfamiliarity with EVSE may also dissipate as consumers gain experience with PEVs and become more comfortable with the technology. For instance, in a demonstration study by the Technology Strategy Board in the United Kingdom, researchers found that the percentage of drivers who were more concerned about reaching their destination with a PEV than in their normal car dropped from 100% to 65% after just three months of PEV use. The researchers attribute this change to an improved understanding of the vehicle capabilities, driving techniques or behavior, and modifications to trip planning.[46] To help improve consumer understanding of PEV performance prior to vehicle purchase, GM encourages "ride-and-drive" events to allow potential consumers to test drive PEVs and become more familiar with the vehicles.[47]

[46] Andrew Everett, et al., "Initial Findings from the Ultra-Low Carbon Vehicle Demonstrator Programme", 2011.
[47] Interview with Britta Gross, General Motors Company (GM), March 2012.

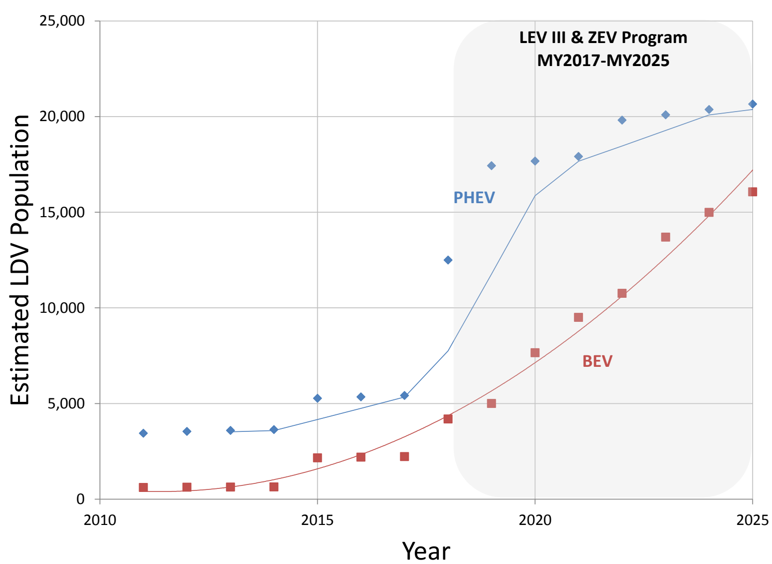
5. Current Deployment of PEVs in the Bay Area and Monterey Bay Region

5.1. Overview of Current Deployment

Consumer demand for PEVs in the Region has been strong to date. Research from Nissan indicates that the San Francisco Bay Area has the highest rate of Leaf adoption in the country on a per household basis. Based on data from the Clean Vehicle Rebate Project (CVRP), nearly 2,500 zero emission vehicles (ZEVs) have been deployed in the Region through April 2012. Most of these vehicles (2,100) are characterized as light-duty BEVs; whereas PHEVs accounted for another 300 vehicles. The remaining 100 ZEVs include about commercial vehicles, motorcycles, and NEVs. The sales of PHEVs have most likely increased significantly in the Region since these numbers released, with more than 6,700 and 4,100 Volts and Plug-in Priuses sold nationwide since these numbers were reported for the CVRP. The Region's strong market for PEVs is also demonstrated in the percentage of rebates issued: the Region accounts for about 22% of all vehicles in California, however, the Region accounted for 41% of light-duty ZEV rebates and 36% of PHEV rebates as of April 2012.

ICF estimates for PEV penetration indicate that there will be moderate growth of PEV sales over the next several years, however, as regulatory drivers such as the Zero Emission Vehicle (ZEV) Program and Low Emission Vehicle (LEV) III Program – both part of California's Advanced Clean Cars Program – become more important during the release of model year (MY) 2017 vehicles, ICF anticipates a significant increase in PHEV deployment.

Figure 4. Forecasted Baseline PHEV and BEV Populations (in the light-duty sector) for the Bay Area[48]



[48] These forecasts will be modified in subsequent documents to include PEV forecasts for the Monterey Bay Region.

ICF developed the penetration scenarios in Figure 4 based on the following inputs and assumptions:

- ICF accounted for PEVs that would be deployed to meet the requirements of the ZEV Program, which requires automobile manufacturers to introduce zero tailpipe emission vehicles in volumes that increase over time. The program is implemented using credits, which vary depending on factors such as emission control technology and vehicle range. ICF used what ARB documentation describes as the most likely compliance scenario,[49] a mix of transitional zero emission vehicles (TZEVs), BEV, and hydrogen fuel cell vehicles (FCVs). To develop the baseline, ICF assumed that TZEVs would all be PHEVs.[50]
- Based on EMFAC and sales data from the California New Car Dealers Association (CNCDA), we estimated that the Bay Area accounts for approximately 21% of vehicle sales in California.
- ICF also used internal analyses of other national- and state-level forecasts of PEV populations, and trends in hybrid-electric vehicle penetration in California and the Bay Area.

These estimates should be considered as equivalent to a regulatory baseline for PEVs in the Bay Area. In subsequent documentation, ICF will provide PEV market forecasts based on additional research and modeling.

5.2. Gaps and Deficiencies

The previous subsection provided an overview of current deployment of vehicles and forecasts of PEV adoption in the Region out to 2025. As the current leader in PEV adoption, the consumer market in the Region has already demonstrated significant potential for the early adoption of PEVs, with the potential for significant and steady increases in consumer interest over the next several years. In that regard, there are limited gaps in terms of planning for vehicle deployment; however, for planning purposes, the following issues have been identified as potential gaps or deficiencies in the Bay Area and Monterey Bay Region:

Lack of PHEV Charging Behavior Data

One of the major benefits of The EV Project is the partnership between ECOtality and Nissan, enabling the collection of valuable data regarding charging behavior. As part of the project, consumers who get a rebate for residential EVSE agree to participate in the EV Project and provide charging data e.g., time of day, time connected to charger, and energy delivered to the vehicle. However, the EV Project, as of March 2012, has not registered any Chevrolet Volts – or other PHEVs – as part of the program in the San Francisco Bay Area. Although the deployment of Nissan Leafs and associated charging behavior of drivers will provide valuable lessons learned, the differences between how PHEV and BEV owners drive and charge their vehicles.

[49] Appendix B, Draft Environmental Analysis for the Advanced Clean Cars Program, CARB, December 2011. We also drew from an ARB Staff Presentation dated November 16, 2010 entitled “ZEV Regulation 2010, Staff Proposal”, available online at: http://www.arb.ca.gov/msprog/zevprog/2011zevreg/11_16_10pres.pdf

[50] Appendix B, Draft Environmental Analysis for the Advanced Clean Cars Program, CARB, December 2011. We also drew from an ARB Staff Presentation dated November 16, 2010 entitled “ZEV Regulation 2010, Staff Proposal”, available online at: http://www.arb.ca.gov/msprog/zevprog/2011zevreg/11_16_10pres.pdf

Data for vehicles outside of The EV Project will also be available from the BAAQMD's program; however, as the majority of infrastructure under that effort is still in the installation phase is expected that these data will not become available until 2013.

Medium- and Heavy-Duty Vehicles

The success of PEVs in the marketplace largely depends on the penetration of PEVs in the mass consumer market for light-duty vehicles; however, energy and environmental goals – such as GHG emission reductions, air quality improvement, and petroleum displacement – require the uptake of the PEVs in medium- and heavy-duty (MD and HD, respectively) sectors as well. Based on an initial review of the literature, PEVs in the MD and HD sector are being deployed; however, there is little guidance available or lessons learned regarding the supporting charging infrastructure that have been shared.

As part of a U.S. DOE program funded by ARRA, two medium-duty truck projects were implemented across the country with vehicle deployments in the Bay Area:

- **Smith Electric Vehicles Project**: Smith Electric Vehicles will build and deploy 500 all-electric medium-duty trucks. The trucks will be deployed in diverse climates across the country. As of April 2012, eight vehicles were deployed in Alameda County (Fremont, Oakland, and San Ramon) and ten were deployed in Santa Clara County (Milpitas and San Jose).
- **EV Delivery Truck Demonstration Project**: Navistar will build and deploy 950 all-electric medium-duty trucks and as of April 2012, vehicles have been deployed in San Leandro (1), Stockton (2), Davis (1), and Woodland (1).

It is unclear to what extent these medium-duty trucks have on-site EVSE capabilities or what infrastructure and site adjustments were made to accommodate the vehicles.

The California **Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)** provides rebates towards the purchase price of medium- and heavy-duty hybrid-electric and electric vehicles. Most of the vehicles that have been deployed to date (i.e., more than 90%) are hybrid electric vehicles, however, ICF and BAAQMD will reach out to ARB (the project sponsor) and CALSTART, who implements the project, to determine if there are data available from deployments in California, or preferably the Region.

According to an infrastructure planning checklist for medium- and heavy-duty trucks prepared by CALSTART, the primary steps for integrating Level 1 or Level 2 EVSE include[51]:

- Determine potential EVSE locations on-site based on proximity to existing electric utility equipment, traffic, pedestrian flow, parking availability and ADA compliance issues.
- Estimate the electrical load at the site. For Level 2 EVSE each truck could potentially add between 12 – 19.2 kW of load per vehicle. Also estimate the EVSE requirements from vehicle and charger manufacturers and the number of EVSE units required.

[51] CALSTART, "Detailed Infrastructure Planning Checklist for E-Truck Fleets." Available online at http://www.calstart.org/Libraries/E-Truck_Task_Force_Documents/E-TTF_Infrastructure_Guidelines_for_Fleets_with_checklist.sflb.ashx.

- Contact EVSE suppliers to obtain a quote.
- Contact the utility to assess the existing electricity supply and if service upgrades would be required. The upgrades could include extra circuits and sub-panel improvement. Consumers should also review metering requirements, such as a time-of-use meters and/or demand charges, which could add cost for service.
- Contact the applicable permitting agencies to obtain requirements for building and use permits.
- Hire a prime contractor and verify credentials to ensure compliance.

Other EVSE considerations for medium- and heavy-duty trucks include the purchase of a demand response charging system which would provide interactions between the utility and the fleet to manage grid load, particularly during peak hours. Another option would be a Load Management System, which would allow fleets to sequence automatically and optimize multiple chargers.

5.3. Concepts and Proposed Solutions

With more than 700 chargers deployed as part of the EVSE Home Charger Rebate Program, no Volts have been registered as part of the EV Project in the Bay Area as of March 2012. The Chevrolet Volt sales rose significantly in March 2012, with 25% of these vehicles sold in California according to Chevrolet. This jump in sales (more than double the previous month's sales nationwide) was likely attributable to sustained higher gas prices, and to California's decision to make the vehicle eligible for HOV lane access. Surprisingly, March also saw the introduction of the Toyota Prius Plug-In, which sold just fewer than 900 units nationwide in its first full month of availability.

Moving forward, it will be important for local and regional agencies, and local utilities in the Bay Area to have robust estimates of PEVs being deployed. The driving and charging behavior of the first adopters of BEVs and PHEVs will help inform the planning and investment decisions of local and regional agencies as they seek to support the ongoing deployment of PEVs, while ensuring a positive experience for existing drivers. The San Francisco Bay Area and Monterey Bay Region can address the lack of data availability regarding PHEVs (e.g., Volts and Prius Plug-ins) through several options:

- **Conduct surveys of and outreach to OEMs and Dealers**: OEMs and dealers are closely watching the deployment of PEVs in the marketplace. To the extent possible, regional agencies can survey and conduct targeted outreach to OEMs and dealers to develop estimates of the PEVs being deployed in the Bay Area.
- **Expand, improve and refine estimates of PEV adoption in the Region.** The initial forecasts presented in this document are focused on private light-duty PEV ownership. For the Plan, ICF will expand these forecasts to include private fleet PEV adoption, public fleet PEV adoption. ICF will also improve and refine estimates for PEV adoption in the Region based on the most recent market research, taking into account updates, for instance, to parameters such as gasoline prices, new vehicle sales, vehicle offerings, and economic

growth. Additional data from automotive manufacturers and fleets will be gathered where available. It is anticipated that the data from employer and fleet surveys currently being conducted by the BAAQMD and information available from the Clean Cities Coalitions will be able to provide additional information on current fleet users and their deployment of vehicles and EVSE.

- **Develop usage patterns for PEVs in the Region using available data.** ICF and BAAQMD will use charging data from EVSE deployed as part of The EV Project dating from March 2011, with data including vehicles by zip code and city, miles driven, and energy (kWh) consumed, as well as charging events by zip code and city, and hourly electricity demand. These data will be used to develop a better understanding of usage patterns. These data will also be used to support EVSE siting and location analysis (see Section 6) for the Region. The Plan will also identify how this and additional data could be gathered for future iterations of the planning document. The charger specific issues (multiunit dwellings, workplace charging, publicly accessible charging and the charging business model) identified in this portion of the analysis are described in greater detail in the next section.
- **Interface with utilities**: In most cases, the first adopters of PEVs will also install a residential charger. Although Chevrolet has observed that nearly 50% of its drivers are opting for Level 1 charging, and technically, this may not require a service upgrade or installation of equipment, the local utility (most likely PG&E) would desire to know which homes have PEVs charging on a frequent basis. In the case of PG&E, drivers may opt into a special time of use rate that makes it cheaper to charge vehicles during hours when demand for electricity is lower. See Section 12 for more information.

6. Siting, Locating, and Maintaining Infrastructure in the Bay Area and Monterey Bay Region

PEVs rely on charging to extend their range (PHEVs and BEVs) and as their main source of propulsion energy (BEVs). Charging infrastructure is a key component of PEV deployment and is a source of constant debate regarding:

- Location: Where should chargers be located? Options are generally characterized as (in the home, at the workplace, public versus private)
- Quantity: How many are needed to support PEV drivers?
- Level of charging: What voltage and power levels are necessary for useful PEV charging at the various locations – Level 1, Level 2, or DC fast charging?
- Investment: Who pays for and maintains public and private infrastructure?
- Payment: How much should individuals pay for "a charge"?

To answer some of these questions, this section provides an overview of the current makeup and state of the charging infrastructure in the region.

6.1. Introduction and Overview

The global roll out of PEVs presents a significant opportunity for the charging/EVSE industry – an industry that includes an array of services beyond EVSE hardware. Pike Research, for instance, has forecasted that the market for charging equipment alone will be worth up to $4.3 billion in 2017; this excludes services such as charging network management software, smart grid energy management, battery recycling, integrated renewable energy technologies and battery second-life applications. In a recent survey, Ernst & Young examined the business strategies of 143 charging/EVSE companies; the results of their survey identified 18 business activities and characterized five strategy variants.[52] In their thorough review and synthesis of charging strategies, one of their observations is a common issue that analysts have identified: the value proposition for potential hosts of charging stations e.g., parking lot owners, is unclear. Similarly, in a moderated discussion hosted by Ernst & Young regarding the market for PEV charging infrastructure, Detroit participants noted that there is a “need to fill gaps between who manages, owns and pays for the charging station.” These observations are buoyed by local anecdotal evidence from City CarShare, which has played an active role in the deployment of infrastructure to support an expanding number of PEVs in its fleet.

With a strong consumer market for vehicles, the Bay Area PEV readiness planning should focus much of its efforts on ensuring that the infrastructure is in place to support PEV deployment. To date, the Region has properly focused on ensuring that early adopters have a positive experience for charging vehicles at home. EPRI has prepared a convenient graphic to illustrate the priorities for likely charging scenarios, as shown in the so-called charging pyramid in Figure

[52] Ernst & Young, Beyond the plug: finding value in the emerging electric vehicle charging ecosystem, 2011.

5. Residential charging is the most important aspect of EVSE deployment; however, as the Bay Area advances in its PEV readiness planning, workplace or retail charging and publicly accessible charging should also be addressed systematically. It is also important to note that over a third of housing units in the Bay Area are multi-unit dwellings (MUDs), and face a similar set of barriers to those associated with workplace and public charging. Fortunately, Bay Area agencies and stakeholders have initiated the deployment of nonresidential charging and are also examining paths to installing EVSE in MUDs, and these efforts will yield valuable lessons learned over the next several years.

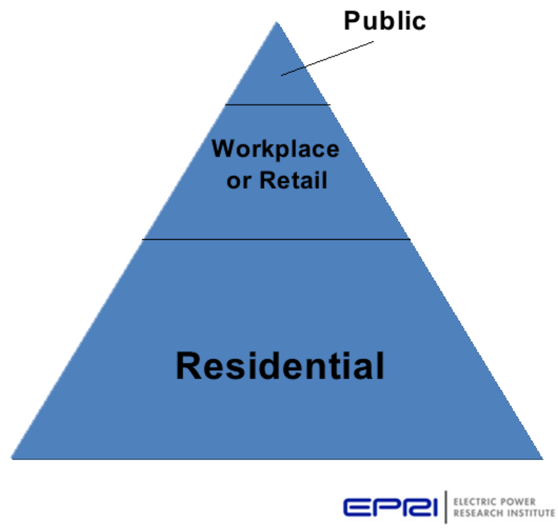


Figure 5. The EPRI Charging Pyramid

Priority Issues for the Region

While there is still work to be done in certain parts of the Region, lessons learned from existing residential EVSE deployments will generally fill the knowledge gaps that most local agencies may have with regard to residential deployment. The focus on nonresidential issues is not meant to deprioritize the necessity of residential EVSE deployment; rather it reflects that PEV readiness in many parts of the Region is sufficiently advanced to expedite the ability of other areas to achieve similar levels of readiness. The following issues specific to infrastructure deployment will be discussed in significant detail in the subsequent plan segments; they are introduced here to familiarize the reader with them as core issues discussed throughout the Plan.

Multi-Unit Dwellings: Charging Opportunities

Consumers living in apartment buildings and other MUDs will face more significant barriers in the process of installing EVSE. The barriers arise from questions about EVSE ownership and the potential cost implications, and about how EVSE would be metered and managed to pass costs on to PEV owners. It is conceivable that DC fast charging stations and battery switch stations could be considered part of the solution for MUDs. Furthermore, MUD charging may have significant similarities with workplace charging and public charging as they may require authentication, point-of-sale, or integrated metering to allocate costs to tenants, and management tools.

Small but important steps, such as the recent promulgation of Senate Bill 880 (SB 880, Corbett, Statues of 2012)[53] which voids any policies or provisions that prohibit or restrict the installation or use of EVSE in a common interest development, are important policy signals for charging at

[53] Senate Bill 880 (Corbett), Common interest developments: electric vehicle charging stations. Available online at: http://leginfo.ca.gov/pub/11-12/bill/sen/sb_0851-0900/sb_880_bill_20120229_chaptered.pdf

MUDs. Unfortunately, the interpretation of the bill is also being utilized as a barrier to EVSE deployment, with some HOAs requiring PEV owners to pay for, install, and remove EVSE.

Further research, more concrete actions, and lessons learned will need to be assembled for the Region to maintain its leadership position in PEV readiness.

Workplace Charging

Although initial data confirms the general view that most (light-duty PEVs) will be charged at home, it will be important to expand charging infrastructure beyond residences to achieve widespread adoption of PEVs. Furthermore, opportunities to charge outside of the residence will help increase the so-called “all-electric” miles for PHEVs and mitigate potential range limitations for BEVs. Workplace charging has garnered particular interest from stakeholders to fill the gap which will increase the all-electric range for PHEVs or extend the range for BEVs because of the amount of time that a vehicle will likely spend parked at a place of work. Furthermore, due to the time vehicles spend parked at workplaces, Level 1 EVSE may be a viable and lower-cost solution that also decreases load impacts. It is also important to note that there is a strong interest in the integration of renewable energy technologies (e.g., solar) with workplace installation to defray the costs of electricity (especially during peak hours).

Publicly Accessible Charging

Similar to workplace charging, publicly accessible charging will be an important part of the supporting infrastructure for PEVs as they reach increased levels of penetration. In the Bay Area, the City and County of San Francisco has established itself as a leader of deploying EVSE in municipally owned parking garages. However, beyond this jurisdiction’s expedited deployment, there are still many barriers that prevent the deployment of publicly accessible EVSE. Many of these barriers are addressed in the current guidance being produced as patents planning effort, however, mechanisms and incentives for implementation still need to be determined.

Charging Business Model

The focus of deployment efforts to date has largely been getting hardware in the ground and giving early adopters sufficient access to EVSE, particularly at residences. As the focus of EVSE deployment shifts toward installing chargers at nonresidential properties and MUDs, the issues of maintenance and financial management of EVSE will need to be addressed. With most EVSE providers currently offering charging freely at public stations, the long-term viability of the charging business is unclear and requires consideration. Anecdotally, vendors have stated that the end-to-end ownership business model shows promise; however, no data were available to demonstrate this at the time of writing of this document. This issue will be further explored as part of the Plan.

Current Deployment in the Region

As a result of consumer interest, regional agencies and EVSE providers have responded to the range anxiety issue and the need for public infrastructure with a variety of deployment projects, as highlighted in Table 3 below.

Table 3. Overview of EVSE Deployment in the Region

Project Title	Lead & Support Agencies	Funding		Chargers		
		Source	Amount	Residential Level 2	Nonresidential Level 2	DC Fast
EVSE Home Charger Rebate Program	ECOtality, Coulomb, AeroVironment, Clipper Creek	BAAQMD	$2.20	2,750		
DC Fast Charger Program	ECOtality, AeroVironment	BAAQMD	$0.61			30
ChargePoint America	Coulomb Technologies	DOE	n/a		1,100	--
Bay Area EV Corridor Project	EV Communities Alliance. ABAG, BAAQMD Local Cities/Counties	CEC	$1.49		335	6
		BAAQMD	$0.40			
Update Existing EV Infrastructure	Clipper Creek	CEC	$2.30		230	--
Local Government EV Projects	Multiple	BAAQMD	$0.15		50	--
		MTC	$2.80			
eFleet: Car Sharing Electrified	City CarShare SFCTA	MTC	$1.70		24	
		BAAQMD	$0.03			
Bay Area Electric Vehicle Taxi Corridor Program	Better Place, SFMTA	MTC	$7.0	*battery switch*		
Tribal Community Sustainable Transportation	Kashia Band of Pomo Indians	MTC	$0.37		6	--
Businesses Deploying EV Infrastructure	Best Buy, McDonald's, Etc.	BAAQMD	$0.34		178	--
Electric Vehicle Charging Station Project	NRG (settlement w/ CPUC)	NRG		1,650 (minimum)		55
			Total	**to be included in Plan**		

CEC – California Energy Commission; DOE – U.S. Department of Energy; SFCTA – San Francisco County Transportation Authority; SFMTA – San Francisco Municipal Transportation Agency

The EV Project: The EV Project, managed nationwide by ECOtality, was funded by the US DOE as part of the American Recovery and Reinvestment Act (ARRA), receiving a total of $115 million of awards. ECOtality is managing the installation of 15,000 commercial and residential charging stations in more than 15 regions across the United States. Through March 2012, ECOtality reports[54] that 891 residential Level 2 chargers and 12 publicly available Level 2 chargers have been installed in the San Francisco Bay Area with 1,210 Nissan Leafs enrolled to date. To date the program has focused on residential installations; however, there are plans to deploy more publicly available chargers in the near future for the San Francisco Bay Area.

BAAQMD EVSE Deployment Programs: The BAAQMD is a local source for over $6 million in support for EVSE deployment in the Bay Area. This funding has been deployed in two phases: Phase 1 is a $1 million program for a publicly accessible EVSE charging network which includes over 200 Level 2 and 6 DC fast charge EVSE and one battery switch station. Phase 2 provides an additional $5 million to install 2,750 residential level 2 and 50 DC fast charge EVSE. ECOtality is one of the contractors for the BAAQMD's EVSE Home Charger Rebate program and DC Fast Charger Program. Of the 2,750 residential chargers slated to be deployed in Phase 2 by the BAAQMD 1,500 will be Blink Home Chargers with Ecotality deploying an additional 30 DC fast chargers (20 of which will be Blink DC Fast Chargers). Through February 2012, 423 EVSE have been installed through this program.[55] The other project partners for the Home Charger Rebate program include Coulomb Technologies who are tasked with installing 500 residential chargers, (see more information on Coulomb below), AeroVironment (500 residential chargers), and Clipper Creek (250 residential chargers). AeroVironment were also selected by the Air District to support the DC Fast Charger Program and will install the remaining 10 DC fast chargers in the Bay Area region.

ChargePoint America: This is a $37 million project, with $15 million from American Recovery and Reinvestment Act (ARRA) funds, administered by Coulomb Technologies focusing on the deployment of infrastructure in 10 regions throughout the United States, including the San Francisco Bay Area. As part of the program, the City of San Francisco has installed 80 Level 2 chargers in municipally-owned garages throughout the city. The ChargePoint America program has also sponsored the deployment of chargers at locations such as the Oakland International Airport, where 8 Level 2 chargers are deployed in the Premier Parking Lot. The Monterey Bay Region also received five (5) Level 2 EVSE as part of Chargepoint America, with the infrastructure deployed in Scotts Valley, Capitola, Aptos, and Santa Cruz.

The California Energy Commission has also funded two projects that are focusing on the deployment of EVSE in the Bay Area. The first is called the **Bay Area EV Corridor Project** and is being implemented by the Association of Bay Area Governments and EV Communities Alliance. This project also includes deployment of EVSE in the Monterey Bay Region, with an estimated 44 dual outlet EVSE deployed in the Monterey Bay Region, managed in coordination with the Monterey Bay Electric Vehicle Alliance (MBEVA) and Ecology Action. The second

54 The EV Project Q1 2012 Summary

55 Not all of the EVSE deployed as part of ECOtality's EV Project in the Bay Area are part of the Air District's Home Charger Rebate Program, hence the difference in number of EVSE installed.

project is a statewide effort managed by Clipper Creek to **update the infrastructure** that was in place from the initial deployment of PEVs from the late 1990s.

The Bay Area Metropolitan Transportation Commission (MTC) has also assumed a proactive role in the deployment of PEVs and charging infrastructure as part of the **Climate Initiatives Program**. MTC awarded nearly $12 million to four projects:

- San Francisco's Municipal Transportation Agency (SFMTA) partnered with the City of San Jose and Better Place for the **Bay Area EV Taxi Corridor Program**, a zero emission electric taxi project to demonstrate 61 electric taxis with battery switch capabilities, 25 electric neighborhood taxis, and install four battery switching stations. The project received about $7 million. Better Place has advanced its project and has the first two sites identified and is nearing the finalization of the permitting process for each site – one in the North Beach neighborhood of San Francisco (near the intersection of Davis St and Broadway) and the other at San Francisco International Airport.
- The **Local Government EV Fleet Project** is administered by eight local governments (led by Alameda County) that are in the process of procuring 90 PEVs for municipal fleets and 90 Level 2 chargers accessible to both the government fleets and, in some cases, the public. The local government agencies plan to deploy 78 light-duty PHEVs and BEVs and 12 vans or shuttles. The project received $2.8 million. As of March 2012, the project partners were on the verge of issuing a bid for procurement of the first round of vehicles and chargers.
- City CarShare is leading a **Car Sharing Electrified Project** to deploy 29 PEVs, which will be a mix of PHEVs and BEVs, and install 24 Level 2 chargers. The project received $1.7 million. City CarShare has also established itself as a leader in the Bay Area with regard to EVSE deployment in a carshare fleet. Despite delays in the deployment of PEVs as part of the MTC grant (due to Buy America provisions in the funding), City CarShare is implementing its **eFleet Program**. Today, they have 7 PEVs in their fleet with plans to expand to 30 PEVs over the next 24 months, and achieve 50% penetration of alternative fuel vehicles by 2015. With a total fleet of about 400 vehicles, they have the potential to deploy 200 PEVs in the Bay Area. For each PEV currently deployed they have at least one dedicated EVSE; and in several cases, they have installed two EVSE (for two vehicles), with the second charger available for public use.
- The Kashia Band Pomo Tribal Government of the Stewarts Point Rancheria received about $370,000 to deploy four PEVs – two sedans and two vans – and six charging stations.

Monterey Bay Unified Pollution Control District (MBUPCD): The MBUPCD has played an active role in the deployment of EVSE in the Monterey Bay Region. They have funded projects such as the following:

- A grant to the Association of Monterey Bay Association of Governments (AMBAG) to install four ECOtality Blink stations. This grant also includes funding for public outreach and policy analysis.

- A grant to the Transportation Agency of Monterey County to install seven Level 2 EVSE in the tri-county Monterey Bay Region.
- A grant the Santa Cruz County Regional Transportation Commission to install one DC fast charging station.
- A grant to the City of Santa Cruz to install EVSE in public parking garages in downtown Santa Cruz, providing a total of about 10 Level 2 EVSE.

NRG Settlement: The most recent development related to the deployment of charging infrastructure that will affect the San Francisco Bay Area is the settlement between NRG Energy Inc. and the California Public Utilities Commission (CPUC) stemming from the California energy crisis in 2000 and 2001. Of the $122.5 million settlement, NRG will spend $102.5 million to fund the installation of EVSE throughout California over a period of four years. More specifically, the settlement will fund:

- 200 **Freedom Stations** will be deployed statewide, with 55 of these deployed in the Bay Area. Each Freedom Station will consist of at least one DC fast charger and one Level 2 EVSE.[56] On top of the $50.5 million earmarked for stations, another $3 million is earmarked for the fixed operating costs of these stations e.g., electricity demand charges, meter charges, and maintenance, over a five year period.
- 10,000 Make-Ready Stubs and 1,000 Make-Ready Arrays,[57] collectively referred to as **Make-Readies**, are to be deployed statewide at a cost of $40 million; unlike the Freedom Stations, Make-Readies are not intended to be available to the general public. At least 1,650 of these Make Ready Stubs will be deployed in the Bay Area, with an additional 4,000 stubs to be deployed at NRG's discretion. The bulk of this money will go towards wiring homes, and preparing workplaces, multi-family buildings, hospitals, and schools for EVSE. ICF anticipates that NRG will target Bay Area with more than the minimum number of installations, since the area has such as high density of the population living in multi-unit dwellings. NRG will not own this equipment, the property owners will, but the company will have exclusive rights for 18 months to sell equipment and related services to the property owners. After 18 months, the locations are open to competition.
- The **Technology Demonstration Program** with $5 million, with potential projects focusing on: stationary battery storage systems to reduce peak electricity demand from Freedom Stations, the installation of Extreme Freedom Stations (i.e., Level 3 DC public chargers exceeding 80 kW), smart charging technology, or a vehicle-to-grid demonstration project.
- The **EV Opportunity Program** with $4 million for projects than enhance social benefits of PEVs and create opportunities for residents of under-served communities. The eligible projects include the deployment of EVSE for PEV carsharing projects, a PEV job training program, or other projects that will help under-served communities.

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[56] Per the terms of the settlement, NRG also has the option of deploying two DC fast chargers at Freedom Stations.
[57] Note that an array can have no more than 10 stubs, which means that there must be at least 1,000 unique locations across the state.

To address equity concerns, both the Freedom Station and Make-Readies deployment have provisions regarding the siting of infrastructure in low- and middle-income areas. For instance, 20% of the Freedom Stations must be installed in an area in which the median income is in the lowest third. It is also anticipated that significant coordination on the siting of this infrastructure will occur between NRG and BAAQMD as part of this planning effort.

Sustainable Community Strategy: Regional agencies in the Bay Area have also demonstrated their long-term commitment to supporting the electrification of the transportation sector as a critical strategy to meet the region's climate change goals. Most notably, on May 18, MTC and ABAG approved the Plan Bay Area Preferred Land Use and Transportation Investment Strategy[58], which outlines the Bay Area's strategy to meet the per capita GHG reduction targets of SB 375, with spending upwards of $275 billion out to 2035. While most of these investments are transit-oriented or for the expansion of roads and bridges; however, there are two key aspects of the Plan Bay Area that will promote the deployment of PEVs and EVSE out to 2035:

- Regional Public Charger Network: With PHEVs likely to be deployed in significant numbers in the Bay Area, this strategy makes targeted investments to help increase the opportunity to increase the number of so-called electric miles for PHEVs. The initial plan is to dedicate approximately $240 million over the span of 15 years to support this program.
- Vehicle Buyback & PEV Incentives Program: This program couples fleet turnover with the deployment of PEVs. The vehicle buyback program is designed as a trade-in for older vehicles that are below a certain fuel economy threshold, with the eligibility restricted to consumers purchasing a PHEV or BEV. The incentive amount varies with the fuel economy of the vehicle being traded in (measured in mpg) as well as the vehicle type being purchased (i.e., PHEV or BEV). The initial plan allocates $180 million for this strategy over the span of 15 years.

Siting and Locating Stations

Residential installations

A major focus of PEV infrastructure deployment to date has been residential EVSE. For instance, The EV Project to date has deployed about half (or 4,600) of its target residential Level 2 EVSE and only a third (or 1,500) of its target publicly available units.[59] As of December 2011, 96% of the "charging events" recorded as part of The EV Project have occurred at residential Level 2 EVSE; in the Bay Area, this percentage jumps to 99.6%.[60] The focus on residential deployment of EVSE is unsurprising – stakeholders, particularly OEMs, have been particularly vocal about emphasizing the need ensure that the home charging experience is positive. Additionally, guidelines and best practices are readily available for all parties (vehicle owner, utility, dealer, installers and local governments) relating to the installation of EVSE in single family residences (California Plug in Electric Vehicle Collaborative guidelines, etc.)

[58] Preferred Land Use and Transportation Investment Strategy for Plan Bay Area, May 2012, available online at: www.onebayarea.org
[59] Conversation with Steve Schey, ECOtality, April 11, 2012.
[60] ECOtality, Q4 2011 Report, The EV Project, February 2012.

However, as a result, the structure of the market for publicly accessible EVSE is still relatively unknown at this point.

Multi-unit dwelling installations

The population density in the Bay Area requires the consideration of deploying EVSE in multi-unit dwellings (MUDs). The San Francisco Department of Environment recently initiated MultiCharge SF in partnership with Coulomb Technologies to bring charging infrastructure to multi-family buildings in San Francisco, where two thirds of residences reside in MUDs (see Table 4 below). The project will help develop a knowledge base and best practices for EVSE deployment in MUDs by covering the costs of charging equipment and subsidizing the costs of installation significantly.

Table 4. Population and MUD Residents in Bay Area Counties

County	Population	% Population in MUDs
Alameda	1,500,000	38%
Contra Costa	1,100,000	24%
Santa Clara	1,800,000	32%
San Francisco	**900,000**	**67%**
San Mateo	750,000	33%

The MultiCharge SF project will help address some of the issues associated with deploying EVSE at MUDs. However, other jurisdictions outside of San Francisco will likely have to deal with the challenges of deploying EVSE at MUDs (see Table 5 below for a list of common challenges). The deployment of PEVs today will require many jurisdictions in the Bay Area and Monterey Bay Region to grapple with these challenges before the lessons learned from the MultiCharge SF project are fully understood.

Table 5. Common Factors that Impact EVSE Installation at MUDs

Physical Challenges	• Availability of capacity in the electrical panel • Availability of space for additional meters in the meter rooms • Distances between utility meters, parking spaces, and unit electrical panels
Cost of Installation and Operation	• Restrictive facility configurations (master meter, remote parking, etc.) • Cost allocation to residents (based on usage, equipment, parking, shared service areas) • Inability to take advantage of off-peaking charging rates • HOA fee structures
Codes, Covenants, and Legalities	• Differences in ownership • Differences between actors who make the investment versus those that reap benefit • Agreements between property owners and residents / renters • Deeded parking spaces assigned to individual residents

Outside of single-family residences and MUDs, non-residential charging locations are being considered. For the purposes of this document, we distinguish between two types of non-residential charging: a) workplace charging and b) publicly accessible installations. It is conceivable that the former, workplace charging, may be publicly available, however, the following sections distinguish between these because of the different policies that can be implemented to target them individually. It has also been suggested that a combination of DC fast charge EVSE and workplace charging can act as a solution to the MUD issues, especially for PHEV where a lower cost Level 1 EVSE solution is used for home charging.

Workplace charging installations

After residences, the workplace is where vehicles spend the most time parked. The Business Council on Climate Change and the Bay Area Council, in coordination with the San Francisco Department of Environment, have developed a guide outlining a step-by-step process for businesses to become EV-ready.[61] Additional guidance on workplace PEV readiness is also being developed by CALSTART under a grant provided by the BAAQMD and South Coast Air Quality Management District (SCAQMD).

Publicly accessible installations

With regard to siting chargers in publicly available spaces, stakeholders (e.g., regional agencies) have used an array of parameters to develop a strategy for siting publicly available EVSE. The first movers in these exercises have been aided by ECOtality as part of "The EV Project." The parameters considered generally include land use, origin-destination modeling (e.g., using travel models), corridor planning, links to transit trips, off-street parking availability and accessibility, carsharing potential, and surveys of PEV drivers.

City CarShare (CCS), a San Francisco based organization, has approached the deployment of PEVs and supporting infrastructure by considering the following:

- Co-location: CCS prefers to co-locate PEVs with other vehicles in their fleet. All vehicles in CCS's fleet – all CCS pods (i.e., vehicles) are selected based on proximity to transit, membership density, and the cost of parking.
- Even distribution: City CarShare sought an even distribution of PEVs around their service area rather than having them clumped in a single area.
- Parking garages: Based on their initial research, City CarShare discovered that putting the charging stations in surface lots would be cost prohibitive and may require environmental impact reports due to trenching for the wiring. Also surface parking lots typically do not have sufficient electrical service to support multiple charging stations without additional meters, transformers, and other equipment. As a result, they focused on underground parking garages and parking structures where charging stations could be mounted on walls using surface conduit.
- Contractual agreements: The three considerations outlined previously – co-locating PEVs with existing CCS vehicles in an evenly distributed fashion in areas with parking garages – help narrow the potential locations for the deployment of PEVs in CCS's fleet. The final step of their siting consideration is the willingness of property owners and/or parking

[61] *Electrify Your Business: Moving Forward with Electric Vehicles, A Bay Area Business Guide*, Business Council on Climate Change and Bay Area Council, April 2011. Available online at: http://www.bc3sfbay.org/uploads/5/3/3/9/5339154/electrify_your_business.pdf

management companies to enter into an extended term agreement. CCS seeks agreements with 3-year terms, with the EVSE connected to existing power panels, whereby CCS reimburse the property owner or parking management company for electricity while retaining ownership of the charging stations.

Environmental Justice Considerations

As the deployment of PEVs expands beyond early adopters – who tend to be older and wealthier consumers (see previous section on consumers) – it will be important to ensure that EVSE is sited and located in all of the communities of the Bay Area and Monterey Bay Region. As noted previously, the settlement between NRG and the CPUC includes provisions that NRG install at least 20% of Freedom Stations (i.e., DC fast charge stations) in regions with median incomes are in the lowest third of Public Use Microdata Areas in the region. For the Make-Ready Arrays, NRG is required to ensure that they are available to Californians of all income levels, and are required to consult with state and local government agencies to identify sites, and will use “best and commercially reasonable efforts” to deploy infrastructure at mixed-income housing. Based on ICF’s review, there are not similar provisions in other siting analyses; however, it is conceivable that the EVSE deployed as part of the NRG settlement will satisfy much of the early demand in EJ communities. Regardless, local and regional agencies will need to monitor progress in EJ communities to ensure equitable distribution of access to PEV infrastructure in the San Francisco Bay Area and Monterey Bay Region.

Operations, Maintenance, and Financial Management of EVSE

The major focus of deployment efforts to date has largely been getting hardware in the ground and giving early adopters sufficient access to EVSE, particularly at residences. As the focus of EVSE deployment shifts towards nonresidential chargers, the issues of operation, maintenance, insurance, safety and financial management of EVSE will need to be addressed. Recent estimates indicate that 90% of public stations are currently free,[62] which is clearly not a sustainable path forward for a self-sustaining industry.

With regard to operation of EVSE, the focus of PEV readiness planning is to ensure that EVSE or vehicles are compatible with and can be integrated with smart grid technologies. As discussed in more detail in Section 12, this will become a more significant issue as PEVs and EVSE are deployed in greater numbers. Prior to mass adoption, however, it will still be important for local agencies and planners to ensure that there are ways to minimize the grid impacts of PEVs – and smart grid technology integration is one of the key considerations to achieving this. Today, the EVSE deployed range from so-called “dumb chargers” which do not have any networking capabilities to “smart chargers” with sophisticated networking capabilities such as the EVSE provided by Coulomb’s ChargePoint network.

In addition to dumb and smart chargers, there are many drivers who are using Level 1 charging for their vehicles – which is generally a simple chord and plug set-up without any sophisticated communication. In the case of Level 1 charging, the burden of minimizing grid impacts generally

[62] Botsford, C. *The Economics of Non-Residential Level 2 EVSE Charging Infrastructure*, EVS26, Los Angeles CA, 2012.

falls on the vehicle-side of charging. In other words, the smart grid integration will be dependent on the vehicle having sufficient software to support something as simple as programmable charging capabilities (by time of day).

The financial management of charging equipment is most relevant for publicly available EVSE, where private stakeholders will be seeking a return on their investment in EVSE deployment. The deployment of EVSE at the Oakland International Airport as part of the ChargePoint America program provides an introduction to some of the initial pricing for public charging: The cost for vehicle charging is $3.00 per 30 minutes for up to 5 hours and $36 for 5-24 hours. Additionally, Walgreens and 350 Green recently initiated a payment program for the EVSE they have deployed, which costs $2 per hour, with a minimum charge of $2.

Recent modifications and clarifications to the Low Carbon Fuel Standard (LCFS) in California also present opportunities for consumers and companies to reduce the cost of charging however, these modifications also present significant challenges for stakeholders. For instance, the modifications effectively restrict utilities and electricity service providers from earning a profit in the LCFS market – credits in the LCFS market are generated by deploying fuels that have a lower carbon intensity (as measured in grams of carbon dioxide equivalents per unit of energy, gCO2e/MJ) than conventional fuels i.e., gasoline or diesel. Electricity as a transportation fuel has significant potential in the LCFS credit market, with a significant differential in carbon intensity between fuels (upwards of 50%, depending on the generation mix of electricity).

Under the proposed modifications to the LCFS, utilities wishing to receive credit must provide 1) off-peak rates and use all credit proceeds to PEV customers and 2) provide the public with education on the benefits of PEV use. . The regulation also requires utilities to include a summary of activities and efforts to satisfy these three requirements as part of LCFS reporting. There are similar LCFS requirements for so-called third-party non-utility Electric Vehicle Service Providers (EVSPs). There are also provisions for a private business or workplace to earn credits, but with less stringent requirements that require the company to educate employees about the benefits of EVs (but not use all of the credit proceeds, as noted previously). The modifications to the LCFS effectively limit (or eliminate) the profit potential for utilities and EVSPs (e.g., ECOtality) in the LCFS marketplace. This will have a material impact on the value proposition proposal for EVSPs, charging-site hosts, utilities, and other stakeholders impacted by the new regulatory language.

6.2. Gaps and Deficiencies

Siting and Locating Non-residential EVSE for the Region

ECOtality is currently negotiating a contract with the BAAQMD to perform a siting analysis for public infrastructure in the Bay Area. This work will need to consider the recent settlement between the CPUC and NRG – with thousands of Level 2 EVSE potentially being installed in the San Francisco Bay Area over the next four (4) years and about 100 DC fast chargers, it will be important to coordinate efforts to the extent possible. This will be particularly challenging because regional agencies and other stakeholders want to encourage PEV adoption, however, it is also desirable to foster competition and innovation for EVSE providers in order to promote and market that is sustainable in the long term.

As part of a report regarding infrastructure for PEVs in the Monterey Bay area,[63] the Association of Monterey Bay Area Governments (AMBAG) developed a suitability index analysis by using the following data inputs and 45 indicators according to different priorities:

- ESRI Business Analyst 2008 (infoUSA, Inc., ESRI, 2009)
- Assessor Parcels (Counties of Monterey, San Benito, Santa Cruz)
- AMBAG Regional Travel Demand Model 2005 (Association of Monterey Bay Area Governments, 2005) Road Network and Traffic Analysis Zones
- EVChargerMaps (EV Charger News, 2009)
- Municipal Facility locations (libraries, parks, city and county administration buildings) (AMBAG, 2010)

The results produced a detailed map analysis of the ideal areas to install EVSE, with 229 locations containing approximately 1,774 acres were identified as priority locations to site public charging stations. This area covers 5,864 parcels that include a total of 5,273 businesses. Locations in the public right-of-way include on-street or curbside parking spaces and public garage and lot parking spaces.

Workplace Charging

Although initial data confirms the general view that most (light-duty PEVs) will be charged at home, it will be important to expand charging infrastructure beyond residences to achieved widespread adoption of PEVs. Furthermore, opportunities to charge outside of the residence will help increase the so-called “all-electric” miles for PHEVs and mitigate potential range limitations for BEVs. Workplace charging has garnered particular interest from stakeholders to fill the gap which will increase the all-electric range for PHEVs or extend the range for BEVs because of the amount of time that a vehicle will likely spend parked at a place of work.

Despite the interest that workplace charging has captured, the actual deployment of charging infrastructure by employers has been very limited. There are a variety of barriers that may prevent the deployment of charging infrastructure at workplaces; most notably, the ownership of the parking structure may prevent employers from deploying EVSE. Also, the issues surrounding benefits and taxes for employees utilizing EVSE pose a considerable issue for employers wishing to provide charging.

In recognition of this existing gap in the PEV ecosystem, the Air District and SCAQMD are sponsoring a project through CALSTART to conduct outreach to targeted companies, create a Workplace Charging Forum, and develop a Workplace Charging Toolkit. That work will also

[63] *Electric Vehicle Infrastructure for the Monterey Bay Area*, Association of Monterey Bay Area Governments, March 2012. available online at: http://ambag.org/announcements/EV_draft_report.pdf

include the identification of issues and barriers that have prevented or are preventing the deployment of workplace charging statewide.

Publicly Accessible Charging

Similar to workplace charging, publicly accessible charging will be an important part of the supporting infrastructure for PEVs as they reach increased levels of penetration. In the Bay Area, the City and County of San Francisco has established itself as a leader of deploying EVSE in municipally owned parking garages. However, beyond that jurisdictions expedited deployment, there are still many barriers that prevent the deployment of publicly accessible EVSE. For the purposes of this subsection, we distinguish between parking garages and other publicly accessible charging.

Parking Garages

- Anecdotal evidence indicates that the ownership structure of parking lots in the Bay Area – specifically in San Francisco – creates confusion when attempting to deploy EVSE. Some parking management companies own the property, whereas others merely manage the structure on behalf of a separate owner. In the latter ownership structure, this can add significant time to the contracting process because it requires an agreement with both the property owner and the parking management company.
- The maintenance and ownership of the EVSE continues to be an ongoing barrier in publicly accessible locations. Interviews conducted by ICF and anecdotal evidence from City CarShare indicate that this is also a primary concern of parking management companies, especially in the cases where a parking management company may have a short-term (1-3 years) lease or contract to operate structure.
- The fundamental question that continues to be posed by parking management companies and others is: What is in this for me? At this point in time, the case for cost recovery of a potentially significant issue; however, even in cases where a company (e.g., City CarShare) is willing to install EVSE freely, there is still resistance as a result of this fundamental question.
- Another more nuanced and technical issue that may present a challenge for EVSE providers and other stakeholders seeking to deploy EVSE (e.g., City CarShare or Zipcar), is the availability and price of electricity for a parking structure.
  - Based on City CarShare's research, there may be a lack of adequate electrical service in many parking garages for future expansion. Parking garages typically do not have much spare electrical service to accommodate each Level 2 EVSE, which requires a dedicated 208/240 volt, 40 amp circuit. In most of the cases, City CarShare has found that there is enough spare capacity for two to three stations; however, deploying more EVSE would require additional sub-panels (room for the required 2-pole circuit breakers) and, in many cases, larger transformers and larger main panels. This has the potential to add substantial cost to the installation of EVSE.
  - With regard to pricing, it will be important to communicate the impacts that EVSE may have on the electricity rates for parking managers (and other owners of parking

structures), if any. Pricing issues are highlighted by the potential for demand charges and times when EVSE may be in use at parking garages (daytime-peak rates). Parking garages do not typically pay high demand charges because their electricity use is fairly stable; their demand is limited to lighting and ventilation during open hours. Demand charges are levied by the utility, separately from metered electricity charges, based on the highest 15 minute average of electricity demand at the meter. Charging stations have the potential to drive up demand charges if several cars are charging simultaneously, and also change the service profile developed by the utility to characterize equipment needs to meet the customer's peak demand. Most garage operators are unfamiliar with the concept and are likely to be surprised at the potential costs. Demand charges in many cases can be equal to, or even more than, the metered electricity charges, but the minimum requirement to be on a demand charge rate varies significantly by utility.

- The installation of charging stations cannot violate any ADA standards for sidewalk, parking spaces, or other accessibility. As a result, careful attention must be given to implementing charging installations that meet the federal and state ADA requirements. California developed Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations in 1997.[64] These guidelines are for state-funded projects; however, they provide some initial guidance for local governments. The current guidance documentation being developed at the State level and for the Bay Area and Monterey Bay Region suggest the following: For lots with accessible parking, the first charging station should be prioritized for an ADA accessible parking space and for every 25th additional station another accessible space is installed.

Other Publicly Accessible Charging

Apart from EVSE in public parking lots, publicly available EVSE also presents many unique challenges for its owners. Issues regarding ADA compliance, maintenance, safety, insurance and service sustainability must all be considered when citing publicly accessible infrastructure on private properties.

The addition of NRG "Freedom Stations" throughout California also changes the dynamic on pricing and location of publicly available EVSE. Due to the fact that this deployment is through a structured settlement versus a traditional business plan, there is significant uncertainty as to how these new stations will become profitable, self-sustaining or how they will affect other EVSE deployment models. As this is a nascent industry, there is significant uncertainty as to how public EVSE installations can be monetized in a sustainable manner and this should be considered during the discussion on location and sustainability of publicly available EVSE as part of this planning effort.

[64] Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations, 97-03, CA Department of General Services, available online at: http://www.documents.dgs.ca.gov/dsa/pubs/policies_rev_01-01-11.pdf

Potential for EVSE Saturation

As noted previously, there are a number of initiatives in the Region to support the deployment of EVSE in residential areas, MUDs, at workplaces, and publicly accessible locations. It will be important for Bay Area and Monterey Bay Region stakeholders to communicate frequently and coordinate siting accordingly to ensure that the market for EVSE is not saturated in the region. As the lessons learned from the initial deployment of PEVs and supporting EVSE become clearer, siting analyses and studies should be updated to ensure that resources are spent in accordance with factors such as utilization of existing assets, while also considering the value of having infrastructure in place for emergency charging and as part of a larger regional network.

Integrating EVSE and Smart Grid Interoperability

Although there have been considerable advances regarding the deployment of Level 2 EVSE, the major focus has been on getting hardware in the ground, particularly at residences. As EVSE is more widely deployed, the issue of networking EVSE and ensuring grid interoperability, particularly through smart grid technologies, arises. This issue is increasingly challenging to address with the deployment of “dumb chargers” for Level 1 charging, which does not generally require modifications to existing infrastructure. This is discussed in more detail in Section 12.

6.3. Concepts and Proposed Solutions

Siting at MUDs

The MultiCharge SF project will help address some of the issues associated with deploying EVSE at MUDs. However, other jurisdictions outside of San Francisco will also have to deal with the challenges of deploying EVSE at MUDs. The deployment of PEVs today will require many jurisdictions in the Bay Area to grapple with these challenges before the lessons learned from the MultiCharge SF project are fully understood. The important factor here is that the entire Bay Area and Monterey Bay Region cannot rely solely on a single project in San Francisco County to develop a uniform knowledge base to deploy EVSE in MUDs. Furthermore, there will be challenges unique to each County or jurisdiction that must be overcome to deploy EVSE at MUDs. Other jurisdictions will have to engage home owner associations (HOAs), developers, and property owners to develop solutions for their community.

As noted in previous sections, there are many challenges associated with the deployment of EVSE in MUDs. Although identified as a gap/deficiency for the Region, particularly the Bay Area, the Department of Environment in San Francisco, in partnership with Coulomb Technologies, has taken a leading role in developing an improved understanding of the barriers to deploying EVSE in multi-family buildings through the aforementioned MultiCharge SF project. The project will help develop a knowledge base and best practices for EVSE deployment in MUDs by covering the costs of charging equipment and subsidizing the costs of installation significantly.

As part of this planning effort, the best practices developed by the MultiCharge SF project will be examined and compared with available information from other California jurisdictions (including the information contained in the California Plug-In Electric Vehicle Collaborative Statewide best practices document). Based on this analysis updates will be suggested to the PEVC for the statewide document and an analysis will be performed on how best to deploy these best practices for adoption in the Bay Area and Monterey Bay Region by local governments.

Siting and identifying locations publicly

As part of this readiness planning exercise, ICF in coordination with BAAQMD will also conduct a siting analysis for comparative purposes. This siting analysis will be conducted over the following steps:

- Estimate demand for PEVs in the Bay Area

Using a combination of demand forecasting and inputs from the Bay Area regional travel demand model (developed by MTC), a forecasted demand for PEVs in the Bay Area will be estimated out to 2020. The demand forecasting will be based on factors such as hybrid ownership, regulatory drivers (e.g., the Low Carbon Fuel Standard and the Zero Emission Vehicle Program), and the travel needs that can be met by PEVs (including a consideration of the potential split between PHEV and BEV technologies). ICF has developed forecasts for PEVs in the Bay Area which can be used as inputs into this task.

- Refine estimates of PEV demand in the Bay Area based on projected ownership characteristics

The initial projections for PEV demand will be refined by taking spatially-explicit demographic data into account. This subtask will also draw from the PEV characteristics of near- and mid-term vehicle deployments and data available regarding PEV owner characteristics. Several basic household demographic profiles for the Bay Area will be considered, including parameters such as household income, education, and family size. These will be informed by findings from initial PEV consumer market research to describe early adopters, likely adopters, possible adopters, unlikely adopters, or any other designations useful for describing the target market segments. Once these basic demographic profiles are established, the next step is to identify the location of these households vis-à-vis the locations of the travel profiles generated previously.

- Estimate parking type availability for PEV purchasers

This step in the analysis will characterize the parking types in the study area based on general descriptive factors such as garage parking, surface lots, or underground parking, and ownership parameters e.g., shared parking or dedicated parking. This step will also require an assessment of off-street parking lots in key areas throughout the San Francisco Bay Area, distinguished between privately owned (and in some cases, managed separately by a parking management company) and municipally owned lots.

- Identify most suitable location for publicly accessible EVSE

The location of publicly-available EVSE is a complicated issue that planning agencies are struggling with across the nation. In a time of fiscal austerity and limited resources, public funding is being scrutinized in extraordinary detail. Even in cases where publically available EVSE is built with private funding, such as chargers in retail centers or parking garages, planning agencies need to track EVSE locations in order to identify gaps in the charging network. Some of the key parameters that we will include in our analysis are highlighted, with a brief description, in Table 6.

Table 6. Parameters to Consider in the Identification of Suitable Locations for EVSE

Category	Parameter	Brief Explanation
Vehicle Characteristics	Vehicle range	Informs trip distance and vehicle type; as well as level of charging that is appropriate
	Charging time	Together with trip characteristics, will help characterize potential for opportunity charging; and provide estimate of level of charging needed (e.g., long charging times are not practical in some cases; fast charging is impractical in others)
PEV Demand	Vehicle type	Distinguishing between demand for PHEVs and BEVs is difficult; however, it would prove useful in the estimate of types of charging required (and cost, by association)
	Trip characteristics	Understanding where people are going and how far; a common output of travel demand models
	Home charging capability	Accessibility to a garage will help indicate the likelihood of a driver charging at home, where the vehicle spends a considerable amount of time. Increased home charging puts downward pressure on the need for public charging
Parking Characteristics	Lot types	The type of lot availability will help us understand, at a first pass at least, the range of costs for deploying EVSE.
	Ownership status	Will enable us to identify barriers associated with gaining access to some lots, targeting incentives, etc.
	Accessibility for installation	Improves cost estimate of EVSE installation; proximity to appropriate wiring/circuitry is useful, otherwise installation can be expensive

Using the parameters and information in Table 6, the siting analysis will subsequently identify the potential charging opportunities, characterized by the options outlined in Table 7. The analysis will also make recommendations regarding the appropriate level of charging for each one of the recommended locations.

Table 7. Types of Charging and Potential Locations

Type of Charging	Location
Workplace charging	Commuter lots
	Commercial lots (e.g., retail)
Opportunity charging (inc. battery switch)	Retail centers
	Cinemas/movies
	Airports
	Cultural venues (e.g., stadiums)
Emergency charging	Mobile chargers
	Safety grid

As noted in Table 7, aside from what has been termed workplace charging and opportunity charging (charging characterized as an opportunity to charge when parked for more than two hours), the analysis will also consider the potential for emergency charging. One of the most straightforward ways to determine emergency charging is to identify a suitable sized grid so that a driver is never more than a defined distance (e.g., three miles) from a charger. An overlay of the proposed or existing stations and the security grid would help a planning agency identify potential areas for emergency charging. Subsequently, the planning agency could evaluate the value of various types of charging.

As noted previously in Section 6.2, the Monterey Bay has conducted a preliminary analysis of siting infrastructure using a suitability index. ICF and BAAQMD will work with AMBAG to review their approach and incorporate results as appropriate in the regional siting analysis. ICF will be coordinating with MTC to use the regional transportation demand model for the Bay Area where appropriate; however, this model does not cover the Monterey Bay. ICF will work with AMBAG, BAAQMD, MTC, and other stakeholders as needed to align the methodology used for each region to maximize compatibility.

Another issue that should be addressed in the planning and siting process is the issue of reporting protocol. Most notably, we recommend that the Plan:

- **Develop reporting protocol for publicly funded chargers**: Based on our research, local and regional agencies have expressed interest in continuing to fund the deployment of infrastructure in the Bay Area. Although projects such as the EV Project and ChargePoint America will be winding down over the next 18 months, local and regional agencies can continue to find ways to collect data on PEV driver and charging behavior by requiring data reporting as part of deployment funds.

Limited electrical capacity at parking garages

One of the areas to explore that could mitigate the issues with charging at public parking facilities identified as part of this document would be to use a technical solution such as a sequencing system. Sequencing systems could be installed to control the electrical power to multiple EVSE ensuring that the total power draw from multiple vehicles charging at multiple parking spots did not exceed the electrical capacity of pre-existing circuits at the parking facility.

This makes sense since certain PEV cars typically charge up in 1-2 hours but stay at the station for longer periods of time while they are parked. Cost of this and other options to make parking garages EV ready will be explored as part of this planning process.

Pairing smart grid technologies with alternative solutions

One of the areas that will be explored in the next phase of planning will be alternative solutions for EVSE that do not have networking capabilities to help minimize the impacts to the grid. As noted previously, many of the EVSE that are being deployed in the Bay Area and Monterey Bay Region have networking capabilities. For instance, EVSE deployed by ECOtality and Coulomb generally have excellent networking capabilities. Furthermore, many of the PEVs deployed today have onboard systems to help manage the charging of the vehicle. However, there will still be "dumb charging" taking place despite these advances and it will be necessary to identify elegant solutions to help minimize any impacts, particularly at times of peak electrical load. Solutions using email services or text messaging will be explored as part of the planning process.

Government vs. Private Industry role in mid- to long-term planning for EVSE deployment

The Ernst & Young review of the charging infrastructure industry succinctly summarizes the primary challenge that the billion dollar industry faces today: "the shape of the value chain is still unclear." In other words, the business case for a rapidly evolving charging industry is still rife with uncertainty. In the Bay Area alone, we see at least a dozen companies that are active in the charging infrastructure space, each of which have varying levels of public grant funding with varying levels of match private funding. Over the next several years, it is likely that we will see consolidation in the industry and the hope is that clear business models for publicly available EVSE emerge. The Region is well-positioned in this regard because public agencies have funded multiple demonstration projects with multiple industry players thus avoiding "picking winners".

Despite the level of interest from private stakeholders in the charging infrastructure industry, there may be a case for more public intervention into the deployment of EVSE. Publicly available EVSE is seen by some as the ultimate enabler of de-carbonizing the transportation sector by displacing petroleum with electricity.

Therefore, if the private sector cannot identify a sustainable business model whereby they receive a sufficient return on their investment while still supplying a cost-effective solution to PEV drivers, then the case for public intervention becomes much stronger. The Association of Bay Area Governments (ABAG) in particular is keen on understanding an alternative to private financing models, with the central role of siting and deploying infrastructure assumed by a public entity.

ICF has outlined the preliminary steps that would be required to analyze the potential for a public alternative to private financing for the deployment of EVSE.

- **Identify the potential signs of market failure**. Despite the concerns about the financial management and maintenance of the charging infrastructure, the sheer number of market players today indicates that there is sufficient private capital to sustain the initial deployment of EVSE over the next several years in the Bay Area. However, with grant funding running out over the next several years, the analysis should identify the market conditions or indicators that would require further public intervention in the EVSE market.
- **Identify the role and responsibilities of the public entity**. As evidenced by the variety of concerns addressed in this document, the deployment of EVSE has multiple-facets and considerations, including: permitting and installation, ongoing maintenance, siting, fees, etc. The analysis should outline the anticipated roles and responsibilities of the public entity, and how these relate to other stakeholders e.g., installers, inspectors, and EVSE providers. The financial viability of a public entity charged with overseeing the deployment of EVSE will require clear roles and responsibilities for the organization and transparent decision-making processes. Furthermore, the agency should seek ways to limit bureaucratic entanglements while actively engaging stakeholders.
- **Estimate the costs of ongoing operation**. One of the inherent assumptions regarding this analysis is that businesses will not be able to earn a sustainable ROI on infrastructure investments. The costs that are likely to be incurred through the program include: analytical siting evaluations, EVSE trouble-shooting, outreach to potential property owners and workplaces for installation of EVSE, hardware costs of EVSE, permitting and installation costs, networking and software costs for streamlined operations and management, electricity costs, and demand charges. Charging data from initial deployments of publicly accessible EVSE will be a key data input to understanding many of these costs.
- **Estimate the costs of administration**. In addition to the costs of the ongoing operation of the program, as outlined in the previous step, the administrative costs are an important factor for consideration.
- **Identify potential revenue streams to offset costs**. With most cities, counties, and local agencies facing funding constraints, the analysis of the feasibility of a publicly-funded entity to manage the deployment of EVSE should identify existing and potential revenue streams for the program. For instance, revenues from the state cap and trade program or a small fee on vehicle licensing (which is similar to the mechanism that funds the programs created by AB 118).
- **Compare benefits and tradeoffs of public entity vs. private market**. Based on the characterization of the proposed public entity conducted in previous steps, the final step of the analysis would be to identify the benefits and tradeoffs for the entity vs. private market actor(s). In other words, this final step is designed to make the case for a public entity managing the deployment of EVSE in consideration of the larger market picture.

Part B: Guidelines for Local Governments: EVSE Deployment in the Bay Area and Monterey Bay Region

There has been a variety of activities at the state and municipal levels related to PEVs and EVSE that are relevant to the deployment of PEVs and EVSE in the Bay Area and Monterey Bay Region. The following segments highlight the specific areas which will impact the siting, locating, and maintenance of charging infrastructure in the Bay Area and Monterey Bay Region. Regardless of the plan that is put in place for siting and locating charging infrastructure throughout the Bay Area and Monterey Bay Region over the next 3-5 years, the development of the PEV Ecosystem will require coordinated public and private action. These areas are introduced here and discussed in detail in each of the segments that follow.

Building Codes. The integration of charging infrastructure into buildings will require the development of building codes. Modifications to building codes can help send the right policy signals and communicate to stakeholders such as developers, electricians, and permitting inspectors that the deployment of PEV and charging infrastructure requires careful consideration.

Construction, Permitting, and Inspection. With an initial focus on deploying charging infrastructure at homes, it is essential that the installation process – including construction, permitting, and inspection – be streamlined to the extent possible without jeopardizing public safety. An expedited installation process will help ease the transition to PEVs and improve the overall consumer experience. With many areas throughout the Bay Area and Monterey Bay Region deploying residential charging infrastructure, it will be important to share the lessons learned throughout the region.

Zoning, Parking Rules, and Local Ordinances. The deployment of an effective and properly incentivized charging infrastructure will require local agencies to update zoning, parking rules, and ordinances. These three areas have many impacts on the deployment of PEVs, most notably the location and siting of publicly available infrastructure. Zoning, parking rules, and ordinances help address details such as accessibility, time restrictions, signage, and enforcement.

7. Building Codes

7.1. Introduction and Overview

The following section of the guidelines offers examples of building code amendments pertaining to EV charging station installations. Agencies can adopt building ordinance amendments as an effective mechanism to require the installation of charging stations, particularly for new construction. For instance, at the state level, the Department of Fair Housing and Community Development adopted CALGreen modifications to require all new construction of single family and multi-unit dwellings to pre-install a dedicated branch circuits for Level 2 EVSE.[65] Similarly, Assembly Bill 475 (Statues of 2011)[66] was passed which amends Section 22511 of the California Vehicle Code to read:

> A local authority, by ordinance or resolution, and a person in lawful possession of an off-street parking facility may designate stalls or spaces in an off-street parking facility owned or operated by that local authority or person for the exclusive purpose of charging and parking a vehicle that is connected for electric charging purposes.

The *Ready, Set, Charge* Document highlights two recommendations regarding the implementation of building codes. The first is related to accommodating the space requirements of EVSE and PEVs:

- Require sufficient area and electrical infrastructure for charging PEVs. Properly size all electric vehicle supply equipment, the electrical room wall, and floor area to accommodate the charging of PEVs.

In new multi-unit, commercial or industrial developments, local agencies may choose to require all conduits leading to the electrical room including electrical service conduits, and the electrical room to be appropriately sized to accommodate future electrical equipment necessary for electric vehicle charging stations, and the voltage and amperage capability of other anticipated infrastructure. As an example, Vancouver (in British Columbia, Canada) has adopted the following building by-law:[67]

> Part 13.2.1.1, Electrical Room: The electrical room in a multi-family building, or in the multi-family component of a mixed use building that in either case includes three or more dwelling units, must include sufficient space for the future installation of electrical equipment necessary to provide a receptacle to accommodate use by electric charging equipment for 100% of the parking stalls that are for use by owners or occupiers of the building or of the residential component of the building.

The second recommendation is focused on preparing areas with new residential construction for

[65] Department of Housing and Community Development, "Final Express Terms for Proposed Building Standards of the Department of Housing and Community Development," *State of California*, January 2010, http://www.hcd.ca.gov/codes/shl/ET_CALGreen_FINAL_REV%207-20-11.pdf.

[66] California General Assembly, "Bill No. 475," accessed on April 19, 2012, http://www.leginfo.ca.gov/pub/11-12/bill/asm/ab_0451-0500/ab_475_bill_20110907_chaptered.pdf.

[67] EV Infrastructure Requirements for Multi-Family Buildings: http://vancouver.ca/sustainability/EVcharging.htm; Bulletin available at http://vancouver.ca/commsvcs/licandinsp/bulletins/2011/2011-002.pdf

- Encourage single-family residential chargers and PEV “pre-wiring” readiness. Local agencies may wish to include basic infrastructure, such as conduits, junction boxes, wall space, electrical panel and circuitry capacity to accommodate future upgrades for solar systems and PEV charging.

For the purposes of this report, the emphasis is on PEV charging, rather than integration with solar systems. The importance of preparing new residential construction for PEV charging is based on issues highlighted previously, namely that most charging will likely occur at homes at night when vehicles are parked for long periods of time and when time-of-use (TOU) rates offer favorable pricing (see Section 12 for more information on TOU rates). Some local agencies have already adopted requirements that new residential developments contain basic infrastructure to capture roof top solar power. Producing renewable energy during peak use periods and charging during off-peak periods is an ideal way to power PEVs.

With regard to code development relevant to the Bay Area, California has its own California Building Code (CBC) and San Francisco uses the San Francisco Building Code (SFBC), both of which are collections of structural, mechanical, and electrical codes, and the NEC is included therein.

Electrical contractors in California are licensed by the state[68] and they must employ only state certified electricians.[69] Renewal requirements for electricians consist of 32 hours of continuing education every three years. The California Green Building Standards (CALGreen) have two tiers of voluntary standards in addition to mandatory standards. Each tier above mandatory add a further set of green building measures. The voluntary Tier 1 code includes the following requirements to accommodate Level 2 EVSE:[70]

> CALGreen, Tier 1 (Voluntary), Electric vehicle charging: One-and two-family dwellings. Install a listed raceway to accommodate a dedicated branch circuit. The raceway shall not be less than trade size 1. The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or 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.

Some cities in the Bay Area have adopted ordinances that modify the building code to account for PEVs and charging infrastructure. For instance,

- The **City of Sunnyvale** adopted Ordinance 2964-11[71] in 2011 to amend Chapter 16.43 (Green Building Code) of Title 16 (Building and Construction) of the Sunnyvale Municipal Code, by requiring pre-wiring for EVSE in new construction to accommodate Level 2 charging stations in all garages or carports attached to single family residential units, and

[68] Contractors State License Board, “Home Page,” State of California, accessed on April 19, 2012, http://www.cslb.ca.gov/.
[69] Department of Industrial Relations, “Division of Apprenticeship Standards,” State of California, accessed on April 19, 2012, http://www.dir.ca.gov/das/ElectricalTrade.htm.
[70] CalGreen, “California Green Building Standards Code,” *California Building Standards Commission*, 2010, http://www.documents.dgs.ca.gov/bsc/calgreen/2010_ca_green_bldg.pdf
[71] City of Sunnyvale, “Ordinance No. 2964-11,” accessed on April 19, 2012, http://qcode.us/codes/sunnyvale/revisions/2964-11.pdf.

12.5% of the total required parking spaces in residential developments with common shared parking.

- The **City of Milpitas** has also adopted detailed specifications for residential and non-residential EVSE into its building code based on the California Energy Code and on Underwriters Laboratory guidelines for charging stations.[72]

7.2. Gaps and Deficiencies

Survey Results: Review of Readiness in the Bay Area

Of the 44 agencies that responded to this section, 26% are involved in creating building codes, while 74% are not. Most agencies (56%) have not started or have only just started to look at how to adapt building code requirements for EVSE. Only 16% of agencies have already adopted best practice requirements for EVSE and only 25% of agencies have adopted building codes for EVSE. None of the agencies have adopted unique building code requirements for new construction.

Table 8. Progress of Building Codes

Response	Count	Percent
Adopted best practice EVSE requirements	7	16%
Not started to look EVSE requirements	20	45%
Started to consider EVSE requirements	5	11%
In the process of adopting EVSE requirements	1	2%
Looking at other agency's EVSE requirements	7	16%
Requires further information on EVSE requirements	4	9%
Total Permitting and Inspection Respondents	44	

Many jurisdictions (39%) have not developed requirements for EVSE; however, some agencies are in the process of developing requirements via their staff (14%), in consultation with other agencies (9%), and by looking at other city or agency requirements (14%). The majority of respondents (86%) would find permitting and inspection best practice references and examples helpful, but only 33% are willing to share their own best practice documents.

7.3. Concepts and Proposed Solutions

Based on the survey results, there is a significant amount of work to be done to update building codes across the region. One of the most effective ways to address this issue will be close coordination with building code officials, particularly as more EVSE is deployed in residential settings, MUDs, commercial spaces, and public places.

[72] City of Milpitas Building Safety Department, "Electric Vehicle Charging System in Single Family Residence Plan Review and Permitting Requirements," 2011, available at: http://www.ci.milpitas.ca.gov/_pdfs/bld_electric_vehicle_charging_system.pdf, and "Commercial or Multi-Family Electric Vehicle (EV) Charging Station," 2011, available at: http://www.ci.milpitas.ca.gov/_pdfs/bld_policy_constructrion_BLG17.pdf

As part of this planning effort, cost, incentives, education and best practices will be examined to determine how best to allow the Bay Area and Monterey Bay Region to update building codes to become PEV ready.

8. Construction, Permitting, and Inspection Processes for Infrastructure

8.1. Introduction and Overview

The installation of EVSE is a critical aspect of the PEV Ecosystem – it requires the consideration of construction, permitting, and inspection processes. The San Francisco Bay Area has established itself as a leader in the deployment of EVSE. The following sections highlight the industry's approach to the installation of EVSE, outlining the key steps by participants such as consumers, electricians, permitting agencies, EVSE providers, and utilities. One of the key objectives of becoming PEV-Ready is outlining a process that expedites the installation of EVSE at various locations, while maintaining the safety of consumers and the public. This requires a permitting process with a quick turnaround time (ideally 24-48 hours), low fees (between $100 and $250), and supplementary guidance to help property owners through the process.

At the municipal level, we highlight readiness activities by other cities that act as a model for other municipalities:

- The **City and County of San Francisco** has taken an active role in the deployment of EVSE, most notably through the Department of Environment.[73] They have provided information for residential installations for EVSE, including a step-by-step guide for individuals seeking to install EVSE at single family homes, public charging, and charging for business and fleets.
- The **City of Milpitas** does not require that single-family homeowners looking to install EVSE submit site plans for review prior to a building inspection. Instead, these homeowners simply schedule an inspection, during which they provide the following information to the inspector:
- The type and UL (or other approved testing laboratory) listing of the EV charging system.
- The panel rating of the existing electrical service and charging system load and circuit size.
- Whether a second electric meter installation is required due to special electric utility rates available for EV charging.
- The proposed location of the EV charging system.

  Milpitas has issued guidance to assist homeowners with preparing for an inspection, and this guidance includes diagrams illustrating typical configurations of EVSE in different garage types in order to assist homeowners with determining the proposed location of the charging system.[74]

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73 For more information, go to: http://sfenvironment.org/transportation/clean-fuels-vehicles/electric-vehicles-sf-electric-drive
74 City of Milpitas, "Electric Vehicle Charging System in Single Family Residence Plan Review and Permitting Requirements," 2011, available at: http://www.ci.milpitas.ca.gov/_pdfs/bld_electric_vehicle_charging_system.pdf

- The **City of Sunnyvale** allows homeowners in single-family residential districts to obtain permits for charging stations online provided that the station will be located within a garage and can be connected to existing electrical panels. The City has also issued guidance for EV charging stations, including a permitting checklist.[75]
- In the **City of Los Angeles**, the Department of Building and Safety handles EVSE permitting. As of late 2011, the Department of Water and Power initiated a stakeholder group to discuss ways to adapt local codes and standards that encourage deployment of electric vehicles. The city also recently approved a new online application for Electric Vehicle Charger to process permits within 24 hours.[76]
- The **City of Riverside** developed installation guidelines[77] to assist homeowners and contractors in streamlining the permitting and installation process for home EVSE. The Riverside Public Utilities provides electricity to residents.

The Cities of Gonzales and Morgan Hill also offer express or over-the-counter permits for EVSE, and Berkeley,[78] Los Altos,[79] and Sebastopol have issued guidance on installing EV charging stations to help guide property owners through the permitting process. Sebastopol's guidance applies both to single-family residences and to MUDs and commercial developments.[80]

At the county level, the County of Sonoma has issued guidelines for the installation of EVSE in that region as part of a concerted effort to install EVSE in locations that aligns with the goals of the Climate Protection Action Plan.[81] Those guidelines highlight similar issues to the ones contained in this document and other PEV readiness planning documents, including: a review of their PEV charging station program with a siting analysis, signage, installation guidelines, installation guidelines with various locations (e.g., single family and MUDs), the permitting process, and plans for public outreach plans.

Residential Installations

Before the delivery of a PEV, consumers looking to install Level 2 chargers will likely seek out a certified contractor (or coordinate through a vehicle dealership) to install EVSE at his/her residence and ensure the residence has adequate electrical capacity. In some cases, EVSE can

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75 City of Sunnyvale, "Electric Vehicle Chargers: Building Division Requirements," 2012, available at: http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CDD/Residential/Electrical%20Car%20Chargers.pdf

76 Department of Building and Safety, "Application for Electrical Permit," *City of Los Angeles*, accessed on April 19, 2012, http://ladbs.org/LADBSWeb/LADBS_Forms/Permits/ElectricalFax.pdf.

77 Building and Safety Division, "Electric Vehicle Charger Installation Guidelines," *City of Riverside*, accessed on April 19, 2012, http://www.riversideca.gov/building/pdf/handouts/EV-Charger-Guidelines.pdf.

78 City of Berkeley, "Plug-In Electric Vehicle (PEV) Residential Charging Systems Guide," 2012, available at: http://www.cityofberkeley.info/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/PEV%20guide.pdf

79 City of Los Altos, "Electric Vehicle (EV) Charging System for Single Family Residence," 2010, http://www.ci.los-altos.ca.us/commdev/building/documents/ELECTRICVEHICLECHARGER.pdf

80 City of Sebastopol, "Electric Vehicle (EV) Charging System in Single Family Residence (SFR)," 2012, available at: http://ci.sebastopol.ca.us/sites/default/files/sbd/electric_vehicle_charging_system_in_single_family_residence_0.pdf, and "Commercial or Multi-family Electric Vehicle Charging Station," 2012, available at: http://ci.sebastopol.ca.us/sites/default/files/sbd/commercial_or_multi-family_electric_vehicle_ev_charging_station_0.pdf

81 Electric Vehicle Charging Station Program and Installation Guidelines, Sonoma County, July 2011, http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf

be plugged into an existing 220 V outlet and bypass the installation process. There are a variety of permitting processes across jurisdictions, some are verbal, and others are in person or online. Sometimes the PEV owner or contractor must then obtain a permit for completion of work by a certified electrician. Nationally, EVSE target deployment markets have begun identifying ways to streamline the permitting process.

Multiple entities including PG&E, a utility provider in northern California have developed a step-by-step installation process to help new buyers of PEVs understand the requirements to charge their new vehicles. Checklists, such as the one outlined below, help residential and commercial consumers understand how to get the EVSE installation process started. The outline of the PG&E checklist is as follows:

- Contact an electrician to assess your home – an electrician will help determine if an upgrade is needed to your electrical service and what permits might be required
- Contact PG&E to start your application for a differential charging rate for your PEV – PG&E will help consumers complete their application online or over the phone. After the application is complete and the PEV delivered, the consumer must contact PG&E to make the rate change effective
- A qualified electrician will install your charging station – depending on the panel upgrade that is required, as determined by an electrician, permits and installation are completed
- PG&E identifies service upgrade requirements and associated cost – in the case of Level 2 charging, the additional load may warrant a service or system upgrade

Multi-unit dwelling Installations

Consumers living in apartment buildings and other MUDs will face more significant barriers in the process of installing EVSE, as noted previously in Section 6. The barriers arise from questions about EVSE ownership and the potential cost implications. With regard to ownership, there are multiple considerations. In many areas across the country, consumers must first determine if a charger can even be installed, which depends on policies established by the homeowner's association (HOA) or other associations making managerial decisions for the property. Based on anecdotal evidence in the Bay Area and other regions (e.g., ICF attended the Garage Free Summit in Philadelphia in February 2012), some HOAs have attempted to restrict EVSE access. These restrictions are put in place for a variety of reasons, such as equity concerns related to the potential costs for the EVSE or reserving dedicated PEV parking spaces. However, in California, the recent passage of Senate Bill 880 (SB 880, Corbett, Statues of 2012)[82] voids any policies or provisions that prohibit or restrict the installation or use of EVSE in a common interest development. Anecdotal evidence suggests, however, that the interpretation of this bill by some HOAs is leading to an additional barrier to EVSE deployment: HOAs are requiring PEV owners to pay for the installation and removal of the EVSE, which drastically increases the costs.

[82] Senate Bill 880 (Corbett), Common interest developments: electric vehicle charging stations. Available online at: http://leginfo.ca.gov/pub/11-12/bill/sen/sb_0851-0900/sb_880_bill_20120229_chaptered.pdf

8.2. Gaps and Deficiencies

Limited Guidelines outside of residential charging

With a focus on residential installations, there is a considerable amount of information available to stakeholders regarding the basics of residential deployments (most of this information is available in the guidelines developed by the PEVC as part of their Statewide best practices document). On the other hand, apart from the guidance issued by the cities of Milpitas and Sebastopol discussed above, there is limited information available regarding the construction, permitting, and inspection processes for MUDs, workplace charging, fleet and private charging, and charging at multi-use buildings. Work currently be conducted by CALSTART on behalf of the BAAQMD and SCAQMD should provide some guidance on fleet and private charging, however, is unlikely that that guidance will cover all of the issues associated with multiuse buildings or the different needs of fleets (these needs are largely dependent on fleet duty and use cycles).

Speed and Coordination

The emphasis on streamlined permitting and coordination has been well placed; however, it will be important for agencies to understand what the processes and steps are needed to streamline the process for construction, permitting, and inspection. A key challenge here will be identifying ways to streamline these processes while considering the significant resource constraints under which local and regional agencies are operating.

Survey Results: Review of Readiness in the Bay Area and Monterey Bay Region[83]

In a survey of 84 Bay Area jurisdictions, including cities, counties, and regional government, there were 63 responses (see table below). Of those respondents, over half of the jurisdictions are in the initial stages of looking into or adopting EVSE permitting and inspection requirements, while 16% have already adopted requirements and 32% have not started looking into requirements. To date, only two jurisdictions (<5%) require a unique PEV infrastructure permit. However, 60% of jurisdictions require an additional permit to trench, cut, or replace concrete and 61% require a permit for ADA compliance.

[83] Note that the survey results presented in this document are preliminary and are in draft form. The results presented will be modified in subsequent documents to reflect additional analysis and additional responses received from participants.

Table 9. Progress of Permitting and Inspection in the Bay Area

Response	Count	Percent
Adopted best practice EVSE requirements	10	16%
Not started to look EVSE requirements	20	32%
Started to consider EVSE requirements	12	19%
In the process of adopting EVSE requirements	2	3%
Looking at other agency's EVSE requirements	11	17%
Requires further information on EVSE requirements	8	13%
Total Permitting & Inspection Respondents	**63**	

In terms of the permitting process, many of the jurisdictions do not have a streamlined online process yet. Only 8% of jurisdictions responding provide online permitting applications. The most common way to provide permits is over-the-counter (75%), while 29% provide permits through a mail-in application. The primary way applicants can check the status of their applications is over the phone (76%), but some jurisdictions do provide updates online (29%) and by mail (25%). The permit application requirements vary by jurisdiction. Most jurisdictions require plans/blueprints (67%) and load calculations (56%), while some also require the applicant to notify the utility (30%). Once the EVSE has been installed, applicants can request an inspection over the phone in 70% of the jurisdictions and in person in 49% of the jurisdictions. Only 14% of the jurisdictions offer inspection requests online. The typical response to an inspection request is 2-5 days (67%), but a significant percentage (31%) of jurisdictions do offer same day inspections.

A third of the responding jurisdictions have not developed requirements for EVSE and two-thirds do not have an EVSE-specific inspector checklist. However, many jurisdictions are in the process of developing requirements via their staff (19%), in consultation with other agencies (17%), and by looking at other city or agency requirements (14%). The vast majority of jurisdictions responding (86%) would find permitting and inspection best practice references and examples helpful, but only 41% are willing to share their own best practice documents.

The type of, cost of, and time to issue the permits depends on the category of the permit – which are distinguished here as single family permits, commercial permits, parking lot permits, and on-street parking permits:

- For single family permits, 45% of the responding jurisdiction permits cost less than $100, 39% cost $101-$250, and 16% cost $251-$500, while none cost more than $500. The time to issue single family permits was generally the same day (60%) with less than 10 jurisdictions (20%) taking 2-5 days. The majority (55%) of the permits were electrical with some jurisdictions requiring both an electrical and building permit (27%). A single post-inspection was the most common requirement among jurisdictions (52%), but 21% required an intermediate and post-inspection and 19% required a pre- and post-inspection.
- For commercial permits, 47% of the jurisdiction permits cost less than $100, 29% cost $101-$250, and 24% cost $251-$500, while none cost more than $500. The time to issue commercial permits was generally 2-5 days (35%) with 30% of jurisdictions issuing same day permits and less than 10 (21%) jurisdictions taking 6-10 days. The majority (43%) of the

permits were electrical with some jurisdictions requiring both an electrical and building permit (36%). A single post-inspection was the most common requirement among jurisdictions (44%), but 31% required an intermediate and post-inspection and 18% required a pre- and post-inspection.

- For parking lot permits, 52% of the jurisdiction permits cost less than \$100, 28% cost \$101-\$250, and 20% cost \$251-\$500, while none cost more than \$500. The time to issue parking lot permits was generally same day (34%) and 2-5 days (34%), while 27% of permits took 6-10 days to be issued. The majority (46%) of the permits were electrical with some jurisdictions requiring both an electrical and building permit (35%). A single post-inspection was the most common requirement among jurisdictions (41%), but 31% required an intermediate and post-inspection and 18% required a pre- and post-inspection.
- For on-street parking permits, 60% of the jurisdiction permits cost less than \$100, 25% cost \$101-\$250, and 16% cost \$251-\$500, while none cost more than \$500. The time to issue on-street parking permits varied widely from same day (31%) to 2-5 days (31%) to 6-10 days (31%), but only 6% took 3-5 weeks. The majority (41%) of the permits were electrical with some jurisdictions requiring both an electrical and building permit (33%) and a smaller percentage (18%) requiring planning entitlement. The inspection requirements for on-street parking permits among jurisdictions varied between a single post-inspection requirement (37%), an intermediate and post-inspection (37%), and a pre- and post-inspection (20%).

Table 10. Estimated Fees for Various EVSE Permits

Permit fee	Residential		Commercial / MUD		Open parking lot		On-street parking	
<\$100	22	45%	26	47%	28	52%	34	60%
\$101-\$250	19	39%	16	29%	15	28%	14	25%
\$251-\$500	8	16%	13	24%	11	20%	9	16%
\$501+	0	0%	0	0%	0	0%	0	0%
total	49		55		54		57	

Table 11. Time to Issue Permits for EVSE

Time	Residential		Commercial / MUD		Open parking lot		On-street parking	
2-5 days	9	20%	15	35%	14	34%	11	31%
3-5 weeks	2	4%	6	14%	2	5%	2	6%
6-10 days	8	17%	9	21%	11	27%	11	31%
Same day	27	59%	13	30%	14	34%	11	31%
total	46		43		41		35	

Table 12. Inspections Required for EVSE Installations

Time	Residential		Commercial / MUD		Open parking lot		On-street parking	
Intermediate & post-inspection	9	21%	12	31%	12	31%	13	37%
More than 1 pre-inspection	2	5%	2	5%	3	8%	2	6%
Plan check only	1	2%	1	3%	1	3%	0	0%
Post-inspection	22	52%	17	44%	16	41%	13	37%
Pre- & post-inspection	8	19%	7	18%	7	18%	7	20%
Total	42		39		39		35	

8.3. Concepts and Proposed Solutions

Compilation of Lessons Learned

Targeted outreach to and interviews with EVSE providers and stakeholders that are deploying infrastructure in the region will be the most effective methodology to understand the issues that they are confronting regarding construction, permitting, and inspection.

- Initial feedback from 350Green indicates that there are multiple sets of guidelines (e.g., CA Interim 97-03, *Ready, Set, Charge!*, ICC Tri-Chapter, etc.) that are regularly presented to them; and in some cases, the municipality introduces its own requirements. They have identified permitting as one of the two biggest barriers to installation (ADA compliance is the other). 350Green reports that the ideal scenario for Level 2 permits would be over the counter permitting, with the charging station treated like a fueling station, which would only require the installer to provide access to the charging station and not at the front entrance of the building. With regard to permitting, some cities that 350Green has worked with consider the PEV charging station to be outside of the normal scope of business and require a use permit. This can increase the cost of permitting significantly. For instance, the City of Berkeley charges $1,800 for a use permit, which makes the installation of Level 2 EVSE cost-prohibitive. 350Green recently deployed the first DC fast charger at the Stanford Shopping Center in Palo Alto (April 2012), so their experience there will also yield valuable information regarding permitting for DC fast charging.
- Better Place is going through a rigorous siting exercise as part of the deployment of its battery switch stations in San Francisco. The construction and permitting requirements for a battery switch station are more significant than those for other EVSE, so this will provide a valuable "upper limit" of sorts with regard to the challengers and barriers that stakeholders face on the ground.
- As part this portion of the planning document, methodologies to reduce the costs of EVSE permitting and decreasing the amount of time to obtain a permit to the DOE's targeted 24 to 48 hour will be investigated. It will be necessary to look at the variation in costs between jurisdictions and to establish how such costs could be brought into line. It will also be necessary to understand how the widespread variation in costs for permits is justified by the jurisdictions charging at the higher end of the permitting spectrum. Cost, incentives,

education and sharing of best practices will all be investigated as part of the planning analysis.

9. Zoning, Parking Rules, and Local Ordinances

9.1. Introduction

As part of a region-wide PEV readiness, Local governments have or will need to implement ordinances or policies to facilitate the access and use of publicly available charging infrastructure. Such policies generally address signage (surface street directional signs and parking facility signs), charging infrastructure installation that incorporates accessibility guidelines, and parking facility policies.

Zoning

Zoning code provisions can encourage appropriate placement of electric vehicle supply equipment (EVSE) in various land-use designations. Zoning code provisions also include requirements regarding purpose, definitions, allowed uses, design and installation criteria, signage, accessibility, quantity, lighting and maintenance.

Local agencies should specify where EVSE is allowed as an outright permitted use, or as an accessory to an outright permitted use, and if applicable, specify which EVSE (Level 1 or Level 2, DC fast charge, and Battery Switch) apply. Suggestions for these criteria are located in the *Ready, Set, Charge* document[84] and PEVC statewide guidelines. Local agencies can also encourage, require, or incentivize EVSE installation through the parking requirements and other provisions within their zoning code.

Parking requirements for PEVs

Local governments routinely specify the amount of parking required for different land uses, often in the form of the minimum amount of parking spaces per dwelling unit or per employee. Communities seeking to accelerate PEV deployment may wish to consider implementing minimum requirements for PEV parking and charging stations.

Ordinances should also be amended to require EVSE for new developments within various land uses, and in existing large parking facilities. PEV adoption is still in its infancy, so available data are scarce with respect to the number of EV charging stations that should be required for a specific development. Ordinances should strive for a balance that achieves an appropriate amount of incentive for PEV use, but do not burden a developer or property owner with onerous, unjustified EVSE requirements. Agencies should consider adopting an ordinance similar to that offered by the City of Mountlake Terrace, Washington[85] or an ordinance which incorporates the guidance provided by the California Green Building Standards Code (CALGreen), Section A5.106.5.3 Electric Vehicle Charging (page 90, voluntary measures). Sample PEV parking requirements from the *Ready, Set, Charge, California!* report[86] are shown in Table 13.

[84] *Ready Set Charge California, A Guide to EV-Ready Communities,* November 2011, Section 3.2, available online at www.readysetcharge.org /
[85] *Ibid.,* Section 3.2.2., Page 20, Table C
[86] *Ibid*., Table B, Section 3.2.1

Table 13. Sample requirement for PEV Charging

Land Use Type	Percent dedicated to PEV parking/charging
Multi-Family residential	10%
Lodging	3%
Retail, restaurant	1%
Office, medical	3%
Industrial	1%
Institutional, Municipal	3%
Recreational, Entertainment, Cultural	1%

These requirements should be considered as a starting point for new developments of a certain size, or expansions (over a certain percentage) of existing facilities. The requirements should allow for an exemption if the applicant can provide reasonable evidence that the PEV parking and charging exists in the vicinity that can be used to reduce these requirements. As an option, ordinances can be amended to require installation of certain infrastructure (e.g. conduit, wiring, junction boxes, electrical panels and circuitry) to serve this level of PEV charging, but only provide a lesser actual number of charging stations. The cost of installing EVSE with pre-existing wiring is one third the cost of having to add wiring during installation. This would significantly lower the costs of installing more chargers to meet increased demand in the future.

Counting PEV parking toward parking requirements

Local governments with minimum parking requirements in place may also wish to consider whether PEV parking should count toward overall parking requirements. Allowing PEV parking to count toward parking requirements would allow developers to provide PEV parking without increasing the total number of spaces required. Such a policy should be considered carefully, so as to avoid parking shortages and potential traffic congestion that may result.

Zoning incentives

Local governments routinely offer developers the opportunity to develop more intensively than zoning codes typically allow in exchange for a contribution to environmental mitigation or public facilities. Instead of requiring dedicated PEV parking, local governments can use this tactic to create incentives for developers to provide PEV parking by allowing more intensive development in exchange for providing PEV spaces.

The City of San Carlos has amended its zoning code in order to create incentives for developers to provide charging stations in mixed use areas. Section 18.05.030.A of the San Carlos Municipal Code allows developers to exceed the maximum allowable floor area ratio by 10% if they provide additional environmental design features on-site or contribute to off-site improvements at open spaces or public facilities. The code lists "electric car facilities" as one of the on-site features that developers can include in order to qualify for this exemption.[87]

Design Criteria

PEV parking and charging spaces should be the same size as standard parking spaces or accessible parking spaces, whichever is applicable. Lighting should comply with local codes at a minimum. Where no local codes apply, criteria should be specified to provide enough lighting to provide visibility of cables, charging equipment and vehicle charging points.

Parking Rules

Parking rules for PEV charging stations should address minimum parking requirements, accessibility, time restrictions, parking supply, location, and preferential parking programs. The PEV Collaborative[88] suggests that a distinction be made between PEV *Charging* and PEV *Parking*. PEV parking should be defined as parking that is preferentially provided to users of PEVs (whether or not charging is provided) while a PEV charging site provides the location where EVSE is available for the purpose of charging the PEV.

Accessibility

PEV charging and PEV parking are different services and should have different accessibility requirements. Accessibility is addressed here for three scenarios: where PEV parking is provided, where PEV charging is provided, and where both are provided and co-located.

PEV Parking should meet the accessibility requirements as parking for other vehicles. Newly constructed facilities and existing facilities that undergo alteration must meet accessibility requirements as found in the Americans with Disabilities Act (ADA) Accessibility Guidelines, the California Building Code, and the California Department of General Services.

Regarding PEV Charging, this plan adopts the general recommendations of the PEV Collaborative[89], which address accessibility of EVSE charging device itself, as well as the path of travel from the vehicle to the EVSE. Recommendations are provided by the PEV Collaborative for new construction as well as for installation of accessible EVSE in existing facilities, including on- and off-street.

Where PEV parking and charging are co-located, the rules for PEV charging (as noted above) would apply.

Time Restrictions

PEV parking should be subject to similar time restrictions as parking for other vehicles in the same area, whether on or off-street[90]. This recommendation also applies if PEV parking and charging are provided at the same location. If PEV charging and parking are provided in a time-

[87] City of San Carlos, City of San Carlos Municipal Code, Development Standards for Mixed-Use Districts, Section 18.05.030.A, revised April 2012, available at http://www.codepublishing.com/CA/sancarlos/

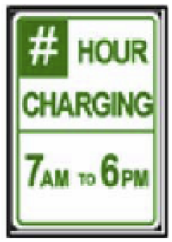
[88] *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure*, PEV Collaborative, May 2012, available online at http://www.evcollaborative.org/sites/all/themes/pev/files/AccessibilityReport-4%2726%20final.pdf

[89] *Ibid*, *p.13.*

[90] A relaxation of existing time restrictions can be considered to incentivize PEV use but this should be considered as a short-term measure.

restricted zone, it is recommended to specify a location with a time restriction of no less than two hours, and to forego a restriction on charging (since the parking time restriction would apply). If PEV charging and parking can only be provided where existing parking is time-restricted to less than two hours, then the restriction on the PEV parking space(s) should be modified to a two-hour restriction.

Figure 6. Example of Sign Displaying Time Restriction on PEV Charging



Location

The location of PEV parking and charging should take into consideration the following, in order of decreasing importance:

- **Accessibility**: If PEV charging/parking needs to be accessible then the location will be dictated by accessibility requirements.
- **Convenience, visibility and safety**: PEV parking and charging should be located such that is easy to locate and convenient and safe to access. To incentivize PEV use, agencies should consider locating PEV parking in a more convenient (i.e., closer to destinations, garage exits and elevators, on lower floors of garages, etc.) location relative to parking for other vehicles.
- **Cost**: PEV charging supply infrastructure (i.e., conduit and wiring) will cost more the farther it is away from the point of connection to the utility service. PEV charging should be located as close to that point of connection as possible.

Preferential Parking Programs

As a means to incentives adoption of PEVs by the public, preferential parking programs should be considered. Parking location-based incentives are discussed above. Cost-based incentives can also be considered. Examples include the following:

- **City of San Jose, Clean Air Vehicle Parking Program**: A temporary incentive that provides free parking for qualifying vehicles in city-owned garages, parks, and downtown.
- **Preferred Parking at San Francisco International Airport (SFO)**: SFO offers preferred parking for PEVs. The charging is currently free for users. The facility has both Level 1 and Level 2 chargers, installed as part of the ChargePoint America program.

Signage and Enforcement Considerations

Signage is needed to help PEV users locate and identify charging stations, and to provide direction regarding how the PEV charging station is to be used. Local authorities have had the flexibility to develop publicly-accessible EVSE signage independently to suit the needs of the community; however, local authorities generally attempt to align signage with the Manual on Uniform Traffic Control Devices (MUTCD) in the Code of Federal Regulations. For public charging purposes, local authorities must implement general service and regulatory signage according to the California MUTCD. Anecdotal evidence from EVSE deployments indicates that in some instances the signage employed by local authorities has created confusion, particularly in areas where the public did not understand the nature of a PEV parking stall, did not understand the need to maintain accessibility for PEVs, and misidentified the designated spots for handicap parking.[91] The early PEV deployment and EVSE deployment efforts nationwide, such as The EV Project, have encountered difficulty with regard to signage.

For that reason, this report takes the position that signs placed in the public right-of-way for the purposes of guiding PEV users to charging stations and regulating their use are considered traffic control devices and must (signs in the private right-of-way should as well) conform to the Manual on Uniform Traffic Control Devices (MUTCD) in the Code of Federal Regulations (CFR).

The PEV Collaborative in May 2012 released a document that offers guidance on signage based on the input of several stakeholders, and on their experience with PEV installations to-date.[92] This document, as does the PEV Collaborative, supports the use of standardized signs to minimize confusion and provide the greatest convenience to PEV users. This includes standardized signs that have interim approval from FHWA, and signs that are not currently approved but have been submitted for approval and are currently being tested in Oregon and Washington.

Figure 7. FHWA-approved PEV General Service Symbol and Sample Parking Sign[93]

The issues related to accessibility and parking enforcement discussed elsewhere in this section may require additional signage at parking spaces. It is important to keep this signage simple and clear in order to provide clear signals to drivers.

Enforcement

In order for regulatory signs to be enforceable, they must be supported by local ordinances that specify time limits, penalties, definitions, etc. Definitions of terms are key to identifying precisely

[91] The EV Project, "Lessons Learned – The EV Project EVSE Signage," *ECOtality*, April 2012.
[92] *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure*, PEV Collaborative, May 2012, p.30
[93] Ibid.

who can park and charge at PEV charging stations. Suggested definitions have been offered by the PEV Collaborative[94] and by ABAG and others[95].

AB 475, passed in October 2011, requires that a PEV charging spot be properly identified with signage, and allows for the owner of the space to remove illegally parked vehicles (in accordance with the law). The CVC also allows the owner of a space to remove a vehicle if it occupies a space in violation of posted regulations, after appropriate notification to the vehicle owner and to local law enforcement.

Marin County recently adopted a series of amendments to its county code focused on electric vehicle parking that address several of the issues discussed above. The code now includes an electric vehicle charging station parking stall designation and states, "It shall be unlawful to park in a designated electric vehicle charging station parking stall unless the vehicle is a charging electric vehicle." The amendments also allow the Board of Supervisors to levy fees on PEV owners who use public charging stations.[96]

It is recommended that local governments and property owners implement signage recommendations identified in the previous section, and as a parallel action, work to modify municipal codes as necessary to make the signage enforceable, and to ensure that the ordinances are understood by those responsible for enforcement.

9.2. Gaps and Deficiencies

As PEV adoption continues, issues will continue to present themselves and these recommendations will need to be considered for amendments. The recommendations herein are an attempt to ensure that enough PEV charging is provided to incentivize PEV use but to avoid being onerous and causing significant oversupplies of EVSE.

Implement parking requirements

One obvious example is the requirement for a certain number of PEV charging stations for new construction and for expansion of existing construction. Planners currently have a good understanding of how much parking is generally needed by different land uses, and this understanding continues to improve as we gather more parking data from sites. Because PEV use is in its infancy, there is little data on how much PEV parking and charging need to be provided, however, some initial guidance is provided by the California Green Building Code, *Ready, Set, Charge* and the PEVC that should be used as initial guidance for local jurisdictions. It is likely, however, as the number of PEV increases over time that these guidelines will need to be amended and new standards be developed and implemented.

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[94] *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure*, PEV Collaborative, May 2012, p.35
[95] *Ready Set Charge California, A Guide to EV-Ready Communities,* November 2011, Section 3.1, available online at www.readysetcharge.org
[96] County of Marin, Ordinance No. 3572. November 15, 2011, available online at http://www.co.marin.ca.us/depts/BS/Main/BOSagmn/ordinances/ord-3572.doc

Signage, zoning, and accessibility requirements

It is also likely that signage and zoning requirements will be revisited once agencies begin to enforce new public EVCS parking rules, and parking citations begin to be challenged in court. Examples of potential issues include the following:

- AB 475 requires EVSE providers and installers to mount a sign that states, “Unauthorized vehicles not connected for electric vehicle charging purposes will be towed away at owner’s expense. Towed vehicle can be reclaimed at ____.” However, the CA Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations states, "An information sign must be posted which reads, “Parking for EV Charging Only; This Space Designed for Disabled Access; Use Last.” To streamline signage requirements, EVSE providers will need reconciliation and clarification on the intent of each requirement so that unnecessarily complicated signage is not installed.
- Regarding ADA compliance, 350Green reports that some cities in the Bay Area require ramps, alter slope, or other significant and potentially costly modifications. Although the CA Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations carry no jurisdiction over local municipalities, the guidelines do state that "for installation at an existing site, an accessible path of travel is required to the extent that the cost of providing such path does not exceed 20% of the cost of the EV equipment and installation of all EV charging stations at the site, when such valuation does not exceed the threshold amount referenced in Exception 1 of Section 1134 of Title 24." Based on 350Green’s experience, many cities do not abide by the 20% cost consideration. As a result, the installation becomes cost-prohibitive.
- The potential for "camping" at charging stations i.e., prolonged use at a particularly spot where EVSE is available. For instance, at airport parking garages where PEVs might be parked for days at a time while plugged into the charging station, the vehicle is charged in a matter of hours but the driver is traveling and the vehicle is camped in the spot. These stations are not available to other users and, even worse, they count towards the total service coming into the garage even though no electricity is flowing through them once the vehicle is charged. The result is that parking lots end up with much more service than they actually require when they allow long-term PEV parking. If an entity wants to enforce a time restriction on charging in a parking zone where there are no time restrictions on parking, it is not clear how the charging time restriction would be enforced.
- In a residential area where a Residential Permit Parking program is in place (where parking is time-restricted except those with a residential permit), it is not clear whether a public PEV charging station could be reserved for residents only.

Survey Results: Review of Readiness in the Bay Area

There were considerably fewer respondents to this section of the survey, with only 22 agencies responding. Of the respondents, only 21% are involved in creating zoning and parking ordinances, while 79% are not. Most agencies (59%) have started considering zoning and parking ordinances or are looking other agency’s ordinances. Only two of agencies have already adopted best practice requirements for EVSE and approximately 14% of agencies responding have not yet started looking into zoning or parking ordinances. Of the two agencies that have existing EVSE zoning and parking ordinances, both include ADA compliance.

Table 14. Progress of Zoning and Parking Ordinances

Response	Count	Percent
Adopted best practice EVSE requirements	2	9%
Not started to look EVSE requirements	3	14%
Started to consider EVSE requirements	7	32%
In the process of adopting EVSE requirements	1	5%
Looking at other agency's EVSE requirements	6	27%
Requires further information on EVSE requirements	3	14%
Total Permitting and Inspection Respondents	22	

Many jurisdictions (31%) have not developed zoning and parking ordinances for EVSE; however, some agencies are in the process of developing requirements via their staff (13%), in consultation with other agencies (2%), and by looking at other city or agency requirements (2%). All agencies (100%) would find zoning and parking ordinance best practice references and examples helpful, but only 33% are willing to share their own best practice documents.

9.3. Concepts and Proposed Solutions

Develop recommendations for PEV parking requirements

Based on feedback from multiple EVSE providers, some cities are operating under the impression that PEV parking does not count toward overall minimum parking requirements. 350Green reports that as a result of this interpretation, there have been instances where they could not install EVSE. The PEV Readiness Plan could clarify whether PEV parking should count toward required minimums and expand on recommendations for number of parking spots that should be reserved for EV parking.

An alternative or complementary initiative to reserving a specific number of parking spots for EV charging would be to require the provision of infrastructure (e.g., conduit, wiring, junction boxes, electrical panels and circuitry) for a minimum number of charging stations. In this situation, the developer or parking manager could install fewer actual charging stations, providing compliance flexibility. This initiative will draw from CalGreen, which recommends parking counts for low-emitting, fuel-efficient vehicles (Section A6.106.5.1) and recommendations for PEV supply wiring for PEV charging (Section A6.106.5.3).

Normalization of parking rules and local ordinances

As noted by many stakeholders, consumers across jurisdictions will invariably share their experiences regarding charging in public places. Furthermore, it is in the best interest of the entire region to ensure that there is an appropriate and equitable distribution of EVSE; onerous zoning ordinances or mismatched parking rules will create more problems for EVSE providers and result in them potentially overlooking certain areas for siting infrastructure without serious modifications. As a result, local jurisdictions may wish to normalize their parking rules and ordinances to the extent possible – this effort will send a clear market and policy signal to EVSE providers to ensure appropriate geographical distribution of EVSE.

As part of the planning process, normalization of zoning ordinances, costs for ordinance updates, incentives, education and sharing of best practices will be explored as methods to determine how best to align local jurisdiction's zoning, parking and ordinance requirements to support PEV readiness.

Part C: Other Areas Requiring Planning for EVSE Deployment

Although the focus of the planning efforts is to upgrade and update local government structures that support PEV and EVSE deployment, it is also important that other areas are addressed to ensure the Bay Area and Monterey Bay Region become PEV ready. These include the following:

Stakeholder Training and Education. PEVs and the supporting charging infrastructure are new technologies. With any new technology, it is important for stakeholders such as electricians, permitting agencies, building inspectors, and first responders to receive the training and education required to ensure public safety and minimize the barriers to widespread adoption. Training and education are low-cost, high-reward investments that local and regional agencies can make to help support the deployment of PEVs and EVSE.

Consumer Marketing, Outreach, and Education. Federal, state, and local governments are doing their part to support the deployment of PEVs via financial and non-financial incentives. While many consumers may be aware of these incentives, it is important that these same agencies work together with the private sector to communicate the benefits of PEVs to a broader audience and share the initial lessons learned from deployment.

Minimizing Grid and Utility Impacts of PEVs. The economic and environmental benefits of using electricity to displace gasoline in the transportation sector are dependent on a reliable and clean electrical grid. Research by academic institutions, federal agencies, and utilities indicates that the electrical grid will be able to meet the demand for electricity from the deployment of PEVs over the next several years. However, the accelerated adoption of PEVs may cause challenges in some areas and will require careful planning by utilities. For instance, it will be important to identify pricing and control signals that will enable consumers to charge their vehicles in a cost-effective manner while minimizing the impacts on the grid. Furthermore, as the adoption of PEVs gain traction, it will be important to plan for next-generation issues such as the integration of renewable energy with PEVs or the potential for vehicle-to-grid applications.

Each of these additional planning areas as discussed in greater detail below.

10. Stakeholder Training and Education

10.1. Introduction and Overview

Training and education enables local officials to become familiar with electric charging infrastructure (for inspection and maintenance purposes) and to understand the safety implications of vehicles and chargers. Other programs train electrical contractors in charging equipment installation.

There are already a number of organizations and stakeholders that are leading efforts at the national, state, and regional level to train stakeholders. For instance:

- The Electric Vehicle Infrastructure Training Program (EVITP): The EVITP is a 24 hour course set up to train and certify electricians throughout California to install residential and commercial scale EVSE. The training program addresses the technical requirements, safety imperatives, and performance integrity of industry partners to ensure that the equipment is properly installed and maintained using the highest quality standards.
- Clean Cities – At the national level, Clean Cities has developed a 30-minute online presentation for electrical contractors and inspectors regarding EVSE residential charging installation. This online video covers a broad spectrum of topics aimed at informing electrical contractors of the key issues related to residential EVSE. The presentation begins with the history and evolution of the EV market and briefly summarizes the benefits of EVs. Then the presentation dives deeper into the responsibilities of electrical contractors and the details of the system setup, codes and standards, specific equipment and parts, types of stations, and safety. The presentation also touches on the importance of project management and communication with the utility and customer.
- The Green Team (Silicon Valley Clean Cities Coalition, Breathe California, and the Electronic Transportation Development Center, ETDC) is offering a series of green transportation technical classes taught by the stakeholder member Green Transportation Workforce Development, Inc (GTWD).The target audience for the workforce development training is fleet technicians, automotive shops, returning veterans, and hobbyist. The following four 50-hour classes are offered: electric vehicles, hybrid electric vehicles, compressed natural gas vehicles, and infrastructure.
- California Plug-in Electric Vehicle Collaborative: The PEV Collaborative is working to launch a PEV Resource Center that will provide answers to key issues. The PEV Resource Center

EVITP Training Agenda

- Overview of Electric Vehicles
- Types of Electric Vehicles—Past and Present
- Electric Vehicle Manufacturers
- Electric Vehicle Charging Unit Manufacturers
- Utility Policy and Integration
- Electric Vehicle Rules and Regulations
- Electrical Vehicle Charging Site Assessment
- Electric Vehicle Charging Stations and Charging Load Requirements
- Code Officials and Inspection
- Electrical Codes, Safety Requirement, Other Regulations and Standards
- Electric Vehicle Charging Installations
- Renewable Energy and Electric Vehicles
- First Responders
- Customer Code of Excellence/Contractor's Role; Electricians Role
- Field Installation Practicum (Lab)
- Electric Vehicle Certification Phase One (Lab)

is currently under construction but is anticipated to be live sometime in 2012. The PEV Resource Center Website Will Target the Following Audiences:

- Vehicle Consumers and Homeowners
- Local Government Officials
- Fleet Managers
- Infrastructure and Electrical Contractors
- Emergency First Responders
- Educators and Instructors

In 1994 the California Community Colleges Chancellor's Office through its Economic and Workforce Development Program created the Advanced Transportation Technology and Energy (ATTE) Initiative in order to maintain California's competitiveness as a national leader in advanced transportation and energy technologies through the development and continuous improvement of technical education at community colleges throughout the state. Since that time the ATTE has served California's transportation and energy technology businesses through a myriad of program and workforce training activities. The ATTE program is offered by several community colleges throughout California and provides 8 to 16 hour courses on:

- Hybrid Electric, Electric, and Gaseous Fuels Vehicle Identification
- Fundamentals of Hybrid Electric, Electric, and Gaseous Fueled Vehicles
- Vehicle components
- Alternative Fuels Infrastructure, Transport, Stations, and Safe Handling
- Equipment Identification for HEVs and Other Alternative Fueled Vehicles
- First Responder Procedures for:
  - Police (securing the area, recognizing the potential hazards, protecting the public, etc.)
  - Firefighters (General Firefighting Measures, etc.)
  - Other Emergency Personnel

10.2. Gaps and Deficiencies

Outreach to Dealers

In most cases, dealers are delivering sound and robust advice to potential PEV consumers, particularly with regard to residential EVSE deployment. However, anecdotal evidence suggests that some initial PEV deployments, and associated EVSE installations, are being performed without the assistance of an electrician and without the required permit. When this happens, it can create a couple of problems. Firstly, these types of cases establish a bad precedent and provide dealers to communicate potentially inaccurate information, thereby perpetuating risk and misinformation regarding the deployment of EVSE. Furthermore, these types of ill-advised situations can cause problems and additional confusion regarding other aspects of the PEV ecosystem e.g., the permitting and installation process and the utility notification.

At this stage, the degree to which this issue may impact (or has impacted) PEV deployment is not well understood. As such, further research is required, particularly performing at least initial outreach to dealers.

Coordinated Stakeholder Education

As outlined in the previous subsection, there are many efforts that have been initiated at the state and regional level to educate stakeholders. As more local and regional agencies seek to educate themselves about the PEV ecosystem, a more coordinated effort will be required by prioritizing the most likely early- and mid-adopter regions. Jurisdictions of these regions should be educated on the available training courses and resources available to them from local community colleges, the DOE Clean Cities and other jurisdictions.

10.3. Concepts and Proposed Solutions

Develop Schedule for Stakeholder Training and Outreach

The diversity of local governments in the Bay Area and Monterey Bay Region makes it difficult to coordinate stakeholder training and outreach. Furthermore, with limited time available, it will always be a challenge to engage stakeholders. However, a regular schedule that is posted to participating agency's websites and advertised on e-mail listservs and other distribution lists will be useful. The cost of the training sessions through an organization such as the EVITP is very affordable – the organization is run by volunteers and typically the cost is to cover the time and travel of a certified instruction, with an estimate price range of $800-$1,450. Based on the interest expressed in the survey responses across the many facets of PEV readiness planning, ICF anticipates significant interest in these sessions, with enough stakeholders to justify three to four sessions per year for the next 12-24 months as PEVs are deployed in larger numbers. Assuming a maximum of eight (8) sessions over the next two (2) years, and using the cost estimates provided by EVITP as a proxy, the estimated cost is between $6,400-$12,000, which is a modest investment with potentially significant returns. In the next phase of the readiness planning, ICF and BAAQMD will identify potential sources of funding to cover the costs of training sessions and identify organizations that are capable of doing the training.

11. Consumer Education for PEVs

11.1. Introduction and Overview

The introduction of new technologies like PEVs requires careful coordination and outreach to consumers. The familiar aspects of car ownership – such as vehicle pricing, fuel pricing, vehicle range, availability of refueling infrastructure – are all changed to varying degrees with PEV ownership. With a focus on providing the market and policy signals at the federal and state level through incentives for vehicles (e.g., tax credits and rebates) and for infrastructure (e.g., through The EV Project or the Home Charger Rebate Program), it is incumbent upon local and regional agencies to provide key, high-level messages that highlight PEV availability and benefits, including total cost of ownership, environmental, health, and community benefits.

At the national level, NREL developed a Vehicle Cost Calculator,[97] which allows users to calculate the purchase price, fuel costs, repair and maintenance costs, and applicable tax incentives, as well as the cost and emissions savings associated with purchasing PEVs compared to the costs associated with conventional vehicles. Furthermore, NREL has provided the option to organizations to host a simplified version of the tool by placing the Cost Calculator widget[98] on their own webpages. Similarly, both the DriveClean website (hosted by ARB) and the California PEVC website host calculators.

Many communities in the Region have already started local outreach campaigns. For instance, Sonoma County has been particularly proactive via community outreach and education campaigns through the Sonoma County Local Governments Electric Vehicle Partnerships. Similarly, the San Francisco City and County government has been actively promoting PEVs through outreach and education, primarily through the Department of Environment. The city maintains a resource for information on electric vehicles called SF Electric Drive. PG&E has also done outreach and education to its consumers to help make them aware of the best rate plans for home charging and stressing the importance of coordination with the utility to make sure that the grid can accommodate increased demand.

At the regional level, MTC and BAAQMD are collaborating to develop a *Go EV Campaign*, which will be implemented in coordination with a consultant (or consultant team) starting in the 3rd Quarter of 2012. The effort will be a promotional campaign aimed at building awareness, action and demand for PEVs (including both BEVs and PHEVs) in the Bay Area. One of the primary objectives of the campaign is to communicate the potential of PEVs to displace gasoline and save consumers money, stimulate the local economy, create jobs, and reduce GHG emissions and improve public health. The specific goals of the Campaign include:

- **Education** of Bay Area residents about electric vehicles, including vehicle operation, differentiation between vehicle types and vehicle charging (e.g., charging station locations, charge times, miles per charge, etc.);

[97] Available online at: http://www.afdc.energy.gov/afdc/calc/
[98] Available online at: http://www.afdc.energy.gov/afdc/widgets/

- **Behavior change** of Bay Area drivers to purchase PEVs or use PEVs when offered the choice;
- Development of **core messages that create awareness** of the benefits of the use of PEVs (e.g., cost savings, convenience, regional economic and job benefits, environmental and health benefits, “fun to drive” and “cool factor”);
- Continuation of the promotion of the Bay Area identity as a **center for high tech and green culture**;
- Identification of **prominent individuals/organizations to deliver campaign messages**, including civic and business leaders, PEV-related companies, auto companies, cities (e.g., San Francisco and San Jose), regional public agencies, environmental groups and prominent EV drivers (e.g., George Schultz, Gavin Newsom, etc.); and
- **Motivate individuals** to reduce their contribution to Bay Area GHG emissions.

11.2. Gaps and Deficiencies

Lack of a Centralized Resource

There are many stakeholders in the Region engaged in the deployment of PEV and EVSE, including public and private actors. The initial deployment of PEVs in the Bay Area has confirmed analysts’ and industry observers’ forecasts about the importance of the Region. However, one of the negative consequences of its position as a market leader in PEV and EVSE deployment is that the sheer volume of stakeholders has led to a lack of centralized resource. As a result of limiting centralized resources e.g., a clearinghouse of lessons learned, some stakeholders are increasing the barriers to EVSE deployment. For instance, in its efforts to deploy EVSE to support its efforts to deploy PEVs in its fleet, City Carshare has taken on the role of educating stakeholders such as parking management companies. The need to educate certain stakeholders has increased the time to deploy EVSE significantly; in some cases, City CarShare has had to engage in a back-and-forth for up to 4 months, adding to an already potentially bureaucratic process.

The PEV ecosystem is complicated and requires coordination across multiple private and public stakeholders; the observation of a missing centralized resource should not be misconstrued as a criticism of the efforts underway. Rather, the observation is that the lessons learned from the existing efforts – from residential and nonresidential EVSE deployment to the potential for the electrification of MD and HD vehicles – should be shared more openly and communicated more effectively.

Regional multi-stakeholder groups such as the EV Strategic Council have started to reverse this trend, and in principle, this PEV Readiness Guide will ultimately provide the region with a centralized resource.

11.3. Concepts and Proposed Solutions

The impending *Go EV Campaign* and the final PEV Readiness Plan for the Bay Area and Monterey Bay Region should be sufficient in the near term future (e.g., the next two years) to fill the gaps and deficiencies identified in the previous subsection.

12. Minimizing Grid and Utility Impacts

12.1. Introduction and Overview

The widespread deployment of PEVs presents an opportunity for electric utilities to increase asset utilization through increased electricity use, potentially reducing overall electricity rates. One of the primary concerns associated with PEV deployment is the potential negative impact from the increased load on the local electric grid. The degree of the impact depends on parameters such as PEV penetration rates, the current condition of local distribution infrastructure, and strategies used by the local utility to manage additional load. Utilities across the country have implemented a wide variety of pilot projects and assessments to better understand consumer usage patterns and how certain management tools, such as smart meters, may mitigate impacts on the grid. Through the use of tariff structures and incentives, utilities are actively seeking solutions to shift PEV charging to periods of lower electrical demand, typically known as off-peak hours.

The following subsections review the key issues that must be addressed to minimize the grid impacts of PEV deployment. We first consider the potential impacts of PEV deployment on the grid, focusing on the **load and transformer impacts**, with implications for the San Francisco Bay Area highlighted to the extent possible. Following the review of potential impacts, we review the **pricing and incentives** that utilities are employing to minimize the impacts of PEVs in the near-term, as well as the importance of **utility notification** in the planning process. Finally, we consider the integration of **renewable energy** purchasing or deployment with the charging of PEVs.

As the largest utility in the Bay Area and Monterey Bay Region, Pacific Gas & Electric (PG&E) has taken a leading role in PEV readiness. PG&E has worked closely with local and regional stakeholders to communicate the importance of utility notification protocols for new EVSE installations, particularly in residential applications. PG&E has proposed two new PEV rates that is aligned with the goal of PEV customers using more electricity to charge on the off-peak hours, EV-A and EV-B. Both PEV rates are non-tiered, which means that the cost of electricity does not increase the more electricity you consume as is typical for all other residential rates. Thus, the PEV rates do not discourage increased electricity consumption for EV purposes. EV-A is a “whole-house” rate and designed so that customers do not need to install a separate meter to monitor the PEV electricity consumption. Instead, under EV-A, the entire home’s electricity consumption is given the PEV rate. EV-B is designed to allow customers to monitor only the PEV’s electricity consumption and gives customers the option to have their home on a different rate. PG&E is planning on sunsetting its current E-9 rates that discourage additional EV charging due to their tiered structure. For the new EV rates, off-peak charging of PEVs is at a significantly reduced rate to the consumer, roughly $0.10/kWh during off-peak hours to $0.35/kWh during on-peak hours.

This section provides information on the projected impacts of EVs on electric utility systems and operation. Information is presented on changes in system peak demand, loading of distribution system transformers, and overall utility system operation when EVs are plugged in. This information is useful in determining the extent of potential utility system upgrades required by the increased load.

Potential Impacts on the Grid

Load Impacts

The nation currently consumes about 4.1 trillion kWh of electric energy each year. If 150 million light-duty EVs each consume 8 kWh of power a day, that would represent an additional 440 billion kWh of power consumed each year. If the power is consumed during off-peak periods, flattening the load curve, then costs could be lowered for all customers. However this may create new peaks from 6:00-10:00 p.m. if EV users charge their vehicles upon return from work.[99]

EPRI performed a first-order macro-analysis showing that even in a very aggressive EV market penetration scenario of achieving 30% market share and a combined installed base of 52 million vehicles in 2030, the impact on the grid capacity is only about 5-6% in the worst electrical grid use case (all EVs charging in summer on-peak periods at the same time).[100] According to the EPRI study, smart grid investment, if successful in shifting 80% of this load to off-peak hours, can result in significant deferred capacity and reduce the grid capacity impact of EV charging to between 1-2% of the total capacity (and a corresponding 4-5% increase in base load). If deferred capacity is valued at $800/kW, this improvement amounts to a significant industry-wide savings of about $42 billion in 2030.

A more moderate EV market penetration scenario without making use of the smart grid and demand response resulted in less addition to grid capacity in the 1-2% range total in 2030 (as against a natural grid capacity growth rate of 1-2% annually). The effect of smart grid and EVs participating in demand response and energy efficiency programs on this moderate scenario resulted in less than 1% of on-peak load growth. Equivalent capacity deferment savings were found to be $15 billion in 2030.

Assumptions for the EPRI Prism study are given in Table 6.

Table 15. EPRI Prism Study Assumptions

Overall Assumptions	Market Penetration Scenarios	Grid Assumptions
All Vehicles charge at 120V, 1.5 kW All charging occurs at summer peak All vehicles uniformly distributed across the entire system	30% total market penetration by 2030	Smart grid enables demand response, load control, and off-peak charging
	Adoption rates same as hybrid in past 10 years	Legacy system without capacity to influence charging times or duration

[99] *Electrification Roadmap, Revolutionizing Transportation and Achieving Energy Security*, Electrification Coalition November 2009
[100] S. Chhaya and M. Duvall, *Impact of Plug-in Electric Vehicle Technology Diffusion on Electricity Infrastructure, Preliminary Analysis of Capacity and Economic Impacts,* EPRI 1016853, December 2008

ARB reported on several studies performed by the DOE, EPRI and other regarding the impact of EVs on the electric grid.[101] A 2007 DOE Study found the nation's supply of fossil-fuel-based, off-peak electricity production and transmission capacity could fuel up to 84% of the country's existing 220 million vehicles if they were all plug-in vehicles. The study assumed drivers would charge their vehicles overnight, when demand for electricity is much lower, and did not include hydroelectric, nuclear, renewable, or peaking power plants in its estimates. The study found that 15-23% of California's and Nevada's 26 million light-duty vehicles could be fueled with idle, off-peak electricity generating capacity within the California/Nevada study area.[102]

Research conducted by EPRI found that more than 40% of the nation's electric generating capacity sits idle or operates at reduced loads overnight and could accommodate tens of millions of plug-in vehicles without requiring new plants. This research also concludes that utilities could better utilize their power-generating assets by allowing for more efficient operation and gaining a new market for off-peak power that now sits idle.[103] The additional 1.8 million electric vehicles by the year 2020 are expected to increase the State's electric system load demand by 4.6 TW-hrs by 2020. If most of this additional demand is supplied by off-peak power, it is likely that electric vehicles would not create an adverse impact on California's supply of available electric power within the 2020 timeframe.[104]

The energy use and demand results from a CPUC analysis are shown in Table 16.[105]

Table 16. Energy Use and Demand Impacts of Low, Medium and High EV Penetration Scenarios

EVs in 2020	GWh/yr	GWh/Yr % increase	Peak Load MW increase	Peak Load MW % increase
3,000 BEVs 58,000 PHEVs	202	0.1%	10	0.01%
33,000 BEVs 312,000 PHEVs	1,136	0.3%	56	0.08%
455,000 BEVs 2,500,000 PHEVs	9,645	3.0%	474	0.64%

The upper bound is a 3% increase in electricity generation and a 0.64% increase in peak demand. Each million EVs would add 2.4-4 TWh of consumption, at a cost to consumers of $0.24-$1.2 billion. EVs can provide more efficient utilization of utility assets and therefore potentially lower rates.

For the planning horizon of this particular effort, the potential for negative grid impacts are minimal and are largely limited to intense clustering of PEVs in areas with stressed

101 *Proposed Regulation to Implement the Low Carbon Fuel Standard Volume I Staff Report: Initial Statement of Reasons*, California Air Resources Board, March 2009

102 M. Kintner-Meyer, K. Schneider, and R. Pratt, *Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids Part 1: Technical Analysis*, PNNL, 2007

103 Driving the Solution: The Plug-In Hybrid Vehicle, Lucy Sanna EPRI Journal, 2005

104 These assessments do not include impacts on local feeders and distribution circuits in areas with high concentrations of electric vehicles needing charging from the grid.

105 *Light-Duty Vehicle Electrification in California: Potential Barriers and Opportunities,* Staff White Paper, Policy and Planning Division, CPUC, May 2009

infrastructure. For instance, a CPUC report cited a Southern California Edison (SCE) analysis that shows potential load shifts and increases in load (shifting the peak from the 4:00 to 5:00 p.m. window to about 7:00 p.m. and adding several thousand MW by 2020) that could be substantial if a *large* number of PEV customers plug in and charge immediately upon returning home from work. The CPUC staff found that in the extreme worst case uncontrolled scenario, when 3 million vehicles were plugged in simultaneously, the added connected load will be 5,400 MW if a 120 V connection is used and 19,800 MW for 220V outlets. The scenario for 3 million vehicles deployed in California by 2020 was considered the high estimate. The long-term potential for PEVs and the increased electricity consumption they might require is highlighted by an analysis from Oak Ridge National Laboratory, which found that if 25% of the U.S vehicle fleet (more than 60 million vehicles nationwide) where PEVs, and all charged at 6:00 p.m., then up to 160 new power plants will be needed nationwide. These projected increases will require a corresponding 20% increase in renewable generation to comply with RPS requirements.[106] These numbers are provided to highlight the potential long-term impacts of PEV adoption, and the reader is reminded that the timeframe for making these grid requirements (e.g., significant increased capacity, widespread transmission upgrades, etc.) are beyond the planning horizon for this analysis.

Transformer Impacts

Although the initial penetration of EVs is expected to be low, local distribution equipment (at the individual residential block level) can fail if several neighbors plug in their vehicles during peak demand. To avoid this potential issues, utilities need to communicate with EV owners at the time of purchase to that they can track where they will be most frequently charged.

An EPRI presentation[107] discussed transmission and distribution issues with calculations performed at the distribution system level (at the house using circuit models and loading) and the higher level substation level (using aggregate feeder loading). The high level loading addressed the sensitivity to vehicle penetration, vehicle types, different charging patterns and customer habits and characterized the aggregate impact of these factors. Specific utility results were incorporated into micro-level analysis to investigate loading profiles of distribution assets. EPRI developed scenarios using information from various sources on EV market penetration, EV charge spectrum and profile, customer charging habits and battery state of charge based on miles driven. The scenarios included the following assumptions:

- At any time no less than 50% of cars are at home and most end up at home each day.
- At any given time a maximum of 12% of people are arriving home and will begin charging.
- Most arrive home during peak electricity use hours.
- By 8:00 p.m., 70% of drivers have arrived home.
- 74% of trips involve less than 40 miles per day.

Profiles were calculated for uncontrolled charging using the following charge profile:

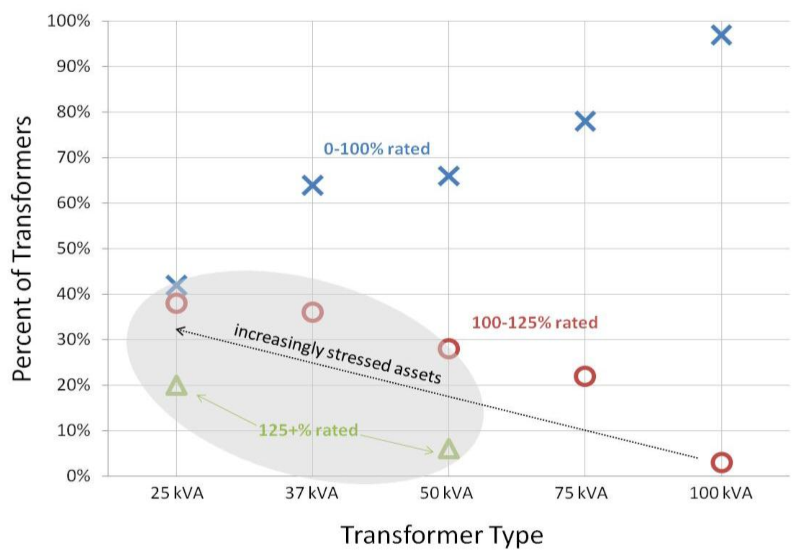
[106] *Light-Duty Vehicle Electrification in California: Potential Barriers and Opportunities,* Staff White Paper, Policy and Planning Division, CPUC, May 2009.
[107] A. Maitra, *Effects of Transportation Electrification on the Electricity Grid*, EPRI, Plug-In 2009 Conference, August 11, 2009

- 50% at 120 V or 1.44 kW
- 20% at 240 V or 3.3 kW
- 30% at 240 V or 6.6 kW

The peak load of about 500 W per vehicle occurs at around 5:00-7:00 p.m. and lasts longer into the evening. If all the vehicles are BEVs then the peak load is about 700 W per vehicle and still occurs at around 5:00-7:00 p.m. and lasts into the evening.

Vehicles can be concentrated in particular neighborhoods. Assets may already be stressed with many 25 kVA transformers already operating with narrow margins today, as shown in Figure 8. Transformers typically serve five to fifteen households.

Figure 8. Transformer Loading by Transformer Size



Source: Figure modified from A Maitra, *Effects of transportation electrification on the grid*, Plug-In 2009 Conference, Long Beach, CA, August 11, 2009.

Figure 9 shows overloading for different transformer voltages. Asset overloading can increase quickly as vehicle charging comes on line. With medium rate charging, it takes less than one PHEV per household to significantly increase the loading on local distribution transformers. The impact of PHEVs and EVs on transformer loading and utility upgrades requires further analysis.[108]

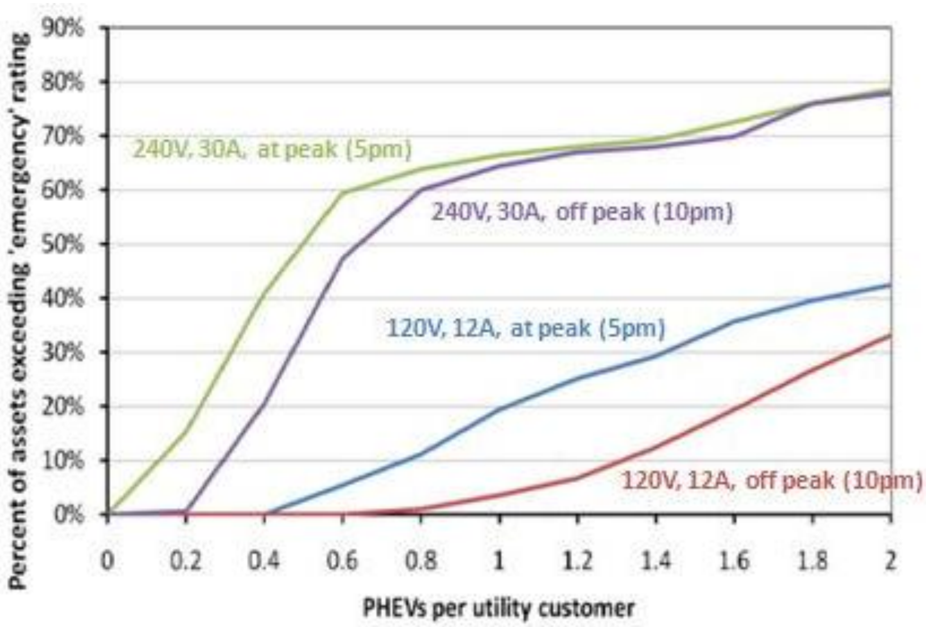
Distribution system impacts including transformer stress could occur due to clusters of EVs increasing loading beyond capacity. Encouraging customers to charge when load is low is important. Rate design and demand response options are targeted to mitigate these issues.[109]

Utilities will need to upgrade transformers in some areas. Understanding where EVs will charge is critical to this task and increased coordination amongst different stakeholders is required to

[108] *Effects of Transportation Electrification on the Electricity Grid*, A. Maitra, EPRI Plugin Conference, Long Beach, CA, August 11, 2009.

allow utilities to receive this information. The last transformer in the network prior to electricity being delivered to residential customers reduces the voltage to 220 volts. These transformers typically serve between five and fifteen homes, often with a relatively small margin of excess capacity. EV charging represents a significant power draw for most U.S. homes. A Level 2 charger operating at 220 volts on a 15 amp circuit is expected to draw 3.3 kilowatts of power, a load that is similar to the average load in a typical home. Utilities will need to upgrade their transformers to accommodate this load and should be able to do this as rate-based infrastructure improvements.[110]

Figure 9. Transformer Overloading at Different Transformer Voltages



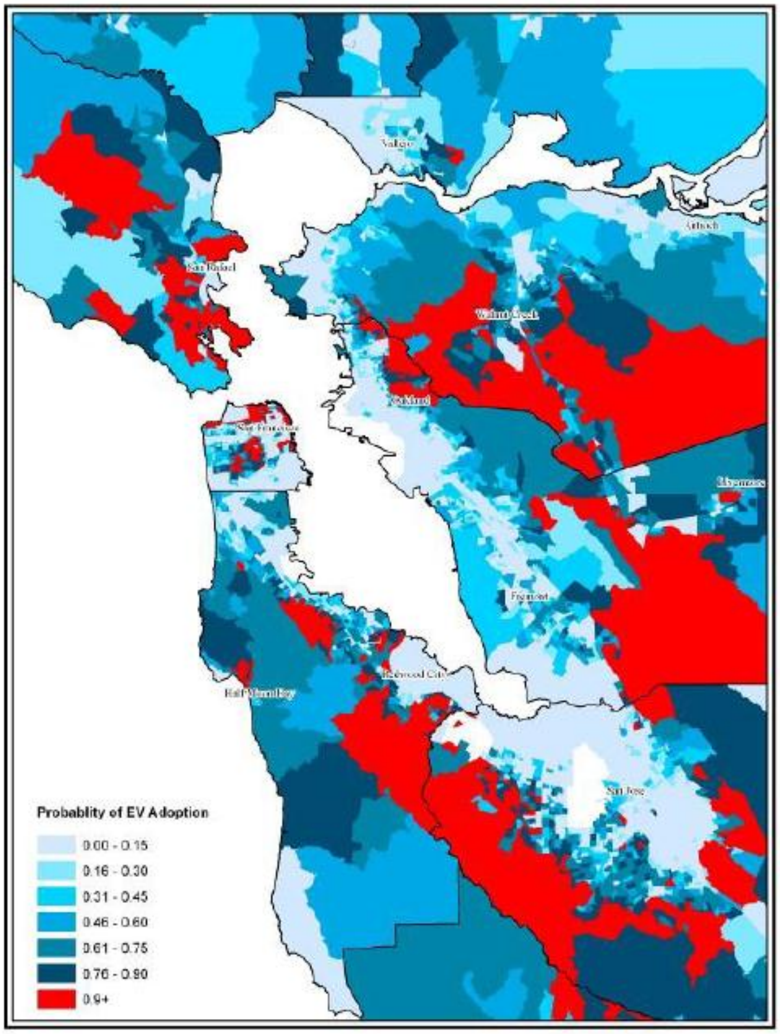
Source: A Maitra, *Effects of transportation electrification on the grid*, Plug-In 2009 Conference, Long Beach, CA, August 11, 2009.

Clustering

PG&E identified the areas in the service territory where PEVs were likely to be located using a linear discriminant analysis to identify the characteristics of potential PEV customers. Figure 10 below highlights PG&E's estimates regarding the probable level of PEV adoption in the San Francisco Bay Area and displays the classification coefficient for each census block group. The census block groups identified as *least likely* to *most likely* to have dense concentrations of PEVs range from pale blue to red. The white areas are not a part of PG&E's electricity distribution area. The areas with the highest levels of probable adoption are concentrated in San Francisco suburbs, Monterey, and the suburbs of Sacramento.

[110] A typical peak demand for an average single family residence is about 5 kW. Thus a PEV charging at 3.3kW would represent a bit more than 50% of one additional house and a PEV charging at 6.6 kW or 7.7kW would exceed the peak demand of one house. The coincidence of the PEV demand and the system or feeder peak demand is a subject for detailed analysis.

Figure 10. Probable level of PEV adoption in the San Francisco Bay Area[111]



According to a study by the University of California, Berkeley, the current California grid (defined as the CAMX grid within the study), is capable of handling a significant number of PEVs, as long as utilities policies promote off-peak charging.[112] This coincides with the study by PG&E, which did not anticipate the need for system level planning (used to determine the needs for generation and bulk transmission infrastructure) based on projected PEV loads. However, even if customers primarily charge during off-peak hours, this assumes a homogenous distribution of PEVs, which is not the case according to demographic data from PG&E (Figure 10).

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[111] Swanson, J., Aslin, R, and Yucel, Z., "Electric Vehicle Penetration Study Using Linear Discriminant Analysis," Pacific Gas & Electric Company, June 2011, p. 8, available online at: http://www.energy.ca.gov/2012_energypolicy/documents/2012-02-23_workshop/comments/Pacific_Gas_and_Electric-Electric_Vehicles_Penetration_Study_2012-03-01_TN-63900.pdf.

[112] DeForest, N., et al., "Impact of Widespread Electric Vehicle Adoption on the Electrical Utility Business – Threats and Opportunities," University of California, Berkeley, August 2009, pp. 13-16, available online at: http://cet.berkeley.edu/dl/Utilities_Final_8-31-09.pdf.

Pricing and Incentives

Time of Use Tariff Structures

Some utilities have opted to charge higher rates during times of peak demand and lower rates during off-peak hours through time of use (TOU) tariff structures. Historically, TOU tariffs have motivated consumers to use electricity during off-peak hours to prevent high utility bills. Technological solutions to reduce grid impacts and minimize costs for consumers include smart charging technologies, which track daily usage patterns and restrict charging to periods when surplus electricity is available.

Currently, many different time-variant structures exist and each has advantages and disadvantages. Since many utilities are just beginning to experiment with demand management, different regions may find different combinations more beneficial. Some of these time-variant structures include:

- **Whole-house Time of Use with One Rate** – this rate has both the house and the PEV on the same rate with one meter. This type of rate encourages electricity consumption during off-peak hours. One of the primary benefits of this rate is that it avoids the need and costs associated with a second meter. The primary requirement to achieve lower bills on this type of rate is that customers need to adjust their typical behavior to minimize the amount of electricity consumed during peak hours and maximize the amount of electricity consumed during off-peak hours.
- **Fixed fee/fixed fee off-peak** – this rate requires PEV owners to pay a flat monthly fee for unlimited charging (the time could be restricted, such as limiting to off-peak charging). Though this rate is easy to use for both the utility and the customer and doesn't require the use of a second meter, the rate does not traditionally encourage use during off-peak periods.
- **Two-meter house with high-differential pricing** – this rate has the house and the PEV on the different rates with one meter for the house usage and another meter for the PEV consumption. This type of rate encourages electricity consumption during off-peak hours for the PEV and allows the house to be on a normal residential rate, such as a flat rate. One of the primary benefits of this rate is that it allows the residents of the house to continue consuming as before without any disincentive to consume during peak hours. The primary requirement to achieve lower bills on this type of rate is that customers need to adjust only their PEV charging times to maximize the amount of electricity consumed during off-peak hours. The disadvantage of this rate structure is the need and costs associated with installing a second meter.
- **Sub-metering off PEV charging circuit with high-differential pricing –** This rate is similar to the two-meter house rate, except the PEV charging circuit is sub-metered and simply subtracted from main meter use. The advantages of this rate are that it is appropriate for MUDs, potentially less expensive for customers, and allows for differential pricing. However, these rates are typically experimental at this time, and may not be available at all

- **Demand response (can be combined with options above) –** in this rate structure, the utility enters into a contract with a user or an aggregator to control the power flow to PEV during high load times or provide a financial incentive for reduced charging level. This feature may be especially useful for local grids near 100% capacity and for providing other grid services to the utility. However, poorly implemented demand response programs by the utility or aggregator could inconvenience PEV drivers if the battery is not charged to the desired level when needed.

Utility Incentives

Table 17 below provides a sample of utility pilot programs offering EVSE incentives and special PEV rates. This list includes a review of pilot programs and the potential applicability of projects to the Bay Area and Monterey Bay regions. Other utilities around the country provide TOU rates specific to PEVs, EVSE purchase and installation incentives, and even PEV purchase incentives. For more information refer to the Alternative Fuels and Advanced Vehicles Data Center's State Incentives and Laws website, which includes relevant utility incentive descriptions.[113]

[113] Alternative Fuels and Advanced Vehicles Data Center, State Incentives and Laws, http://www.afdc.energy.gov/afdc/laws/state

Table 17. Utility Pilot Programs with PEV rates and EVSE incentives

Utility/Location	Pilot Program Name	Incentive Type	EVSE Included	PEV Rate
Austin Energy Austin, Texas[114]	Plug-in Everywhere	Rebate up to $1,500 for Level 2 EVSE	Level 2 EVSE installed ; need pre-approved contractor	None
Consumers Energy Michigan[115]	PEV Incentive Program	Rebate up to $2,500 for purchase and installation of Level 2 EVSE; limited to first 2,500 participants	Must supply EVSE	Option 1: no additional meter - combines PEV and household usage Option 2: second meter, TOU rate Option 3: second meter; flat rate for PEV only, limited to 250 participants
Dominion Resources (DOM) Virginia[116]	EV Rates Pilot	PEV-specific pricing rates; each rate plan limited to first 750 participants	Must supply EVSE	Requires installation of second meter to be supplied by DOM; Off-peak 8 hour window; in EV + Home Pricing Plan meter is replaced by interval meter which allows DOM to read in 30 second increments
DTE Energy Michigan[117]	Plug-in Ready Option 1	Rebate up to $2,500 for installation of a separately metered Level 2 EVSE; limited to first 2,500 customers participants	Level 2 EVSE provided and installed by SPX; DTE installs second meter	D1.9 (EV TOU Rate); $40 Monthly Flat Rate available to the first 250 customers
Duke Energy North & South Carolina[118]	Charge Carolinas	Rebate up to $1,000 of installation costs for residential customers	Level 2 EVSE provided w/ maintenance; can purchase the EVSE for $250 at end of pilot	None
Duke Energy Indiana[119]	Project Plug-IN	Rebate up to $1,000 of installation costs for residential customers and $1,500 for commercial customers	Level 2 EVSE provided with maintenance for the duration of the pilot program	None

114 Austin Energy, "Plug-In Partners," accessed March 13, 2012, http://www.austinenergy.com/About%20Us/Environmental%20Initiatives/Plug-In%20Partners/index.htm.
115 Consumers Energy, "Plug-In Electric Vehicles," accessed March 13, 2012, http://www.consumersenergy.com/content.aspx?ID=3363.
116 Dominion Power, "Plug-In Electric Vehicles," available online at: http://dom.com/about/environment/electric-vehicles.jsp.
117 DTE Energy, "Powering Your Energy Future," available online at: http://www.dteenergy.com/residentialCustomers/productsPrograms/electricVehicles/overview.html.
118 Duke Energy, "Plug-in Electric Vehicles (PEVs)," available online at: http://www.duke-energy.com/plugin/default.asp.
119 Duke Energy, "Plug-in Electric Vehicles (PEVs)," available online at: http://www.duke-energy.com/plugin/default.asp.

Utility/Location	Pilot Program Name	Incentive Type	EVSE Included	PEV Rate
Hawaiian Electric Company Hawaii[120]	EV Pilot Rates	Participants receive new TOU meters free of charge; limited to first 1,000 participants on Oahu, first 300 in Maui, and first 300 on the Island of Hawaii	Must supply EVSE; load control and load monitoring devices will be installed free of charge	Customers enrolling on the TOU-EV or Schedule EV-R rates will have a new meter installed exclusive for EV charging. The rate EV-R customer's existing load will remain on the existing meter and account
LADWP Los Angeles, California[121]	Charge Up LA!	Rebate up to $2,000 for purchase and installation of Level 2 EVSE; limited to first 1,000 participants	Must supply EVSE	EV TOU rate available and requires separate meter; PEV discount of 2.5 ¢/kWh during off-peak, nighttime hours, and on weekends
SMUD[122] Sacramento, CA	Discount Rate	Discount rate for residential customers that own or lease PEVs and install a time-of-use meter at the charging location	Must supply EVSE	Discount of 2.43 ¢/kWh off the winter off-peak residential rate and 2.71 ¢/kWh off the summer off-peak residential rate. Customers must provide proof of vehicle registration
SDG&E[123] San Diego, CA	Clean Transportation Program	Two time of use (TOU) discount rates are available for EV charging	Must supply EVSE	The TOU rate is available to residents in single family dwellings flats and apartments. The super off peak rate is 14.5 ¢/kWh
SCE[124] Los Angeles, CA	Discount Rate	Two time of use (TOU) discount rates are available for PEV, NEV and golf cart charging	Must supply EVSE	The first rate provides discount of 8.1 ¢/kWh for off-peak summer; 9.2 ¢/kWh for off-peak winter. The second rate provides discounts for off-peak and super off-peak as well as a peak time rebate

[120] Hawaiian Electric Company, "Residential EV Pilot Rates," available online at: http://www.heco.com/.
[121] Los Angeles Department of Water and Power, "Charge Up L.A.! Utility Support for Electric Vehicles," available online at:http://www.caletc.com/wp-content/uploads/2012/01/LA_DWP_LA_Auto_Show_Nov_20111.pdf.
[122] Sacramento Municipal Utility District, "PEV Rates," available online at: https://www.smud.org/en/residential/environment/plug-in-electric-vehicles/PEV-rates.htm.
[123] San Diego Gas and Electric, "EV Rates," available online at: http://sdge.com/clean-energy/electric-vehicles/ev-rates.
[124] Southern California Edison, "Rate Information – Residential Rates," available online at: http://www.sce.com/CustomerService/rates/residential/electric-vehicles.htm.

Utility Notification

PEV consumer notification programs are typically voluntary data provided to the utility by automakers, dealers, third-party organizations, and utility customers. The information provides insights into where new PEVs are charging and allows the utility to evaluate if the local distribution system is adequate to serve PEV charging needs. In California, advance notification began on an ad hoc basis, but in July 2011 the California Public Utilities Commission (CPUC) directed utilities to conduct an assessment of early notification efforts and evaluate opportunities to formalize the process.

In a joint report with SCE regarding PEV notification,[125] PG&E identified the following requirements for notification data needs to meet its needs:

- **Comprehensiveness**: To ensure grid reliability, safety and stability, PG&E would require data to be as comprehensive as possible to properly anticipate areas where transformer loading is nearing failure. This would include data for charging locations for not only new PEVs, but used PEVs or use resulting from a change of address. PG&E estimated it had captured 80% of new PEVs sold in the service territory using existing notification processes.
- **Granularity**: The location information should be as specific as possible, ideally with a street-level address as opposed to a zip code or city block. The data should also include charging levels to evaluate potential demand and impact on circuits. Though privacy and confidentiality concerns exist, PG&E expressed commitment to protecting customer data in compliance with applicable regulations and laws. Currently, OEMs are sharing notification data at the street address level, but may require PG&E to pay for supplemental reports including delivery date to customer.
- **Timeliness**: Utilities would prefer notification of new EVSE prior to the installation in order to identify potential distribution infrastructure problems resulting from incremental coincident peak loading. Currently, a reporting period from OEMs and other third parties has not been standardized and should be addressed.
- **Scalability**: As the PEV market becomes more mature, PG&E has expressed concern about the amount of manual activities required to collect data, and that unless they could become automated in some way, the process would not scale well with increased PEV adoption. Notification sources could provide data in a standardized way that would allow it to be automated. Currently, reports provided by OEMs are based on internal processes and will require additional automation to be able to be useful at higher PEV adoption rates.
- **Costs**: PG&E expressed concern about potential internal and external costs for obtaining notification data, including the costs to secure notification commitments from third parties and analysts to compile the data. Though costs are currently not high, there is a potential for costs to increase in the future and options to mitigate notification costs will be evaluated.

[125] Southern California Edison Company, "Joint IOU assessment report for PEV notification," December 2011, p. 14, available online at: http://docs.cpuc.ca.gov/efile/REPORT/156710.pdf.

According to the same report, [126] the primary methods PG&E uses to collect PEV data in its service territory include data provided by OEMs, such as General Motors and Nissan. GM's regional manager for California provides data to PG&E on a biweekly basis and Nissan shares data quarterly through its third-party analytics firm, Oceanus. ECOtality provides PG&E weekly reports on its Level 2 charger installations. Individual customers also contact PG&E by phone or via its on-line PEV reporting tool to schedule a service appointment or discuss the EV rate options.[127] As of the end of March 2012, PG&E estimated 3,096 PEVs were owned or operated by customers in its service territory, but at that time did not track PEV ownership over time except to the extent an individual customer required service planning support or an EV rate option.[128]

Through recent legislation, utilities are also able to get data from the DMV. Senate Bill 859 (SB 859, Padilla, Statutes of 2011), sponsored by the California Electric Transportation Coalition (CalETC), LADWP and SMUD, authorizes California utilities to obtain PEV registration data from the DMV; however, the law also imposes restrictions on how to use DMV data to protect consumer privacy.[129]

Integrating Renewable Energy with PEVs

Investor owned utilities (IOUs) in California are at various stages of preparedness regarding the deployment of PEVs. Based on ICF research, the IOUs in California – SCE, SDG&E, and PG&E – have not prioritized providing opportunities for PEV drivers to purchase greener electricity for charging i.e., green charging. The IOUs are currently focused on ensuring that the PEV customers and their neighbors have reliable service, which includes, but is not limited to, interconnection, ensuring that distribution infrastructure is sufficient for residential EVSE (especially in areas where PEV purchasers may be clustered), and interfacing with EVSE providers to facilitate PEV deployment.

Some PEV drivers may opt to install solar panels as a renewable option to offset the power draw of their vehicles, and some employer/fleet sites may provide direct daytime charging to their PEVs, but this is generally seen as a higher-cost option. For example, the Ford Company plans to offer a 2.5 kilowatts solar array produced by the SunPower Corporation (Richmond, CA) at a cost of under $10,000 following federal subsidies. With the incremental cost of PEV already well above that of an ICE vehicle, the ROI for consumers in this case could potentially be even longer.

The two viable and relatively lower cost pathways for consumers to pursue renewable energy as part of the deployment for PEVs are likely:

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[126] Pacific Gas & Electric Company, "Filing of Information in Response to Administrative Law Judge's Ruling," March 2011, p. 4, available online at: http://docs.cpuc.ca.gov/efile/RESP/166108.pdf.

[127] Pacific Gas & Electric Company, "Contact PG&E to get plug-in ready," available online at: http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/contactpge/.

[128] Pacific Gas & Electric Company, "Filing of Information in Response to Administrative Law Judge's Ruling," March 2011, p. 4, available online at: http://docs.cpuc.ca.gov/efile/RESP/166108.pdf.

[129] Senate Bill No. 859, Chapter 346, Padilla, Vehicles: records, c onfidentiality. Available Online: http://leginfo.ca.gov/pub/11-12/bill/sen/sb_0851-0900/sb_859_bill_20110926_chaptered.pdf

- Green Pricing Programs
- Community Choice Aggregators (CCAs)

The existing green pricing programs and CCAs are listed below with a brief description of each program.

Green Pricing Programs

The most common pathway for consumers to send a market signal indicating a demand for renewable energy today is via voluntary green pricing programs provided by the local utility. These programs are more common for MOUs; of the 3 major California IOUS, PG&E offered a green pricing program, called ClimateSmart™, which recently ended, and has proposed a new green option for customers that want to purchase a higher percentage than normal of renewable energy. The programs are voluntary and provide customers the opportunity to commit to paying a premium for electricity with the understanding that this contribution will go towards purchasing renewable energy. MOUs throughout California have been particularly successful in getting consumers to sign up for green pricing programs, most notably Sacramento Municipal Utility District (SMUD), the City of Palo Alto Utilities, and Silicon Valley Power.

Utility Provider	Program Name	Brief Description
City of Palo Alto Utilities	PaloAltoGreen	1.5 ¢/kWh
Silicon Valley Power	Santa Clara Green Power	1.5 ¢/kWh, 100% renewable

The provision of renewable energy to interested consumers is a high priority for some utilities; however, in the context of PEV deployment and vehicle charging, it is not a high priority at this time. In the future, it will be important for utilities to have green pricing programs to incorporate renewable electricity purchasing for PEV charging, as it is likely that there is significant overlap between customers interested in the opportunity to purchase green electricity and interested PEV purchasers.

Premiums for green pricing are generally around $5-10 per month for customers, and this cost would increase with the additional usage from PEV charging. It will be important for customers to be aware of the potential costs associated with PEV charging and how this impacts green pricing programs. The operational savings of electricity usage for PEVs compared to gasoline in conventional vehicles is a major incentive for consumers; if these savings are inflated due to a lack of understanding by the consumer, then this may have a small but negative impact on PEV deployment. Furthermore, consumers should be aware that even using the average mix of generation sources in California yields significant GHG reductions compared to gasoline use.

Community Choice Aggregation

Another pathway for those that live in an area that has a Community Choice Aggregator (CCA) to couple the deployment of PEVs with renewable energy is through a CCA green rate option. Community Choice Aggregation was established in California by the Legislature via AB 117 (Statutes of 2002) to give cities and/or counties the authority to procure electricity on behalf of consumers in their jurisdiction. Under a CCA, the IOU is still responsible for the transmission and electrical grid, metering, and billing, and the local CCA authority is responsible for the purchasing the electricity for its customers. There are only 3 confirmed and registered CCAs currently in California: 1) San Joaquin Valley Power Authority (approved in 2007), 2) Marin Energy Authority (MEA) (approved in April 2010), and 3) CleanPower SF (approved May 2010).

The process of establishing a confirmed CCA can be a protracted process. For instance, it took MEA 7 years to complete the process. Although the timeframe is likely to decrease as there is an opportunity for the first mover CCAs to share lessons learned with other areas interested in developing CCAs, the process is still likely to be lengthy and contentious. The MEA includes the Cities of Belvedere, Mill Valley, San Rafael and Sausalito; the Towns of Fairfax, San Anselmo, and Tiburon; and the County of Marin, and the MAE board recently approved a request from the City of Richmond in Contra Costa County. Their immediate plans regarding renewable electricity offerings to consumers include two levels:

- Light Green – a 50% renewable electricity provision
- Deep Green – a 100% renewable electricity provision

MEA is currently in the implementation phase of the program and is phasing in these options by first offering the program to a smaller sample of consumers – about 9,200. At full subscription, MEA estimates 72,000 customers.

It is beyond the scope of this work to consider the potential benefits and drawbacks of CCAs. Similarly, because CCAs are relatively new and there are so few of them in California, it is impossible to conclude one way or another that CCAs are more or less capable of providing green charging options to consumers. At this point, regional and state agencies should continue to coordinate and observe CCA developments in the context of PEV deployment..

12.2. Gaps and Deficiencies

Clustering

Though the generation and transmission capacity may be sufficient to serve a statewide PEV adoption rate of a certain percentage, in local areas where city or neighborhood adoption rates are much higher, the local distribution grid may not be sufficient resulting in the overloading of the local distribution grid and causing premature degradation of infrastructure such as pole-top transformers and decreased reliability.

The clustering of PEV loads may be one of most immediate threats to utilities in the Bay Area and Monterey Bay Region, and accordingly each utility should examine the structure and condition of the local distribution grid as it relates to the potential for local PEV clusters. In order to avoid serious or long-term degradation of electricity reliability, PG&E and other local utilities will need to continue to evaluate the efficacy of existing utility notification protocols and refine the PEV adoption model to provide additional insight to local transmission planners responsible for projecting local area loads and ensuring sufficient infrastructure exists.

Congestion and Exceeding Capacity

Even if Bay Area and Monterey Bay Region utilities are able to overcome the threat of local clusters, long-term challenges will be created by high levels of PEV adoption. If PEV loads push peak demand higher, there will be additional costs to ensure that sufficient generation capacity is available to meet consumer demand. Shifting PEV loads to off-peak hours will mitigate the increases in peak demand.

Municipal Utility Gaps

Despite PG&E's leadership, other utilities serving Bay Area and Monterey Bay Region communities will need support from local communities regarding issues such as notification protocols and understanding potential demand for PEVs in order to assess the potential impact on local distribution infrastructure. These utilities should consider adopting TOU rates to encourage off-peak charging, comparable to those outlined previously from PG&E.

12.3. Concepts and Proposed Solutions

Utility notification measures

PG&E has developed an initial assessment of necessary action items to improve the utility notification process, but it is unclear what utility notification processes other utilities in the Bay Area and Monterey Bay Region have developed. As previously discussed, notification programs enable utilities to properly plan for local distribution infrastructure upgrades and repairs to meet the needs of PEV charging. These protocols should ideally integrate automakers, consumers, EVSE installation manufacturers and installers, and other relevant stakeholders. At this time, utility notification programs are entirely voluntary, so as part of this planning effort, solutions such as uniform checklists, incentives, outreach to dealers, PEV purchasers and EVSE retailers and the associated costs will be investigated.

Pricing structures

In order to avoid the detrimental effects of clustering and congestion, effective pricing structures for PEV charging should be evaluated. According to the California Plug-In Electric Vehicle Collaborative[130], to optimally address the needs of the community, utilities, regulators, government officials and consumer representatives in the area should collaborate to develop PEV pricing structure options. These pricing options could include one, or a combination of, time-of-use rate structures as described in section 1.1. The pricing structure(s) should reflect the supply and demand of electricity in each utility service territory and be clearly understood by the customer. There should be a proper incentive for the customer to maximize off-peak charging and a sufficient disincentive to minimize on-peak charging.

[130] California Plug-In Electric Vehicle Collaborative, *Taking Charge: Establishing California Leadership in the Plug-In Electric Vehicle Marketplace*, December 2010, p. 47, available online at: http://www.evcollaborative.org/sites/all/themes/pev/files/docs/Taking_Charge_final2.pdf.

Upgrade distribution infrastructure

When utilities in the Bay Area and Monterey Bay Region upgrade or add distribution infrastructure, utilities, regulators and planners should include the potential for PEV charging impacts as part of the analysis and, where possible, make strategic and cost-effective investments. PG&E has been installing new equipment to proactively accommodate electric vehicle advancements since 2010 as part of its multi-year Electric T&D Modernization Plan.[131] However, it is unclear to what extent these modifications have been adopted at other local municipal utilities.

Smart grid

PG&E has prepared a smart grid deployment plan, which includes steps to prepare for electric vehicles in the service territory.[132] The utility is working with a large number of partners to test PEV "smart charging" technologies, which examine the effect of temporarily reducing the amount of power drawn by PEVs to minimize grid impacts and provide other valuable grid services.

In addition to utilizing existing technologies, PG&E is monitoring vehicle-to-home and vehicle-to-grid applications for the future, which may provide opportunities to reduce peak load through battery storage. PG&E is also working closely with automakers, technology vendors, regulators, and standards organizations, such as the National Institute of Standards and Technology, to ensure that a viable smart charging market that rewards customers that provide these services to utilities will develop.

It is unclear what smart grid activities municipal utilities in the Bay Area and Monterey Bay Region have developed at this time. In order to mitigate potential impacts of PEV deployment, municipal utilities should also investigate opportunities for the smart grid, particularly as a way to potentially monitor and control charge events. As part of this planning effort, methods for ensuring the charging infrastructure and vehicles are able to send and receive information needed to interact with the grid and be compatible with smart grid technologies will be explored.

Consumer outreach

In addition to addressing transmission and distribution concerns, utilities should take necessary steps to ensure consumers are well informed about PEV opportunities. According to a report prepared by the Edison Electric Institute,[133] utilities should present a uniform set of PEV facts, utility rates, incentives and program information to customers through a wide variety of mediums, including bill inserts, brochures, public events and presentations, online material, videos, school curriculum, emails and other media. Residential customers should know about the availability and benefits of PEV rates, vehicle fueling costs, charging, as well as the utility

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131 Pacific Gas & Electric, *PG&E Smart Grid Deployment Plan: Deployment Baseline*, June 2011, p. 60, available online at: http://www.pge.com/includes/docs/pdfs/shared/edusafety/electric/SmartGridDeploymentPlan2011_06-30-11.pdf.

132 Pacific Gas & Electric, *PG&E Smart Grid Deployment Plan: Deployment Baseline*, June 2011, p. 94-95, available online at: http://www.pge.com/includes/docs/pdfs/shared/edusafety/electric/SmartGridDeploymentPlan2011_06-30-11.pdf.

133 Edison Electric Institute, *The Utility Guide to Plug-In Electric Vehicle Readiness*, November 2011, pp. 4, 15-22, available online at: https://workspace.icfi.com/ect/ccs/aerc/EVSE/Edison%20Electric_The%20Utility%20Guide%20to%20PEV%20Readiness.pdf.

role in the installation process. Public and private fleet managers should also receive guidance from the utilities regarding the best method for integrating PEVs into fleets. Local media and local government may also play a role through reporting the information to the public and seeking guidance on a variety of issues. It is anticipated that this type of messaging will be built into the *Go EV Campaign*, currently being designed by the BAAQMD and MTC.

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Appendix A: Sample Plan Outline

Per the language in the original DOE solicitation: "At a minimum, completed plans should consider the following elements:"

1. Documentation demonstrating a substantial partnership with relevant stakeholders, which may include:

   a. State, local, and tribal governments;

   b. all relevant generators and distributors of electricity and utility regulatory authorities;

   c. as appropriate, owners and operators of regional electric power distribution and transmission facilities;

   d. departments of public works and transportation;

   e. owners and operators of property that will be essential to the deployment of a sufficient level of publicly available charging infrastructure (including privately owned parking lots or structures and commercial entities with public access locations);

   f. plug-in electric drive vehicle manufacturers or retailers;

   g. third-party providers (such as vendors, installers, etc.) of charging infrastructure or services;

   h. fleet(s) that will participate in the program;

   i. Clean Cities Coalitions

2. A clear description of the role and responsibilities of each stakeholder; and a plan for continuing the engagement and participation of the stakeholders, as appropriate, throughout the implementation of the plan. This includes engagement of major fleet operators to encourage electrification of fleets such as taxis, municipal operations and delivery vehicles.

3. Analysis of barriers to the implementation of plug-in electric vehicles and infrastructure in your proposed area and a discussion of steps to reduce or eliminate the identified barriers.

4. Current plans for plug-in electric drive vehicle deployment in the area/region covered by the plan including:

   a. the number of plug-in electric drive vehicles anticipated to be plug-in electric drive privately owned personal vehicles; a justification should be provided for these estimates

   b. the number of plug-in electric drive vehicles anticipated to be privately owned fleet or public fleet vehicles; a justification should be provided for these estimates

   c. An analysis of usage patterns of vehicles

5. A plan for deploying residential, workplace, private, and publicly available charging infrastructure, including

a. primary and secondary potential charging locations:

- an estimate of the number of consumers who will have access to private residential charging infrastructure in single-family or multifamily residences;

- an estimate of the number of consumers who will have access to workplace charging infrastructure;

b. a plan for ensuring that the charging infrastructure or plug-in electric drive vehicle be able to send and receive the information needed to interact with the grid and be compatible with smart grid technologies to the extent feasible

c. a plan that identifies and addresses the unique challenges of installing infrastructure at multifamily residential buildings;

d. an estimate of the number and location of publicly and privately owned charging stations that will be publicly or commercially available;

e. an estimate of the number and location of charging infrastructure that will be privately funded or located on private property;

f. an estimate of the potential costs associated with EVSE deployment and potential sources of funding.

6. Descriptions of updated building codes (or a plan to update building codes before or during the grant period) to include charging infrastructure or dedicated circuits for charging infrastructure, as appropriate, in new construction and major renovations; EVSE must be commercially available (i.e. pre-commercial demonstration or research & development components are not desirable). “Commercially Available” EVSE is defined as equipment that is available for purchase and unrestricted operation by the general public and are fully compliant with all applicable standards and safety regulations (ex: SAE, UL Listing or equivalent) and will be installed by a certified electrician.

7. Descriptions of updated construction permitting or inspection processes (or a plan to update construction permitting or inspection processes) to allow for expedited installation of charging infrastructure for purchasers of plug-in electric drive vehicles, including a permitting process that allows a vehicle purchaser to have charging infrastructure installed rapidly (24 - 48 hours is a suggested target goal for private residential applications or permit by notification) ;

8. Descriptions of updated zoning, parking rules, or other local ordinances as are necessary to facilitate the installation of publicly available charging infrastructure and to allow for access to publicly available charging infrastructure, as appropriate. Also attention should be given to compliance American with Disabilities Act if applicable;

9. A plan for effective marketing, outreach, training, and education relating to plug-in electric drive vehicles, charging services, and infrastructure; the plans should include specialized training and education necessary to ensure that vehicles and related electric charging equipment is installed, maintained, and operated in a safe and proper manner. This could

include training for electric charging point users, first responders, public safety officers, inspectors, installers, and construction permitting officials in areas where electric charging is being introduced, among other target audiences.

10. An assessment and plan to communicate available or anticipated benefits or incentives for plug-in vehicle owners; and identify and establish other potential needed or desired benefits or incentives. These may include:

a. rebates of part of the purchase price of the vehicle;

b. state and federal tax incentives/credits

c. reductions in sales taxes or registration fees;

d. rebates or reductions in the costs of permitting, purchasing, or installing home plug-in electric drive vehicle charging infrastructure; and

e. rebates or reductions in State or local toll road access charges;

f. additional consumer benefits, such as preferred parking spaces or single-rider access to high-occupancy vehicle lanes for plug-in electric drive vehicles;

11. A description of utility, grid operator, or third-party charging service provider, policies and plans for accommodating the deployment of plug-in electric drive vehicles, including--

a. rate structures or provisions and billing protocols for the charging of plug-in electric drive vehicles;

b. analysis of potential impacts to the grid;

c. plans to minimize the effects of charging on peak loads;

d. A proposed plan for making widespread utility and grid upgrades;

Appendix B: EVSE Installation Checklist

<table>
<tr><th></th><th>Residential</th><th>Non-Residential</th></tr>
<tr><td rowspan="2">Phase 1

Pre-Work Contractor</td><td>✓ Understand intended use of the EVSE (i.e. personal)</td><td>✓ Obtain an address for the location
✓ Determine ownership of the site and/or authorization to install equipment at site
✓ Understand intended use of the EVSE (i.e. fleet, employee, customer, visitor, etc.)
✓ Determine number of vehicles charging and connectors per charging station
✓ Determine source of power and authorization to use source</td></tr>
<tr><td colspan="2">✓ Determine type of vehicle(s) to be charged at EVSE
✓ Evaluate mounting type options (i.e. bollard, pole-mount, wall-mount, ceiling-mount)
✓ Clarify communication requirements (i.e. ethernet, cellular, wi-fi, none, or other)
✓ Determine the NEMA Enclosure type
✓ Determine the physical dimensions of the space(s)
✓ Inspect the type of circuit breaker panel board intended for the installation</td></tr>
<tr><td>Phase 2

Pre-Work Customer</td><td colspan="2">✓ Identify incentives or rate structures through the utility
✓ Determine size of electrical service at the site
✓ Identify and contact applicable local permit office(s) to identify specific requirements, including local fire, environmental, construction, building, concealment and engineering requirements
✓ Identify incentives available through local, state, or federal programs
✓ Contact insurance company to acquire additional insurance or separate coverage as needed
✓ Hire the contractor and verify credentials with all subcontractors. Ensure electrical contractor's license for electrical work is current</td></tr>
<tr><td>Phase 3

On-Site Evaluation</td><td colspan="2">✓ Verify EVSE meets UL requirements and is listed by UL or another nationally recognized testing laboratory
✓ Verify EVSE has an appropriate NEMA rated enclosure (NEC 110.28) based on environment and customer needs, such as weatherization or greater levels of resistance to water and corrosive agents
✓ Determine the level of charger meets customer's PEV requirements (most vehicles require the maximum of a 240V / 32A circuit (40A breaker)
✓ Based on proposed EVSE location, determine if cord length will reach a vehicle's charging inlet without excessive slack and does not need to be more than 25' in length (NEC 625.17)
✓ Cord management methodologies have been considered to reduce the risk of tripping hazards and accidental damage to the connector
✓ Mounting type selection based on requirements to meet site guidelines
✓ Determine whether EVSE communication options are beneficial to customer and/or local utility</td></tr>
</table>

	Residential	Non-Residential
Phase 4 On-Site Survey	✓ Ensure overhead doors and vehicle parking spot do not conflict with EVSE location ✓ Place EVSE in a location convenient to charging port on vehicle and typical orientation of the vehicle when in garage (i.e. backed in or head-first) ✓ Ensure functionality of lighting in the garage to meet NEC code 210.70.	✓ Space(s) should be visible to drivers and pedestrians ✓ Determine proximity to building entrance (could be considered an incentive for PEV use) ✓ Select spaces proximate to existing transformer or panel with sufficient electrical capacity ✓ EVSE installation should maintain a minimum parking space length to comply with local zoning requirements ✓ If available, use wider parking spaces to reduce the risk of cord set damage and minimize the intersection of cords with walking paths ✓ Ensure sufficient lighting at proposed space(s) to reduce risk of tripping and damage to charging station from vehicle impact or vandalism. Light levels above two foot candles are recommended ✓ For lots with accessible parking, the first charging station should be prioritized for an ADA accessible parking space and for every 25th additional station another accessible space is installed ✓ Determine availability of space for informative signage ✓ EVSE with multiple cords should be placed to avoid crossing other parking spaces ✓ All available charging station mounting options should be considered and optimized for the space ✓ Determine if hazardous materials were located at the site PARKING DECKS ✓ Place EVSE towards the interior of a parking deck to avoid weather-related impacts on equipment PARKING LOTS ✓ Avoid existing infrastructure and landscaping to mitigate costs, potential hazards and other negative impacts ON-STREET ✓ Install on streets with high foot and vehicle traffic to mitigate vandalism ✓ Avoid existing infrastructure and landscaping to mitigate costs, potential hazards and other negative impacts ✓ Installations at ADA accessible spaces should be considered in public streets where accessible parking exists ✓ For pull-in spaces, EVSE should be placed in front of the spaced and either centered on the space or placed between two spaces (if two connectors are available). EVSE with more than two connectors should not be used in on-street applications ✓ For parallel parking locations, the charging station should be installed at the front third of the parked vehicle and based on the direction of traffic flow. EVSE with a single connector is recommended to reduce potential trip hazards

<table>
<tr><th></th><th>Residential</th><th>Non-Residential</th></tr>
<tr><td></td><td colspan="2">✓ Mount the connector at a height between 36” and 48” from the ground (NEC 625.29) unless otherwise indicated by the manufacturer
✓ Install wall or pole-mount stations and enclosures at a height between 36” and 48”
✓ Ensure sufficient space exists around electrical equipment for safe operation and maintenance (NEC 110.26). Recommended space is 30” wide, 3’ deep, and 6’6” high
✓ Minimize tripping hazards and utilize cord management technologies when possible
✓ Equipment operating above 50 volts must be protected against physical damage (NEC 110.27). Ensure the vehicle is out of the line of vehicle travel and use wheel stops or other protective measures
✓ EVSE must be located such that ADA routes maintain a pathway of 36” at all times</td></tr>
<tr><td>Phase 4

Contractor Installation Preparation</td><td colspan="2">✓ Price quote submitted to customer and approved including utility upgrades
✓ Order equipment
✓ Provide stamped engineering calculations as needed
✓ Provide site plan modification with diagrams as necessary
✓ Complete all necessary service upgrades and/or new service assessments
✓ Complete permit applications as required by local permitting department
✓ Ensure permit is approved and collected
✓ Schedule all necessary contract work (i.e. boring, concrete, and/or paving restoration) and utility work (i.e. utility marking, service upgrade, new service and/or meter pull)
✓ Ensure utility marking of existing power lines, gas lines or other infrastructure is completed and utilize “Call Before You Dig” services</td></tr>
<tr><td rowspan="2">Phase 5

Installation</td><td>✓ Residential garages may permit the use of nonmetallic-sheathed cable in lieu of conduit</td><td>✓ Run conduit from power source to station location
✓ For EVSE great than 60 amperes, a separate disconnect is required (NEC 625.23) and should be installed concurrently with conduit and visible from the EVSE</td></tr>
<tr><td colspan="2">✓ Post permit at site in visible location
✓ Remove material to run conduit and/or wiring (i.e. drywall, insulation, pavers, concrete, pavement, earth, etc.)
✓ Contractors are encouraged to examine requirement for installation sites and types of wiring in Chapter 3 of the NEC
✓ Pull wiring. Charging stations require a neutral line and a ground line and equipment is considered to be a continuous load
✓ Conductors should be sized to support 125% of the rated equipment load (NEC 625.21)
✓ Prepare mounting surface and install per equipment manufacturer instructions
✓ Floor-mount: typically requires a concrete foundation with J-bolts on station base plate with space to allow conductors to enter through the base
✓ Wall/Pole/Ceiling-mount: install brackets for mounting of the equipment
✓ Install bollard(s) and/or wheel stop(s) as needed
✓ Install informative signage to identify the EVSE and potential trip hazards
✓ Install additional electrical panels or sub-panels as needed
✓ Install service upgrades, new service and/or new meter as needed. Utility may also pull a meter to allow for charging station wires to be connected to a panel
✓ Make electrical connection
✓ Perform finish work to repair existing infrastructure, surfaces, and landscaping</td></tr>
</table>

	Residential	Non-Residential
Phase 6 Inspection	✓ An initial electrical inspection by applicable building, fire, environmental and electrical authorities should occur after conduit has been run and prior to connecting equipment and running wires. If necessary, contractor should correct any issues and schedule a second rough inspection ✓ If required, the inspector will perform a final inspection to ensure compliance with NEC and other codes adopted within the jurisdiction by inspecting wiring, connections, mounting and finish work ✓ Contractor should verify EVSE functionality	
Additional Resources	✓ National Codes and Standards ✓ American National Standards Institute (ANSI) ✓ National Fire Protection Association (NFPA) ✓ Underwriters Laboratories, Inc. (UL) ✓ International Association of Electrical Inspectors (IAEI) ✓ International Code Council (ICC) ✓ NECA-NEIS Standards ✓ NECA and NFPA Webinars ✓ Electric Vehicle Infrastructure Training Program (EVITP) Installer Training Course/Certification	

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NECA, "Managing Electric Vehicle Supply Equipment (EVSE) Installations, http://iaei-western.org/Files/2011/Programs/NECA%20EVSE%20Presentation%20NECA%20SD%202011%20Western%20IAEI%20Section.pdf

**If AC Level 1 EVSE is utilized, NECA recommends connection to NEMA 5-15R or 5-20R receptacles and an individual branch circuit (NECA, "Managing Electric Vehicle Supply Equipment (EVSE) Installations, p. 27, http://iaei-western.org/Files/2011/Programs/NECA%20EVSE%20Presentation%20NECA%20SD%202011%20Western%20IAEI%20Section.pdf).