Bay Area and Monterey Bay Area Plug-in Electric Vehicle Readiness Plan

Background and Analysis

December 2012

Prepared for the:

Bay Area Air Quality Management District

In Partnership with:

Association of Bay Area Governments

Metropolitan Transportation Commission

Prepared by:

ICF International

Disclaimer

This report was prepared as a result of work sponsored, paid for, in whole or in part, by a U.S. Department of Energy (DOE) Award to the South Coast Air Quality Management District (SCAQMD). The opinions, findings, conclusions, and recommendations are those of the author and do not necessarily represent the views of SCAQMD or the DOE. The SCAQMD and DOE, their officers, employees, contractors, and subcontractors make no warranty, expressed or implied, and assume no legal liability for the information in this report. The SCAQMD and DOE have not approved or disapproved this report, nor have the SCAQMD or DOE passed upon the accuracy or adequacy of the information contained herein.

This document was also prepared as a result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees, or the State of California. The Commission, the State of California, its employees, contractors, and subcontractors make no warranty, expressed or implied, and assume no legal liability for the information in this document; nor does any party represent that the use of this information will not infringe upon privately owned rights.

Acknowledgments

The Bay Area and Monterey Bay Area are fortunate to have a broad and diverse set of contributors working to move this region towards plug-in electric vehicle readiness. Many of these stakeholders greatly contributed to the preparation of this document by conducting targeted outreach and interviews with local government officials and by providing key data and valuable feedback on the information contained in this document. Specifically, the Bay Area Air Quality Management District would like to acknowledge the contributions of the staff at the Association of Bay Area Governments; Metropolitan Transportation Commission; Monterey Bay Unified Air Pollution District; Association of Monterey Bay Area Governments; Monterey Bay Electric Vehicle Alliance; and East Bay, San Francisco, and Silicon Valley Clean Cities Coalitions.

In addition, the Bay Area Air Quality Management District would like to acknowledge the stakeholders who took the time to provide feedback on documents prepared as part of the planning process, including members of the EV Strategic Council, SF BayLEAFs, Plug In America, local chapters of the Electric Auto Association, and representatives from local governments and planning agencies.

The Bay Area Air Quality Management District would also like to acknowledge the members of the public who attended the informational sessions that were held as part of the planning process, including those who submitted written comments and those who participated in the surveys of local employers, EV Project participants, and City CarShare members.

Lastly, the Bay Area Air Quality Management District would also like to acknowledge Timothy Lipman from UC Berkeley and Michael Nicholas, Thomas Turrentine, and Gil Tal from UC Davis for providing peer review of this document; and representatives of the California Plug-in Electric Vehicle Collaborative and staff at ECOtality for providing additional analyses and review of the planning documents. Public involvement is a key aspect of the planning process and the enthusiasm of the Bay Area's and Monterey Bay Area's residents will be the main driver for the development of a thriving market for plug-in electric vehicles.

Bay Area and Monterey Bay Area
Plug-in Electric Vehicle Readiness Plan

Contents

The Bay Area and Monterey Bay Area Plug-in Electric Vehicle Readiness Plan is comprised of two parts: the Summary and the Background and Analysis. The Summary is a high level review of the Plan, while the complementary Background and Analysis contains more detailed information about key planning elements covered in the Summary. The numbered sections in the Summary correspond to the numbered sections in the Background and Analysis. Additionally, the Background and Analysis includes a glossary, a complete list of references, and appendices containing additional information that was used to develop the Plan. The following is an overview of the contents of the Plan:

Summary

- Overview
- Needs Analysis (Sections 1-4)
- Recommendations for Local and Regional Governments (Sections 5-10)
- Actions for Further Regional Readiness

Background and Analysis

- Glossary
- Sections 1-10
- Appendices
- Bibliography

Table of Contents

List of Figures

List of Tables

Glossary of Terms, Abbreviations, and Acronyms

Abbreviation or Acronym	Description
A	Amperes or amps: The International System of Units base unit of electric current.
AB	Assembly Bill
ABAG	Association of Bay Area Governments
AC	Alternating current: Electric current that changes direction with a regular frequency.
AC Wh/mi	Alternating current watt-hours consumed per mile
ADA	Americans with Disabilities Act
AMBAG	Association of Monterey Bay Area Governments
ARRA	American Recovery and Reinvestment Act
AT PZEV	Advanced technology partial zero emission vehicle
ATTE	Advanced Transportation Technology and Energy
BAAQMD	Bay Area Air Quality Management District
BEV	Battery electric vehicle: Any vehicle that operates exclusively on electrical energy from an off-board source that is stored in the vehicle's batteries and produces zero tailpipe emissions or pollution when stationary or operating. A BEV is a subcategory of plug-in electric vehicle (see "Plug-in Electric Vehicle, PEV").
CalETC	California Electric Transportation Coalition
CALGreen	California Green Building standards
CAP	Climate Action Plan
CARB	California Air Resources Board
CCA	Community Choice Aggregation
CCR, Title 24	California Code of Regulations, Title 24: Commonly known as the California Building Standards Code.
CEC	California Energy Commission
CFR	Code of Federal Regulations
charger	An electrical component assembly or cluster of component assemblies designed specifically to charge batteries or other energy storage devices within electric vehicles. Chargers include standardized indicators of electrical force, or voltage (see "charging levels") and may charge batteries by conductive or inductive means.
charging level	Standardized indicators of electrical force, or voltage, at which an electric vehicle's battery is recharged and referred to as Level 1, Level 2, and Level 3 (or DC/AC Fast Charging).
circuit breaker	A device that automatically interrupts the flow of electric current in an overloaded electric current.
CNCDA	California New Car Dealers Association
CNG	Compressed natural gas
CPUC	California Public Utilities Commission
CVRP	California Air Resource Board's Clean Vehicle Rebate Project
DC	Direct current: Electric current that moves in one direction from anode to cathode.

Abbreviation or Acronym	Description
DMV	Department of Motor Vehicles
DOE	US Department of Energy
EAA	Electric Auto Association
EMFAC	California Air Resources Board's tool for estimating emissions from on-road vehicles
EPRI	Electric Power Research Institute
EV Council	Bay Area EV Strategic Council
EVITP	Electric Vehicle Infrastructure Training Program
EVP	The EV Project, managed by ECOtality
EVSE	Electric vehicle supply equipment: Inclusive of all of the components for electric vehicle charging stations, including: the conductors; the ungrounded, grounded, and equipment grounding conductors; electric vehicle connectors; attachment plugs, and; all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy from the grid to an electric vehicle.
EVSP	Electric vehicle service providers
FHWA	US Department of Transportation Federal Highway Administration
GHG	Greenhouse gas: Any of the gases (e.g., carbon dioxide, methane, ozone, and fluorocarbons) emitted that contribute to the greenhouse effect by absorbing solar radiation once in the atmosphere.
HEV	Hybrid electric vehicle: A motor vehicle that is powered by both an electric propulsion system with a conventional internal combustion propulsion system and meets the applicable federal motor vehicle safety standards and state registration requirements. A hybrid electric vehicle does not plug into an off-board electrical source.
HOA	Homeowners Association
HVIP	California Air Resource Board's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
HOV	High occupancy vehicle
ICC	International Code Council
ICE	Internal combustion engine: An engine which combusts petroleum-based fuel as a means of delivering power.
IOU	Investor owned utility
J1772	Industry-wide standard EV connector for Level 2 charging.
kW	Kilowatt: A unit of power equal to 1,000 watts.
kWh	Kilowatt hour: A unit of energy commonly used for measuring the energy capacity of a battery. This is the normal quantity used for metering and billing electricity customers.
LADWP	Los Angeles Department of Water and Power
LCFS	Low Carbon Fuel Standard
LEV	Low emission vehicle
Li-ion	Lithium ion: The type of chemical used in a majority of modern electric vehicle batteries. Lithium-ion batteries are lighter in weight and have higher energy density than previous types of batteries designed.
MAP-21	Moving Ahead for Progress in the 21st Century Act

Abbreviation or Acronym	Description
MBEVA	Monterey Bay Electric Vehicle Alliance
MBUAPCD	Monterey Bay Unified Air Pollution Control District
MCE	Marin Clean Energy
MDU	Multi-family dwelling units
MEA	Marin Energy Authority
MOU	Municipally-owned utility
MTC	Metropolitan Transportation Commission
MUTCD	Manual on Uniform Traffic Control Devices
MY	Model year
NEC	National Electrical Code
NiMH	Nickel metal hydride: A popular batter type for hybrid electric vehicles.
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
PEV	Plug-in electric vehicle: Any motor vehicle for on-road use that is capable of operating solely on the power of a rechargeable battery or battery pack (or other storage device that receives electricity from an external source, such as a charger) and meets the applicable federal motor vehicle safety standards and California State registration requirements. PEVs include, but are not limited to: all-electric vehicles (e.g., BEVs), plug-in hybrid electric vehicles, neighborhood electric vehicles, and electric motorcycles.
PEVC	California Plug-in Electric Vehicle Collaborative
PG&E	Pacific Gas and Electric
PHEV	Plug-in hybrid electric vehicle: A type of plug-in electric vehicle (see “Plug-in Electric Vehicle”) that is powered by an internal combustion engine, as well as an electric motor, and is capable of being powered solely by electricity. PHEV batteries are primarily charged by connecting to the grid or another off-board electrical source but may also be able to sustain battery charge using an on-board internal-combustion-driven generator.
Plan	Plug-in Electric Vehicle (PEV) Readiness Plan
pre-wiring	The practice of providing sufficient basic infrastructure, such as conduits, junction boxes, outlets serving garages and parking spaces, adequate wall or lot space for future EVSE, and adequate electrical panel and circuitry capacity, to meet anticipated future demand for EVSE.
the Region	Bay Area and Monterey Bay Area
RFID	Radio Frequency Identification subscription service.
SAE	Formerly Society of Automotive Engineers: SAE International is developing standards to create consistency in the design of electric vehicles and their associated charging equipment.
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SCS	Sustainable communities strategy
SDG&E	San Diego Gas and Electric
SFMTA	San Francisco’s Municipal Transportation Agency

Abbreviation or Acronym	Description
SFPUC	San Francisco Public Utilities Commission
SMUD	Sacramento Municipal Utility District
STA	Spare the Air; an outreach initiative sponsored by the Bay Area Air Quality Management District that provides Bay Area residents information about the effects of air pollution and encourages them to take action to improve air quality
STP	Surface Transportation Program
SVP	Silicon Valley Power
TAZ	Transportation analysis zone
TOU	Time-of-use: An electricity billing method with rates based upon the time of usage during the day.
TUCC	Tri-Chapter Uniform Code Committee
TZEV	Transitional zero emission vehicles: A vehicle class characterized in the Advanced Clean Cars regulations promulgated by the California Air Resources Board.
UL	Underwriters' Laboratory
V	Volt: The electrical potential difference or pressure across a one ohm resistance carrying a current of one ampere.
VMT	Vehicle miles traveled
V2G	Vehicle-to-grid: The concept of using electric vehicles as energy storage devices for the electric grid.
W	Watt: A unit of power, defined as one joule per second, which measures the rate of energy transfer.
ZEV	Zero emission vehicle: A vehicle that emits no tailpipe pollutants from the onboard source of power.

blank page

1. Stakeholders and Partnerships[1]

The Bay Area and Monterey Bay Area (the Region) has been proactive and successful in its efforts to deploy plug-in electric vehicles (PEVs) as a result of engaged stakeholders and strong partnerships. Partnerships in the Region include a broad and diverse group of Bay Area and Monterey Bay Area stakeholders that are working together and in parallel to support advances in PEV deployment. The following is a listing of the stakeholders and their role in this effort:

- **PEV Advocacy**: Clean Cities coalitions—East Bay, San Francisco, and Silicon Valley; Plug-In America; Electric Auto Association—Golden Gate Electric Vehicle Association, Silicon Valley, San Jose, East Bay, North Bay, Central Coast; SF BayLEAFs; CALSTART; City CarShare; American Lung Association; Natural Resource Defense Council; Bay Area Climate Collaborative; Monterey Bay Electric Vehicle Alliance; and Ecology Action
- **Electric Vehicle Supply Equipment (EVSE) Vendors and Providers**: AeroVironment, Better Place, Clipper Creek, Coulomb, ECOtality, NRG, GE, Schneider, 350 Green, SPX, and Greenlots.
- **Electrification of Public and Private Fleets:** State, regional, and local government fleets; and local employer fleet owners and operators (e.g., Yellow Cab, Frito-Lay/ PepsiCo, Waste Management, Bauer's Intelligent Transportation, East Bay Municipal Utility District)
- **Funding Agencies**: Bay Area Air Quality Management District, Metropolitan Transportation Commission, California Energy Commission, US Department of Energy, and California Air Resources Board
- **Grid Solutions and Utility Service Providers**: California Public Utilities Commission, Pacific Gas and Electric, Alameda Municipal Power, City of Healdsburg Electric, Hercules Municipal Utility, San Francisco Public Utilities Commission, City of Palo Alto Utilities, Silicon Valley Power, and Marin Clean Energy
- **Policies, Codes, and Guidelines Development**: California Governor's Office of Planning and Research, California Plug-in Electric Vehicle Collaborative, Bay Area Air Quality Management District, Association of Bay Area Governments, Tri-Chapter Uniform Code Committee, and local cities and counties (e.g., elected officials, public works and transportation representatives, building inspection and permitting officials, first responders, and sustainability coordinators)
- **Public Charging Opportunity Providers**: Owners and operators of publicly accessible parking locations, including private and public workplaces, multi-family dwelling unit properties, schools and transit hubs, and commercial properties (e.g. gas stations)
- **Regional PEV Readiness Planning**: Bay Area Air Quality Management District; Metropolitan Transportation Commission; Association of Bay Area Governments; Bay Area

[1] This section corresponds to the requirements described in Section 1 and Section 2 of the sample outline contained in the US Department of Energy solicitation (see Appendix G: Sample Plan Outline).

EV Strategic Council; Monterey Bay Unified Air Pollution Control District; Association of Monterey Bay Area Governments; Monterey Bay Electric Vehicle Alliance; Clean Cities coalitions; and local cities and counties

- **Technical Innovation and Research**: Coulomb, Better Place, Google, City CarShare, Intel, academic institutions (e.g., University of California—Berkeley, Stanford University; California State University—San Francisco, San Jose, East Bay, Monterey Bay, Sonoma), and Electric Power Research Institute
- **Training and Outreach**: US Department of Energy, Clean Cities coalitions, California Community Colleges, and the Electric Vehicle Infrastructure Training Program
- **Vehicle Manufacturers and Retailers**: BMW, CODA, Daimler, Ford, GM, Honda, Nissan, Tesla, and Toyota

During the development of this Region's Plug-in Electric Vehicle Readiness Plan (Plan) the Bay Area Air Quality Management District (BAAQMD) served as lead agency and collaborated with the five regions involved in the statewide readiness process, and other key stakeholders, including the California Energy Commission (CEC), California Public Utilities Commission (CPUC), California Building Standard Commission, California Air Resources Board (CARB), California Plug-in Electric Vehicle Collaborative (PEVC), South Coast Air Quality Management District (SCAQMD), and California's Clean Cities coalitions. Together, these groups comprise the California Plug-in Electric Vehicle Coordinating Council. This council has provided oversight in the development of PEV readiness guidelines, six regional deployment plans, and a compiled statewide PEV deployment plan for California.

Locally, the BAAQMD partnered extensively with its sister regional agencies, the Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC), to develop the Plan. These three organizations are all members of the Joint Policy Committee, which coordinates these agencies' efforts on growth in the Bay Area. In addition, BAAQMD partnered with the three Clean Cities coalitions—East Bay, San Francisco, and Silicon Valley—to conduct outreach and to facilitate public participation and input, and with the Monterey Bay Unified Air Pollution Control District (MBUAPCD) and the Monterey Bay Electric Vehicle Alliance (MBEVA), for the development of the Plan for areas in the Monterey Bay Area. The BAAQMD also partnered with the Bay Area EV Strategic Council (EV Council), which has four committees, each of which provides vetting and steering for the planning documents developed as part of the US Department of Energy (DOE) grant:

- The Steering Committee is the core executive-level voting group that sets policy and strategy for the EV Council;
- The Executive Committee sets the agenda and budget for the EV Council;
- The Technical Committee is an advisory committee of technical experts; and
- The Planning Committee supports all aspects of the planning process for the EV Council.

The EV Council is a voluntary public–private partnership created in early 2011 with a mission to establish the greater San Francisco Bay Area as the “EV Capital of the United States,” as measured by the proportion of EVs deployed in the region. The EV Council focuses on the 2011–2013 timeframe as a critical “tipping point” in the regions’ transition to electrified transportation. An overview of the EV Council, its members, roles, and responsibilities is presented below in Table 1.

Table 1. EV Council Members

Stakeholder	Role and Responsibilities
Regional and State Agencies	
Association of Bay Area Governments	Lead on EV Corridor Project ($4M EVSE project supported by CEC, BAAQMD, and local partners) Co-lead on SB 375 sustainable communities strategy
Bay Area Air Quality Management District	Lead on the DOE- and CEC-funded Plan Invested $6M+ in PEV infrastructure in 2010–12
California Energy Commission	Provides $20M annually in AB 118 program funds for PEV infrastructure Establishes energy policy and planning for California
Metropolitan Transportation Commission	Invested $15M+ in PEV projects as part of Climate Initiatives Program Grants Co-lead on SB 375 sustainable communities strategy
Monterey Bay Unified Air Pollution Control District	Coordinates efforts in the Monterey Bay Area with MBEVA and Ecology Action on the DOE-funded Plan
Congestion Management Agencies	
San Francisco County Transportation Authority	Establishes transportation policy and funding for the county
Transportation Authority of Marin	Establishes transportation policy and funding for the county
Sonoma County Transportation & Climate Protection Authority	Establishes transportation policy and funding for the county
Local Jurisdictions	
City and County of San Francisco	Regional leader in investing in PEVs, including EVSE, electric taxis, PEV fleets, PEV car share
City of San Jose	Placed PEVs as a centerpiece of the Green Plan, and invested in EVSE and PEV fleets
City of Oakland	Developed Climate Action Plan that features PEV fleet and charging initiatives
City of Berkeley	Embraced PEVs in municipal fleet and PEV car sharing integration with municipal fleet
Marin County	Leader in low-carbon electricity supplied by the Marin Energy Authority, and allocated local transportation funding for EVSE
Industry	
Kleiner Perkins Caulfield Byers	Lead venture fund in Silicon Valley and sponsored a large portfolio of PEV related companies

Stakeholder	Role and Responsibilities
Pacific, Gas, & Electric	Developed a robust PEV and clean fuel vehicle program and is preparing to integrate PEVs on the smart grid Assess impact of PEVs on the electric grid and develop strategies to reduce or mitigate these impacts
Itron	Global leader in smart grid infrastructure and services, including PEV-related metering and software
Better Place	Developing a $20M pilot battery switch station demo project in the Bay Area focused on taxis and shuttles, with BAAQMD, MTC, City of San Jose, and City and County of San Francisco
Coulomb Technologies	Deployed 5,000 chargers globally including the ChargePoint America program in California and beyond
ECOtality	Lead on the $100M DOE-funded EV Project, now in San Francisco Bay Area, San Diego, and Los Angeles
Tesla Motors	Battery electric vehicle factory in Fremont for Tesla Model S and drivetrain for Toyota vehicles
CODA Electric	Original equipment manufacturer
Non-Governmental Organizations	
Bay Area Clean Cities Coalitions	Actively driving PEV adoption in fleets region-wide
Bay Area Climate Collaborative	Project manager for *Ready, Set, Charge* EV Guidelines Project manager for $2.8M MTC-funded PEV fleet demonstration project
City CarShare	Developing $1.7M PEV car share project with MTC funding
EV Communities Alliance	Lead facilitator for ABAG's EV Corridor Project Helped develop *Ready, Set, Charge* EV Guidelines
Plug-In America	Publishes leading resources on PEV products Advocates for PEV-friendly legislation and policy
Silicon Valley Leadership Group	Co-sponsored annual PEV conferences, an executive PEV demonstration program, and developed the Bay Area Climate Collaborative to help drive the low-carbon transition

Stakeholder engagement in the Monterey Bay Area has taken shape largely through MBEVA. MBEVA formed in March 2009 with initial support from the Monterey College of Law in Seaside and since then has held regular meetings to advance PEV goals related to funding, policy improvement, public outreach, economic development/workforce development, and infrastructure development for the Monterey Bay Area. MBEVA's steering committee is comprised of representatives from businesses, higher education, labor, local government agencies, and non-profit organizations. MBEVA is the only tri-county body in the Monterey Bay Area dedicated to accelerate adoption of PEVs in support of the region's implementation of state legislation to reduce greenhouse gas (GHG) emissions. Most recently, MBEVA became a project under the umbrella of Ecology Action, a nonprofit consultancy in Santa Cruz. MBEVA's primary goals are to:

- Increase funding for, and installation of, publicly-available PEV charging stations;
- Ensure local governments adopt supportive policies, including streamlined PEV charging station permit processing and increased number of PEVs in their fleets;
- Increase public awareness about PEVs; and
- Increase training of local workforce for green jobs related to the PEV industry, and attract PEV businesses to the region.

An overview of MBEVA, its members, roles and responsibilities are presented below in Table 2.

Table 2. Monterey Bay Electric Vehicle Alliance

Stakeholder	Role and Responsibilities
Regional and State Agencies	
Association of Monterey Bay Area Governments	Providing planning support related to PEVs and EVSE deployment in the Monterey Bay Area Started with a $50,000 grant to help pay for 4 charging stations and produce report published in Jan 2012
Monterey Bay Unified Air Pollution Control District	Liaison to EV Council Funded several smaller grants for several deployment projects, including 7 Level 2 EVSE, 1 DC fast charger, and 4 BLINK stations installed Member of Steering Committee of MBEVA Helping fund upcoming National Plug-In Day for Monterey Region via $1,000 contribution
Local Governments	
Transportation Agency of Monterey County	Engaged with MBEVA steering committee ; applicant on behalf of MBEVA to deploy 7 Level 2 EVSE
City of Salinas	Member of Steering Committee of MBEVA
City of Santa Cruz	Member of Steering Committee of MBEVA
Santa Cruz County Regional Transportation Commission	Applicant on behalf of MBEVA to deploy 1 DC fast charger
Labor	
International Brotherhood of Electrical Workers (IBEW) Local 234	Member of Steering Committee of MBEVA Serves as on-the-ground implementer for EVSE in the Monterey Bay Area; have provided event space to host meetings as a central location for engaged stakeholders
Education	
California State University Monterey Bay	Member of Steering Committee of MBEVA Providing support on CEQA-related issues
Non-Governmental Organizations	
Ecology Action	Recently became official host of MBEVA; serve as point agency for readiness grant and the EVSE deployment grant from CEC Member of Steering Committee of MBEVA
Industry	
Green Fuse Energy	Providing technical and organizational support to MBEVA, on a volunteer basis Helps coordinate on the ground action for EVSE deployment Working with IBEW and other EVSE installation contractors Previous experience on EV1 development team at GM
Envirocentives	Member of Steering Committee of MBEVA Provided grant writing support
Chevrolet of Watsonville Nissan, Santa Cruz Nissan, Seaside	Active automotive dealerships in the Region that have supported event planning and local/regional efforts.

Stakeholder Engagement throughout the Implementation of the Plan

As is evidenced by the robust framework described above, there is substantial coordination among PEV stakeholders throughout the Region. Many of these partnerships are anticipated to continue throughout the implementation of this Plan (through 2014) due to a number of factors. These are as follows:

- *Commitments to the California Energy Commission:* Both the Bay Area and Monterey Bay Area have received funding from the CEC to continue work on PEV readiness. BAAQMD is the fiscal agent for both grants (which run through 2014) and as a requirement of these grants, local PEV coordinating councils must be maintained and used as a mechanism to vet and receive input on the content of regional readiness plans that will be submitted to CEC. BAAQMD will work with the EV Council as a whole to collaboratively gauge the need to continue EV Council activities at the end of that period. BAAQMD is willing to assume the role of coordinator for the Bay Area to continue stakeholder engagement, if necessary at that time. BAAQMD will also seek to engage its regional agency partners and partners in Monterey to support this effort and to support a similar continuation of regional engagement as needed in the Monterey Bay Area.
- *California Plug-In Electric Vehicle Collaborative:* This statewide organization is a multi-stakeholder, private–public partnership working to ensure a strong and enduring transition to PEVs in California. BAAQMD is the Region's lead for this organization which discusses strategy, tactics, policy, incentives and market expansion for PEVs with automotive and EVSE manufacturers, electric utilities, state agencies, non-governmental organizations, and other stakeholders. This organization is slated to continue its work through 2014 and will allow direct engagement with key stakeholders regarding the implementation actions contained in this Plan that lie outside the purview of regional and local governments.
- *Clean Cites Coalitions:* The coalition members work to provide information and education to reduce petroleum use in the transportation sector and have provided the Region with a major advantage in terms of the adoption of PEVs. More recently, the East Bay, San Francisco, and Silicon Valley Clean Cities Coalitions have been co-funded by BAAQMD to increase their outreach efforts to local and regional fleets, including utilities, taxi companies, distribution and delivery services, and public and transit agencies. Based on the success of that program, BAAQMD will continue to utilize these coalitions as a conduit to engage stakeholders throughout the implementation of the Plan.
- *Consumer Education:* BAAQMD and MTC have initiated a consumer marketing and education campaign, which will focus on accelerating PEV purchases and use. The campaign is anticipated to provide a major conduit to maintain stakeholder engagements through marketing partnerships throughout the timeframe of the Plan.
- *Sustainable Communities Strategy:* A significant GHG emissions reduction strategy that underlines the Bay Area's sustainable communities strategy (SCS), as outlined by ABAG and MTC, relies on the mass adoption, deployment, and use of PEVs. The time frames for the PEV strategies run through the year 2035 and help achieve the overall target of a 15% per capita reduction in GHG emissions from light-duty vehicles. To achieve these targets, it

will be necessary for regional agencies to engage with local governments to make sure that PEVs can be easily adopted throughout the Region and to ensure that local governments are ready to deal with the increased numbers of PEVs projected in the SCS. This provides a conduit to engage major municipal fleet owners and local governments throughout the timeframe of the Plan.

- *Incentives:* As part of ABAG and MTC's effort to reduce GHGs and BAAQMD's effort to reduce air pollution, BAAQMD and MTC will be working to prioritize available grant and incentives funding on projects that help to achieve PEV deployment targets outlined in the Plan. The grant program scoping and solicitation process provide an opportunity for the regional agencies to engage directly with major fleets to encourage electrification of taxis, municipal operations, and delivery vehicles. The BAAQMD has extensive history dating back to the 1990s in terms of providing grant funding for the deployment of electric vehicles and its associated infrastructure. Additionally, both BAAQMD and MBUAPCD have extensive connections with major fleets in the Region due to diesel emissions reductions programs that have provided incentives for the replacement of thousands of vehicles over the past 20 years. MTC and Association of Monterey Bay Area Governments (AMBAG), as the conduit for transportation funding in the Region also has extensive experience and pre-existing connections with local transit agencies and their associated fleets. This provides the Region with multiple avenues to engage stakeholders outside of the coordinating councils listed above and to catalyze their adoption of PEVs.

2. Need for a Regional Plan[2]

PEVs are a critical path towards reducing air pollution in communities and harmful emissions that cause climate change. PEVs can also help consumers save money over the life of their vehicle, while reducing the Region's dependence on petroleum.

2.1. Introduction

The Region is currently one of the country's leading markets for PEVs. As of December 2012, it is estimated that there are more than 6,000 PEVs on the road in the Region[3], with more than 700 publicly available charging stations in the ground,[4] and at least another 1,500[5] charging spots planned over the next two years. The first retail DC fast charging station in California was opened in April 2012 at the Stanford Shopping Center, which is the first of at least 50 that will be deployed in the Region by 2014. In addition to the planned publicly available EVSE, an even greater number of EVSE are being installed at residential homes.

Over the past few years, many of the Region's public agencies have implemented a variety of public policy initiatives aimed at transitioning the transportation sector towards increased reliance on zero-emission vehicles. For example, in 2010 the BAAQMD's Board of Directors adopted the Bay Area's 2010 Clean Air Plan, which includes mobile source measure A-2: Zero Emission Vehicles (ZEVs) and Plug-in Hybrid Electric Vehicles (PHEVs). This measure was developed in cooperation with local businesses, city and county governments, and state and federal agencies, and established goals and suggested implementation measures to help accelerate the deployment of Bay Area PEV passenger vehicles and light-duty trucks, including battery electric vehicles (BEVs) and PHEVs[6]: The goals for this measure are as follows:

- By 2012, place 1,000 ZEVs and 5,000 PHEVs into service, primarily in fleets;
- By 2012, expand regional recharging network with 500 new charging stations;
- By 2020, place 10,000 ZEVs and 100,000 PHEVs into service;
- By 2020, expand regional recharging network with 2,000 new charging stations.

Although the goals set for 2012 were exceeded, significant effort will be required to ensure that there is continued progress to achieve the goals established for 2020 and beyond.

---

[2] This section corresponds to the requirements described in Section 3 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

[3] As of November 30, 2012, the California Air Resources Board's Clean Vehicle Rebate Project (CVRP) has issued more than 5,200 rebates for the Region. The Chevy Volt was not eligible for the California state rebate until February 2012 and are therefore not included in the CVR P numbers. Approximately 2,300 Chevy Volt's were sold in CA during this time, with approximately 35% (~800) of these being located in the Region. Purchased by and are, therefore, not reflected in the CVRP database.

[4] Alternative Fueling Station Locator, Alternative Fuels Data Center, available online at: http://www.afdc.energy.gov/locator/stations/

[5] Based on EVSE scheduled to be installed in the Bay Area through various projects, including NRG's settlement agreement with CPUC. More information is available in Section 3.

[6] More information about PEVs such as vehicle architecture is available in Appendix A: Background Information on PEVs and EVSE.

What the vehicle and EVSE deployment numbers do not tell us is: How PEV ready are we and what major barriers to mass adoption of PEVs still exist? In other words, as a Region, how well prepared are local governments and other stakeholders to support an increasing number of consumers who decide to purchase a PEV and/or to install EVSE at their home? The simplicity of plugging in an electric vehicle belies the complexity of what mass adoption entails—from both a planning and technical perspective. Furthermore, although the PEV driving experience is comparable to or better than conventional vehicles, which is paramount to their success in the market place, there are a few crucial differences (and may be perceived by some as barriers to adoption) between the ownership experience of PEVs and conventional vehicles. Ensuring positive end-users' experiences related to these differences will require behind-the-scenes coordination and answers to questions such as:

- How do I get EVSE installed?

This is an important question, particularly because refueling a PEV is different from a conventional vehicle. While the opportunity to refuel at home is extremely convenient and affordable; getting equipment installed at home is a unique aspect of the PEV ownership experience. For PEV drivers who choose to install equipment at home, permits and inspections are required—and it is important that the fees and timing for these processes are minimized and streamlined while ensuring public safety.

- Where can I charge?

Although most charging will likely occur at home (>80%),[7] PEV drivers will be able to better maximize their zero emission miles driven if they also have access to charging away from home at locations such as workplaces, retail centers, and public transit hubs/connections. Some charging needs can be satisfied by ensuring access to 120V outlets; however, other faster rates of charging, including Level 2 and fast charging, will also be necessary.

- Where can I get more information?

PEVs and supporting charging infrastructure are new and emerging technologies that will require education for all parties involved in PEV market, including potential vehicle buyers, dealers, inspectors and other local government staff, electrical contractors, emergency responders, and utilities. While significant amount of targeted stakeholder educational information has been developed, more effort will be needed to ensure that all stakeholders have access to this information.

- Can PEVs (plugging in) cause harm to the utility grid?

In the near-term future, utilities and analysts have demonstrated through research and analysis that it is highly unlikely that deployment of PEVs will lead to negative impacts on the grid. However, in the mid- to long-term future, utilities will need to adapt their infrastructure

[7] The percent of charging at home is discussed in more detail in Section **Error! Reference source not found.**. In the 2nd quarter of 2012, the EV Project reports hat for LEAFs enrolled in the project that more than 95% of charging occurred at home; however, in the most recent report, 67% of LEAF drivers charged at home nationwide and 78% of Volt drivers charged at home nationwide. ECOtality reports that while it may be too early to make an assertion, "common wisdom is that 80% of charging events for a typical driver will be at home."

maintenance plans to account for increased rates of PEV adoption, while also providing PEV owners with incentives to charge off-peak. Although PG&E provides electrical service to the majority of residents in the Region, there are many municipally-owned utilities and a couple of community choice aggregations operating in the Region that will also have to consider how to manage increased PEV adoption. Although the utility will bear the sole burden of managing its services and setting rates, other stakeholders have a role of helping utilities understand where vehicles and EVSE are being deployed.

The progress made in the Region to date has been exemplary; however, there are many critical areas, as discussed in more detail below, for continued improvement that can ensure a successful transition to large-scale adoption of PEV technology.

2.2. Readiness: Where Are We Today?

As part of the PEV readiness planning process, a variety of surveys were conducted of (1) local government agencies, (2) private and public fleets and employers, (3) BEV drivers, and (4) City CarShare users, to learn about the existing and potential barriers to PEV adoption and opportunities to improve the Region's readiness. While these surveys only represent a snapshot in time, they do provide valuable data points regarding the experiences faced by each as regional and local stakeholders chart their respective pathways to getting ready. The following sections highlight key results from the four surveys.

Local Government Survey

BAAQMD conducted a survey of local governments, from March to August 2012, to understand their level of PEV readiness. Many local governments are engaged in the process of becoming PEV ready, so the results of the survey should be understood as a snapshot in time during a dynamic process. The survey sought to answer questions across the key areas of PEV readiness, including the following areas, with an introduction to each PEV readiness element below:

• Building Codes	• Stakeholder Training and Education
• Permitting and Inspection	• Consumer Education and Outreach
• Zoning, Parking, and Local Ordinances	• Incentives for Charging: MDUs, Workplace, and Public

Representatives from more than 100 of the Region's government agencies participated in this self-reported survey of local governments. The results reveal that the Region is in vastly different states of readiness in terms of their attention to developing PEV specific building codes, permitting and inspection practices, and zoning and parking ordinances. Based on the responses to the survey, the five highest-ranking cities in terms of readiness in the Region are San Carlos, Rio Vista, Novato, Santa Rosa, and Brentwood. Recognizing that even the cities that scored well based on survey responses, there are still many steps that can be taken to improve each jurisdiction's PEV readiness. Some of the key results that highlight the need for a regional plan and barriers to PEV adoption include the following:

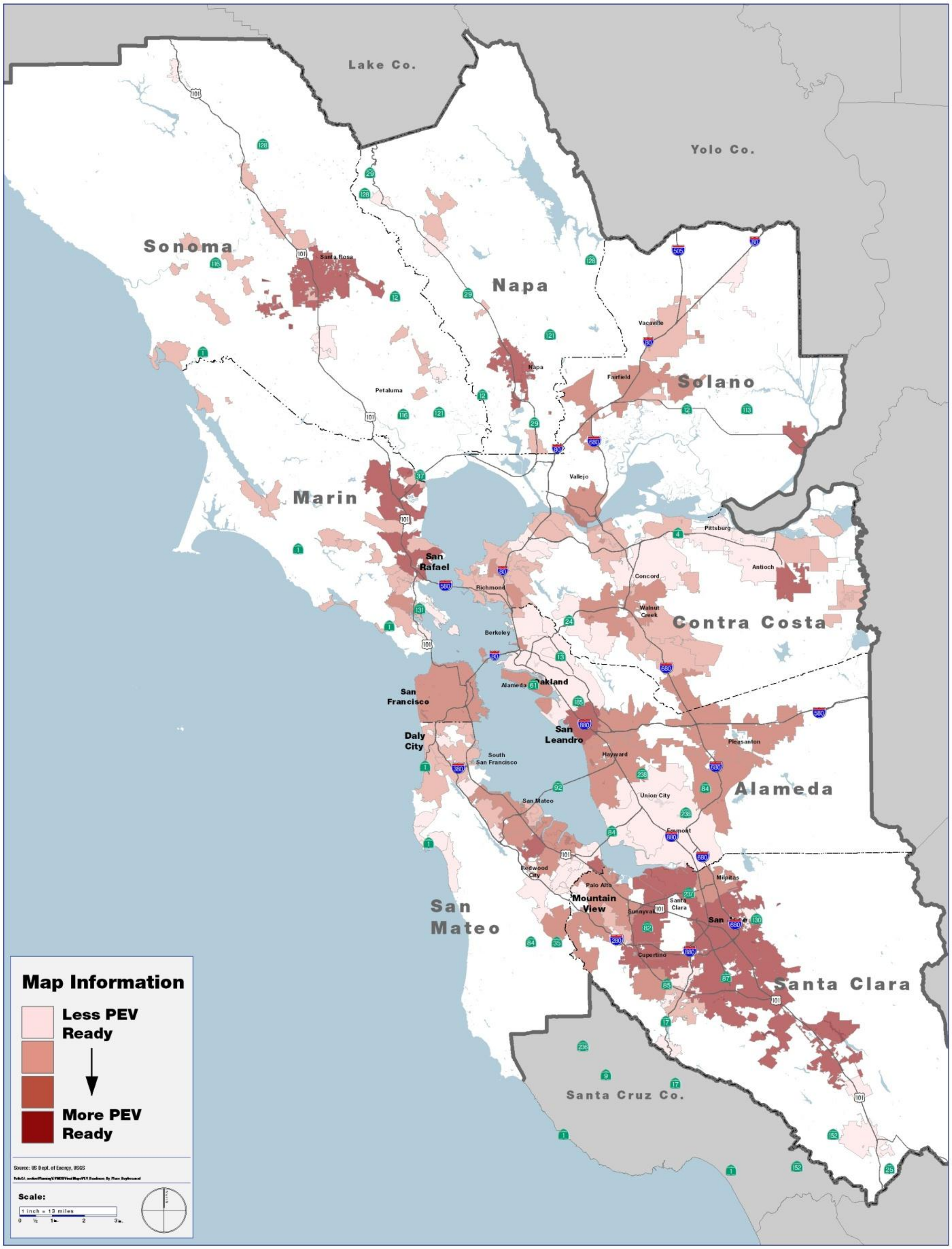
- Only 1 in 6 local governments surveyed have adopted EVSE requirements for permitting; although about 1 in 3 respondents are in the process of or considering the adoption of EVSE-specific requirements for permitting.
- Most agencies are generally close to meeting the goal of 24-48 hour permitting at a cost of less than $250; however, approximately 25% reported taking longer than 6 days to issue permits and approximately 20% reported charging more than $250 across all property types (i.e. residential, commercial).
- The level of readiness regarding zoning and parking ordinances is difficult to ascertain because more than half of the survey respondents indicated that they are not actively involved in these issues. In many cases, two-thirds of the respondents left questions related to zoning and parking ordinances blank. Of the agencies that did respond, only 5% have adopted zoning and parking ordinances related to EVSE.
- Only 1 in 10 local governments have pro-actively adopted building codes for EVSE.

More detailed results of the survey are available in Appendix B: Review of Local Government Readiness Survey.

The maps in Figure 1 and Figure 2 below show the assessment of readiness in the Bay Area and the Monterey Bay Area, respectively. Note that while the maximum PEV readiness score achievable is 100, the top tier of local governments in the Region scored between 48 and 63 on the readiness scale.[8] These scores are based solely on the survey responses, which are self-reported assessments of readiness.

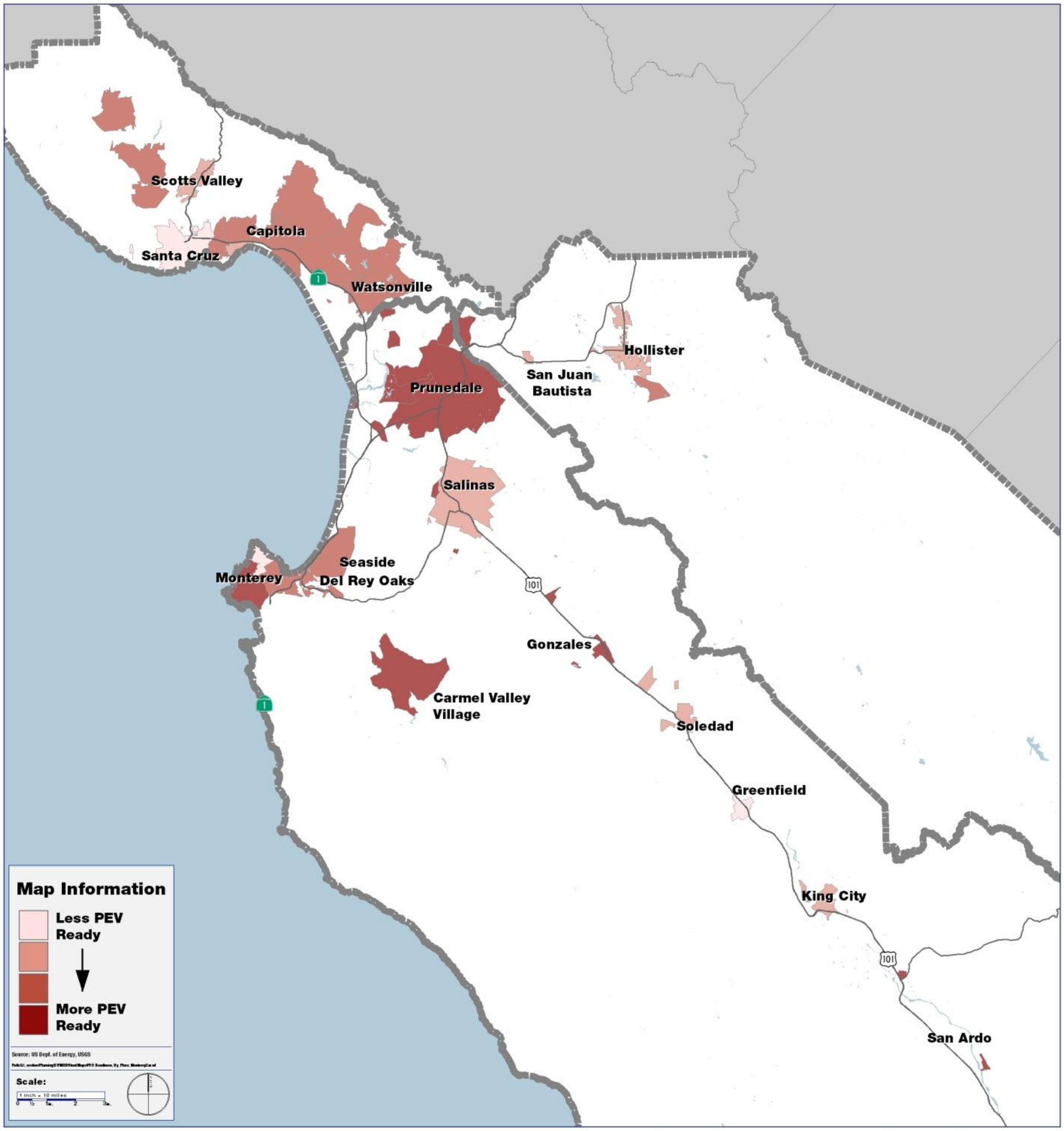
8 Note that in Figure 1and Figure 2, unincorporated towns and communities were given a score based on the responses provided by the corresponding County government.

Figure 1. PEV Readiness in the Bay Area, August 2012



Source: ICF, MTC GIS Unit

Figure 2. PEV Readiness in the Monterey Bay Area, August 2012



Source: ICF, MTC GIS Unit

Regional Fleet and Employer Survey

BAAQMD also issued a survey to Bay Area and Monterey Bay Area workplaces to assess their PEV readiness and to identify tools and resources that would help employers, who are interested in PEV deployment, to successfully provide PEV infrastructure for their employees and fleets. The survey was conducted from June to August 2012, with over 500 responses. More detailed results of the survey are available in Appendix C: Regional Employer Survey. The summary results of the data reported include the following:

- Almost half of the responses are from employers with 100+ employees (45%); 97% of employers have either on-site parking, off-site parking, or both on-site and off-site parking; and 60% of employers own, rent, or a combination of own and rent vehicles.
- Half of employers reported having at least one vehicle that travel on average less than 60 miles each day.
- 21% are considering PEVs for fleet replacement or expansion.
- One out of five employers (22%) have electric vehicle charging stations currently installed at the workplace.
- The top 3 challenges that employers have encountered during the PEV charging station installation or operation are: cost of the installation (19%), cost of the equipment (15%), and no one uses this equipment (13%).

BEV Driver and City CarShare User Surveys

Two other surveys that were conducted for the Plan provide some insight into the readiness planning process, barriers to adoption, and highlight the need for a plan. BAAQMD and ECOtality conducted a survey of Bay Area participants in The EV Project; and MTC, City CarShare, and ICF conducted a survey of City CarShare members regarding their familiarity with and interest in PEVs. The full results from each study are available in Appendix D: Survey of Bay Area EV Project Participants and Appendix E: City CarShare PEV Survey.

The results of the survey of Bay Area participants in The EV Project, conducted from September to October 2012, were very encouraging—one of the limitations of the survey; however, is that it includes only BEVs, specifically Nissan LEAF drivers. The results of the survey reflect a nascent market going through some growing pains:

- Although early adopters report being relatively unconcerned about range anxiety, one of the clear and overwhelming responses was the need for more publicly-available EVSE or away-from-home charging, especially at employment centers, and access to fast chargers along highway corridors to facilitate intra- and inter-regional transportation.
- Keeping in mind that EV Project participants were generally not directly involved with the permitting process and that EVSE installation program eligibility was limited to drivers living in single family homes, the majority of respondents stated that they were satisfied with the permitting process during the installation of residential EVSE; however, one quarter of

respondents still rated their experience as neutral or expressed some level of dissatisfaction.

- 4 out of 5 survey respondents have opted into a time-of-use rate with their utility.

The results from the survey of City CarShare members, conducted in July 2012, help communicate the enthusiasm of the Region's population for new technology, while also highlighting some common misconceptions about PEVs:

- Respondents had good awareness of PEVs and were not seriously concerned by the issues that might dissuade a consumer from purchasing a PEV (e.g., range anxiety, vehicle performance, and safety).
- Respondents were overwhelmingly eager to drive one of the PEVs in City CarShare's fleet. When asked to indicate why they were interested in PEVs the most popular responses (in order) included: environmental reasons, curiosity, affinity for new technology, and the potential cost savings.
- The survey responses are largely consistent with what market analysts generally use to characterize the Region's residents: environmentally conscious consumers with an interest in and curiosity of new technology.
- The responses also indicated some confusion about PEV technology: although a majority of respondents indicated they were familiar with electric vehicles, when asked to identify specific vehicle models, nearly 1 in 5 respondents identified a vehicle that was not a PEV, most notably hybrid electric vehicles (HEVs) such as the Toyota Prius or the Honda Insight. Furthermore, when asked to characterize the all-electric range of PHEVs and BEVs, survey respondents did not typically distinguish between the vehicle architectures properly.

The results of the surveys discussed here also underscore the educational barriers in the Region and the need for a coordinated effort of public and private stakeholders to ensure that the necessary training and education is available to the Region's key stakeholders including permitting and inspection officials, first responders, electricians and installers, car dealers and maintenance workers, and consumers to support early adopters while also facilitating accelerated adoption of PEVs.

Discussion of Barriers to Adoption and Proposed Solutions

A complete discussion of the barriers to PEV adoption and recommended solutions are included in Appendix A: Background Information on PEVs and EVSE. The primary barriers for consumers are highlighted here:

- Vehicle pricing is the most significant barrier to PEV adoption today. Even with incentives, the initial cost of PEVs remains considerably higher than HEVs and internal combustion engine (ICE) vehicles.
- Similarly, consumers' expectations regarding price, range, and charging time are in many cases not met by PEVs available today.

- 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.
- 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 opportunities to charge away from home.

A variety of strategies can be employed to overcome pricing, range concerns, and the availability of EVSE. These include the following:

- For vehicle pricing, the most common strategy to overcome high initial costs of PEVs is to provide consumers with purchasing incentives. There is a federal incentive for qualified PEV purchases, and California also has a program that provides rebates to PHEV and BEV buyers. 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. Incentives are discussed in more detail in Section 9.
- 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.
- 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 – and this is one of the key aspects of this regional readiness planning effort.
- Range anxiety and unfamiliarity with EVSE may also dissipate as consumers gain experience with PEVs and become more comfortable with the technology.

As the technology for PEVs improves and consumer interest increases, it will be important for local and regional governments to reduce or eliminate barriers that fall within their jurisdiction. Sections 5 through 10 include an in-depth discussion of the barriers to adoption (gaps and deficiencies) that local and regional governments can help address through targeted planning and coordination.

3. Current Deployment in the Region[9]

The Region leads in consumer demand for PEVs and has the highest rate of LEAF adoption in the country and in the state on a per household basis. The Bay Area has the most number of vehicles deployed of any of the 22 regions participating in The EV Project, according to a nationwide study of PEV drivers and EVSE deployment. Furthermore, according to the California Center for Sustainable Energy, administrators of the California Air Resources Board's Clean Vehicle Rebate Project (CVRP), more than 5,100 rebates have been issued in the Region for PHEVs and BEVs. This represents 30% of the PHEV rebates and 42% of the BEV rebates issued Statewide,[10] even though the Region only accounts for approximately 17% of the State's population.

The following section contains an overview of the number of PEVs and EVSE that have been deployed and/or are planned for deployment in the Region, the estimated numbers of PEVs that are projected for the Region, and an analysis of vehicle usage patterns.

3.1. Status of Vehicle Deployment

There are currently more than 5 million on-road vehicles in service in the Region. The following is a review of current PEV deployment and forecast for two broad segments of vehicle end-users: personal light-duty vehicles (i.e., passenger cars and trucks) and fleet vehicles (i.e., government and commercial vehicles).

Current Deployment of Light-duty PEVs

Based on data from the CVRP, as of November 2012, more than 5,100 light-duty PEVs have been deployed in the Region (see Table 3 below). Although these data represent the majority of vehicles deployed in the Region (estimated at greater than 75%), the following is a listing of the data limitations that contribute to underreporting of PEVs:

- The most significant limitation is that the first-generation Chevrolet Volts were not eligible for the California rebate. Approximately 7,600 Volts were sold nationwide in 2011 and about 30% of those were sold in California. Considering that the Region accounts for approximately 40% of the California market for PEVs to date, there may be up to 1,000 more Volts (a PHEV) on the road in the Region than what is reported in Table 3 below.
- Although the majority of consumers take advantage of the California rebate, not all PEV purchasers opt for the California rebate incentive.
- There are some PEVs that were likely purchased before the rebate was available to California consumers; the data available extend back to April 2010.

[9] This section corresponds to the requirements described in Sections 4 and 5c-5e, of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

[10] The twelve counties covered in this Plan represent approximately 17% of the State's population whereas combined adoption rate of PEVs is approximately 40% of all vehicles sold in the State.

- This rebate only covers new vehicles sold; PHEV retrofits are not eligible for the rebate and are not represented in the rebate data.

Table 3. Rebates for PEVs issued in the Region

	County	PHEV	BEV	Total
Bay Area	Alameda	407	576	983
	Contra Costa	231	265	496
	Marin	97	138	235
	Napa	15	19	34
	San Francisco	96	226	322
	San Mateo	184	384	568
	Santa Clara	768	1,248	2,016
	Solano	43	32	75
	Sonoma	63	127	190
Monterey Bay Area	Monterey	31	15	46
	San Benito	7	4	11
	Santa Cruz	39	89	128
	Total	1,981	3,123	5,104

Source: CVRP, CCSE and Air Resources Board, November 2012

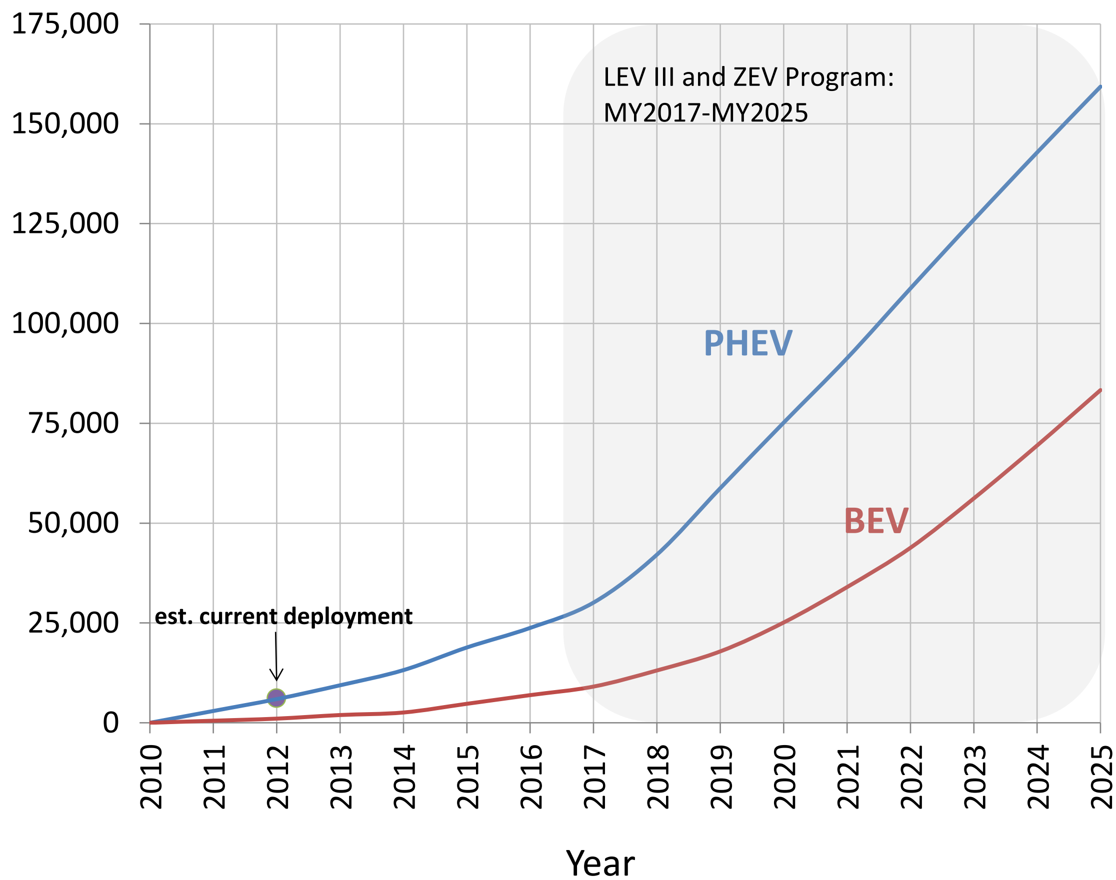
One of the more surprising results is the balance of PHEVs and BEVs to date, since initial forecasts had predicted higher sales in PHEVs than BEVs. CVRP data shows more BEV sales than PHEVs, which may be a result of two factors: (1) the relatively high costs of PHEVs (e.g., the Volt) compared to BEVs (e.g., LEAF); and (2) the fact that neither CVRP rebates nor the California High Occupancy Vehicle (HOV) stickers that allows HOV lane access were available for the early PHEV model. However, as noted previously, there are likely more than 1,000 PHEVs that are not accounted for in these estimates. Furthermore, more recent data show that sales of the Volt and Toyota Prius Plug-In are outpacing sales of the Nissan LEAF. Therefore, based on the more recent sales trends and the data provided via the CVRP, it is anticipated that that there may be more PHEVs on the road than BEVs within the next 12 months.

From a vehicle deployment perspective, the split between PHEVs and BEVs on the road is not particularly important; however, from a policy perspective, the focus of local and regional efforts can shift significantly depending on the vehicle architecture. Where appropriate, these issues are highlighted throughout the Plan; otherwise, the focus on readiness for the Plan is independent of vehicle architecture.

Moving forward, projections show strong continued growth in the PEV market in the Region over the next 10–15 years, with moderate growth of PEV sales over the next several years as shown in Figure 3. In addition to the Region's early adopter culture, it is anticipated that regulatory drivers such as the ZEV Program and Low Emission Vehicle (LEV) III Program—both part of

California's Advanced Clean Cars Program—will increase the availability of PEVs beginning with the release of model year (MY) 2017 vehicles, and accelerate PEV adoption in the Region and throughout the state. Furthermore, battery costs—the most significant driver for PEV costs—are estimated to decrease by about 30% by 2020,[11] making PEVs more affordable and therefore more accessible to a larger demographic of consumers.

Figure 3. Forecasted Baseline PHEVs and BEVs (in the light-duty sector) for the Region



Penetration scenarios in Figure 3 are based on the following inputs and assumptions:

- Based on CARB's most likely compliance scenario,[12] a mix of transitional zero emission vehicles (TZEVs), BEVs, and hydrogen fuel cell vehicles must meet the requirements of the ZEV Program, which requires automobile manufacturers to introduce zero tailpipe emission

[11] 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

[12] Appendix B, Draft Environmental Analysis for the Advanced Clean Cars Program, CARB, December 2011. We also drew from an CARB 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

vehicles in volumes that increase over time. This baseline assumes that TZEVs would all be PHEVs.[13]

- Based on EMFAC, and sales data from California New Car Dealers Association (CNCDA), this baseline assumes that the Region accounts for 21% of new vehicle sales in California.
- Analyses of other national- and state-level forecasts of PEV populations, and trends in HEV penetration in California and the Region were incorporated into the estimates.

Fleet Vehicles

The fleet vehicle market is considerably different than the personal vehicle market; for instance, fleet managers generally procure a vehicle for specific purposes with a narrower focus on vehicle attributes. The following subsections consider the market potential for PEVs in government fleet vehicles, commercial fleet vehicles, and rental and carshare fleet vehicles.

Government Fleet Vehicles

It is currently estimated that there are 50 or more newly-purchased, commercially-available PEVs (i.e., not hybrids that have been retrofitted as PHEVs) in the Region's local government fleets. Of the fleets surveyed, about 50% of respondents indicated that they plan to deploy PEVs and another 35% indicated that they may be deploying PEVs to replace existing vehicles or expand their fleet. However, given the current economic situation faced by government agencies, at least for the foreseeable future, the addition of PEVs in government fleets will likely be highly dependent upon the availability of incentive funds to help offset the higher incremental cost. This is reflected in efforts like the Local Government EV Fleet Project, being led by Alameda County in coordination with the Bay Area Climate Collaborative, which has received significant funding from the MTC, CEC, and BAAQMD. This project is working to procure 90 PEVs for municipal fleets and install 90 Level 2 chargers that will be accessible to government fleets and, in some cases, the public.

There is great potential to impact the PEV market through accelerated deployment of PEVs in government fleets. Government fleet vehicles typically have relatively low mileage relative to consumer-owned vehicles and are in many cases ideally suited for PEV technology. As of 2008, there were approximately 55,000 government fleet vehicles in the Region, with about 1,600 hybrids in service. Of the 55,000 vehicles, about 23,000 were passenger cars (6% hybrids) and the other 32,000 vehicles were light-duty trucks (1% hybrids), or about 56% of the total government fleet. Since light-duty trucks make up about 40% of the overall light-duty vehicle fleet, the potential for electrification in that vehicle category may be limited in the near-term future given that most vehicle forecasts for the next several years indicate that the overwhelming majority of PHEV and BEV offerings will be light-duty cars as opposed to trucks.

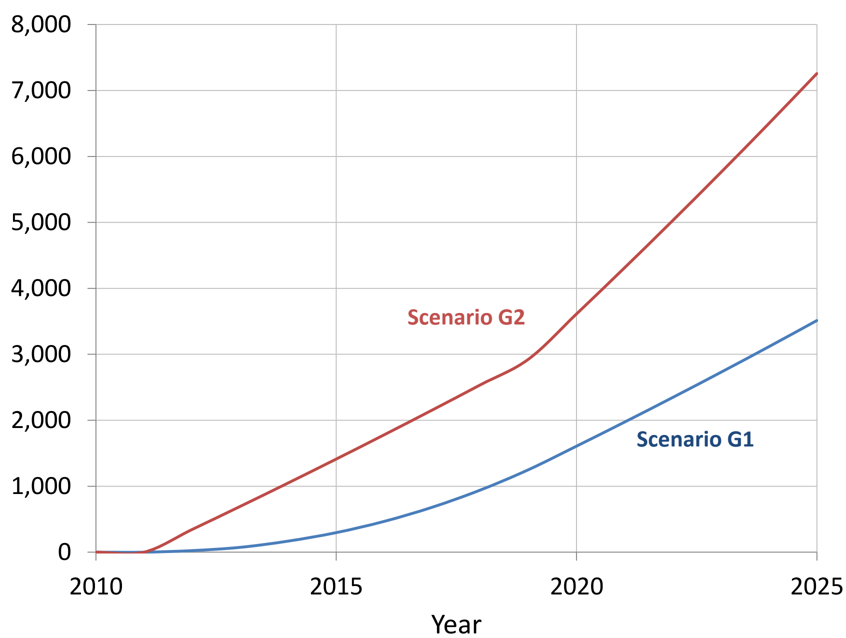
PEV penetration scenarios for government fleets in the short and medium term have been developed and are shown below in Figure 4. Based on an analysis of the Department of Motor

[13] Appendix B, Draft Environmental Analysis for the Advanced Clean Cars Program, CARB, December 2011. We also drew from an CARB 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

Vehicles (DMV) data from 2008, both of these scenarios assume that government fleets are purchasing vehicles on an annual basis equivalent to 4.8% of the existing fleet, while retiring 2.4% of the vehicles in the fleet. These scenarios also consider average growth in the Region's publicly-owned vehicles by model year. According to statistics published by the US Department of Transportation Federal Highway Administration (FHWA), California public fleets grew by an average of about 1.6% for automobiles and 2.5% for trucks from 2000-2009. Based on these increases and the model year population counts as of 2008, it is estimated that on average, government fleets in the Region are retiring vehicles at the rate of 50% for each new vehicle that they purchase.

- Scenario G1: assumes compliance with the goal set forth by the Governor's ZEV Action Plan for the state's vehicle fleet that calls for 10% of new light-duty automobile purchases are ZEVs beginning in 2015 and up to 25% of purchases are ZEVs in 2020. For the purposes of this analysis, ZEVs are assumed to be PEVs.
- Scenario G2: assumes that about 30% of new light-duty automobile purchases are PEVs beginning in 2012 and that about 15% of new light-duty truck purchases are PEVs beginning in 2020.

Figure 4. Forecasted PEVs in Government Fleets for the Region



Commercial Fleet Vehicles

The commercial light-duty vehicle fleet in the Region is about 10% of the total light-duty vehicle fleet. There are also a significant number of medium-duty vehicles in commercial fleets in the Region; for the purposes of this section, truck Class 2b and truck Classes 3-5 are considered. There are about 4.4 million light-duty vehicles on the road in the Region today; 650,000 commercial fleet vehicles are estimated to be in service in the Region today, including light-duty vehicles and trucks up to Class 5 (see Table 4 below).

Table 4. Estimated Commercial Vehicle Fleet Population, 2012

Vehicle class	Est. Population in 2012
Light-duty cars	228,000
Light-duty trucks	234,000
Trucks, Class 2b	141,000
Trucks, Class 3-5	47,000
Total	650,000

Based on data from EMFAC2011, these vehicles populations are forecasted to increase between 0.5–1.5% annually. Based on DMV registration data from 2008, commercial fleets in the Region are much more likely to have registered a HEV than the personal vehicle fleet (see Table 5). For light-duty cars, the penetration rate of hybrids in the commercial fleet sector is more than double the rate of the personal (or private) vehicle fleet; for light-duty trucks, the commercial sector has a penetration rate nearly two thirds higher than the personal vehicle fleet. These penetration rates are likely reflective of the fuel cost savings over the life of the vehicles in fleets; commercial fleet managers are likely more price sensitive than the average consumer and are more willing to invest in hybrid vehicles to realize potential fuel savings. It is also possible that commercial fleets in the Region are keen on promoting an environmentally friendly business via green fleet adoption.

Table 5. Hybrid Penetration Rates in the Personal and Commercial Vehicle Fleet, 2008

County		Light-duty Cars		Light-duty Trucks	
		%Hybrid, Personal	%Hybrid, Commercial	%Hybrid, Personal	%Hybrid, Commercial
Bay Area	Alameda	2.4%	5.3%	0.6%	0.9%
	Contra Costa	2.1%	6.7%	0.6%	1.1%
	Marin	4.6%	8.4%	1.7%	1.7%
	Napa	2.5%	4.3%	0.6%	1.6%
	San Francisco	2.8%	7.7%	1.3%	2.4%
	San Mateo	2.6%	6.2%	1.0%	1.4%
	Santa Clara	2.4%	4.8%	0.7%	1.0%
	Solano	1.7%	3.1%	0.4%	0.5%
	Sonoma	2.8%	5.8%	0.6%	0.7%
Monterey Bay Area	Monterey	1.7%	3.2%	0.4%	1.1%
	San Benito	1.6%	3.4%	0.3%	0.6%
	Santa Cruz	3.0%	6.0%	0.6%	1.1%
	Total	**2.5%**	**5.6%**	**0.7%**	**1.2%**

Source: ICF analysis of California DMV data

Based on data collected from the CVRP, California licensed businesses in the Region have purchased 42 light-duty PHEVs, 119 light-duty BEVs, and 15 heavy-duty BEVs. These figures do not reflect PEVs that were purchased for businesses that are registered as sole proprietors nor data for any PEVs purchase that did not receive a rebate. Based on a survey of regional employers, about 15% of fleets that own, lease, or rent their vehicles have PEVs in their fleet; most of these are either light-duty cars or trucks and forklifts. About 1% of fleets reported having medium- or heavy-duty PEVs in their fleet. Of the fleets surveyed that have vehicles, about 30% of respondents indicated that they plan to deploy PEVs and another 40% indicated that they may be deploying PEVs to replace existing vehicles or expand their fleet.

Despite the operational cost savings from PEVs, the high vehicle purchase prices will continue to be a barrier for PEVs in commercial fleets, and adoption will likely be dependent to some extent on the availability of financial incentives. In California, incentives are currently available for medium- and heavy-duty electric vehicles through the CARB's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP); however, vehicle offerings are limited at this time. Also, the federal tax incentive for PEVs is available to commercial fleet owners, but is limited to entities with an income tax liability. Research conducted for this Plan indicates that there is limited uptake of the federal incentive from fleets and that fleets generally have a difficult time taking advantage of income tax credits. Another incentive that must be considered moving forward for commercial fleet vehicles is the Low Carbon Fuel Standard (LCFS). The recently approved modifications to the LCFS define the following as a potential regulated party (i.e., an entity that can earn LCFS credits) for electricity:

> For transportation fuel supplied to a fleet of three or more EVs, a person operating a fleet (fleet operator) is eligible to be a regulated party. If the fleet operator is not the regulated party for a specific volume of fuel, or has not otherwise fully complied with the requirements of this subarticle, the Electrical Distribution Utility is eligible to opt-in as the regulated party with Executive Officer approval. For transportation fuel supplied to a fleet of less than three EVs, the Electrical Distribution Utility is eligible to be the regulated party. To receive credit for transportation fuel supplied to an EV fleet, the regulated party must include in annual compliance reporting an accounting of the number of EVs in the fleet.[14]

In other words, commercial fleets that operate more than 3 PEVs and install EVSE can earn LCFS credits, which can improve the value proposition (e.g., the payback period) of purchasing an electric vehicle compared to a conventional vehicle or HEV.[15]

Commercial fleet vehicle projections are shown in Table 6 below. These estimates are based on DMV data, expected vehicle population growth from EMFAC, responses from the regional employer survey, and market research. These forecasts considered information such as the following:

[14] Subchapter 10, Article 4, Subarticle 7, § 94584(a)(6)(C.1) of the California Code of Regulations. Available online at: http://www.arb.ca.gov/fuels/lcfs/CleanFinalRegOrder_112612.pdf

[15] To date, only 9 trades of LCFS credits have been reported, ranging in value from $10-$30 per credit (which is equivalent to 1 metric ton of GHG reductions)

- In the light-duty vehicle segment, commercial fleets are forecasted to adopt light-duty PEVs at a faster rate by 2015 than the personal vehicle market, reflecting to a lesser extent the current adoption rate of HEVs in the commercial fleet sector.
- In the Class 2b and Class 3-5 segments, there are fewer options and sales volumes are much lower. Based on vehicle populations in EMFAC2011, about 2,500-3,000 vehicles are added to the Class 2b segment in the Region annually and about 800-1,100 vehicles are added to the fleet annually in the Class 3-5 segment. For these heavier vehicles, there are currently fewer options available for purchase and it is forecast that PEV sales in these segments will likely focus on PHEVs in the near-term future, with only some BEV sales.
  - In the heavier vehicle classes, particularly Class 5, HEVs have only recently been put into service at modest penetration rates, largely as a result of investments through the HVIP.
  - The estimates for the Class 2b and the Class 3-5 trucks are low and high estimates based on factors such as uncertainty in the number of vehicle offerings in the market, and the likely high incremental cost of PEV ownership compared to other vehicles.
  - It is also important to note that PEVs are forecasted to face significant competition from compressed natural gas (CNG) in the Class 2b and Class 3-5 truck segments. Many larger fleets (e.g., AT&T) already have made a significant commitment to CNG. Furthermore, the fuel price differential between CNG and diesel has been persistent for the last 12 months and is currently about $2.00 per diesel gallon equivalent. This price differential is forecasted to remain unchanged according to the most recent Annual Energy Outlook[16] for the next several years.

Table 6. Commercial Vehicle Fleet Projections for the Region, 2012-2025

Year	Light-duty Vehicles	Class 2b	Class 3-5
2012	200	0	15
2015	1,700	200-400	100-200
2020	13,500	500-1,000	200-400
2025	46,100	800-1,600	300-600

Rental and Carshare Fleet Vehicles

Rental and carshare applications also have great potential to positively influence the overall PEV market because of the emphasis on operating costs and by providing exposure to a large subset of the population that would otherwise not have access to PEVs. Trips taken in carshare vehicles are typically short, and usually fall well within the all-electric range of PEVs provided that PEVs have ample time to charge between uses.

[16] Annual Energy Outlook 2012, EIA. Available online at: http://www.eia.gov/forecasts/aeo/er/index.cfm

To date, both Enterprise and Hertz have deployed PEVs in the Region. Despite these deployments, there are insufficient data available to estimate the existing number of PEVs in rental car fleets or forecast the number of PEVs in rental car fleets at this time.

The carsharing market is of particular importance in the Bay Area with an estimated 60,000 members. Since carsharing business models include the cost of fuel in their pricing, it is more cost-effective to manage a fleet that is as fuel efficiency possible. BEVs present an opportunity to reduce operating costs further due to the lower cost of fuel (electricity) compared to gasoline. City CarShare and Zipcar have both started introducing PEVs. City CarShare, with grant funding from MTC, BAAQMD, and the Reformulated Gas Settlement Fund via the Bay Area Clean Air Foundation (discussed in more detail below), is deploying more than 30 PEVs into its fleet. Zipcar recently announced the deployment of a Honda Fit EV into its San Francisco fleet.[17] Similarly, BMW is partnering with a carshare service to deploy up to 100 BMW ActiveEs in the Bay Area – there are currently 37 vehicles in the program placed near the San Francisco International Airport, Oakland International Airport, and downtown San Francisco.[18]

Based on estimates from City CarShare, there are currently approximately 1,250 vehicles in carsharing fleets in the Region. Based on estimates of recent rates of membership increases in the Region, and assuming that the ratio of vehicles-to-members is constant, the number of vehicles in carsharing fleets is anticipated to double by 2020. Based on existing PEV deployments and plans for deploying PEVs, PEVs are projected to represent between 10-20% of the carshare fleet in 2020, representing 250-500 PEVs in carshare fleets in the Region.

3.2. EVSE Deployment

It is estimated that as of November 2012 that there are more than 3,000 residential EVSE and 700 publicly available EVSE in the Region. The following is a review of current EVSE deployment, forecasts for future deployments, and a discussion of strategies to overcome identified and potential barriers to EVSE deployment.

Residential EVSE

For the first year of the release of the Nissan LEAF, vehicles were only sold to consumers who committed to install EVSE in their home. As more vehicles have come to market, this requirement has been waived with original equipment manufacturers (OEMs) taking proactive measures to 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 (PG&E, PEVC guidelines, etc.).

Although relatively few EVSE installations have occurred at MDUs to date, several efforts have been initiated to provide guidance and best practices for potential PEV owners at MDUs. The PEVC has been developing a high level reference manual for MDU residents and property managers to provide guidance on elements and issues associated with PEV charging

[17] More information is available online at: http://ir.zipcar.com/releasedetail.cfm?releaseid=706763

[18] More information is available online at: https://us.drive-now.com/

operations and supporting electrical charging infrastructure at MDUs. To date, several factors that are unique to MDUs have been identified as issues that MDU residents will likely have to address when deploying EVSE (see Table 7 below for a list of common issues). In addition, pertinent laws regarding PEV charging at MDUs will be touched on to provide a brief synopsis on legal responsibilities as they currently stand.

In addition to guidelines and best practices, several projects have emerged to collect data and test different installation scenarios. For example, in the City and County of San Francisco, the San Francisco Department of Environment is currently conducting MultiCharge SF in partnership with Coulomb Technologies to bring 100 Level 2 EVSE to MDUs in San Francisco, a place where up to two-thirds of residents reside in MDUs. The project, which covers the costs of charging equipment and significantly subsidizes the costs of installation, will help develop a knowledge base and best practices for EVSE deployment in MDUs.

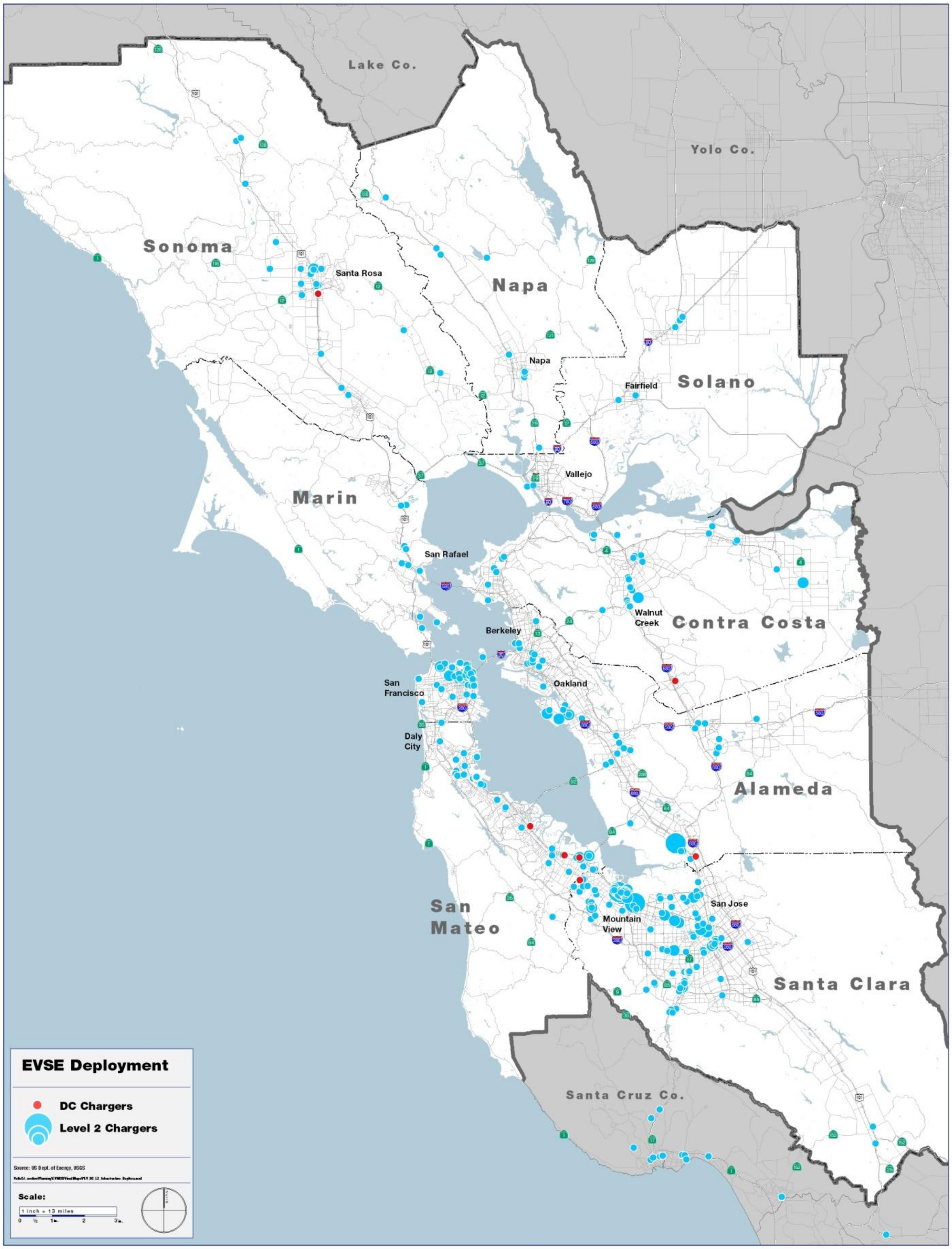
Table 7. Common Issues for Consideration that Impact EVSE Installation at MDUs

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 • Homeowners Association 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

Publicly Available EVSE

In response to the Regions' consumer interest, regional agencies and electric vehicle service providers (EVSPs) have initiated efforts to deploy publicly available infrastructure, as highlighted in Table 8 and discussed in the following sections below. The current map of EVSE in the Region is also shown in Figure 5 and Figure 6 below.

Figure 5. EVSE Deployed in the Bay Area, December 2012



Source: MTC GIS Unit; data retrieved from AFDC on December 3, 2012

Figure 6. EVSE Deployed in Monterey Bay Area, December 2012

Source: MTC GIS Unit; data retrieved from AFDC on December 3, 2012

Table 8. Overview of EVSE Deployment Projects in the Region

Project Title	Lead & Support Agencies	Incentive Funding: Source	Incentive Funding: Amount (millions)	Match Funding	Charging Stations: Residential Level 2	Charging Stations: Nonresidential Level 2	Charging Stations: DC Fast
EVSE Home Charger Rebate Program	ECOtality, Coulomb Technologies, AeroVironment	BAAQMD	$2.50	n/a	3,000		
		DOE	$5.00				
DC Fast Charger Program	AeroVironment, TBD	BAAQMD	$0.45	$1.20[a]	--		50
ChargePoint America	Coulomb Technologies	DOE	$1.17[a]	$1.71 [a]		330	--
Bay Area and Monterey Bay Area EV Corridor Project	EV Communities Alliance. ABAG, Local Cities/Counties	CEC	$1.49	$2.60	--	186	18
		BAAQMD	$0.40		--		
Reconnect CA	Clipper Creek	CEC	$2.30	$1.20	--	65	--
Local Government EV Projects	Multiple	BAAQMD	$0.15	$1.94		50	--
		MTC	$2.80				
eFleet: Car Sharing Electrified	City CarShare SFCTA,	MTC	$1.70	$0.74	--	24[b]	
		BAAQMD BACAF/RFG	$0.53				
Bay Area Electric Vehicle Taxi Corridor Program Better Place, SFMTA		MTC	$7.00	$8.00	*6 battery switch stations*		
		CEC via BAAQMD	$3.00				
		BAAQMD	$0.43				
Tribal Community Sustainable Transportation	Kashia Band of Pomo Indians	MTC	$0.37	$0.08		6	--
Businesses Deploying EV Infrastructure	Best Buy, McDonald's, Etc.	BAAQMD	$0.34	$0.75		178	--
Electric Vehicle Charging Station Project	NRG (settlement w/ CPUC)	n/a	--	$25.00[c]	1,650 [c] (minimum)		55
				Total (maximum)	**3,990**	**1,499**	**123**

[a] Values were estimated based on the total project funding, match funding, and grant funding. [b] City CarShare has been installing EVSE through the ChargePoint America program. These charging stations are not included in the total because they are already accounted for in the ChargePoint America line item. [c] To estimate the match funding for the Region, we assumed about 25% of the settlement would be invested in the Bay Area and Monterey Bay Area. For the purposes of our EVSE estimates, we assume that 60% of the Make Readies (see below for more information) to be deployed by NRG will ultimately be residential Level 2 EVSE and the other 40% will be nonresidential Level 2 EVSE.

The EV Project

The EV Project (EVP), a $230 million project managed nationwide by ECOtality, was partially funded by the DOE as part of the American Recovery and Reinvestment Act (ARRA), receiving a total of $115 million. In the 9-County Bay Area, the EV Project is also co-funded by the BAAQMD via the EVSE Home Charger Rebate Program. Through June 2012, ECOtality reports[19] that 871 residential Level 2 chargers and 16 publicly available Level 2 chargers have been installed in the Bay Area with 1,260 Nissan LEAFs enrolled to date. To date the Bay Area's program has focused mainly on residential installations; however, ECOtality reports that they plan to deploy additional DC fast chargers in the Region in the near future.

BAAQMD EVSE Deployment Programs

The BAAQMD is a key local funding source that has allocated more than $6 million over the past three years to support EVSE deployment in the 9-County Bay Area. This funding is being deployed in two phases: Phase 1 has awarded more than $1.3 million to projects that are deploying more than 200 publicly available Level 2, 6 DC fast charging EVSE and four battery switch stations. In addition, the BAAQMD and its non-profit affiliate, Bay Area Clean Air Foundation, in partnership with the Reformulated Gas Settlement Fund, are also providing funding to City CarShare to deploy 10 converted PHEVs and EVSE in a carsharing environment.

Phase 2 provides an additional $5 million to install 3,000 residential Level 2 and 50 DC fast charging EVSE. EVSPs currently participating in BAAQMD's Phase 2 *EVSE Home Charger Rebate Program* include ECOtality (1,500 Blink home chargers), AeroVironment (500 residential chargers), and Coulomb Technologies (500 residential chargers). Through July 2012, more than 800 EVSE have been installed through this program.[20] AeroVironment was also selected by BAAQMD to install 10 DC fast chargers in the Bay Area region by December 2013. Recommendations for the allocation of the remaining funds from Phases 1 and 2 are pending upon the completion of this Plan.

ChargePoint America

This is a $37 million project, with $15 million from 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 eight (8) Level 2 chargers are deployed in the Premier Parking Lot and five (5) EVSE in the Monterey Bay Area, with the infrastructure deployed in the cities of Scotts Valley, Capitola, Aptos, and Santa Cruz.

---

19 The EV Project Q2 2012 Summary

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

California Energy Commission

The CEC has funded three projects that are focusing on the deployment of EVSE in the Bay Area. The **Bay Area EV Corridor Project** is being implemented by ABAG and the EV Communities Alliance. This project also includes deployment of EVSE in the Monterey Bay Area, with an estimated 44 dual outlet EVSE deployed in the Monterey Bay Area, managed in coordination with MBEVA and Ecology Action. The CEC has also provided funding to Clipper Creek to manage a statewide effort to **update the infrastructure** that was in place from the initial deployment of PEVs from the late 1990s. Finally, in October 2012 the CEC awarded $3 million to the BAAQMD to provide additional funding to Better Place to expand the scope and duration of the **Bay Area Electric Vehicle Taxi Corridor Program** that is described further below.

Metropolitan Transportation Commission

The MTC is another key regional agency that has provided significant funding in the 9-County Bay Area through its **Climate Initiatives Program** to support EVSE and PEV deployment:

- 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 four battery-switching stations. The project received approximately $7 million in Climate Initiatives funds, $0.45 million from BAAQMD and $3 million from CEC via the BAAQMD.

- 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 in Climate Initiative funding and additional funding from the BAAQMD and CEC.

- 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 from MTC and an additional $0.53 million in funding from the BAAQMD that includes funds from the Reformulated Gas Settlement via the Bay Area Clean Air Foundation. City CarShare has also established itself as a leader in the Bay Area with regard to EVSE deployment in a carshare fleet. Through its **eFleet Program,** they currently have more than 10 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 Bay Area fleet of about 400 vehicles, they have the potential to deploy 200 PEVs. 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 charging station available for public use.

- The Kashia Band Pomo Tribal Government of the Stewarts Point Rancheria received approximately $370,000 to deploy four PEVs – two sedans and two vans – and six charging stations. As part of the project, the tribal government will integrate solar power to reduce the carbon intensity of the electricity generated and used to power vehicles.

Monterey Bay Unified Air Pollution Control District

The MBUAPCD has played an active role in deploying EVSE in the Monterey Bay Area. They have recently providing funding for the following projects:

- AMBAG received funding to install four ECOtality Blink stations and funding for public outreach and policy analysis.
- Transportation Agency of Monterey County received a grant to install seven Level 2 EVSE in the tri-county Monterey Bay Area.
- Santa Cruz County Regional Transportation Commission received a grant to install one DC fast charging station.
- City of Santa Cruz received a grant to install EVSE in public parking garages in downtown Santa Cruz, providing a total of about 10 Level 2 EVSE.

NRG Settlement with the California Public Utilities Commission

The most recent development related to the deployment of charging infrastructure that will affect the Region is the settlement between NRG Energy Inc. and the CPUC stemming from the California energy crisis in 2000 and 2001. Of the $122.5 million settlement,[21] NRG will invest $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** to be deployed statewide, with 55 of these deployed in the Bay Area. Each Freedom Station will consist of at least one 50 kW DC fast charger and one Level 2 EVSE.[22] On top of the $50.5 million earmarked for stations, another $3 million is earmarked for the 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,[23] collectively referred to as **Make-Readies**, are to be deployed statewide at a cost of $40 million. An estimated 1,650 Make Ready Stubs will be deployed in the Region, with an additional 4,000 stubs to be deployed at NRG's discretion. The bulk of the $40 million will go towards wiring homes, and preparing workplaces, multi-family dwelling units (MDUs), hospitals, and schools for EVSE. It is anticipated that NRG will target the Region with more than its proportionate share of installations, given its higher rate of PEV adoption and also higher proportion of residents living in MDUs. Property owners who choose to allow make-readies to be installed on their property will grant NRG exclusive rights for 18 months to sell the equipment and related services to the property owners and or operators.

21 The CPUC news release and more information about the settlement is available online at : http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M033/K171/33171185.PDF

22 Per the terms of the settlement, NRG also has the option of deploying two DC fast chargers at Freedom Stations.

23 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.

- The **Technology Demonstration Program** will apply $5 million towards 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 that 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, and other projects that will help under-served communities.

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, at least 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 Communities Strategy: Plan Bay Area

Bay Area Regional agencies 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, 2012, MTC and ABAG approved the Plan Bay Area Preferred Land Use and Transportation Investment Strategy.[24] This 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 2040. While most of these investments (88%) go towards maintaining the existing road network and transit system; there are two key aspects of Plan Bay Area that will promote the deployment of PEVs and EVSE through 2040:

- **Regional Public Charger Network:** With PHEVs likely to be deployed in significant numbers, this strategy makes targeted investments to help increase the number of pure electric miles traveled by PHEVs while expanding the range of BEVs. The initial plan is to dedicate approximately $80 million over the span of 15 years to support this program.
- **Vehicle Buyback & PEV Incentives Program:** This buyback program allocates $120 million over the span of 15 years for the trade-in of 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).

3.3. PEV Driver Behavior: Charging and Trips

Given that fully commercialized PEV technology is in its infancy there are very few large-scale studies that have been conducted on PEV driver and charging behavior. Nonetheless, keeping in mind that the data sets that are available are not fully representative of all types of PEV drivers' habits, it is helpful to review data that are available in order to better anticipate and understand the potential needs of future early adopters and fast followers.

[24] Preferred Land Use and Transportation Investment Strategy for Plan Bay Area, May 2012, available online at: www.onebayarea.org

Overview of Data

Aggregated charging and trip data provided by ECOtality as part of the EVP engagement in the Bay Area were analyzed for the Plan.[25] EVP participation in the Bay Area was limited to drivers living in single-family homes with on-site garages, so this study does not address behaviors of potential PEV owners living in MDUs. It is also important to note that the EVP in the Bay Area is only available to Nissan LEAF drivers[26]; and as a result, charging data for other types of BEVs or PHEVs is not reflected in the following analysis.

The summary results of the data reported include the following:

- There were 735 residential EVSE (reported) serving 668 vehicles in the Region, with San Jose accounting for nearly 20% of the vehicles in the Program (see Table 9 below for a distribution across the top 5 cities, representing about 40% of all vehicles in the program)
- Bay Area EV project participants have driven more than 4.8 million all electric miles, and consumed 1.1 million kWh of electricity.
- Participating vehicles spend about 34% of the time plugged in and about 7% of the time charging (i.e., drawing power from the EVSE).
- The average daily distance driven (when vehicle was driven) was 31.2 miles.
- The total number of plug-in events (not charging events) and number of vehicles is a linear relationship, with little variation between cities (see Figure 7).
- Based on the maximum demand profiles for charging events, there are some small differences between charging behavior on the weekend vs. weekdays (see Source: ECOtality
- Figure 12).
- There are small variations in weekday maximum charging demand between cities, with the most noticeable differences around the so-called shoulder of peak demand, post 6pm (see Figure 13).

Table 9. EVP Vehicle Counts in 5 Highest Ranking Cities (Highest Rates of Participation in the Bay Area)

Rank	City	Vehicle Count
1	San Jose	130
2	Fremont	46
3	Oakland	38
4	Palo Alto	28
5	San Francisco	28

25 The data reported here are derived from a report submitted for the 2nd Quarter of 2012.

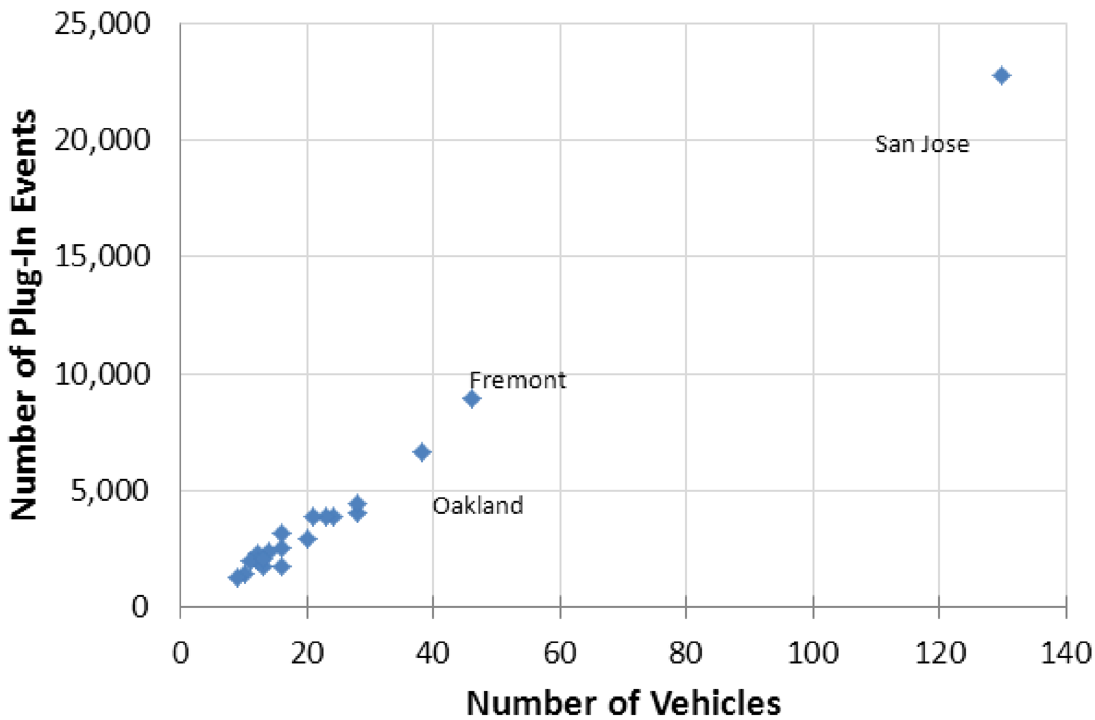
26 The charger that comes standard with Nissan LEAFs that participated in the EVP is capable of accepting up to 3.3 kW power.

The data reported via the EVP, the corresponding description, and some limitations are highlighted in Table 10 below.

Table 10. Overview of EVP EVSE and Vehicle Data Elements

Parameter	Description and Limitations
No. of Level 2 EVSE	Monthly data, and total to date
Percent of time w/ EVSE connected	Monthly data, and total to date Data are only reported when >10 EVSE in zip code
Percent of time vehicle drawing power from EVSE	Monthly data, and total to date Data are only reported when >10 EVSE in zip code
Total electricity consumed by EVSE (AC kWh)	Monthly data, and total to date Data are only reported when >10 EVSE in zip code
No. of vehicles	Data reported by city Data are only reported when >10 vehicles in zip code
Sum of all miles	Data reported by city Data are only reported when >10 vehicles in zip code
Vehicle Id	Vehicles identified by zip code and city; no usage metrics are reported, only vehicle counts
Charging Events	Monthly data and total to date Data are only reported when >10 EVSE in zip code or city These are plug-in events, not charging events Data cannot be linked to individual vehicle
Time of Day Demand (AC kW)	Min and Max Charging Demand, hourly Data are only reported when >10 EVSE in zip code or city

Figure 7.Plug-in Events and Number of Vehicles, by City, 2nd Quarter 2012

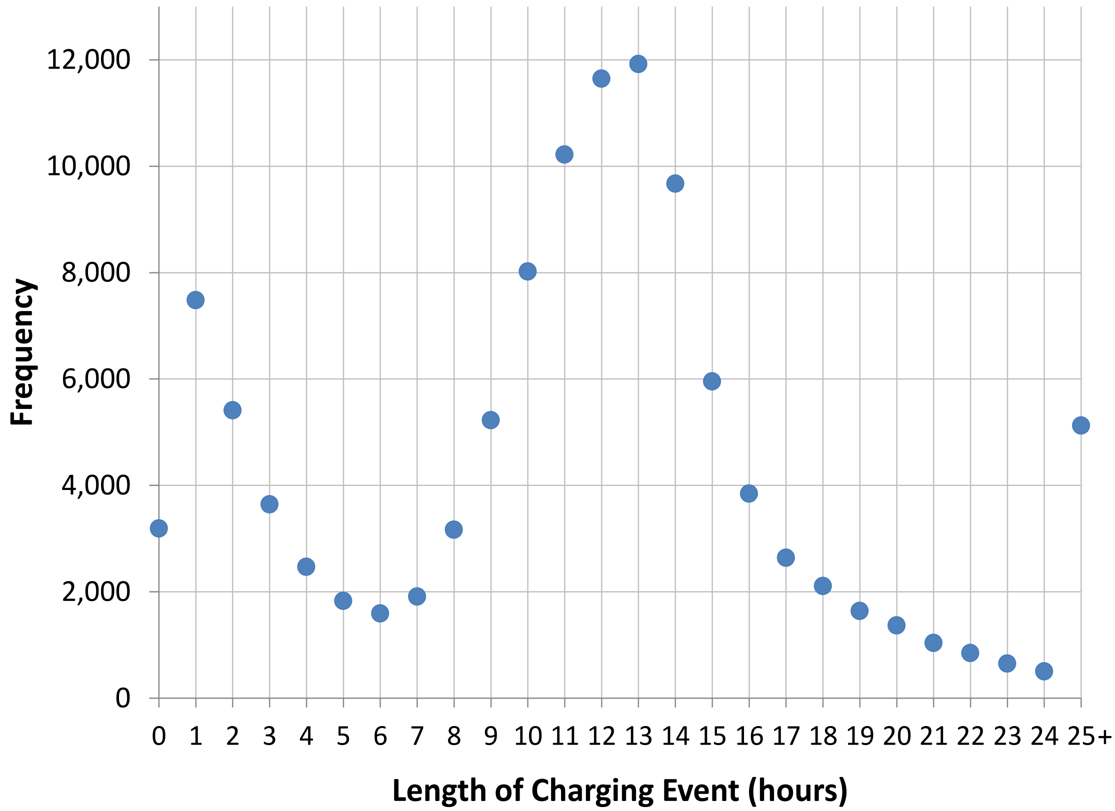


Source: ICF analysis of data provided by ECOtality

Residential Connectivity and Charging

The EVP report includes data related to residential charging – only those vehicles for which data can be matched with a residential EVSE are considered. In the overview of the region, there were a total over 51,000 charging events on residential EVSE. On average, these EVSE had a vehicle connected 34% of the time and the vehicle was drawing power 7% of the time. Figure 8 shows the frequency of charging events by the length of time over which PEVs were connected to EVSE. When connecting at home, about 54% of the connections are for 8 to 14 hours, which would be expected for overnight charging. Of interest are the connections at home that are less than 4 hours duration that might indicate a recharge prior to another trip.

Figure 8. Residential Charging Event Frequency in the Bay Area – EV Project LEAF Drivers, 2nd Quarter 2012



Source: ICF analysis of data provided by ECOtality

The percent of time a vehicle is connected generally seems to be lowest for zones in urban areas and closer to job centers, such as San Francisco and Mountain View (in Santa Clara County). On the other hand, the percent of time that vehicles are connected tends to be highest in suburban areas away from job centers, such as Santa Rosa (in Sonoma County) and Solano County. This may indicate that LEAF drivers in these areas have longer commutes and generally connect their vehicles for a longer part of the day. A similar pattern emerges for the percent of time that vehicles spend charging. For example, drivers in Solano County and Santa Clara County generally draw power at higher rates than San Francisco and Mountain View.

Away From Home LEAF Driver Behavior

The EVP only collects data on those units provided by the Project and in the Bay Area, the EVP has provided very few away from home EVSE. The report for the 2nd quarter 2012 identifies 16 EVP-sponsored publicly available EVSE at which 493 charging events occurred. These were workplace units with an average of just over 27 charges per EVSE. On average, these EVSE had a vehicle connected 6% of the time and the vehicle was drawing power 3% of the time. There were also a significant number of away from home charging events that occurred on EVSE not provided or instrumented by the EVP. A majority (72%) of the vehicle charging was conducted at home, while 23% of the charging was conducted away from home, as shown in

Table 11. Note that 6% of the charges could not be identified as either residential or non-residential because of anomalies in the GPS data.

Table 11. Frequency of Charging at Different Locations, 2nd Quarter 2012

Charging Location	Frequency
Home	72%
Non-residential / away from home	23%
Unknown*	6%
* Note: These charging events are identified as such because of anomalies in the GPS data	
Source: ECOtality	

In all areas of the EVP study, the majority of charging events and time parked occurs at home. In most areas that are not near urban areas or job centers their tended to be a higher frequency of charging events occurring at home. On the other hand, EVP participants near Stanford University stand out for example, with a particularly low fraction of charging events occurring at home. Vehicles from San Francisco also tend to spend a higher percentage of time parked at home, which may in part be the result of other transportation options.

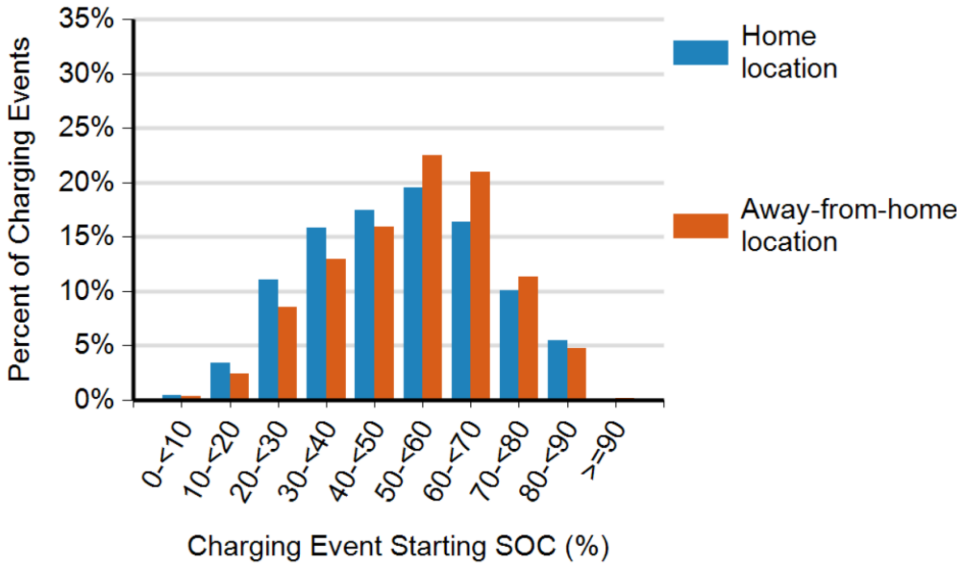
Data from the EVP also indicate that a significant amount of away from home charging events occurs near Milpitas and parts of Santa Clara, Sunnyvale, and San Jose. There is a significant number of retail shopping areas, restaurants, and employment centers in this zone. Stanford University, Palo Alto, and Mountain View also have a significant number of away from home charging events; many of the vehicles traveling to these locations originate in Alameda and San Mateo Counties. Downtown San Francisco, Cupertino, and northern San Mateo County also have moderate levels of away from home charging events.

The time spent parked in San Francisco and Berkeley (in Alameda County) appears to be more significant. This may indicate the potential for greater EVSE usage if they are installed in these cities in the future. There is also parking occurring due to vehicle travel from Santa Rosa (in Sonoma County) to Marin County and from Solano County (to northwestern Contra Costa County. There may be additional demand for EVSE in these areas in the future, to help alleviate range concerns in these suburban areas.

State of Charge and Trip Behavior

The EVP reports provide an overview of the vehicle state of charge (SOC) at the beginning and end of charging events. Figure 9 below shows the beginning SOC for charging events.

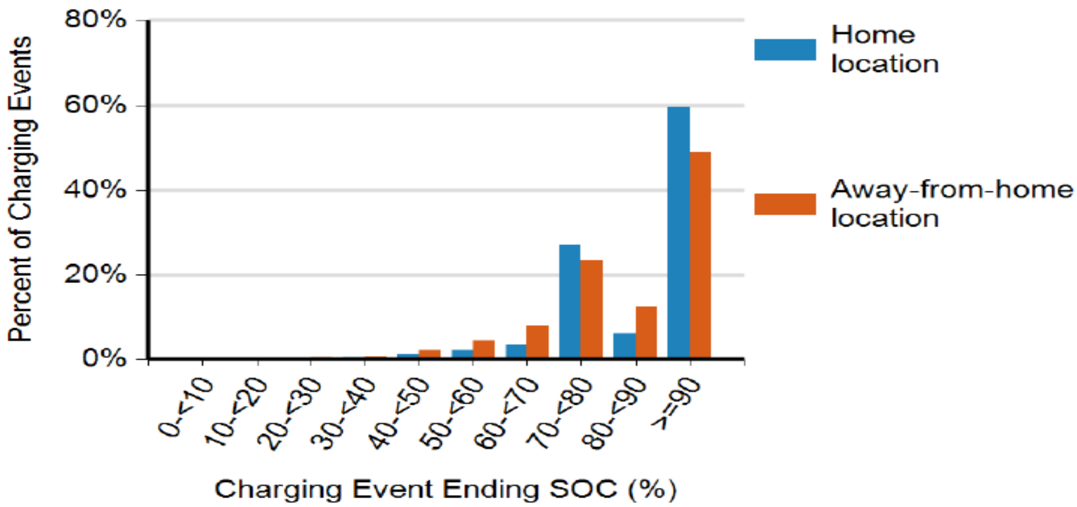
Figure 9. Nissan LEAF Battery Initial SOC, 2nd Quarter 2012



Source: ECOtality

In general, PEV drivers who charge at home are more likely to begin their charge with a low SOC than those who charge away from home. This is not unexpected, since drivers who charge at home are most likely to charge in the evenings after a day of driving, whereas drivers who charge away from home are more likely to be using the opportunity to "top off" their charge. ECOtality assumes that initiating a charge away from home at a SOC above 50% may be indicative of opportunity charging i.e., it may not be necessary to complete the schedule trip, but drivers are taking advantage of the opportunity. However, a significant number of drivers who charge while away from home begin charging with an SOC below 50%. This could indicate that drivers are using away-from-home charging to extend the range of their trips, or that drivers are taking advantage of freely-available public charging instead of paying for electricity at home. The initial SOC for away-from-home charging will likely change as publicly-available chargers that are currently free begin charging fees.

Figure 10. Nissan LEAF Battery Ending SOC, 2nd Quarter 2012



Source: ECOtality

As can be seen in Figure 10, which shows the ending SOC for home and away-from-home charging, once connected, the Nissan LEAF driver will typically allow the battery to reach a relatively high SOC. Because the average trip length between charges is 30.0 miles (close to the average daily travel), it does not take very long to recharge the battery. On average, drivers take 3.9 trips of 7.8 miles length between charging events. A trip is defined as a vehicle start/stop cycle. A more detailed look at SOC and trip length by zones follows.

Generally, SOC data reflect that drivers with homes farther from job centers and urban areas have a greater difference between median SOC at the end and the beginning of charging events. For example, drivers with homes in Solano County, Santa Rosa (in Sonoma County), and Santa Clara County have high values for SOC at the end of charging events and low values for SOC at the beginning of charging events. The low values for SOC at the beginning of charging events for suburban drivers seem to be fairly common across the Bay Area, which is also observed for Nissan LEAF drivers in Contra Costa County and eastern Alameda County. On the other hand, EVP drivers with homes in San Francisco, Palo Alto, and Mountain View have relatively high median values for the SOC at the beginning of charging events, and low median values for the SOC at the end of charging events. This seems to indicate that these drivers are likely taking shorter commutes and charging more often on non-commute trips, since they have homes in urban areas or near job centers.

Table 12 displays information on the number of trips and distance traveled by vehicles between charging events. Although a clear trend is difficult to identify from these data, it seems that drivers with a home in counties further away from employment centers tend to drive longer distances (e.g., Solano County); however, this correlation is not particularly strong based on these data.

Table 12. Trips and Distance Traveled Between Charging Events, 2nd Quarter 2012

County	Mean No. of Trips	Mean Distance Traveled
Alameda	4	36.0
Contra Costa	4	36.2
Marin	4	31.6
Napa	4	35.5
San Francisco	5	30.2
San Mateo	4	33.5
Santa Clara	4	35.0
Solano	3	37.8
Sonoma	4	35.2

Source: ECOtality

Charging Availability and Charging Demand

Although there are significant limitations to the data sets as discussed above, the EVSE deployed through the EVP provide a significant amount of data as do the Nissan LEAF vehicles. This data can help the region to anticipate charging requirements for PEVs as demand and adoption rates of these vehicles increases over time.

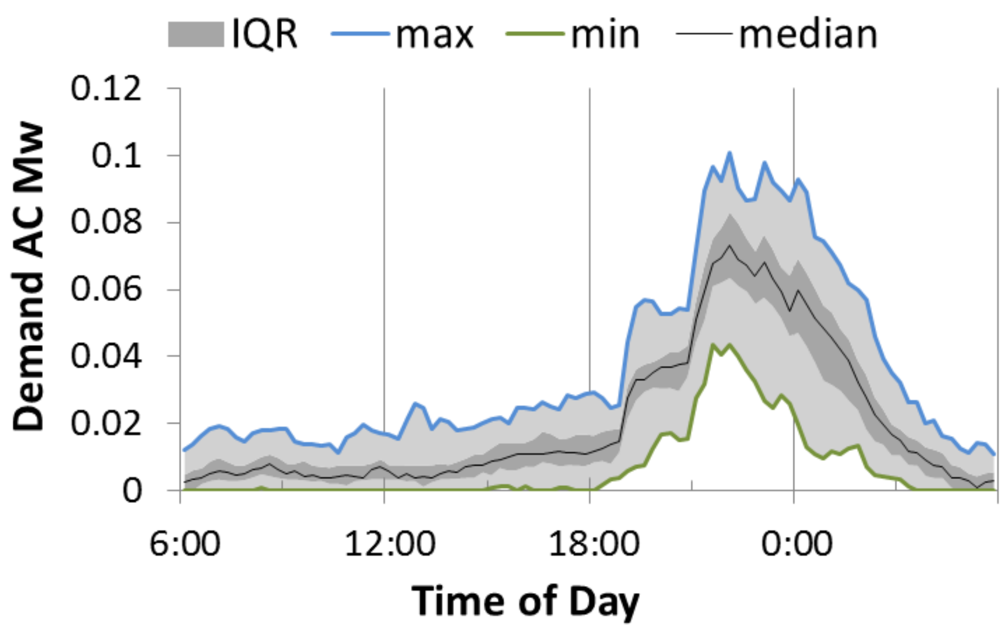
- Charging availability means that the EV is connected to the EVSE and available for energy transfer (whether or not that energy transfer is taking place). Availability is plotted to show the percentage of vehicles connected to their residential EVSE over time.
- Charging demand occurs when energy is transferred from the EVSE to the vehicle. Charging demand is plotted to show charging demand on the grid over time. The residential EVSE provided by The EVP are AC Level 2, 30 amp/240 VAC capable of delivering up to 6.6 kW power; however the charger that comes standard with Nissan LEAFs that participated in the EVP is capable of accepting up to 3.3 kW power.

There are also differences between driver behavior on weekdays and the weekend, so time plots have been separated as needed. Generally, during weekdays the typical LEAF driver plugs the vehicle in at about 5 p.m., presumably about the time that the driver gets home from work, and this trend steadily increases to about midnight. Then the unplug events begin at about 6 a.m. as people begin their daily routine. Based on data collected across the EVP, this is similar to behavior observed across all EVP regions nationwide.

It is interesting to note in the Bay Area, as elsewhere, not all LEAFs are used for commuting as there are typically at least 5% of the vehicles connected to residential EVSE during the day (note: these are not necessarily the same vehicles every day).

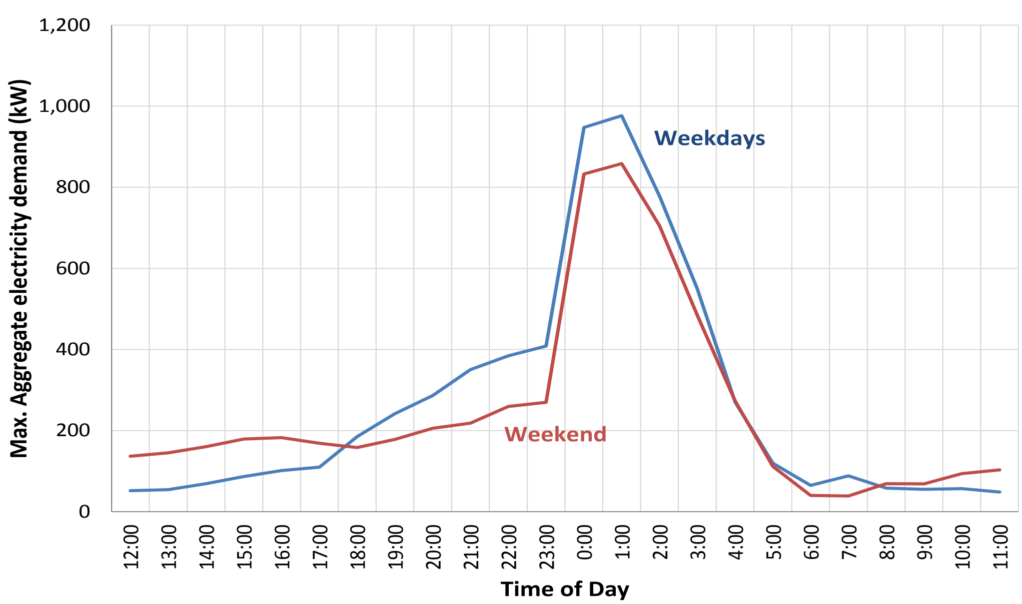
According to ECOtality, the charging demand curve follows the availability curve very closely for most EVP regions. For instance, Figure 11 below indicates that for most EV drivers in the Arizona Public Service territory in Phoenix, the charge commences as soon as the vehicle is connected. Some of the first to connect have already completed their charge when the later vehicles connect.

Figure 11. Arizona Public Service Territory Weekday Charge Demand, 2nd Quarter 2012



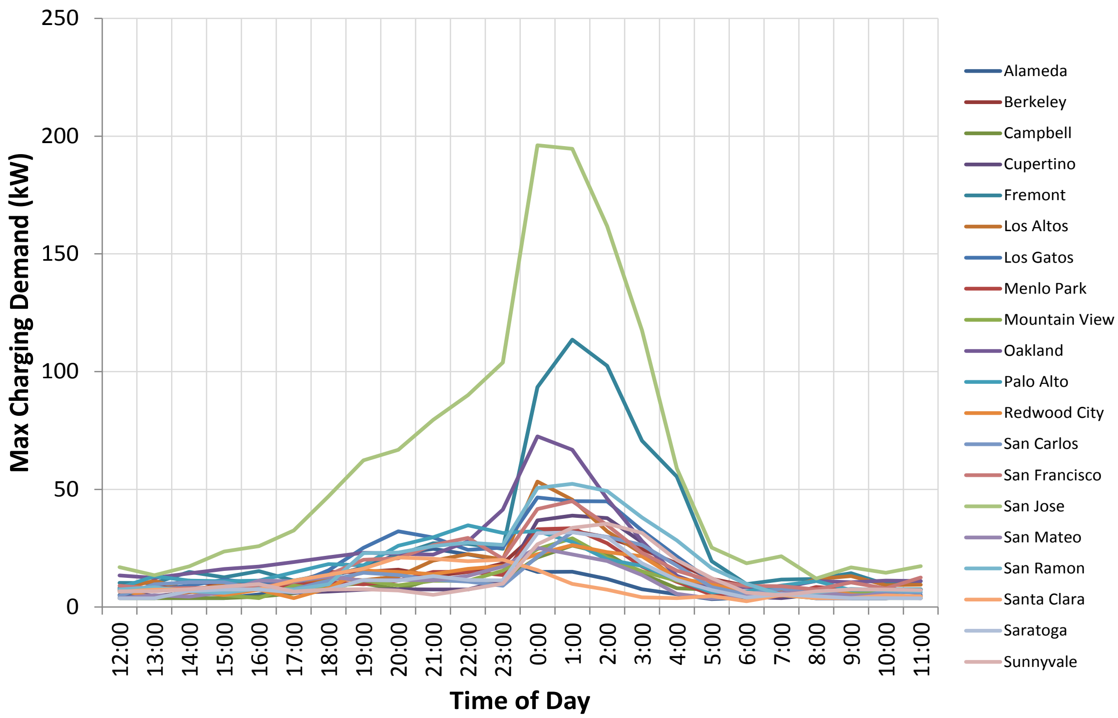
Source: ECOtality

Figure 12. Maximum Aggregated Demand for the Region, by weekday and weekend, 2nd Quarter 2012



Source: ICF analysis of data provided by ECOtality

Figure 13. Maximum Charging Demand (kW) for the Region, by City, 2nd Quarter 2012



Source: ICF analysis of data provided by ECOtality

Figure 12 and Figure 13 show the maximum aggregated demand for the entire region and by city, respectively. Although vehicles are plugged in at approximately the same time of the day as those in Phoenix and other EVP regions, the actual charging events do not start later until midnight in the Bay Area. This may be attributable to the time-of-use (TOU) rates offered by PG&E or other utilities in the Region. ECOtality finds that drivers who opt into the TOU rate will typically program the charge to occur after the start of the TOU rate to make sure that the entire charge is conducted off peak. Interestingly, San Jose, which has the largest electricity demand also has a disproportionately higher demand prior to midnight, indicating lesser use of TOU rates. For more information about TOU rates, please see Section 10.

Comparing Driver Behavior: San Francisco Bay Area and Other Regions

This section provides a comparison of data for the Bay Area versus 13 other regions across the US. The information is divided between vehicle data, EVSE data, and differences between Volt and LEAF drivers. Note that much of this information is obtained from the EVP Second Quarter Report.[27]

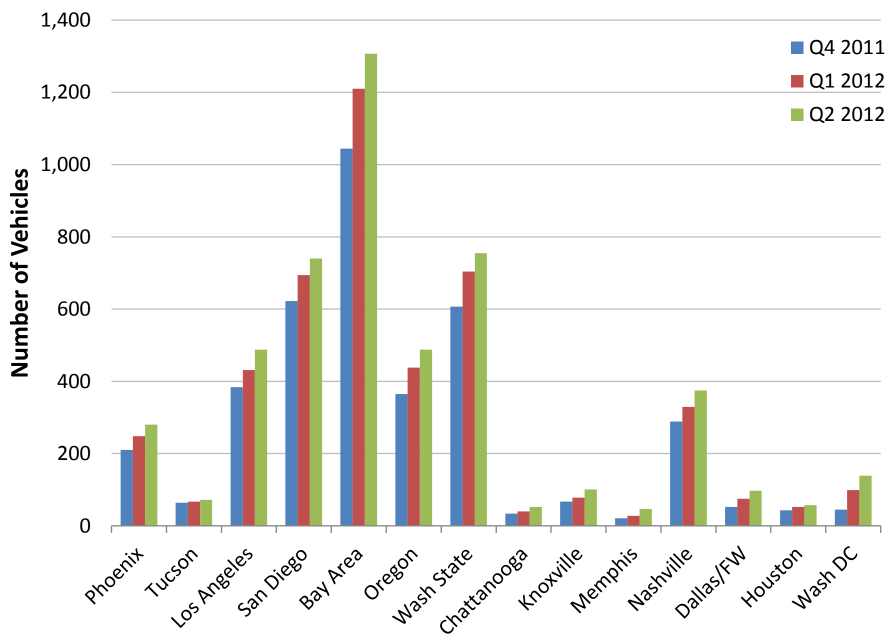
Vehicle Data

[27] The complete report can be found online at http://www.theevproject.com/education.php.

Figure 14 displays the number of EVP vehicles enrolled for each region at the end of each quarter from Q4 2011 through Q2 2012.

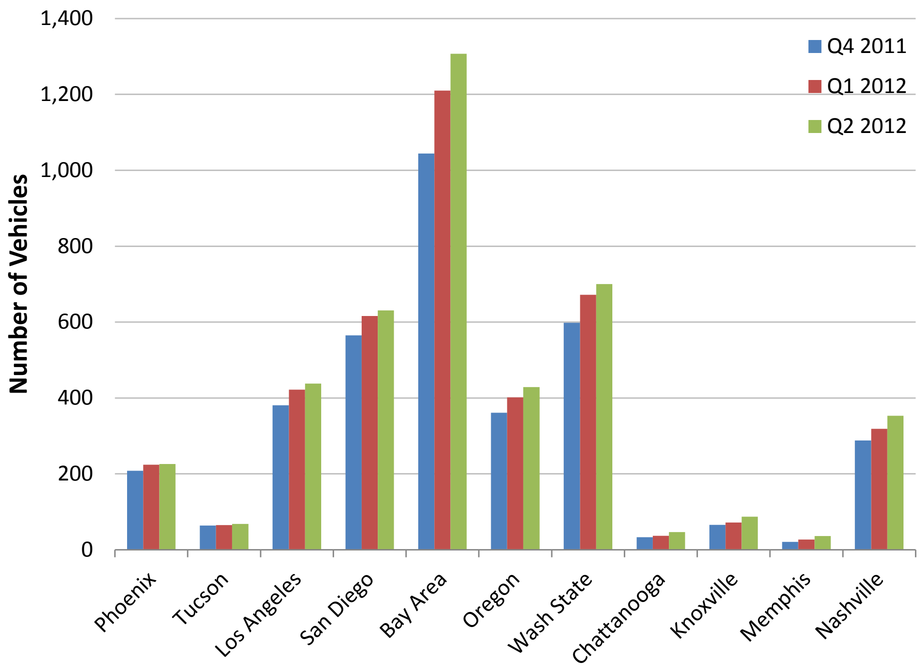
Figure 15 displays the number of LEAFs enrolled in each region at the end of each quarter. The Bay Area clearly represents the highest percentage of vehicles enrolled across the US. This is further exaggerated when accounting only for LEAFs, since the EVP in the Bay Area does not include Volts or other PHEVs.

Figure 14. Number of Total EVP Vehicles Enrolled for All Regions (By End of Quarter)



Source: ECOtality

Figure 15. Number of EVP LEAFs Enrolled (By End of Quarter)



Source: ECOtality

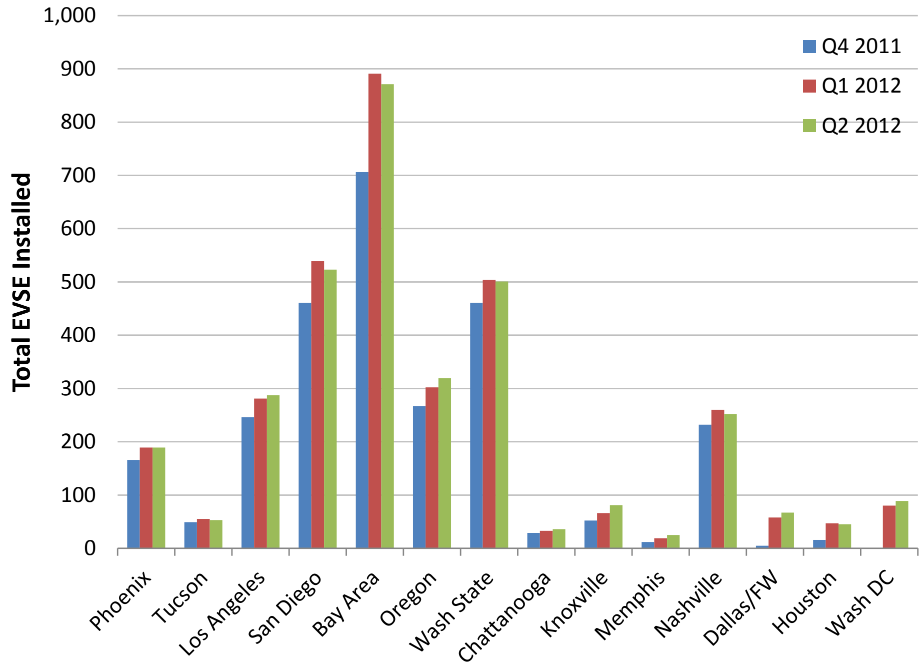
Data show that Bay Area PEV drivers are taking somewhat longer trips than drivers in some regions, despite the fact that Bay Area residents generally drive fewer miles per day than average residents of U.S. metropolitan areas.[28] This may indicate that Bay Area drivers have, as early adopters, found that range limitations are not a significant concern, and therefore they travel farther before charging their vehicles. These data also correlate with the relatively low number of charging events per day by Bay Area drivers.

EVSE data

Data comparing EVSE usage in the various EVP regions are shown in Figure 16. These figures show the number of residential Level 2 EVSE that have been installed. The Bay Area clearly leads in the number of residential EVSE that have been installed. However there have been only a small number of public stations installed under the EVP (not shown), which has not been an emphasis of the project in the Bay Area, as previously mentioned.

[28] Federal Highway Administration (2011), Office of Highway Policy Information, Highway Statistics 2010, Table HM-71: Urbanized Areas – 2010 Miles and Daily Vehicle-Miles of Travel, http://www.fhwa.dot.gov/policyinformation/statistics/2010/hm71.cfm.

Figure 16. Number of Residential EVSE Installed in the US by EVP (To End of Quarter)

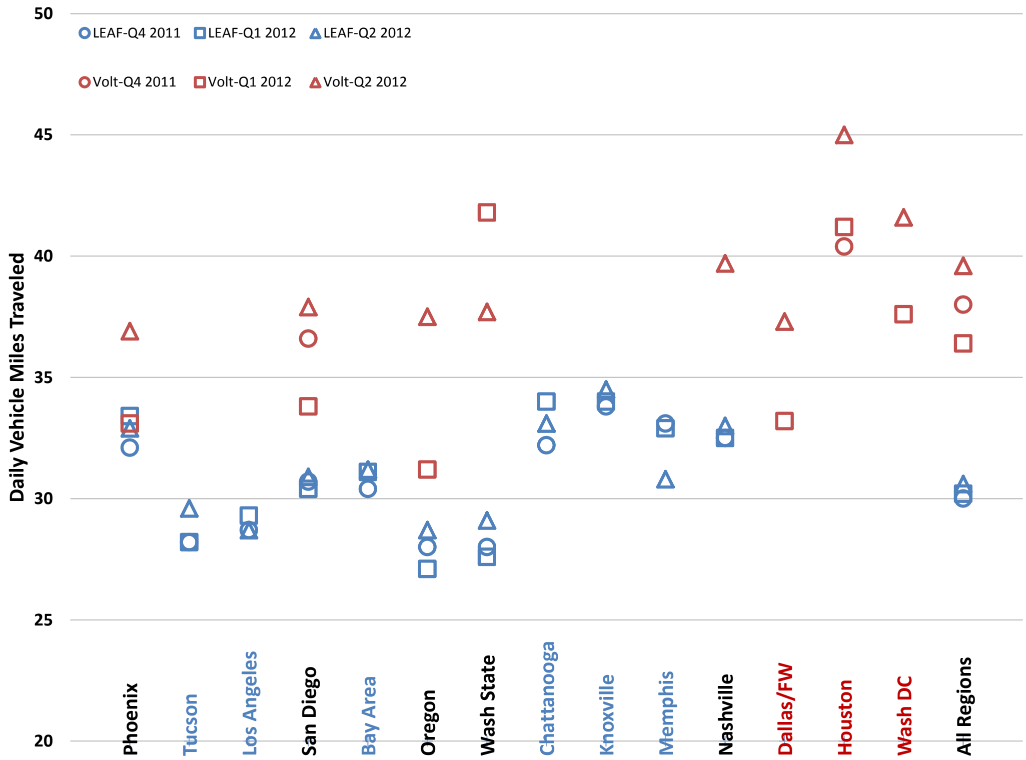


Source: ECOtality

Electric Vehicle Type

Even though the Volt is not supported in the Bay Area by the EVP, there are significant vehicle sales in the area. Figure 17 shows the average distance traveled for LEAFs (in blue) and Volts (in red) enrolled in the EVP nationally during the 2nd Quarter of 2012.

Figure 17. Average Distance Traveled Per Day when Driven During the 2nd Quarter for the LEAF (blue) and the Volt (red)



Source: ICF analysis of data provided by ECOtality

Note that the regions/cities along the x-axis in Figure 17 that are in blue only have LEAFs enrolled in the EVP; the regions/cities in red only have Volts enrolled in the EVP; and the regions/cities in black have both LEAFs and Volts enrolled. On average, Volt drivers are driving further than LEAF drivers.

As shown in Table 13, Chevrolet Volt drivers generally drive further each day that they are driven than Nissan LEAFs drivers even within the same market area. The average number of charge events per day for the Nissan LEAFs drivers was 1.1. The daily drive is typically within the battery's capacity. The average for the Chevrolet Volt drivers was 1.5. It would appear that the Volt driver, who drives a greater distance each day than the LEAF, is very interested in driving as much as possible on battery power.

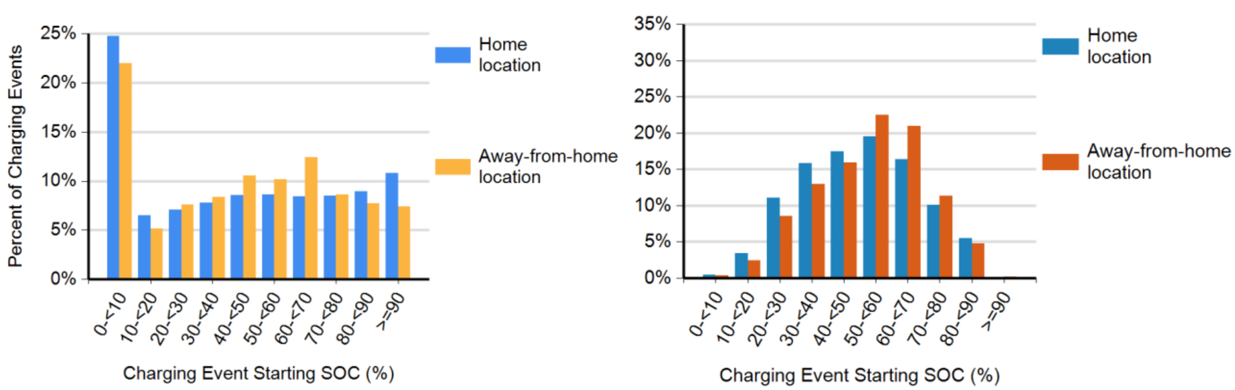
Table 13. Nissan LEAF and Chevrolet Volt Overview Summary, All Regions, 2nd Quarter 2012

	Nissan LEAF	Chevrolet Volt
Number of trips	787,895	147,886
Total distance traveled	5,666,469	1,184.265
Avg trip distance	7.2	8.0
Avg distance traveled per day when the vehicles was driven	30.6	39.6
Avg number of trips between charging events	3.9	3.2
Avg distance traveled between charging events	28.1	26.0
Avg number of charging events per day when the vehicle was driven	1.1	1.5
fuel economy	--	155
overall electricity energy consumption (AC Wh/mi)	--	242

Source: ECOtality

The battery state of charge (SOC) at the beginning of charging events is quite different between the Volt and the LEAF driver (see Figure 18). The Volt generally starts the charge at a low SOC while the LEAF SOC is more widely distributed. This is likely due to the lower capacity battery with the Volt and that the Volt driver can continue to drive on gasoline with the battery at the low SOC. The LEAF driver would typically not want to allow the SOC to approach zero before beginning the charge for fear of being stranded.

Figure 18. Battery State of Charge for Volt (left) and LEAF (right) Vehicles All Regions Q2 2012



The EVP will continue to collect data from vehicles and EVSE through 2013. The information provided here represents early trends and areas of interest. However, while a significant number of residential EVSE have been installed through this point, there remain significant inventory yet to install. It is expected that more will be installed by the end of 2012 so that the data collected in 2013 can lead to further refinement in the conclusions and lessons learned that are contained in this Plan.

4. Regional Siting Plan[29]

Given the projected rate of PEV adoption in the Region over the next 20 years, readiness planning must also address strategies to ensure sufficient charging infrastructure is in place to meet the increasing demand for charging as greater numbers of PEVs are deployed over time.

The following section contains the regional siting analysis, the estimated number of EVSE needed to support charging needs of projected PEVs in the Region through 2025, an assessment of the PEV market, and prioritized areas for residential, workplace, publicly available EVSE deployment. This section also discusses other key factors for consideration related to the siting analysis including prioritizing EVSE deployment in impacted communities, the costs to acquire, operate, and install EVSE, and ensuring EVSE is compatible with the smart grid.

4.1. Introduction

To date, the Region has properly focused on ensuring that early adopters have a positive experience for charging vehicles at home. The Electric Power Research Institute (EPRI) has prepared a convenient graphic to illustrate the relative priorities for likely charging scenarios, as shown in the triangle in Figure 19.

With respect to PEV fueling or charging, vehicle architecture plays a significant role in determining both the frequency and amount of charging needed during any fueling session - since different types of PEVs use electricity somewhat differently. For example, PHEVs use electricity to extend the range of the vehicle and to provide a dual-fuel option, while BEVs use electricity as their sole source of propulsion energy. With this in mind, siting of charging infrastructure is a key component of successful PEV deployment and requires consideration of the following questions:

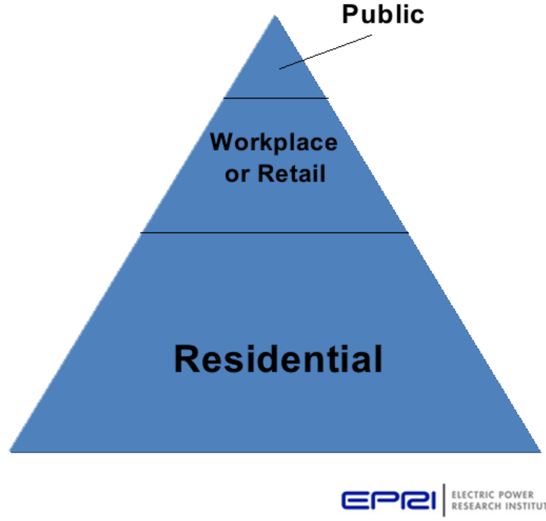


Figure 19. The EPRI Charging Triangle

- **Location:** What are potential venues and areas to locate EVSE? Options are generally characterized as at home, at workplaces, and on public or private property.
- **Quantity:** How many EVSE 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?

[29] This section corresponds to the requirements described in Sections 5(a-b) and 5(f) of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

- **Investment:** Who pays for and maintains public and private infrastructure?
- **Payment:** How much should individuals pay for "a charge"?

In the context of EVSE deployment there is no single “right” answer to any of these questions, given the potential size of the PEV market (in this Region alone, there are more than 5 million registered vehicles) the different PEV types (architecture) and end-users types involved (e.g. light-duty versus heavy-duty business fleets, individual consumers). Furthermore, the approach taken to answer these questions will also have to adapt and be re-evaluated over time in response to advances in PEV technology, such as increased battery efficiency and increased rate of charging via changes in PEV’s on-board chargers to allow faster charging speeds. Therefore, since it is neither possible to predict nor prescribe a single answer approach, and recognizing that over time the requirements will need to be reevaluated in light of current technology, this section provides an overview of the different PEV market segments and recommends criteria for consideration of siting future PEV charging infrastructure.

4.2. Need for a Regional Siting Plan

Although residential EVSE is likely where the vast majority of PEV owners will charge most of the time, in order to provide the greatest flexibility and full utilization of PEVs’ range potential, solutions to expedite the availability of charging at workplaces and other locations will also need to be addressed systematically. The goal of a siting plan is to help guide and coordinate future PEV charging infrastructure-siting efforts based on anticipated or projected demand for EVSE. To that end, this siting analysis combines various parameters such as characteristics of PEV ownership, PEV usage, EVSE usage, land use, and regional travel patterns to identify the most likely areas to:

- Extend the range of PEVs for intra- and inter-regional travel along various corridors;
- Maximize all-electric miles by providing ample opportunities for charging while minimizing the risk of stranded PEVs; and
- Provide charging opportunities for PEV owners who lack access to home charging;

4.3. Siting Plan

Market Segmentation

The first step of the siting plan is to segment areas based on the likelihood of PEV adoption. The potential for PEV adoption for specific catchment areas in the Region are characterized based on existing research, such as correlations between PEV ownership and income, and correlations between PEV ownership and HEV ownership.

Suitability Criteria

The siting plan for suitable locations for EVSE was designed to identify optimal places to deploy EVSE for the consideration of various stakeholders. The analysis underlying the plan was driven by the parameters listed in Table 14. This exercise is not intended to prescribe or to identify specific addresses for deployment, but rather to guide infrastructure siting more broadly at the sub-regional level. As noted above, the siting plan focuses on: a) residential charging, b) workplace charging, and c) publicly accessible charging (also referred to as opportunity charging). This section concludes with estimates of the number of EVSE that should be deployed to support the forecasted PEVs in the Region. The number of EVSE needed to support PEV deployment will change based on parameters such as the price of charging. EVSPs are still developing their business models, and the price that consumers are willing to pay for vehicle charging is largely undetermined at this point.

Table 14. Parameters Considered 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, helps 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	PEV forecasts were differentiated by PHEVs and BEVs.
	Trip characteristics	Understanding purpose of trips (e.g., home to work) and distance traveled.
	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.
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	Helps identify barriers associated with gaining access to some lots e.g., deploying EVSE at a lot that is owned and operated by separate entities is challenging.
	Accessibility for installation	Improves cost estimate of EVSE installation; proximity to appropriate wiring/circuitry is useful, otherwise installation can be expensive.

Residential Charging Projections

Based on parameters identified above, the residential siting analysis yields the map in Figure 20 for the Bay Area and Figure 21 for the Monterey Bay Area. The areas with the darkest shades of red are most likely to include a higher percentage of PEV adopters than regions with lighter shades of red.

Figure 20. Most Likely PEV Adopters in the Bay Area

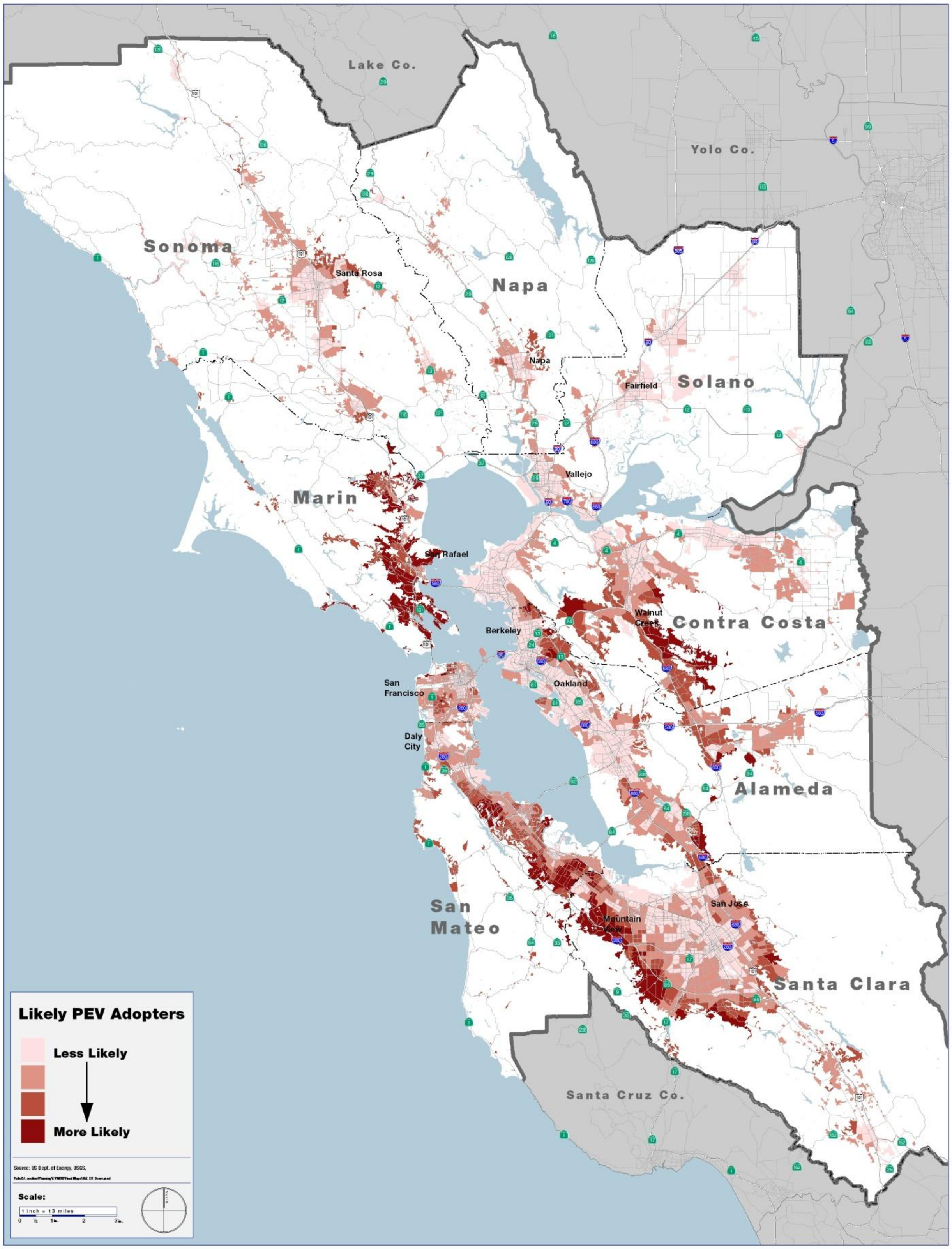
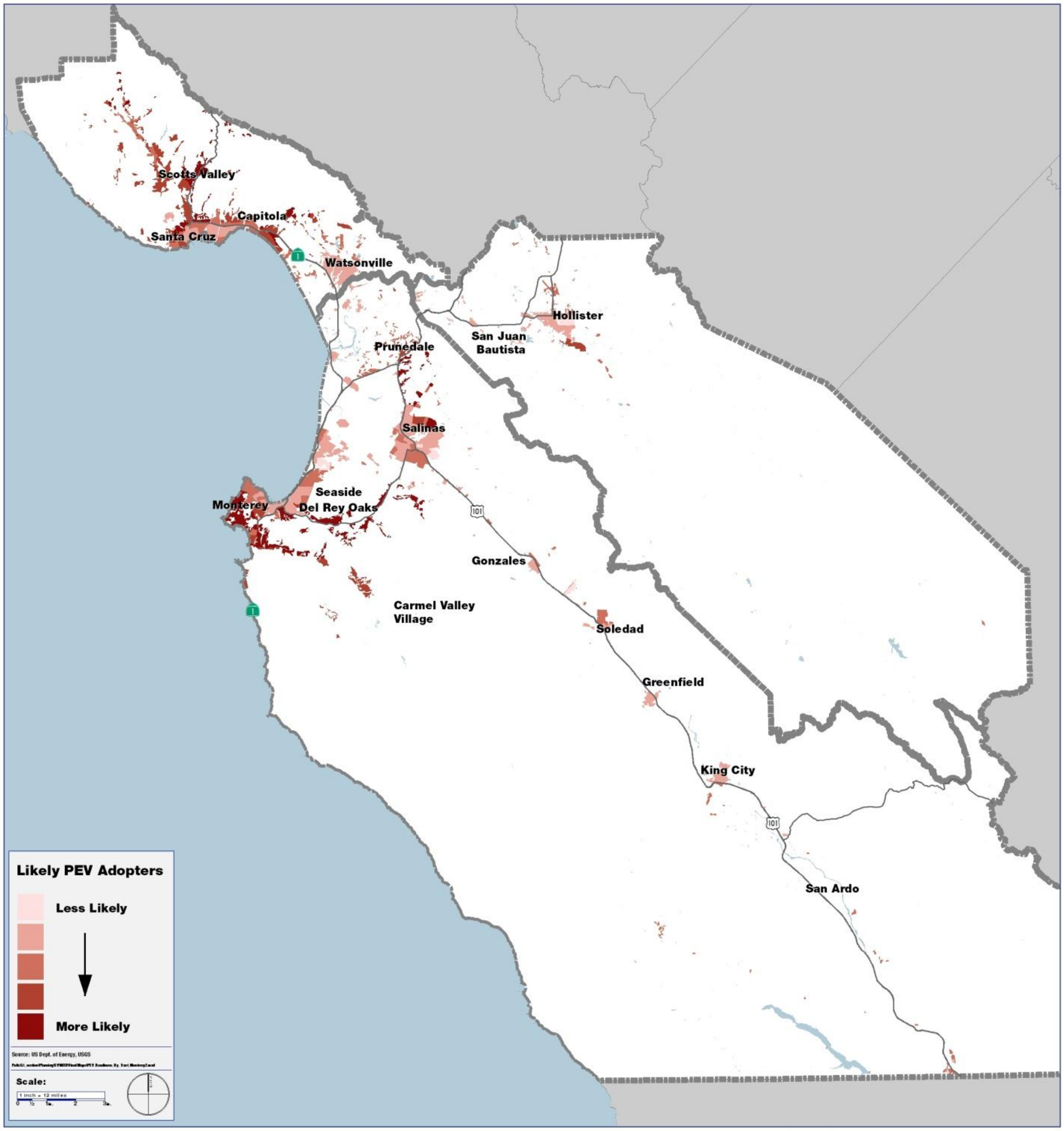


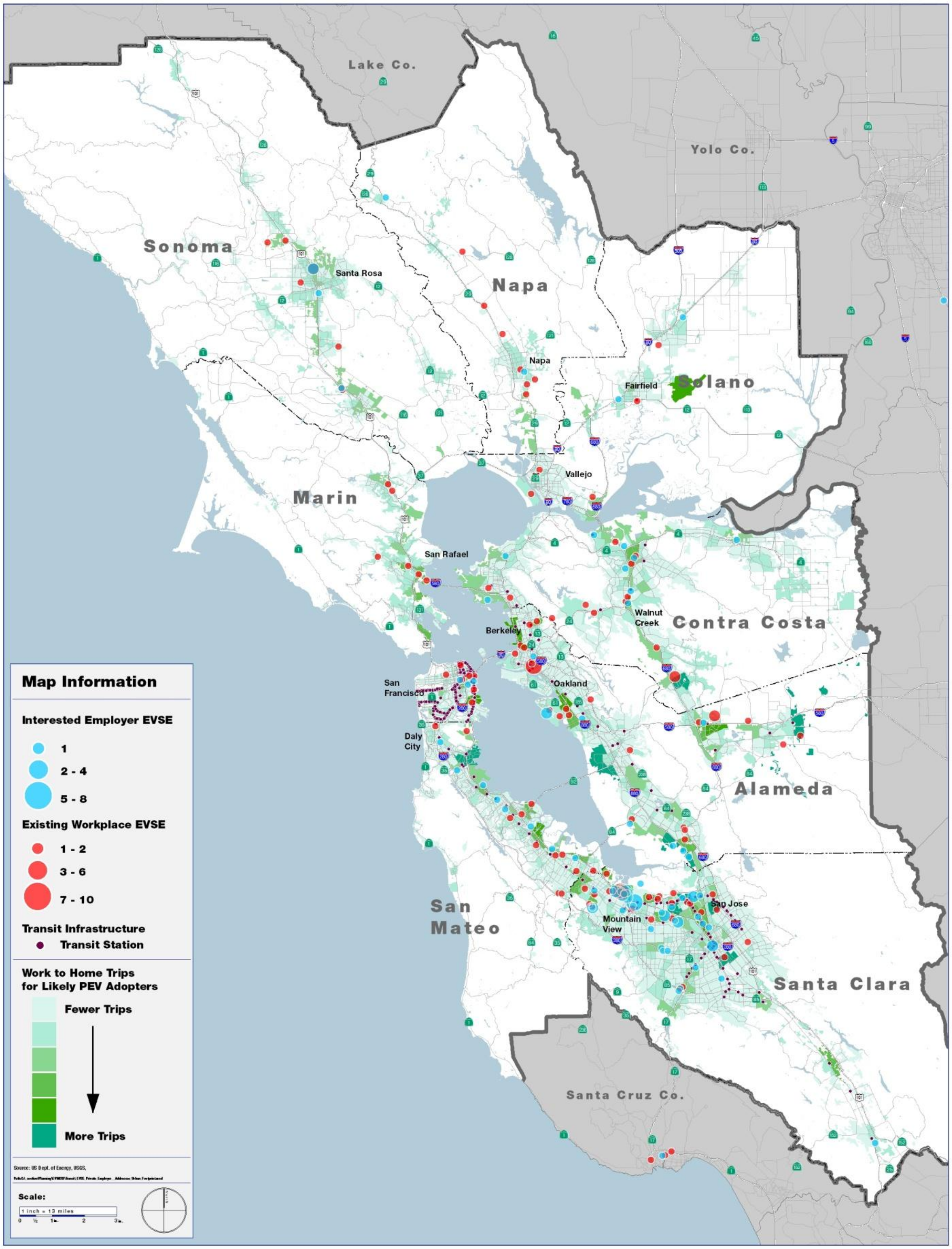
Figure 21. Most Likely PEV Adopters in the Monterey Bay Area



Workplace Charging Siting Analysis

The map in Figure 22 below shows an overlay of the following data: the most likely destination zones for workplace trips (different shades of green), areas with existing workplace Level 2 EVSE (red dots), areas with employers interested in deploying workplace EVSE for employee charging (blue dots), and transit stations (purple dots).

Figure 22. Workplace Siting of EVSE for the Bay Area



Source: MTC, GIS Unit, Fehr&Peers, ICF, BAAQMD

The siting analysis for workplace charging was distinguished further by trip distances. The map in Figure 23 shows the locations of employment centers as a function of trips and distance of those trips, for trip distances 0-15 miles. The map in Figure 24 shows the same information, except for trip distances 16-30+ miles.

Workplace charging deployment should be prioritized in areas that can increase electric miles driven based on the capacity of typical PHEVs and BEVs. The travel distances were grouped according to the needs that these workplace charging locations may serve.

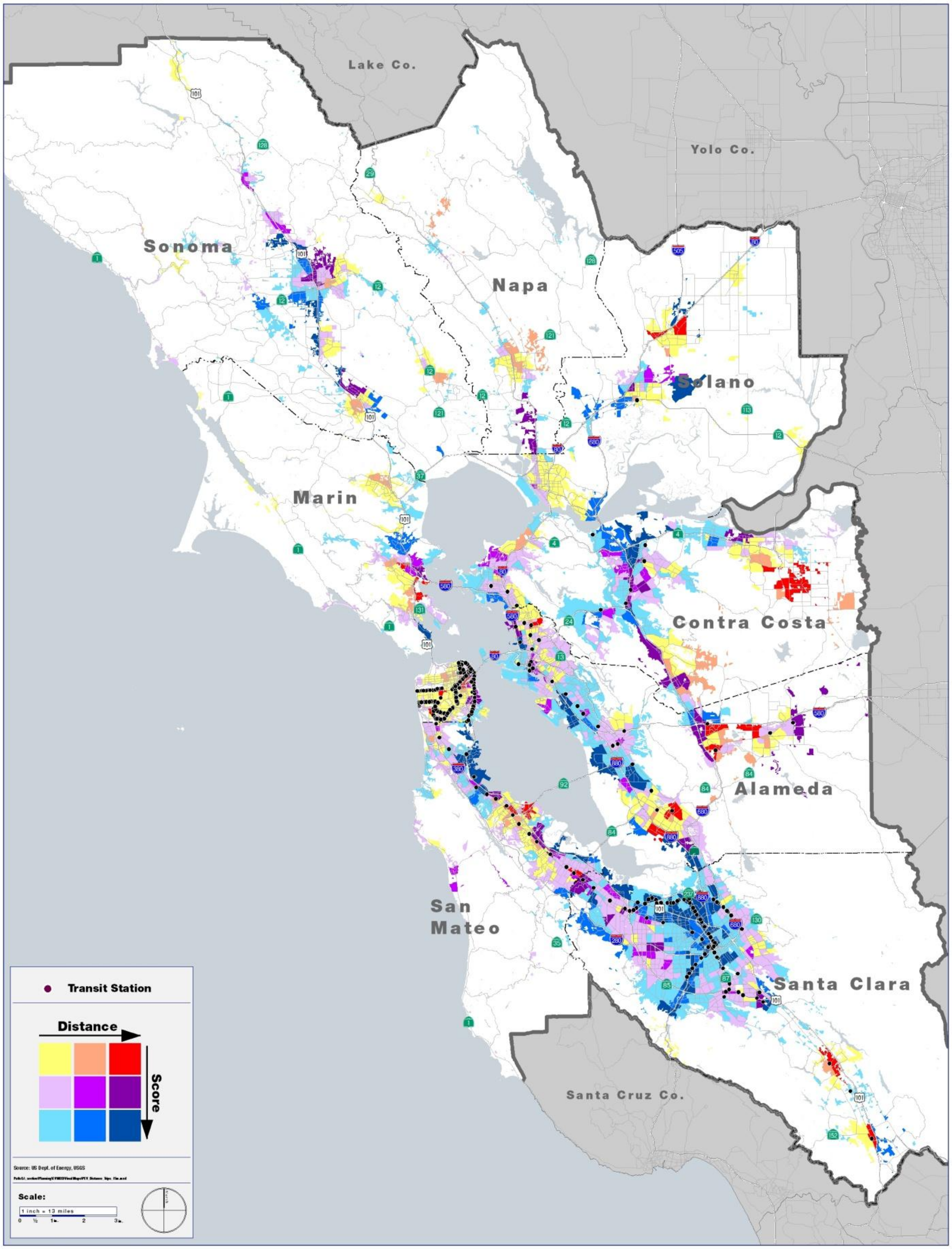
For Figure 23, the legend shows 9 colors representing a matrix of scores across 3 groups of distances and 3 groups of PEV-weighted trips. Each block or color in the horizontal direction (left to right) represents 5 miles of trip distance (see below for more discussion on those ranges). Each block or color in the vertical direction (top to bottom) represents the highest number of work trips by likely PEV adopters to that zone. In other words, the blue shaded blocks represent the most trips by likely PEV adopters to that particular zone. The lightest shade of blue (bottom left of the 3x3 matrix in the legend) represents a large number of trips by likely PEV adopters in the 0-5 mile range. Whereas the red block (upper right of the 3x3 matrix in the legend) represents a lower number of trips by likely PEV adopters in the 11-15 mile range. Based on charging times and likely time parked at workplaces, the prioritized locations in Figure 23 are likely best served by Level 1 charging. In the cases of shorter parking times at workplaces and/or for visitor use, access to some Level 2 workplace charging in these zones can supplement Level 1 charging.

- 0–5 miles: Zones with a high number of trips that are less than 5 miles do not need to be prioritized. If EVSE are deployed in these areas, Level 1 EVSE should be prioritized. Although the availability of workplace charging in these zones can increase the number of all electric miles travelled by PHEVs and enable additional all-electric trips outside of home-work (and reverse) trips, the benefits of providing opportunities for charging for BEVs taking trips to work that are less than 5 miles are minimal.

- 6–10 miles: Zones with a high number of trips in the range of 6-10 miles are ideal for Level 1 charging, particularly for PHEVs. Trips in this range are not ideal for Level 2 charging unless the installation costs can be reduced significantly.

- 11–15 miles: Zones with a high number of trips in the range of 11-15 miles have significant potential for PHEVs. The limited lower all-electric range of PHEVs (ranging from 11 miles for the Prius Plug-in up to about 38 miles for the Chevrolet Volt) makes Level 1 charging particularly attractive in these zones. For employees with an eight hour or greater work day, Level 1 charging for BEVs is likely sufficient.

Figure 23. Daily Trips and Distance Traveled (0-15 miles) to Major Employment Centers

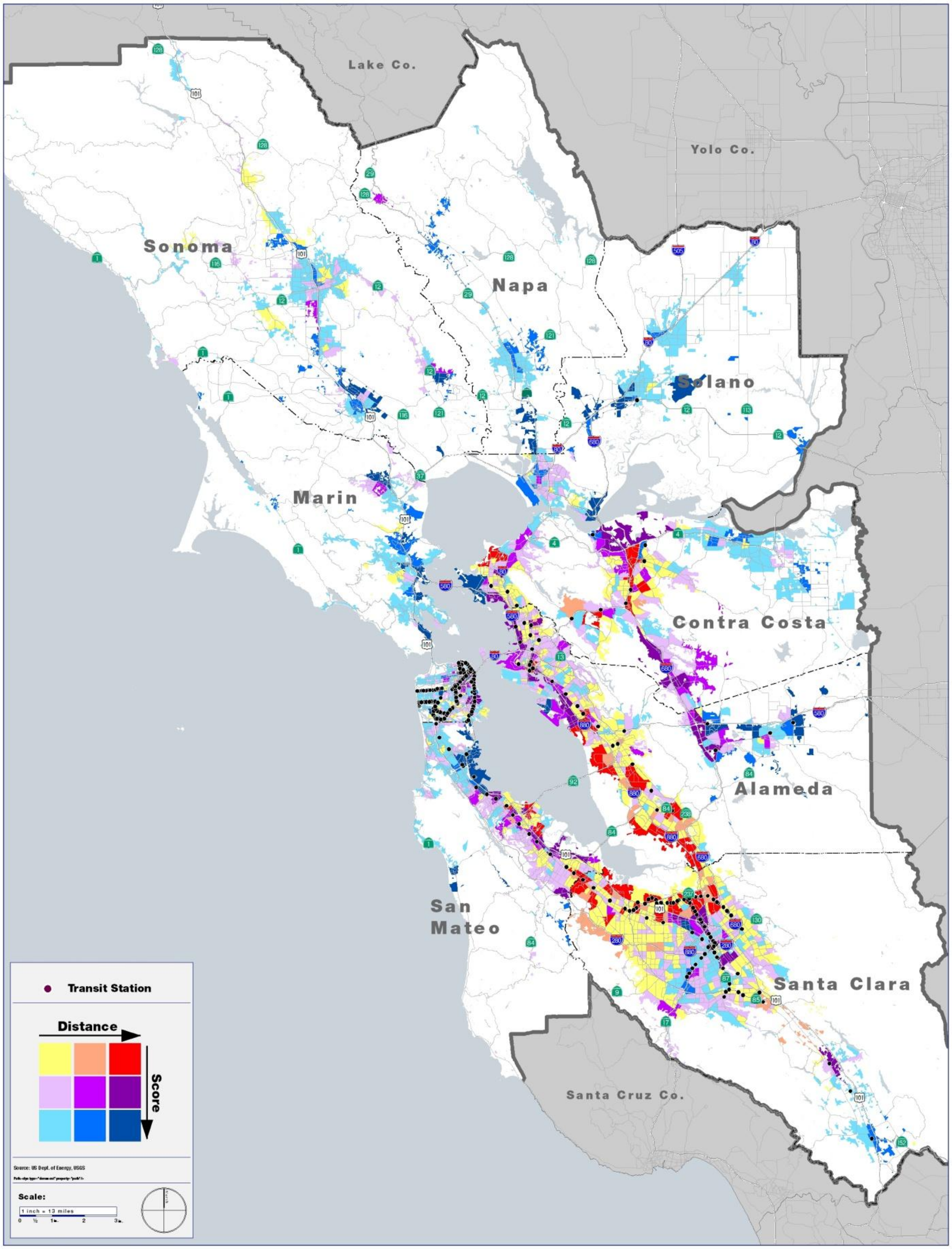


Source: MTC GIS Unit, Fehr&Peers, ICF

For Figure 24, the legend shows the same color scheme representing a matrix of scoring across 3 groups of distances and 3 groups of PEV-weighted trips. Each of the blocks in the horizontal direction (left to right) represents the follow trip distances:16-20, 21-25, 26+ miles (see below for more discussion on those ranges). Each block or color in the vertical direction (top to bottom) represents the highest number of work trips by likely PEV adopters to that zone. Based on charging times and likely parked times at workplaces, the prioritized locations in Figure 23 are likely best served by Level 1 charging complemented with Level 2 charging.

- 16-20 and 21–25 miles: Similar to the 11-15 mile range of trips to the workplace, there is significant potential for trips in this range for PHEVs and BEVs. This range starts to maximize or exceed the all-electric range for PHEVs; however, workplace charging can help increase the electric miles travelled for return trips. This zone is considered to have more potential for BEVs than the 11-15 mile range by providing additional confidence to drivers. With ranges of 60-100 miles, a round-trip commute in this range (i.e., 42-60 miles) is feasible; however, the availability of workplace charging could support additional side trips (i.e. trip chaining) and increase the confidence of BEV drivers in the Region.
- 26+ miles: Access to Level 1 and Level 2 workplace charging for drivers who are commuting more than 25-one way miles to work will be needed to ensure that PHEV drivers have adequate charge available to return home in electric mode and to provide additional range and confidence to BEV-owners. As an alternative, especially for BEV drivers with commutes that are 50 miles one-way or greater, strategically placed DC fast charging EVSE (discussed in more detail below) may provide additional flexibility. One of the key determining factors will be how individuals value their time and their willingness to stop for the 15-20 minutes to reach 80% state of charge using a DC fast charger and the cost to fast charge.

Figure 24. Daily Trips and Distance Traveled (16-30+ miles) to Major Employment Centers



Source: MTC GIS Unit, Fehr&Peers, ICF

Publicly Accessible Charging

Bay Area

Publicly accessible charging is characterized as either a) opportunity charging (includes Level 1 and Level 2) or b) DC fast charging.

Opportunity charging - Level 1 and Level 2 EVSE

Opportunity charging is distinguished from residential and workplace charging and covers a wide range of situations where a PEV driver could potentially charge when away from home and/or work. Within this category, there are different sub-categories specific to the type of venue –such as retail parking lots, on-street parking, airport long- and short-term parking, cultural and recreational centers, etc.

This Plan provides general guidance with respect to whether chargers should be Level 1, Level 2, or a mix of these – and if so, in what ratio - to anyone who is considering installing EVSE. Table 15 below shows that the preference for one type of charging over another will be mainly biased by the duration of time that the PEV driver may be parked at that specific location:

Table 15. Example of Charging Type based on Purpose[30]

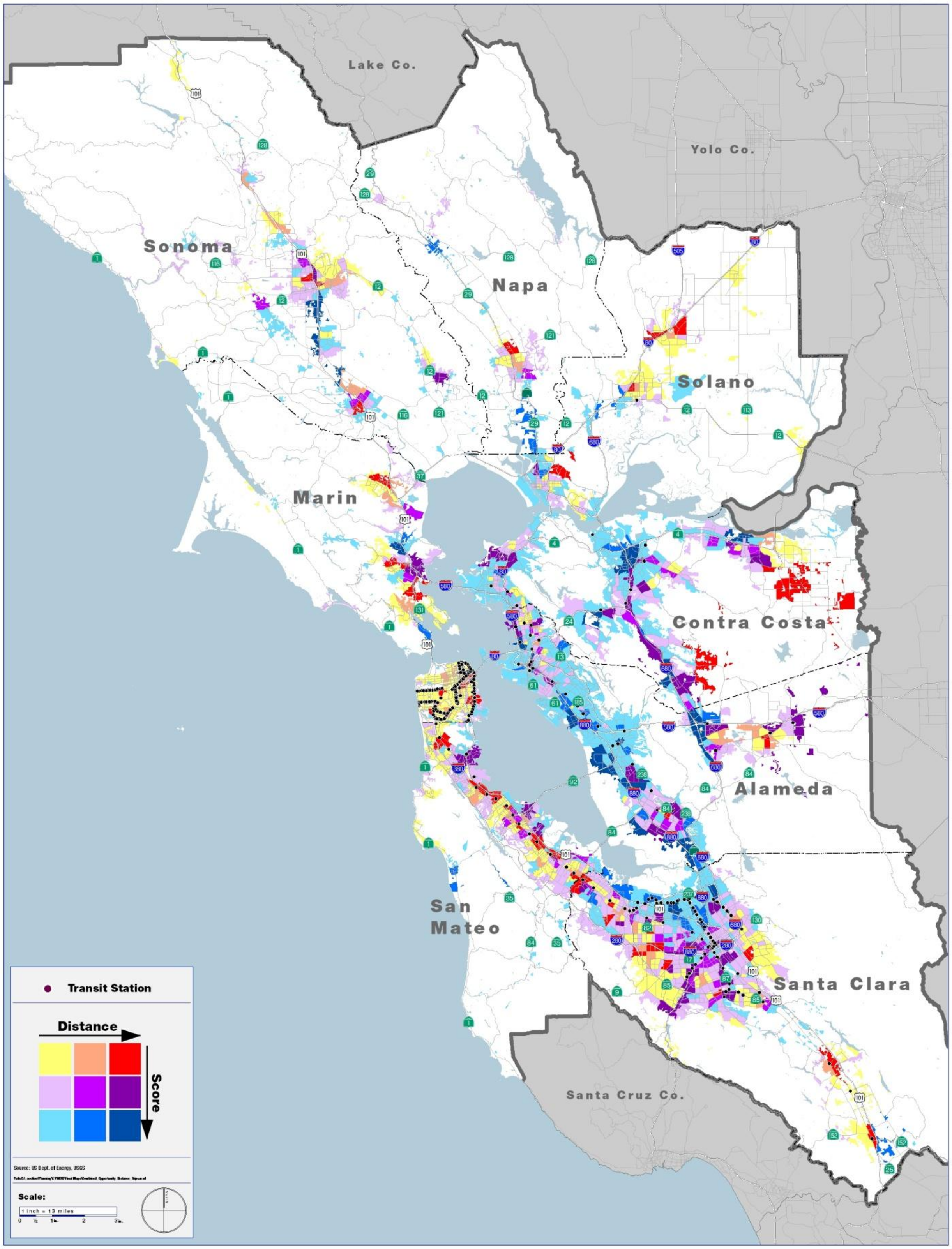
Category	Typical Venues	Available Charging Time	Charging Method (Primary/Secondary)
Opportunity and Destination	Shopping Centers	0.5 – 2 hours	Level 2/DC Fast
	Airport (short term parking)	< 1 hour	Level 2/DC Fast
	Other	< 1 hour	Level 2/DC Fast
	Street/Meters	1 – 2 hours	Level 1/Level 2
	Cultural and Sports Centers	2 – 5 hours	Level 2/Level 1
	Parking Garages	2 – 10 hours	Level 2/Level 1
	Hotels/Recreation Sites	8 – 72 hours	Level 2/Level 1
	Airports (long term parking)	8 – 72+ hours	Level 1/Level 2
Corridor/Pathway	Interstate Highways	< 0.5 hours	DC Fast/Level 2
	Commuting/Recreation Roads	< 0.5 hours	DC Fast/Level 2
Emergency	Fixed	< 0.1 hours	DC Fast
	Mobile	< 1 hour	Level 2/DC Fast

For the purposes of this analysis, due to the variation in parked times, trips were considered based on purpose rather than parked times. Similar to previous maps shown, the legend in Figure 25 shows 9 colors representing a matrix of scoring across 3 groups of distances and 3 groups of PEV-weighted trips. Each block or color in the horizontal direction (left to right) represents the following trip distances: 0-5 miles, 6-10 miles, and 11+ miles. Unlike other maps shown, however, it is important to note that opportunity trips are generally in addition to other daily trips (e.g., home to work and work to home trips). As a result, even though these trips may

[30] Adjusted table that was provided by the SF BayLEAFs, October 24, 2012.

be short, they do not reflect the driver's tour (note: the sum of all individual trips equals a tour). Therefore, even though these distances are short, they most certainly do not correlate with the state of charge of the battery. Each block or color in the vertical direction (top to bottom) represents the highest number of trips by likely PEV adopters to that zone. In other words, the blue shaded zones (light, medium, and dark blue) represent the most trips by likely PEV adopters to that particular region. Retail locations (e.g., shopping malls or dining establishments) in the zones with shades of blue (represented in the bottom of the 3x3 matrix in the legend) should be considered the highest priority areas for Level 2 EVSE deployment for opportunity charging.

Figure 25. Opportunity Charging for Level 2 EVSE



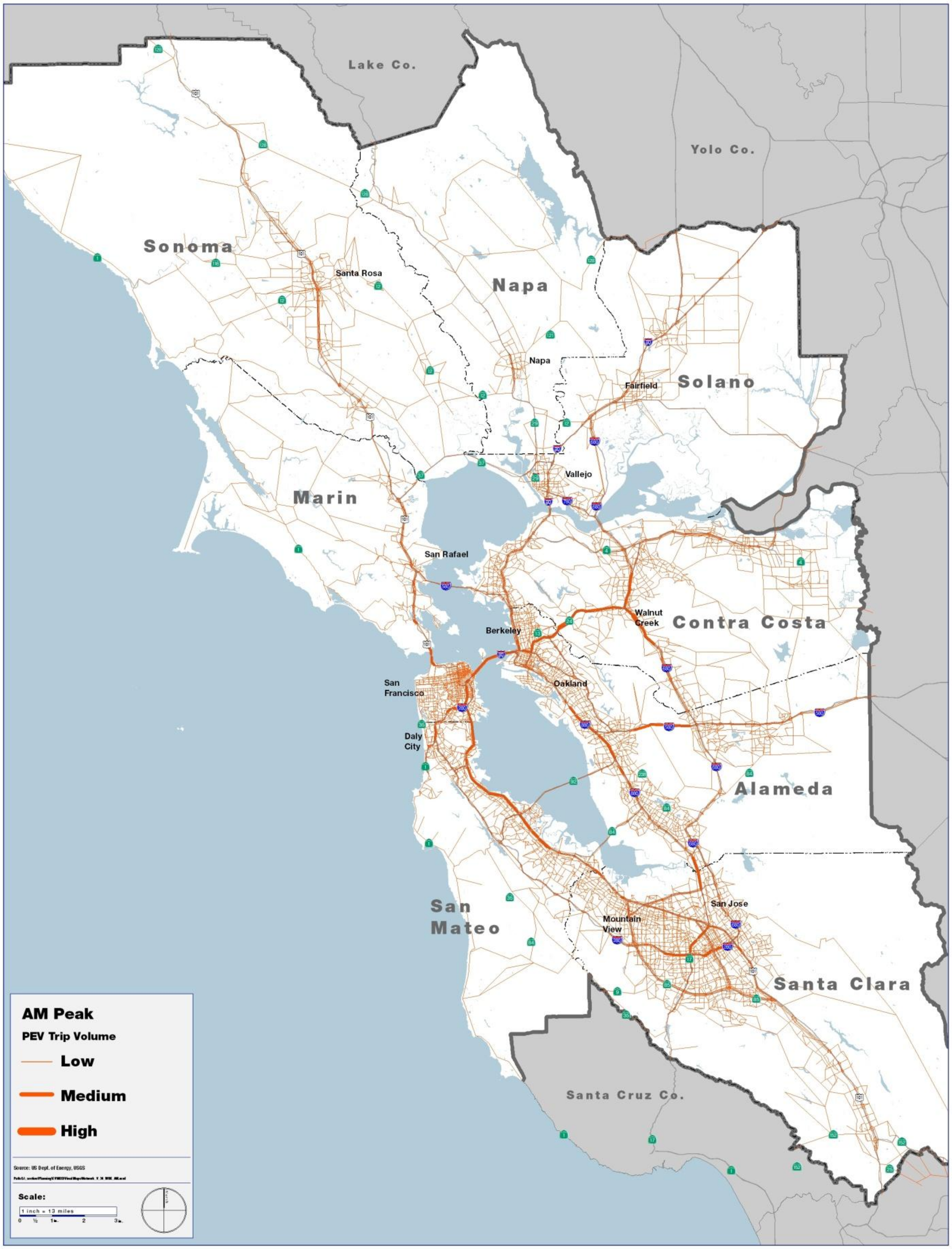
Source: MTC GIS Unit, Fehr&Peers, ICF

DC Fast charging

Fast charging is similar to opportunity charging in that it covers a range of situations where a PEV driver could potentially charge when away from home and/or work. These include, as a method to extend range for inter- and intra-regional travel, as an alternative for PEV owners who do not have access to charging at home, as a backup for Level 2 charging until Level 2 EVSE are ubiquitous, and for emergency charging situations. However, at least in the short term, it is a technology that is likely limited to only certain BEVs. Only DC fast charging is discussed in this section given that it is the most commercially readily available technology at this time. However, as new types of fast charging technologies emerge (AC fast charging, battery switch) the analysis and conclusions contained in this section may largely be applicable to those technologies as well. Finally, it is important to note that as fast charging is deployed in the Region, that there may be a reduced demand on the Level 1 and Level 2 opportunity-charging network.

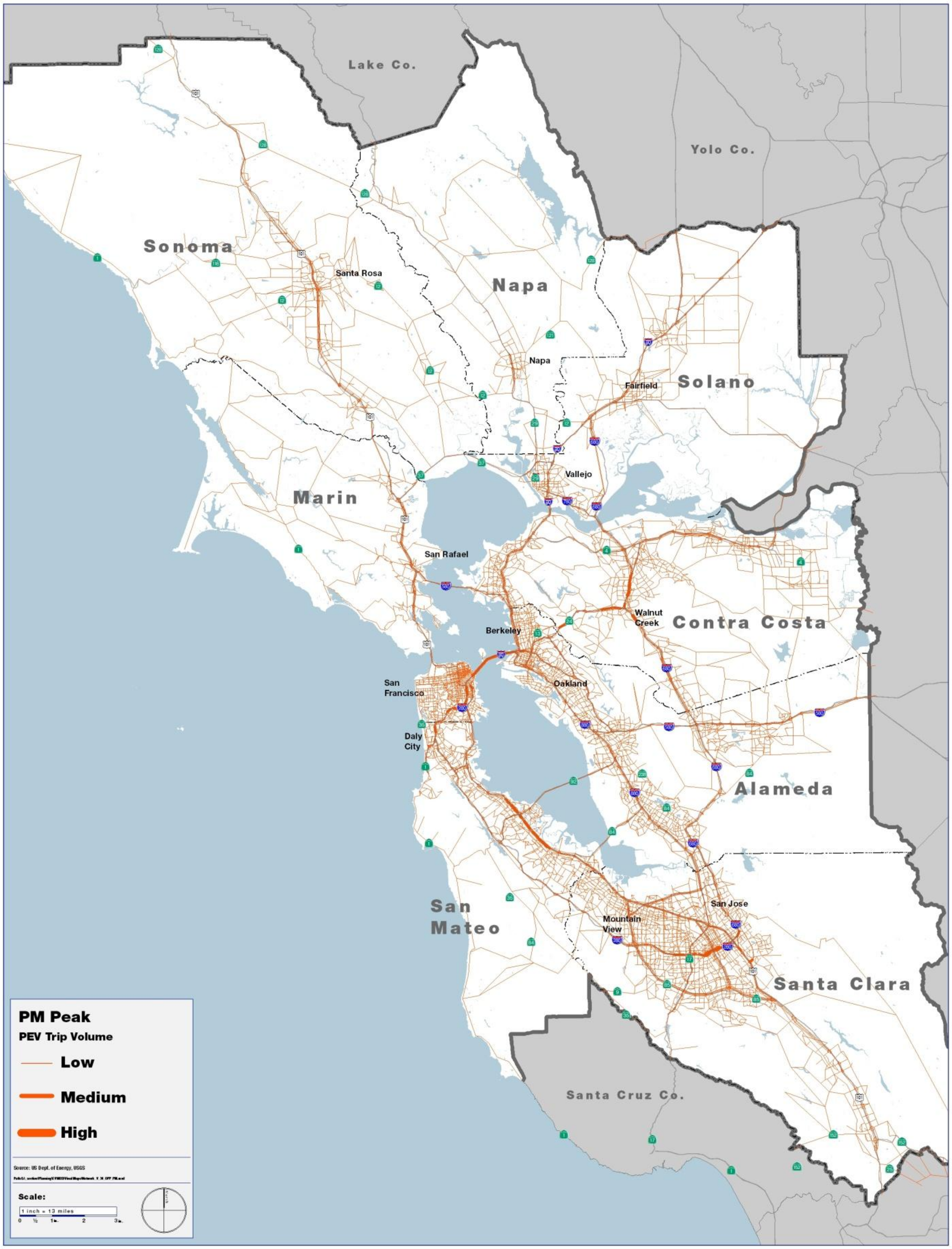
The analysis for this section considers likely PEV adopters who were tracked on the network at two times of day – the morning and evening peak traffic times – and each link in the corridor was assigned a score based on PEV traffic volume. The morning and evening peak traffic times were selected because they represent the highest traffic volumes on the network during the day and reveal the most about daily travel patterns that will impact the siting of DC fast chargers. These data are shown in Figure 26 and Figure 27 below. The links shown with high traffic volume (the thickest lines on the map) indicate the links with top 10% of likely PEV traffic volume on the regional transportation network.

Figure 26. Heavy Volume Corridors during morning peak traffic: Siting for DC fast charging



Source: MTC GIS Unit, Fehr&Peers, ICF

Figure 27. Heavy Volume Corridors during evening peak traffic: Siting for DC fast charging



Source: MTC GIS Unit, Fehr&Peers, ICF

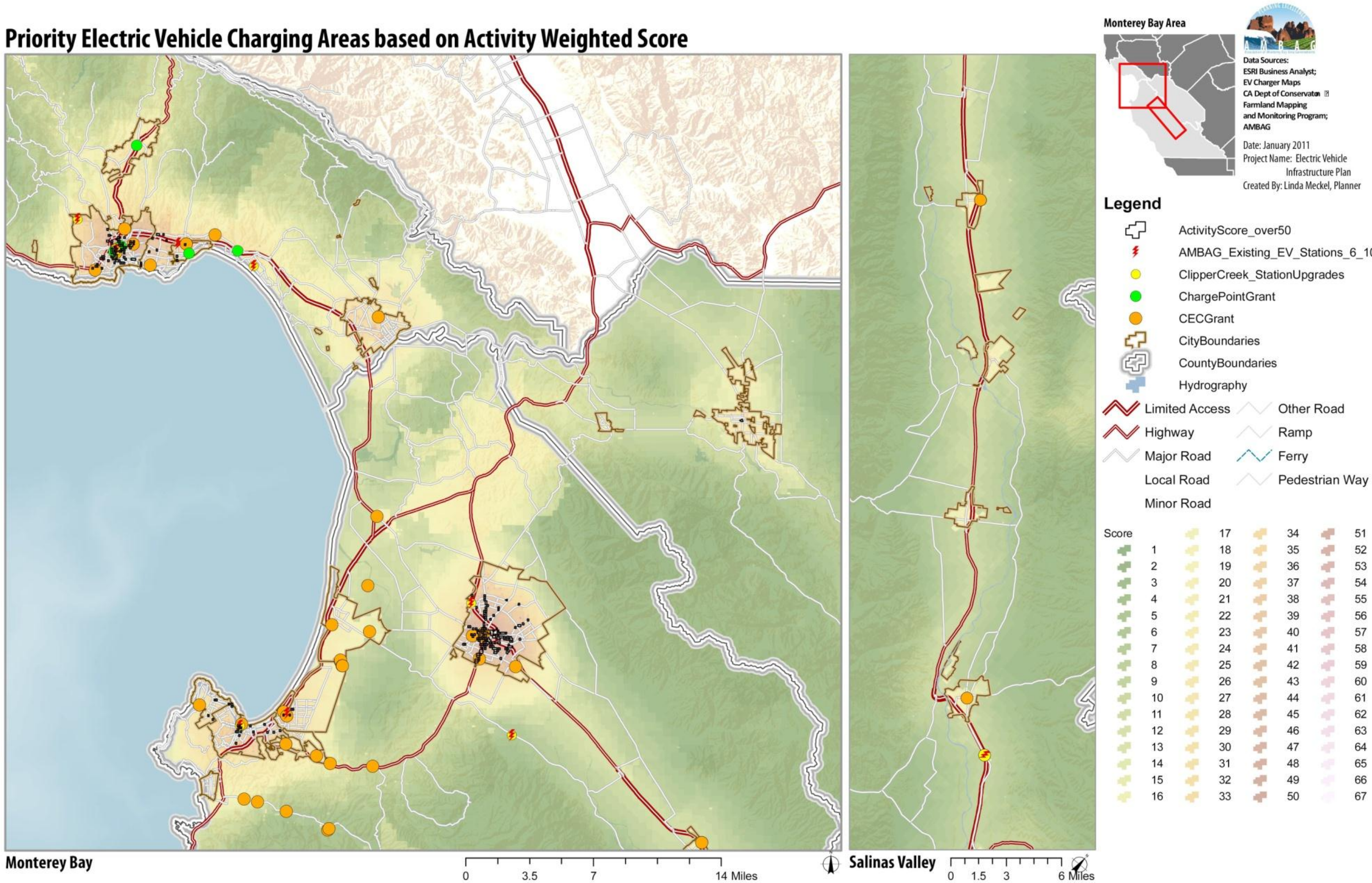
The links with forecasted high PEV traffic volumes provide guidance for the locations of DC fast charging stations. The final step in the siting of DC fast charging, as mentioned previously is using local knowledge to pinpoint the locations along these corridors that a) facilitate BEV traffic within the Region and b) facilitate BEV traffic between regions (i.e., between the Bay Area and Monterey Bay Area as well as between the Bay Area and the Greater Sacramento region).

Monterey Bay Area

For Level 2 EVSE siting in the Monterey Bay Area, AMBAG developed a suitability analysis,[31] which considers both workplace and publicly accessible charging that is summarized and presented here. AMBAG identified areas where a PEV driver would spend 1-3 hours as a reasonable amount of time to charge. Using a combination of data inputs, including the AMBAG Regional Travel Demand Model, AMBAG developed the suitability analysis from 45 different indicators. These indicators are largely the same as those employed in the siting analysis in the Bay Area, and include: existing parking locations, activity locations, high visibility locations, tourism attractors, distance from highways, route popularity, gas stations locations, and large employers. The results of the suitability analysis are mapped in Figure 28 below. Note that the black dots in the map are actually the borders of areas that should be prioritized for Level 2 EVSE siting based on high activity weighted scores.

[31] Draft Electric Vehicle Infrastructure for the Monterey Bay Area, AMBAG, January 2012.

Figure 28. Prioritized Locations for Level 2 EVSE Deployment in the Monterey Bay Area



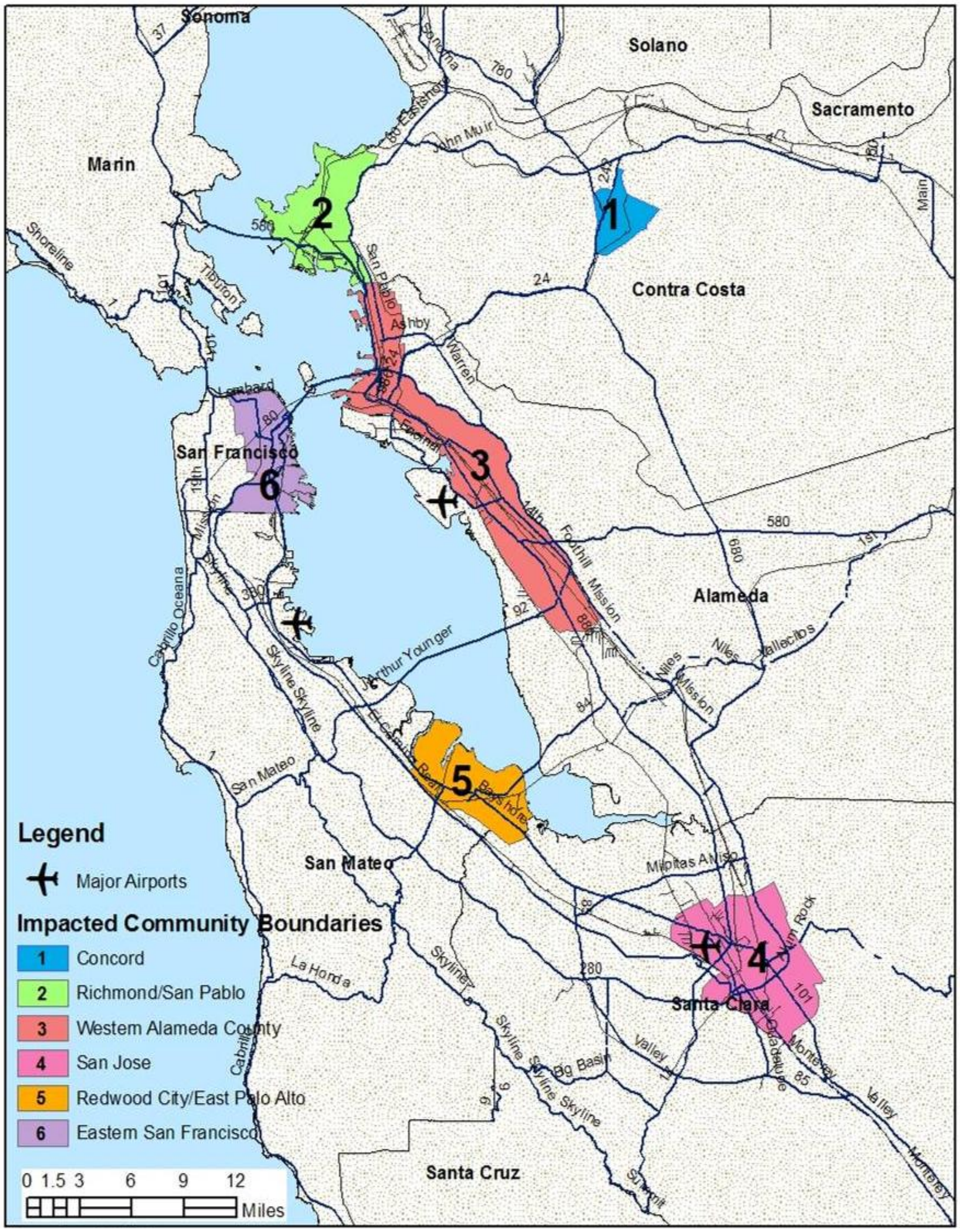
Source: AMBAG and MBUAPCD, 2012

Impacted/Environmental Justice Communities

As part of the planned deployment of EVSE in the Region, it will be necessary for regional and other granting agencies to monitor the uptake of PEV in Impacted/Environmental Justice communities. While current research and analysis shows that uptake in low income communities is likely to occur at a slower pace over the next several years, it is important that communities that are disproportionately impacted by transportation sources be targeted for PEV adoption to assist in the reduction of harmful particulate emissions from both light- and heavy-duty vehicles.

Currently, the BAAQMD prioritizes its grant funding towards projects in the 6 communities identified in Figure 29 below. Also, as part of the NRG settlement identified in Table 8, at least 20% of the DC fast charging EVSE to be installed as part of that project are required to occur in Impacted/Environmental Justice Communities. Based on the analysis performed in the Plan, it is anticipated that this deployment will provide sufficient EVSE for vehicles located in and travelling through these communities through 2015. Although the BAAQMD and NRG's effort will likely assist in the deployment of additional EVSE in Impacted/Environmental Justice communities moving forward, it is strongly suggested that the regional agencies monitor deployment under this program and coordinate siting with both NRG and the CPUC.

Figure 29. Impacted Community Boundaries in the Bay Area



Source: BAAQMD, Applied Method for Developing Polygon Boundaries for CARE Impacted Communities, December 2009

Estimating the Number and Costs of Charging Stations for the Region

The market is in the early stages of vehicle adoption and our understanding of driver behavior and optimal EVSE deployment is evolving. The analysis in this section draws research mainly from EPRI and the University of California, Davis to estimate the number of EVSE that will likely need to be deployed in the Region to support the forecasted PEVs.

Only non-residential charging was considered for the estimates discussed below.

Level 1 and 2 EVSE

EPRI conducted research on how much electric vehicle charging is needed, with a focus on workplace and public usage.[32] EPRI reviewed the impacts of free charging and a benefits tested scenario on usage as a measure of charging stations per vehicle. EPRI's analysis yields a benefits tested scenario in which the charging station-to-vehicle ratio ranged from 0.01 to 0.15 for BEVs and PHEVs.

For the purpose of this Plan, an EVSE deployment model was developed that decreases the demand for chargers over time to account for potential market saturation and the benefits of increased station utilization. Table 16 below compares the model's estimates for Level 1 and 2 EVSE with the estimates from EPRI's research and also show the projected number of EVSE that may be needed to support the projected number of PEVs at all types of away-from-home locations, including workplaces.

Table 16. Estimated Non-residential Level 1 and 2 EVSE to Support Forecasted PEV Population

Year	Vehicle Forecasts		L1 and L2 EVSE		
			Estimates		EPRI Method (mid-level)
	PHEV	BEV	low	high	
2015	18,854	4,753	2,647	9,412	4,323
2020	75,161	25,111	8,808	27,069	17,389
2025	159,296	83,313	18,139	44,343	37,606

Based on the vehicle forecasts for the Region and considering the average of the low and high scenario estimates as well as EPRI's methodology (mid-level), it is estimated that by 2015 the Region's Level 1 and Level 2 network of EVSE may need to be increased by 1,000–2,000 EVSE.

The costs of EVSE acquisition, operation, and installation are discussed in considerable detail in Appendix A: Background Information on PEVs and EVSE. For the purposes of this analysis, installation costs of Level 2 EVSE were estimated to range from $900-$2,350 for deployment at MDUs or workplaces. This cost range can increase significantly for publicly-accessible charging, depending on site characteristics. For instance, trenching and cutting costs can increase the installation costs by upwards of $3,000-$5,000 for Level 2 EVSE installations. These costs apply to installing EVSE at existing buildings or parking lots; whereas introducing EVSE as part of new construction is much easier because the costs can be amortized as part of a much higher capital investment.

The level of investment required to support the forecasted PEV populations for the Region is difficult to estimate for many reasons. The most significant reasons include: a) it is unclear what the split between Level 1 and Level 2 charging needs will be as the market develops and

[32] D. Bowermaster, EPRI. *How Much Electric Vehicle Charging is Needed?* California Plug-in Electric Vehicle Collaborative Meeting, August 2012.

expands; b) the costs of installation will vary considerably based on site characteristics; and c) the level of charging that will be required or requested is uncertain. It is also important to note that Level 1 and Level 2 AC charging do not exist in a vacuum. In other words, DC fast charging and other emerging charging technologies may put downward pressure on the price and need for Level 1 and Level 2 charging. For the purposes of this Plan, it is estimated the additional Level 1 and Level 2 EVSE required to support the forecasted PEV population in the Region by 2015 will cost $1-$5 million, depending on the focus of deployment.

The BAAQMD continues to be supportive of incentives for PEV and EVSE deployment. At present, a substantial amount of the funding that goes towards PEV-related projects in the Region comes from Assembly Bill (AB) 434. This bill provides local air districts the ability to assess a $4 DMV fee on vehicles registered within their jurisdictions and to use that funding to reduce criteria pollutants stemming from automobiles by directly funding projects that reduce tailpipe emissions and reduce vehicle miles traveled. In the Bay Area over the past three fiscal years, more than $6 million from AB 434 funds have been devoted to PEV-related projects. BAAQMD's Board will continue to consider the needs of the Region, particularly as it applies to EVSE deployment and determine if additional incentive funding should be used to further support EVSE deployment.

Recent changes to some of FHWA's core programs could also benefit the Region's commitment to EVSE deployment. The Moving Ahead for Progress in the 21st Century (MAP-21) Act (Public Law 112-141) added several eligible project-types to the Surface Transportation Program (STP) that align with the Region's goals of supporting PEV deployment: electric vehicle charging infrastructure that is added to existing or included in new fringe and corridor parking facilities are eligible for STP funding. MTC and the BAAQMD will work together to determine the feasibility of using STP funds to supports PEV deployment and deploy Level 2 EVSE in the Region.

As the market for public and workplace charging expands and evolves, it will be important that there be a shift towards increasing levels of private capital investment in EVSE deployment. It is a commonly accepted fact that the EVSE market cannot be entirely dependent on the support of the public sector. As shown in Table 8 previously, there are varying levels of match funding for projects funded in the Region; it is expected that as the market expands, the ratio of private investment to public investment will increase significantly.

DC Fast Charging

Survey research conducted as part of the planning process indicates there is a significant need for increased fast charging in the Region. To determine the number of DC fast chargers that may be required to support the PEV forecasts for the Region, research conducted by the University of California, Davis was reviewed and considered. That research evaluated various California statewide EV deployment and charging scenarios to estimate how many DC fast chargers would be needed to provide sufficient coverage for most of California.[33] Their research focuses on expanding coverage for BEVs, and minimizing the percentage of miles traveled that

[33] Nicholas, M; Tal, G; Woodjack, J; and Turrentine, T. Statewide Fast Charging Scenarios, presented at EVS26 in Los Angeles, CA, May 2012.Available online at: http://phev.ucdavis.edu/research/evs-26/EVS26%20-%20Nicholas.pdf.

are “unserved” using a combination of home and public charging with Level 2 and DC fast charging. Their initial results indicate that DC fast chargers at 200 locations will be enough to serve the majority of Californians. The number of charging stations deployed at those locations, however, is dependent on the number of vehicles deployed. At a deployment of about 10,000 PEVs, the researchers report that about 225 stations are needed at 200 locations; and that as the number of PEVs increases, the number of stations will need to increase accordingly; however, it can be a non-linear increase as the number of charges per charging station are maximized per day. Based on the BEV forecasts for the Region and findings from UC Davis, it is estimated that, depending on the utilization of fast charging stations, 75-170 fast charge stations located at an estimated 35-50 locations that are suitable sites along freeways and other high capacity roads will serve the needs of the Region out to 2020. More than one charger may be sited at a location depending on high traffic and electric capacity.

Based on current deployment plans and funding dedicated to DC fast charging (as highlighted previously in Table 8), more than 120 DC fast charging stations will likely be deployed in the Region prior to 2015. For the lower estimate outlined above (i.e., 75 fast chargers), the existing funding and investment commitments should be sufficient to meet forecasted demand. If the Region’s PEV population exceeds forecasts, particularly if there is a shift in the market towards BEVs, then it is feasible to expect that the higher estimate of 170 DC fast charging stations (or more) may be required.

As noted previously in the discussion regarding funding for the deployment of Level 1 and Level 2 EVSE, there will be similar opportunities for DC fast charging. The BAAQMD has already made a significant commitment of funding a portion of the cost to install up to 55 DC fast chargers for the Region. As the market for vehicles that take advantage of DC fast charging expands, the BAAQMD will continue to monitor the needs of the Region and consider dedicating incentives to DC fast charging EVSE as appropriate. In the near-term future, however, the funding available via the Surface Transportation Program at FHWA will be particularly attractive for DC fast charger deployment and should be explored further as the structure of this new eligibility becomes clearer.

Also, as was noted previously, it is expected that private investment in DC fast charging equipment increase over time given the limited ability of the public sector to support the changing needs of a mature PEV market.

Smart Grid Technologies

Moving forward, it will also be important to ensure that the EVSE deployed are compatible with the smart grid to the extent feasible. Broadly speaking, the smart grid refers to the ability of computers to control and automate the delivery of electricity. Smart grid communication technologies are developing at the same time as PEVs and if these technologies can be integrated, there would be benefits for both PEV owners and electricity suppliers because of potential efficiencies in the power market. For instance, this technology would allow two-way communication between the smart grid and a PEV. This could be valuable during periods of high demand, at which time a smart grid enabled EVSE could restrict or cease delivering power to the PEV depending on the state of charge. Similarly, if the utility had an off-peak TOU rate, a

PEV owner may choose to charge only when TOU rates are below a specified threshold – this is made possible today by programming on-board chargers (i.e., on the vehicle) or by programming residential EVSE.

With regard to smart grid development, there are a number of technical issues that must be addressed before ensuring seamless integration with PEVs. For software, communication protocols need to allow the proper data transfer between PEVs, EVSE, PEV owners, and utilities; for hardware, an EVSE needs to handle the physical connection between both the grid and the PEV. A consortium in Denmark, including utilities, corporations, the Danish Technical University, and the Danish Energy Association, has been working on a research project known as the Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks (EDISON) project.[34] Currently, EDISON employs an architecture that has the PEV connected to the EVSE and the EVSE connects to the utility. However, the PEV owner must also communicate to the utility through a mobile app or website when the EV should be charged – immediately or later when the electricity rate may be cheaper.

Another benefit of the smart grid is the concept of vehicle-to-grid (V2G) technologies. While the above examples help reduce strain on the grid by delaying PEV charging to periods of low electricity demand, this technology would allow PEVs with a surplus of energy stored in its battery to act as sources of power and provide electricity back to the grid. If there is a large population of PEVs with stored energy, that could provide significant amounts of electricity back to the grid. This strategy is known as peak-shaving and although there are few PEVs currently in the vehicle population, peak-shaving could become more significant if PEVs gain more popularity, especially when they are concentrated in a particular region.[35]

Both smart grid integration and V2G capabilities are still long term technologies. However, discussion of their potential effects on the grid will help utilities in the Region adapt to changes that may arise in the future. Other issues that will need to be studied and resolved include understanding the level of strain that is placed on a PEV's battery as daily discharging of stored energy to the grid would increase cycles on the battery and may reduce its life. Furthermore, this would void any warranties on the battery and create safety concerns. Depending on the battery pack design and battery chemistry, the constant charging and discharging may overheat the battery and cause a fire.

From an economic perspective, there is the potential for arbitrage. If a PEV owner can charge at work or the mall for free and then sell the electricity from home back to the grid, there is a potential to make a profit. However, with electricity rates ranging from 10-15 cents per kWh in the Region (see Section 10 for further discussion about electricity rates) it may not be worth the cost of potential damage to the battery.[36] Furthermore, if dynamic pricing reduces the electricity rate during off-peak charging, there might not be enough benefit for an owner to wait to charge a PEV.

[34] Danish Energy Association, "About | Edison," Accessed October 1, 2012, http://www.edison-net.dk/About_Edison.aspx.
[35] The flip side to the peak-load leveling coin would be valley filling when the PEV is charged during periods of low demand, thus evening out the load on the grid.
[36] Kempton, Willett, Francesco Marra, Peter Bach Andersen, and Rodrigo Garcia-Valle. "Business models and control and management architectures for EV electrical grid integration ." In *Electric Vehicle Integration Into Modern Power Networks*, Chapter 4. IEEE Innovative Smart Grid Technologies Europe, 2012.

Siting Methodology

For the purpose of this Plan, existing market research was reviewed and a scoring system was developed to evaluate the potential for a given area (e.g., transportation analysis zone (TAZ) or census tract) to adopt PEVs. The scoring was based on the following criteria: income, HEV ownership, property ownership, dwelling type, and household vehicles.

- Income: Market research suggests that households with higher incomes are more likely to purchase a PEV (see Table 17 below). Based on surveys to date, a significant majority of PEV buyers have a household income greater than $100,000. Because PEVs have higher upfront costs, income can also be a limiting factor.
- HEV Ownership: Households that value non-economic benefits are more likely to purchase PEVs. HEV owners show a willingness to pay to reduce gasoline use that goes beyond the economic benefits of using an HEV. Research from other surveys supports this assumption, including research from University of California (UC) Davis, a survey conducted by BAAQMD, and information provided by Chevrolet regarding Volt drivers (see Table 17).
- Property Ownership: Households who own their property are more likely to adopt a PEV than those who rent, according to market research by Nissan, Chevrolet, and a survey by UC Davis. Home ownership reduces both financial and non-financial barriers to EVSE deployment.
- Dwelling Type: Dwelling type (e.g., single-family detached, single-family attached, or MDUs) can indicate PEV ownership. The analysis assumes that consumers with a single-family detached home generally have fewer barriers to EVSE deployment. Consumers living in MDUs are more likely to encounter barriers to EVSE deployment (e.g., limited space, homeowners association restrictions, installation costs for trenching, additional metering requirements, power availability).[37]
- Total Household Vehicles: Based on research from UC Davis and based on the results of a survey of LEAF buyers conducted by BAAQMD, PEV purchasers in California tend to live in households that have more than one vehicle. The UC Davis study also indicates that PEV adopters tend to live in houses that have recently purchased two new vehicles. With that in mind, the analysis assumes that households with two or more cars are more likely to purchase a PEV.

[37] Graham, R.L., J. Lieb, J. Sarnecki, R. Almazan, B. Neaman. 2012. Wise Investment in Electric Vehicle Charging Infrastructure through Regional Planning. EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium.

Table 17. Surveys of PEV Owners: Characteristics of Early Adopters

Source	Income	Hybrid ownership	Home Ownership	Dwelling Type	Vehicles Available
California PEV survey • vehicles: LEAFs • region: California [1]	• 54%, $150k + • 25%, $100k-$150k • 18%, $50k-$100k • 3%, <$50k	n/a	n/a	• 91% in single family w/ attached garage • 6% single family, detached garage • 3% in apartment • <1% other	n/a
Bay Area LEAF survey • vehicles: all LEAFs • region: SF Bay Area, CA [2]	n/a	• 34% had a HEV in their home	n/a	n/a	• nearly all households have at least 1 other vehicle • 30% have more than 2 vehicles
Tal *et al*, California Survey • vehicles: mostly LEAFs • region: California [3]	• 46%, $150k + • 37%, $100k-150k • 16%, declined	• 32% owned a HEV before they purchased PEV • 11% replaced a HEV w/ a PEV • 25% own HEV and PEV	• 96% own their home	• 96%, single family house	n/a
Chevrolet information [4]	• average income: $170k	• 7% of buyers replaced a Toyota Prius HEV with the Volt	n/a	n/a	n/a
Nissan Information [5]	• average household income: $159k	n/a	• home value of $640k	n/a	n/a
Ford information [6]	• average household income: $120-140k	Typical Ford Focus Electric buyers have purchased HEVs in the past	n/a	n/a	n/a

[1] California PEV Owner Survey. California Center for Sustainable Energy, data collected in February 2012. Available online at: http://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project/vehicle-owner-survey. [2] Bay Area LEAF Survey. Conducted by Bay Area Air Quality Management District, analyzed by ECOtality and ICF International. October 2012. [3] Tal, G; Nicholas, MA; Woodjack, J; Scrivano, D. Who Is Buying Electric Cars in California? Exploring Household and Fleet Characteristics of New Plug- In Vehicle Owners. Submitted to Transportation Research Record, August 2012. Available online at: https://sites.google.com/a/ucdavis.edu/gil-tal/evs-market. [4] Cristi Landy, Chevrolet. The Customer Experience: Reaching Buyers Beyond Early Adopters. GM Marketing, February 2012. Available online at: http://umtri.umich.edu/content/Crisit.Landy.GM.Marketing.PT.2012.pdf . [5] Nissan EV Information, handout from EVS26. [6] Mike Tinsky, Associate Director, Sustainability and Vehicle Environmental Matters, Vehicle Electrification and Infrastructure, Ford Motor Company. Phone interview, April 9, 2012.

Approach to Characterizing PEV Market

The five parameters above were used to identify the most likely adopters of PEVs in the Region. Using household data from the MTC Travel Model and from the DMV, profiles of various types of PEV adopters were developed. Although there is some initial research regarding the current adopters of PEVs, there is a disproportionate amount of information regarding purchasers of BEVs (e.g., the LEAF) compared to PHEVs (e.g., the Volt or the Prius Plug-In). This is not a flaw in the surveys; rather it is reflection of the status of the market when the surveys were conducted. For instance, the surveys were generally conducted in February 2012, shortly before the Chevrolet Volt qualified for HOV lane access in California and the Toyota Prius Plug-In was available to consumers. As a result, there is a significant amount of information available about Nissan LEAF purchasers. However, the market is already starting to show a shift towards PHEVs, with the Volt and Prius Plug-In currently outselling the LEAF by a combined factor of 5 or 6 to 1. This is especially salient because BEVs have different requirements for consumers e.g., drivers are more likely to purchase a BEV if they have a predictable use of their vehicle or a second vehicle for longer trips. Furthermore, there is significant overlap between the survey respondents: the survey conducted by the California Center for Sustainable Energy, UC Davis, and the BAAQMD all included individuals who received a rebate as part of the CVRP.

Due to lack of publicly available data and the modest levels of PEV adoption, there are insufficient data to determine statistical correlations between socioeconomic characteristics and likely PEV purchasers. The parameters outlined in the table above were weighted based on literature review conducted as part of this Plan (and highlighted in the footnotes of the table). The timeframe of readiness planning – out to 2015 at least – was also considered and modifications were incorporated to identify the most likely PEV adopters in the Region. These are highlighted where appropriate in the steps below.

- The primary filter to identify the most likely PEV adopters over the near- to mid-term future (e.g., 2-4 years) was household income. For the purposes of this analysis, household incomes were divided into the following five (5) groups:
  - < $75,000 per year
  - $75,000-$100,000 per year
  - $100,000-$150,000 per year
  - $150,000-$200,000 per year
  - $200,00+ per year
- The results were weighted towards the highest income earners. Although the current surveys of PEV adopters indicate that an overwhelming majority of PEV drivers have incomes higher than $100,000, this analysis accounts for an expansion of the PEV market across all income groups to some extent. The income filter accounts for about 60% of the scoring system for households that are likely PEV adopters.

- Households were further distinguished by HEV ownership data available. Due to data limitations, HEV ownership from 2008 was available at the County level. Because data were only available at the County-level, only a small factor was applied to households that adjusted for HEV ownership. The factor was a function of the adoption rate in a County compared to the average adoption rate in the Region. Although this parameter is probably a stronger indicator of likely PEV adoption, data limitations required that this parameter only account for about 15% of the scoring system for households that are likely PEV adopters.

- Despite data indicating that an overwhelming number of PEV drivers own their property, the timeframe of the analysis dictated that more than property owners be considered as potential PEV adopters. Furthermore, the rates of home ownership in the Bay Area require a more nuanced consideration of the impact of home ownership on vehicle purchasing. For the lowest income brackets, households that rented their home were filtered out of the residential siting. However, for the top three income groups, home ownership provided only minor distinction between households. This accounts for about 7% of the overall rating for likelihood to adopt a PEV.

- Similar to home ownership, the current understanding of the correlation between dwelling type and PEV ownership is skewed towards individuals that live in a single detached garage. However, there is work under way in the Region and in California to minimize the barriers to EVSE installation at multi-family units, and it is important that this residential siting analysis not discount the potential for individuals in MDUs to purchase PEVs. However, recognizing that single-family homes have fewer barriers to residential EVSE installation, a small multiplier was introduced to distinguish between dwelling types. This accounts for about 7% of the overall rating for likelihood to adopt a PEV.

- The number of vehicles in a household was the last parameter considered in the residential siting analysis. The number of vehicles in a household is likely a much stronger indicator for BEV ownership; as more data become available regarding the characteristics of PHEV owners, it is anticipated that a smaller portion of buyers will have multiple vehicles. However, because there is likely to be a strong correlation between the number of vehicles in a household and purchasers of BEVs – until the batteries in PEVs enable greater all-electric range – this factor accounts for about 10% of the overall rating for likelihood to adopt a PEV.

Workplace Charging

Based on the market segmentation presented above regional travel demand as it corresponds to the likelihood of PEV adoption was reviewed. The project team reviewed the origin-destination pairs for workplace taken by each of the households identified in the residential siting analysis in the Bay Area. Due to data constraints, a separate approach was employed for the Monterey Bay Area and is discussed in more detail below.

For the Bay Area, trips were weighted according to the likelihood of PEV adoption. Each destination TAZ (i.e., where individuals work) was then assigned a weighted score representing the likelihood of a PEV driver traveling to that zone. The distance traveled during each of these trips was also determined using the MTC travel demand model.[38]

The likelihood of a zone being a workplace destination for a PEV driver is augmented with additional data including:

Privately accessible EVSE extracted from the Alternative Fuels Data Center (AFDC); these EVSE are assumed to be employer installed charging stations and represent the first stages of workplace EVSE deployment. These data were cross-checked with information provided from an employer survey conducted by BAAQMD. The assumption that the EVSE locations extracted from the AFDC database are deployed at workplaces is consistent with self-reported data from regional employers.

Employers who have expressed an interest in deploying workplace charging. In the employer survey conducted by BAAQMD, about 120 around the Region expressed an interest and likelihood of deploying EVSE at workplaces in the next 18 months.

Existing transit links. Transit connections, particularly in the Bay Area, are an excellent location to install EVSE because vehicles spend a considerable amount of time at these stations during the day. EVSE are already deployed at places like the Redwood City Caltrain stop and at the Tiburon Ferry Terminal. EVSE deployed within ¼-½ miles of a transit station can be considered workplace charging. One of the challenges of deploying EVSE at transit stations will be making it cost effective; in some cases, the trenching and cutting for Level 2 EVSE may make the installation cost-prohibitive, and potentially low throughput rates due to “tied up” charging stations is also an issue.

Publicly Accessible Charging

Publicly accessible charging is divided into DC fast charging and Level 2 EVSE considerations in the following subsections. Furthermore, due to varying levels of data availability and modeling capabilities, separate analyses were conducted for the Bay Area and Monterey Bay Area.

Bay Area

To estimate the locations for publicly accessible charging, a select trip analysis was employed. For this analysis, the travel demand model only keeps track of specific trips while including total trips used to determine congestion levels.

For the Level 1 and 2 EVSE siting analysis in the Bay Area, non-work trips were considered in the model, which are characterized with the following purposes: shopping, personal business or services and medical appointments, social and recreational, and eating outside of the home. Each of these purposes is assumed to correspond with a timeframe that is conducive to Level 1 and 2 charging and in some cases DC fast charging.

For metropolitan areas, such as the Bay Area, the most useful locations for DC fast charging stations during the initial build out of charging infrastructure will typically be near highways so

[38] Trips were loaded on to the network to determine vehicle miles traveled; the distances were not straight-line estimates between TAZs.

that they are accessible to significant number of drivers. Even after significant deployment the majority of publicly funded infrastructure locations are likely to be near highways or major roads. Therefore, in order to reduce the complexity of the problem of determining how to allocate stations across a two-dimensional region, one can consider the region to be made up of a set of linear corridors. The approach employed here was modified based on an approach developed by a research team at ECOtality.[39]

ECOtality recommends assigning each traffic corridor a catchment area so that demand variables (e.g., population and traffic) associated with the cities surrounding the corridor are assigned to a point along the corridor. It should be noted that the catchment area can vary greatly depending on the desired solution. For example, the catchment area for I-680 is likely to extend much farther from the highway in many locations than the catchment area for I-280 in San Francisco, since the former serves suburban cities. Therefore corridors and their associated catchment areas must be designed with an approximate solution in mind. Information regarding the highway network and demand data is used in the methods described in the following sections, from which the optimal solution provided is the density of charging stations along all corridors with units of ports/mile.

However, rather than using catchment areas, MTC maintains a rich dataset of trip choice data on a household basis that were employed in this analysis. In this case, the likely PEV adopters are modeled on the transportation network and their traffic volumes are tracked as a function of overall congestion.

Highway links are used for station allocation optimization where a link is defined as being a specific subsection of a corridor. The travel demand model includes highway links that are used in optimization, corresponding with various corridors and intersections. In some cases, highways that run parallel to one another and are close together can be redefined as being a single link. For instance, much of SR-82 runs near US-101 and I-280, so there is no need to distinguish SR-82 as a link in these areas. For highway intersections, only one link should be defined. For example, the intersection of SR-92 and US-101, the US-101 link would continue through the intersection, whereas the SR-92 link would be divided into two separate links. This eliminates the problem of double assigning stations near intersections in the optimization process.

[39] Personal communication with Nakul Sathaye at ECOtality North America, 2012.

Recommendations for Local and Regional Governments

The following sections of the Plan focus on the role of local and regional governments and the stakeholders they will likely interact with the most: PEV consumers (Section 9) and utilities (Section 10). In each of the following sections an introduction to and overview of the readiness elements is provided, followed by a review of the gaps and deficiencies in the Region that impact readiness. Each section concludes with a series of recommendations based on research (including stakeholder outreach and interviews) and analysis. Section 5 through Section 7 identify key actions that local governments can take to accelerate PEV readiness through their building codes, permitting and inspection processes, and zoning codes. Table 18 summarizes these recommended implementation actions, dividing them into short- and long-term actions, and lists resources related to each action. These actions and resources are discussed in more depth in the following sections of this document.

The short-term actions described in Table 18 can generally be implemented without major changes to municipal codes, and for which ample resources are available for local governments to draw upon. Implementing these four actions will ensure that PEV owners who are interested in installing EVSE have clear guidance on how to do so in a safe and effective manner, and will typically require minimal agency staff time. Therefore, it is anticipated that local governments interested in becoming PEV ready will be able to implement these actions by 2014. The seven long-term recommended actions potentially involve in-depth changes to local plans, codes, and departmental staffing. Implementing these changes will ensure that new development includes appropriate PEV charging opportunities, remove key barriers to installing EVSE, and mitigate long-term risks that increased PEV charging poses to the electrical grid. Since amending local plans and codes can be a complex and costly process, local governments are encouraged to implement these actions as opportunities arise through comprehensive updates to the relevant plans and codes. The Governor's Office of Planning and Research recommends that local governments update their comprehensive General Plans every ten years, and many plan updates currently underway include actions to increase PEV deployment, so it is anticipated that local governments interested in becoming PEV ready will be able to implement these actions by 2021.

Regional agencies will continue to explore the feasibility of prioritizing funding to local governments for future PEV planning and infrastructure for agencies that have completed the actions listed in Table 18. BAAQMD also intends to conduct ongoing assessments of the Region's PEV readiness, which will include surveys of local governments in the horizon years of 2014 and 2021 to determine how many agencies have completed these actions. These assessments will include analysis of data on PEV purchases across the Bay Area in order to assess whether the region is on track to meeting the assumptions regarding increased adoption of PEVs in the SCS.

Table 18. Local Government Implementation Actions and Available Resources

Short-term (2014) Implementation Actions	Available Resources
Adopt California Building Code standards for EVSE into local building codes	• 2010 California Building Code • 2010 California Electrical Code
Create a permitting checklist for residents and contractors	• South Bay Tri-Chapter Uniform Code Committee • City of Milpitas • City of Sunnyvale
Train permitting and inspection officials in EVSE installation	• Electric Vehicle Infrastructure Training Program • Department of Energy Clean Cities Webinars
Specify design guidelines for PEV parking spaces	• Sonoma County *Electric Vehicle Charging Station Program and Installation Guidelines* • California PEV Collaborative *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure* • South Bay Tri-Chapter Uniform Code Committee
Long-term (2021) Implementation Actions	**Available Resources**
Adopt requirements for pre-wiring[40] EVSE into the building code	• 2010 California Green Building Code • City of Sunnyvale Building Code • City of Los Angeles Green Building Code
Work with local utilities to create a notification protocol for new EVSE through the permitting process	• PG&E Getting Started Guide to Plug-In Electric Vehicles
Staff the permitting counter with electrical permitting experts	
Adopt a climate action plan, general plan element, or stand-alone plan that encourages deployment of PEVs and EVSE	• City of Berkeley General Plan • City of Salinas General Plan • City of San Carlos Climate Action Plan • Sonoma County *Electric Vehicle Charging Station Program and Installation Guidelines*
Create minimum requirements for PEV parking	• Recommended PEV parking requirements in this document • City of Emeryville Draft Planning and Zoning Code • *Ready, Set, Charge California!*
Allow PEV parking spaces to count toward minimum parking requirements	• *Ready, Set, Charge California!*
Adopt regulations and enforcement policies for PEV parking spaces	• City of Santa Rosa • Marin County Code

[40] For a definition of pre-wiring, see Section 5.1.

5. Building Codes[41]

Local governments can modify building codes to ensure that new buildings have adequate space and electrical wiring for EVSE installations to support accelerated PEV adoption. The following section serves as a guide to assist local government agencies with their efforts to adopt building codes that support current and future installation of EVSE.

5.1. Introduction

Building codes contain minimum safety standards and specifications applicable to new construction and existing buildings. Local governments can modify these codes to ensure that new buildings have adequate space and electrical wiring to support EVSE installations. There are two major opportunities to create building codes to support PEV deployment. The first is to specify standards for EVSE in the building code to ensure that any EVSE installations are safe and accessible. The second is to require pre-wiring for EVSE. “Pre-wiring” refers to the practice of providing sufficient basic infrastructure, such as conduits, junction boxes, outlets serving garages and parking spaces, adequate wall or lot space for future EVSE, and adequate electrical panel and circuitry capacity, to meet anticipated future demand for EVSE. Pre-wiring can lower the cost of installing EVSE by an estimated 65%.[42]

California’s Building Code and Electrical Code both contain specifications related to EVSE. These codes apply in all cities and counties, unless local governments have taken action to adopt their own codes. Thus, many local governments in California already have standards for EVSE in place, and those that use their own building codes can simply adopt the relevant sections of the state code into their own codes. Another resource is California Green Building standards (CALGreen),[43] which includes two levels of voluntary standards in addition to the base level, mandatory standards that add a further set of green building measures. These voluntary standards include requirements for pre-wiring EVSE, which local governments can choose to adopt as mandatory standards into their own codes.

5.2. Issues, Gaps, and Deficiencies

Requirements in Single Family Residences (SFRs), Commercial Buildings and MDUs

Establishing building codes that regulate or require EVSE in SFRs is relatively straightforward, since SFRs generally have low demand for electricity compared to commercial buildings and buildings with MDUs, contain simple electrical systems, and the property owner will most likely be the user of the charging station. This is not the case in commercial buildings and MDUs, where electricity use is much higher and where the level of demand for EVSE is often difficult to estimate. As a result, a greater number of local governments have established requirements related to EVSE for SFRs than for commercial buildings and MDUs.

[41] This section corresponds to the requirements described in Section 6 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

[42] ICF International correspondence with ChargePoint / Coulomb Technologies, July 2012.

[43] California Building Standards Commission, 2010 California Green Building Standards Code (CALGreen), California Code of Regulations, Title 24, Part 11, Section A5.106.5.3, http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

This chapter contains a summary listing of the local and state codes that relate to SFRs, commercial properties and MDUs.

5.3. Recommendations

Building codes are the appropriate place for local governments to specify the technical requirements for EVSE, as well as to require installation or pre-wiring for EVSE in new construction. This section contains two recommendations for the Region's local government agencies to consider:

- Adopt standards for EVSE into the building code
- Adopt requirements for pre-wiring EVSE into the building code

Adopt standards for EVSE into the building code

Implementing this recommendation is relatively straightforward as the California Building Standards Code already contains standards for EVSE. Local governments that adopt the Building Standards Code therefore have standards for EVSE in place, while those that use their own building codes can simply adopt the relevant sections of the state code. If local governments wish to instead adapt or create their own building code standards for EVSE, they are encouraged to address the following elements:

- Location of EVSE, including acceptable EVSE sites on a typical property and recommended locations of EVSE relative to vehicles and electrical panels.
- Electrical and technical standards for EVSE, including construction of equipment, wiring methods, and safety protection. Relevant standards can be found in the California Electrical Code[44] and the Underwriters Laboratories (UL) guidance on EVSE.[45]
- Signage and marking requirements.
- Ventilation requirements.
- Permitting and inspection requirements. Section 6 discusses permitting and inspection requirements in more depth. Please note that these requirements may vary according to the type of building (residential or non-residential), the type of charging equipment (Level 1 or Level 2), and whether the building's existing electrical capacity is sufficient to power EVSE.
- Accessibility requirements. California's Building Code also establishes accessibility requirements for different types of buildings. However, no official design standards currently exist for accessible PEV parking or charging stations. Local governments have been choosing from existing resources when creating parking requirements and design

[44] California Building Standards Commission, 2010 California Electrical Code, http://rrdocs.nfpa.org/rrserver/browser?title=/NFPACA/CaliforniaElectricalCode2010.

[45] Underwriters' Laboratory, UL 2202, Standard for Safety of Electric Vehicle (EV) Charging System Equipment, 2009.

guidelines that address accessibility; these resources are discussed under the related recommendations in Section 7.3.

In order to make the process of complying with local building and permitting requirements easier for residents, it is recommended that local governments make available both online and in hard copy at the building department or permit counter a stand-alone guidance document that summarizes local building code and permitting requirements related to EVSE installations.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that the level of effort required to adopt standards for EVSE into the building code varies widely. Some local governments would only require five to ten staff hours to draft code language, write a staff report, and respond to feedback on the proposed changes, while other agencies estimated that it would require 50 percent of one full-time staff member's time for six months to create reports for and respond to questions from the public and public officials. The total cost of the staff time to implement this recommendation would therefore vary between $500 and $20,000 depending upon the extensiveness of changes to the building code and the level of staff involved. Because of the extensive availability of existing codes related to EVSE, it is likely that the cost to most local governments would be toward the lower end of this range.

For the discussion of how to cover the costs of building code updates and other local PEV readiness actions, see the next steps discussed in the Summary.

Sample standards and best practices

- Section 406.7 of the **California Building Code** discusses electrical requirements, ventilation requirements, and electrical interface requirements related to EVSE. The California Building Code is available online at http://publicecodes.cyberregs.com/st/ca/st/b200v10/index.htm. The relevant section is listed under Chapter 4.
- Article 625 of the **California Electrical Code** contains in-depth electrical requirements for EVSE, including requirements for wiring methods, equipment construction, control and protections, and locations. The California Electrical Code can be viewed online at http://rrdocs.nfpa.org/rrserver/browser?title=/NFPACA/CaliforniaElectricalCode2010.
- **UL Standard 2202** contains in-depth technical specifications for EVSE, including requirements for construction, injury protection, performance, ratings, and markings.

Adopt requirements for pre-wiring EVSE into the building code

Adopting building code standards enables the installation of EVSE, but requiring pre-wiring removes a key barrier by dramatically lowering the costs of installing EVSE in the future. Pre-wiring requirements can be adopted either through the building code or through the zoning code, as discussed in Section 7. If local governments choose to amend both the building and zoning codes to create pre-wiring requirements for EVSE, the requirements in the two codes should be consistent with one another.

Issues to Consider

Consistency with Minimum PEV Parking Requirements in the Zoning Code

These amendments are similar to the recommended minimum PEV parking requirements for inclusion in the zoning ordinance discussed in Section 7. They can either complement or act as an alternative to zoning code parking requirements, depending upon the type of building to which they apply:

For **residential properties**, the building code should be amended to require pre-wiring for EV charging stations in all SFRs and for a certain percentage of parking spaces in multi-family buildings. These requirements should be consistent with any PEV parking requirements adopted through the zoning ordinance.

For **non-residential properties**, existing building codes typically require that a certain proportion of parking spaces contain PEV charging stations. Zoning ordinance minimum requirements, which typically adjust the number of PEV parking spaces according to anticipated demand at different land uses, are preferable to the uniform standards found in building codes, because they allow local governments to account for the fact that there is likely to be more demand for charging at certain locations, such as large retail centers or workplaces. However, the uniform non-residential PEV parking requirements typically found in building codes can serve as an interim measure while a jurisdiction is developing more in-depth parking requirements for inclusion in its zoning ordinance.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that formally amending the building code can require only five to ten staff hours to draft code language, write a staff report, and respond to feedback on the proposed changes, or can require much more extensive involvement in local governments that have more extensive requirements for outreach and communication with the planning commission. The total cost of the staff time to implement this recommendation could range between $500 and $20,000, with costs toward the lower end of the range if local governments simply adopt language from CALGreen or the local codes discussed in the following section. The incremental cost of adopting sections related to PEV charging in CALGreen will also be relatively low if local governments undertake a comprehensive adoption of CALGreen voluntary requirements. However, local governments should ensure that the number of EVSE spaces required at multi-family or commercial buildings is appropriate to the anticipated level of EV demand in their area. Section 7.3 contains recommended PEV parking requirements for MDUs, as well as for workplaces and commercial locations that are likely to see demand for opportunity charging, based on projections of EV demand through 2025. Table 19 below contains examples of current requirements from various state and local building codes.

As noted previously, if local governments have not adopted their own codes then they are automatically subject to the current versions of the California Building Code. Though the current version of the code does not include requirements for EVSE, future updates, beginning with the current 2012 update cycle, may include such requirements. ***If this is the case, local governments that do not plan on adopting their own building codes may soon have***

requirements for EVSE in place without any additional effort. Local planners and building officials should monitor the progress of the 2012 updates to the state building code to determine whether any EVSE requirements contained therein are applicable to their jurisdiction.

For the discussion of how to cover the costs of building code updates and other local PEV readiness actions, see the next steps discussed in the Summary.

Sample Standards and Best Practices

Several resources contain guidance on the number of spaces that should be pre-wired for electric vehicles at different building types, as well as code language framing these requirements, and a growing number of local governments around the state have adopted requirements for PEV charging stations in new construction. Table 19 below summarizes PEV charging requirements contained in California state and local codes.

Table 19. PEV Charging Requirements from California State and Municipal Codes

Source	Building or land use type	Number/Percent of spaces dedicated to EV charging	Requirements for EV charging spaces	Voluntary / Required
CALGreen	One- and two-family dwellings	1 per dwelling unit	Listed raceway to accommodate a branch circuit for Level 2 EVSE	Voluntary
CALGreen	Multi-family dwellings	3% of all spaces; at least one space	Listed raceway to accommodate a branch circuit for Level 2 EVSE	Voluntary
CALGreen	Nonresidential	~2% (varies by size of lot)	Pre-wiring for Level 1 and 2 charging	Voluntary
CALGreen	Nonresidential	~10-12% (varies by tier and size of lot)	Designated parking for fuel efficient vehicles	Voluntary
City of Sunnyvale Building Code	Single-family dwellings	1 per dwelling unit	Pre-wiring for Level 2 charging	Required
City of Sunnyvale Building Code	Residential developments with common shared parking	12.5% of all spaces	Pre-wiring for Level 2 charging	Required
City of Los Angeles Green Building Code	One- and two-family dwellings	1 per dwelling unit	Level 2 outlet or panel capacity and conduit to accommodate a Level 2 outlet	Required
City of Los Angeles Green Building Code	Residential developments with common shared parking	5% of all spaces	Level 2 outlet or panel capacity and conduit to accommodate a Level 2 outlet	Required
City of Emeryville Draft Planning and Zoning Code	Multi-unit residential and lodging with 17+ parking spaces	3% of all spaces	Charging stations (level not specified)	Required

The remainder of this section contains the relevant code sections from each of the building codes listed below. Note that Table 19 contains both requirements from building codes and zoning codes; zoning codes are discussed in Section 7.

Section A4.106.6 of **CALGreen** includes the following voluntary requirements for electric vehicle charging at residential buildings.[46] These measures are required in order to meet CALGreen Tier 1 and 2:

> **A4.106.6. Electric vehicle (EV) charging.** Dwellings shall comply with the following requirements for the future installation of electric vehicle supply equipment (EVSE).
>
> > **A4.106.6.1 One-and two-family dwellings.** Install a listed raceway to accommodate a dedicated branch circuit. The raceway shall not be less than trade size 1. The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure. Raceways are required to be continuous at enclosed or concealed areas and spaces. A raceway may terminate in an attic or other approved location when it can be demonstrated that the area is accessible and no removal of materials is necessary to complete the final installation.
> >
> > > **Exception:** Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 2 EVSE.
> > >
> > > **Note**: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation, and should be consulted during the project design and installation.
> > >
> > > **A4.106.6.1.1 Labeling requirement.** A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and next to the raceway termination point.
> >
> > **A4.106.6.2 Multi-family dwellings.** At least 3 percent of the total parking spaces, but not less than one [parking space], shall be capable of supporting future electric vehicle supply equipment (EVSE).
> >
> > > **A4.106.6.2.1 Single charging space required.** When only a single charging space is required, install a listed raceway capable of accommodating a dedicated branch circuit. The raceway shall not be less than trade size 1. The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure.
> > >
> > > **Exception:** Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 2 EVSE.

[46] California Department of Housing and Community Development, *A Guide to the California Green Building Standards Code – Low-rise Residential,* June 2012: 81, http://www.hcd.ca.gov/codes/shl/CALGreenGuide_COMPLETE.pdf.

A4.106.6.2.2. Multiple charging spaces required. When multiple charging spaces are required, plans shall include the location(s) and type of the EVSE, raceway method(s), wiring schematics and electrical calculations to verify that the electrical system has sufficient capacity to simultaneously charge all the electrical vehicles at all designated EV charging spaces at their full rated amperage. Plan design shall be based upon Level 2 EVSE at its maximum operating ampacity. Only underground raceways and related underground equipment are required to be installed at the time of construction.

Note: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation, and should be consulted during the project design and installation.

A4.106.6.2.3 Labeling requirement. A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and the EV charging space.

Section A5.106.5.3 of **CALGreen** includes the following voluntary requirements for the number of designated PEV charging spaces at nonresidential locations.[47] These measures are required in order to meet CALGreen Tier 1 and 2:

A5.106.5.3 Electric vehicle charging. Provide facilities meeting Section 406.7 (Electric Vehicle) of the California Building Code and as follows:

A5.106.5.3.1 Electric vehicle supply wiring. For each space required in Table A5.106.5.3.1 [Table 20 of this report], provide one 120 VAC 20 amp and one 208/240 V 40 amp, grounded AC outlets or panel capacity and conduit installed for future outlets.

Table 20. CALGreen Table A5.106.5.3.1

Total Number of Parking Spaces [a]	Required Number of Parking Spaces
1-50	1
51-200	2
201 and over	4

a. In a parking garage, the total number of parking spaces is for each individual floor or level.

Section A5.106.5.1 of **CALGreen** also contains requirements for the number of parking spaces that are designated for fuel-efficient vehicles (which includes low-emitting, fuel efficient, and carpool/van pool vehicles, as well as PEVs) and signage requirements for these spaces.[48] These measures are required in order to meet CALGreen Tier 1 and 2. Local governments that

[47] California Building Standards Commission, 2010 California Green Building Standards Code (CALGreen), California Code of Regulations, Title 24, Part 11, Section A5.106.5.3, http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

[48] California Building Standards Commission, 2010 California Green Building Standards Code (CALGreen), California Code of Regulations, Title 24, Part 11, Section A5.106.5.1, http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

wish to encourage PEVs as the primary form of fuel efficient technology may prefer to adapt these minimum parking requirements to apply solely to PEVs, using the definition provided in A5.106.5.3 above:

> **A5.106.5.1 Designated parking for fuel-efficient vehicles**. Provide designated parking for any combination of low-emitting, fuel-efficient and carpool/van pool vehicles as shown in Table A5.106.5.1.1 or A5.106.5.1.2. [DSA-SS] Provide 10 percent of total designated parking spaces for any combination of low-emitting, fuel-efficient and carpool/van pool vehicles as follows:

Table 21. CALGreen Table A5.106.5.1.1

Total Number of Parking Spaces	Number of Required Spaces
0-9	0
10–25	2
26–50	4
51–75	6
76–100	9
101–150	11
151–200	18
201 and over	At least 10 percent of total

Table 22: CALGreen Table A5.106.5.1.2

Total Number of Parking Spaces	Number of Required Spaces
0–9	1
10–25	2
26–50	5
51–75	7
76–100	9
101–150	13
151–200	19
201 and over	At least 12 percent of total

The **City of Sunnyvale** adopted Ordinance 2964-11[49] in 2011 to amend its green building code and incorporate the residential voluntary requirements in CALGreen.

> California Green Building Code Section 4.106.4 is hereby added:

[49] City of Sunnyvale, "Ordinance No. 2964-11," accessed on April 19, 2012, http://qcode.us/codes/sunnyvale/revisions/2964-11.pdf.

(a) **Section 4.106.4 Pre-Wiring for Electric Car Chargers.** Effective July 1, 2012, parking spaces shall be pre-wired to accommodate Level 2 electric car chargers in accordance with Chapter 16.32, as follows:

(1) All garages or carports accessory to single-family dwelling;

(2) All garages or carports in residential developments with attached individual garages or carports;

(3) Twelve and one-half percent of the total required parking spaces in residential developments that provide common shared parking.

Pre-wiring requirements for EVSE, based on CALGreen in both single-family and multi-family residential units are contained in the **City of Los Angeles' Green Building Code** Section 99.04.106.6:[50]

99.04.106.6. Electric Vehicle Supply Wiring.

1. **For one- or two- family dwellings and townhouses**, provide a minimum of:
   a. One 208/240 V 40 amp, grounded AC outlet, for each dwelling unit; or
   b. Panel capacity and conduit for the future installation of a 208/240 V 40 amp, grounded AC outlet, for each dwelling unit.

   The electrical outlet or conduit termination shall be located adjacent to the parking area.
2. **For other residential occupancies where there is a common parking area**, provide one of the following:
   a. A minimum number of 208/240 V 40 amp, grounded AC outlets equal to 5 percent of the total number of parking spaces. The outlets shall be located within the parking area; or
   b. Panel capacity and conduit for future installation of electrical outlets. The panel capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to 5 percent of the total number of parking spaces. The conduit shall terminate within the parking area; or
   c. Additional service capacity, space for future meters, and conduit for future installation of electrical outlets. The service capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to 5 percent of the total number of parking spaces. The conduit shall terminate within the parking area.

[50] City of Los Angeles, Los Angeles Green Building Code, Ordinance no. 181840, adopted Dec. 14, 2010, http://ladbs.org/LADBSWeb/LADBS_Forms/Publications/LAGreenBuildingCodeOrdinance.pdf.

> When the application of the 5 percent results in a fractional space, round up to the next whole number.

A building by-law requiring that electrical rooms in multi-family buildings be adequately sized to accommodate equipment for PEV charging stations has been adopted by the City of Vancouver, BC, Canada:[51]

> 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.

Review of Local Agencies' Readiness in the Region: Building Codes

As of August 2012, 19% of the Region's local agencies report adopting building codes specific to EVSE installations. This finding is based on the results of a readiness survey conducted by BAAQMD (see Appendix B: Review of Local Government Readiness Survey). This same survey also found that slightly less than half of the agencies in the Region have begun to consider EVSE-related building code changes or are seeking more information, and about one-third (35%) indicated that they have not yet initiated any work in this area.

Although many local governments in the Region have not yet adopted building codes related to PEVs, this aspect of readiness can – and hopefully will – change quickly. In California, local governments that have not adopted their own codes are automatically subject to the current version of the California Building Code. Though the current version of the code does not include requirements for EVSE, future updates, beginning with the current 2012 update cycle, may include such requirements. If the next version of the code is updated to include requirements for EVSE, then the status of readiness in the Region as it pertains to building codes is updated uniformly.

[51] 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

6. Permitting and Inspection[52]

A permitting and inspection process that expedites the installation of EVSE, provides the service at a reasonable cost, while maintaining the public safety, can support accelerated PEV adoption. The following section serves as a guide to assist local government agencies with their efforts to implement expedited and affordable permitting and inspection practices that ensure a high level public safety.

6.1. Introduction

One of the key objectives of being PEV Ready is to have in place a permitting and inspection process that expedites the installation of EVSE at appropriate locations, provides the service at a reasonable cost to consumers, while maintaining the safety of consumers and the public. The key challenge for local governments is how to expedite permitting with limited resources while maintaining public safety and limiting liability. The recommendations in Section 6.3 offer in-depth guidance on how to maintain safety without creating undue barriers to EVSE installation.

6.2. Issues, Gaps, and Deficiencies

The challenges associated with EVSE permitting and inspection vary depending upon whether the EVSE is located at a single-family residence or at an MDU or commercial property. The following two sections discuss the issues associated with each of these cases in more depth.

Installations in Single-Family Residences

When purchasing a PEV, consumers living in single-family homes will likely also make decisions about the type of EVSE that they wish to have in their residence. Many consumers looking to install Level 2 EVSE, or even Level 1 EVSE that establish the rate at which vehicles consume electricity, will likely seek out certified contractors to install EVSE, while some will seek to install the equipment themselves.

As far as permitting of basic or routine EVSE in residential settings, a large amount of guidance material is available (see Section 6.3). However, even in residential settings, a major issue is the notification of local utilities, which may have to make upgrades to local service (i.e. transformers) to accommodate new PEVs. To address this issue, PG&E, which provides electricity for the majority of the Region, has developed guidance to walk consumers through the process of installing residential EVSE. This includes a checklist with the following steps:

Contact an electrician to assess your home – the electrician can 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

[52] This section corresponds to the requirements described in Section 7 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

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, then 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[53]

The primary issue with installations in single-family residences is that some consumers will disregard these guidelines and seek to install EVSE themselves, in some cases without seeking a permit from the city. This creates potential safety risks if installations are conducted incorrectly, and may impact the electric grid if a significant number of homes in the same area install EVSE without notifying utilities.

Installations in Multi-Family Dwelling Units (MDUs) and Commercial Properties

Installing EVSE at MDUs and commercial properties is potentially more complicated due both to the greater complexity of electrical systems at these properties and questions about ownership and management of EVSE. At this time, little guidance exists for municipalities on how to complete permitting for these installations. On one hand, the technical complexity of these installations means that property owners are more likely to seek out certified contractors to conduct installations, which reduced the safety risks associated with single-family residences. However, homeowners associations (HOAs) or property managers typically have ultimate say over EVSE installations in commercial properties and MDUs, and often are unaware about the costs of installation, how to manage payment for use, or how to regulate use of EVSE and associated parking spots.

Senate Bill 880 (SB 880, Corbett, Statues of 2012)[54] voids any policies or provisions that prohibit or restrict the installation or use of EVSE in a common interest development. However, if property managers and HOAs do not have adequate information to help them navigate the different decisions that need to be made, the issues listed above may act as barriers and reduce the likelihood, or at least slow down the process, of installing EVSE at these properties.

The PEVC is a multi-stakeholder public-private partnership that collaborates on efforts to ensure a strong and enduring transition to a PEV market in California. Through its member-driven process, the Collaborative is working over the next year on developing recommendations and guidelines that will provide additional information and resources to stakeholders that wish to deploy EVSE in workplaces and in MDUs.

[53] Pacific Gas and Electric (PG&E), Getting Started Guide: Plug-In Electric Vehicles, http://www.pge.com/includes/docs/pdfs/shared/environment/pge/cleanair/electricdrivevehicles/pev_home_installation.pdf.

[54] 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

6.3. Recommendations

As local governments explore options for expediting and streamlining the permitting process, they will also need to seek to balance convenience with quality control. This point is essential given that EV charging stations, particularly Level 2 EVSE, may consume more electricity than other residential appliances—and in some cases as much as all other uses in the house combined—and require careful attention to safety and potential grid impacts, which can drive up the costs and time associated with permitting.

The five recommendations in this section are focused on helping local governments balance these seemingly competing objectives while removing barriers to installing EVSE without sacrificing safety and quality control:

- Expedite permitting for EVSE in single-family residences
- Create a permitting checklist for applicants, and post the checklist online
- Require load calculations for Level 2 EVSE, and work with local utilities to create a notification protocol for new EVSE through the permitting process
- Train permitting and inspection officials in EVSE installation
- Staff the permitting counter with electrical permitting experts

Expedited permitting for EVSE in single-family residences

In order to encourage EVSE installations, it is recommended that local governments consider implementing the following actions to streamline and expedite their permitting and inspection of EVSE installations:

- Issue permits under 48 hours
- Levy fees between $100 and $250
- Issue supplementary guidance to help applicants through the permitting process, and post this guidance online.
- Make permits available online or over-the-counter
- Limit the number of required inspections to one.
- Minimize requirements for supporting materials to information about the EV charging system (i.e., level of charger, compliance with national standards, proposed location) and electrical service (i.e., existing electrical panel service information, load calculations, whether panel upgrades or a new meter installation are required).[55] Do not require site plans for EVSE in SFRs.

[55] This document adopts the permitting requirements for SFR permitting in TUCC Policy 17 (ICC Tri-Chapter Uniform Code Committee (TUCC), Policy 17: Electric Vehicle (EV) charging system in Single Family Residence (SFR), April 14, 2011. Available online at: http://tinyurl.com/TUCC-Policy. For more information on the TUCC Policy, see the following recommendation and Appendix F: Permitting Checklist.

These recommended actions are mutually supporting; minimizing permit requirements will reduce the amount staff time devoted to permit review, which will enable local governments to process permits more quickly and levy lower fees to recover costs.

According to the readiness survey results (see Appendix B: Review of Local Government Readiness Survey), many local agencies are already meeting this goal with respect to single-family residences. Over half (53%) of local governments in the Region issue same-day permits for EVSE in single-family residences, and 80 percent charge under $250 for these permits.

Issues to Consider

Consistency with pre-wiring requirements

Local governments that adopt pre-wiring requirements as discussed in Sections 5 and 7 may wish to further expedite permitting or eliminate permitting requirements altogether for Level 2 EVSE installed in pre-wired single-family residences. Pre-wiring requirements may eliminate the need to upgrade electrical service in order to accommodate new EVSE, which is the primary safety concern regarding most EVSE installations.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that the estimated cost to local government agencies to expedite permitting for single-family residences may range from $500 up to $10,000 in agency staff time depending upon the level of effort and level of staff involved. This estimate is based on the assumption that the work involves up to ten hours to research best practice permitting requirements and to coordinate between different departments to implement this action.

Guidance and Best Practices

- **Eliminate requirements to submit site plans.** The **City of Milpitas** does not require that applicants of single-family residences looking to install EVSE submit site plans for review prior to a building inspection. Instead, these applicants 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 EVSE.
  - The panel rating of the existing electrical service, the load of the existing system, and the EVSE 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.
- **Allow applicants in single-family detached residences to obtain permits for charging stations online.** The **City of Sunnyvale** has implemented this strategy, which also allows applicants to obtain permits without submitting plans for review, provided that the station will be located within a garage and can be connected to existing electrical panels. **The City and County of San Francisco** allows qualified contractors to obtain permits online.

- **Express or over-the-counter permits** for EVSE are offered by agencies including the cities of Gonzales and Morgan Hill and the City and County of San Francisco.

Create a permitting checklist for EVSE permit applicants, and post the checklist online

Regardless of what information agencies choose to require in EVSE permit applications, it is a best practice to combine requirements and guidance into a single document that can guide PEV owners through the process, and make this document available online. This document should contain information on the conditions under which an EVSE permit is required, EVSE permit application requirements, the number and type (e.g. pre-installation, post-installation) of inspections required, and applicable codes and guidance regarding EVSE installation. At a minimum, it is a best practice for local governments to require that applicants for EVSE permits provide the following information:

- The EVSE manufacturer's name and the level of EVSE that will be installed (e.g. Level 1, Level 2).
- Existing electrical service at the premises and a load calculation of demand at the premises.
- Whether the EVSE will require upgrades to the building's electrical system.
- Whether the EVSE will include installation of a second meter, if allowed by the local utility.
- A certification from a nationally approved testing laboratory for the EVSE in accordance with the National Electric Code.

In order to verify the safety of the system, local governments may wish to require additional information during the application process, including a site assessment, a sketch of the site showing the location of EVSE relative to vehicle parking and to electrical panels, or an electrical plan. However, it is also considered a best practice not to require detailed site plans for plan review for EVSE installations in single-family residences.

Issues to Consider

Addressing different land uses and charging equipment

Permitting requirements, and hence the elements included in the permitting checklist, may differ according to the building type and the type of EVSE being installed. Permitting checklists should be designed to accommodate these variations and provide guidance to applicants. Permitting requirements are likely to differ among single-family, multi-family, and commercial properties since the latter are likely to involve more complicated electrical permits and potentially a greater number of EVSE. Permitting requirements will also vary by the type of charging equipment being installed. Many PEVs come equipped with a 120V cord that plugs into a standard wall outlet, which will typically not require any upgrades to electrical service as long as the wall outlet is on a circuit with adequate capacity to accommodate the load of the PEV. On the other hand, a Level 2 EVSE at a single-family residence may require a service upgrade. Though permitting and inspection will need to be more thorough for Level 2 EVSE, clear guidance regarding Level

2 EVSE permitting requirements can help to ensure that the permitting process does not act as a deterrent to potential applicants.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that the estimated cost to local government agencies to create a permitting checklist for applicants may range from $500 up to $5,000 in staff time depending upon the level of effort and level of staff involved. This estimate is based on the assumption that the work involves up to five hours to research best practice permitting requirements and to coordinate between different departments to implement this action. Note that these costs can be reduced substantially by drawing upon the growing number of permitting checklists issued by local governments, which are discussed in detail below.

Guidance and Best Practices – Create a permitting checklist for applicants

A number of local governments in the Region have created checklists or guidance to help applicants, such as property owners and contractors, understand the process and requirements for obtaining a permit for EVSE. Note that many of the documents listed below also serve as an example of cases in which local governments have streamlined permitting for EVSE. They serve as illustrative examples of the type of guidance that local governments can issue to clarify the permitting process, as well as the steps that some agencies have taken to expedite the permitting process. Appendix F: Permitting Checklist contains complete versions of many of the documents discussed below.

- For **single-family residences**, the **South Bay TUCC** has created permitting guidelines for EV charging stations recommends requiring the following information:
    1. EV charging system information: level 1 or 2, EVSE system with UL listed number or other approved nationally recognized testing laboratory, in compliance with UL2202, “Standard for Electric Vehicle (EV) Charging System Equipment”
    2. Existing electrical service panel information at the residence. Include EVSE load and circuit size to determine if electric panel upgrade is required.
    3. Panel upgrade and electrical wiring shall be in conformance with the California Electrical code.
    4. Identify if a second electric meter is required to be installed because of electric utility rate for EV charging [such as a time-of-use rate].
    5. Clarify EVSE location: EVSE shall be installed in accordance with manufacturer’s guideline and must be suitable for the environment (indoor/outdoor).
    6. Manufacturer installation guideline has to be available for the inspector at the site.[56]
- For multi-family and commercial properties, the South Bay TUCC requirements are as follows:

[56] ICC Tri-Chapter Uniform Code Committee (TUCC), Policy 17: Electric Vehicle (EV) charging system in Single Family Residence (SFR), April 14, 2011, http://www.eastbayicc.org/pages/TUCCPolicy/TUCC%20policy%2017%20-%20EV%20SFR%20revised%2004-14-11.doc.

1. Identify all EV charging station locations on the plan.
2. Identify if site is in the flood zone. If so, charging station shall be elevated or designed according to the flood requirement.
3. Identify if a second electric meter is required to be installed because of electric utility rate for EV charging [such as a time-of-use rate].
4. EV system with UL listed number or other approved nationally recognized testing laboratory shall be provided on plan.
5. Provide electric load calculation and design for the charging stations. Dedicated new branch circuits from the central meter distribution panel to the charging station may be required.
6. Planning, Engineering and Fire Departments approval may be required.
7. EVSE shall be installed in accordance with manufacturer's guideline and shall be suitable for the environment (indoor/outdoor).
8. Manufacturer installation guideline shall be available for the inspector at the site.[57]

Other local governments in the Region have adopted the TUCC guidelines, sometimes with modifications. For example, the **City of Sebastopol** has adopted the **guidelines for both single-family and multi-family and commercial buildings,** and the **City of Los Altos** has adopted the **guideline for single-family residences**, with additional requirements that bollards be placed in areas subject to vehicular damage and that applicants submit installation guidelines.[58]

- The **City of Milpitas** has issued guidance that summarizes the requirements for an EVSE permit and includes diagrams illustrating typical configurations of EVSE in different garage types in order to assist applicants of single-family residences with determining the proposed location of the charging system.[59]

- **City of Sunnyvale** has issued a guidance document that contains the following permitting requirements:

  The electric vehicle charging system shall be listed by a nationally recognized testing laboratory (i.e., UL) in compliance with UL 2202 "Standard for Electric Vehicle (EV) Charging System Equipment." (CEC 90.7)

  The electric vehicle charging system shall be installed in accordance with manufacturer's guideline and shall be suitable for the environment (indoor/outdoor). If installed indoors, the charging station shall be labeled "Ventilation Not Required" in a location clearly visible after installation. (CEC 625.15)

---

[57] ICC Tri-Chapter Uniform Code Committee (TUCC), Policy 18: Commercial or Multi-Family Electric Vehicle (EV) charging station, June 9, 2011, http://www.eastbayicc.org/pages/TUCCPolicy/TUCC%20policy%2018%20EV%20Comm%20Guide%20-rev%201%202011.doc.

[58] City of Los Gatos, Electric Vehicle (EV) charging system in Single Family Residence, http://www.ci.los-altos.ca.us/commdev/building/documents/ELECTRICVEHICLECHARGER.pdf

[59] 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

Provide size of the existing electrical panel, existing load on the panel, and proposed load/circuits from the electric vehicle charging system in order to determine if there is adequate capacity in the existing panel. (CEC 220)

If installed indoors, the electric vehicle charging coupling (the nozzle) shall be located between 18" and 48" above the finished floor. If installed outdoors, the electric vehicle charging coupling (the nozzle) shall be located between 24" and 48" above the finished grade. (CEC 625.29, 625.30)

If the electric vehicle charging equipment is located in an area subject to vehicular damage, an adequate barrier must be installed (e.g. 4" diameter steel pipe filled with concrete, a minimum of 40" above the finished floor/grade, installed in a footing measuring 12" in diameter and 3' deep). (CEC 110.27)

If the project site is in an AE or AO flood zone, the charging equipment shall be elevated or designed according to the flood requirement (Sunnyvale Municipal Code 16.62). Flood zone information is available on-line at www.e-onestop.net.[60]

Require load calculations for Level 2 EVSE, and work with local utilities to create a notification protocol for new EVSE through the permitting process

Whereas most appliances and motors consume electricity intermittently, EVSE consumes electricity continuously while in use, which means that clustering from multiple charging events on the same transmission lines has the potential to overload the grid. Although it is safe to conclude that PEVs will have only a very insignificant effect on the grid in the next 10 or more years, it is more likely that they have the potential to bring localized distribution problems. Knowing where those loads will occur and the ability to easily share information about these new loads with the local utility will be key to achieving a successful transition towards increased rates of PEV adoption. To this end, it is a best practice for local governments to require that EVSE permit applications, particularly applications for Level 2 EVSE permits, contain load calculations, since only utilities have the ability to address these potential impacts, and to address them, they will need the information from these load calculations.

However, most utility service providers are for-profit corporations, and CPUC regulations prevent local governments from providing residents' information to for-profit corporations. Also, many local governments currently do not have established channels of communication with local utility service providers. In order to create a notification protocol for new EVSE through the permitting process, local governments are encouraged to engage their utility service providers about local permitting processes and utility service provider notification needs.

All EVSE installation guidelines recommend that PEV purchasers notify their utility service provider of new EVSE installations. This is an important first step, but recommended voluntary protocols do not guarantee that utilities will have all of the information they need to address potential grid impacts from new EVSE. By local governments taking a more active role in

[60] City of Sunnyvale (2012). "Electric Vehicle Chargers: Building Division Requirements." http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CDD/Residential/Electrical%20Car%20Chargers.pdf

notifying utilities about EVSE installations, it will result in more thorough and consistent reporting since local governments will potentially have information on a greater percentage of permitted EVSE installations within their jurisdictions. It would also likely result in more accurate reporting, because technical specialists rather than PEV owners would be responsible for notifying utilities.

Given that PEV technology is still in its early stages, there are very few examples of notification protocols to currently draw from. However, it will be important to develop best practices and guidance for agencies to consider as the industry matures and adoption rates increase, and to ensure that these requirements address anticipated new developments in charging, such as DC fast charging, while also protecting consumers' privacy.

Issues to Consider

Municipally-owned utilities

Several local governments in the Region operate municipally-owned utilities, or MOUs. It may be significantly easier for the permitting department and the utility to collaborate in these jurisdictions because there will not be regulatory barriers preventing local governments from sharing information with utilities. Local governments in areas with MOUs are encouraged to take the lead in establishing a notification protocol for EVSE installations through the permitting process. These protocols can serve as a model for other local governments that must coordinate with PG&E or other investor-owned utilities.

Alternatives

Conduct outreach encouraging contractors to notify utilities of new EVSE installations

Local governments that are unable to establish EVSE notification protocols through the permitting process because of financial, regulatory, or other barriers can instead consider working to encourage local electrical contractors and vehicle dealers to explain the utility notification protocols to customers when installing EVSE and during the vehicle purchasing process. Training programs for electrical contractors, such as the Electric Vehicle Infrastructure Training Program, are readily available and can provide extensive customer relations training on utility notification processes.

Costs

The upfront costs of establishing a utility notification program are estimated at $5,000 to cover local staff time to meet with utility representatives to develop the program and monitor, evaluate, and improve the program in its initial phases. The ongoing costs of maintaining such a program will depend upon the arrangement between the local government and the utility. However, keeping the additional labor for local governments to implement a utility notification program low may help sustain the program.

Guidance and Best Practices

Although there are no existing examples of local governments in the Region that have established a notification protocol with local utilities, PG&E's initial notification protocol for PEV owners can serve as a potential model for local efforts. PG&E recommends that potential PEV drivers contact the utility 30 days before the delivery of their vehicle to discuss special rates for charging, ensure that homes have adequate capacity to accommodate EVSE, and avoid neighborhood service disruptions.[61]

Train permitting and inspection officials in EVSE installation

Local governments that anticipate significant EVSE installations should consider training their electrical inspection officials in EV installation through the Electric Vehicle Infrastructure Training Program (EVITP) or an equivalent educational program. The EVITP offers courses that train and certify electricians throughout the United States to install EVSE. It has developed a 6- to 8-hour course curriculum especially tailored for local government staff and stakeholders, and often works with local governments to tailor classes to local needs and constraints. At a minimum It is recommended that any staff EVSE training cover the following topics:

- EV battery types, specifications, and charging characteristics
- National and California code requirements for EVSE
- Utility interconnect, notification, policies and requirements, and grid stress precautions.
- Brand- and model-specific installation instructions for Level 1 and 2 EVSE and hands-on installation demonstrations.
- Service-level site assessments, load calculations, and upgrade implementation

Additionally, a series of free training webinars on EVSE residential charging installations is available from the DOE Clean Cities. For more information on the DOE, EVITP and other training programs, see Section 8.

Costs

An EVITP course typically costs between $800 and $1,450 to cover time and travel for volunteer instructors. Local governments can split these costs among a number of jurisdictions by organizing courses through organizations such as the International Code Council (ICC) or a sub-regional Clean Cities coalition. Assuming that a course has 15 attendees, fees will be no more than $100 per attendee. This means that the total cost of sending a single staff member to be certified would be under $1,000, which accounts both for fees and three days of staff time to attend the course.

Staff the permitting counter with electrical permitting experts

In order for a local government to implement over-the-counter or another form of express permitting, it should have sufficient staff at the counter to process permits quickly. In addition, the staff working the permit counter should be adequately familiar with the technical aspects of EVSE to evaluate applications with minimum delay before issuing permits. This may require a change in permitting practices, since many local governments staff the counter with employees

[61] Pacific Gas and Electric (PG&E), Plug-In Electric Vehicles: Contact PG&E to get PEV Ready, http://www.pge.com/mybusiness/environment/whatyoucando/electricdrivevehicles/contactpge/.

who are focused on helping applicants navigate the permitting *process* in general, not with technical staff.

This recommendation is particularly important for local governments looking to minimize grid impacts. In order to minimize potential negative grid impacts, local governments should consider requiring that EVSE permit applications, particularly applications for Level 2 EVSE permits, contain load calculations. Expert permitting staff are needed to verify these load calculations, which will help utilities to analyze the strain that new EVSE will place on electricity infrastructure.

Alternatives

Due to many competing priorities and the financial strain that many local jurisdictions are experiencing, this recommendation may be challenging for many local governments to implement. The two alternative approaches discussed below focus on maintaining public safety and expediting permitting while reducing costs to local governments.

Expedite permitting for dedicated Level 1 circuits in single-family residences only

If local governments are too constrained to staff permitting counters with expert staff that can both turn around permits quickly while ensuring quality control, they should consider limiting eligibility for express permitting to instances in which property owners wish to install a dedicated circuit to accommodate Level 1 charging in single family residences. Since Level 1 EVSE can be plugged in to an existing dedicated wall outlet, it often does not require upgrades to electrical service, just an upgrade to a dedicated circuit if property owners wish to avoid overloading the existing circuit or to take advantage of time-of-use (TOU) rates. Level 1 EVSE is less likely to create negative impacts on the grid because it consumes electricity at a lower rate, and because longer charge times make it more likely to be used at night, when overall electricity usage is low. This will effectively streamline permitting for the EVSE that most local governments are most likely to see immediate demand for, while concentrating staff time on Level 2 EVSE or EVSE in multi-family and commercial buildings, which are most likely to require additional attention due to high levels of electricity demand and more complex site design issues.

Limit expedited permitting to certified contractors

Another alternative is for local governments to limit expedited permitting for EVSE installations to electrical contractors that have been certified by EVITP or a similar educational program, and requiring that these electrical contractors install EVSEEVSE to the standards of the program in order to avoid negative impacts to the grid. This can be either an alternative or a complimentary measure to moving technical staff to the counter. Local governments that have sufficient technical staff at the counter to process permits both quickly and thoroughly can further streamline the permitting process for certified electrical contractors by reducing permit fees or forgoing certain permit requirements, such as plan review for EVSEEVSE at certain building types. This would create an incentive for more Bay Area and Monterey Bay Area electrical contractors to get certified in EVSE installation. It would also encourage PEV owners to hire certified electrical contractors, which can help ensure public safety and avoid damage to electrical systems caused by homeowner self-installations.

Costs

The annual salary for an electrical permitting specialist can be up to $20,000 more than for an entry-level permit technician, and it can be correspondingly expensive for local governments to station specialists at the permitting counter since this level of technical expertise may not be necessary for addressing the majority of questions that come to the counter. This approach can also save agencies money from responding to any safety issues or power outages that result from improperly installed or poorly planned EVSE in the long term.

The two alternative approaches, limiting expedited permitting to Level 1 EVSE and requiring certified electrical contractors to pull permits for EVSE, would likely require under five hours of staff time to draft procedural changes, and would cost under $500.

Review of Local Agencies' Readiness in the Region: Permitting and Inspection

In general, local governments in the Region have made mixed progress in streamlining permitting and inspection processes for EVSE. The majority charge low fees and take five days or less to process permits, particularly for SFRs. However, a significant number of local governments still charge higher fees or take longer to process permits. The number of local governments that have adopted best practices indicates that it should be feasible for others to streamline permitting.

Based on the results of the readiness survey conducted by BAAQMD (see Appendix B: Review of Local Government Readiness Survey), the majority of jurisdictions are in the initial stages of looking into or adopting EVSE permitting and inspection requirements. 16% have already adopted requirements and 29% have not started looking into requirements. Table 23 summarizes local agencies' self-assessed progressed toward implementing best practices in permitting and inspection of EVSE.

Table 23. Progress of Permitting and Inspection in the Region

Response	Count	Percent
Adopted best practice EVSE requirements	20	16%
In the process of adopting EVSE requirements	8	6%
Started to consider EVSE requirements	19	15%
Looking at other agency's EVSE requirements	20	16%
Requires further information on EVSE requirements	9	7%
Not started to look EVSE requirements	37	29%
Total Permitting & Inspection Respondents	113	

Table 24, Table 25, and Table 26 below summarize the fees, turnaround time, and inspections required by the Region's local governments for EVSE in different contexts. In general, a plurality of agencies meet the Plan's recommended requirements for permitting in single-family residences. 70% of agencies charge under $250 for these permits, 53% of them offer same-day permit processing, and 45% only require one inspection for EVSE in single-family residences. Though permitting processes will vary between local governments as agencies seek to cover inspection costs while addressing local needs, these responses suggest that it is feasible for many of the local governments that are still developing EVSE permitting requirements to adopt best practices. On the other hand, fees, turnaround times, and the number of inspections required are higher for EVSE installations at commercial buildings, MDUs, and parking lots. Local governments should consider further expediting permitting for these installations, particularly as the PEVC issues its forthcoming guidance on EVSE installations in MDUs.

Table 24. Estimated Fees for Various EVSE Permits

Permit fee	Residential		Commercial / MDU		Open parking lot		On-street parking	
<$100	26	28%	14	16%	14	16%	9	13%
$101-$250	48	52%	33	38%	32	37%	33	48%
$251-$500	15	16%	33	38%	31	36%	21	30%
$501+	3	3%	8	9%	9	10%	6	9%
total	92		88		86		69	

Table 25. Time to Issue Permits for EVSE

Time	Residential		Commercial / MDU		Open parking lot		On-street parking	
Same day	53	53%	25	26%	23	24%	18	23%
2-5 days	21	21%	32	33%	29	31%	25	32%
6-10 days	18	18%	22	23%	28	30%	23	29%
3-5 weeks	8	8%	15	16%	12	13%	11	14%
>5 weeks	0	0%	2	2%	2	2%	2	3%
Total Respondents	100		96		94		79	

Table 26. Inspections Required for EVSE Installations

Time	Residential		Commercial / MDU		Open parking lot		On-street parking	
Intermediate & post-inspection	28	29%	34	37%	31	34%	30	38%
More than 1 pre-inspection	4	4%	6	7%	8	9%	7	9%
Plan check only	2	2%	2	2%	2	2%	1	1%
Post-inspection	41	43%	28	30%	23	26%	17	22%
Pre- & post-inspection	20	21%	22	24%	26	29%	23	29%
Total	95		92		90		78	

7. Zoning, Parking Rules, and Local Ordinances[62]

Local governments in California have exclusive authority over all land use decisions within their jurisdictions. These decisions extend from general plans and other policies that guide the long-term growth of a community to zoning and parking ordinances that regulate the physical form of streets, buildings, and public spaces. At every step of the planning process, local governments have opportunities to prepare to accommodate greater numbers of PEVs. These include establishing an overarching policy framework for PEV readiness as well as adopting standards, guidelines, and requirements for PEV parking and charging stations.

The following section serves as a guide to assist local government agencies with their efforts to update their 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 with the Americans with Disabilities Act (ADA),[63] if applicable.

7.1. Introduction

Through zoning codes and parking rules, local governments have the opportunity to ensure both that there are sufficient charging opportunities to meet projected PEV demand and that PEV parking spaces are effectively designed and regulated to accommodate charging vehicles. Zoning codes can allow, encourage, or require appropriate placement of EVSE in various land use designations. Zoning code provisions and parking rules can also specify requirements for design and installation, signage, accessibility, fees, time limits, lighting, and maintenance.

Many resources, including Sonoma County's *Electric Vehicle Charging Station Program and Installation Guidelines*[64] and reports issued by the PEVC include guidance on amending zoning and parking rules to prepare for increased PEV usage. The latter part of this section contains sample best practices from these resources as well as examples of other best practices that have been adopted by local governments across the Region.

7.2. Issues, Gaps, and Deficiencies

The following section summarizes common gaps and deficiencies with respect to parking requirements, issues associated with MDUs, enforcement, and site design issues related to accessibility and signage, and suggests actions and options for local government to bridge these gaps and deficiencies.

---

[62] This section corresponds to the requirements described in Section 8 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

[63] Note that when discussing disabled access, we refer generally to "disabled access" or "accessibility" rather than referring specifically to the Americans with Disabilities Act (ADA) to reflect the fact that California has its own requirements for disabled access, which are often more stringent than the ADA requirements.

[64] County of Sonoma, *Electric Vehicle Charging Station Program and Installation Guidelines*, July 2011, 40, http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf

Parking Requirements

For Opportunity and Workplace Charging

With respect to requirements and incentives for EVSE, a key question is, "how much is enough?" Requiring more pre-wired[65] spaces or charging stations creates more opportunities for PEV charging, but setting requirements too high may drive up the cost of new development or lead to under-utilized EVSE. Though a growing number of resources are available for local governments to draw upon when setting requirements, PEV use is still in its infancy, and there is little data on how much demand there is for PEV charging in public spaces. Estimating this demand can be particularly challenging since local jurisdictions vary widely in terms of their context, population, and the type and extent of potential charging opportunities. There is also little guidance on whether PEV charging requirements should apply to pre-wiring for EVSE or to actual EVSE, and on how parking regulations can accommodate PEVs while ensuring that required PEV parking also meets parking demand at the land use at which it is located. The following section includes recommended PEV charging requirements derived from regional PEV demand forecasts as highlighted in Section 3 as well as sample code language from the Region's local governments requiring or incentivizing PEV charging.

For Multi-family Dwelling Units

In several counties in the Region, over a quarter of the population lives in MDUs. MDUs are likely to see high demand for charging from residents, and deserve special consideration when adopting parking requirements. However, installing EVSE in MDUs requires property owners to address additional issues related to management, such as how to pass charging and maintenance costs on to residents and how to configure parking lots to connect EVSE to electrical infrastructure.

Restrictions, Fees, and Enforcement

When creating PEV parking spaces, local governments need to consider how to best ensure that these spaces are available to PEVs that need to charge, and are not blocked by conventional vehicles or non-charging vehicles. Agencies can use a combination of restrictions, time limits, and fees to achieve this goal.

The California Vehicle Code (CVC) requires that an off-street PEV charging spot be properly identified with signage, and 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.[66] However, local governments may adopt additional restrictions, time limits, or fees for PEV parking and charging in on-street spaces in lieu of or in addition to the restrictions on off-street parking in the CVC.

Regardless of which of these mechanisms local governments choose to use to ensure availability of publicly-owned PEV parking spaces, enforcement is an important factor to consider. Local governments need to ensure that enforcement of policies is feasible and that, if

[65] For a definition of "pre-wiring," see Section 5.1.

[66] California Vehicle Code §22511.1(a).

restrictions are in place, enforcement officers are trained to distinguish between allowed PEVs and conventional vehicles and/or non-charging PEVs. Even the language in the CVC that requires vehicles to be connected to charging stations in order to utilize designated off-street spaces[67] is not necessarily sufficient to ensure that vehicles are actually charging while they are plugged in, since PEVs may remain connected even after they are fully charged. Since there is no universal standard for indicating a PEV's state of charge, it can be challenging for parking officials who are not trained in this area to identify vehicles that are simply using charging spaces for long-term parking, leaving those spaces unavailable for other PEV drivers. Furthermore, some conventional vehicles contain appliances that can be connected to chargers, which can make it difficult for enforcement officials to discern whether vehicles are actually charging. Rigorously enforcing restrictions on non-charging vehicles requires careful training and consideration of the disincentives it may create for PEV owners to use public charging spaces.

Site Design

Accessibility

Currently, no official design standards exist for accessible PEV parking or charging stations. Local governments can choose from several existing resources when creating standards, but when choosing between these resources they need to consider trade-offs between accessibility and costs. Some accessibility requirements, such as ramps or grading, significantly alter the cost of creating PEV parking spaces. The recommendations below related to parking requirements and design guidelines for PEV parking spaces include in-depth discussions of accessibility issues.

Signage

Conflicting guidance exists on signage for PEV parking spaces, and signage at actual parking spaces around the Bay Area varies widely as a result. For example, the CVC requires that signs at designating off-street PEV parking spaces state: “Unauthorized vehicles not connected for electric vehicle charging purposes will be towed away at owner’s expense. Towed vehicle can be reclaimed at _______.”[68] 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.”[69] Meeting all these requirements would increase costs and create unnecessarily complicated signage. Fortunately, the governor's office has taken on this issue and is expected to make a determination in 2013 to provide guidance to all agencies in the state of California. In the meantime, this report suggests that private property owners use the signage recommended in AB 475 for off-street PEV parking spaces, since the Interim Disabled Access Guidelines only apply to state-owned parking spaces.

---

[67] Ibid.

[68] Ibid.

[69] California Department of General Services, Division of the State Architect, Policy 97-03: California Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations, June 1997. http://www.documents.dgs.ca.gov/dsa/pubs/policies_rev_01-01-11.pdf.

7.3. Recommendations

This chapter contains five recommendations for local government agencies to consider to ensure that adequate charging opportunities are available for PEVs and that these charging spaces are designed to accommodate PEVs as efficiently as possible:

- Incorporate specific recommendations to encourage deployment of PEVs and EVSE into local plans such as climate action plans, general plan elements, or a stand-alone plan.
- Create minimum requirements for PEV parking.
- Allow PEV parking spaces to count toward minimum parking requirements.
- Adopt regulations and enforcement policies for PEV parking spaces.
- Specify design guidelines for PEV parking spaces.
- Each of these recommendations is discussed below in detail.

Adopt a Climate Action Plan, General Plan update, or stand-alone plan that encourages deployment of PEVs and EVSE

Local governments that have taken steps to amend their municipal codes to encourage PEV deployment have found that adopting such policies is a critical first step in building consensus among policymakers and the public in support of more specific implementation measures. The exact policies that local governments choose to include will vary, and can run the gamut from broadly encouraging increased adoption of PEVs to requiring or encouraging EVSE at specific land uses or sites where local governments see development opportunities or anticipate high demand for charging. These policies not only build consensus, but also make it easier to fund plans and capital projects that accelerate the deployment of PEVs. The incremental cost of PEV readiness planning is lower if it is part of a larger-scale effort. For example, tying PEV readiness to local policies can make it easier to allocate different funding streams toward PEV plans and projects. Incorporating implementation strategies related to PEVs in general plans or climate action plans (CAPs) can also streamline environmental review of these strategies in the future, since the CEQA Guidelines allow lead agencies to streamline project-level environmental review off of these plans.

Issues to Consider

Local governments have three opportunities to integrate PEV readiness strategies into high-level policies:

- Climate Action Plans, which establish targets for reducing GHG emissions and outline actions to meet these targets.
- Amendments to the General Plan, which guides the long-term growth of a city or county.
- Stand-alone EV readiness plans.

Since General Plans set the policies that guide development of the Region's cities and counties, PEV readiness efforts will ultimately be most effective if General Plans are amended to accommodate requirements and policies relating to PEVs. However, local governments are often at different stages of plan updates and adoptions. Another approach to become PEV ready is simply to adopt PEV policies at the first available opportunity, and ultimately amend the General Plan in accordance with these policies during the next update cycle. Below are in-depth discussions of the three opportunities to create PEV readiness policies, as well as additional issues that may also influence local governments' approach.

Many local governments have adopted CAPs that establish targets for reducing GHG emissions and outline actions to meet these targets. Even if a CAP does not mention specific actions related to PEVs, it can still help to establish a framework for encouraging increased adoption of PEVs and deployment of EVSE, since significant PEV adoption can help the Region meet GHG emissions targets. However, CAPs will lay a much more effective groundwork for future EV deployment measures if the plan discusses specific measures and quantifies the anticipated GHG reductions from these measures.

Local governments can also **update their General Plans** to include policies, goals, and objectives that encourage the deployment of PEVs. Since General Plans are the guiding policy documents for both cities and counties, this is the most effective way to establish a policy direction in favor of PEV readiness. As with CAPs, more specific actions (i.e. actions and objectives instead of policies) are more useful in laying the groundwork for future implementation measures. The primary benefit of incorporating PEV readiness into a General Plan is that it lays the groundwork for local governments to allocate funding from a wider variety of sources toward these efforts rather than limiting funding for these efforts to grants and other sources that are specifically devoted to PEV readiness. Integrating PEV readiness policies and strategies into a General Plan can also be less labor-intensive than creating a CAP because it does not require local governments to conduct a quantitative analysis of GHG reductions for each strategy in the plan. However, analysis of GHG impacts may be required as part of environmental review of the plan. The most thorough approach is for local governments to both thoroughly outline and analyze PEV readiness strategies in the context of a CAP or PEV readiness plan and adopt policies, objectives and actions to support these strategies when updating their general plan.

In addition to including PEV readiness policies and strategies in CAPs and General Plans, local governments also have the option to create a **stand-alone PEV readiness plan**. General plans and CAPs are wide-ranging documents that will address issues other than EVs, and are expensive to create and update. Though the incremental costs of addressing PEVs in these plans is significantly lower than the cost of creating a stand-alone PEV readiness plan, the latter may be a preferable option for local governments that do not have any immediate plans to update their General Plans or create a CAP, or for agencies where there is sufficient political will and funding to address PEVs in depth through a separate planning process.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that General Plans and CAPs are relatively expensive and labor-intensive to create and update. A CAP or a comprehensive General Plan update for a medium-size city with a population between 50,000 and 100,000 can cost as much as $100,000, and potentially more depending upon factors such as the level of public outreach and environmental review required. Even an amendment to the General Plan can cost up to $50,000, which may prevent many jurisdictions from creating or updating CAPs and General Plans for the sole purpose of incorporating PEV readiness elements. However, it may be a cost-effective option for agencies that are already working to create or update these plans, given that the additional effort required to include policies or strategies related to PEVs can amount to as little as five to ten hours of staff time.

There are currently only a few examples of local governments that have created stand-alone PEV readiness plans. The cost of creating such plans would likely be comparable to the cost of creating a city- or countywide plan focused on another transportation mode, such as a bicycle or pedestrian plan, which typically ranges from $50,000 to $100,000 or more, depending upon the level of public outreach and environmental review involved. However, these costs are likely to decrease in the future due to the growing number of regional, sub-regional, and county plans that local governments can draw upon.

Guidance and Best Practices

A number of local governments in the Region have taken steps to amend their CAPs and General Plans or to adopt stand-alone plans to encourage PEV deployment, as discussed in the examples below. These documents vary widely in terms of the type of policies that they include and issues that they address. They serve as illustrative examples of local government actions to incorporate PEV friendly policies and requirements into either their CAPs or General Plans, or to adopt stand-alone PEV plans.

- An example of a **stand-alone plan that comprehensively addresses many of the elements of PEV readiness**, including siting, design guidelines, and outreach strategies to local property owners is the *Sonoma County's Electric Vehicle Charging Station Program and Installation Guidelines*[70].
- **An example of a specific action to encourage EVSE in mass-transit parking areas** is contained in the Transportation Element of the ***City of Berkeley's General Plan***, which calls for the City to collaborate with BART to include EVSE at BART stations:[71]

  Policy T-2 Public Transportation Improvements

  B. Work with BART to:

  1. Maintain and expand the frequency and hours of BART service through Berkeley.

---

[70] County of Sonoma General Services Department, Electric Vehicle Charging Station Program and Installation Guidelines, July 2011, http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf.

[71] City of Berkeley Department of Planning and Development, General Plan, Transportation Element, http://www.ci.berkeley.ca.us/contentdisplay.aspx?id=498.

2. Continue its efforts to provide electric charging stations and electric vehicles at BART stations.
3. Provide 24-hour service in support of Downtown cultural and residential uses and provide direct connections to San Francisco in evening hours.

- Examples of specific actions to encourage installation of EVSE in new developments:
  - The Conservation and Open Space element of the ***City of Salinas' General Plan*** encourages PEV charging stations through discretionary review:[72]

    The relationship between project design and future energy requirements should be considered when reviewing proposals for new development. The City promotes energy conservation by implementing State Title 24 energy performance requirements through building codes. Utility company incentive programs to retrofit existing developments with energy efficient lighting, air conditioning and heating systems are also used in the City. Energy is conserved in public buildings, and electric vehicle charging areas will be encouraged in new public and private developments.

  - The **City of San Carlos'** CAP includes a strategy to encourage developers to include more PEV charging infrastructure and quantifies the GHG benefits of doing so:[73]

    10.3. Encourage developers to dedicate parking lot spaces to electric vehicle recharging stations

    Initial Cost: The cost to the City for encouraging electric vehicle recharging stations is negligible. Most likely it would be incorporated into existing incentives and concessions for project approval. As a point of information, the cost to the developer is estimated to be five thousand dollars per lot for recharging stations, including equipment and installation initial cost.

    Greenhouse Gas Emissions Reductions: Based on current research, it is estimated that 25 electrical vehicle recharging stations would cause a 30 metric ton decrease in CO_2e levels per year.

Create minimum requirements for PEV parking

Over the long term, the most effective way to ensure that there is adequate PEV charging infrastructure to support increased rates of adoption of PEVs is for local governments that have minimum parking requirements in place to also consider adopting minimum requirements for the number of PEV parking spaces at different land uses. Figure 30 and Figure 31 show recommended parking requirements for both Level 2 charging stations and pre-wiring for future Level 2 EVSE in the Bay Area and the Monterey Bay Area, respectively. These requirements are based on the PEV demand forecasts contained in Section 3 and upon likely demand for different types of charging opportunities.

[72] City of Salinas, City of Salinas General Plan, September 2002, COS-43, http://www.ci.salinas.ca.us/services/commdev/generalplan/GeneralPlan.pdf.

[73] City of San Carlos, Climate Action Plan, October 12, 2009, http://www.cityofsancarlos.org/civica/filebank/blobdload.asp?BlobID=5883.

Figure 30. Recommended Minimum PEV Parking Requirements for the SF Bay Area

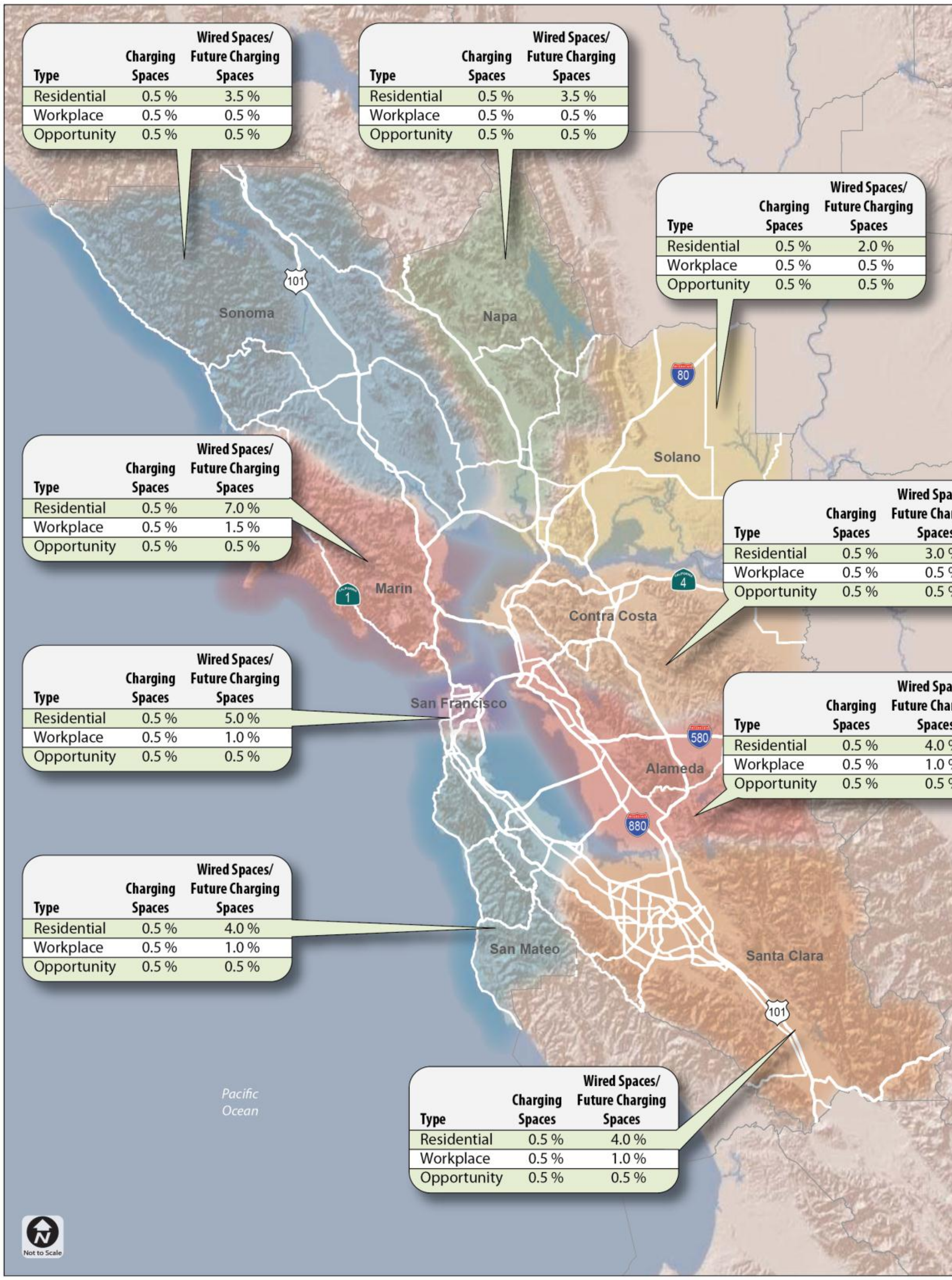
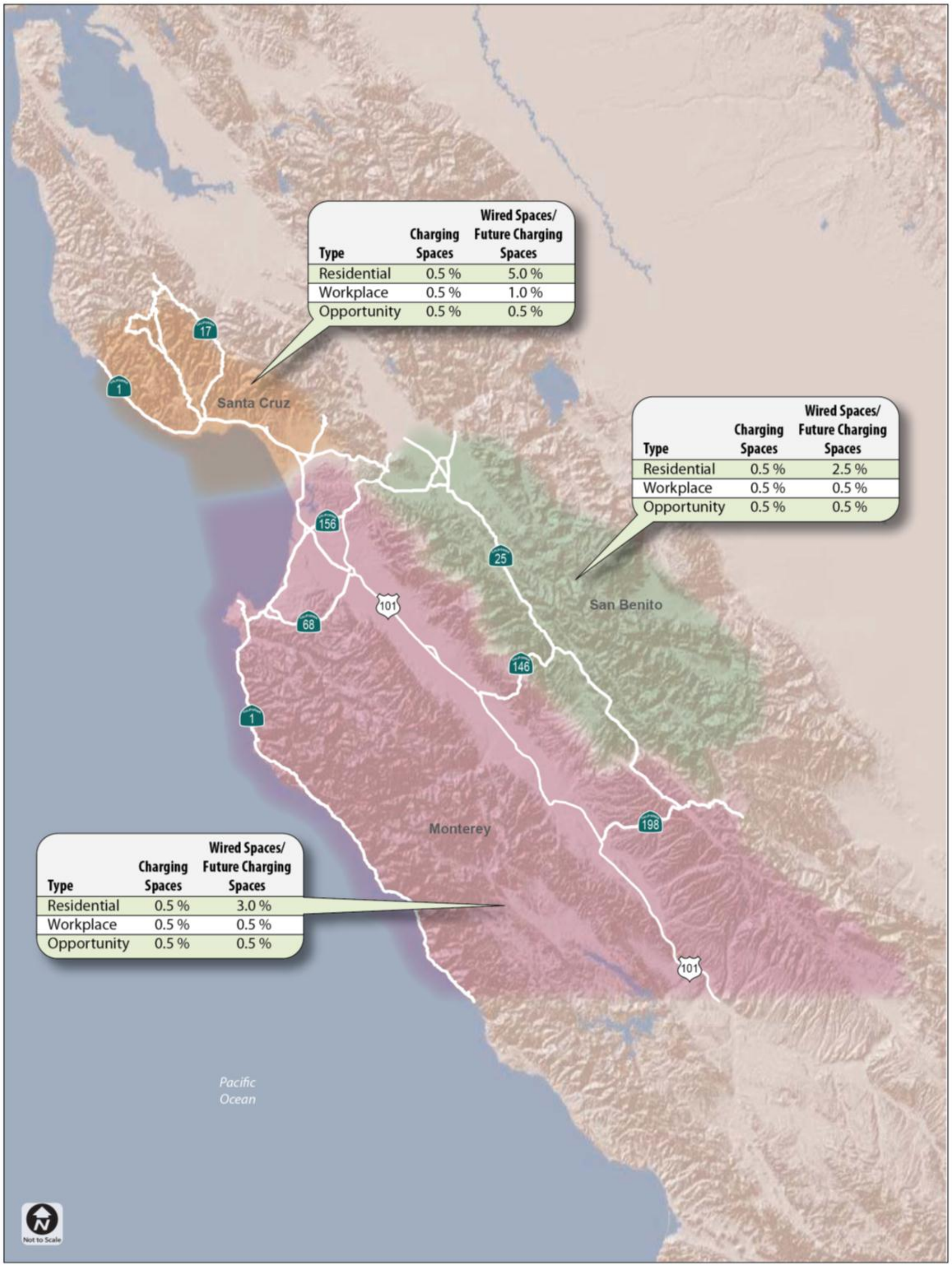


Figure 31. Recommended Minimum PEV Parking Requirements for the Monterey Bay Area



Note that the preliminary requirements shown in Figure 30 and Figure 31 vary by county, by the type of charging (residential, workplace, or opportunity charging), and by the type of infrastructure required (charging stations or pre-wired charging spaces). Requirements are expressed as the percentage of total parking spaces at a given land use that should either contain Level 2 EVSE or be pre-wired for Level 2 EVSE. For example, Figure 30 recommends that 0.5% of parking spaces (or one out of every 200 spaces) in an MDU in San Francisco County contain EVSE, and that 5.5% of spaces (or 11 out of every 200 spaces) be pre-wired for Level 2 EVSE. As discussed above, these preliminary requirements are based on projected consumer demand though 2025. They focus on Level 2 EVSE because it is the fastest-charging technology that is currently widely available.

The emerging best practice among the Region's local governments is to require pre-wiring in all single-family residential units and at least a portion of the parking area in MDUs and commercial properties. In general, the residential charging requirements shown in Figure 30 and Figure 31 should apply to MDUs as well as any new single-family developments that do not include private garages. The workplace requirements should apply to office buildings and other high-volume employment centers where employees typically work long enough shifts to complete a significant charge, such as medical centers.

What appears to be a relatively low requirement for opportunity charging shown in Figure 30 reflects the fact that some of the demand for charging will be satisfied by Level 1 EVSE. Additionally, many retail centers are already installing EVSE on their own initiative in order to attract and retain PEV drivers. For instance, the first retail fast charging station in the state was installed at the Stanford Shopping Center in Palo Alto in 2011, co-funded in part by BAAQMD, and several other shopping centers in the Region have either already added or are in the process of installing EVSE in parking lots. Therefore the actual number of EVSE in opportunity charging spaces will likely be much higher than the numbers shown in Figure 30 and Figure 31.

Local governments should allow for an exemption into their parking requirements if the applicant can provide reasonable evidence that publically-available PEV parking and charging exists in the vicinity. In order to meet PEV drivers' charging needs without over-burdening developers, local governments could also allow for shared parking. In the case of PEV parking at a mixed-use center, for example, PEV parking could be shared by office workers and movie viewers since they generally use parking areas at different times on the weekdays. Accounting for this when creating PEV parking requirements would lower the overall requirements compared to the conventional approach of calculating the required parking discretely for each land use and summing across all land uses to calculate the total requirement.

As discussed in detail in Section 5, some local governments in California have amended their building code to require a number of spaces in multifamily buildings to be pre-wired for Level 2 EVSE. It is recommended that local governments specify PEV parking requirements through zoning codes and parking ordinances rather than building codes, because the requirements in zoning codes are more likely to vary according to land use or other factors that may influence charging demand. However, the requirements in Figure 30 and Figure 31 can also be used as the basis for creating parking requirements in the building code, particularly for MDUs.

Issues to Consider

These requirements in Figure 30 and Figure 31 should be considered as a starting point for new developments of a certain size, or expansions of existing facilities. In order to apply these preliminary requirements locally, cities and counties should consider the following:

Anticipated level of PEV demand

The preliminary requirements in Figure 30 and Figure 31 reflect average countywide demand for PEVs. However, cities that anticipate higher or lower demand than the county average may wish to adjust these requirements upward or downward accordingly. For example, demand for EVSE is likely to be higher than average in major regional employment centers, mixed-use areas where travelers can reach a greater number of destinations with shorter trips, and communities that currently have high levels of HEV ownership.

Demand for Opportunity Charging at Different Land Uses

The preliminary requirements in Figure 30 and Figure 31 reflect average demand for different types of charging, but the demand for opportunity charging will vary among different land uses. Demand for opportunity charging is likely to be concentrated in commercial land uses with high volumes of visitors that are on site long enough to complete a significant charge, such as major retail and entertainment centers. These land uses may experience significantly higher-than-average demand for opportunity charging, while other commercial land uses may experience less demand. Requirements at major retail and entertainment centers should take into account the need for PEV charging among both employees and visitors such as shoppers.

Type of EVSE Required

Local governments are encouraged to specify the type of EVSE to which parking requirements apply. Figure 30 and Figure 31 show recommended requirements both for charging spaces with full EVSE and for pre-wired spaces in order to meet both short- and long-term demand. This is in keeping with a best practice among many local governments that currently have minimum EVSE requirements to require pre-wiring for Level 2 chargers rather than requiring installation of the chargers themselves, under the assumption that demand will increase in the future. Pre-wiring can dramatically reduce the cost of charger installation by up to 65 percent,[74] making it much more feasible to install chargers at a later date. Though pre-wiring dramatically lowers costs, it does not create immediate charging opportunities. Local governments that wish to take a more aggressive approach to making EVSE available or that anticipate updating parking requirements frequently in order to meet changing demand of PEVs may wish to increase the requirements for charging spaces to be closer to the requirements for pre-wired spaces.

Restrictions on PEV Parking

When adopting minimum requirements for PEV parking, local governments will need to create additional regulations on PEV parking spaces to ensure that PEV spaces associated with a given land use are actually used by visitors to that land use, and not by drivers who are solely taking advantage of charging. These include time limits that prevent PEV drivers from taking unlimited advantage of charging. This is especially the case for publicly available fast chargers.

[74] ICF International correspondence with ChargePoint /Coulomb Technologies, July 2012.

Accessibility

With regard to accessibility, this plan adopts recommendations from the Sonoma County *Electric Vehicle Program Guidelines*. For new charging station installations in existing parking lots, the Sonoma County Guidelines state that the first charger shall be accessible according to the standard for accessible fueling stations in Section 1101C of the California Building Code, and for new construction the Guidelines state that one in ten chargers shall be accessible. In both cases, the Guidelines note that for charging stations equipped with card readers, the California Building Code requires that the first two be accessible..[75] Though the Guidelines state design requirements for accessible spaces, use of these spaces is not limited to vehicles with a disabled parking placard or license plate. Later recommendations in this section discuss the design of accessible spaces in detail.

Multi-family Dwelling Units (MDUs)

As mentioned previously, in several counties in the Region, over a quarter of the population lives in MDUs. However, EVSE in multi-unit dwellings presents challenging management issues, such as ensuring access to EVSE for all PEV-owning residents in buildings where there is not a charging station for every unit. Though this is an important issue for property managers, it is not necessarily an issue that agencies can address through zoning and parking ordinances. This plan therefore recommends that local governments adopt the residential parking requirements shown in Figure 30 and Figure 31 for multifamily buildings, which currently require a relatively low number of actual charging stations—one for every 200 spaces—but substantially lower the cost of installing future EVSE through pre-wiring. This will lay the groundwork for best management practices to emerge as more MDUs install EVSE. In the meantime, local governments should consider allowing for or requiring current best practices for providing EVSE in MDUs through zoning and parking ordinances, or through discretionary review of projects subject to minimum EVSE requirements. These include:

- Allowing for PEV car-sharing spaces with dedicated EVSE to substitute for PEV charging spaces.
- Encouraging unbundling of PEV parking spaces, which would allow residents the option of purchasing access to a PEV space. Under unbundling, parking spaces are priced separately rather than included in the price of a housing unit. This strategy has been successful in managing standard parking spaces in MDUs, and is considered a best practice for transit-oriented development in some contexts.[76]

Trade-offs with other transportation policies

Though the majority of local governments in the Bay Area have minimum parking requirements in place, some agencies are eliminating minimum requirements or switching to maximum

---

[75] County of Sonoma, *Electric Vehicle Charging Station Program and Installation Guidelines*, July 2011, 22-23, http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf

[76] Metropolitan Transportation Commission, Reforming Parking Policies to Support Smart Growth, Toolbox/Handbook: Parking Best Practices and Strategies for Supporting Transit-Oriented Development in the San Francisco Bay Area, June 2007, http://www.mtc.ca.gov/planning/smart_growth/parking/parking_seminar/Toolbox-Handbook.pdf.

parking requirements in order to encourage use of transit and other alternatives to driving. The PEV parking requirements shown in Figure 30 and Figure 31 may still be applied to new development in the absence of minimum parking requirements, but if this is the case local governments should take additional care in implementing these requirements to ensure that they align with other transportation policy goals. For example, maximum parking requirements may encourage high-density parking configurations that limit the feasibility of EVSE installations under current design guidelines.

Requirements for emerging technologies

The preliminary requirements in in Figure 30 and Figure 31 focus on Level 2 EVSE because it is the fastest-charging technology that is currently widely available. However, local governments may wish to apply a portion or all of the preliminary Level 2 charging requirements in Figure 30 and Figure 31 to DC fast charging or to other new technologies as they become available. The lack of widespread DC fast charging opportunities makes it challenging to specify the exact amount of parking that should be allotted for these chargers. Furthermore, it may be advisable to require additional waiting spaces adjacent to DC fast chargers if local governments anticipate high demand and increased turnover.[77]

Alternative Approaches

While this plan recommends that local governments adopt minimum PEV parking requirements, some local governments may wish to take a more conservative, incentive-based approach in the short term.

Density Bonuses

One potential approach is to amend zoning codes to offer density or floor area ratio bonuses for buildings that include PEV charging stations. This approach will provide developers with additional developable area to offset the cost of providing EVSE. Local governments can use Figure 30 and Figure 31 as a basis for determining whether a developer has provided a sufficient number of charging stations to qualify for incentives.

Encouraging Rather than Requiring Electric Vehicles in the Zoning Code

Instead of creating parking requirements for electric vehicles, local governments can amend their zoning code to encourage electric vehicles in certain districts. Explicitly stating this in the zoning requirements can give local governments a rationale for requiring EVSE in certain projects through discretionary review while still allowing them the flexibility to not require EVSE in instances where market conditions, design constraints, or other circumstances legitimately restrict developers' ability to install EVSE.

77 For an example, see City of SeaTac, Washington, Chapter 15.40, Section 15.40.040.B., Ordinance 10.1031, adopted December 2010. http://www.codepublishing.com/WA/Seatac/html/Seatac15/seatac1540.html#15.40.

Creating Requirements for Designated PEV Parking Spaces

In addition to or instead of creating parking requirements for PEV charging, local governments can create additional incentives for drivers to purchase PEVs by creating dedicated parking spaces or waiving parking fees for these vehicles.

Allowing PEV Parking

Local governments can allow rather than require parking. In order to clarify regulations for applicants, local governments that take this approach should include guidance in the zoning code identifying the districts in which different types of EVSE are allowed and specifying whether EVSE are allowed as a stand-alone use or as an accessory to a principal use.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that local governments that are developing parking requirements, the incremental costs of researching and adopting parking requirements for EVSE can be quite low if it is done in the context of a comprehensive zoning code update. In this case, creating parking requirements requires roughly five to ten staff hours to draft code language, write a staff report, and respond to feedback on the proposed changes, and the total cost of the associated staff time would be under $1,000. However, the price is much higher if local governments are working outside of a comprehensive code update, since it would require additional coordination between multiple departments and more substantial outreach. Survey respondents estimated that it could take up to 0.5 FTE for one year to develop and adopt stand-alone parking requirements in this case.

Guidelines and Best Practices

No local governments in the Region have yet adopted minimum parking requirements for EVSE into their zoning codes or parking ordinances. However, one city, Emeryville, has proposed requirements for PEV charging stations in its planning and zoning code, and others have adopted requirements into their building codes. Table 27 summarizes PEV-related parking requirements in existing building or zoning codes. Section 5 discusses the building codes summarized below in detail.

Table 27. PEV Charging Requirements from California State and Municipal Codes

Source	Building or land use type	Number/Percent of spaces dedicated to PEV charging	Requirements for PEV charging spaces	Voluntary / Required
CALGreen	One- and two-family dwellings	1 per dwelling unit	Listed raceway to accommodate a branch circuit for Level 2 EVSE	Voluntary
CALGreen	Multi-family dwellings	3% of all spaces; at least one space	Listed raceway to accommodate a branch circuit for Level 2 EVSE	Voluntary
CALGreen	Nonresidential	~2% (varies by size of lot)	Pre-wiring for Level 1 and 2 charging	Voluntary
CALGreen	Nonresidential	~10-12% (varies by tier and size of lot)	Designated parking for fuel efficient vehicles	Voluntary
City of Sunnyvale Building Code	Single-family dwellings	1 per dwelling unit	Pre-wiring for Level 2 charging	Required
City of Sunnyvale Building Code	Residential developments with common shared parking	12.5% of all spaces	Pre-wiring for Level 2 charging	Required
City of Los Angeles Green Building Code	One- and two-family dwellings	1 per dwelling unit	Pre-wiring for Level 2 charging	Required
City of Los Angeles Green Building Code	Residential developments with common shared parking	5% of all spaces	Pre-wiring for Level 2 charging	Required
City of Emeryville Draft Planning and Zoning Code	Multi-unit residential and lodging with 17+ parking spaces	3% of all spaces	Charging stations	Required

In addition, a growing number of projects contain parking spaces with EVSE, and these can serve as guidelines for requirements at comparable land uses. Table 28 contains current examples of EVSE deployment in the Bay Area. The responsible entities tend to not collect parking occupancy data, so these examples do not necessarily reflect demand for PEV charging.

Table 28. Examples of EVSE Supply (Source: Fehr and Peers field observations, September 2012)

Entity	Land Use Type	Number and type of charging stations	Percentage of total parking spaces with available EVSE
Walnut Creek	City-owned parking garage[78]	3 Level 2 EVSE	0.2%
Pleasanton	Municipal	9 Level 2 EVSE	3%
Brentwood	City-owned parking garage	5 Level 2 EVSE	4%[79]
Google	Office	330 Level 2 EVSE 140 Level 1 EVSE	4%
Facebook	Office	2 Level 2 EVSE	0.07%[80]
88 Townsend[81]	Multi-Family residential	1 Level 2 EVSE	0.8%
Park Merced[82]	Multi-Family residential	15 Level 2 EVSE 3 Car-share PEVs	0.9%

Further guidelines and best practices on zoning and parking can be found in the following sources:

- **An example of EVSE in MDUs and hotels.** The **City of Emeryville** has developed the following draft parking requirements for EVSE in MDUs and hotels as part of an update to its planning and zoning code.[83] Note that the city also uses a point-based system to allocate development bonuses, and proposes to allocate points to developers for each one percent of parking spaces that include EVSE:

  9-4.406 Design Standards for Parking Lots and Structures.

  Electric Vehicle Charging Stations. In parking facilities containing 17 or more spaces serving Multi-Unit Residential and Lodging: Hotels and Motels uses, at least three percent of parking spaces shall be electric vehicle (EV) charging stations. Such spaces may be counted towards the parking requirements of this Article. For all other uses, EV charging stations are eligible for development bonuses pursuant to item (16) in Table 9-4.204(c).

  Size. Electric vehicle charging stations shall be the same size as other spaces, as specified in Section 9-4.406(a). The electric vehicle charging equipment shall not reduce the size of the space.

[78] Chargers are distributed across three separate city-owned garages.

[79] Approximate; parking is shared between multiple uses.

[80] These chargers were shared by four different vehicles on the day the observation was made.

[81] Part of the MultiCharge SF Project, described in a presentation at *Charged 2012* Conference, August 23, 2012

[82] Ibid.

[83] City of Emeryville, Proposed Emeryville Planning Regulations, Public Review Draft, September 28, 2012, http://www.emeryville.org/DocumentView.aspx?DID=1934.

Signage. Each electrical vehicle charging station shall be clearly marked with a sign reading "Electrical Vehicle Charging Station."

Equipment. Electrical vehicle charging stations shall be equipped with electrical outlets, and may also be equipped with card readers, controls, connector devices and other equipment as necessary for public use. All such equipment shall be in compliance with the Building Regulations in Title 8 and applicable provisions of the California Green Building Standards Code pertaining to electrical vehicle charging.

- **An example of minimum parking requirements** and ordinance language adopting these requirements, as well as sample zoning code tables specifying the type of EVSE that is allowed in different zoning districts has been adopted by **Mountlake Terrace, WA** and is discussed in **Ready, Set, Charge, California**:[84]

A. Beginning July 1, 2011, development for each of the land uses identified in Table 1 of subsection B of this section [Table 29 of this report] shall be required to provide electric vehicle infrastructure as shown in the table. For purposes of Table 1, electric vehicle charging stations shall be provided when the development is 10,000 square feet or more and one of the following occurs:
   a. A new building or a new off-street parking facility is developed;
   b. An addition or improvement to an existing building is made that meets a certain threshold, pursuant to (insert relevant code section); or
   c. The parking capacity of an existing building, site, or parking facility is increased by more than 50%.

B. The first column in Table 1 shows the type of land use for which electric vehicle charging stations shall be provided, pursuant to this section. The second column shows the minimum percentage of the facility's parking spaces that shall provide a connection to electric vehicle charging stations.

C. Design for Expansion. To allow for additional electric vehicle charging in the future, beginning [insert date], all development that meets the criteria of subsection A of this section shall be designed to allow for double the amount of electric vehicle parking shown in Table 1.
   a. Site design and plans must include the locations(s) and type of the EVSE, raceway methods(s), wiring schematics and electrical calculations to verify that the electrical system has sufficient capacity to simultaneously charge all the future EV charging stations at Level 2 charging levels with (240V/40 amperes per station.

[84] City of Mountlake Terrace, Washington, Chapter 19.126.050, Ordinance 2553, adopted November 2010. Accessed September 2011, http://www.mrsc.org/subjects/planning/energy/eplanning.aspx. Cited in Ready Set Charge California, A Guide to EV-Ready Communities, November 2011, Section 3.2.1, available online at www.readysetcharge.org.

Table 29. Mountlake Terrace Table C-1: Required number of electric vehicle charging stations

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%

- **An example of a density bonus for providing parking with EVSE.** Section 18.05.030.A of the **City of San Carlos'** Zoning Code allows developers to exceed the maximum allowable floor area ratio by 10% if they provide additional environmental design features, including "electric car facilities":[85]

  18.05.030 A. Increased FAR for Mixed-Use Buildings. The maximum allowable FAR may be increased by up to ten percent for buildings that contain a mix of residential and nonresidential uses through the provision of one or more of the following elements beyond what is otherwise required, subject to conditional use permit approval:

  1. Car-share or electric car facilities.
  2. Additional public open space or contribution to a parks fund.
  3. Provision of off-site improvements. This may include off-site amenities and/or infrastructure (other than standard requirements and improvements) such as right-of-way improvements or funding for public safety facilities, libraries, senior centers, community meeting rooms, childcare or recreation.
  4. Provision of green roofs, solar panels, and other green building measures.

- **An example of code that encourages parking with EVSE.** The **City of Salinas**' Zoning Code[86] states that parking areas in residential, industrial, commercial, and mixed-use areas are "are encouraged to be designed to provide facilities for vehicles with alternative fueling systems (such as appropriate outlets for electric vehicle charging, etc.)." This requirement also applies to new or remodeled residential garages. In addition, the code states that "Whenever possible, electric vehicle charging areas shall be provided in parking areas" in the Central City Overlay District.

Allow PEV parking spaces to count toward minimum parking requirements

Many jurisdictions have minimum parking requirements specifying the number of spaces that developers must provide for new construction in different land uses. For these jurisdictions, if

85 City of San Carlos (2012). "Municipal Code: Development Standards for Mixed-Use Districts, Section 18.05.030.A." http://www.codepublishing.com/CA/sancarlos/.

86 City of Salinas, City of Salinas Municipal Code, Chapter 37, Article III: Zoning. http://library.municode.com/index.aspx?clientId=16597.

PEV parking is not counted toward these requirements it can discourage developers from installing EVSE, since developers must either build more structured parking or reduce the amount of developed space to accommodate the extra parking needed for PEVs to access charging stations. Amending the zoning or parking code to allow PEV parking to count toward parking requirements would allow developers to provide PEV parking without increasing the total number of parking spaces required. This is similar to the way that many local governments currently treat accessible parking, allowing it to count toward minimum requirements in spite of the fact that it has additional design requirements and is restricted to certain users.

Issues to Consider

Restrictions on PEV Parking

In order to establish a nexus between PEV charging stations and parking requirements for the associated land use, local governments will need to create additional regulations on PEV parking spaces in order to ensure that PEV spaces associated with a given land use are actually used by visitors to that land use, and not by drivers who are solely taking advantage of charging. These include restrictions, time limits or parking fees that prevent PEV drivers from taking unlimited advantage of charging.

Costs

ABAG contacted several local governments to solicit their input on these issues and found that amending parking codes to allow PEV charging stations to count toward minimum parking requirements would require up to ten staff hours to draft code language, write a staff report, and respond to feedback on the proposed changes. The total cost of staff time to implement this recommendation would range from $1,000 up to $20,000, depending upon whether these changes were part of a comprehensive zoning code update and on potential local controversy over parking requirements.

Guidelines and Best Practices

An example of code that counts PEV parking spaces towards minimum parking requirements has been adopted by City of SeaTac, WA and cited in the Ready, Set, Charge, California guidelines:[87]

> **15.40.040 Electric Vehicle Charging Station Spaces – Allowed as Required Spaces**
>
> A. Electric vehicle charging station spaces shall be allowed to be used in the computation of required off-street parking spaces as provided under SMC 15.15.030; provided, that the electric vehicle charging station(s) is accessory to the primary use of the property.

Adopt regulations and enforcement policies for PEV parking spaces

After establishing policies and strategies to encourage the deployment of PEVs, a next step for local governments is to amend parking ordinances to specify the regulations that apply to

---

[87] City of SeaTac, Washington, Chapter 15.40, Ordinance 10.1031, adopted December 2010. http://www.codepublishing.com/WA/Seatac/html/Seatac15/seatac1540.html#15.40. Cited in Ready Set Charge California, A Guide to EV-Ready Communities, November 2011. Available online at: www.readysetcharge.org.

parking spaces designated for PEVs. The goal of these amendments is to ensure that PEVs have unobstructed access to PEV charging, to create incentives for drivers to purchase PEVs, and to make sure that local governments can recoup the costs of publicly-available charging in the event that the local jurisdiction owns and operates the equipment.

Issues to Consider

When designating PEV parking, local governments should consider applicable definitions, restrictions, enforcement policies, time limits, and fees. Note that local governments may not have sufficient information to establish these regulations during the early stages of EVSE deployment. As a result, many local governments initially provide access to EVSE for free, while working with EVSE infrastructure providers to collect data on usage patterns, which they can later use as a basis for creating regulations. While this practice is not considered a best practice, it can serve as a temporary gap-bridge while data collection is still in the beginning stages.

Restrictions and Enforcement

In general, it is a best practice to restrict use of PEV charging stations to vehicles that are currently charging to ensure that EVSE are available for drivers who need them. This is supported by recent changes to the California Vehicle Code, which only allows vehicles that are "connected for electric charging purposes"[88] to park in spots designated for electric vehicles, and authorizes local governments to tow vehicles that are illegally using these spaces.

In addition, local governments may also consider imposing time limits on PEV parking spaces that correspond to the average charge time of PEVs using the EVSE supplied (i.e. four hours for a Level 2 EVSE). This is not necessarily sufficient to ensure that vehicles are actually using charging stations, since PEVs may remain connected even after they are fully charged. Additional time limits will simplify enforcement of restrictions on PEV parking spaces. In addition, at locations where local governments anticipate high demand for charging, time limits or parking fees for charging stations will help to increase turnover and ensure that EVSE are available. If parking requirements for PEV spaces are in effect, time limits on these spaces should be consistent with time limits on adjacent conventional parking, or, if no time limits are in place, allow for sufficient charging while discouraging drivers from parking in these spaces just to charge their vehicles without visiting the associated land use. Note that the optimal time limit for PEV charging spaces will depend upon the level of EVSE that is available, and emerging technologies such as DC fast charging may dramatically shorten recommended time limits.

The Vehicle Code does not prohibit local governments from adopting additional parking ordinances, including designating preferential or free parking for non-charging PEVs. For example, local governments may wish to consider offering additional incentives for drivers to purchase fuel-efficient vehicles, including but not limited to PEVs, by creating dedicated parking spaces or waiving parking fees for these vehicles. Local governments that are providing PEV

[88] California Vehicle Code §22511.1(a).

parking that exceeds current demand may also wish to specify interim regulations that allow conventional vehicles to use these spaces in order to avoid under-utilization.

Fees

So far, most local governments that provide public EVSE have been providing free charging initially with the intention of levying fees on EVSE users in the future. Fees that are set should be sufficient to cover electricity consumed by charging vehicles, operations and maintenance costs to EVSE provides, and any fees charged by charging station operators. In areas where additional parking fees are charged, local governments can streamline payment by combining parking and charging fees in a single payment, if feasible. In order to protect themselves from legal challenges when levying fees, local governments need to demonstrate that fees are reasonable given the associated costs.

Signage

In order to direct drivers to charging stations and communicate regulations for PEV parking spaces, local governments will need to adopt signage indicating PEV spaces. General service signs, or wayfinding signs are signs placed in the public right-of-way for the purposes of guiding PEV users to charging stations and regulating their use. Charging stations in large parking lots can be particularly challenging for PEV drivers to locate, so local governments may wish to create design guidelines that address not only signage at PEV charging spaces, but also wayfinding signage at lot entrances or throughout lots that can help drivers locate spaces. Wayfinding signs are traffic control devices, which mean that they must conform to the Manual on Uniform Traffic Control Devices (MUTCD) in the Code of Federal Regulations (CFR). Currently, local governments in the Region use a variety of signs to indicate PEV charging spaces. In order to standardize signage across the Region, local governments should use signage that has received approval or interim approval[89] from the Federal Highway Administration and are contained in the California MUTCD. MUTCD-approved wayfinding signs, are shown in Figure 32 and Figure 33.

---

[89] Interim Approval allows interim use, pending official rulemaking, of a new traffic control device, a revision to the application or manner of use of an existing traffic control device, or a provision not specifically described in the MUTCD.

Figure 32. FHWA-approved PEV General Service Symbol and Sample Parking Signs[90]

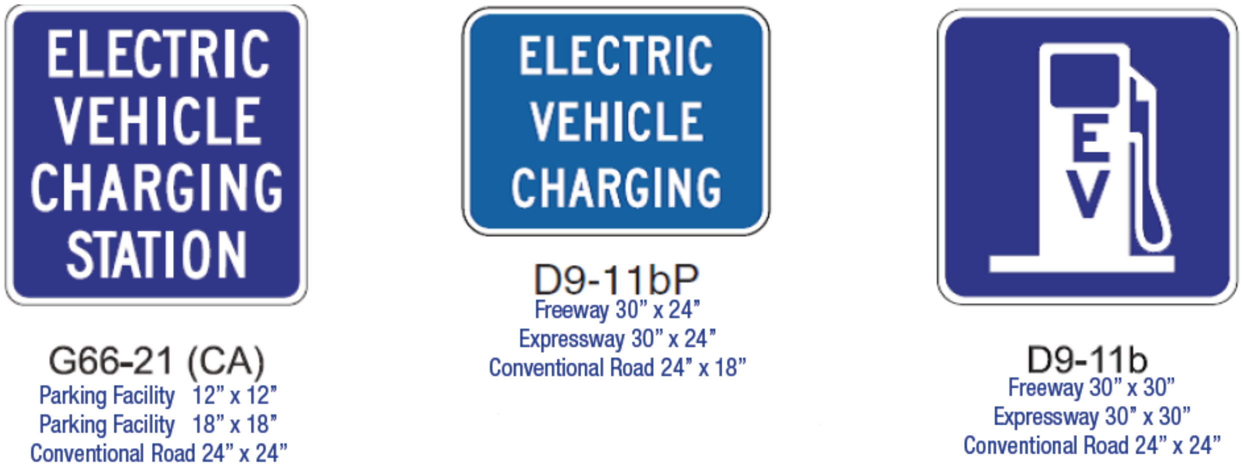
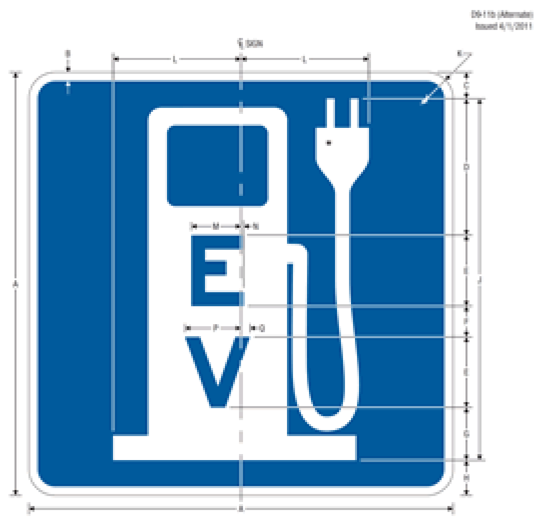


Figure 33: FHWA PEV General Service Sign with Interim Approval[91]



The FHWA has not yet approved any **regulatory signage**, signs that reinforce regulations, for PEV charging stations. Instead, local governments should use a combination of the regulatory signs shown in Figure 34, which are being tested or are in use in Oregon, Washington, and Michigan.

[90] *Ready Set Charge California, A Guide to EV-Ready Communities,* November 2011, 30, www.readysetcharge.org
[91] Federal Highway Administration (FHWA), "Interim Approval for Optional Use of an Alternative Electric Vehicle Charging General Service Symbol Sign (IA-13)

Figure 34. Examples of Regulatory Signs for PEV Charging Stations[92]

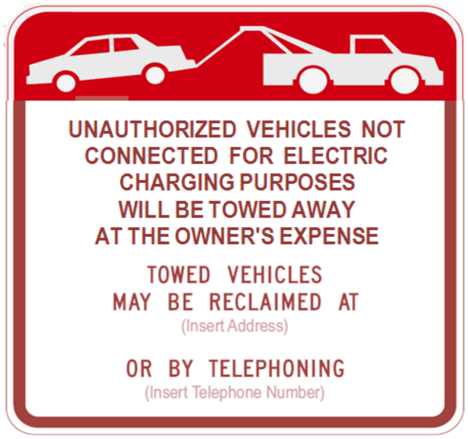
Finally, the California Vehicle Code requires that all spaces designated as PEV parking spaces: "Unauthorized vehicles not connected for electric vehicle charging purposes will be towed away at owner's expense. Towed vehicle can be reclaimed at _______."[93]

Guidance on PEV signage in California may soon be changing. On October 12, 2012 the Governor's Office of Planning and Research requested to delete two existing signs (Db-11bP and D9-11b in Figure 32), add five new signs (Figure 35), add an optional pavement marking (Figure 36), and amend the California MUTCD, 2012 edition, with Electric Vehicle Charging Station information. This proposal was scheduled for a public hearing before the California Traffic Control Devices Committee on December 6, 2012.

[92] Ibid., 31.

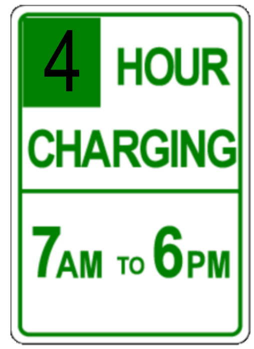
[93] California Vehicle Code §22511.1(a).

Figure 35. Proposed signage for the California MUTCD



Rxxx(CA)

Ryyy(CA)

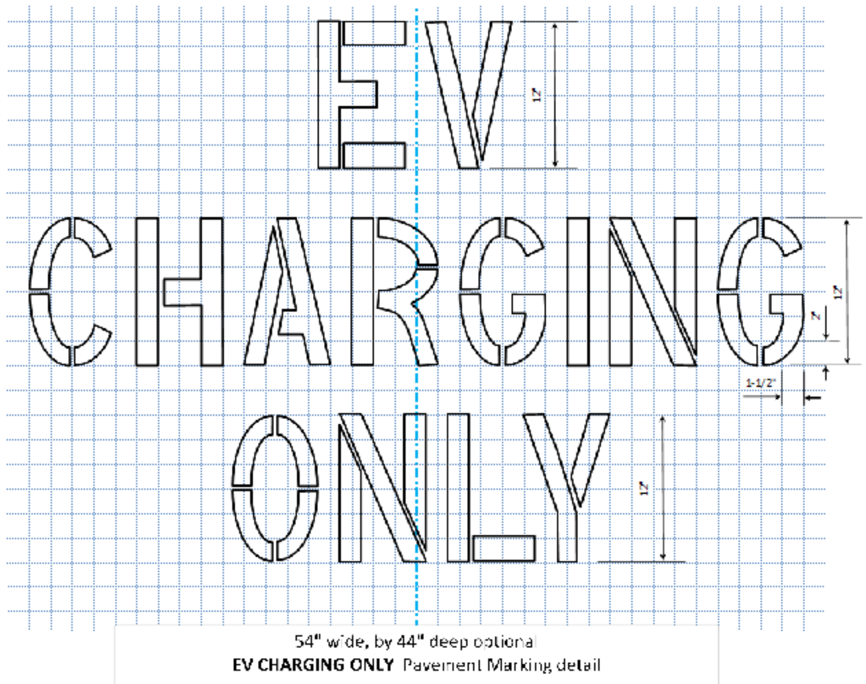


Rzzz(CA)

G66-21B(CA)
Electric Vehicle Charging Station
Symbol Sign (new)

G66-21C(CA)
FAST Electric Vehicle Charging Station
Header Plaque

Figure 36. Proposed pavement marking for the California MUTCD



Costs

ABAG contacted several local governments to solicit their input on these issues and found that adopting regulations for PEV charging spaces into the parking code can require extensive outreach and revisions because of public concerns over parking availability, and costs can vary accordingly. While many local governments report spending no more than five staff hours to draft code language, write a staff report, and respond to feedback on the proposed changes, some staff in jurisdictions where there has been more scrutiny from the public and elected officials report spending up to 48 hours. Interviewees also report that working with EVSE providers to establish fees on charging stations and a mechanism for collecting them can require extensive consultation with legal staff. The total cost of the staff time to implement this recommendation therefore can range from $500 up to $5,000, depending upon the amount of public outreach required and on the complexity of fee arrangements.

Guidance and Best Practices

- A fee of one dollar per hour for use of its PEV charging stations has been established by the **City of Santa Rosa**. Approximately 25 percent of the fee will go toward paying the city’s electricity costs, and the remainder will go toward covering maintenance and operations of the PEV charging stations. The City pays Coulomb Technologies, the manufacturer of the charging stations, 50 cents for every charging session plus 7.5 percent of total transaction fees, as well as subscription fee of $320 per month for each charger.

- **Marin County** recently adopted a series of amendments to its county code (§§3.58 and 15.30) to create an electric vehicle charging station parking stall designation for county-owned and operated parking spaces, restrict non-charging vehicles from using these spaces, and allow the Board of Supervisors to levy fees on PEV owners who use public charging station:[94]

Chapter 3.58: Electric Vehicle Charging Station Fee

Sections:

3.58.010 Definitions.

3.58.020 Fee.

3.58.010 Definitions.

Except where the context otherwise requires, the definitions given in this section govern the construction of this chapter:

a. An Electric Vehicle (EV) shall be defined as a 'motor vehicle' as defined in the California Vehicle Code, and (i) which displays the State of California Air Board ZEV (Zero emission Vehicle) sticker or (ii) any vehicle defined by the Air Resources Board as "Off-vehicle charge capable" meaning having the capability to charge a battery from an off-vehicle electric energy source that cannot be connected or coupled to the vehicle in any manner while the vehicle is being driven.
b. 'Charging' shall mean an electric vehicle parked at an electric vehicle charging station and is electrically connected to the charging station equipment.

3.58.020 Fee.

The Board of Supervisors may, by resolution, specify the fees which the Department of Public Works shall charge members of the public for each electric vehicle charging session.

15.30.060 Electric Vehicle Charging Station Parking Stalls.

It shall be unlawful to park in a designated electric vehicle charging station parking stall unless the vehicle is a charging electric vehicle.

a. An Electric Vehicle (EV) shall be defined as a 'motor vehicle' as defined in the California Vehicle Code, and (i) which displays the State of California Air Board ZEV (Zero Emission Vehicle) sticker or (ii) any vehicle defined by the Air Resources Board as "Off-vehicle charge capable" meaning having the capability to charge a battery from an off-vehicle electric energy source that cannot be connected or coupled to the vehicle in any manner while the vehicle is being driven.
b. 'Charging' shall mean an electric vehicle parked at an electric vehicle charging station and is electrically connected to the charging station equipment.

[94] Marin County Board of Supervisors, Ordinance No. 3572, November 15, 2011, http://www.co.marin.ca.us/depts/BS/Main/BOSagmn/ordinances/ord-3572.pdf.

The PEVC has issued a report, *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure,* which offers guidance on signage for PEV parking spaces based on input from stakeholders that have been involved in the creation of such spaces.[95]

Specify design guidelines for PEV parking spaces

Local governments should also adopt design guidelines that address the many unique considerations associated with PEV parking spaces. At a minimum, these guidelines should address the following issues:

- Minimum dimensions of PEV parking spaces.
- Parking configurations, including guidance on whether it is preferable to locate EVSE in perpendicular, parallel, or angled parking spaces, and on the location of wheel stops, guard posts, and signage.
- Adopted technical standards that apply to EVSE.
- Regulatory signage and signs directing drivers to available PEV parking.
- Area lighting.
- Clearances, including minimum clearances around chargers in order to maintain access to controls, as well as on adjacent walkways to maintain pedestrian access. Pedestrian clearance guidelines should also include recommendations for keeping sidewalks and walkways clear of cords and cables.
- Location relative to other spaces, adjacent land uses, and electrical infrastructure. For example, Sonoma County's EV Program Guidelines include the following guidance on locating on-street parking: "The last space on the block in the direction of travel will usually minimize cord management issues, and places user closer to crosswalks and curb ramps."[96]
- Additional considerations that apply in overlay zones, such as flood control zones.
- Design of disabled access spaces, including requirements for the number of spaces in areas that must be accessible in areas with multiple PEV parking spaces and design standards for accessible spaces. These requirements are discussed under the above recommendation regarding parking requirements; this section focuses on design guidelines.

This can be a complex process, and parking configurations in local jurisdictions across the Region vary too widely for this plan to include detailed design guidance. However, there is a wealth of existing guidance summarized in the section below that local governments can draw upon when creating design guidelines.

[95] *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure*, California PEV Collaborative, May 2012, http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Accessibility_120827.pdf.

[96] County of Sonoma, *Electric Vehicle Charging Station Program and Installation Guidelines*, July 2011, 40, http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf

Issues to Consider

Local governments will likely need to create multiple sets of PEV parking guidelines that apply to a wide variety of parking scenarios. Design guidelines will likely vary depending upon the configuration of the parking and upon the context in which parking is located.

Chargers serving multiple spaces

In the absence of restrictions, time limits, and enforcement policies to ensure that charging stations are available to PEVs in need of charging, PEV drivers may find PEV charging stations in commercial and multifamily developments blocked by conventional vehicles or by PEVs that have already completed their charge. If regulations and enforcement policies are not already in place, local governments may wish to specify and encourage PEV parking configurations that allow chargers to serve multiple spaces in order to increase opportunities for drivers to use these chargers. Many of the best practices referred to below contain examples of such configurations.

Accessibility

Currently, no standards exist for accessible PEV parking or charging stations. Local governments can choose between two relevant sets of standards in the California Building Code: the standards for required accessible parking (Section 1129B) and the standards for accessible fueling equipment (Section 1101C). A key distinction is that the former have a maximum grade of two percent, while the latter have a maximum grade of five percent. This means that applying the standards for fueling equipment can save money for local governments and businesses looking to designate PEV parking spaces because it is less likely to require additional grading of sites. The Sonoma *Electric Vehicle Program Guidelines* apply the standard for accessible fueling equipment to accessible PEV charging stations. However, local governments adopting some of the other recommendations in this section, such as creating minimum requirements for PEV parking or allowing PEV parking to count toward overall parking requirements, may find that the standards for accessible parking are more appropriate, because they are designed to ensure access between parking and adjacent land uses.

The PEVC's *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure,* [97] discussed in more depth in the best practices section below, contains design guidelines for PEV charging stations in many configurations. Implementing these guidelines when converting existing parking spaces to PEV charging stations can drive up the cost of creating these spaces or require property owners to give up more than one conventional parking space to gain a PEV parking space. In order to maximize accessibility without making it unduly expensive to create a PEV parking space, local governments can adopt language limiting additional expenditures on accessibility. For example, the California Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations state, "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

[97] *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure*, PEV Collaborative, May 2012, http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Accessibility_120827.pdf.

the PEV equipment and installation of all PEV charging stations at the site, when such valuation does not exceed the threshold amount referenced in Exception 1 of Section 1134 of Title 24."[98]

Costs

The cost of creating design guidelines from scratch can be quite high, but many local governments have instead adopted guidelines from one or more of the sources below ABAG contacted several local governments to solicit their input on these issues and found that the anticipated cost of formally adopting design guidelines based on existing sources is under $1,000 if a local government compiles design guidelines from existing sources, but can be much more expensive if local governments develop their own guidelines.

Guidance and Best Practices

This section summarizes several resources that contain guidance on design of electric vehicle charging stations and includes examples of design schematics from each resource. However, note that these examples are for illustrative purposes only, and this plan does not endorse any particular set of design guidelines. Local governments should select guidelines that are most applicable to the local context and PEV policies.

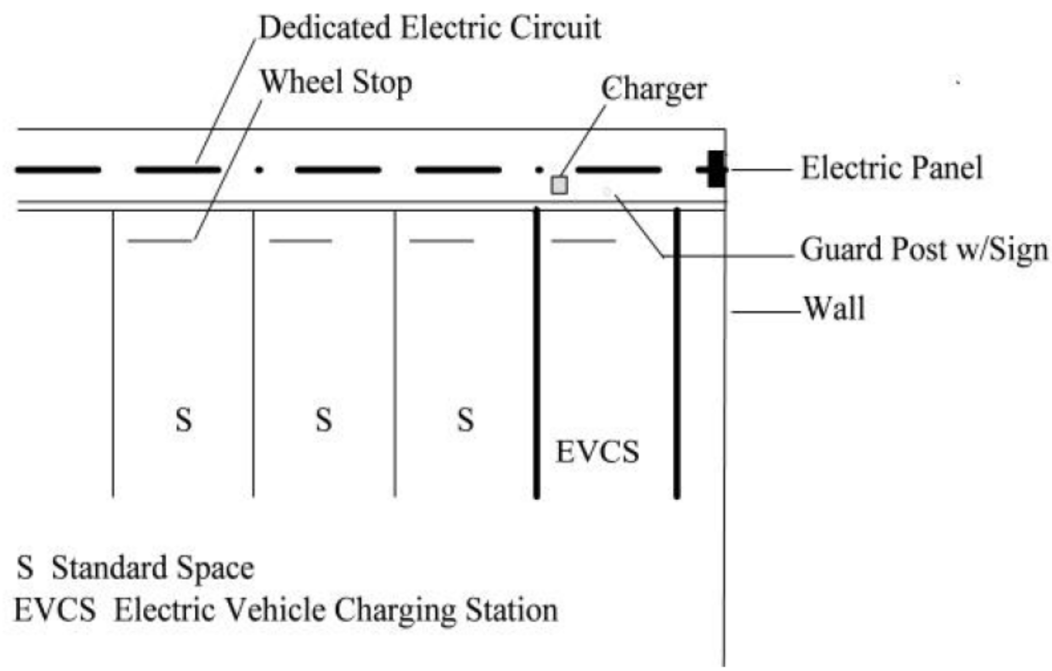
- **Sonoma County's** *Electric Vehicle Charging Station Program and Installation Guidelines* that contain thorough design recommendations for PEV parking in a variety of different configurations and contexts (see Figure 37 for an example).[99] Many local governments, both within Sonoma County and across the Region, have either formally adopted these guidelines or used them when installing EVSE.

---

98 California Department of General Services, Division of the State Architect, Policy 97-03: California Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations, June 1997. http://www.documents.dgs.ca.gov/dsa/pubs/policies_rev_01-01-11.pdf.

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

Figure 37. Sonoma County Illustration of a Single Charging Space in Perpendicular Parking[100]

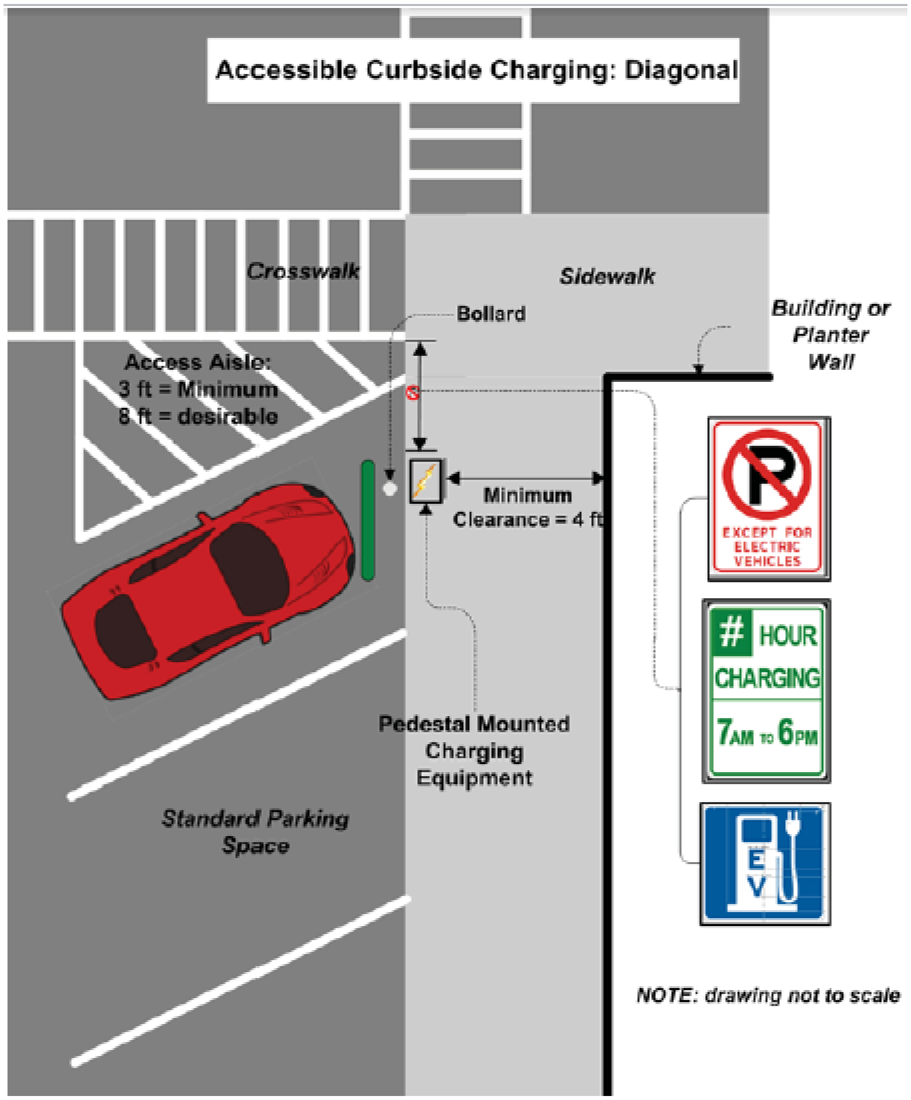


- The **PEVC** has issued a report, *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure,* which offers guidance on signage and on the design of accessible PEV parking spaces (such as the one shown below in Figure 38) based on input from stakeholders that have been involved in the creation of such spaces.[101]

[100] Ibid., 26.

[101] *Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure*, California PEV Collaborative, May 2012, http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Accessibility_120827.pdf.

Figure 38. PEVC Illustration of Accessible PEV Charging in Diagonal Parking[102]



- The **PEVC** has also issued a report on *Accessibility at Public EV Charging Stations*[103] that focuses on lessons learned regarding accessibility in publicly-available PEV charging.
- The **South Bay TUCC** has created permitting guidelines for EV charging stations in single-family residences[104] and in multi-family and commercial properties[105] that include installation diagrams and discuss accessibility requirements (an example is provided in Figure 39 below).

---

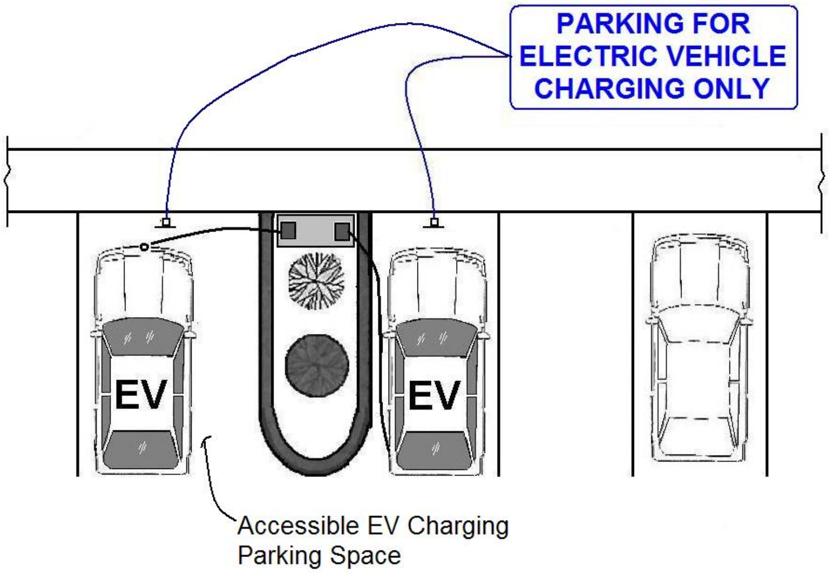
102 Ibid., 16.

103 http://www.theevproject.com/downloads/documents/EV%20Project%20-%20Accessibility%20at%20Public%20EV%20Charging%20Locations%20(97).pdf

104 ICC Tri-Chapter Uniform Code Committee (TUCC), Policy 17: Electric Vehicle (EV) charging system in Single Family Residence (SFR), April 14, 2011 http://www.eastbayicc.org/pages/TUCCPolicy/TUCC%20policy%2017%20-%20EV%20SFR%20revised%2004-14-11.doc.

105 TUCC, Policy 18: Commercial or Multi-Family Electric Vehicle (EV) charging station, June 9, 2011. http://www.eastbayicc.org/pages/TUCCPolicy/TUCC%20policy%2018%20EV%20Comm%20Guide%20-rev%201%202011.doc.

Figure 39. TUCC Illustration of EV Charging Stations in Commercial and Multi-Family Developments



- The **California Manual on Uniform Traffic Control Devices** contains interim signs indicating PEV parking. The manual will be updated as new signage is approved.
- **Section 22511(d) of the California Vehicle Code** specifies signage requirements and other specifications for spaces that are restricted to charging EVs.
- **Ready, Set, Charge, California**, a guide to EV readiness created by a group of regional agencies and electric vehicle advocacy groups, summarizes design and signage guidelines for PEV parking from many resources, including those listed above.

Review of Local Agencies' Readiness in the Region: Zoning and Parking Ordinances

Perhaps as a result of the challenges discussed above, only 22 agencies responded to the questions in the PEV readiness survey related to zoning and parking. Table 30 summarizes the survey responses.

Table 30. Progress of Zoning and Parking Ordinances

Response	Count	Percent
Adopted best practice EVSE requirements	2	9%
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%
Started to consider EVSE requirements	7	32%
Not started to look at EVSE requirements	3	14%
Total Permitting and Inspection Respondents	22	

8. Stakeholder Training and Education[106]

Transitioning PEVs into the region's vehicle mix in a significant way will require extensive marketing, outreach, training, and education relating to PEVs, charging services, and infrastructure. This section reviews the specialized training and education for PEV industry service providers that is currently available that addresses those needs. This section also identifies additional training, to be developed, to ensure that vehicles and related electric charging equipment is installed, maintained, and operated in a safe and proper manner. Later, in Section 9, organizations whose work focuses on educating the general public consumers on the benefits of PEVs are discussed.

8.1. Introduction and Overview

There are already a number of organizations and stakeholders that are leading efforts at the national, state, and regional level to develop curriculum and specialized training for electrical contractors and inspectors, workforce development training for PEV fleet technicians, public charging station owners and operators, fleet managers, dealers, and automotive shops, and first responders and other safety officials. The following is a listing of the organizations that are working to provide training opportunities in the Region today:

- **Advanced Transportation Technology and Energy (ATTE) Initiative** - In 1994 the California Community Colleges Chancellor's Office through its Economic and Workforce Development Program created the 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. For more information, please visit http://www.attecolleges.org/. 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 potential hazards, protecting the public, etc.)

[106] This section corresponds to the requirements described in Section 9 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

- Firefighters (General Firefighting Measures, etc.)
- Other Emergency Personnel

- **California Plug-in Electric Vehicle Collaborative (PEVC)** -The PEVC is working to launch a PEV Resource Center that will provide answers to key issues. The PEV Resource Center is currently under construction, but is anticipated to be live sometime in 2012. For more information, please visit http://www.evcollaborative.org/.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
- **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. For more information, please visit http://www.cleancities.tv/FeaturedContent/Training/EVSEResidentialChargingInstallation.aspx.
- **Electric Power Research Institute (EPRI**) – EPRI conducts research and development related to the generation, delivery and use of electricity for the benefit of the public. EPRI developed a plethora of technology, policy and economic analyses to drive long-range research and development planning and to support research in emerging technologies. This includes the development of research and resource material on electric vehicles, such as installation guidelines, grid interface requirements, and life-cycle cost analysis. For more information, please visit http://my.epri.com/portal/server.pt?.
- **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. For more information, please visit http://www1.eere.energy.gov/cleancities/evitp.html.

- **Electrification Coalition** - A nonpartisan, not-for-profit group of business leaders committed to promoting policies and actions that facilitate the deployment of electric vehicles on a mass scale. They developed two policy reports: the fleet electrification roadmap and the electrification roadmap. For more information, please visit http://www.electrificationcoalition.org/.
- **Green Transportation Workforce Development** - located at De Anza College part of the Green Team (Silicon Valley Clean Cities Coalition, Breathe California, and the Electronic Transportation Development Center) is offering a series of green transportation technical classes taught by the stakeholder member, Green Transportation Workforce Development. The target audiences for the workforce development training are fleet technicians, automotive shop employees, returning veterans, and hobbyists. The CEC is providing a 50% rebate on the fleets training investment. The following four 25-hour classes are offered: electric vehicles, hybrid electric vehicles, compressed natural gas vehicles, and infrastructure. For more information, please visit: www.GreenTransWD.com.
- ***Ready, Set Charge, California*** - Provides guidance to cities and counties on uniform inspection codes and PEV policy development and deployment. For more information, please visit http://www.baclimate.org/impact/evguidelines.html.
- **Tri-chapter Uniform Code Committees (TUCC)** - Information on code specifications and standards on PEV installation is available from the TUCC. For more information, please visit http://www.eastbayicc.org/pages/TUCC.php.
- **U.S. Department of Energy** - Has developed a series of training material for consumers, electrical contractors, fleet managers, and public charging stations hosts. These resources communicate benefits of PEVs and provide guidelines to installing infrastructure and maintaining PEVs. For more information, please visit http://www1.eere.energy.gov/cleancities/publications.html.

The PEV market is changing – vehicles are being redesigned and new vehicles and charging designs are emerging every few months at this stage of the PEV market development. As a result, many of these types of programs may be outdated quickly and require updating with the help of agencies like BAAQMD and its regional partners.

8.2. Issues, Gaps, and Deficiencies

Outreach to Vehicle Dealers

Based on the survey of LEAF purchasers participating in The EV Project, dealers are delivering sound and robust advice to potential PEV consumers, particularly with regard to PEV vehicle specifications and residential EVSE deployment. However, some respondents to the survey indicated that they received misleading information about vehicle range. Furthermore, some feedback from stakeholders throughout the planning process has indicated that there are mixed reviews for dealers' performance as it relates to promoting PEV sales.

Most of the PEV manufacturers have developed preferred provider relationships with one or more EVSE suppliers. These suppliers in general have training materials for the local dealership that address the installation and operation of the EVSE along with available incentives, credits and rebates that might apply. At the dealership level, the PEV buyer is presented this information and available options along with suggested installation support. Managing the installation of EVSE at a buyer's residence is not a typical responsibility of a dealer salesperson and they would prefer to outsource that effort. The buyer then has choices to accept these options or others and whether to accept installation support or not. Even a well-trained and informed dealer sales force has little control over inappropriate installation decisions by the buyer. At the same time, it is incumbent upon the EVSE preferred providers to adequately train and monitor the installation activities of its installation contractors to ensure quality and correct performance.

The dealership may also be the best location to insure the buyer is aware of any electric utility special rates that may apply. However, the survey of PEV drivers indicated that more than half of the respondents took the initiative to reach out to the utility for information. Only about 15% indicated they received this information at the dealership. At this early 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 and Expanded 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 landscape, a more coordinated effort could be undertaken to prioritize the most likely early- and mid-adopter regions. Jurisdictions of these regions should be educated on the training courses and resources available to them from local community colleges, the DOE Clean Cities, and other organizations.

Furthermore, anecdotal evidence from the Region indicates that there are some key stakeholders who are largely unfamiliar with their role in PEV deployment efforts. As a result, this uncertainty may cause additional challenges to PEV and EVSE deployment. For instance, in its efforts to deploy EVSE for the new PEVs placed in its fleet, City CarShare (https://www.citycarshare.org/) has taken on the role of educating stakeholders such as parking management companies. City CarShare has stated that the process to educate these stakeholders about the issues associated with EVSE, in some cases, has taken more than 4 months, which increases the time required to deploy EVSE. There is similar anecdotal evidence in the Region regarding the need to provide extensive education to stakeholders such as property management companies and HOAs. Due to the diversity of the Bay Area's residential and commercial buildings, effective outreach and education for these stakeholders is essential.

8.3. Recommendations

Develop Schedule for Stakeholder Training and Outreach

Based on the review of gaps and deficiencies identified via stakeholder interviews and survey responses, it is clear that coordination of efforts and additional stakeholder training and outreach is necessary. As a result, the following steps have been outlined for a regional plan to train stakeholders, with a focus on local government staff.

Identify roles and responsibilities

BAAQMD anticipates that there will be significant stakeholder engagement required to develop a coordinated training schedule. Recommended stakeholders and their corresponding roles are highlighted in Table 31 below:

Table 31. Recommended Roles and Responsibilities of Stakeholders Engaged in Stakeholder Training and Outreach

Stakeholder / Agency	Role / Responsibility
East Bay, San Francisco and Silicon Valley Clean Cities Coalitions	• Hosts: organize venues, coordinate outreach, and advertising • Coordinate day-of logistics
MTC, BAAQMD**, and ABAG DOE / CEC Utilities	• Co-funding and logistical support • Advertising and outreach to promote events • Utilities could conceivably use revenue from LCFS credits to help co-fund training*
EVITP	• Training instructor

* Assuming that proposed modifications to the LCFS are approved

**BAAQMD has recently applied to DOE for funding for training for first responders and local officials via the Clean Cities Funding Opportunity "Implementation Initiatives to Advance Alternative Fuel Markets"

Scope of training

For municipal planning and permitting staff, a 6–8 hour training session is recommended, focusing on codes, safety, standards, site assessments, electric load calculations, permitting processes, and utility notification.

Identify attendees

Based on responses to the Regional PEV Readiness Survey, a survey recently conducted by the BAAQMD of local Bay Area governments, these estimates assume approximately 130 agencies in the Region have staff requiring some degree of training and outreach. It is also assumed that 2-3 staff per agency will likely require training. If about 5% of agencies are already or on the way to being PEV ready, then approximately 250-370 local government staff will require training. BAAQMD recommends an over-estimate for staff because it is likely that more than just local government staff will be interested in the training session.

Additionally, the BAAQMD has applied to DOE on behalf of the State of California in partnership with the SCAQMD, PEVC, and 13 Clean Cities coalitions to perform an assessment of training that has already been offered to first responders and local jurisdictions. If this application is selected for award, funding in the amount of $200,000 will also be provided for additional training to local jurisdictions and first responders via ATTE training organizations and other locally offered PEV training. In the event this application is not selected for award, BAAQMD may seek other sources of funding (AB118 funding from CEC) to begin this assessment and conduct training.

Devise schedule

BAAQMD devised a schedule assuming that staff at all local governments would need to be trained by December 2014 – this timeline is intended to reflect the varying levels of PEV adoption that are anticipated across the Region based on considerations such as socioeconomic data (e.g., income, home ownership, dwelling type), infrastructure availability, and other parameters (e.g., HEV ownership). It is also assumed that each training session would include 25-30 participants. To ensure the full range of staff receive the recommended training, it is estimated that 8-15 sessions will be required; if training sessions commence in the first quarter of 2013 and end in December 2014, then training sessions will have to be held quarterly or bi-monthly. The estimates refer to the scenario with 8 sessions as aggressive and the scenario with 15 sessions as conservative.

Estimate costs of sessions

Each of the training seminars will incur a number of costs, including renting a venue, paying an instructor, catering, and materials. Estimates for these costs are shown in Table 32 below.

Table 32. Breakdown of Training Session Costs

Cost Item	Low Cost	High Cost	Includes:
Venue Rental[1]	$800	$1,000	Seats 30 people at tables
Instruction[2]	$850	$1,450	One instructor plus reimbursement for travel expenses
Catering[3]	$731	$878	Breakfast: coffee/tea/juice, pastries and fresh fruit Lunch: sandwiches served w/ salad
Materials	$125	$150	Notebook, Handbook, and Pen
Total	**$2,506**	**$3,478**	

(1) http://www.pge.com/mybusiness/edusafety/training/pec/events/facilinfo.shtml, (2) Based on information provided by EVITP. (3) http://www.pge.com/mybusiness/edusafety/training/pec/events/catermenu.shtml

In order to estimate the cost of a training seminar, PG&E's Pacific Energy Center in San Francisco is used as a proxy. Renting a venue that fits 30 attendees seated at a table would cost between $800 and $1,000. Depending on the number of attendees, catering breakfast and lunch at the Pacific Energy Center would cost between $731 and $878. Based on EVITP, instruction and travel expenses would cost approximately $800 and $1,450. Lastly, printing a take-home handbook or presentation notes and providing a notebook and pen to attendees would cost between $125 and $150. Based on these estimates, it is estimated a cost of $2,506–$3,478 per training session. For the sake of simplicity, the conservative scenario, assuming 15 sessions, yields a total cost between $37,600 and $52,170 (see Table 33).

Table 33. Estimated Costs for Stakeholder Training

Scenario	Sessions	Low Cost	High Cost
Aggressive	8	$20,000	$27,800
Conservative	15	$37,600	$52,170

As noted previously, although this is a substantial investment, the return on this investment via benefits such as streamlining permitting processes and expanding local consideration of zoning modifications to incentivize PEV parking has the potential to reduce barriers to PEV adoption in the Region. As noted throughout, BAAQMD developed these costs using conservative estimates; it is conceivable that there are ways to reduce the cost burden through avenues such as donated venue space. In many cases, it may be possible to incorporate the training session into existing agendas for other events related to alternative fuels or similar initiatives. It is important, however, to note that a 6-8 hour session is not something that can be added to any agenda; and based on feedback from instructors from EVITP, BAAQMD recommends against shortening the training sessions.

Regardless of cost share potential, the scope of these training session falls well within the purview of regional Clean Cities coalitions; with regional support, it is highly likely that sources such as the CEC or DOE would support these activities. Coordinated and collaborative action in the Region – with the support of BAAQMD, MTC, and ABAG – will also bolster the chances that these training sessions can be funded. ABAG and the Clean Cities coalitions are well positioned to ensure that the sessions generate sufficient interest to warrant a quarterly or bi-monthly frequency.

9. Consumer Education for PEVs[107]

The introduction of new technologies like PEVs requires careful coordination and outreach to consumers. This section discusses strategies for educating consumers on the benefits of PEV ownership, as well as the incentives available to owners. The Summary, under Actions for Further Regional Readiness, discusses additional incentives that regional agencies are planning to offer to encourage PEV readiness.

9.1. Introduction

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 – changes with PEV ownership. With support at the federal and state level through incentives for vehicles (e.g., tax credits and rebates) and for infrastructure (e.g., through federal tax credit and the BAAQMD's 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.

Federal, State and Local Incentives

While the Region's early adopters have shown a strong commitment to PEV technology, the current and future success of PEV deployment is believed to be significantly tied to the availability of financial and nonmonetary incentives. Some of the key incentives that are available to consumers and commercial fleets today include:

- **Federal Tax Credit up to $7,500 for PEVs.** The value of the tax credit is tied to the capacity of the battery in the PEV. The minimum value is $2,500.
- **California State Rebate up to $2,500 is available through CARB's CVRP.** The minimum value of the rebate is $1,500 for light-duty vehicles.
- **California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)** is sponsored by CARB. It provides incentives for medium- and heavy-duty electric vehicles, with vouchers ranging in value from $30,000-$50,000.
- **Access to HOV lanes:** California law allows single-occupant in qualifying clean alternative fuel vehicles access to HOV lanes. The State issues an unlimited number of White stickers for BEVs and other qualifying zero emission and CNG vehicles, and Green stickers to the first 40,000 applicants that purchase or lease cars meeting California's enhanced advanced technology partial zero emission vehicle (AT PZEV) requirements. White and Green stickers are valid through January 1, 2015.

[107] This section corresponds to the requirements described in Section 10 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

- **Local Incentive Funds**: Regional agencies also provide incentive funding for vehicle and infrastructure deployment. Agencies, including the **BAAQMD**, **MTC**, and **MBUAPCD** are working to provide additional funding to meet the Region's needs to ensure that adequate charging infrastructure is available. For instance, in partnership with ECOtality through the EV Project, BAAQMD is helping to defray the costs of residential EVSE installation for early adopters.

To fully implement the recommendations contained within this Plan, additional incentives may be necessary to ensure continued adoption of PEV technology. For example, the federal government previously provided a federal tax credit to help reduce the cost of installation of EVSE at homes and workplaces. It is hoped that this type of incentive will be renewed in future funding cycles. BAAQMD and MTC will also monitor the need for incentives that complement available opportunities for funding to meet future deployment capacity needs.

Other National Efforts

At the national level, the National Renewable Energy Laboratory (NREL) developed a Vehicle Cost Calculator,[108] 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[109] on their own webpages. Similarly, both the DriveClean website (hosted by CARB) and the PEVC website host calculators.

Other Local Efforts

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.

Educational Resources

Several national and local organizations are dedicated consumer advocates for PEVs and have been working to promote PEV ownership and outreach to potential and current PEV drivers to help them navigate PEV-specific ownership and operational requirements and to access available incentives and funding. The following is a listing of established organizations that provide consumer-specific PEV education to Bay Area and Monterey Bay Area residents:

[108] Available online at: http://www.afdc.energy.gov/afdc/calc/
[109] Available online at: http://www.afdc.energy.gov/afdc/widgets/

- **BAAQMD's Spare the Air Program (STA)** – The BAAQMD maintains a website that serves locally as a clearinghouse for Region-specific information about upcoming PEV-related events and training opportunities, updates on the development of the PEV Regional Plan, and PEV incentive opportunities. http://www.BAAQMD.gov/EVready

- **California Air Resources Board (CARB)** - Sponsors the DriveClean.ca.gov website that provides information about the cleanest, most efficient cars on the market. The site allows users to look up incentives in a specific region, or search and compare vehicles by make / model, vehicle category, technologies & fuel types, Smog Score, Global Warming Score or engine family number. The site also contains a calculator to help users calculate potential savings by inputting information on their driving habits and regional fuel costs, and to find out how much the vehicle pollutes, and compare it other vehicle makes and models. CARB recently launched the PEV Resource Center website http://www.driveclean.ca.gov/pev/ that contains information developed by the PEVC that provides California State consumers information about PEVs, charging, incentives, costs and safety.

- **Clean Cities** and locally associated **coalitions – East Bay, San Francisco, and Silicon Valley -** Clean Cities is the DOE's flagship alternative transportation deployment initiative. Today, a nationwide network of nearly 100 Clean Cities coalitions are working together to reduce petroleum use from the transportation sector. Clean Cities coalitions are composed of businesses, fuel providers, vehicle fleets, state and local government agencies, and community organizations. These stakeholders come together to share information and resources, help craft public policy, consumer education and outreach, and collaborate on projects that advance use of alternative fuels. http://www.afdc.energy.gov/cleancities/coalitions/coalition_locations.php.

- **Electric Auto Association and locally associated chapters** – Golden Gate Electric Vehicle Association (EAA), East Bay EAA, North Bay EAA, San Jose EAA, Silicon Valley EAA, and Central Coast EAA – Provides information on the developments of electric vehicle technology, sponsors public exhibits and events to educate its members and the public on the progress and benefits of electric vehicle technology. The EAA hosts regularly scheduled member meetings open to members and the general public. http://www.electricauto.org/.

- **Monterey Bay Electric Vehicle Alliance (MBEVA)** – A project of Ecology Action is a public-private partnership of stakeholders from Monterey, San Benito, and Santa Cruz counties. MBEVA Teams meet regularly to advance goals related to: funding, policy improvement, public outreach, economic development/workforce development, and infrastructure development. MBEVA's Outreach Team organizes communication and education initiatives to educate and involve a variety of audiences. http://www.mbeva.org/.

- **Pacific Gas & Electric (PG&E)** - The Region's largest utility service provider's website contains information to help their customers select best rate plans for home charging. They also developed a PEV installation guide to assist their customers and a PEV electric rate calculator to estimate PG&E electricity costs for various PEV models. http://www.pge.com/about/rates/rateinfo/rateoptions.

- **Plug In America (PIA)** - Consumer-oriented voice in the U.S. promoting the use of electric vehicles and effective policy at the local, state and federal levels. PIA provides a range of expert assistance related to the widespread adoption of electric vehicles and conducts consumer outreach and awareness - through individual events and aggressive use of online campaigns - to connect prospective drivers to new electric vehicles now available. PIA outreach efforts include supporting National Plug-In Day, a multi-city celebration of consumer enthusiasm that brings together current and prospective drivers; the event's second year, 2012, included activities in over 60 cities. PIA maintains a consumer-focused website that provides extensive information about the emerging PEV market that features a consumer guide to new products that is updated annually and an online vehicle tracker that has the most comprehensive set of information about the products currently available in the market. http://www.pluginamerica.org/.
- **San Francisco BayLEAFs** – Provides a community to the Nissan LEAF owners in the San Francisco Bay Area. Although membership is open to all PEV enthusiasts, SF BayLEAFs is focused on the Nissan LEAF owner and to maximize the LEAF EV owner experience. SF BayLEAFs provides a forum for its members to communicate directly with Nissan about their current and future EV products, and advocates on behalf of its members to federal, state, and local government agencies as they develop public policy for EV and other clean energy transportation programs. SF BayLEAFs also participates regularly in community outreach and awareness events such as parades, festivals, and trade shows. http://www.sfbayleafs.org/.
- **U.S. Department of Energy** - Has developed a series of educational material for consumers that communicate benefits of PEVs including a Vehicle Cost Calculator,[110] 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. http://www1.eere.energy.gov/cleancities/publications.html.

Although the general public is becoming more aware of PEVs as a result of vehicles being on the road, more work in this arena is needed. This need is highlighted by the results of a survey recently conducted (during July 2012) by City CarShare, ICF, and TrueNorth Research in conjunction with MTC as part of the Climate Initiatives Program. Assuming that City CarShare members are a reasonable proxy for the average level of consumer awareness in the Bay Area, the general public's understanding of electric vehicles is in good shape; however, there are some gaps. For instance, 84% of respondents indicated that they were slightly, somewhat, and very familiar with electric vehicles. However, when asked to identify an electric vehicle, more than 20% of survey respondents identified vehicles that were not electric vehicles. Generally, these respondents listed a HEV or a small, fuel-efficient vehicle such as the Smart Car or the Fiat 500. Despite some confusion in the market, survey respondents generally demonstrated a good understanding of the features and limitations of electric vehicles, while also expressing their interest in learning more about them e.g., test driving an electric vehicle.

[110] Available online at: http://www.afdc.energy.gov/afdc/calc/

9.2. Go EV Campaign for the Bay Area

Gaps and deficiencies that are not currently covered by the aforementioned efforts will be addressed in a *Go EV Campaign* that is currently under development for the Bay Area.

There are many stakeholders in the Region engaged in the deployment of PEVs and EVSE, including public and private sector participants, who have greatly contributed toward helping to realize the growth of the PEV vehicle and infrastructure market in the Bay Area. With a large potential market of PEVs, a local, well-coordinated PEV marketing campaign that specifically targets Bay Area consumers is needed in order to successfully capture the attention and acceptance of the broader general public. The key regional stakeholders – led by MTC in collaboration with ABAG and BAAQMD – have responded to that need and are developing a *Go EV Campaign* that will target potential consumers in the Region. The campaign development began in October 2012, led by a firm specializing in public interest campaigns. The campaign is anticipated to be completed in winter/spring 2013, and publicly launch in summer 2013.

Campaign Objectives

The effort will be a promotional campaign aimed at building awareness and demand for PEVs (including both BEVs and PHEVs) in the Bay Area along with helping to stimulate additional supportive actions including for infrastructure development. The campaign will continue to promote the Bay Area identity as a market leader in PEV growth. 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, reduce GHG emissions, and improve public health. The specific goals of the Campaign include:

- Behavior change of Bay Area drivers to purchase PEVs or otherwise use PEVs when offered the choice (including when renting vehicles or carsharing);
- Develop core messages that create awareness to communicate PEV benefits (e.g., cost savings, convenience, regional economic and job benefits, environmental and health benefits, “fun to drive” and “cool factor”);
- Continue to promote the Bay Area identity as a center for high tech, green culture, and the EV capitol of the US;
- Educate Bay Area residents about PEVs. This may include information on vehicle operation, differentiation between vehicle types and vehicle charging (e.g., charging station locations, charge times, miles per charge, etc.); vehicle rebates; State and Federal tax incentives/credits, reductions in sales taxes or registration fees (if available); rebates or cost reductions on the permitting, purchasing, or installation of EVSE or EV infrastructure; rebates or reductions in State or local toll road access (if available) and other consumer benefits such as preferred parking spaces and HOV lane access;
- Demonstrate PEVs for potential consumers through targeted outreach. This may include providing BEV and PHEV ride and drive opportunities at targeted locations throughout the Bay Area. Initial research shows that consumers who drive the vehicles are most likely to communicate to their peers about the vehicles, which will help to dispel myths and create

excitement. Also, utilizing existing BEV and PHEV owners/drivers at the events will provide test drivers the ability to ask questions of those who have hands-on experience with operating and charging the vehicles and will allow PEV owners to tell their stories.

- Identify 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.

Implementing the Campaign

For local government engaged in PEV readiness planning, it will be important to identify the key areas for coordination with the *Go EV Campaign* – this will help maximize the utility of the outreach efforts. Similarly, partnerships with local communities and other stakeholders moving forward will help maximize limited funds for this important effort. In an effort to identify these opportunities in advance, the following steps highlight the initial steps for scoping the *Go EV Campaign*, distinguished as four (4) phases over five to six months, followed by the Campaign approval and subsequent implementation. Please note that the phases below are occurring now.

Phase 1: Research and Discovery

Over a span of several months, MTC will be reviewing existing research on potential EV consumers and their knowledge and interest in PEVs, as well as reviewing existing campaigns. More specific research in the Region will be conducted by using survey tools to develop an improved understanding of how consumers are “talking” about and sharing information regarding PEVs. This work will focus on websites and social media platforms, and will seek to identify where the most robust conversations are already taking place, and how key actors are using digital technology to communicate. MTC will also be conducting stakeholder interviews, including with local governments that have been the most actively engaged in PEV readiness planning. This aspect of the planning for the *Go EV Campaign* will be an important integration point for the most proactive local governments.

Phase 2: Strategy Development

Based on the research and discovery in Phase 1, MTC will develop a target audience profile and develop the initial brand story language. The target audience will be a key factor for local governments trying to understand the needs and concerns of their constituents that are most likely to purchase PEVs in the region in the near-term future.

The strategy development will also include an assessment of the current communication landscape, which will seek to identify the strengths and weaknesses of existing efforts while characterizing the opportunities for the campaign moving forward. This analysis will, to some extent, be informed via engagement with stakeholders. The local governments that have been the most engaged in EVSE deployment should be actively involved in this process to help communicate the on-the-ground feedback that they are receiving, which perhaps may not have been reflected in the survey of information sharing on websites and social media.

Phase 3: Message and Content Testing

MTC will execute Phase 3 of the scoping process for the *Go EV Campaign* by conducting informal focus groups. Focus groups are an effective mechanism to ensure that the outreach and communication strategies being developed resonate with various audiences. The focus groups are also a convenient way to test more granular aspects of the *Go EV Campaign*, including campaign language and mock materials.

Phase 4: Full Plan Development

At the conclusion of the 6 months of scoping, MTC will have an outline of a full plan, which will include:

- Specific measureable campaign goals;
- An updated audience profile;
- Strategies and tactics and recommendations on the organizing structure of the campaign; and
- A master brand story with rationale, talking points and recommendations for branded materials on how to talk about civic engagement and a sample success story.

After the four phases of the scoping effort are complete, MTC will seek approval on the completed campaign. If approved, MTC, in conjunction with its partners ABAG and BAAQMD, will implement the campaign over the subsequent 12-18 months.

The four initial scoping phases will help regional stakeholders ensure that the *Go EV Campaign* will fulfill the need for a centralized resource for consumers in the Region.

10. Minimizing Grid Utility Impacts[111]

The widespread deployment of PEVs presents an unprecedented opportunity for electric utilities to increase asset utilization through increased electricity use, and potentially reduce electricity rates. One of the primary concerns associated with PEV deployment is the potential negative impact from 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. This section provides a review of the Region's utility providers policies and plans for accommodating PEV deployment and strategies for ensuring safety to the grid.

10.1. Introduction

Utilities across the country have implemented a wide variety of pilot projects and assessments to better understand consumer PEV usage patterns and how certain management tools, such as smart meters, may help mitigate impacts on the grid. Through the use of tariff structures and incentives, utilities are actively seeking solutions that maximize PEV charging during periods of lower electrical demand, such as off-peak hours, helping to mitigate grid impacts.

The utilities in the Region include:

- Alameda Municipal Power
- City of Healdsburg Electric
- City of Hercules
- City of Palo Alto Utilities
- Marin Clean Energy
- Pacific Gas & Electric Company
- San Francisco Public Utilities Commission
- Silicon Valley Power

The following subsections review the key issues that must be addressed to minimize the potential for negative impacts to the grid as a result of high rates of PEV adoption. First is a review of potential impacts of PEV deployment on the grid, focusing on the load and transformer impacts, with implications for the Bay Area highlighted to the extent possible. Following the review of potential impacts, is a summary of the pricing and incentives that utilities are employing to minimize the negative impacts of PEVs in the near-term, as well as the importance of utility notification in the planning process. Concluding this section, are considerations of integrating renewable energy purchase or deployment with the charging of PEVs.

As the largest utility in the 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 also proposed two new PEV rates that are aligned with the goal of maximizing PEV charging during 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 with the more

[111] This section corresponds to the requirements described in Section 11 of the sample outline contained in the DOE solicitation (see Appendix G: Sample Plan Outline).

electricity consumed as is typical for all other residential rates. For the new EV rates, off-peak charging of PEVs is at a significantly reduced rate to the consumer, ranging from roughly $0.10/kWh during off-peak hours to $0.35/kWh during on-peak hours. Thus, the PEV rates do not discourage increased electricity consumption that is associated with charging PEVs. EV-A is a “whole-house” rate designed so that customers do not need to install a separate meter to monitor the PEV’s 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 to phase out its current E-9 rates that discourage additional PEV charging due to their tiered structure.

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, this 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 significant adoption of PEVs could create new peaks from 6:00-10:00 p.m. if PEV users charge their vehicles upon return from work.[112]

EPRI performed a first-order macro-analysis showing that even in a very aggressive PEV 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 (with all PEVs charging in summer on-peak periods at the same time).[113] According to the EPRI Prism study, smart grid investments, 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 PEV 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 PEV 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

112 *Electrification Roadmap, Revolutionizing Transportation and Achieving Energy Security*, Electrification Coalition November 2009
113 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

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 34 below.

Table 34. 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

ARB reported on several studies performed by the DOE, EPRI and others regarding the impact of PEVs on the electric grid.[114] 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.[115]

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 PEVs 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.[116] The additional 1.8 million PEVs 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 PEVs would not create an adverse impact on California's supply of available electric power within the 2020 timeframe.[117]

The energy use and demand results from a CPUC analysis for PHEVs and BEVs are shown in Table 35.[118]

---

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

[115] 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

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

[117] 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.

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

Table 35. 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 PEVs would add 2.4-4 TWh of consumption, at a cost to consumers of $0.24-$1.2 billion. The results of this study demonstrate how PEVs can provide more efficient use 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 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 demand for 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 PEVs 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 PEVs 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) were 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.[119] These numbers are provided to highlight the potential long-term impacts of PEV adoption; however, the timeframe for making these grid requirements (e.g., significant increased capacity, widespread transmission upgrades, etc.) are beyond the planning horizon for this Plan.

Transformer Impacts

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

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

An EPRI presentation[120] discussed transmission and distribution issues with calculations performed at the distribution system level (at the house using circuit models and loading) and the higher 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 PEV market penetration, PEV 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:

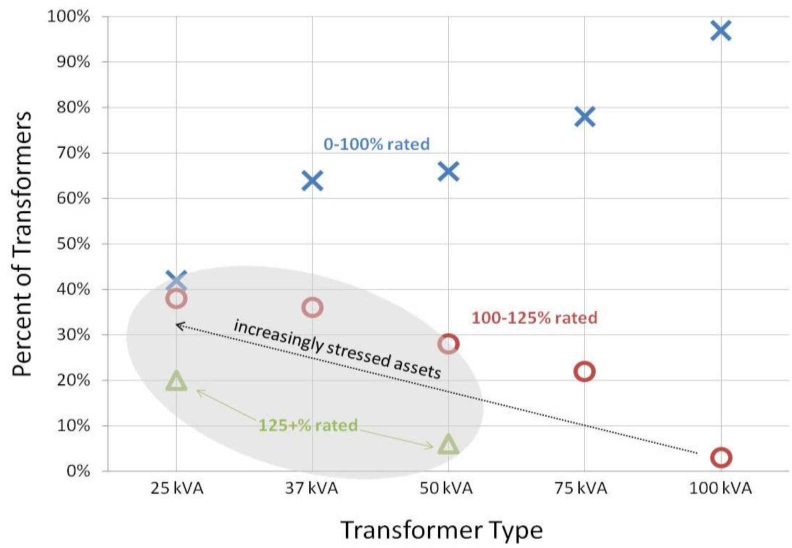
- 50% at 120 V or 1.44 kW
- 20% at 240 V or 3.3 kW
- 30% at 240 V or 6.6 kW

PEVs are likely to be concentrated in particular neighborhoods. Particularly, with respect to older equipment, assets may already be stressed with many 25 kVA transformers already operating with narrow margins today, as shown in Figure 40. Transformers typically serve five to fifteen households. 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 40.

[120] A. Maitra, *Effects of Transportation Electrification on the Electricity Grid*, EPRI, Plug-In 2009 Conference, August 11, 2009

Figure 40. 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 41 shows one estimate of overloading for different transformer voltages. Asset overloading can increase quickly as PEV 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.[121]

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.

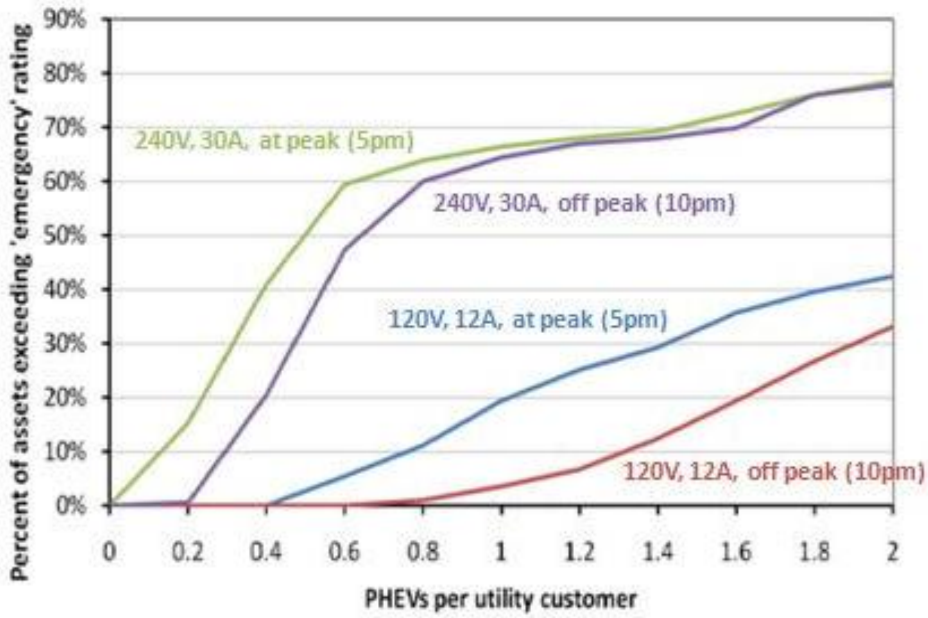
Utilities will need to upgrade transformers in some areas. Understanding where PEVs will charge is critical to this task and increased coordination amongst different stakeholders is essential to allow utilities to receive this information. The last transformer in the network prior to electricity being 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. PEV charging represents a significant power draw for most U.S. homes. A Level 2 charger operating at 220 V on a 15 A circuit is expected to draw 3.3 kilowatts of power, a load that is equivalent to between 50-100% of the average load in a typical home. Utilities will need to upgrade their transformers to accommodate this additional load and should be able to do this as rate-based infrastructure improvements.[122]

---

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

[122] 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 41. 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.

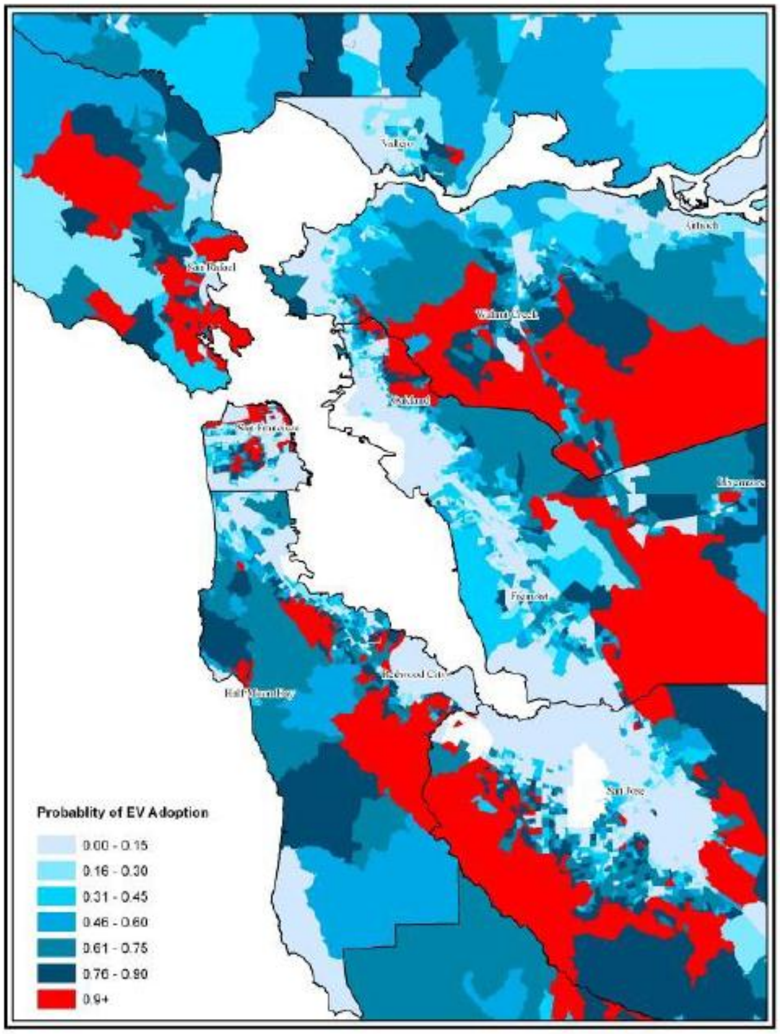
Clustering

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 42 below highlights PG&E's estimates regarding the probable level of PEV adoption in the 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.

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.[123] 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 (see Figure 42).

[123] 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.

Figure 42. Probable level of PEV adoption in the San Francisco Bay Area[124]



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,

[124] 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.

different regions may find different combinations more beneficial. Some of these time-variant structures include:

- **Whole-house Time of Use with one rate** – this time of use (TOU) 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 may not necessarily 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 encourages electricity consumption during off-peak hours for the PEV with a TOU rate and allows the house to be on a normal residential rate, such as a flat rate. One of the primary benefits 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 MDUs, 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 36 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 Region. 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 Driveclean.ca.gov website, which includes relevant utility incentive descriptions.[125]

[125] California Air Resources Board website, http://www.driveclean.ca.gov/

Table 36. Utility Pilot Programs with PEV rates and EVSE incentives Outside of the Region

Utility/Location	Pilot Program Name	Incentive Type	EVSE Included	PEV Rate
Austin Energy Austin, Texas[126]	Plug-in Everywhere	Rebate up to $1,500 for Level 2 EVSE	Level 2 EVSE installed ; need pre-approved contractor	None
Consumers Energy Michigan[127]	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[128]	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[129]	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[130]	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[131]	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

[126] Austin Energy, "Plug-In Partners," accessed March 13, 2012, http://www.austinenergy.com/About%20Us/Environmental%20Initiatives/Plug-In%20Partners/index.htm.
[127] Consumers Energy, "Plug-In Electric Vehicles," accessed March 13, 2012, http://www.consumersenergy.com/content.aspx?ID=3363.
[128] Dominion Power, "Plug-In Electric Vehicles," available online at: http://dom.com/about/environment/electric-vehicles.jsp.
[129] DTE Energy, "Powering Your Energy Future," available online at: http://www.dteenergy.com/residentialCustomers/productsPrograms/electricVehicles/overview.html.
[130] Duke Energy, "Plug-in Electric Vehicles (PEVs)," available online at: http://www.duke-energy.com/plugin/default.asp.
[131] 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[132]	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 PEV charging. The rate EV-R customer's existing load will remain on the existing meter and account
LADWP Los Angeles, California[133]	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[134] 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[135] San Diego, CA	Clean Transportation Program	Two time of use (TOU) discount rates are available for PEV 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[136] 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

[132] Hawaiian Electric Company, "Residential EV Pilot Rates," available online at: http://www.heco.com/.
[133] 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.
[134] Sacramento Municipal Utility District, "PEV Rates," available online at: https://www.smud.org/en/residential/environment/plug-in-electric-vehicles/PEV-rates.htm.
[135] San Diego Gas and Electric, "EV Rates," available online at: http://sdge.com/clean-energy/electric-vehicles/ev-rates.
[136] 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 or housed 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 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,[137] 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 issues 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 regarding the deployment of PEVs in the Region, 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.

[137] 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, [138] 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.[139] 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.[140]

Through recent legislation, utilities are also able to get data for vehicles registered with the State of California directly from the Department of Motor Vehicles (DMV). Senate Bill 859 (SB 859, Padilla, Statutes of 2011), sponsored by the California Electric Transportation Coalition (CalETC), LADWP and Sacramento Municipal Utility District (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.[141]

Integrating Renewable Energy with PEVs

Investor owned utilities (IOUs) in California are at various stages of preparedness regarding the deployment of PEVs. Based on research, the IOUs in California – PG&E, SCE and SDG&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.

10.2. Issues, 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. Although the size of distribution transformers and the number of locations they serve vary throughout a utility's service territory, in general, a residential transformer serves 5-10 homes. Thus, the addition of a PEV could mean an

138 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.
139 Pacific Gas & Electric Company, "Contact PG&E to get plug-in ready," available online at: http://www.pge.com/myhome/environment/whatyoucando/electricdrivevehicles/contactpge/.
140 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.
141 Senate Bill No. 859, Chapter 346, Padilla, Vehicles: records, confidentiality. Available Online: http://leginfo.ca.gov/pub/11-12/bill/sen/sb_0851-0900/sb_859_bill_20110926_chaptered.pdf

increase of 10-20% above expected load for that transformer and the addition of more than one PEV can start to cause problems, especially for homes served by smaller transformers. This clustering of PEV buyers in one localized region may be of serious concern.

The clustering of PEV loads may be one of most immediate challenges to utilities in the 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 that sufficient infrastructure exists.

Congestion and Capacity Expansion

Even if the Region's utilities are able to avoid transformer overloading as a result of local PEV clustering, long-term challenges will be created by high levels of PEV adoption. If PEV loads were to 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 through pricing will mitigate the increases in peak demand, but some needs for additional capacity can be expected as the market grows.

Potential Gaps at Municipal Utility

With assistance from PG&E's leadership in developing programs for PEVs, other utilities serving the Region communities will also 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. If not already done, these utilities should consider adopting TOU rates to encourage off-peak charging, comparable to those outlined previously from PG&E.

10.3. Rate Structures, Provisions, and Billing Protocols for PEVs

Utilities in the Region have a variety of different rate structures, provisions and billing protocols – only a few of which are specifically designed for PEVs. There are a variety of opinions concerning consumer fairness and equity concerning PEV rate structures and provisions, particularly as it relates to public utilities obligated under California's Proposition 26. Proposition 26 was a regulation passed in 2010 that limits the ability of a public utility to provide subsidies to a subset of a rate class, which in this case may be PEV drivers. Fairness and equity is an issue that utilities in the Region, and elsewhere, will need to consider when developing experimental or permanent rates in the future. Another potential barrier to PEV adoption is the prevalence of tiered residential rate structures among the utilities in the Region. California has long used the tiered structure to incentivize conservation. Unfortunately, the tiered rate structure does not take into account the environmental benefits of PEVs and in many cases could result in significantly higher utility bills for the average PEV driver.

The subsequent sections outline the current rate structures available to PEV drivers in the Region with scenarios for residential consumers using demand curves generated by The EV

Project through a partnership with ECOtality and Bay Area utilities and stakeholders. The data have been accrued from the inception of the project in 2010 through June 2012 and most closely represents the average monthly charging patterns of PEV owners in the Region.

Prior to the evaluation of rate structures, an overview of driver behavior is provided for reference. In the Bay Area, as elsewhere, not all LEAFs are used for typical daily commuting as there were always at least 5% of the PEVs connected to their residential EVSE during the day. It cannot be assumed that it is the same 5% all day. At the same time it is noted that the maximum number of residential EVSE connected at any time in the day was 65%. This reflects the other EVP data that show that the LEAF driver's average daily travel is 31.2 miles. It is not necessary that all LEAFs recharge every night. Generally, the weekday plot shows the typical PEV driver behavior of plugging in the PEV when arriving at home starts at about 5 p.m. and the load steadily increasing to about midnight. Then the unplug events begin at about 6 a.m. as people begin their daily routine. ECOtality reports that this behavior is similar to that seen across all EVP regions.

This section does not analyze the costs for public or workplace infrastructure due to the prevalence of PEV rates targeted at residential customers and the wide diversity of commercial and industrial rates. Additionally, unforeseen grid impacts may be far more acute at the residential sector than within public or workplace charging locations because of the infrastructure in place that serves residential and commercial loads. Public infrastructure using Level 2 and DC fast charging is much more likely to go through a utility notification process than a residential system due to the energy requirements and likelihood of a system upgrade.

Alameda Municipal Power

The Alameda Municipal Power currently offers an experimental PEV discount, which is applicable to customers operating registered, street-legal PEVs with a vehicle weight between 750 and 8,000 lbs, to privately-owned golf courses operating electric golf carts, and to electric fleet operations. The program is voluntary and will remain in effect until Alameda Municipal Power implements a superseding TOU rate schedule for PEVs or until cancelled by the Public Utilities Board. The EV-X discount will be applied to the charges under the applicable residential (D-1 or D-2), commercial (A-1, A-2, A-3, A-4, CT, or OL) or municipal rate schedules (MU-1, MU-2, or MU-3).

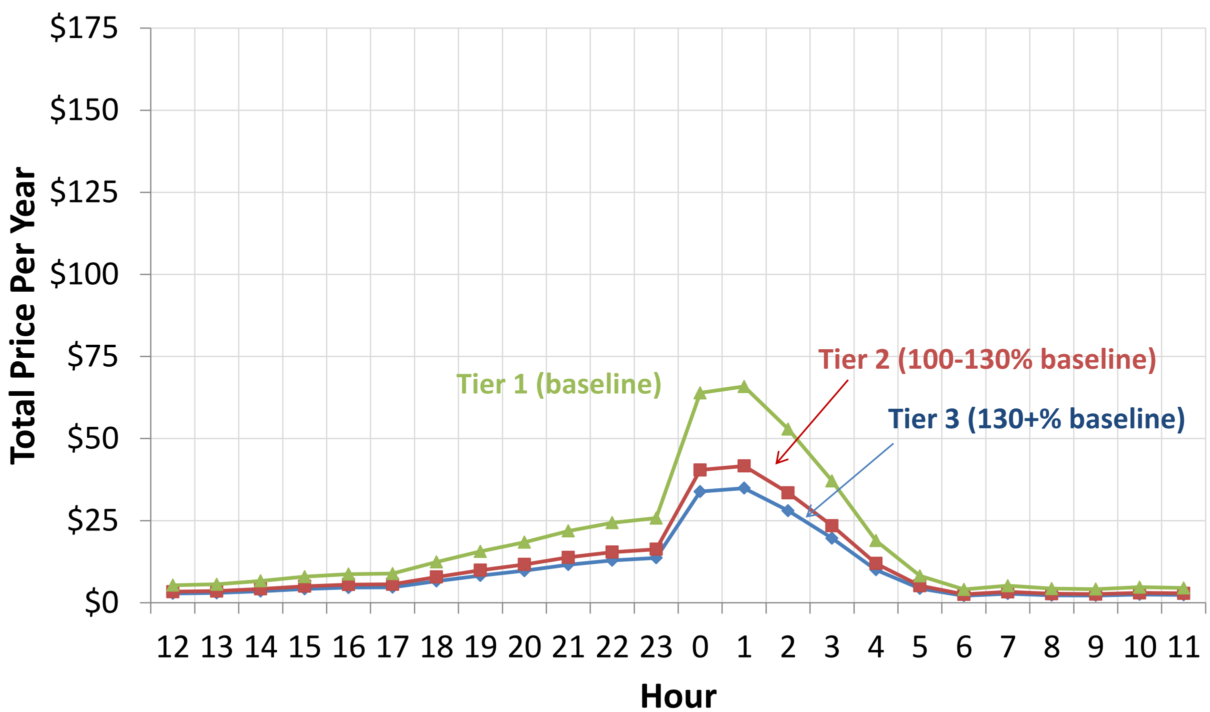
In order to get the discount the customer must agree to charge the vehicle during off-peak hours (between 8:00pm and 8:00am) Monday through Friday and anytime on the weekends and holidays. The discount cannot be greater than the total charges for the month and if the average monthly usage falls below a certain level without proper justification (e.g., vacation), Alameda Municipal Power can remove the customer at any time from the EV-X discount program. With the exception of golf carts and fleet electric vehicles, a separate electric meter is not required, but the utility may incorporate one for research and forecasting purposes. Customers may be asked to participate in an energy audit and a customer survey and must re-qualify for the rate annually by submitting an application and proof of registration. The total annual discount for a very light-duty vehicle (750 lbs – 1,999 lbs GVW) is $108 per year, for a light-duty vehicle (2,000 lbs – 4,999 lbs GVW) is $180 per year, and for a Medium Duty Vehicle (5,000 lbs – 8,000 lbs

GVW) is $252 per year. Commercially-operated golf carts and fleet vehicles may discount 50% of the sub-metered kWh. Considering the low kWh rates and the attractive EV-X discount, it is extremely cost-effective to operate a PEV in the Alameda Municipal Power service territory. For illustrative purposes, the D-1 Rate Schedule was analyzed using the EV-X discount for the light-duty vehicle category only. This is largely because the energy demand for very light-duty vehicles and medium duty vehicles will be considerably different than the energy demand that has been characterized to date using Nissan LEAF driver behavior. As shown in Table 37 below, the discounts for the Tier 1, 2, and 3 average annual costs are significant.

Table 37: Total Annual Cost with EV-X Discount for D-1 Rate Schedule Customers

Tier	Average Annual Cost	Total Annual Cost with EV-X Discount
1, Baseline	$350	$170
2, 100 - 130% Baseline	$420	$250
3 130%+ Baseline	$435	$480

Figure 43. Alameda Municipal Power D-1 Residential Rate (without EV-X discount)



Note: In this figure, as in all subsequent figures related to estimate annual pricing for various rates, the x-axis goes from 12noon to 12noon; the midpoint of the graph is 12midnight.

City of Healdsburg Electric

The City of Healdsburg does not currently provide a special PEV rate and does not anticipate providing one in the future.[142] The utility does provide the E-7 Residential TOU rates for customers who can shift load to the off peak hours, which may benefit PEV owners, but according to a utility survey, very few customers take advantage of the TOU rates. Currently, the City is aware of two PEV charging stations within the service territory, both of which are privately owned. The utility is under the impression these charging stations are operated during both peak and off-peak hours. At this time, the City has not promoted PEVs among utility customers due to a slow adoption rate in the area and the lack of requests for assistance from current PEV drivers.

The D-1 Residential Rate Schedule is comprised of four tiers that are each assigned a daily baseline quantity based upon the billing season. The tiers are set by a baseline quantity, 10.2 kWh per day for each tier in the summer (May 1 – October 31) and 10.8 kWh per day for each tier in the winter (November 1 – April 30). The tiers are designed to indicate annual average usage; first and second tier represent the average household consumption, while the third and fourth tier represent above average household consumption. For PEV customers with above average consumption, the E-7 Residential TOU rate may be a good option to consider. Below is a table portraying the costs for the D-1, Tier 2, 3 and 4 rates compared to the E-7 TOU rate using the average PEV electricity demand within the region. The D-1 Tier 2 rate comes in at the lowest price at $313 per year, just below the price for the E-7 TOU rate at $319. It is worth nothing that it may be difficult for the average household to accommodate both PEV charging needs and average residential consumption at the daily consumption levels required to reach the pricing listed here.

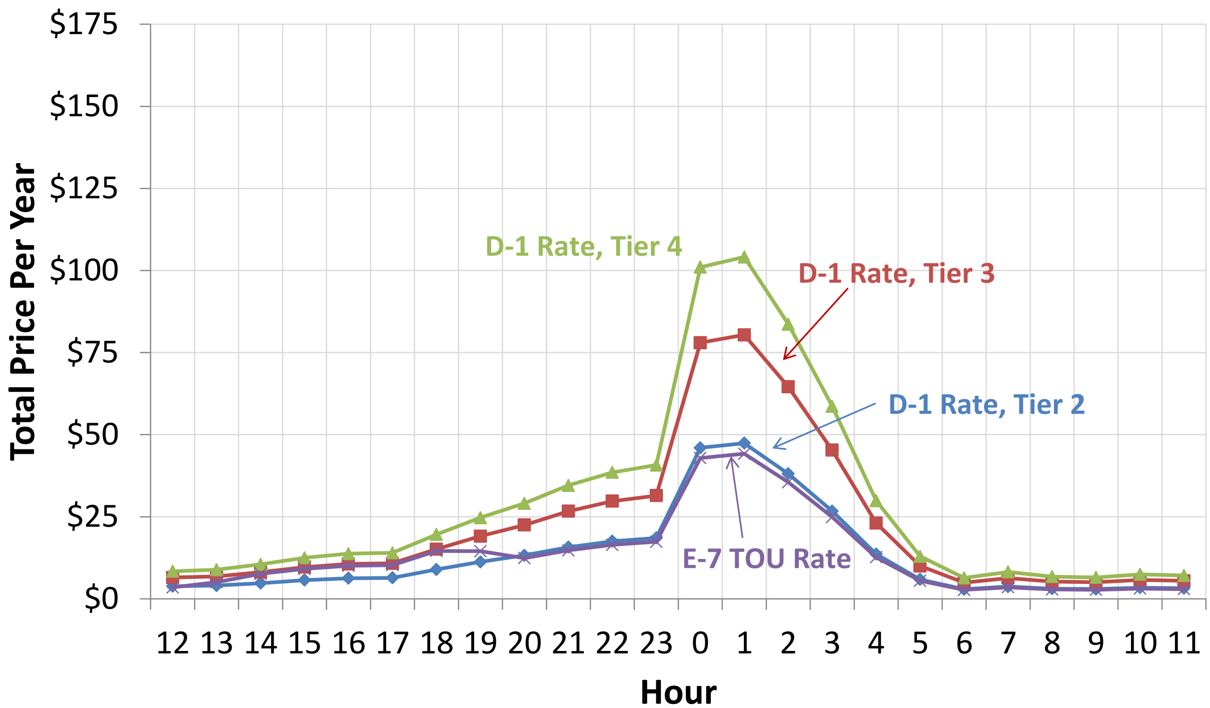
Table 38: Average Annual Cost for the City of Healdsburg D-1 Rate Schedule & E-7 Time of Use Rate

Rate	Daily Consumption	Average Annual Cost
E-7 Time of Use	Unlimited	$319
D-1 Tier 2	20.4 kWh/day summer 21.6 kWh/day winter	$313
D-1 Tier 3	30.6 kWh/day summer 32.4 kWh/day winter	$531
D-1 Tier 4	40.8 kWh/day summer 43.2 kWh/day winter	$688

Figure 44 below portrays the average expenses spread out over the course of the year by rate structure. The E-7 TOU rate does have a slight increase in cost over the D-1 Tier 2 rate, due to a slight increase in costs in the late afternoon.

[142] Email interview, Terry Crowley, Electric Director, City of Healdsburg, August 31, 2012.

Figure 44: City of Healdsburg D-1 Rate Schedule compared to the E-7 Time of Use Rate



The City does not have an official notification protocol for new EVSE. However, most EVSE would require a building permit, which would be issued by the City's Electric department and the City's Building department. To date, the City has not performed a detailed analysis of potential grid impacts to the service territory by PEVs. Until the customer adoption rate increases significantly, the City is not concerned about PEV integration. PEVs would only add a load to the system equivalent to a large hot tub or large AC unit, and customers generally add these appliances without significant impact to the system. The City has never experienced grid impacts in the past from the integration of other high power demand equipment, and to minimize system consumption the City promotes energy efficiency through a variety of customer rebates.

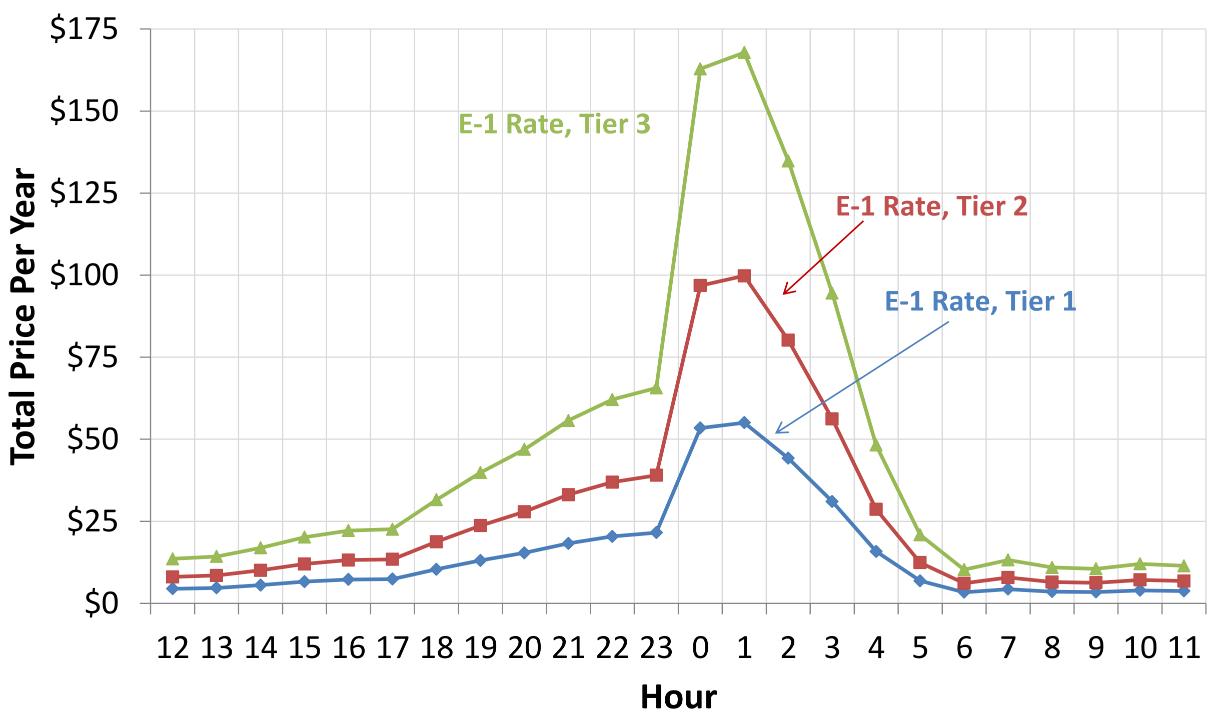
The City has not made plans to integrate PEVs with smart grid technology or to minimize peak usage through the use of battery banks or solar systems. These options are far less cost-effective than shifting commercial AC peak load to off-peak periods through the use of chillers or ice-storage. The City is currently requesting proposals for a pilot program to install chillers on a municipal building. If the pilot project works as planned, roughly 35 kW will be shifted to the off-peak period. This single "shift" will make room for roughly 5 EVSE or 10 households.

City of Hercules

The City of Hercules does not currently provide a special PEV rate and does not anticipate providing one in the future. The City also does not offer a Time of Use rate for customers. So far, the City has documented a few residents with EVSE in the service territory and permit residents to meter their EVSE separately to reduce their rates as needed, but only a few customers have taken this option. [143] The City has not engaged in any type of public outreach or education for PEVs, other than demonstrating their commitment through the installation of two PEV charging stations at City Hall.

The City has an E-1 Residential Rate Schedule applicable to all residential customers receiving metered service and applies to customers in single family dwellings and apartments metered separately by unit. The rate includes a tiered structure that is based on daily energy consumption. Tier 1 is defined as using 0–12 kWh per day, Tier 2 is from 12–35 kWh per day, and Tier 3 is anything above 35 kWh per day. Figure 45 below demonstrates the average yearly costs by hour using the average PEV electricity demand within the region. If residents choose to meter separately, they could easily stay within the Tier 1 service level, spending an average of $364 per year. If residents chose not to meter separately they would most likely be charged at the Tier 2 rate for an average of $659 per year or Tier 3 rate for an average of $1,109 per year.

Figure 45. City of Hercules E-1 Rate Schedule



The City does not have any official notification protocols for the installation of PEV infrastructure, other than informal notification through City staff. The City also has not performed any research to analyze demand for PEVs in the service territory or potential grid impacts, but feels confident given the low number of PEVs to date that they could handle future loads. The City has never ever experienced grid impacts in the past from the integration of other high power demand equipment. So far the City has not seen the need to integrate PEVs with smart grid technologies or to reduce peak demand with battery storage or renewable energy.

143 Email interview, John McGuire, Municipal Services Director, City of Hercules, August 29, 2012.

City of Palo Alto Utilities

The City of Palo Alto Utilities does not currently have a special PEV rate for residential customers, but intends to conduct a PEV pilot study of specialized time of use rates in the 2013 fiscal year. The Utilities Advisory Commission submitted a resolution to the Utilities Department in 2012 with an outline of the PEV pilot program rate and conditions.[144] It is expected that this resolution will be adopted in November or December of 2012.[145] The special PEV rate, also known as the E-1 EV TOU rate, would be based on the E-1 tiered rate structure with a rate reduction during off-peak hours from 11pm to 6am coupled with a rate increase from Noon – 6pm during summer peak. The TOU rate will require the entire house to be on the same rate; a secondary meter is not an option at this time in part due to the additional costs borne by customers and potential lack of interest.[146] The average annual cost to charge a PEV at the Tier 1, 2 and 3 rates, is approximately $195, $270 and $365 respectively. It is unlikely that a household could charge a PEV and maintain average household consumption at Tier 1, so most likely the household would be billed for the Tier 2 or Tier 3 rate.

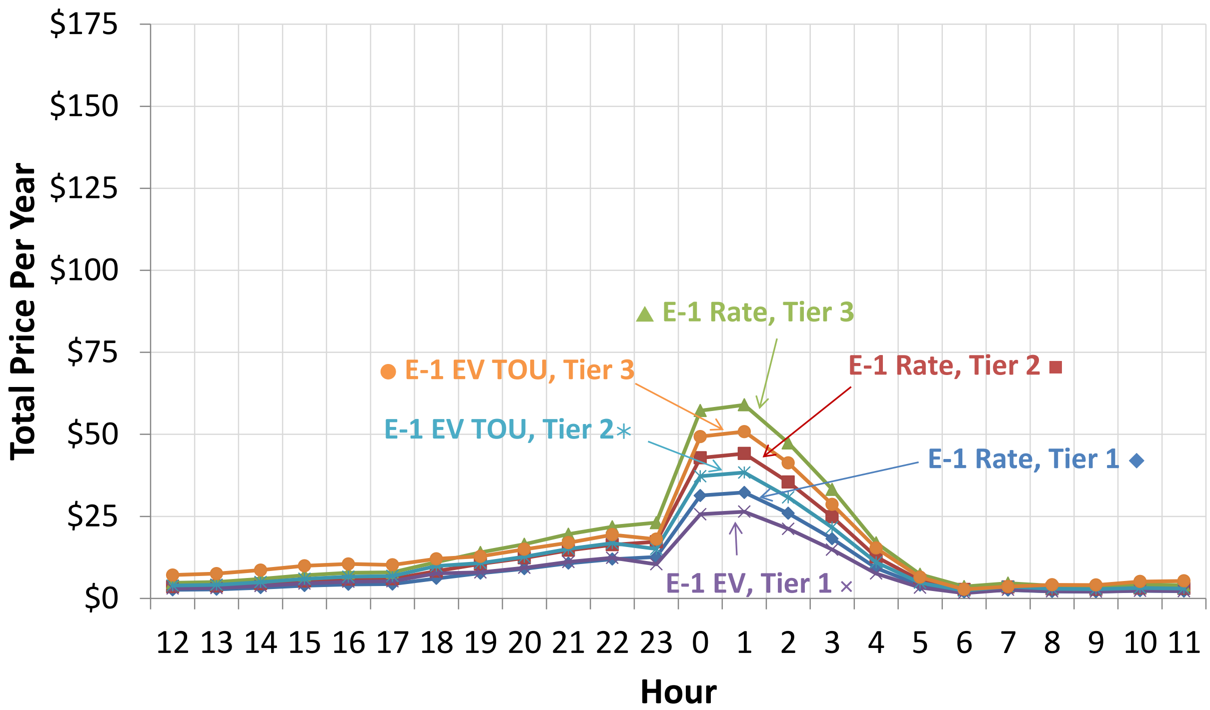
The City's tiered residential flat rate, otherwise known as the E-1 Residential Rate Schedule, is based on 10 kWh per day, regardless of the season. Based on PEV consumption data, it is likely that the average annual Tier 1, 2, and 3 rates would cost approximately $210, $290 and $390 per year respectively. Given the uncertainties surrounding the potential cost savings from the TOU rate, it is unclear whether or not customers will choose this rate. Based on information from the City of Palo Alto, the utility currently has a commercial TOU rate, which includes a demand charge. To date, no commercial customers have opted for this rate.

[144] City of Palo Alto Utilities Advisory Commission, "Memorandum," July 11, 2012, http://www.cityofpaloalto.org/civicax/filebank/documents/30094.

[145] Telephone interview, Shiva Swaminathan, Senior Resource Planner, City of Palo Alto Utilities, August 7, 2012.

[146] City of Palo Alto Utilities Advisory Commission, "Memorandum," July 11, 2012, pg. 5, http://www.cityofpaloalto.org/civicax/filebank/documents/30094.

Figure 46: Palo Alto Utilities E-1 Rate Schedule



The City estimates it currently has between 180 and 200 PEVs currently within its service territory of 25,000 residential and 4,000 commercial customer accounts. The City primarily educates its customers through its website, joint efforts with regional PEV groups, and through City policies, such as the Electric Vehicle Infrastructure Policy, which created recommendations to streamline city EVSE permitting processes and develop City public infrastructure guidelines.[147] The City also has five openly accessible charging stations in downtown Palo Alto that are free to the public.

The City does not have any official notification protocols for EVSE installations. However, the City does require permits for certain residential EVSE installations and the City building permit department notifies the Utilities Department when permits are approved. The City also obtains vehicle sales information from GM and Nissan as part of The EV Project. Based on preliminary growth projections from the CEC, Palo Alto may have an additional 3,000 to 10,000 PEVs in the area by 2020. This would increase consumption by 1–2%; however, it is not clear what specific grid impacts would occur under that scenario.

The City has taken precautions to prevent potential grid impacts by providing an EV TOU rate and through a demand response program that would reduce load during critical times. They currently have an on-going pilot project with a local organization that would include features such as remote disconnection of charging units and vehicles. However, the utility does not have plans to immediately implement these programs at this time. Most of the current grid impacts

[147] City of Palo Alto, "Electric Vehicle Infrastructure Policy," December 19, 2011, http://archive.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=29734.

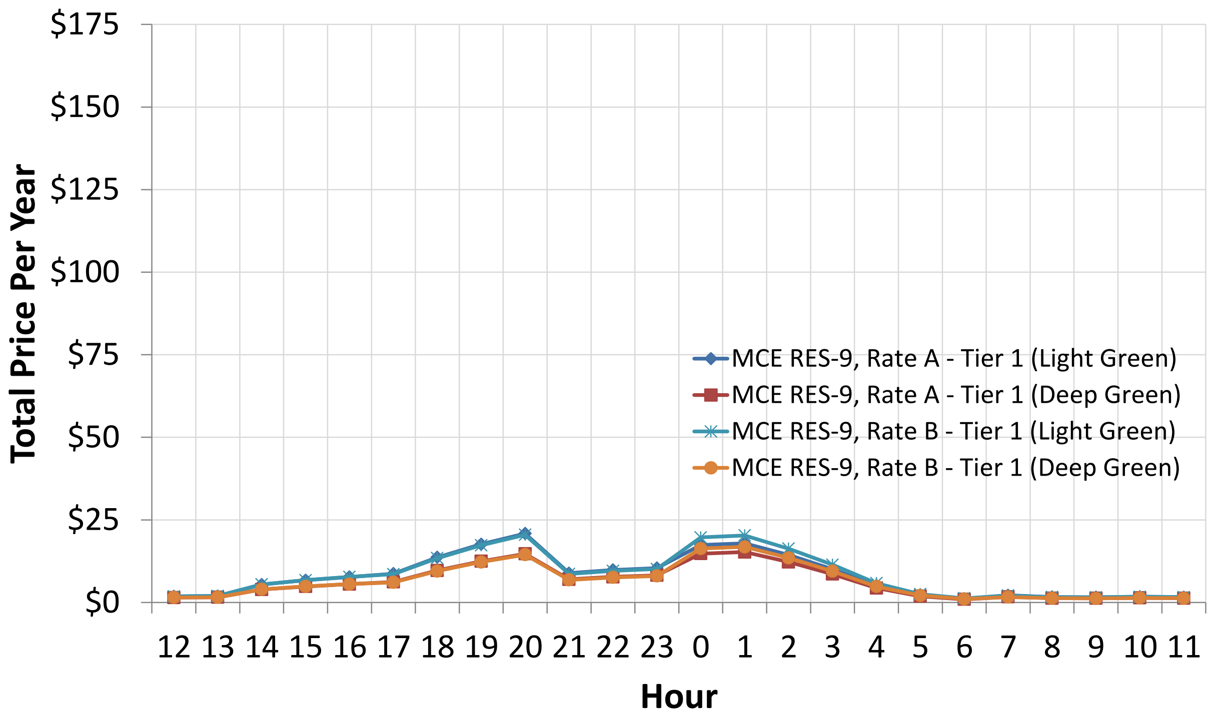
experienced within the City are related to frequent power quality issues, more so than residential demand. The City does not have any future plans to promote PEVs through other incentives, such as rebates, and has not made plans to mitigate peak PEV charging through battery storage or renewable energy.

Marin Clean Energy (MCE)

Marin Clean Energy (MCE) is a non-profit electric service provider that is governed by the Marin Energy Authority. MCE offers two renewable energy options for customers within the PG&E service territory. The Light Green option provides 50% renewable energy and the Deep Green option provides 100% renewable energy for an extra penny per kWh. MCE has a special PEV rate, known as the RES-9, which is comparable to PG&E's E-9 rate. Like all of MCE's TOU schedules, and due to transmission and distribution services from PG&E, the RES-9 schedule uses the same TOU periods to PG&E's current E-9 rate schedule. MCE also offers other flat rate and TOU options comparable to PG&E. The RES-1 is the equivalent flat-rate option to PG&E's E-1, and is tiered in the same way as PG&E's rates, via PG&E's Conservation Incentive Adjustment. For purposes of Figure 47, only Tier 1 rates and the current PG&E Schedule E-9 are shown, since MCE has not yet released their revised generation costs for the new PG&E Schedule EV.

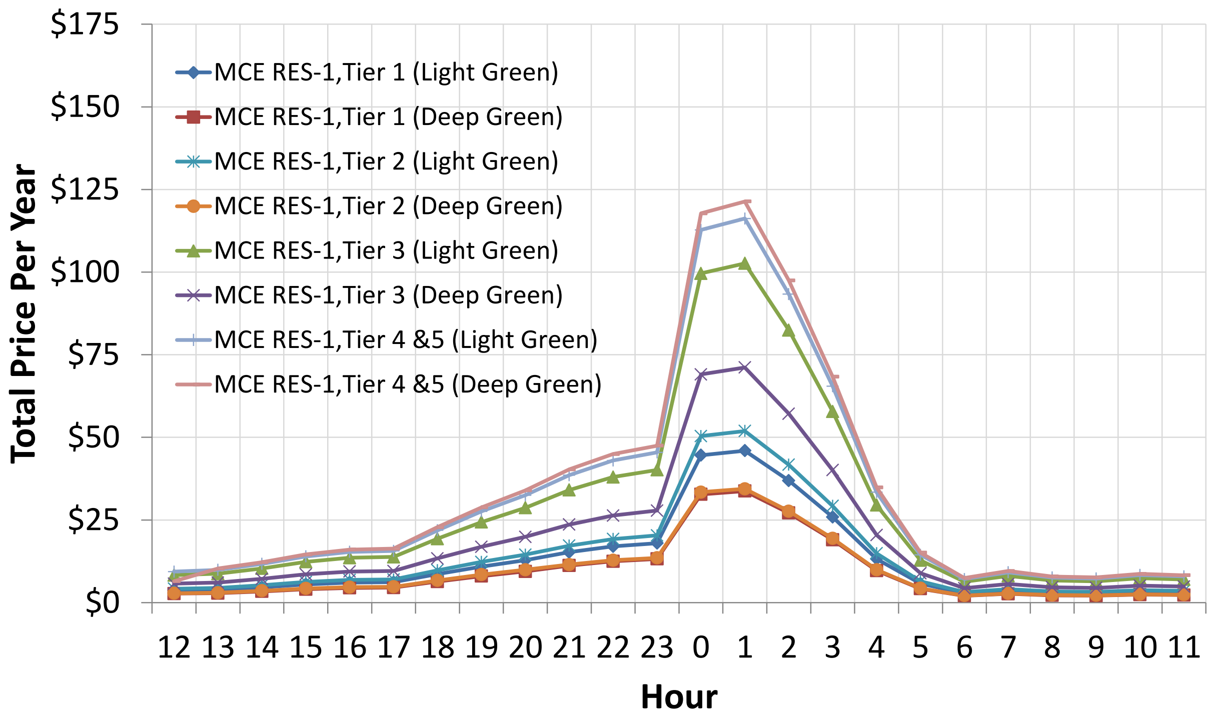
If a customer were to switch to MCE after July 2012, PG&E would charge a PCIA Fee of $0.00841/kWh and a Franchise Fee of $0.00049/kWh, in addition to corresponding PG&E transmission charges and fees. As customers remain with a third-party electric provider, they can expect these fees to decrease. Despite the additional customer charges, the MCE Light Green RES-9, Rate A and Rate B are both affordable at $190 and $200 per year respectively as shown in Figure 48 below. The Deep Green option adds an extra $35 per year.

Figure 47: Marin Clean Energy RES-9 Rate Schedules



The RES-1 tiered rate schedule may be potentially much more costly for consumers. The Tier 1 rates are very attractive at $304 per year, but it is unclear whether or not the average household would be able to remain under that threshold with the baseline quantities ranging from 7.5–23.5 kWh per day in the summer depending on the baseline territory. As customers advance to the Tier 2, Tier 3, and Tier 4 & 5 (same rate) their yearly costs go up to $343, $678, and $768 per year respectively. The Deep Green option adds an extra $34 per year.

Figure 48: Marin Clean Energy RES-1 Rate Schedules



Since MCE does not have any way of tracking how many PEV customers are in their service territory, it is unclear how many PEVs are currently in operation.[148] MCE does not encourage PEV customers to use any particular rate, as it greatly depends on the lifestyle and consumption patterns of the individual customer. Additionally, all rate changes for MCE customers must still be done through PG&E, so MCE is rarely asked to participate in such decisions.

MCE supports PEVs and has assisted with the installation of five electric vehicle charging stations for its member agencies. While MCE does frequently discuss PEV usage during company activities, the company does not spend significant effort educating customers, as it is outside of their scope of business. MCE has been supportive of PEVs and have been making community investments to promote their use. The RES-9 rate schedules have only seen limited use, and will need to be evaluated for their efficacy as MCE continues to serve additional customers with PEVs.

MCE does not have any notification protocols for PEV customers, as installers would need to contact PG&E, which handles all of the relevant transmission, distribution, and interconnection issues. Transmission and distribution services for Marin, including grid reliability, are still covered through PG&E service and PG&E charges. Unlike a municipal utility, Community Choice Aggregations are only responsible for procuring electricity for its customers' demand, not for interconnections and maintenance of the grid. As such, MCE has not performed any research to analyze PEV demand in their service territory.

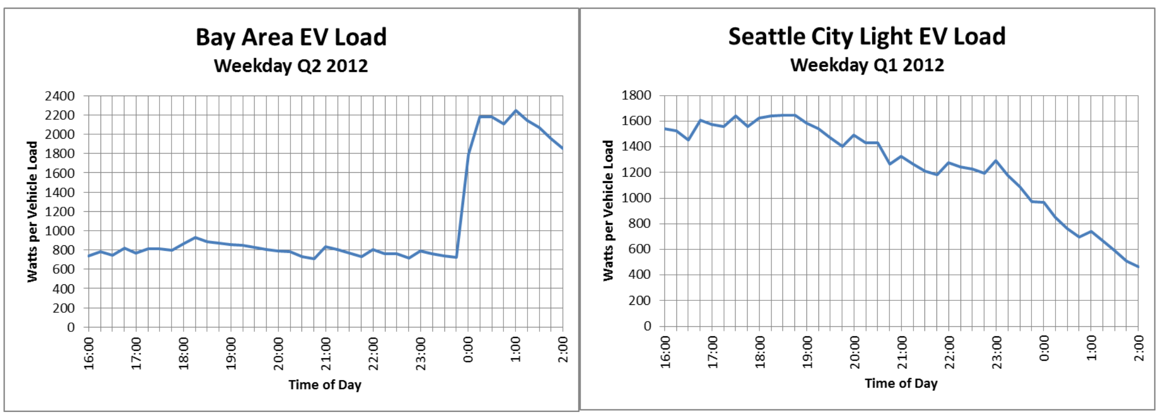
148 Email interview, Justin Kudo, Account Manager, Marin Clean Energy, August 29, 2012.

Pacific Gas & Electric (PG&E)

As the largest utility in the 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.

According to ECOtality, the impact of TOU rates is evident from looking at the charging profile of customers in PG&E's service territory. As noted previously, PEV drivers in the Bay Area plug in their vehicles around the same time of day as drivers in other regions participating in the EV Project. However, the actual charging events do not start until around midnight, with the first peak actually occurring about 15 minutes later. ECOtality reports that many drivers will program the charge to occur after the start of the TOU rate to make sure that the entire charge is off peak.

Seattle City Light is typical of most regions that participate in the EV Project (shown on the right below): The PEV driver connects the vehicle upon arrival at home. Without an incentive for delay of charging, the driver immediately commences the charge.



PG&E has proposed two PEV rates that are aligned with the goal of PEV customers using more electricity to charge on the off-peak hours, EV-A and EV-B. 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 plans on sunsetting its current E-9 rates by December 2014, which discourage additional PEV charging due to their tiered structure. For the new EV-A and EV-B 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.

According to information provided by PG&E, approximately 1/3 of PEV customers are currently using the E-9 rate, with only 2-3% selecting the E-9 Rate B (requires the installation of a secondary meter). Approximately 95% of the installations are located at single-family homes.

PG&E seeks to increase the number of EV rate users through a series of marketing and outreach activities, including the development of a PEV Rate Plan Comparison Calculator[149] on its Electric Vehicle website and a real-time energy consumption tool on its 'Myenergy Tool' for existing customers. PG&E does not have any immediate plans to introduce sub-metering or to develop a commercial rate for EVs.[150]

The most significant differences between the current Schedule E-9 and the new Schedule EV is the elimination of the tiered structure, elimination of the monthly customer charge, and modification of the TOU periods to increase the number of off-peak hours on weekends. In order to address concerns about consumer fairness, PG&E did increase rates for off-peak charging, but with all of the other adjustments to streamline the program and mitigate other costs, the rate increase would most likely benefit the greatest number of PEV customers over the long-term. The current and proposed new rates are listed in Table 39 below.

149 PG&E, "Plug-In Electric Vehicle Rate Plan Comparison Calculator," accessed October 10, 2012, http://www.pge.com/cgi-bin/pevcalculator/PEV/.

150 Interview with David Ulric, PG&E, October 8, 2012.

Table 39: Current Schedule E-9 compared to future Schedule EV

	Current Schedule E-9		Illustrative Schedule EV	
	E-9(A)	E-9(B)	EV(A)	EV(B)
Summer				
Peak	Tier 1 – 0.30178 Tier 2 – 0.31994 Tier 3 – 0.50415 Tier 4 – 0.54415	Tier 1 – 0.29726 Tier 2 – 0.31541 Tier 3 – 0.49962 Tier 4 – 0.53962	0.35656	0.35120
Partial-Peak	Tier 1 – 0.09876 Tier 2 – 0.11692 Tier 3 – 0.30113 Tier 4 – 0.34113	Tier 1 – 0.09424 Tier 2 – 0.11239 Tier 3 – 0.29661 Tier 4 – 0.33661	0.19914	0.19646
Off-Peak	Tier 1 – 0.03743 Tier 2 – 0.05559 Tier 3 – 0.16011 Tier 4 – 0.20011	Tier 1 – 0.04479 Tier 2 – 0.06295 Tier 3 – 0.24716 Tier 4 – 0.28716	0.09712	0.09674
Winter				
Peak	Not Applicable	Not Applicable	0.26694	0.26118
Partial-Peak	Tier 1 – 0.09864 Tier 2 – 0.11679 Tier 3 – 0.30101 Tier 4 – 0.34101	Tier 1 – 0.09462 Tier 2 – 0.11277 Tier 3 – 0.29699 Tier 4 – 0.33699	0.16472	0.16184
Off-Peak	Tier 1 – 0.04680 Tier 2 – 0.06495 Tier 3 – 0.16011 Tier 4 – 0.20011	Tier 1 – 0.05339 Tier 2 – 0.07155 Tier 3 – 0.25576 Tier 4 – 0.29576	0.09930	0.09889
Meter or Customer Charge	$0.21881/meter per day	$0.21881/meter per day	$0	$0.04928/meter per day

For illustrative purposes, the current Schedule E-9 to the new Schedule EV for the Tier 1, 2, 3, and 4/5 rates are shown. It is evident that the current Schedule E-9 could save consumers money if they were able to remain within the lower Tier 1-2 categories. The Schedule E-9 in the Tier 1 bracket would cost an average of $156 or $247 per year in addition to a $96 annual fee for Rate A and B respectively, but would go up significantly past the new rate once consumers went into the Tier 3, 4 or 5 rates as shown in Table 40 below. According to documents published by the California PUC[151], it appears that PG&E may be receptive to grandfathering consumers who are currently in this rate schedule for an additional period of time. The new EV-A and EV-B rates may help to reduce costs for the average PEV driver if they use more energy or if they are currently on the E-1 Rate Schedule. The EV-A rate will cost a consumer on

[151] Public Utilities Commission of the State of California, Resolution E-4805, August 23, 2012.

average about $380 per year and the EV-B rate will cost an average of $320 plus an annual meter charge of $18.

Table 40: Average Annual Cost for PG&E Schedule E-9 and Schedule EV

Rate	Tier	Baseline	Average Annual Cost	
			Rate A	Rate B
Schedule E-9	1	Baseline	$156	$247
Schedule E-9	2	101-130% of Baseline	$195	$202
Schedule E-9	3	131-200% of Baseline	$465	$594
Schedule E-9	4	201-300%+ of Baseline	$551	$680
Schedule EV	N/A	N/A	$380	$320

Figure 49: Current PG&E Schedule E-9 compared to the new Schedule EV

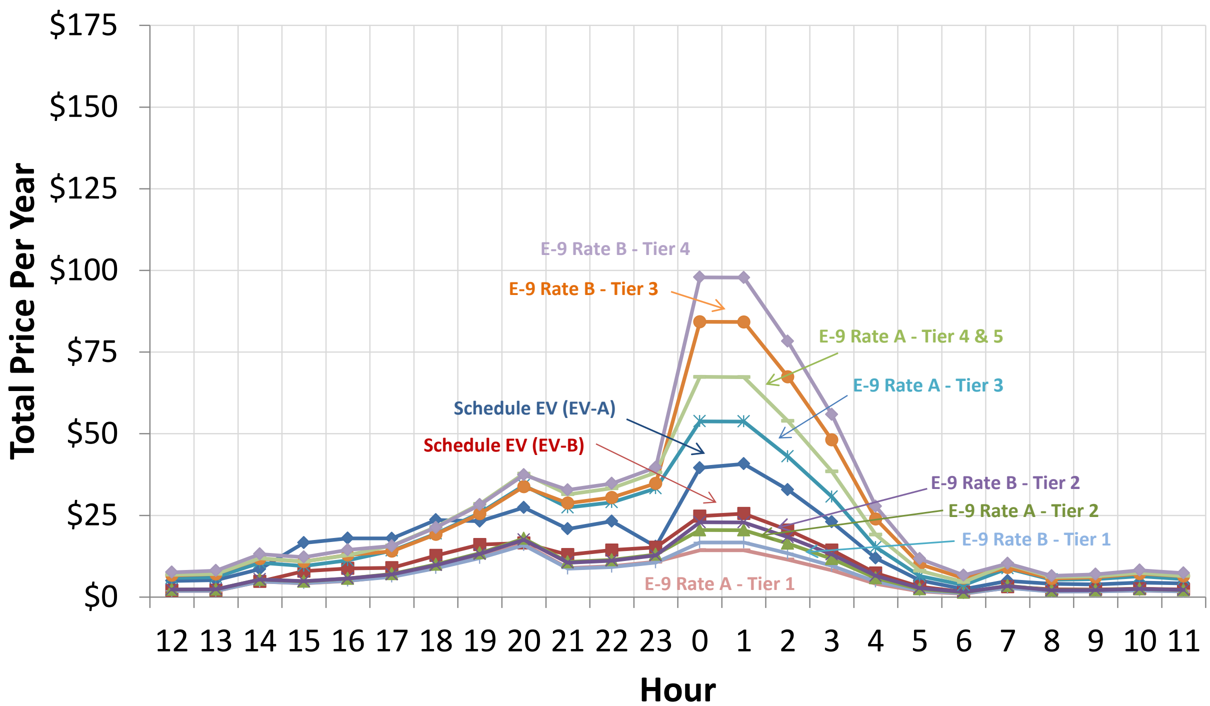
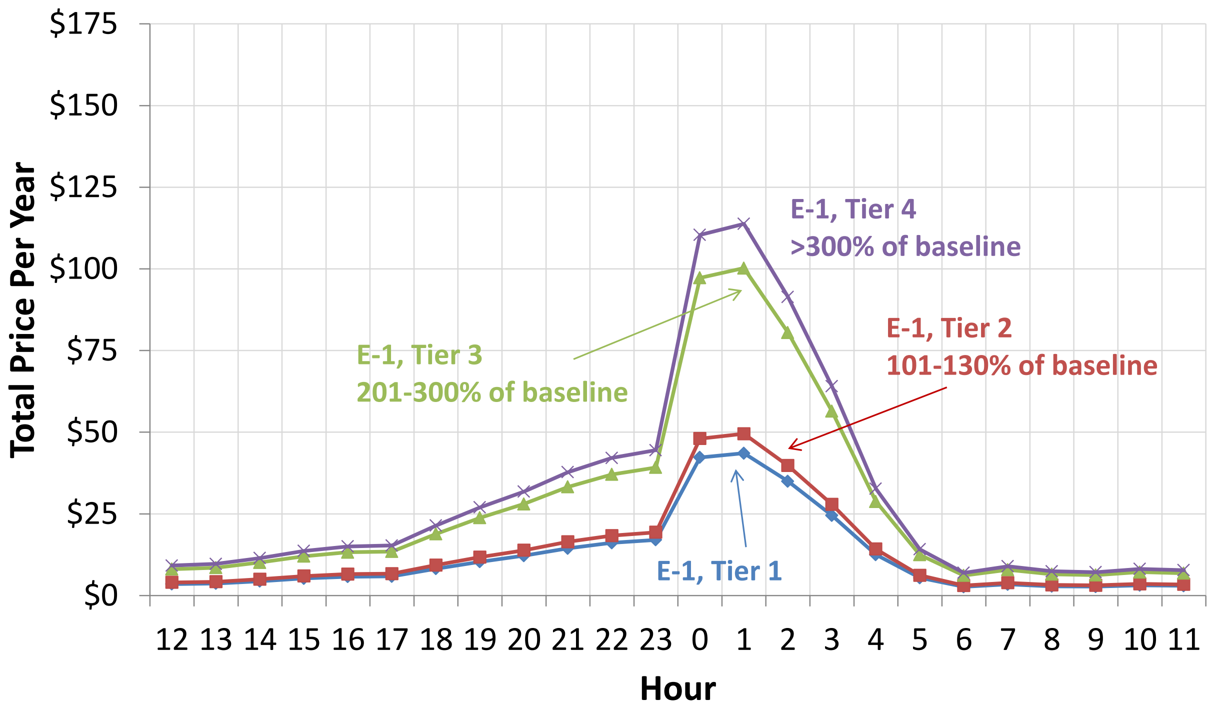


Figure 50: PG&E E-1 Tiered Rates



PG&E has released a smart grid analysis report as requested by the CPUC and is currently developing a set of criteria for smart grid and automated demand response (ADR) services. PEVs are considered good candidates for smart grid technologies and ADR, but will need to compete with a larger suite of technologies to address reliability and available power. PG&E will likely have PEV pilot projects as part of their future smart grid efforts to understand the potential role for PEVs as part of a broader smart grid strategy. To date, PG&E has not experienced any adverse grid impacts from PEVs and do not anticipate any issues in the near-term future assuming moderate levels of PEV adoption. Moving forward, PG&E plans to expand its local outreach to consumers and interaction with local governments as needed, with some focus on utility notification protocols. To date, PG&E has interacted with the California DMV and the OEMs for notification purposes, but is keen on ensuring that more customers are notifying them directly.[152]

San Francisco Public Utilities Commission (SFPUC)

The SFPUC does not provide electricity to retail customers, other than a portion of the housing authority.

Silicon Valley Power (SVP)

Silicon Valley Power does not have a special PEV rate and does not anticipate creating a separate PEV rate in the next five years, but will reassess the need for Santa Clara electric

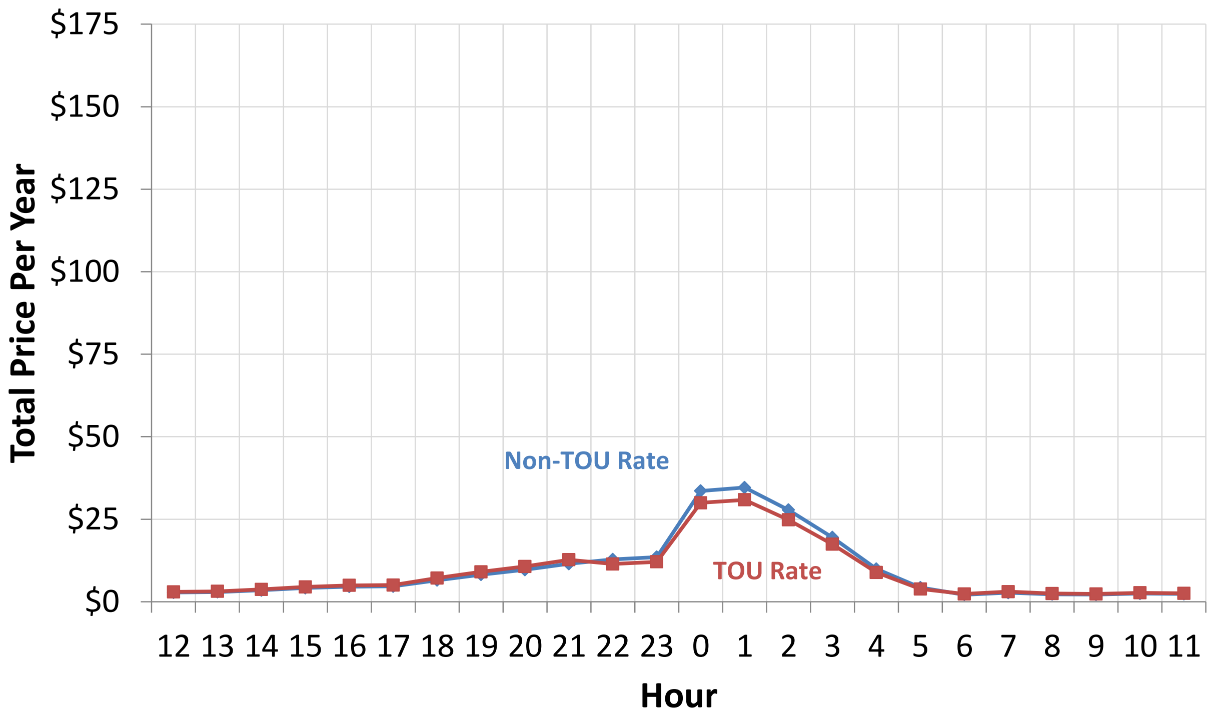
[152] Interview with Ulric Kwan, PG&E, October 8, 2012.

customers at that time.[153] To date, SVP has nearly 50 customers out of approximately 50,000 who have either purchased or are purchasing PEV's with Level 1 or Level 2 EVSE. The City of Santa Clara's permitting department has worked collaboratively with permitting agencies in the three counties of the South Bay Area to standardize and expedite EVSE permitting with a publicized set of guidelines. SVP has not engaged in any substantive or organized public education on this topic, but has responded to inquiries very positively.

SVP has a D-1 Rate Schedule for Domestic Service defined as single-family dwellings or any other multi-unit dwellings that are individually metered. The D-1 rate offers two options, a non-TOU rate and a TOU rate. The non-TOU rate is $0.08877/kWh for the first 300 kWh each month, and then any excess is $0.10205/ kWh. The TOU option has a peak and off-peak price for the first 300 kWh and a different rate over 300 kWh. At this time, SVP does not have any TOU customers. SVPs unusually high system load factor (a very flat load curve with virtually no summer peak) greatly reduces the on-peak, off-peak cost differential when buying wholesale power, which is characterized by SVPs on-peak time window from 6:00 AM to 10:00 PM. According to SVP, no customers have yet seen the TOU rate as attractive. For purposes of comparison, since sub-metering is not yet an option for EVSE in SVP, Figure 51 below assumes that PEV charging will be charged at the rate over 300 kWh per month given average household consumption and PEV electricity demand for the region. Interestingly, the TOU rate for PEV charging is slightly less than the non-TOU rate at an average of $219 per year compared to $229 per year. However, a residential customer would need to take into account average household consumption over the course of the day, which may negate any potential savings from the TOU rate.

[153] Email interview, Larry Owens, Manager of Customer Services, Silicon Valley Power, August 30, 2012.

Figure 51: Silicon Valley Power Non-Time of Use Rate compared to the Time of Use Rate



EVSE notification is done in two ways at SVP; through the permitting department and through a special PEV industry report (via Oceanus) of sales to businesses and residents of Santa Clara. SVP does not have an official notification protocol at this point and relies primarily on the above two methods. SVP cannot account for new PEVs in instances where a PEV driver uses Level 1 charging and therefore does not require a permit, or missing notifications from the permitting office as SVP only requests permits related to service panel upgrades.

SVP commissioned a telephone survey in 2010 of residents in its service territory that covered a variety of topics including interest in PEVs. A full 25% of those surveyed expressed interest in owning or leasing an electric vehicle with 72% of those considering a move in the next 2-3 years. SVP anticipates the potential for grid impacts to be minimal and focuses primarily at the local distribution transformer level for grid upgrades. SVP has more than enough generation, transmission and distribution capacity to accommodate even the highest penetration estimates for PEVs and that the majority of its existing distribution transformers can handle the addition of PEV charging at the expected penetration without concern. As a practice, SVP designs and builds its system to handle twice the expected load. SVP runs its distribution loaded to 50% and make upgrades when that level is exceeded. SVP does this intentionally so that added load (expected and unexpected) is not a problem. A 25% penetration of PEVs would not cause impacts to SVP's grid, with the potential exception of overloading a local distribution transformer. However, if issues arise at the local distribution transformer level, SVP is prepared to upgrade any suspect transformer at its own cost.

SVP has prepared to react to such overloading and are working to predict that potential overload through its SVP MeterConnect program (advanced metering). SVP has designed the advanced metering system program to obtain data and device carrying capacity with a robust set of options for communicating with PEVs, solar photovoltaic systems and smart appliances. SVP has expressed interest in sub-metering EVSE, but to date has not enacted a policy. One of the primary reasons for sub-metering PEV charging stations is to account properly for GHG production. A second reason for sub-metering is to analyze the merits of load management. SVP is not interested in unnecessarily limiting a PEV customer's flexibility to charge whenever they want, but may need to institute demand response upgrades through electric vehicles to avoid transformer overload instead of the preferred and simple upgrade of a transformer. At this time, SVP has not invested in battery storage or on-site renewable energy for PEV integration, as less expensive alternatives are available.

10.4. Recommendations

The following sections outline prioritized steps for utilities in the Region and their corresponding local governments to modify utility rates and grid infrastructure to prepare for increased deployment of PEVs. As there are significant differences between an approval process for an investor-owned utility, such as PG&E, and a publicly-owned utility, such as Alameda Municipal Power, each community will need to assess the relevance and likelihood of adoption for certain portions of the plan.

It is important to note that in many cases, the prioritized elements below apply almost exclusively to utilities and are likely beyond the purview of local government action. However, many local governments in the process of becoming PEV Ready may not be involved in utility planning. This is particularly true for local governments that are in PG&E's service territory. In these cases, it is incumbent upon PG&E to identify the optimal pathway for becoming PEV Ready. However, the issues outlined below should be familiar to local government staff as they work to become PEV Ready – and increased familiarity with these issues and concerns will improve the communication between local governments and utilities like PG&E.

Evaluate Rate Structures and Impact on PEVs

Utility rate structures are one of several key decision factors for potential PEV consumers, and can represent the difference between a consumer accruing a return on their investment or a realizing a net loss. Given the higher purchase price of PEVs compared to conventional vehicles, the most significant savings for consumers is from a reduction in fuel expenditures. Utilities in the region should evaluate their rate structures in the context of the potential impact on PEV consumers. These include an analysis of a secondary meter options, alternatives to the traditional tiered rate structure, and options for existing or future of TOU rates.

A detailed analysis of current rate structures available to PEV drivers in the Region was performed using a combination of charging data provided via The EV Project and BAAQMD. The data have been accrued from the inception of the project in 2010 through June 2012 and most closely represents the average monthly residential charging patterns of PEV owners in the Bay Area and Monterey Bay Area. The key findings of this analysis of existing rates and current charging profiles include the following:

- To date, the most attractive rates and programs available to PEV drivers are through Alameda Municipal Power, which has an experimental PEV discount and Silicon Valley Power, which has low residential rates.
- PG&E may want to consider amending an existing PEV rate. The PG&E PEV TOU rate, also known as the E-9 Rate Schedule, was initially very confusing for consumers and has since been revised. However, the rate does not align the peak and mid-peak rates to correlate with the average demand curves of customers. This has resulted in a spike in energy usage in the late evening, which could cost the average PEV driver an extra $130-$160 per year.

As a result of this analysis and outreach to local government staff and utilities, BAAQMD recommends the following priority actions related to residential rate structures:

Assess alternatives for tiered rate structures

A potential barrier to PEV adoption is the prevalence of tiered residential rate structures among the utilities in the Region. California has used the tiered structure to incentivize energy conservation. Unfortunately, the tiered rate structure does not take into account the environmental benefits of PEVs and in many cases could result in significantly higher utility bills for the average PEV driver. According to the analysis presented in Section 10.3, the most significant annual costs were the direct result of the highest tiered rate structures. Given their high daily consumption of approximately 9 kWh, charging a PEV at home may bump a residential consumer into to a higher tier. To remedy this problem, some utilities have evaluated alternatives to tiered rates. For instance, Silicon Valley Power offers a single rate structure for PEVs and PG&E offers TOU rates for PEV charging.

Utilities should consider amending existing tiered rate tariffs to include PEV-friendly programs, such as:

- Offer a PEV rate structure comparable to a medical baseline program. A medical baseline rate increases the baseline level for qualified consumers who have significant energy consumption at home due to the use of medical equipment. A similar program could be made available to qualifying PEV owners.
- Offer a PEV discount rate comparable to that offered by Alameda Municipal Power, which provides a flat discount based on gross vehicle weight to eligible customers off their tiered rates. Customers must apply annually for the program and agree to charge during off-peak hours.
- Offer alternative to tiered rate structure for PEV drivers.

Evaluate Time of Use Rates

As discussed previously, TOU rates can be an effective tool to mitigate grid impacts by encouraging consumers to charge during certain periods. However, based on information gathered from utilities in the Region, not all utilities offer a TOU rate option. Among the utilities that do offer a TOU rate option, very few customers currently use that rate. Utilities cited lack of interest, concerns about costs, particularly for whole-house TOU rates, and lack of consumer information as the primary reasons for the lack of adoption. PG&E and municipal utilities should consider TOU rate options that preserve fairness to other ratepayers, allow for secondary metering at low cost to the customer, and do not include eliminate or prevent the introduction of demand charges (if applicable), and ensure that consumers have adequate information to select the best rate for their lifestyle.

In addition to mitigating grid impacts, there are other reasons why utilities may want to encourage TOU rates among customers. For example, under recently approved modification to the LCFS regulation, utilities that earn LCFS credits for electricity supplied as a transportation fuel must use proceeds from the sale of said credits to benefit current PEV customers. Among these benefits, the modifications explicitly state that utilities must provide rate options that encourage off-peak charging and minimize adverse impacts on the electrical grid. The differential between the carbon intensity of PEVs and conventional vehicles using gasoline is significant; even at relatively modest levels of PEV adoption, the revenue potential from the sale of LCFS credits earned by utilities is significant. This is effectively a built-in mechanism for utilities to recoup some of, if not all of, the costs associated with evaluating TOU rates that benefit consumers while avoiding on-peak charging.

Review options for secondary meter

Only a few utilities within the Region currently offer an option for residential customers to install a secondary meter for EVSE, such as the City of Hercules and PG&E. A secondary meter, or sub-meter, would provide a number of added benefits to both the consumer and the utility. These benefits include:

- For the consumer, the benefits of secondary metering are largely based on potential cost savings:
  - Secondary metering may save consumers substantially on the installation of EVSE. About 75% of California's residential building stock was constructed before 1985, which means that many homes will have circuits ranging from 60–100 A. Newer homes may have circuits up to 200 A. The costs of upgrading to a more appropriate circuit for EVSE and PEV charging (e.g., 200 A) are substantial: These costs have been estimated up to $12,000 depending on the work required and the service territory. On the other hand, the cost for a consumer to add a secondary meter using a new drop would be between $500 and $1,500[154], representing a significant cost savings.
  - Maintaining low bills for residential customers. A second meter option would guarantee a reduced rate for the majority of PEV drivers in the Region by staying within the baseline level of tiered rate structures and eliminating the need to be on a whole-house TOU rate structure, which is typically not optimal for the majority of residential customers.
- For the utility, the benefits may include the following:

[154] Telephone interview, Shiva Swaminathan, Senior Resource Planner, City of Palo Alto Utilities, August 7, 2012.

- Analyzing the merits of load management and demand response programs. With a second meter option, a utility could accurately account for charging patterns of its consumers and determine whether or not load management or demand response programs would be sufficient to mitigate grid impacts.
- Built-in assessment for local grid upgrades. The installation of a second meter would provide an opportunity for the utility to determine if upgrades to the local distribution infrastructure and transformers are required in certain service territories – particularly in areas experiencing PEV clustering. This differs from an installation that does not require a second meter because that may only involve the utility via notification.
- Improved accounting for GHG emission reductions. A second meter option would potentially simplify and streamline the process of earning LCFS credits for electricity consumed by PEVs. Based on proposed modifications to the LCFS regulation (December 2011 proposed regulatory amendments), utilities will have an opportunity to earn LCFS credits.

Utilities without a second meter option could request an amendment to the tariffs from their local utility review boards to approve the inclusion of a second meter option. Considering all of the potential benefits to the utility for a second meter, utilities may want to consider providing a rebate program that would supplement the consumer's cost of installing the second meter or pro-rate the cost of the second meter over a period of time on the monthly utility bill instead of requiring the cost to be paid for entirely up front.

The impact of second meters will be dependent to some extent on the CPUC's Submeter Protocol. The CPUC directed the California IOUs to work with EV industry stakeholders to establish a Submeter Protocol. The Protocol will identify meter and communications requirements and address needed tariff changes in order to facilitate customer billing from readings from an embedded EVSE or vehicle meter. This ability will allow more flexibility for the customer to select a PEV rate without having to install a second panel and separate meter and should result in simpler and cheaper options for customers. Several issues have been identified in the process including the traditional electric utility operation with the meter itself. For instance, utility meters are typically accessible to the utility at any time and can be removed or replaced for testing and accuracy validation and calibration. Access does not require entry to the home and all meters are equipped with tamper evident seals to prevent energy theft. If the meter is located inside the EVSE in an enclosed garage or within a PEV that is on the road away from home, how can these traditional requirements be met? The Protocol development is ongoing and a final draft is expected to be submitted to the CPUC in September 2013.

Create Utility Notification Protocol

As noted previously, one of the primary causes for concern for PEVs is clustering of the load. Utilities generally have a transformer replacement program to target regularly transformers that have reached the end of their useful life or have been identified as grossly overloaded. However, the adoption of PEVs may occur faster in some areas, thereby causing gaps in the information that utilities would generally use to inform their replacement programs. Some replacements occur because a transformer fails while in service; utility notification protocols can help avoid transformer failure. In order for utilities to minimize the potential grid impacts of charging PEVs, they need to know where the vehicles are being deployed and how they are being charged (e.g., Level 1 vs. Level 2). This information allows the utility to evaluate if the local distribution system is adequate to serve PEV charging needs. For commercial installations that require electrical inspectors and permitting (e.g., Google's facilities team installing 40 Level 2 EVSE at its main campus), there is less risk associated with utility notification because the entities involved are more accustomed to dealing with utilities. However, with residential installations, utility notification protocols that can adequately manage large volumes of residential notifications through automated processes are non-existent.

The typical residential installation will have three (3) parties: 1) the homeowner and PEV driver, 2) the contractor, and 3) the electrical inspector. The electrical inspector is there to protect the interests of the homeowner on behalf of the local government. Contractors engaged in the installation of EVSE have generally been trained to encourage the homeowner to contact his/her local utility and notify them of the installation. Even if homeowners do not contact their utility expressly to notify them of an EVSE installation, most homeowners likely will take advantage of special PEV rates offered by utilities. Despite these various opportunities to notify the utility, there is still considerable anecdotal evidence of homeowners who have chosen to forgo utility notification after installing EVSE and charging a PEV. Even at low rates of non-notification, this has the potential to become a significant problem.

In California, advance notification began on an ad hoc basis, but in July 2011 the CPUC directed utilities to conduct an assessment of early notification efforts and evaluate opportunities to formalize the process. As discussed previously, in a joint report with SCE regarding PEV notification,[155] PG&E has indicated that notification data and protocols needs to be a) comprehensive, b) sufficiently granular at the local level, c) received in a timely fashion, d) scalable to ensure against intensive manual activities (e.g., data entry), and e) affordable.

As noted previously, utilities are also able to obtain data directly from the DMV as a result of SB 859 (Padilla, Statutes of 2011); however, the law also imposes restrictions on how to use DMV data to protect consumer privacy.[156]

Upgrade Distribution Infrastructure

When utilities in the 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 proactively installing new equipment to accommodate increasing rates of PEV adoption since 2010 as part of its multi-year Electric T&D Modernization Plan.[157]

---

155 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.

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

157 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.

Based on feedback, municipal utilities appear to be less focused on infrastructure upgrades related to EVSE, in large part due to the small number of PEVs currently deployed in their service territories. However, all utilities should begin to explore vulnerable infrastructure, particularly in areas more likely to experience PEV clustering and large public infrastructure projects.

Data from ECOtality regarding non-residential charging indicate potential locations where utilities may have to make distribution system improvements. For instance, there are significant amount of non-residential charging events in Milpitas and surrounding parts of Santa Clara, Sunnyvale, and San Jose. There are many retail shopping, restaurants and employment centers in this zone. Stanford University and the many companies based in Palo Alto and Mountain View also attract a significant number of charging events. Many of the vehicles traveling to these locations originate in Alameda and San Mateo counties, which suggest that DC fast charging stations may be especially useful along connecting highways. Therefore, utilities may need to prepare for potential corridors with DC fast charging. Downtown San Francisco, Cupertino and northern San Mateo County also seem to attract a decent number of non-residential charging events.

Implement Consumer Outreach Programs

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,[158] utilities should present a uniform set of PEV facts, utility rates, incentives and program information to customers through a wide variety of media, 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 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.

Based on the success of programs such as the Flex Alert program[159], outreach can have a significant impact and help shift charging to off-peak. In this program, when a flex alert is called, Californians are asked to turn off unnecessary lights, postpone use of major appliances, and turn up the thermostat (when it is hot and consumers are running A/C systems). These actions are voluntary, but users know that if they do not take action, their electric service could be interrupted due to unavailability of power. Although these programs can be effective, the difficulty with relying exclusively on voluntary action to shift load, there is less predictability of how many people will participate and what types of actions they will take. This type of outreach program should be paired with a TOU rate, for instance, which also provides a financial incentive for consumers to shift charging to off-peak.

[158] Edison Electric Institute, *The Utility Guide to Plug-In Electric Vehicle Readiness*, November 2011, pp. 4, 15-22, available online at: http://www.eei.org/ourissues/EnergyEfficiency/Documents/EVReadinessGuide_web_final.pdf

[159] More information available online at: http://flexalert.org/.

This type of messaging will be built into the *Go EV Campaign*, currently being designed by MTC in coordination with BAAQMD. However, this campaign should be considered complementary to utility efforts and not replace them. Furthermore, as noted previously, utilities that earn and sell LCFS credits for electricity supplied as a transportation fuel must use the proceeds to benefit current PEV customers. In addition to the rate options that encourage off-peak charging and minimize adverse impacts on the electrical grid, utilities must make efforts to educate the public on the benefits of PEVs, which also must be documented as part of compliance.

Evaluate Smart Grid Opportunities

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 non-networked Level 1 charging, which does not generally require modifications to existing infrastructure.

PG&E has prepared a smart grid deployment plan, which includes steps to prepare for electric vehicles in the service territory.[160] 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.

Based on initial feedback, no municipal utilities in the Region have developed smart grid integration plans for PEVs due to the relative expense of the upgrades compared to other peak load reduction techniques such as energy efficiency retrofits. The City of Palo Alto has explored options for demand response programs, but does not have plans to implement them in the near future.

In order to mitigate potential impacts of PEV deployment, municipal utilities should 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 should be explored.

---

160 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.

Provide Renewable Energy Options for PEV drivers

As noted previously, utilities have not prioritized providing incentives for PEV drivers to purchase greener electricity for charging i.e., green charging. Utilities are at different stages of focusing 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. Research shows that some early PEV adopters prioritize environmental benefits as a key reason to switch from internal combustion engine (ICE) vehicles. By integrating renewable energy options into existing or future PEV rates, some utilities in the Region may see accelerated PEV adoption rates.

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 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:

- Green Pricing Programs
- Community Choice Aggregations

The existing green pricing programs and Community Choice Aggregations 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 a higher percentage of their electricity to be generated from renewable sources. 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

Interviews with utility stakeholders indicated that the provision of renewable energy to interested consumers is a high priority in some cases; 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 PEVs.

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 higher 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 informed 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 Aggregation (CCA) to couple the deployment of PEVs with renewable energy is through a CCA green rate option. CCAs 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 MEA board recently approved a request to include 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 Plan 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 are encouraged to continue to coordinate and observe CCA developments in the context of PEV deployment.

Appendix A: Background Information on PEVs and EVSE

Key Technical Characteristics of PEVs and Infrastructure

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, vehicles that use electricity from the grid are referred to as plug-in electric vehicles (PEV), a term that includes both PHEVs and BEVs.[161]

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 (a BEV) and the Chevrolet Volt (a PHEV) have been available since early 2011 and in 2012 new entrants into the vehicle marketplace included the Toyota Plug-In Prius (a PHEV), Tesla Model S (a BEV), and Ford Focus Electric (a BEV).[162]

Review of PEV Drivetrain Architecture

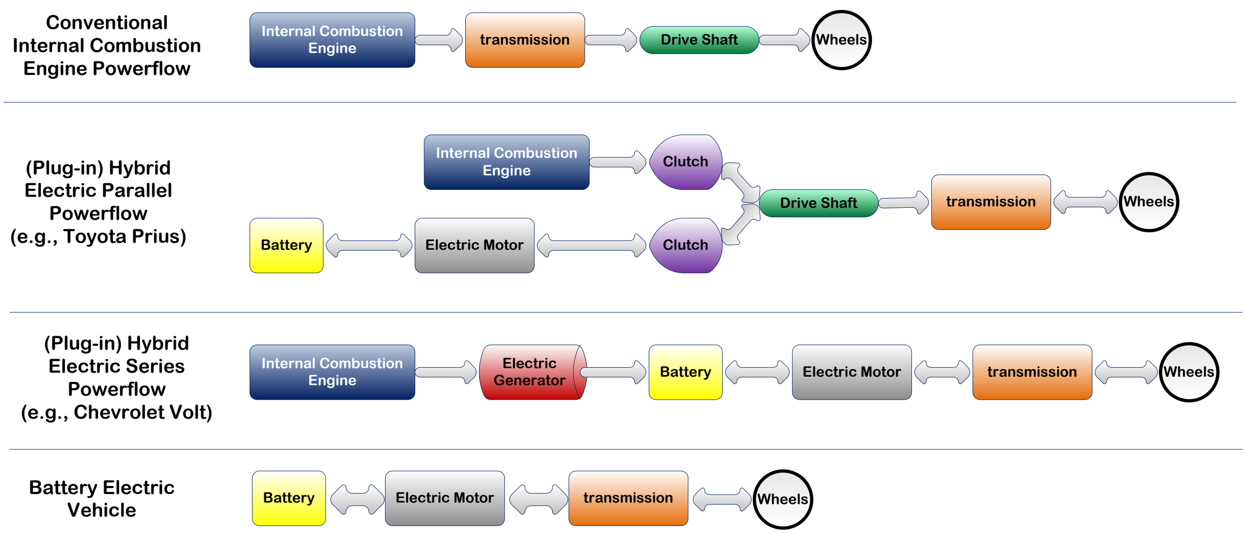
Most PHEVs are designed to provide an all-electric driving range of 10 to 40 miles. When the battery state of charge falls to a predetermined limit, the system automatically switches to the ICE. Battery-related costs tend to be lower for PHEVs as compared to BEVs because of the smaller battery size, 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

[161] 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.
[162] The Renault Fluence ZE entered in the global PEV market in 2012, however, it is not available in the U.S.

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.

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 52 below illustrates the variations between PEVs as compared to conventional ICEs.

Figure 52. Simplified explanation of power flows for different vehicle types[163]



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, nickel-metal-hydride, and sodium-nickel chloride.

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 vehicle price), and ensure reliability.

In a study for the European Commission, ICF assessed the current status of battery technology.[164] 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

[163] 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.

[164] 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

components that are around $250/kWh and these costs will fluctuate depending on the supply and demand of lithium.

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 cost reductions 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 PEVs 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.[165]

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.[166] 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 PEVs in the long-term that should be considered in the long-term planning for PEV deployment.

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:

165 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.
166 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/.

- **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 (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 53 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). SAE recently approved the DC charging standard for the Level 1 and 2 DC coupler and connector as part of the J1772 standard.[167] The central component of the standard is the Combo Connector which maintains the functionality of the previous J1772 connector and introduces two new pins which provide the option of charging via DC.

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 53.

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

[167] EVs get boost from new SAE standard for dc fast charging, SAE Vehicle Engineering Online. Available online at: http://www.sae.org/mags/sve/11484/

vehicles.[168] 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 the option of switching the battery out of the vehicle via a network of automated stations. In this scenario, the ownership of the battery 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 region's taxi fleet.

Figure 53. (L to R): J1772 standard connector for Level 2 AC,[169] CHAdeMO plug for DC fast charging,[170] and the HomePlug GreenPHY plug for DC fast charging[171]

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

---

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

169 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/

170 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.

171 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.

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.[172]

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 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.[173]

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 41. 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.[174] Idaho National Laboratory (INL) is conducting research on 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.[175]

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

Table 41. 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.

Economics of EVSE Acquisition, Installation, and Operation

The main cost elements for EVSE include hardware, permitting, and installation costs. The latter is generally labor costs associated with installation. In some cases, it is important to note that the costs of EVSE installation can increase significantly depending on factors such as utility upgrades, trenching or cement cutting to route circuitry, compliance with local ordinances or similar considerations (e.g., ADA accessibility). For organizational purposes, the costs for EVSE are distinguished in the following locations:

- Single-family homes with dedicated parking
- MDUs and workplace
- Public installations (e.g., parking lots or on-street parking)

Residential EVSE Deployment

EVSE costs are primarily comprised of hardware, permitting, and installation costs. For most single-family homes, the electrical service available in the garage or through dedicated parking is likely suitable for Level 1 EVSE, which is designed for a 110 V connection. For Level 1 charging at a home, a PEV does not requires additional or special equipment - a simple cord and plug arrangement will suffice. In fact, Chevrolet has reported in a variety of forums that about 50 percent of Volt drivers are opting for Level 1 charging. There are not many factors that will increase the cost of using Level 1 charging, unless a separate meter is required in order to take advantage of special PEV utility rates.

For drivers that have PEVs with larger batteries, such as the Nissan LEAF, Level 1 charging may not be a viable option based on the time requirements to charge fully a depleted battery (up to 20 hours). The estimated costs for a Level 2 EVSE, including the hardware and installation are listed in Table 42.

Table 42. Estimated Level 2 EVSE costs at a single-family Home with dedicated parking

Cost Element	Low Estimate	High Estimate
Hardware	$500	$1,100
Permitting	$100	$250
Installation	$300	$1,000
Total	**$900**	**$2,350**

Most PEV manufacturers have partnered with suppliers to install Level 2 EVSE. For example, GM partnered with SPX, which sells EVSE from $490 to over $1,000. Nissan and Mitsubishi partnered with AeroVironment, which sells EVSE for about $1,100. Toyota partnered with Leviton, which sells EVSE from about $1,000. Retailers, such as Best Buy and Home Depot, sell Level 2 EVSE ranging from $750 to $1,000. Other suppliers sell EVSE well above $5,000,[176] but for the purposes of this analysis, a high estimate of $2,350 was used for Level 2 EVSE.

The range of installations costs shown in the table above reflects the hours required from a professional electrician at an estimated hourly rate of approximately $75 per hour. The number of hours worked depends on the level of difficulty to install the infrastructure. A new circuit box, conduit to the garage, and networking capabilities of the EVSE could increase the total costs of installation closer to $2,500.

Single-family homes without a garage may face additional hurdles of obtaining approval from a neighborhood association. Local zoning requirements may also require a public hearing and a lengthy pre-approval process. Workplace charging may be another option for a PEV owner.

MDU and Workplace EVSE Deployment

A recent study by AeroVironment[177] notes the economics of workplace charging is more comparable to MDU charging than to single-family home charging because employers or building management are more likely to own the EVSE than the employees or tenants. Also, tenants and employees are more likely to be responsible for the operational costs. As a result, MDU and workplace charging will be discussed together. Table 43 below summarizes the costs of MDU and workplace charging for Level 1 EVSE and Level 2 EVSE.

176 Plug-In America, "How Will You Charge Your Ride?" accessed November 14, 2012, http://www.pluginamerica.org/accessory-tracker?type=All&level=2&nrtl=All.
177 C. Botsford, "The Economics of Non-Residential Level 2 EVSE Charging Infrastructure," *EVS26, Los Angeles CA,* 2012.

Table 43. Estimated costs for MDU and Workplace EVSE Installations[178]

Cost Element	Level 1		Level 2		DC fast charge	
	Low	High	Low	High	Low	High
Hardware	$200	$500	$500	$2,000	$10,000	$30,000
Permitting	$100	$500	$100	$1,000	$500	$1,000
Installation	$500	$5,000	$2,000	$6,000	$3,500	$6,000
Trenching /Concrete [a]	$3,000	$25,000	$3,000	$25,000	$3,000	$25,000
Total, installed [b]	**$3,800**	**$11,000**	**$5,600**	**$14,000**	**$17,000**	**$42,000**
Networking (annual)	$120	$300	$120	$300	$120	$300
Maintenance	$100		$100		$100	

[a] The high cost scenario does not assume a $25,000 cost associated with trenching and concrete because this inflates the costs significantly and is considered more of an outlier than a true indication of the high cost that might be expected. Rather, the project team used a trenching cost of $5,000.

[b] The total cost does not include the annual costs associated with networking. These are shown for illustrative purposes only.

The values presented in Table 43 are based on each EVSE location installed and generally include two ports. It is also worth noting that the marginal cost of the next EVSE installations – for each level of EVSE shown in the table above – is a fraction of the total installed cost listed. The EVSE hardware is the only cost element which does not yield some benefit with increased number of installations. This is particularly relevant because the hardware represents a small fraction of the overall cost for both Level 1 and Level 2 EVSE. Even for DC fast charge EVSE, there is potentially significant savings with about 25-60% of the installed cost represented by the hardware. There is already some downward pressure on the hardware costs of DC fast charging EVSE, as evidenced by Nissan's recent partnership with Sumitomo to market a charger for $9,900.[179]

The installation of Level 1 EVSE at a MDU or workplace will likely require more equipment than an extension cord so an employer will likely need to meter electrical usage. If an employer choses to charge employees for EVSE use, AeroVironment estimates potential revenue of $520-838 per year per port, which could be a significant means of recouping installation costs.[180] The installation costs are much higher than for an installation at a single-family home because an office parking lot or garage may only have minimal wiring for lighting. The management or employer may elect to install multiple ports at the same time in which case the circuitry needs to be replaced and conduit laid to an area dedicated to PEV parking spots. Based on discussions with manufacturers and review of product literature, in addition to adding conduit, the trenching and concrete costs are necessary for signage, structure, access, and safety provisions.

178 Electric Transportation Engineering Corporation, "Electric Vehicle Charging Infrastructure Deployment Guidelines for Greater San Diego," pgs. 55-58, May 2010.
179 Nissan, "DC Quick Charger," accessed November 14, 2012, http://nissanqc.com/.
180 Botsford, Charles, "The Economics of Non-Residential Level 2 EVSE Charging Infrastructure," pg. 5, accessed November 21, 2012, http://www.e-mobile.ch/pdf/2012/Economics_of_non-residential_charging_infrastructure_Charles-Botsford-EVS26.pdf.

Level 2 and DC fast charging EVSE costs for MDUs and workplaces will vary considerably depending on siting characteristics. For instance, PG&E has conveyed a range of $500-$30,000 for Level 2 charging. A number of factors could significantly increase the cost of DC fast charging such as distribution upgrades and increased construction costs (e.g., increased trenching and repair or concrete work).

If the initial costs are too high, an employer may consider another technology called inductive or wireless charging.[181] It uses a mat that a PEV would drive over and receive a charge without a plug connecting to the PEV. This technology is still being developed and has its drawbacks such as a 10 percent loss in efficiency (based on current estimates; this will likely decrease with technology improvement) and a cost of $2,000, but it could potentially reduce the costs related to trenching and concrete work, which are often the most significant cost elements in the installation of EVSE.

Table 43 also includes annual costs for maintenance and networking costs – these are additional costs pertinent to MDU and workplace EVSE installations that are not necessary for single-family home applications. Operational and maintenance costs of $100 per year cover semi-annual inspections of the EVSE and reporting vandalized equipment. Networking costs would cover costs for a cellular network to transfer data related to payment and usage. It may also have capabilities of shifting charging times to reduce stress on the grid.

Another consideration is ADA compliance with regards to parking spaces for persons with disabilities. These spaces may be underutilized with minimal potential to recoup the costs of the EVSE installation. One solution has been to provide a charging space that is wide enough to accommodate access for a person with a disability but not having a sign indicating the spot as handicapped parking. This solution, even though indicating PEV use, would still allow disabled/handicapped persons to use this space as they can park anywhere in the lot. This also raises the issue of the placement of PEV charging spaces. It would seem that the most practical place to provide those spaces would be close to ordinary handicap spots. This would have the additional benefit of advertising PEVs. However, this may also build resentment in the general public because PEVs are receiving preferential parking spaces.

Publicly-Accessible EVSE Deployment

The installation of publicly-accessible EVSE will have similar costs to MDU and workplace charging costs. However, the issue of maintenance is significant and often overlooked, particularly in the rush to deploy infrastructure. There are significant costs that may be underestimated with the ongoing maintenance of charging infrastructure, regardless of whether public agencies maintain ownership or pay for a maintenance service through a PEV service provider. In the event a public agency owns EVSE (e.g., for a government fleet, publicly-owned garages, or mass transit parking lots), government maintenance will likely be required.

---

[181] M. Clothier, "EV market races to offer wireless charging," *Automotive News*, accessed November 14, 2012, http://www.autonews.com/apps/pbcs.dll/article?AID=/20120701/OEM05/306309998/1295/ev-market-races-to-offer-wireless-charging.

Although vandalism was previously identified as an area of concern by ECOtality, recent interviews with the company indicate it is a less significant issue.[182]

Business Model Factors

Table 44 lists the business model options in developing PEV infrastructure. These are discussed below.

Table 44. EVSE Business Model Factors

Characteristic	Business Model Options
Usage Accessibility	Private, Semi-Public, or Public
Active Ports per Station	Single, Dual Sequential, or Dual Simultaneous
Billing Systems	Credit Card, Smart Card, RFID, or Parking Meter
Cable Management	Cable Reel or Retraction/Locking Mechanism
Charging Level	AC Level 1, AC Level 2, or DC fast charger
Complementary Services	Truck stop, Post Office, Nighttime Fleet Charging, or Grid Storage
Connection Type	Unidirectional or Bidirectional
Costs to Site Owner	Installation and Maintenance
Energy Provider	COOP, MUNI, REP, or Investor Owned Utility
EVSE Site Owner	Private, Semi-Public, Utility, Workplace or Government
Metering	No metering, Separate metering for station, EVSE internal meter, Use current on-site meter, Vehicle meter
Ownership	Site Owner, EVSE Company, Utility, Government
Profit Sharing Between Site Owner & EVSE Provider	Percentage split or Fixed rate to owner
Revenue Sources	Electricity, Parking, or Advertising
Type of Billing	Fixed energy rate, Fixed rate subscription, Pay for time, Pay per use
Wholesale Energy Processing	Day-ahead, Intra-day, and Real-time

Usage Accessibility

Accessibility is the EVSE control function that assures that the person connecting and charging is authorized to do so. Some accessibility is controlled through the installation of the EVSE in secure or private locations. Garage and behind the fence workplace or fleet charging locations are examples. Some charging stations are located where both a private fleet and the general public may have access. A university may require that the general public pay a fee for charging, but provide it at no cost to their faculty. EVSE generally available to the public would typically control access for revenue generation. Accessibility involves identification of the individual or vehicle, comparison to an approved database and activation of the EVSE once authentication is

[182] Interview, Steve Schey, ECOtality North America, Inc., April 11, 2012.

complete. This typically involves a communications system between the EVSE and a provider network.

Methods for accessibility may involve subscriptions or memberships in an EVSE provider's network for which an activation card is waved by a radio frequency identification (RFID) reader in the EVSE. A credit card on file in the network is charged the access fee. Some providers may allow credit card payments at the EVSE, mobile phone payment applications or other options for guest usage. See also profit sharing noted below.

Active Ports per Station

In the design of AC Level 2 and DC faster charging EVSE, manufacturers have selected to produce equipment that is designed to charge a single vehicle and some have equipment that may charge more than one vehicle. Most multiple units will charge two vehicles either simultaneously or sequentially. Figure 54 shows a dual port AC Level 2 EVSE and Figure 55 shows a dual port DC fast charging. Some EVSE provider designs include up to four AC Level 2 ports. Design is driven by the providers' business plans and location applications.

Figure 54. Level 2 Charging[183]

[183] Coulomb Technologies. 2012a. “ChargePoint Networked Charging Stations.” http://www.coulombtech.com/files/CT2020-Family-Data-Sheet.pdf.

Figure 55. DC fast charging Installation[184]

Billing Systems

Multiple options for billing exist. Revenue can be collected using mechanisms such as RFIDs, smart cards, credit cards, or parking meters. RFIDs and smart cards require communication to verify that a driver can begin charging, whereas parking meters can be locally controlled.

Cable Management

Cables must be managed to ensure that they do not create a tripping hazard or that they are damaged. Simple techniques involve using a cable wrap at a station, such as shown in Figure 54 and for the AC Level 2 station in Figure 55, whereas more sophisticated techniques involve retraction, overhead cable support, or tilting equipment. The complexities involved in these more sophisticated methods also result in higher costs and increased maintenance.

Charging Level

There is a significant difference in equipment costs between charging station levels. AC Level 2 delivers the 240 V AC power from the electric utility directly to the vehicle. The conversion to DC for battery charging occurs in the on-board vehicle charger. These chargers are typically 3.3 or 6.6 kW chargers. Higher power ratings of the on-board charger add size, weight, and cost to the vehicle price. The cost of the EVSE then is in providing the safety circuits and other features for accessibility and data recording. In DC fast charging, the conversion from AC to DC occurs off-board where size and weight are not as significant a factor. Power ratings of up to 10 times or more the power of AC Level 2 are possible. Along with that power is the added cost of the unit.

[184] ECOtality, Inc. 2012. "Blink Membership." https://www.blinknetwork.com/membership.html.

The strategy surrounding the placement of AC Level 2 or DC fast chargers is also involved. An AC Level 2 can provide a significant recharge of the BEV battery in two to three hours. A typical site host for an AC Level 2 would then be a destination where the driver would stay two to three hours. Such places include restaurants, movie theaters, golf courses, professional business offices, etc. The BEV is recharged conveniently while the driver is engaged at the location. A DC fast charger provides a significant recharge in 15 minutes. Thus, the destinations for DC fast chargers users may include fast food restaurants, convenience stores, gas stations, etc. These businesses are designed around high turnover of people who do not stay long periods of time.

Complementary Services

In order to enhance the potential profitability of EVSE, additional services can be combined, other than common charging for light-duty vehicles, to more efficiently utilize the EVSE. For example, stations can be used to electrify trucks and delivery vehicles. Fleet owners may make their EVSE available to the public during the day and charge their fleet vehicles at night. In addition, grid storage can be provided to help reduce electricity costs and power requirements.

Connection Type

At the present time, all connectors are unidirectional. Power flows only from the electrical source through the EVSE and into the PEV. Bidirectional power flow would allow the stored energy in the battery to be used to reverse power through the EVSE to power other vehicles, the local building, or back to the power grid. This is called V2B (vehicle to building) or V2G (vehicle to grid). Power flow from the battery to the electric grid may be useful as a power source if sufficient numbers of connected batteries can be aggregated. Power flow to and from the grid can also be useful in voltage and frequency regulation for grid stability. For both of these functions, among others that have been explored, it is possible that sufficient revenue can be generated to make a business a case for bi-directional flow. Several tests and demonstrations of this capability have occurred. However, at the time of this writing, the communication and equipment standards have not been approved to fully identify the specific business advantages of bidirectional power flow.

As noted previously in Section 1 regarding charging technology, the approved connector for 240 V AC charging is called the J1772 connector. This is the common standard used by most EVSE suppliers and EV suppliers. It insures that an EV with this standard inlet can charge at any EVSE which provides this standard connector. The J1772 standard was amended to also include the Combo Connector for optional DC fast charging. The Japanese CHAdeMO standard is also in use on select PEVs in the US since 2010 uses the Japanese CHAdeMO standard.

Costs to Site Owner

Equipment costs are an important consideration for the business case. Ownership of the EVSE is addressed further below, but in general, a charging site host must consider the capital cost of the equipment, the cost of installation of the electrical circuit and related construction, anticipated maintenance costs, costs associated with the parking location devoted to PEV parking, signage, vandalism, and insurance. Some or all of these costs can be negotiated in a services contract with an EVSE supplier or third party, depending on specific locations. The charging site host must also see the other advantages of hosting the EVSE which may result in increased business revenue. Information from the EV Project suggests that users of charging stations may stay longer inside a retail location. Retailers know that this means increased sales. In addition, the host can advertise the EVSE at their location and gain new business.

Energy Provider

Electric utilities are in many cases offering special rates for PEV drivers to encourage off-peak charging. This would require a means of measuring the electricity usage for charging the PEV independent of the balance of the load. This is accomplished by the installation of a second utility meter in-line with the EVSE or by using an embedded meter within the EVSE, if provided. The embedded meter needs to be certified as a revenue grade meter.

EVSE Site Owner

The availability of EVSE to the general public may be classified as private, semi-public or public. Private use includes a single family home environment, some multi-family dwelling applications, fleet operations and employer workplace charging. In these cases, access to the EVSE is controlled either by its physical unavailability to the public or by controlling the access through the network authentication. Other than a private owner in a private location, the employer or multi-family dwelling owner may charge access fees for the equipment use even though it is not in a public location. The employer may wish to avoid concerns over preferential treatment of PEV drivers over internal combustion vehicle drivers or questions related to taxable benefits. The multi-family dwelling owner may install EVSE for the shared use by their tenants. The access fee provides for the common equipment installation, maintenance and operational costs.

Semi-public applications include sites that may serve two purposes such as a fleet operator making his/her equipment available for general public charging when not in use by the fleet. Access control authentication would select whether the user is charged a fee for service or the charge is part of the fleet operations.

Publicly accessible units may be operated by retailers, government, private owners or the electric utility. In general, access will be controlled for these units although some may elect to provide the recharge at no cost for a time. Retailers may elect to provide the free service as an enticement to customers to shop. Many retailers know specifically how much time spent in their store relates to the amount of purchase. Longer dwell times result in higher purchases. Municipal governments may provide charging at no cost to the consumer but pay for the costs from a general budget citing the common good provided.

Metering

Metering refers to the collection of data regarding the amount of electrical energy transferred during the recharge process. This data can be collected through a submeter located within the EVSE, by a separate meter installed in line with the EVSE (if provided), by the meter that serves the whole premise and does not specifically collect EVSE energy information, or through the vehicles' on-board meter (if provided by some PEV manufacturers). In most cases, EVSE access fees are not directly tied to the cost of the electricity provided to the vehicle, although some suppliers are beginning to consider this option. The electrical usage is a cost to the host, and other costs identified above need to be considered as well. The metering provides a measure so that the host can be assured that this part of the cost is covered by the access fee or other contracts with EVSE or third party providers. In some locations, the electric utilities are testing the embedded sub meter within the EVSE to verify accuracy for billing purposes. If accepted, this meter will take the place of the in-line meter to provide accurate energy usage information.

Ownership

EVSE ownership can be retained by the EVSE provider or transferred to the charging site host or other third party. The traditional sale method would make the host, whether residential or commercial, the owner and operator of the EVSE and responsible for the operation and maintenance of the equipment. Under some contracts, the EVSE provider may retain ownership of the EVSE and provide compensation to the host for the use of the site. The EVSE provider then may be responsible for the maintenance and operation of the equipment. More information on non-host ownership models is provided below.

Profit Sharing Between Site Owner & EVSE Provider

As noted previously, few business models relate to providing charging at no cost to the driver. Access fees, whether through the subscription method or pay per use generate revenue discussed below, are expected to be charged at most publicly available EVSE. This revenue may be shared with the charging site host. Some models will provide a percentage split with the host based upon negotiated terms. This method would encourage the host to maximize the utilization of the equipment. Other contracts may provide a fixed rate to the host. This fixed rate may be designed to compensate for the host's identified costs associated with hosting that EVSE or rent for the space. The balance of any revenue then would be retained by the EVSE provider.

Revenue Sources

Revenue for an EVSE is typically obtained through charging for electricity, parking, or advertising through media and communications on the EVSE. Various companies are trying different business models to date with some mixes of these sources.

Type of Billing

When access fees are assessed, they may be set on a fixed fee, a fixed rate or a pay per energy consumed basis. Fixed fee would mean that each connect has a set cost. It would not matter how long the connection is made or how much energy is charged into the battery, since the set connection fee is charged. The fixed fee may be assessed by an employer in a workplace setting or when charging is provided as part of a parking lot fee. It may be expected that the owner will be parked for a significant period of time in this location. A fixed rate fee may be charged if high utilization and turnover of vehicles is desired. Fees may be charged per hour or other intervals for AC Level 2 charging and a per minute basis for DC fast charging. It would be desirable for the PEV driver to be aware of the time the vehicle is charging to maximize the charge with the convenience of gaining range. A pay per energy consumed basis would require measuring the energy delivered and charging a rate based upon the cost of electricity to the host. A multiplier on this cost may be applied to recover other operational costs.

Membership or subscription programs may offer the same type of services. A fixed rate may be charged to the driver on a monthly basis for an unlimited number of connects or time connected at any publicly available EVSE. Discounts on the fixed rate may be provided by the membership program for a tiered membership fee. In most cases, a pay per use is generally available although restrictions may apply based upon the membership program.

Wholesale Energy Processing

Electric utilities are very aware of their costs in providing electrical services. They know their costs to generate or purchase power. The costs can vary from day to day, during the day and in real time. Some EVSE are designed to be responsive to pricing signals from the local electric utility, if provided. When convenient, the PEV owner may set the EVSE to only charge when the pricing signal is below a certain threshold and to stop charging should that threshold be exceeded. Real time communications between the electric utility and the EVSE will be required to implement these features.

Networks, Communications and Data Collection

Several of the EVSE providers support their EVSE through networked communications. This communication is required not only for access control and authentication, but also allows for remote monitoring of the unit, data collection and reporting as well as software updates over the air. This capability results in fewer maintenance trips for the supplier at keeps the equipment up to date. The data reporting capabilities provide valuable information related to equipment utilization and driver behavior. Such information is useful in determining whether additional units should be provided to augment the existing station.

Examples of Membership Programs

ECOtality has announced a membership program for subscribers that contains tiered levels.[185] An RFID card is required for access and authentication at their Blink® brand public EVSE. The card holder registers the card on the Blink network and associates a credit card with that account. There are several tiered levels of membership with the basic level at no cost to the member who pays the basic pay per use at each connect. Additional levels of membership provide discounts and other features.

NRG has announced a membership program with multiple levels, which also uses an RFID card for access at their eVgo® EVSE.[186] The levels are differentiated by whether the driver can charge at home, or at home and at public stations. In addition, the various levels give the option to pay a fixed monthly rate or a fixed fee per energy use.

Coulomb has announced a membership program for its ChargePoint® EVSE, for which they provide RFID cards or users can use contactless credit cards.[187] Charging prices vary depending on Coulomb’s agreement with the site owner.

[185] ECOtality. 2012. “eVgo Charging Plans Offer Flexibility, Freedom and Peace of Mind.” https://www.evgonetwork.com/charging-plans-form/.

[186] eVgo. 2011. “Charging Plans.” https://www.evgonetwork.com/Charging_Plans/.

[187] ECOtality. 2012b. “ChargePoint Cards.” ChargePoint Network. http://www.chargepoint.net/chargepoint-card.php.

Reservation Systems

Networked EVSE providers have announced plans for adding the capability for reservations with their equipment. The programs have not been specifically identified but it is expected that a fee for the reservation and penalties for failure to comply with the reservations made will exist. This again involves fees to be charged to the owner's credit card and interoperability is again in question. It is likely that mapping service companies may also offer the reservations capability and will work out the rules and payment systems with each of the networked EVSE providers.

This is of particular importance in corridor charging. The PEV driver will plan the trip in advance and plan on locations for recharging. It will not be desirable to arrive at a station expecting to charge and find the station occupied. ECOtality and Coulomb have announced reservation plans to assist the driver in completing the trip.

For the Bay Area charging systems, it is expected that the stations will provide multiple functions, such as supporting longer distance intercity travel, travel within communities and serving as backup to the residential AC Level 2 charging. This may mean that the station contains an AC Level 2 EVSE as well as DC fast charging. There are several examples where the DC fast charging and AC Level 2 equipment are installed at the same site.

For Bay Area public charging stations, it can be expected that several EVSE suppliers will continue to seek charging site hosts to own and operate the EVSE on their property. There is risk for these companies in the early years while the adoption of PEVs is still in its infancy. The business plan for success will be based upon utilization and PEV adoption. It is also likely that some EVSE companies will retain ownership of the units for the near future. Revenue systems will likely be employed as outlined above. Placement of these stations will be important to be convenient to intercity drivers as well as for local communities. The site will likely contain a destination feature, such as a restaurant, to be convenient to the driver while the PEV is charging and to be of interest to the facility to be the host.

Cost Factors[188]

Given the array of business model options for EVSE, installations require planning on the macro scale, such as throughout a mega-region or a large city, and on the micro level, such as a major employer, retailer or restaurant. The costs associated with installing a charging infrastructure can, likewise, be categorized. This section outlines the key cost factors that are considered when deploying charge infrastructure and some estimates of EVSE installation costs. These factors are categorized and outlined below for large-scale deployment programs for AC Level 2 and DC fast charging installation scenarios.

Geographical Cost Factors

Investment made into EVSE deployment across large geographic areas requires planning and data analysis. For example, deployment across a large city, a highway corridor or a large retail

[188] ECOtality. Task 4: Discussion of PEV Charging Business Model Factors, Costs Factors, and Charge Rate Structures.

mall involves multiple stakeholders. A list of key factors considered in large scale deployment projects can be seen below:

- Consumer Interest
- Employment Density
- Security and Vandalism Risk
- Retail Density
- Traffic Corridors
- Hills / Level Parking for Accessibility
- Proximity to Destinations
- Proximity to other EVSE stations
- Visibility
- Residential Population Density
- Future Growth Areas
- Demographics Ownership Models
- Availability to Drivers Reserved Parking
- ADA Compliance
- EV Charging Signage

AC Level 2 Cost Factors

Narrowing down to the individual charger commercial building or public facility, the cost factors involved relate to equipment, labor and ongoing operation of the charging stations. Variables such as whether the site is a newly constructed project or renovation, the electric panel's location and size, and underground conduit and wire requirements affect the price of the installation. Other costs like service upgrades, wiring costs, and permit fees also add to the installation price. Publicly available charging stations and commercial charging station locations share many of the same cost factors. A list of these factors can be seen below:

- Appropriate Voltage and Amperage
- Electric Rates / Time of Use
- Spare Capacity or Electric Service Upgrades
- EVSE Features and Equipment Costs
- Nearby Power Access
- Concrete/Asphalt – patchwork for trenching
- Transformer Upgrade
- Communications systems
- Panelboards or electrical panels – possible subpanels, panel upgrades and additional circuits
- Above Ground vs. Trenching
- Access – shared or single user
- Shelter
- Lighting
- Barriers / Bollards / Wheel Stops
- Concrete Boring

As with all EVSE, the cost of installation can range significantly due to the site-specific conditions. Currently, the base cost of an AC Level 2 non-residential charging station is approximately $750-$3000, and grid and wiring upgrades can cost up to about $1500. The advanced communication systems in EVSE stations, if equipped, must also be considered. Some communications are cellular and others are internet serviced. As long as cellular service is available in the area, those EVSE, if equipped, should be able to complete the communications path. EVSE which rely on internet access either through a wireless or networked system may require additional conduit and cable to reach a local modem. While most charging equipment is designed to be maintenance free, components such as the connector and cable may wear. Methods are employed by the EVSE suppliers to discourage vandalism and it has not been an issue with the units installed thus far. The cost of yearly maintenance is estimated to be around $50-$250.[189] Table 45 provides a generic cost worksheet for an AC Level 2 location with the two stations.

Table 45. Estimated Cost for Public Electric Vehicle Charging Station

Public Charge Station- AC Level 2 (Quantity 2)			
Description	*Quantity*	*Estimated Cost*	*Total*
Labor (hours)			
Consultation with Property Owner/Tenant	4	$ 75.00	$300.00
Initial Site Visit	2	$ 75.00	$150.00
Engineering Drawings	16	$ 90.00	$1,440.00
Permit Application/Acquisition	2	$ 75.00	$150.00
Installation	24	$ 75.00	$1,800.00
Approval	2	$ 75.00	$150.00
Labor Sub-Total			$3,990.00
Materials			
Distribution Panel (400 amp)	1	$250.00	$250.00
EVSE-40amp	2	$780.00	$1,560.00
EVSE Pedestal	2	$450.00	$900.00
40amp Breaker	2	$35.00	$70.00
#8 THHN Wire	400	$0.30	$120.00
Conduit – ¾ EMT	100	$3.00	$230.00
40amp Fused Disconnect	2	$115.00	$250.00
Signage	2	$250.00	$500.00
Miscellaneous	2	$60.00	$120.00
Material Sub-Total			$4,300.00
Trenching & Repair	100	$45.00	$4,500.00
Permit	1	$85.00	$85.00
		Total	*$12,875.00*

DC Fast Charging Installation Cost Factors

Many of the same cost factors exist for the installation of DC fast charging stations. The voltage and amperage of the DC fast charging station may also require a new electrical service and additional coordination with the local utility company for grid reinforcement and transformer

[189] Schroeder, Andreas, and Thure Traber. 2012. "The Economics of Fast Charging Infrastructure for Electric Vehicles." *Energy Policy* 43: 136–144.

replacement. These decisions depend on the grid infrastructure which is present and demand expected at the DC fast charging station.

The base cost of a DC fast charging station can range from $25,000 to $50,000 per plug. Generally, a location where the installation costs exceed $25,000 is not likely to be approved by either the host or the EVSE supplier without additional subsidy. If transformer replacement and/or grid reinforcement is required, cost estimates are approximately $35,000 for the former and $20,000 for the latter. Again the design of the DC fast charging provides units relatively free of maintenance. Yearly maintenance cost has been estimated to be up to about $5,000.[190] It should be noted that although these costs are significantly higher than those of an AC Level 2 station, the cost per kWh provided are comparable for a well-utilized station, since cars spend much less time at a DC fast charging station. This makes DC fast charging stations far more beneficial for high demand locations.

Charge Rate Structure[191]

The section above discussed the several different types of billing choices for hosts and EVSE providers. The type selected will depend upon the specific circumstances and conditions for the host. In general, providing charging services at no cost to the consumer provides no revenue stream for the host and unless revenue is captured in increased sales or other areas, provides no offset to equipment and operational costs. No cost charging in public encourages EV drivers to charge at public locations during peak power periods rather than at home during off-peak times since zero cost beats the low off-peak rates. No cost also encourages long stay times at a public EVSE which makes it unavailable for other users. No cost charging at multi-family dwellings means that all residents subsidize the charging of the EV. No cost charging at the workplace provides preferential treatment to some employees over others. Therefore, assuming that a fee for use is desired, the following sections discuss factors to be considered in selecting one of the billing choices identified above.

Fixed Fee

As noted above, a fixed fee would mean that each time a vehicle connects, it has a set cost. The duration of the connection and energy transferred are of no interest to the host. This type of fee may be of highest interest when it is known and accepted that the EV will remain connected for a significant period of time. After approximately 3 – 5 hours, the EV will likely be fully charged and no additional electrical cost would be anticipated. The fee to be charged then would be a combination of this maximum energy cost plus a fee for the parking space, if desired. This type of fee may be desirable at long-term parking at airports, over-night charging at a parking facility, multi-family dwelling common parking, employee parking, or car-share programs. In these cases, the fee could be calculated by considering the prevailing electric utility rate times the maximum charge energy expected for the EV plus any additional factors for operations and maintenance. The fee for the space could be handled separately. If the electric utility rate is $0.06 per kWh and the maximum vehicle battery capacity is 24 kWh, the energy

---

190 Schroeder, Andreas, and Thure Traber. 2012. “The Economics of Fast Charging Infrastructure for Electric Vehicles.” *Energy Policy* 43: 136–144.

191 ECOtality. Task 4: Discussion of PEV Charging Business Model Factors, Costs Factors, and Charge Rate Structures.

cost would be at most $1.44. The host then may charge $2.50 per connect event to cover costs or $75 per month added to the parking space costs, if any. In this way, accounting is simple and no record of kWh usage or time reporting is required.

Fixed Rate

A fixed rate fee may be charged if high utilization and turnover of vehicles is desired. The fee may not be directly related to the amount of energy delivered to the vehicle but rather on the time that the vehicle is occupying the charging space. It may be that the vehicle's battery is unable to accept a charge or the state of charge is high so little energy is transferred but the vehicle still remains in the parking stall for the time and it denies others the opportunity to charge. Publicly available EVSE are generally well suited for this rate. The rate selected needs to account for the cost of the energy and other operational and maintenance factors but at the same time needs to recognize that this charge is generally provided for the convenience of the EV driver. A fee that is too high will discourage use and thus reduce revenue to the host.

The currently available on-board chargers are either a 3.3 or 6.6 kW chargers. Assuming the former capability, the maximum energy transferred in an hour then is 3.3 kWh. At a daytime electric rate of $0.12 per kWh, the maximum cost for the charge then is $0.39. If other operational and maintenance costs then are about $0.25, the total cost for the hour charge is $0.64. An hourly fee of $1 - 2 would provide revenue for the host (and EVSE provider if a fee sharing program is in effect) to offset the costs and recover capital costs.

It may be desired to keep the cost for public charging near the cost of fuel for an internal combustion vehicle. If gasoline costs about $4 per gallon and the vehicle has an equivalent gasoline version which achieves 30 miles per gallon efficiency, $4 cost provides 30 miles of range. Assuming that one hour charge can provide energy for 10 miles for the EV, 3 hours of charge would be required to deliver the same range. The 3 hour cost should be close to $4 if this comparison is important. That would mean a fee of $1.33 per hour which fits in the range identified above. The convenience factor for providing this recharge while the driver is otherwise engaged then can be applied.

The driver is thus incentivized to use the EVSE but not to over-stay since the clock is running whether or not energy is delivered. How much energy the vehicle can accept is not a factor in this fee structure. The driver does know in advance what the costs associated with the charge will be.

Another type of model is a fixed rate per month for network access, which is employed by eVgo. In this case the driver pays a monthly fee for access to all public stations included in the EVSE network. Such a plan can work well for drivers who are using public charging multiple times each month and who are consistently driving to the locations included in the EVSE network. An example rate structure in Houston, TX has monthly cost that can range from $39/month to $89/month, depending on the options selected.[192]

[192] eVgo. 2011. "Charging Plans." https://www.evgonetwork.com/Charging_Plans/.

Energy Consumption

Some EVSE suppliers are considering a fee based upon the energy consumed. The EVSE internal meter or other in-line meter measures the energy delivered and applies a multiplier on the electric utility rate to offset the electrical costs and other operational and maintenance costs. For example, if the electric utility charges $0.12 per kWh, the fee charged at the EVSE may be $0.50 per kWh. While this fee structure is directly related to the amount of energy transferred, it does not consider the time taken to deliver that energy nor that the vehicle may be parked in the location well beyond the full charge received. In fact, this structure would encourage longer stay times.

Because this method requires the in-line or embedded meter and measurement of that energy, the fee is more complicated than the fixed fee approach and the driver will not know the cost of the charge until it is completed.

This method may be applied as above where the duration of the stay is not important or where long stay times are anticipated. Workplace charging might find this method to be desirable since the parking lot is sufficient for all employees and no additional fee for the space is necessary. Once parked, there is little incentive for employees to return to the parking lot to move their vehicle so turnover at a station is not anticipated. Charging the fee eliminates the preferential treatment concern. Multi-family dwellings might also consider this method although more administrative work will be required to account for the energy used.

PEV Ownership and Barriers

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.[193] Additionally, consumers expect PEVs to be cost-competitive with similar ICE vehicle models, with a majority desiring a sticker price under $30,000.[194] 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 46 shows a general comparison between similar vehicles.

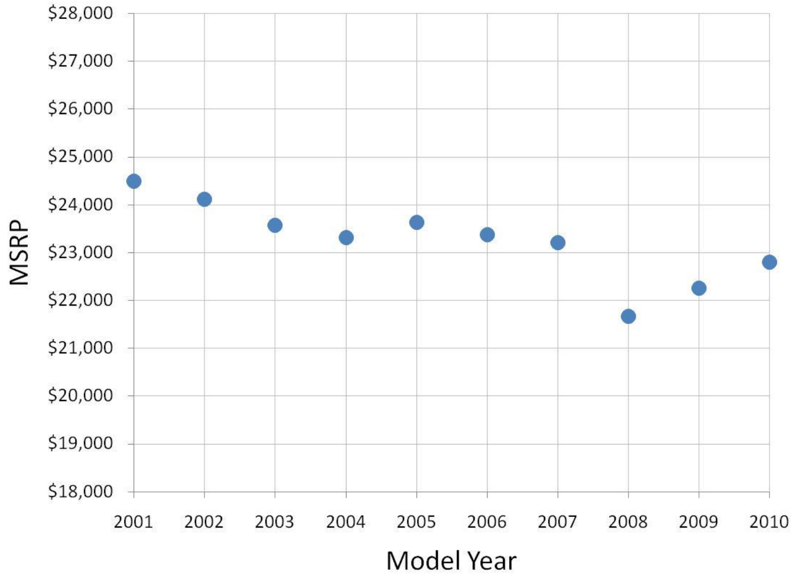
Table 46. MSRP Comparisons: PEVs vs. Conventional Vehicles

PEVs		Conventional Vehicles		Price Difference [A]-[B]	Tax Credit		Price Difference after credits [A]-[C]-[D]
Make/Model	MSRP [A]	Make/Model	MSRP [B]		Fed [C]	State [D]	
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 manufacturing 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 56), with a range of less than $3,000 when adjusted for inflation, despite declining battery costs.

193 Deloitte Touche Tohmatsu Ltd, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 2010.
194 Ibid.

Figure 56. 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. As conventional vehicles become more expensive to comply with more stringent fuel economy standards, the additional or incremental cost of PEVs will decrease accordingly; however, the increased fuel economy of the 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.[195]

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.[196]

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

---

195 Interview with Stephanie Janczak, Barbara Rogers, and Mike Tinsky, Ford Motor Company, April 2012.

196 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[197] as does the California Air Resources Board's (CARB's) Drive Clean site.[198]

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.[199] 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.[200] 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. [201] 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.[202]

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.[203]
- 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.[204]
- 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 HOV lanes (where available).[205]

---

197 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/.
198 DriveClean, A buying guide for clean and efficient vehicles, CARB. http://www.driveclean.ca.gov.
199 Charul Vyas and Clint Wheelock, "Energy & Environment Consumer Survey: Consumer Attitudes and Awareness about 13 Clean Energy Concepts," *Pike Research*, 2012, 2.
200 Deloitte Touche Tohmatsu Ltd, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 2010, 6.
201 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.
202 Pacific Gas & Electric Company, "Electric Vehicle Penetration Study Using Linear Discriminant Analysis," June 2011, 4.
203 Interview with Britta Gross, General Motors Company (GM), March 2012.
204 Interview with David Peterson, Nissan North America, Inc., March 2012.
205 Interview with Stephanie Janczak, Barbara Rogers, and Mike Tinsky, Ford Motor Company, April 2012.

Although the demographics of early adopters are relatively 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.

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.[206]

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 DOE’s 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 in-car climate controls to increase range.[207] The most frequent adaptation was to simply use a second, conventional vehicle, as cited by 94% of the MINI E users.[208]

---

206 Deloitte Touche Tohmatsu Ltd, “Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market,” 2010.
207 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.
208 *Ibid*.

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.[209] 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.[210]

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.[211] 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".[212]

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.

---

209 *Ibid*.
210 EPRI and SCE, "Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results," May 2010/
211 Charul Vyas et al., "Executive Summary: Electric Vehicle Consumer Survey," *Pike Research*, 2012.
212 Ernst & Young, *Cleantech matters: moment of truth for transportation electrification*, 2011 Global Ignition Sessions Report, 2011.

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,[213] consumers' expectations regarding price, range, and charging time are in many cases not met by PEVs available today.[214] 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."[215]

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.[216] 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.[217]

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.[218] 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 MDUs where PEV users may face additional challenges, followed by the development of workplace charging.[219] As the market for PEVs grows, the placement and quantity of EVSE both influences and is influenced by PEV growth.

---

213 Accenture, "Plug-in electric vehicles: Changing perceptions, hedging bets," 2011.
214 Deloitte, "Gaining Traction: Will Consumers ride the electric vehicle wave?" *Deloitte Global Services Ltd*., 2011.
215 Dr. Jeffrey Dubin, et.al, "Realizing the Potential of the LA EV Market," *University of California Los Angeles Luskin Center for Innovation*, May 2011.
216 D. Greene and S. Plotkin, "Reducing Greenhouse Gas Emissions from U.S. Transportation," *Pew Center on Global Climate Change*, 2011.
217 Indiana University, "Plug-in Electric Vehicles: A Practical Plan for Progress," *Indiana University*, 2011.
218 Dr. Jeffrey Dubin, et.al., "Realizing the Potential of the LA EV Market," *University of California Los Angeles Luskin Center for Innovation*, May 2011.
219 Interview with David Peterson, Nissan North America, Inc., March 2012.

Recent research from Ford Motor Company [220] and the University of Delaware[221] 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.[222] 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 inform policies to 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.[223] 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 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.

---

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

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 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 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.[224] 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.[225]

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

Appendix B: Review of Local Government Readiness Survey

Introduction

BAAQMD conducted a survey of local governments as part of the readiness planning effort. Of the 120 local government agencies that were contacted, 103 submitted responses. The survey included more than 200 questions across the following areas:

• Permitting	• Training & Education
• Building Codes	• Zoning and Parking Ordinances
• Marketing & Outreach	• Public Charging
• Workplace Charging	• Charging at multi-family dwellings
• Fleets	• Incentives for EVSE deployment
• Integrating EVSE and Renewable Energy	• Other

The survey also included a section that was specifically for agencies that also provide utility services e.g., electricity.

Quantifying Readiness: Analyzing the Survey

BAAQMD developed a scoring methodology to analyze the survey responses to quantify the readiness of local governments across three core areas covered in Sections 5 through 7: building codes, permitting, and zoning and parking ordinances. Each readiness area was scored separately based on a subjective determination of the responses that would indicate the highest level of readiness. For instance, agencies that reported having a low permitting fee (e.g., less than $250) and a fast turnaround time for permit issuance (e.g., same day) were scored higher than responses that indicated higher permitting fees and a slower turnaround time for permit issuance.

After each section was scored separately, the scores were combined via weighting according to the percentages highlighted in the table below. For the purposes of this readiness planning process, the weighting factors in the table below were applied to each section of the readiness surveys:

Readiness Survey Element	Weighting
Building Codes	20%
Permitting	45%
Zoning and Parking Ordinances	35%

The scoring across the three core readiness elements listed in the table reflect the focus of the readiness planning efforts on getting local governments prepared to facilitate the deployment of EVSE.

- Building Codes, 20%: These only impact new construction and major renovations; cities can require EVSE in new construction through building codes in addition to streamlining EVSE installations. However, state-level guidance and codes are currently in good shape (and may be getting better soon), so local government action is not considered to have as significant an impact in this area as in the other two areas.
- Permitting & Inspection, 45%: Permitting can make it easier or harder to install EVSE in existing SFRs, which are the type of EVSE installations for which the highest demand is expected. Streamlining permitting is primarily going to act as an incentive for EVSE in existing single-family residences. New construction will be regulated through the building/zoning codes, and larger projects (MDUs, commercial) are likely to have an expert contractor pulling permits, so we don't see permitting posing a significant obstacle to larger projects.
- Zoning & Parking, 35%: Though the zoning and parking actions that local governments take will also largely apply to new construction, they can include both requirements and incentives, giving local governments a much more flexible (and hopefully effective) approach to encouraging PEV deployment than through building codes and permitting. Over time, this readiness area may be more important for EVSE deployment than permitting and inspection, however, given the timeframe of the analysis, it is weighted slightly less. The Readiness Plan calls for a variety of high level policy and planning elements in this section, which have a number of additional effects, and therefore merit a heavier weighting:
  - Including EVSE policies in high-level plans can make it easier for locals to devote funding to EVSE planning and infrastructure.
  - EVSE parking design guidelines and requirements are likely to have a much greater impact on EVSE installations in existing non-SFR (MDUs/commercial/office) than permitting, because they dictate how much space EVSE requires, and therefore whether or not property owners must sacrifice more than one regular parking space to create an EVSE space.
  - Local governments that have given thought to zoning and parking w/r/t EVSE are often motivated by a desire to site/charge public EVSE. Though we don't anticipate public EVSE playing a major role in meeting long-term demand, it plays an important role in raising awareness of/demand for PEVs.

The other readiness areas were scored similarly, however, these scores were not factored into the total readiness score.

Finally, it is important to note that the surveys are self-reported information from local governments and certain aspects of readiness may be over-stated. For instance, although a local government may state that they have same day permitting, it is conceivable that the time to issue a permit could take longer. Due to the large response rate from local governments in the Region, it was not feasible to verify the claims of survey participants.

Overview of Results

As a whole, the local governments and agencies in the Region are taking the steps to becoming PEV ready. Considering that were are the early stages in the deployment of PEVs and EVSE, the state of readiness for the Region is good. Based on the subjective weightings developed for this survey, the highest score achieved was 63%. Based on the subjective weightings, this high score can effectively be considered nearly two thirds of the way to being considered PEV ready. The average and median scores were both about 23%. In other words, more than half the region has made significant strides towards becoming PEV ready. Again, considering the current state of the market, this is to be expected.

Despite the relatively low scores on an average or median basis, there is encouraging news buried within each of these overall statistics. For instance, in the core areas of readiness for local governments the agencies that have taken action to become PEV ready are doing quite well. After removing the null scores (i.e., agencies that have not done anything in these areas), the average scores across these elements range from 25% to 46%. In other words, the agencies that have taken action, have made significant progress towards becoming PEV ready. Local governments have made the most strides in the highest prioritized area: permitting. With an average score of 46%, about half the region is half-way to being PEV ready.

The following sections are distinguished by the two major areas involved in the planning efforts: the San Francisco Bay Area and the Monterey Bay Area. Within each of these sections, the responses to the survey are distinguished by county and then city. The key aspects of the survey are reviewed at the city level within each county.

San Francisco Bay Area

Alameda County

City / County	Permitting				Building Codes	Incentives
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*		
Alameda County	$101-$250	Same day	Over the counter	Intermediate and post-inspection	best practice; 2010 CBC and guidelines developed by Tri-Chapter Code Committee	-
City of Alameda	$101-$250	6-10 days	Over the counter	Pre and post inspection	not started	Assistance with infrastructure costs
City of Albany	$101-$250	2-5 days	Over the counter	Intermediate and post-inspection	not started	None
City of Berkeley	-	-	-	-	looking at other agencies	Rebates for the vehicles and equipment
City of Dublin	less than $100	Same day	Over the counter	Post-inspection	best practice; All EVSE requirements related to 2010 CBC, CEC, CGBSC	-
City of Emeryville	less than $100	Same day	Over the counter	Post-inspection	-	-
City of Hayward	$101-$250	Same day	Over the counter	Post-inspection	not started	-
City of Livermore	$101-$250	Same day	Over the counter	Intermediate and post-inspection	-	-
City of Newark	$101-$250	Same day	Over the counter	Post-inspection	not started	-
City of Piedmont	$251-$500	6-10 days	Over the counter	Pre and post inspection	not started	-
City of Pleasanton	$101-$250	Same day	Over the counter	Pre and post inspection	looking at other agencies	-
City of San Leandro	$101-$250	Same day	Over the counter	Post-inspection	in process	-
City of Union City	-	6-10 days	Over the counter	-	-	-

Notes:

- The Cities of Fremont and Oakland provided mostly blank responses. The City of Fremont has just started on the permitting process and the City of Oakland provides grant incentives to pay for charging infrastructure and the incremental cost.

- None of the cities listed above have started updating zoning or parking rules.
- Both the City of Alameda and the City of Berkeley have marketing and outreach websites and provide public EV users with free parking spaces and free charging.

Contra Costa County

City / County	Permitting			
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*
Contra Costa County	$101-$250	Same day	Over the counter	Intermediate and post-inspection
City of Antioch	less than $100	Same day	Over the counter	Post-inspection
City of Brentwood	$101-$250	2-5 days	Over the counter	Pre and post inspection
City of Clayton	$101-$250	6-10 days	Over the counter	Intermediate and post-inspection
City of Concord	-	3-5 weeks	Over the counter	BLANK
City of El Cerrito	$101-$250	2-5 days	Over the counter	Post-inspection
City of Lafayette	less than $100	Same day	Over the counter	Plan check only
City of Martinez	$101-$250	2-5 days	Over the counter	Intermediate and post-inspection
City of Oakley	$101-$250	2-5 days	Over the counter	Intermediate and post-inspection
City of Pinole	-	6-10 days	Over the counter	Intermediate and post-inspection
City of Richmond	less than $100	Same day	-	Intermediate and post-inspection
City of San Pablo	less than $100	Same day	Over the counter	Post-inspection
City of San Ramon	$101-$250	Same day	Over the counter	Intermediate and post-inspection
City of Walnut Creek	$101-$250	Same day	Over the counter	Post-inspection
Town of Danville	$101-$250	Same day	Over the counter	Post-inspection
Town of Moraga	-	-	-	-

Notes:

- The following cities within Contra Costa County provided mostly blank responses: City of Hercules, City of Orinda, City of Pittsburg, and City of Pleasant Hill.
- None of the cities listed above have started updating zoning or parking rules.
- Only the City of Walnut Creek has developed adopted building code requirements. The City considers them to be best practice and participated in Tri-Chapter Uniform Code Committee.
- In terms of incentives, the City of El Cerrito provides grant funding and the City of San Ramon provides rebates.
- Three agencies have received funding from 511 Contra Costa, including Martinez, Pittsburg, and the Contra Costa Transportation Authority.

Marin County

City / County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*	*Building Codes*	*Marketing and Outreach*
City of Belvedere	less than $100	2-5 days	over the counter	pre and post inspection	not started	-
City of Larkspur	more than $501	3-5 weeks	over the counter	pre and post inspection	just started	-
City of Mill Valley	less than $100	same day	over the counter	post-inspection	not started	free charging and parking for EVs
City of Novato	less than $100	same day	over the counter	post-inspection	just started	free charging and parking for EVs
City of San Rafael	$101-$250	same day	over the counter	intermediate and post-inspection	best practice	-
City of Sausalito	$251-$500	6-10 days	over the counter	post-inspection	not started	-
Marin County	$101-$250	same day	over the counter	intermediate and post-inspection	just started	-

Notes:

- The City of San Rafael is the only city to have started updating zoning or parking rules.
- The Town of Tiburon provided blank responses.
- Towns of Corte Madera, Fairfax, Ross, and San Anselmo did not respond to the survey.

Napa County

City / County	Permitting				Other	
	Permit fee (single family)	*timeframe*	*application*	*Additional info*	*Building Codes*	*Incentives*
City of American Canyon	<$100	same day	over the counter		Not started	
City of Napa	<$100	same day	over the counter		Already adopted requirements	Plan to offer free parking spaces for PEVs
City of St. Helena	$251-500	6-10 days	over the counter		Not started Will take from the existing code though; will adopt these in "3-6 months"	Offers free parking spaces for PEVs
Town of Yountville	$101-250	same day	over the counter		Only started to consider	
Napa (County)	$101-250	same day	over the counter	Napa has created a simple submittal checklist for applicants	comfortable with CALGreen codes. Feel that these cover it for them	

Notes:

- The City of St. Helena reports that it takes 3-5 weeks to get a permit for an installation of EVSE at commercial, MDU, or open lot.
- The Town of Yountville requires more than one pre-inspection (this is probably excessive for a single family installation).
- The City of Calistoga did not answer questions.
- None of the cities listed above have started updating zoning or parking rules.

San Francisco County

City/ County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*	*Building Codes*	*Public Charging*
City and County of San Francisco	$101-$250	Same day	Over the counter	Post-inspection	Looking at other agencies	Yes; BAAQMD/TFCA, CEC, and USDOE funding

Notes:

- The City and County of San Francisco is looking at other agencies regarding updating zoning and/or parking rules.
- The SF Department of Environment provides incentives for buy-downs for PEV purchase and for charging infrastructure.

San Mateo County

City / County	Permitting					Zoning and Parking
	Permit Fee	*Timeframe*	*Application*	*Permit Required*	*Process*	
City of Belmont	$101-$250	Same day	Over the counter	Electrical	Post-inspection	Not started
City of Brisbane	less than $100	3-5 weeks	Over the counter	Building & Electrical	Intermediate and post-inspection	Not started
City of Burlingame	$101-$250	Same day	Over the counter	Building & Electrical	Post-inspection	-
City of Daly City	$101-$250	Same day	Over the counter	Electrical	Post-inspection	-
City of East Palo Alto	$251-$500	6-10 days	Over the counter	Building & Electrical	More than one pre-inspection	Looking at other agencies
City of Foster City	$101-$250	Same day	Over the counter	Electrical	Post-inspection	-
City of Half Moon Bay	-	-	-	-	-	-
City of Menlo Park	more than $501	3-5 weeks	Over the counter	Building & Electrical	Pre and post inspection	-
City of Millbrae	$251-$500	6-10 days	Over the counter	Building	Pre and post inspection	-
City of Pacifica	$101-$250	Same day	Over the counter	Building & Electrical	Post-inspection	-
City of Redwood City	less than $100	2-5 days	Over the counter	Building	Intermediate and post-inspection	-
City of San Bruno	$101-$250	6-10 days	Over the counter	Building & Electrical	Post-inspection	Just started
City of San Carlos	less than $100	Same day	Over the counter	Building	Post-inspection	Best practice
City of San Mateo	$101-$250	Same day	Over the counter	Building & Electrical	Pre and post inspection	-
City of South San Francisco	$251-$500	6-10 days	Over the counter	Building & Electrical	Intermediate and post-inspection	Looking at other agencies
San Mateo County	-	-	-	-	-	-
Town of Atherton	$101-$250	Same day	Over the counter	Electrical	Post-inspection	-
Town of Colma	BLANK	6-10 days	Over the counter	Building & Electrical	Intermediate and post-inspection	-
Town of Hillsborough	$251-$500	2-5 days	Over the counter	Electrical	Pre and post inspection	Looking at other agencies
Town of Portola Valley	less than $100	Same day	Over the counter	Electrical	Post-inspection	Not started
Town of Woodside	more than $501	3-5 weeks	-	Planning Entitlement	Intermediate and post-inspection	-

Notes:

- None of the cities listed above have started updating zoning or parking rules.

- The City of East Palo Alto and the Town of Woodside are the only agencies to have implemented the 2010 California Electrical Code.
- The Town of Portola Valley is the only agency to provide incentives.

Santa Clara County

City / County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Process*	*Building Codes*	*Marketing and Outreach*
City of Cupertino	$101-$250	Same day	Over the counter	Post-inspection	Best practice	Not started
City of Los Altos	$101-$250	2-5 days	Over the counter	Post-inspection	-	Just started
City of Milpitas	$101-$250	Same day	Over the counter	Pre and post inspection	-	-
City of Monte Sereno	$251-$500	3-5 weeks	Over the counter	Pre and post inspection	Just started	Just started
City of Morgan Hill	$101-$250	Same day	Over the counter	Post-inspection	Looking at other agencies	Looking at other agencies
City of Mountain View	less than $100	Same day	Over the counter	Post-inspection	Not started	Not started
City of Palo Alto	$101-$250	Same day	Over the counter	Post-inspection	Looking at other agencies	Best practice
City of San Jose	-	Same day	Over the counter	Post-inspection	Looking at other agencies	-
City of Saratoga	less than $100	Same day	Over the counter	Post-inspection	Looking at other agencies	Not started
City of Sunnyvale	$101-$250	Same day	Over the counter	Intermediate and post-inspection	Best practice	In process
Santa Clara County	-	-	Over the counter	-	-	-
Town of Los Altos Hills	less than $100	Same day	Over the counter	Pre and post inspection	Best practice	Not started
Town of Los Gatos	$251-$500	6-10 days	Over the counter	Intermediate and post-inspection	Just started	Not started

Notes:

- The Cities of Campbell, Gilroy, and Santa Clara provided mostly blank responses.
- The City of San Jose is the only agency to start updating zoning or parking rules.
- The City of Monte Sereno is the only agency to provide rebate incentives.

Solano County

City / County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Process*	*Building Codes*	*Public Charging*
City of Benicia	$101-$250	Same day	Over the counter	Intermediate and post-inspection	Not started	-
City of Dixon	$101-$250	2-5 days	Over the counter	Pre and post inspection	Just started	-
City of Fairfield	less than $100	Same day	Over the counter	Post-inspection	Not started	Yes; Grant from SMUD for one charging station at the Fairfield Civic Center
City of Rio Vista	less than $100	2-5 days	Over the counter	Pre and post inspection	Looking at other agencies	Yes
City of Suisun City	$101-$250	6-10 days	Over the counter	Intermediate and post-inspection	Just started	Yes
City of Vacaville	less than $100	2-5 days	Over the counter	Post-inspection	Not started	-
Solano County	$251-$500	2-5 days	Over the counter	Intermediate and post-inspection	Best practice	-

Notes:

- The Cities of Rio Vista and Suisun City are the only cities to have started updating zoning and/or parking rules.
- None of the cities listed above provide incentives.
- The City of Vallejo did not respond to the survey.

Sonoma County

City/ County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*	*Building Codes*	*Public Charging*
City of Cloverdale	$251-$500	6-10 days	Over the counter	Intermediate and post-inspection	Not started	-
City of Healdsburg	$251-$500	2-5 days	Over the counter	Post-inspection	Looking at other agencies	-
City of Rohnert Park	-	-	-	-	Not started	Yes; Coulomb Tech ARRA grant
City of Santa Rosa	$101-$250	Same day	Over the counter	Intermediate and post-inspection	-	Yes; DOE Grant
City of Sebastopol	$101-$250	Same day	Over the counter	More than one pre-inspection	Best practice	Yes
City of Sonoma	$251-$500	3-5 weeks	Over the counter	Pre and post inspection	More info	Yes; County of Sonoma
Sonoma County	-	Same day	Over the counter	-	-	Yes

Notes:

- The City of Santa Rosa and Sonoma County are the only agencies to have started updating zoning and/or parking rules.
- None of the cities listed above provide incentives.
- The City of Cotati provided mostly blank responses.
- The City of Petaluma and Town of Windsor did not respond to the survey.

Monterey Bay Area

Monterey County

City / County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*	*Building Codes*	*Zoning and Parking*
City of Carmel By The Sea	$101-$250	6-10 days	Over the counter	Post-inspection	-	looking at other agencies
City of Gonzales	less than $100	2-5 days	Over the counter	Pre and post inspection	2010 California Electrical Code	-
City of King City	$101-$250	2-5 days	Over the counter	Intermediate and post-inspection	2010 California Electrical Code	-
City of Monterey	$101-$250	2-5 days	Over the counter	Post-inspection	-	-
City of Salinas	$251-$500	2-5 days	Over the counter	Post-inspection	2010 California Electrical Code	more info
City of Sand City	less than $100	2-5 days	Over the counter	Post-inspection	-	just started
City of Seaside	less than $100	6-10 days	Over the counter	Pre and post inspection	2010 California Electrical Code	just started
City of Soledad	$101-$250	3-5 weeks	Over the counter	Intermediate and post-inspection	-	more info
Monterey County	$101-$250	Same day	Over the counter	Post-inspection	-	looking at other agencies

Notes:

- None of the cities listed above provide incentives.
- The Cities of Del Rey Oaks, Greenfield, and Pacific Grove are in Monterey County, but provided blank responses.
- The City of Marina did not respond to the survey.

San Benito County

City / County	Permitting				Zoning & Parking Ordinances
	Permit fee (single family)	*timeframe*	*application*	*Permitting process*	
City of Hollister	-	Same day	Over the counter	Pre and post inspection	Only started
City of San Juan Bautista	less than $100	2-5 days	Over the counter	Plan check only	-
San Benito County	less than $100	Same day	Over the counter	Post-inspection	-

Notes:

- None of the cities listed above have started updating building codes or provide incentives.

Santa Cruz County

City / County	Permitting				Other	
	Permit Fee (single family)	*Timeframe*	*Application*	*Permitting Process*	*Building Codes*	*Public Charging*
City of Capitola	$101-$250	2-5 days	Over the counter	Pre and post inspection	Looking at other agencies	-
City of Scotts Valley	-	6-10 days	Over the counter	More than one pre-inspection	Looking at other agencies	Yes
City of Watsonville	$101-$250	Same day	Over the counter	Post-inspection	More info	Yes; AMBAG grant; possible MBUAPCD grant; Possible DC fast charging installation in public parking garage
Santa Cruz County	$251-$500	Same day	Over the counter	Intermediate and post-inspection	Best practice; 2010 California Electrical Code	-

Notes:

- None of the cities listed above have started updating zoning or parking rules.
- None of the cities provide incentives.
- The City of Santa Cruz provided mostly blank responses.

City and County Scoring Across Readiness Elements

The table below includes the readiness score, the three (3) core areas considered for the readiness score (as discussed previously), as well as the scoring for the other readiness elements that were surveyed and not factored into the total readiness score. Some agencies responded that are not city or county governments (e.g., Port of Oakland); scoring of their responses are shown, however, a total score is not shown.

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
Alameda County												
Alameda County	**36%**	68%	50%	0%	*0%*	*0%*	*30%*	*0%*	*0%*	*43%*	*0%*	*0%*
City of Alameda	**30%**	14%	36%	30%	*0%*	*80%*	*14%*	*0%*	*0%*	*7%*	*100%*	*0%*
City of Albany	**22%**	0%	49%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Berkeley	**11%**	14%	4%	17%	*0%*	*96%*	*30%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Dublin	**32%**	45%	51%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Emeryville	**39%**	0%	64%	30%	*73%*	*0%*	*0%*	*57%*	*10%*	*0%*	*0%*	*0%*
City of Fremont	**2%**	0%	4%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Hayward	**28%**	0%	63%	0%	*0%*	*1%*	*8%*	*0%*	*0%*	*7%*	*0%*	*0%*
City of Livermore	**36%**	0%	71%	13%	*19%*	*1%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Newark	**12%**	0%	27%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Oakland	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*43%*	*100%*	*100%*
City of Piedmont	**8%**	0%	18%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Pleasanton	**32%**	23%	60%	0%	*0%*	*11%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of San Leandro	**47%**	45%	77%	9%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Union City	**2%**	0%	5%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Port of Oakland	**n/a**	n/a	n/a	65%	*2%*	*77%*	*30%*	*0%*	*0%*	*0%*	*0%*	*100%*
Contra Costa County												

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
City of Antioch	**17%**	0%	37%	0%	*0%*	*6%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Brentwood	**51%**	41%	59%	48%	*25%*	*4%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Clayton	**21%**	9%	42%	0%	*0%*	*1%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Concord	**8%**	0%	18%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of El Cerrito	**30%**	14%	46%	17%	*27%*	*58%*	*16%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Hercules	**2%**	0%	5%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Lafayette	**28%**	0%	62%	0%	*0%*	*0%*	*16%*	*0%*	*10%*	*0%*	*0%*	*0%*
City of Martinez	**22%**	0%	49%	0%	*0%*	*75%*	*18%*	*0%*	*0%*	*100%*	*0%*	*0%*
City of Oakley	**23%**	9%	47%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Orinda	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Pinole	**15%**	23%	23%	0%	*0%*	*54%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Pittsburg	**5%**	0%	1%	13%	*0%*	*76%*	*35%*	*0%*	*0%*	*43%*	*0%*	*0%*
City of Pleasant Hill	**2%**	0%	0%	4%	*4%*	*0%*	*1%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Richmond	**23%**	9%	47%	0%	*0%*	*48%*	*50%*	*14%*	*30%*	*71%*	*0%*	*0%*
City of San Pablo	**39%**	0%	86%	0%	*0%*	*4%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of San Ramon	**33%**	14%	68%	0%	*19%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Walnut Creek	**38%**	36%	69%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Contra Costa County	**21%**	0%	46%	0%	*2%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Contra Costa Transp. Authority	**n/a**	n/a	3%	13%	*2%*	*1%*	*30%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Danville	**27%**	0%	60%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Moraga	**1%**	0%	3%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Marin County												
City of Belvedere	**17%**	9%	33%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
City of Larkspur	**20%**	32%	31%	0%	*0%*	*4%*	*16%*	*57%*	*0%*	*43%*	*0%*	*0%*
City of Mill Valley	**36%**	9%	76%	0%	*0%*	*59%*	*30%*	*0%*	*0%*	*0%*	*100%*	*100%*
City of Novato	**55%**	23%	92%	26%	*0%*	*75%*	*41%*	*0%*	*0%*	*43%*	*0%*	*0%*
City of San Rafael	**40%**	55%	38%	35%	*0%*	*1%*	*30%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Sausalito	**16%**	0%	35%	0%	*0%*	*0%*	*27%*	*0%*	*0%*	*57%*	*0%*	*0%*
Marin County	**27%**	9%	56%	0%	*0%*	*0%*	*22%*	*0%*	*0%*	*43%*	*0%*	*0%*
Town of Tiburon	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Transportation Authority of Marin	**n/a**	n/a	n/a	0%	*38%*	*55%*	*49%*	*14%*	*0%*	*43%*	*100%*	*0%*
Napa County												
City of American Canyon	**22%**	0%	49%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Calistoga	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Napa	**41%**	55%	68%	0%	*0%*	*4%*	*35%*	*0%*	*0%*	*64%*	*0%*	*0%*
City of St. Helena	**8%**	0%	17%	0%	*0%*	*6%*	*0%*	*0%*	*0%*	*43%*	*0%*	*0%*
Napa County	**24%**	0%	54%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Yountville	**20%**	9%	40%	0%	*0%*	*3%*	*9%*	*0%*	*0%*	*100%*	*0%*	*0%*
San Francisco County												
City and County of San Francisco	**39%**	14%	71%	13%	*27%*	*65%*	*76%*	*57%*	*40%*	*50%*	*100%*	*100%*
San Mateo County												
City of Belmont	**32%**	0%	64%	9%	*23%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Brisbane	**23%**	0%	51%	0%	*6%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Burlingame	**29%**	0%	65%	0%	*0%*	*0%*	*0%*	*0%*	*10%*	*0%*	*0%*	*0%*

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
City of Daly City	**23%**	9%	47%	0%	*2%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of East Palo Alto	**50%**	77%	27%	65%	*35%*	*14%*	*28%*	*0%*	*0%*	*57%*	*0%*	*0%*
City of Foster City	**25%**	23%	46%	0%	*0%*	*52%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Half Moon Bay	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Menlo Park	**10%**	0%	22%	0%	*0%*	*3%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Millbrae	**12%**	0%	26%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Pacifica	**26%**	14%	51%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Redwood City	**31%**	18%	60%	0%	*2%*	*69%*	*27%*	*0%*	*10%*	*50%*	*0%*	*0%*
City of San Bruno	**23%**	5%	38%	13%	*0%*	*0%*	*0%*	*0%*	*0%*	*21%*	*0%*	*0%*
City of San Carlos	**63%**	0%	88%	65%	*15%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of San Mateo	**36%**	55%	56%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of South San Francisco	**21%**	0%	29%	22%	*25%*	*10%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
San Mateo County	**4%**	14%	3%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Atherton	**11%**	0%	24%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Colma	**12%**	0%	26%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Hillsborough	**22%**	0%	40%	13%	*2%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Portola Valley	**30%**	5%	58%	9%	*4%*	*20%*	*32%*	*0%*	*10%*	*7%*	*100%*	*100%*
Town of Woodside	**12%**	14%	21%	0%	*0%*	*4%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Santa Clara County												
City of Campbell	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Cupertino	**48%**	64%	78%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Gilroy	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Los Altos	**21%**	0%	40%	9%	*0%*	*3%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
City of Milpitas	**32%**	0%	71%	0%	*60%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Monte Sereno	**13%**	9%	26%	0%	*0%*	*49%*	*0%*	*0%*	*0%*	*0%*	*100%*	*0%*
City of Morgan Hill	**41%**	36%	74%	0%	*0%*	*8%*	*0%*	*14%*	*0%*	*0%*	*0%*	*0%*
City of Mountain View	**34%**	9%	71%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Palo Alto	**35%**	27%	55%	13%	*67%*	*85%*	*30%*	*43%*	*0%*	*0%*	*0%*	*0%*
City of San Jose	**44%**	18%	50%	52%	*2%*	*0%*	*0%*	*0%*	*30%*	*0%*	*0%*	*0%*
City of Santa Clara	**3%**	0%	6%	0%	*0%*	*0%*	*4%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Saratoga	**33%**	23%	63%	0%	*0%*	*1%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Sunnyvale	**42%**	77%	56%	4%	*0%*	*63%*	*0%*	*0%*	*90%*	*0%*	*0%*	*0%*
Santa Clara County	**9%**	0%	21%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Los Altos Hills	**28%**	55%	38%	0%	*0%*	*0%*	*20%*	*0%*	*0%*	*0%*	*0%*	*0%*
Town of Los Gatos	**19%**	23%	32%	0%	*0%*	*61%*	*19%*	*0%*	*0%*	*0%*	*0%*	*0%*
Solano County												
City of Benicia	**32%**	9%	67%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Dixon	**18%**	9%	36%	0%	*0%*	*3%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Fairfield	**28%**	0%	63%	0%	*0%*	*0%*	*24%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Rio Vista	**62%**	73%	49%	74%	*0%*	*73%*	*81%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Suisun City	**23%**	18%	33%	13%	*0%*	*0%*	*19%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Vacaville	**23%**	0%	51%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Solano County	**36%**	73%	47%	0%	*8%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Sonoma County												
City of Cloverdale	**12%**	0%	26%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Cotati	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
City of Healdsburg	**22%**	41%	31%	0%	*0%*	*4%*	*1%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Rohnert Park	**0%**	0%	0%	0%	*0%*	*4%*	*24%*	*0%*	*0%*	*43%*	*0%*	*0%*
City of Santa Rosa	**53%**	0%	78%	52%	*35%*	*85%*	*76%*	*57%*	*0%*	*64%*	*0%*	*0%*
City of Sebastopol	**42%**	59%	67%	0%	*0%*	*51%*	*16%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Sonoma	**11%**	5%	23%	0%	*0%*	*10%*	*32%*	*43%*	*0%*	*14%*	*0%*	*0%*
Sonoma County	**23%**	0%	41%	13%	*33%*	*8%*	*62%*	*43%*	*0%*	*43%*	*0%*	*0%*
Monterey County												
City of Carmel By The Sea	**40%**	36%	35%	48%	*0%*	*32%*	*24%*	*57%*	*0%*	*0%*	*0%*	*0%*
City of Del Rey Oaks	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Gonzales	**45%**	68%	71%	0%	*35%*	*4%*	*16%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Greenfield	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of King City	**23%**	32%	36%	0%	*0%*	*4%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Monterey	**33%**	27%	60%	0%	*38%*	*4%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Pacific Grove	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*43%*	*0%*	*0%*
City of Salinas	**27%**	18%	45%	9%	*0%*	*11%*	*41%*	*14%*	*0%*	*64%*	*0%*	*0%*
City of Sand City	**35%**	0%	71%	9%	*65%*	*8%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Seaside	**31%**	14%	36%	35%	*0%*	*4%*	*20%*	*0%*	*0%*	*14%*	*0%*	*0%*
City of Soledad	**19%**	0%	29%	17%	*50%*	*4%*	*0%*	*0%*	*0%*	*43%*	*0%*	*0%*
Monterey County	**42%**	5%	78%	17%	*0%*	*4%*	*4%*	*0%*	*0%*	*0%*	*0%*	*100%*
San Benito County												
City of Hollister	**23%**	0%	45%	9%	*48%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of San Juan Bautista	**27%**	0%	59%	0%	*0%*	*45%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*

County / City	Total	Bldg Codes	Permitting	Zoning & Parking	*Train & Edu*	*M & O*	*Public Charging*	*Work Charging*	*MDUs*	*Fleets*	*Incentives*	*Renewables*
San Benito County	**32%**	0%	72%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Santa Cruz County												
City of Capitola	**26%**	23%	49%	0%	*0%*	*65%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Santa Cruz	**0%**	0%	0%	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Scotts Valley	**19%**	36%	26%	0%	*60%*	*49%*	*49%*	*0%*	*0%*	*0%*	*0%*	*0%*
City of Watsonville	**31%**	5%	67%	0%	*0%*	*10%*	*30%*	*0%*	*30%*	*0%*	*0%*	*0%*
Santa Cruz County	**39%**	59%	60%	0%	*10%*	*0%*	*0%*	*0%*	*0%*	*43%*	*0%*	*0%*

Appendix C: Regional Employer Survey

Overview

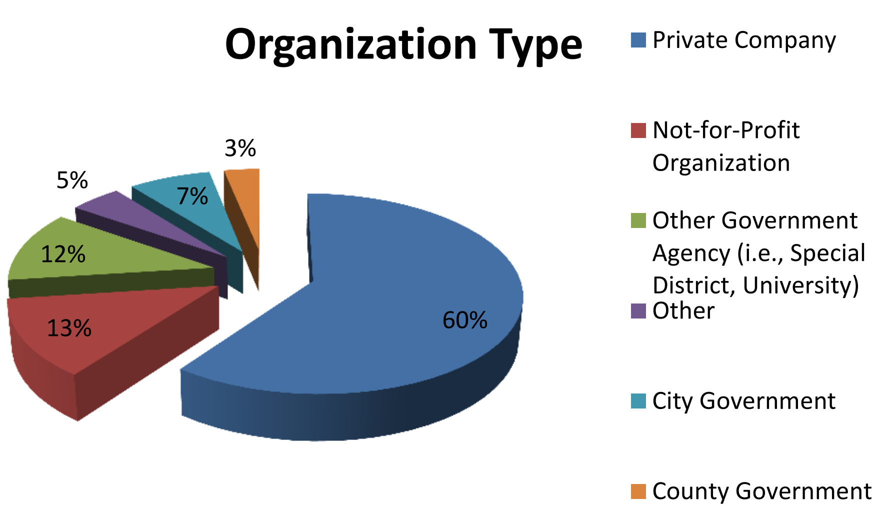
509 employers in the Bay Area and Monterey Bay Area responded to the Regional Employer Survey conducted by BAAQMD. Of these responses, 39 were either blank or faulty, which left 470 responses for evaluation. The survey is divided into three parts: 1) general questions about the employer, 2) questions regarding the employer's fleet and parking availability (e.g., number and types of vehicles), and 3) questions about the employer's interest in learning more about PEVs and EVSE deployment in the Region.

General Questions

Question 10 - Organization Type

The majority of employers were private companies (60%) with non-profits representing 13% and government agencies representing approximately 22% of employers.

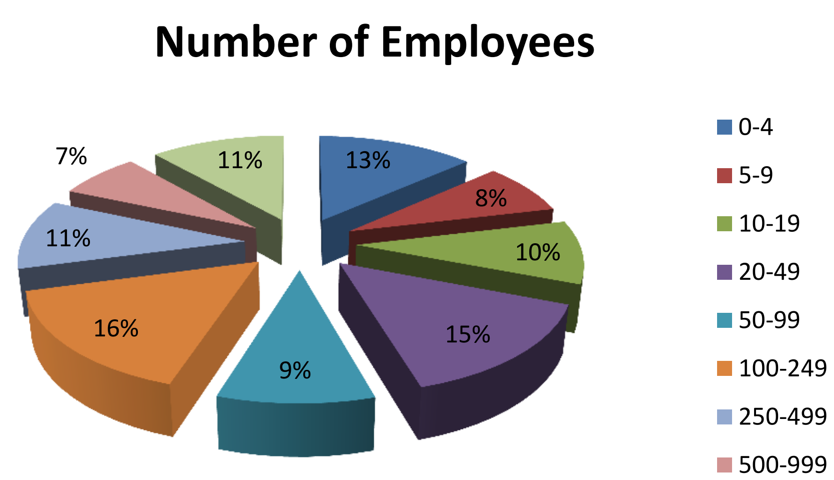
Category	Count	Percent
Private Company	283	60%
Not-for-Profit Organization	60	13%
Other Government Agency (i.e., Special District, University)	55	12%
Other	22	5%
City Government	35	7%
County Government	15	3%
TOTAL	470	



Question 11 - Approximate Number of Employees?

The employers varied widely in size. Approximately 45% of employers had more than 100 employees, 35% between 20 and 100 employees, and 20% less than 20 employees.

No. of Employees	Count	Percent
0-4	63	13%
5-9	37	8%
10-19	45	10%
20-49	69	15%
50-99	44	9%
100-249	75	16%
250-499	50	11%
500-999	33	7%
1,000+	54	11%
TOTAL	470	



Question 12 - What type of business is your organization?

The employers also varied widely in type of organization across 13 categories. Approximately 11% fell into the Educational Services, Health Care and Social Assistance category, 16% in the Government/Public Agency category, 17% in the Professional, Scientific, Technical, Management, Administrative category, and 17% in the Other category.

Business Type	Count	Percent
Agriculture, Forestry, Fishing and Hunting, and Mining	5	1%
Arts, Entertainment, Recreation, Accommodation, and Food Services	25	5%
Construction	19	4%
Educational Services, Health Care and Social Assistance	51	11%
Finance and Insurance, Real Estate and Rental and Leasing	34	7%
Government/Public Agency	75	16%
Information (i.e. newspaper, radio, broadcasting, telecommunication)	9	2%
Manufacturing	40	9%
Other	81	17%
Professional, Scientific, Technical, Management, Administrative	78	17%
Transportation and Warehousing	16	3%
Utilities (i.e. electric, gas, water, sewage)	12	3%
Wholesale Trade, Retail Trade	20	4%
BLANK	5	1%
TOTAL	470	

Fleet and Employer Questions

Question 13 - Does your company have on-site or off-site parking?

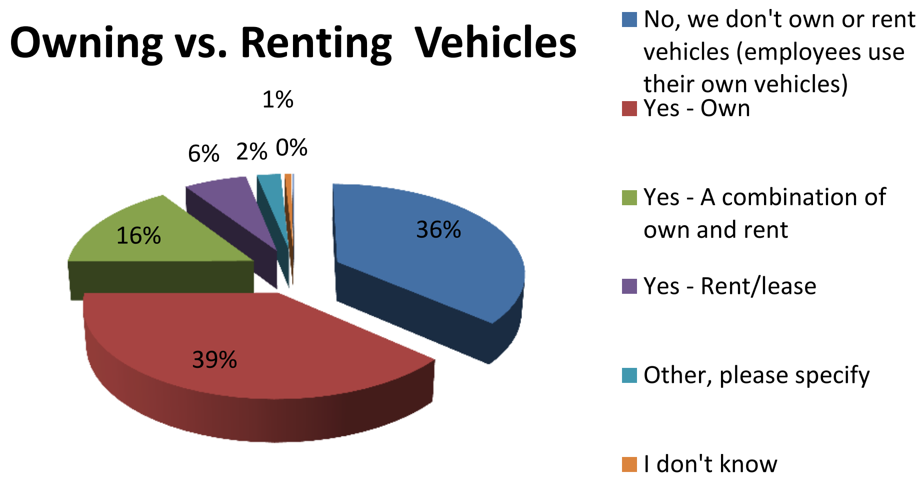
97% of employers have on-site parking, off-site parking, or both.

Question 13: Does your company have on-site or off-site parking?	Count	Percent
Yes - On-site parking	358	76%
Yes - Off-site parking	9	2%
Yes - Both on-site and off-site parking	91	19%
No	1	0%
Other, please specify	11	2%
BLANK	0	0%
TOTAL	470	

Question 14 - Does your company own or rent vehicles?

61% of employers own, rent/lease, or own and rent vehicles.

Question 14: Does your company own or rent vehicles?	Count	Percent
No, we don't own or rent vehicles (employees use their own vehicles)	171	36%
Yes - Own	181	39%
Yes - A combination of own and rent	74	16%
Yes - Rent/lease	29	6%
Other, please specify	11	2%
I don't know	3	1%
BLANK	1	0%
TOTAL	470	



Question 15 - How many Light-Duty Passenger Cars and Trucks are in your fleet (i.e. vehicles that are no more than 8,500 lbs such as passenger cars, pick-up trucks, SUVs, minivans)?

Question 15: How many Light-Duty Passenger Cars and Trucks are in your fleet (i.e. vehicles that are no more than 8,500 lbs such as passenger cars, pick-up trucks, SUVs, minivans)?	Count	Percent
1-4	126	27%
5-9	34	7%
10-19	60	13%
50-99	15	3%
100-199	9	2%
BLANK	181	39%
I don't know	4	1%
More than 200	25	5%
None	16	3%
TOTAL	470	

Question 16 - How many Medium- and Heavy-Duty Trucks are in your fleet?

Question 16: How many Medium- and Heavy-Duty Trucks are in your fleet?	Count	Percent
1-4	84	18%
5-9	32	7%
10-19	42	9%
50-99	12	3%
100-199	7	1%
BLANK	194	41%
I don't know	5	1%
More than 200	7	1%
None	87	19%
TOTAL	470	

Question 17 - How many Shuttle, Transit, or other type of Bus are in your fleet?

Question 17: How many Shuttle, Transit, or other type of Bus are in your fleet?	Count	Percent
1-4	34	7%
5-9	12	3%
10-19	14	3%
50-99	5	1%
100-199	3	1%
BLANK	210	45%
I don't know	2	0%
More than 200	2	0%
None	188	40%
TOTAL	470	

Question 18 - How many Fork Lifts are in your fleet?

Question 18: How many Fork Lifts are in your fleet?	Count	Percent
1-4	134	29%
5-9	27	6%
10-19	15	3%
50-99	3	1%
100-199	2	0%
BLANK	201	43%
I don't know	4	1%
More than 200	1	0%
None	83	18%
TOTAL	470	

Question 19 - Are any of the vehicles in your fleet plug-in electric vehicles?

Question 19: Are any of the vehicles in your fleet plug-in electric vehicles?	Count	Percent
Yes – Light-duty passenger cars and/or trucks	59	13%
Yes – Medium and/or heavy-duty trucks	3	1%
Yes – Shuttle, transit, and/or other type of bus	3	1%
Yes – Fork lifts	57	12%
No	185	39%
I don't know	5	1%
TOTAL	312	

Question 20 - What is the approximate average number of vehicle miles traveled on a daily basis by each vehicle in your fleet?

Question 20: What is the approximate average number of vehicle miles traveled on a daily basis by each vehicle in your fleet?	Count	Percent
1-20 miles	134	29%
21-40 miles	64	14%
41-60 miles	32	7%
60+ miles	35	7%
Other	24	5%
BLANK	181	39%
TOTAL	470	

Question 21 - How many of your vehicles travel on a fixed route?

Question 21: How many of your vehicles travel on a fixed route?	Count	Percent
None	185	39%
1-9	67	14%
10-49	20	4%
More than 50	16	3%
BLANK	182	39%
TOTAL	470	

Question 22 - For vehicles on fixed routes with required break times for employees (drivers) and their vehicles, what is the average duration time of each break?

Question 22: For vehicles on fixed routes with required break times for employees and their vehicles, what is the average duration time of each break?	Count	Percent
Less than 15 minutes	35	7%
15-29 minutes	45	10%
More than 30 minutes	22	5%
None, or vehicles continue to operate even while employees go on break	35	7%
BLANK	333	71%
TOTAL	470	

Question 23 - How many new vehicles does your organization plan to acquire in the next 18 months?

Question 23: How many new vehicles does your organization plan to acquire in the next 18 months?	Count	Percent
1-9 vehicles	122	26%
10-49 vehicles	29	6%
50-99 vehicles	4	1%
100-199 vehicles	4	1%
200 or more vehicles	5	1%
None	233	50%
I don't know	60	13%
BLANK	13	3%
TOTAL	470	

Question 24 - Is your organization considering plug-in electric vehicles for fleet replacement or expansion?

Question 24: Is your organization considering plug-in electric vehicles for fleet replacement or expansion?	Count	Percent
Yes	100	21%
Maybe / I don't know	134	29%
No	222	47%
BLANK	14	3%
TOTAL	470	

Question 25 - Are any electric vehicle charging stations CURRENTLY installed at your business?

Question 25: Are any electric vehicle charging stations CURRENTLY installed at your business?	Count	Percent
Yes	104	22%
No	326	69%
I don't know	17	4%
Other	22	5%
BLANK	1	0%
TOTAL	470	

Question 26 - If yes, WHAT TYPE OF CHARGING STATIONS have been installed?

Question 26: What type of charging stations have been installed?	Count	Percent
Level 1 (120 v) – J1772	38	25%
Level 2 (240 v) – J1772	70	45%
Fast Chargers (480 v)	7	5%
I don't know	39	25%
Other	0	0%

Question 27 - If yes, HOW MANY CHARGING STATIONS have been installed?

Question 27: How many charging stations have been installed?	Count	Percent
1	28	6%
2	21	4%
3	15	3%
4	11	2%
5	5	1%
6	5	1%
8	6	1%
9	1	0.2%
11	2	0.4%
12	4	1%

Question 27: How many charging stations have been installed?	Count	Percent
13	2	0.4%
14	1	0.2%
15	1	0.2%
20	2	0.4%
30	1	0.2%
400	1	0.2%
BLANK	364	77%
TOTAL	470	

Question 28 - In the next 18 months, are any electric vehicle charging stations PLANNED for installation?

Question 28: In the next 18 months, are any electric vehicle charging stations PLANNED for installation?	Count	Percent
No	247	53%
Yes	67	14%
I don't know	81	17%
Maybe	58	12%
BLANK	17	4%

Question 29 - WHAT TYPE OF CHARGING STATION(s) is being considered for installation by December 31, 2013?

Question 29: What type of charging station(s) is being considered for installation by December 31, 2013	Count	Percent
Level 1 (120 v)	20	8%
Level 2 (240 v)	80	34%
Fast Chargers (480 v)	19	8%
I don't know	119	50%

Question 30 - HOW MANY CHARGING STATIONS are being considered for installation by December 31, 2013?

Question 29: How many charging stations are being considered for installation by December 31, 2013?	Count	Percent
1	16	3%
2	18	4%
3	5	1%
4	8	2%
5	3	1%
6	5	1%
7	1	0.2%
10	1	0.2%
15	3	1%
18	1	0.2%
35	1	0.2%
40	1	0.2%
60	1	0.2%
80	1	0.2%
100	1	0.2%
BLANK	404	86%
TOTAL	470	

Question 31 - If any, which of the following challenges have you encountered during PEV charging station installation or operation?

Respondents can make multiple selections. The top three challenges are: cost of installation (19%), cost of equipment (15%), and no one uses this equipment (13%).

Question 31: Which of the following challenges have you encountered during PEV charging station installation or operation?	Count	Percent
Obtaining approval from senior/property management	30	5%
Obtaining approval from parking lot/garage owner/manager	10	2%
Choosing a vendor	27	5%
Choosing a technology	33	6%

Question 31: Which of the following challenges have you encountered during PEV charging station installation or operation?	Count	Percent
Physical constraints(in parking area)	50	9%
Utility/load issues	38	7%
Cost of equipment	69	12%
Cost of installation	91	16%
Figuring out how to collect fees/reimbursement	44	8%
Compliance with American Disabilities Act	33	6%
Maintenance costs	24	4%
Permitting issues	31	5%
Liability issues	17	3%
No one uses this equipment	62	11%
Issues over employee benefit/equity	23	4%
Other	0	0%

Question 32 - Would you provide access to charging stations to your employees and/or to the general public?

Question 32: Would you provide access to charging stations to your employees and/or to the general public?	Count	Percent
We are interested in providing this benefit to our employees only	47	10%
We are interested in providing this benefit to our employees and the general public	63	13%
We already provide this benefit to our employees AND the general public	48	10%
We already provide this benefit to our employees	25	5%
Other	57	12%
No	87	19%
Maybe	125	27%
BLANK	18	4%
TOTAL	470	

The "Other" responses varied widely. Some employers reported that the on-site EVSE were for company fleets only, while others reported they did not know if their company would provide EVSE access. Other employers mentioned that providing EVSE would be up to the landlord of the property and some reported having EVSE on-site available to employees and guests, but not the general public. Many employers also reported that right now there is no need for EVSE at their facility and thus they have not considered it yet.

Question 33 - Would access to vehicle charging stations be provided for a fee or at no cost (free) to the user?

An overwhelming majority of employers would provide access to charging stations for free to employees, and at a cost to the general public.

Question 33: Would access to vehicle charging stations be provided for a fee or at no cost to the user?	Employee's personal vehicles (Count)	Visitors (Count)	General public (Count)
Fee	79	103	177
No Cost	223	168	71
BLANK	168	199	222
TOTAL	470	470	470

Question 34 - What type of incentive would encourage you to install new or additional PEV charging stations at your business?

Respondents can make multiple selections. The majority of employers say that funding/grant would encourage them to install charging stations at their business.

Question 34: What type of incentive would encourage you to install new or additional PEV charging stations at your business?	Count	Percent
Funding/grant	282	60%
Low utility rate	174	37%
Public recognition as PEV-friendly	159	34%
None needed	74	16%
Other	36	8%

In the "Other" category there were a wide range of responses. The majority of "Other" responses stated that funding is the key to installing EVSE. Several employers also stated that significant need and interest from employees is required first. Specifically, one employer indicated that they are waiting for a significant percent of employees interested and willing to pay for the EVSE prior to making the investment. Additionally, several of the employers mentioned that they rent their facility and would require approval and/or support from the landlord.

Education

Question 35 - Would you be interested in learning more about plug-in electric vehicles, charging infrastructure, and related funding and incentive opportunities?

Respondents can make multiple selections. The majority of employers are interested in learning more about PEVs, charging infrastructure, and funding and incentives. Almost half of employers are particularly interested in funding and incentive opportunities.

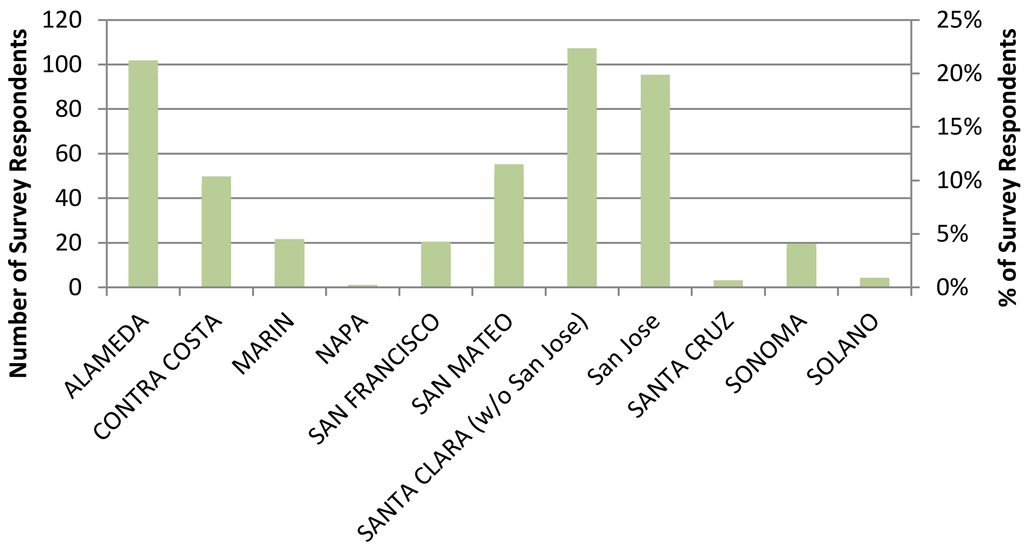
Item of Interest	Count	Percent
Yes, Plug-in electric vehicles	166	35%
Yes - Charging infrastructure	174	37%
Yes - Funding and other incentive opportunities	217	46%
No, not interested	180	38%

Appendix D: Survey of Bay Area EV Project Participants

BAAQMD, in coordination with ECOtality, issued a survey to EV Project (EVP) participants in the Bay Area to learn about their experience obtaining and owning PEVs. In the case of the Bay Area, only Nissan LEAFs are eligible to participate in the EVP; thus this survey only contains data from Nissan LEAF drivers. The core set of questions are presented in sequential order, numbered from Question 6 through Question 26, as in the original survey.

443 participants completed the survey. As shown in Figure 57, the number of respondents with homes in various counties greatly varied, with Santa Clara County having by far the highest number. In Figure 57 the City of San Jose is separated from the rest of Santa Clara County due to the high number of respondents. As can be seen, Alameda also has a significant number of respondents. The percentage of survey respondents by county is fairly representative of the distribution of EVP participants.

Figure 57. Home counties of survey respondents.

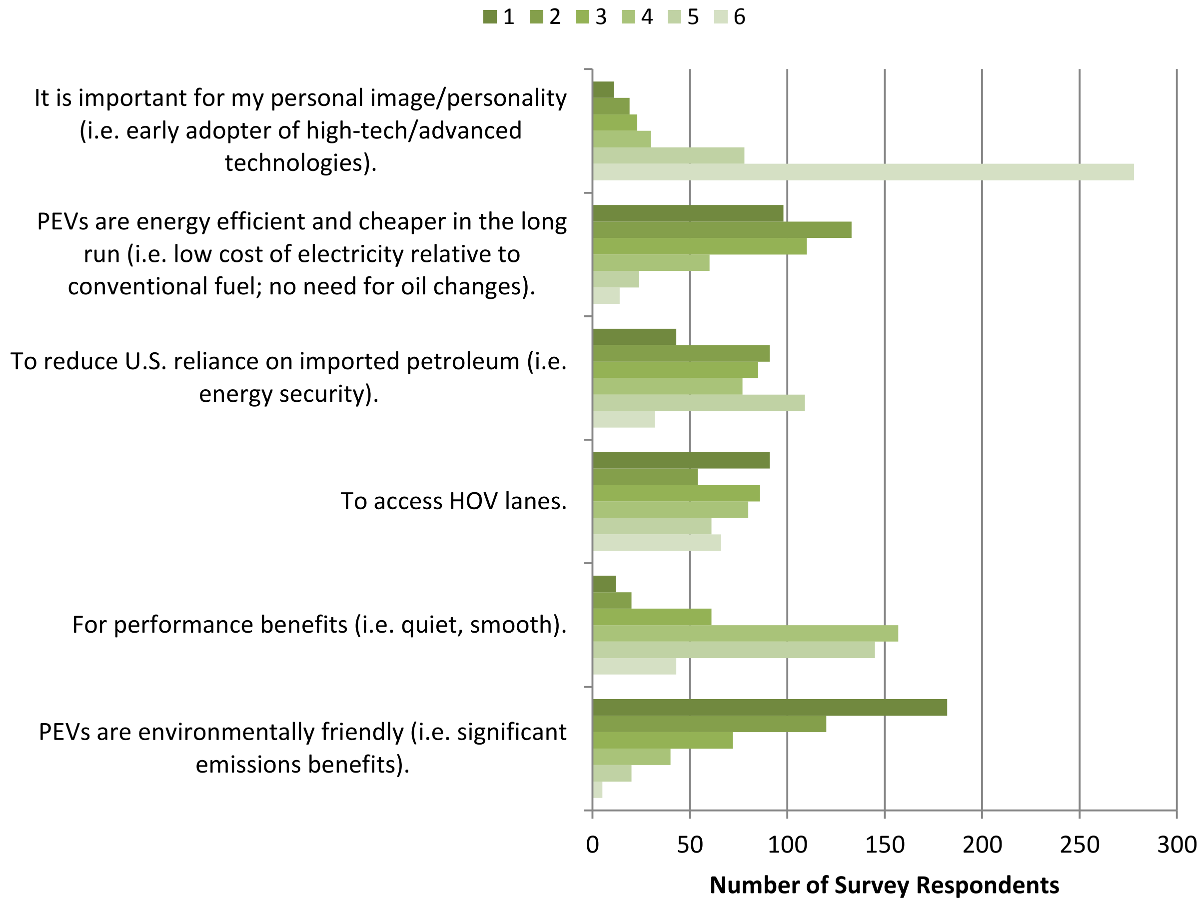


Note that San Jose is part of Santa Clara County.

Question 6: Why do you drive a PEV? Please rank the following items in the order of importance (1 = most important, 6 = least important).

Figure 2, which corresponds to Question 6, presents the number of respondents selecting the ranking values ranging from 1 to 6 for each item. A large number of respondents rank the importance of environment as being very high, with 85% ranking this item as 3 or higher. Energy efficiency/cost, energy security, and HOV lanes are also ranked as being fairly important. On the other hand, a fair number of respondents also did not rank energy security and HOV lanes as being very important. Performance also does not seem to rank highly and image ranked particularly low, with nearly 90% of respondents giving this item a ranking of 4 or lower.

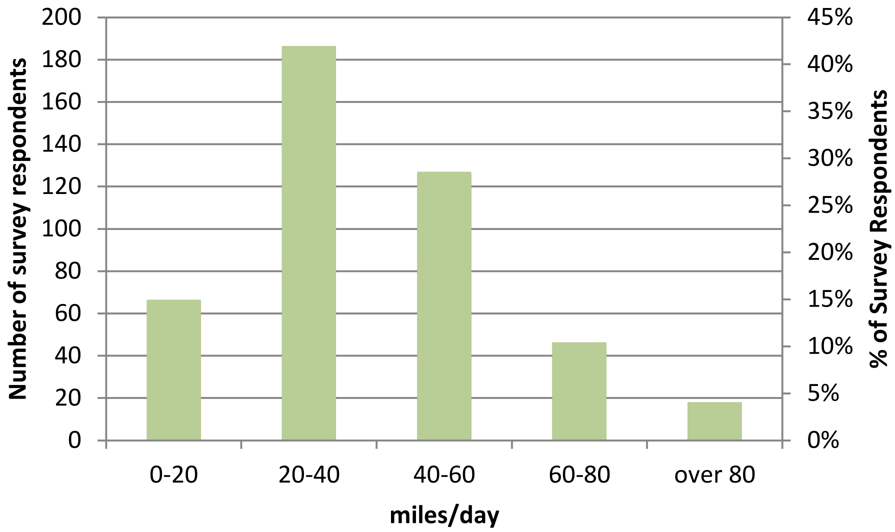
Figure 58. Reasons for driving a PEV



Question 7: Before you purchased a PEV, how many miles per day were you driving on average?

As shown in Figure 59, the majority of respondents drove less than 40 miles per day, indicating significant potential for usage of PEVs.

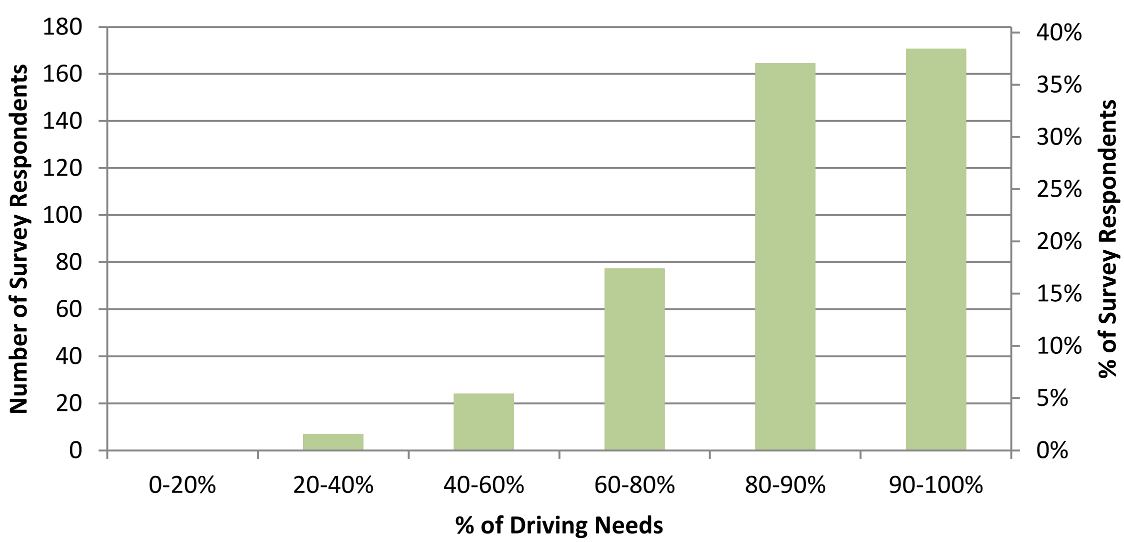
Figure 59. Number of miles per driven per day by respondents before joining the EVP



Question 8: What percentage of your driving needs are met by PEVs?

The results for question 7 correspond to those in question 8, which are presented in Figure 60. As can be seen the majority of respondents indicate that over 80% of their driving needs are met by PEVs, with only a small number of respondents indicating that less than 40% of their needs are met by PEVs.

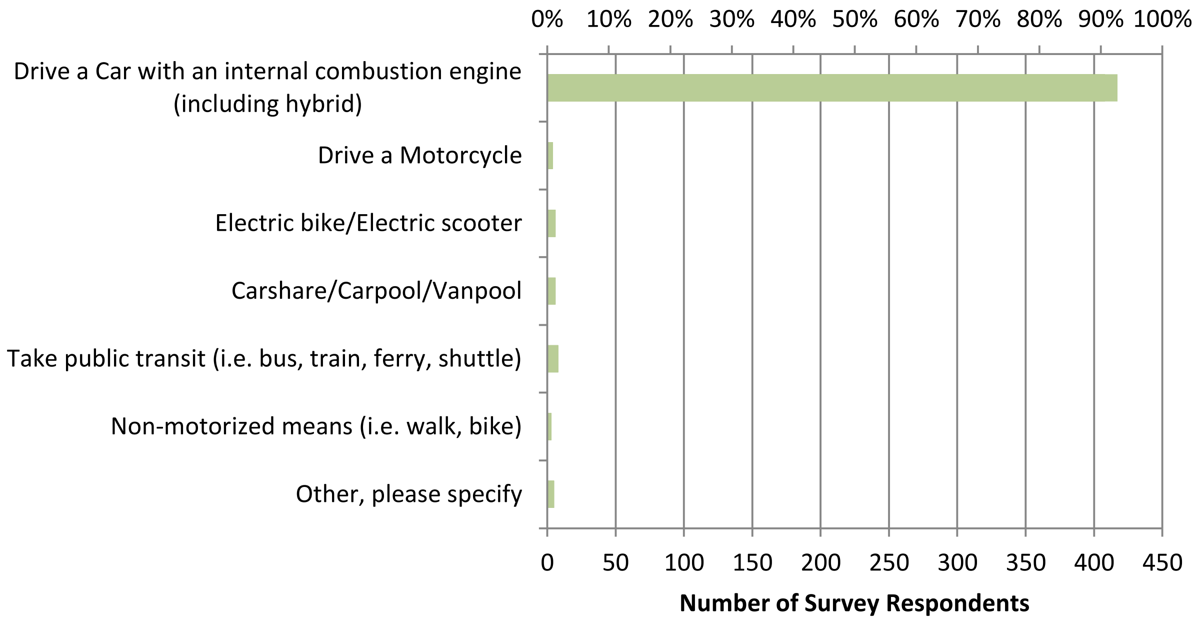
Figure 60. Percent of driving needs which are met by PEVs



Question 9: Imagine that you no longer own a PEV. How would you substitute the majority of your travel that you had previously used for your PEV for?

Figure 61 presents the result for question 9, which indicates that nearly all respondents would drive a conventional vehicle if they did not have their PEVs. Those respondents that selected 'Other, please specify' indicate that they would select another BEV or a natural gas vehicle.

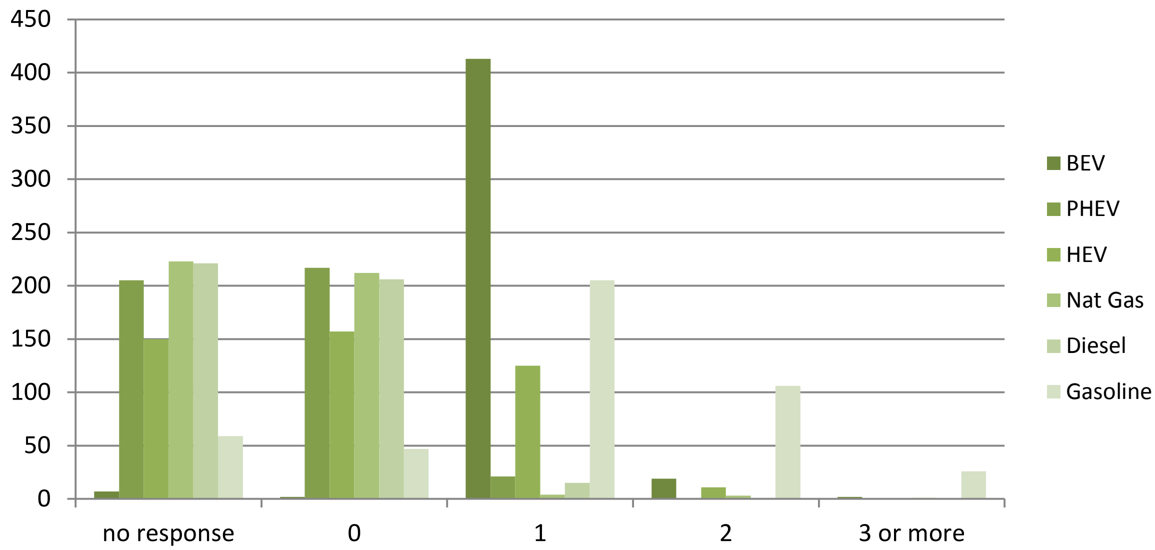
Figure 61. Transport options that respondents would substitute if they did not have PEVs



Question 10: How many vehicles are in your household of the following type (include your current LEAF)?

Figure 62 displays the results for question 10. Note that 'no response' likely indicates that the household does not have cars of this type, so these can be interpreted as being response '0'. The results indicate that nearly all households have at least one vehicle that is not a BEV. This can be ascertained by summing all non-BEV bars to the right of the tallest bar, which represents the number of households with one BEV. The other vehicle type is typically gasoline or HEV. In fact, over 30% of the households appear to have at least two vehicles other than the BEV. This corresponds to expectations that few households are initially willing to have BEVs and no other options. Nevertheless, question 8 shows that most driving needs are satisfied by BEVs, so education related to this fact would likely encourage more households to purchase BEVs.

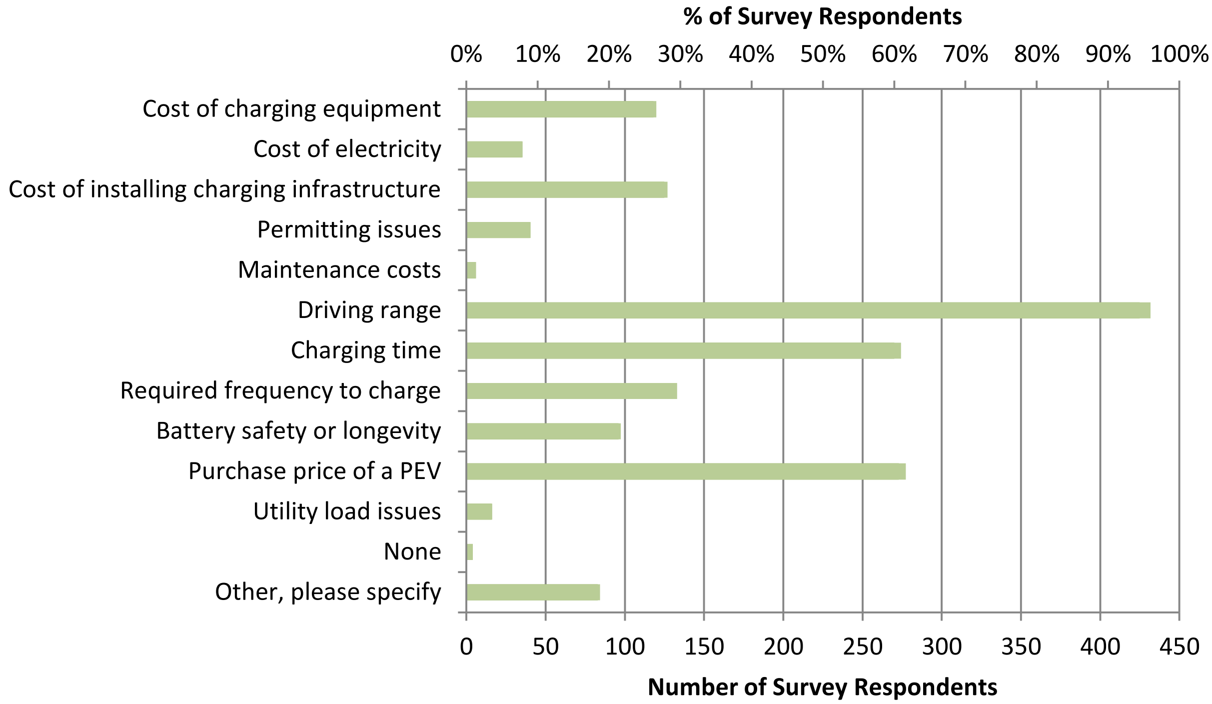
Figure 62. The numbers of various types of vehicles per household



Question 11: Based on your experience as an early adopter, which do you think are current obstacles people will have when switching over to a PEV? Please check all that apply.

Respondents are allowed to check several responses. Figure 63, which corresponds to question 11, shows that range limitations, charging time and purchase costs for PEVs are likely barriers to potential buyers of PEVs. On the other hand electricity costs, batteries and utility considerations do not seem to be significant barriers for individual consumers.

Figure 63. Current obstacles people will have when switching to a PEV



Responses listed under 'Other, please specify' for potential obstacles are summarized below.

- Lack of AC Level 2 or DC fast charging infrastructure, 42 respondents (53%): There is a lack of charging stations at destinations at the moment.
- Lack of education on these topics, 11 respondents (14%): More education to raise awareness about PEVs is needed.
- Costs, 7 respondents (9%): Costs of batteries, vehicles, fast charging stations and electricity are cited as concerns.
- Range, 6 respondents (8%): Range anxiety is an obstacle for some drivers.
- Difficulties with multi-family dwelling units, 4 respondents (5%): Respondents indicate problems with getting charging stations at rental apartments.

Question 12: Please share with us any solutions that you believe will help to address these current obstacles and/or barriers.

Responses to question 12 are summarized below.

More public stations, 217 respondents (61%): There is a strong desire to have more away-from-home charging stations, especially at employment centers, and more fast chargers along highway corridors to facilitate intercity transportation. 128 respondents (36%) specifically state that the number of public fast charging stations should be increased.

Battery technology improvement, 132 respondents (37%): Many respondents indicate that improvements in battery technology would be beneficial to reduce range issues. There is also concern regarding variation in battery range and misleading information potentially being provided to vehicle manufacturers.

Costs, 48 respondents (14%): Many respondents indicate that a reduction in both vehicle costs and EVSE costs would great help PEV adoption. In addition, there are multiple respondents who indicate that PG&E's rate schedule is unsatisfactory, since non-PEV electricity usage ends up costing more.

Government subsidies and incentives, 32 respondents (9%): Respondents indicate that government programs should be continued to encourage adoption of PEVs and infrastructure.

Education and information to improve public awareness, 31 respondents (9%): Respondents state that there should be education available to the public on how much people drive on an average day to show that range is rarely a concern. Information on battery costs and warranties are also not well known. This makes it difficult for consumers to estimate lifecycle costs and many do not realize the extent of battery warranty coverage.

Swappable batteries, 14 respondents (4%): Some respondents state that they would like to have the option of swapping/replacing the battery to extend range.

Reservation systems and car sharing, 13 respondents (4%): Multiple respondents state that reservation systems are needed, especially to facilitate long trips. In addition, in some areas EVSE parking spots are often filled so there should be some time limits imposed on parking. Some respondents indicate that more PEVs should be provided through car sharing programs with potential integration with public transit.

Common standards, 13 respondents (4%): Respondents state that they would like to see better mapping and smart phone applications to make information about available charging stations for all companies easily accessible through a single display. In addition, interoperability to allow for payment systems to be uniform across EVSE companies is highly desirable. Statewide EVSE permitting standards for installations could also reduce obstacles in many jurisdictions. Respondents state that permitting processes should be made as easy as possible.

Residential installations, 9 respondents (3%): Some respondents say that multi-family dwelling units were a concern. In addition, a few states that home installation costs and permitting are concerns.

HOV Lanes, 4 respondents (1%): Some respondents indicate that HOV lane access for PEVs should be continued. However, one respondent also indicates that HOV lane access is being abused by hybrid drivers who can exclusively use gasoline.

Solar power generation, 4 respondents (1%): Some respondents want to have more EVSE be integrated with solar panels.

Inductive charging, 4 respondents (1%): Some respondents indicate a desire for roadway inductive charging.

Question 13: Based on your experience as an early adopter, how significant is your "range anxiety" (definition: worried about being stranded away from a charging location with no battery power)?

Figure 64, which corresponds to question 13, shows that there is much variation in concerns about range anxiety. Nevertheless, the majority of respondents indicate that range anxiety is less than 'Somewhat Significant'. The median value on the scale of 1 to 10 is [4.69].

Figure 64. Significance of range anxiety concerns

Question 14: Please rate your level of agreement with the following statements in regards to alleviating any "range anxiety" you may have.

This question encourages a response to each of the statements. Figure 65, which corresponds to Question 14, indicates that many respondents plan their travel accordingly, don't drive far from home, or know of away-from-home charging locations when using their PEVs. Fairly high numbers of respondents also do not seem to have charging options at work, and do not think that Level 1 charging would alleviate range concerns.

Responses listed under 'Other, please specify' for other range alleviating methods include that many drivers have a conventional vehicle for long trips. Some feel that a safety net exists with the Nissan Roadside Assistance and AAA services. Smart phone applications are useful in finding charging stations and fast charging stations reduce these concerns. However, one driver indicated that stations can be hard to find if they are not in plain view. Level 1 charging is thought to be nearly useless by multiple drivers. These results are summarized below:

More stations, 19 respondents (32%): Respondents state that more public stations would alleviate range anxiety. Availability, functionality, and placement at desirable destinations are concerns. 6 respondents (10%) specifically state that more fast charging stations are needed.

Station availability and functionality, 8 respondents (13%): Respondents indicate that they fear that stations may be unavailable or not functioning. In addition, there is concern about being able to locate a station once on site, since the station may not be in plain view.

Having a second gasoline car or hybrid, 8 respondents (13%): Having another car with an ICE gives respondents the option of not using their PEV for certain trips.

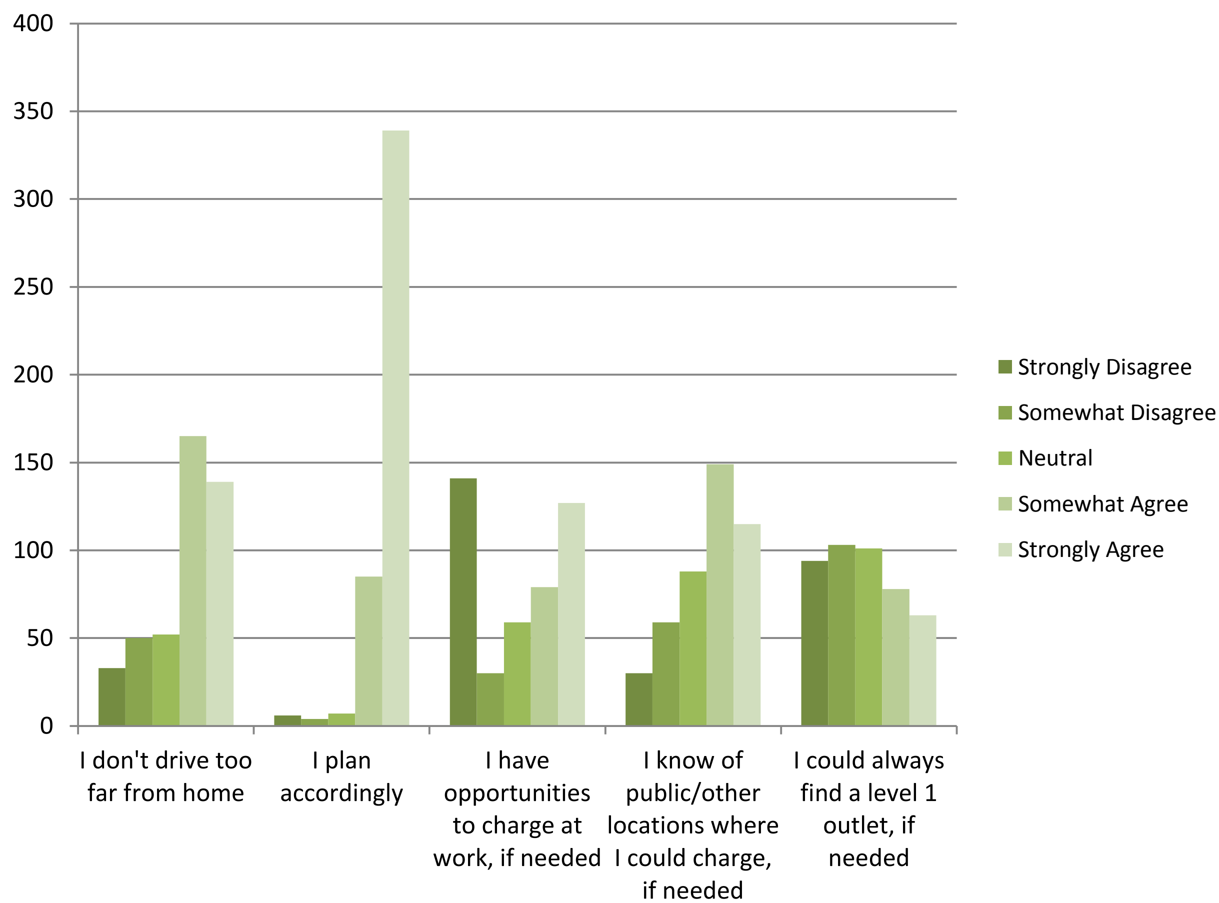
Planning trips accordingly, 7 respondents (12%): Respondents indicate that they plan their trips to fit within the range limitations of their vehicles.

Level 1 charging is too slow, 6 respondents (10%): Respondents state that Level 1 charging is too slow to be useful.

Knowing station locations, 4 respondents (7%): Respondents use smart phone applications to alleviate concerns regarding locating stations, however others cite this is as a concerns since information can sometimes be inaccurate.

Nissan Roadside Assistance or AAA, 4 respondents (4%): Having a service that can be called alleviates range concerns for some Respondents.

Figure 65. How respondents deal with range concerns



Question 15: What do you think is the greatest myth about PEVs and how would you suggest to go about dispelling it?

A summary of the responses is included below.

Myths:

Range, 129 respondents (41%): The public is generally unaware of how many miles people travel on a typical day or how to plan travel when owning a PEV. DC fast charging stations should also help reduce this concern.

Performance, 60 respondents (19%): Several respondents indicate that non-PEV drivers are generally unaware of the great performance in terms of speed, power, and smoothness that a PEV has versus conventional vehicles.

Costs, 48 respondents (15%): Several respondents indicate that most people do not realize how much potential savings there is in fuel and maintenance costs. One respondent states that home electricity costs decreased after purchasing a PEV.

Image, 48 respondents (15%): Respondents indicate that the general image of PEVs is still negative for many people. Terms used include ‘weak’, ‘middle-aged geeks’, ‘toys’ and ‘golf carts’.

Environmental Impacts, 29 respondents (9%): There is not much information about environmental impacts. People do not know the overall power generation portfolio for their area or that charging at night typically results in much less emissions.

Battery life, 10 respondents (3%): Respondents say that there is not enough information being given to the public on battery life and that the warranty alleviates much of the related concerns.

Safety, 6 respondents (2%): A few respondents indicate that safety concerns are a myth with regards to the vehicle and battery.

Charging Time, 6 respondents (2%): People are generally unaware of how much public charging time is really required for a PEV owner, and that it is typically very little.

Solutions:

Better education and public relations, 42 respondents (13%): The myths can be dispelled by bringing the information to the public in an accessible manner. Example stories of LEAF drivers can help other potential drivers understand the issues.

Trials and test drives, 24 respondents (8%): Giving people the chance to actually drive PEVs will have a positive impact on people’s perceptions.

Increase the number of charging stations, 20 respondents (6%): Increasing the number of charging stations can help dispel myths about driving limitations.

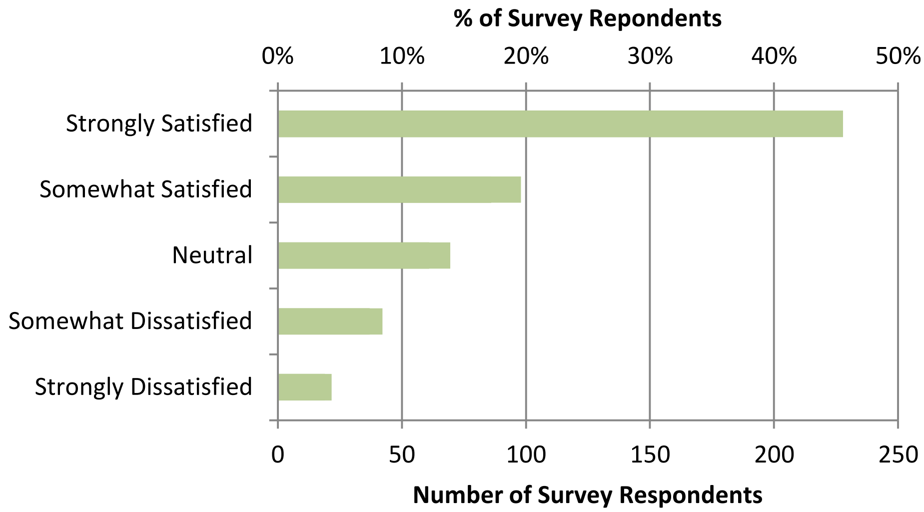
Solar panels, 9 respondents (3%): Solar panels should be combined with PEVs to reduce life-cycle costs and environmental impacts.

More like a smart phone than a gas car, 1 respondent: A respondent gives a particularly good description of how the image of PEVs should change. The LEAF should be described more like a modern technological product rather than simply a replacement for the conventional car. This image can help people understand better the issues associated with PEVs and lead people away from trying simply to make direct comparisons with conventional cars.

Question 16: When you installed your home charging station, you most likely had to obtain a permit from your local jurisdiction. Please rate your satisfaction with your jurisdiction's permitting process.

Although EVP participants were generally not directly involved in the permitting process, Figure 66, which corresponds to question 16, indicates that the majority of respondents were satisfied with the permitting process for home charging stations.

Figure 66. Satisfaction with permitting process for home charging station



Question 17: Where was your home charging station installed?

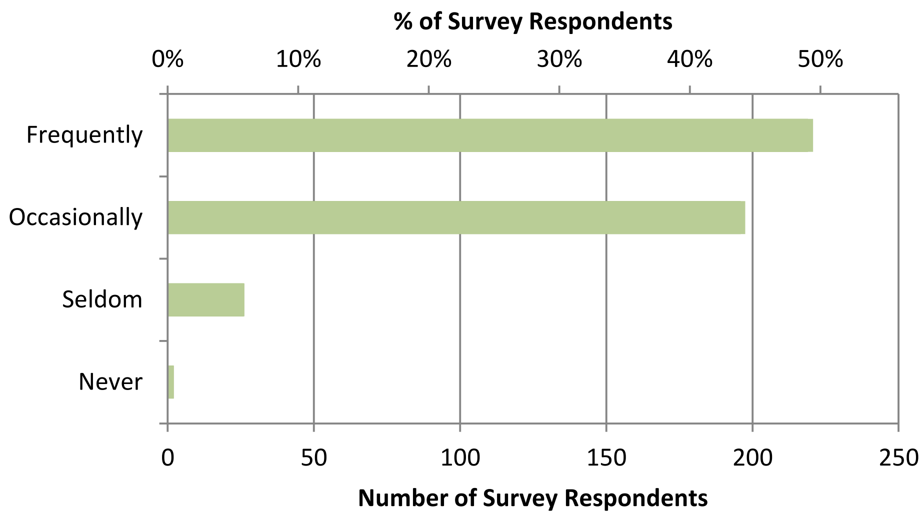
Figure 67, which corresponds to question 17, indicates that most home chargers were installed in attached, enclosed garages. Most respondents that indicate 'Other, please specify' state their charger was installed on the outside wall of their garage or home.

Figure 67. Type of building for home charger

Question 18: Do non-PEV drivers ask you questions about your PEV driving experience?

Figure 68, which corresponds to question 18, shows that many drivers get questions about their PEV experience from non-PEV drivers.

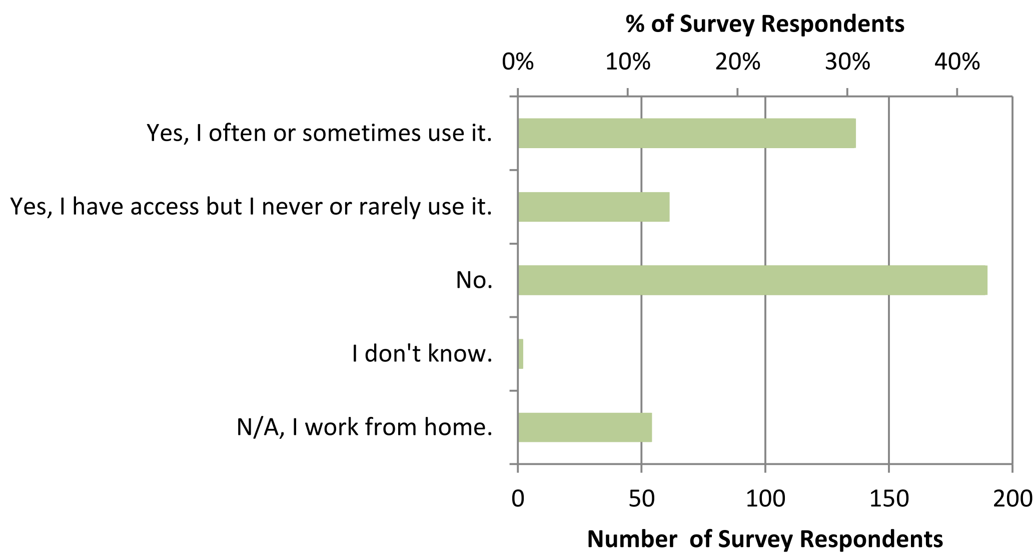
Figure 68. Questions from non-PEV drivers



Question 19: Do you have access to charging at work?

Figure 69, which corresponds to question 19, shows that about half of the respondents have access to charging at work, but do not necessarily use it frequently. About the same number of respondents indicated they do not have access to charging at work.

Figure 69. Charging Access at Work



Question 20: On average, how many hours per week do you spend charging your PEV at the following locations with Level 1 charging? Please enter only numbers below.

Table 47, which corresponds to question 20, has rows that represent bins for the number of hours that respondents charge with AC Level 1 EVSE at various locations. Each column represents a different location. The bin intervals used curve brackets to indicate that the endpoint is not included and a square bracket to indicate that the endpoint is included. Note that hours listed are hours per week.

Table 47 shows that 85% of respondents do not use Level 1 charging at home at all. The rest vary from light to significant use at home. Above 20 hours per week (about 3+ hours per day could be considered significant use). 13% of respondents have access to outlets and use AC Level 1 charging at work. Little AC Level 1 charging is conducted elsewhere.

Table 47. Number of respondents that charge a particular number of hours at various locations

Hours per week	At home	At work	At school	At public parking lots	At stations with charging infrastructure (i.e. gas stations)	Other locations
0	299	273	340	334	339	325
(0,5)	7	18	0	6	1	13
[5,10)	5	13	0	0	0	2
[10,15)	4	5	0	0	0	0
[15,20)	1	3	0	0	0	0
[20,25)	8	7	0	0	0	0
[25,30)	4	3	0	0	0	0
[30,35)	4	4	0	0	0	0
[35,40)	1	4	0	0	0	0
>40	7	10	0	0	0	0

Question 21: On average, how many hours per week do you spend charging your PEV at the following locations with Level 2 charging?

Table 48, which corresponds to question 21, shows that many respondents charge at home the most, at work for a fairly high number of hours, and public parking lots for small amounts of time. Figure 70 provides the cumulative distribution for the number of hours charged at home, which indicates that the number of hours charged at home is approximately uniformly distributed between 0 and 40 hours per week.

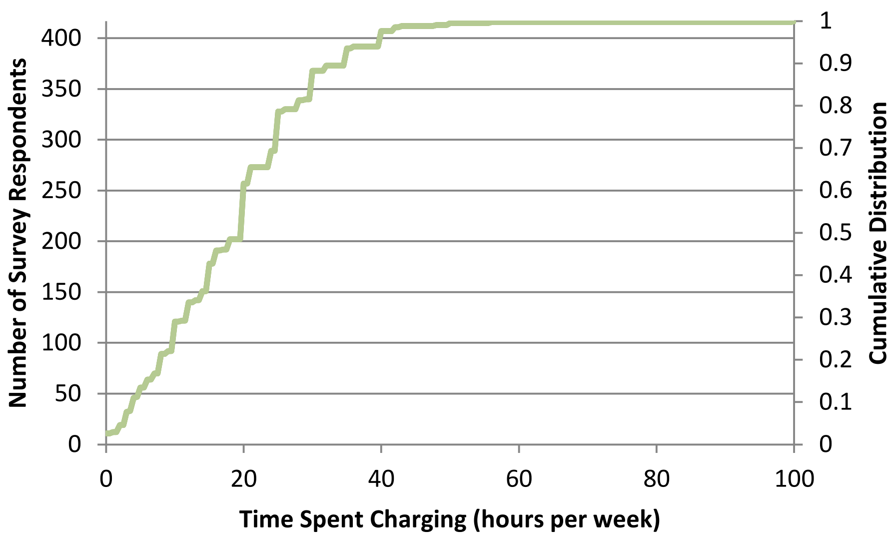
Table 48. Number of respondents that charge a particular number of hours at various locations

Hours per week	At home	At work	At school	At public parking lots	At stations with charging infrastructure (i.e. gas stations)	Other locations

0	16	321	420	297	410	398
(0,5)	36	28	1	107	9	18
[5,10)	45	17	0	11	2	4
[10,15)	59	16	0	0	1	1
[15,20)	51	13	0	2	0	1
[20,25)	87	13	1	3	0	0
[25,30)	51	5	0	2	0	0
[30,35)	33	6	0	0	0	0
[35,40)	19	0	0	0	0	0
>40	25	3	1	0	0	0

The mean value for at home charging is 19 hours (an average of 2.7 hours per day).

Figure 70. Cumulative distribution for time spent charging at home by respondents



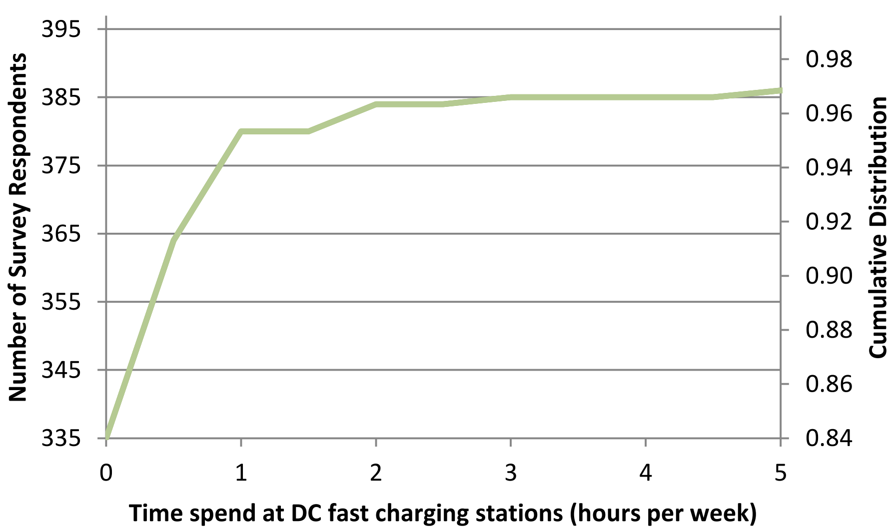
Question 22: On average, how many hours per week do you spend charging your PEV with fast charging?

Table 49, which corresponds to question 22, shows that most survey respondents do not charge at DC fast charging stations. This is reasonable, since there are very few DC fast charging stations installed in the Bay Area to date. Figure 71 provides the cumulative distribution for hours per week spent charging at DC fast charging stations. The figure is focused only on part of the distribution, since so many drivers spend 0 hours per week at DC fast charging stations. The figure shows that 90% of respondents spend less than 30 minutes charging at DC fast charging stations per week. The figure also indicates that of the respondents that do charge at DC fast charging stations, around 50% charge more than 30 minutes per week. This may indicate the potential for significant DC fast charging demand, if more DC fast charging stations are installed.

Table 49. Number of respondents that charge a particular number of hours at DC fast charging stations

Hours per week	Number of Survey Respondents	% of Survey Respondents
0	335	84%
(0,5)	50	13%
[5,10)	1	0%
[10,15)	1	0%
[15,20)	1	0%
[20,25)	6	2%
[25,30)	0	0%
[30,35)	1	0%
[35,40)	0	0%
>40	2	1%

Figure 71. Cumulative distribution for time spent charging at DC fast charging stations by respondents (only part of the distribution is shown)



Question 23: Which of these barriers or issues have prevented you from charging outside of the home? Please check all that apply.

Figure 72, which corresponds to question 23, shows that the majority of drivers find the lack of away-from-home charging stations to be a barrier to charging outside of their homes. In addition, few respondents indicate that there are no barriers to away from home charging. Many respondents also indicate that stations are not conveniently located to accommodate their trips, that charging stations have been occupied, and that charging away from home takes too long. This seems to indicate that there is significant potential demand for additional away-from-home charging stations. In particular, there may be potential demand for DC fast charging stations to reduce charging times. Nevertheless, it should be noted that a fair number of respondents (over 20%) indicate that they have no need to charge away from home.

Below is a summary of are additional comments for respondents that selected 'Other, please specify'.

Lack of fast charging stations, 16 respondents (25%): Respondents state that there not enough fast charging stations for charging away from home.

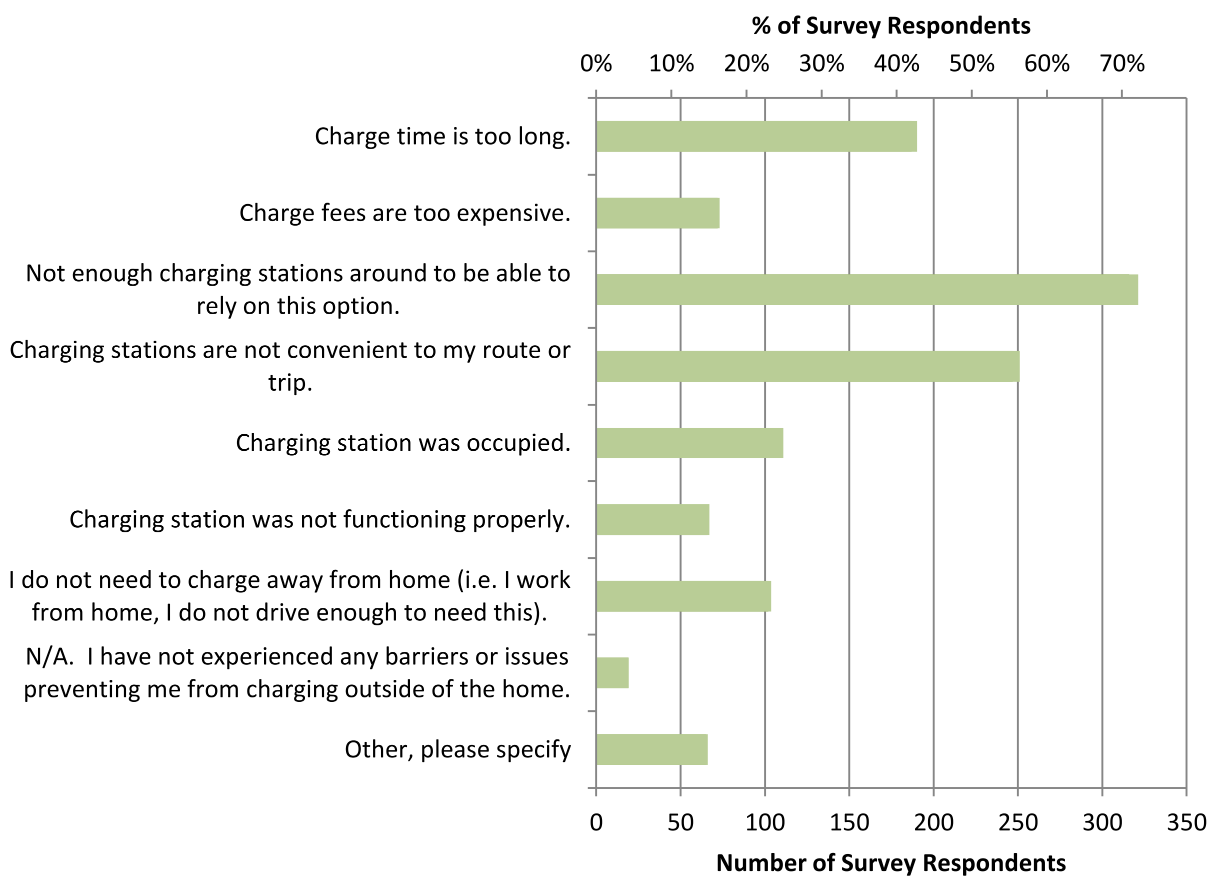
Location and timing for availability of chargers, 12 respondents (18%): Respondents indicate that there are not enough stations at their destinations or that they are not open during the night.

Space occupied, 8 respondents (12%): Respondents state that stations can be occupied by other vehicles.

Interoperability, 7 respondents (11%): Respondents noted that having to deal with multiple payment types for various charging companies is a hassle.

Functionality, 5 respondents (8%): Charging stations are often not functioning properly. Many respondents do not trust that they can charge due to this problem.

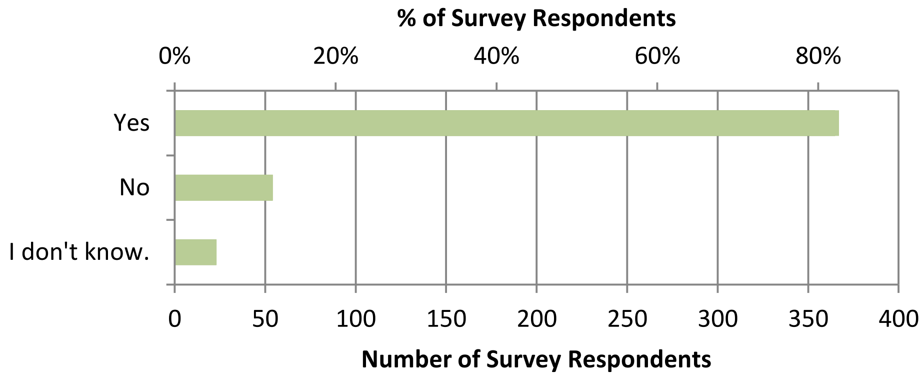
Figure 72. Barriers or issues that have prevented respondents from charging away from home



Question 24: Does your electric utility offer special time of use (TOU) rates that make it beneficial to charge your PEV at certain times?

Figure 73, which corresponds to question 24, indicates that the electric utility for the majority of respondents offers TOU rates.

Figure 73. Respondents whose homes are serviced by utilities that offer time of use rates



Question 25: If your electric utility offers TOU rates, did you select this rate?

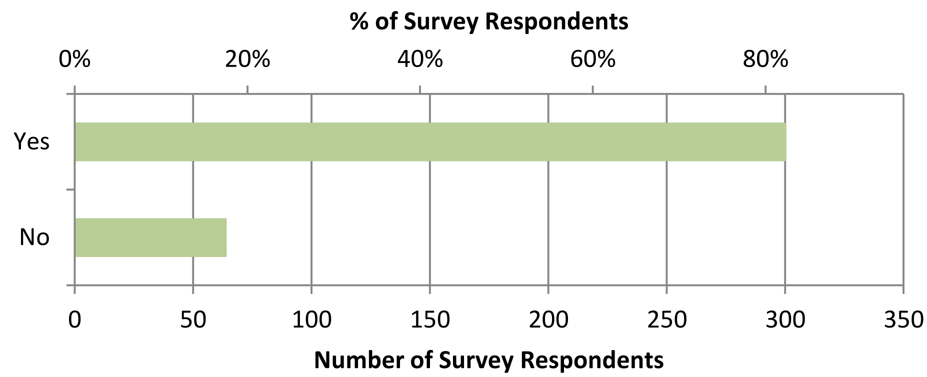
Figure 74, which corresponds to question 25, shows that 80% of respondents that have the option to use TOU rates, make use of this rate option. Many respondents that had this option, but did not select the TOU rate, indicated that TOU rates were not economically beneficial for them. A summary of comments can be seen below.

Peak rates are too high, 28 respondents (38%): The most common comment is that TOU rates cause peak period rates to be so high that there is no benefit associated with the PEV rate schedule. There is also added, unwanted stress related to reducing energy consumption during the peak hours.

Solar power, 19 respondents (26%): Many respondents indicate that they would prefer to use rates geared towards maximizing the benefits of their solar panels, rather than rates for their PEVs.

Cost of a separate meter, 9 respondents (12%): Respondents indicate that the cost of a separate meter can be too high.

Figure 74. Respondents that use time of use rates



Question 26: If your electric utility offers TOU rates, how did you learn about these special rates? Please check all that apply.

Figure 75, which corresponds to question 26, shows that most respondents learned about time of use rates by contacting their electric utility.

Below are comments from respondents that selected ‘Other, please specify’.

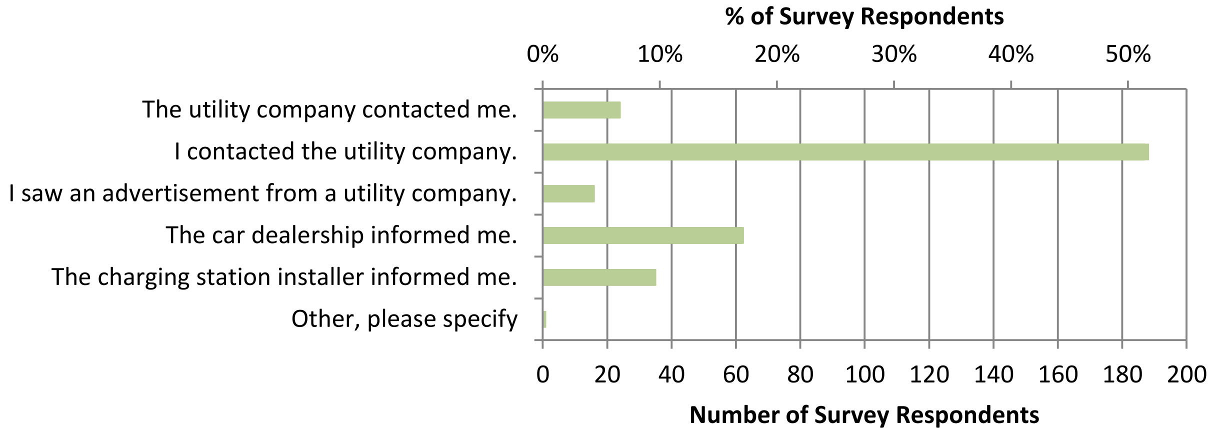
Already had solar, 44 respondents (32%): Many respondents already had TOU rates, since they had solar panels before purchasing a PEV.

Websites or general online reading, 39 respondents (28%): Many respondents found out about TOU through various websites.

EV community online or in person, 28 respondents (20%): Respondents indicate that PEV groups or online forums are where they were told about TOU rates.

Friend or word of mouth 20 respondents (14%): Many respondents heard about TOU rates by talking with other people.

Figure 75. How did you learn about availability of time of use rates?



Appendix E: City CarShare PEV Survey

Introduction

City CarShare's Plug-in Electric Vehicles (PEV) survey was conducted in the first three (3) weeks of July 2012 and received 1,163 responses. The survey assessed City CarShare member's familiarity with, perception of, and potential for using PEVs. The survey included 5 parts:

- **Part 1: Introduction**. This section introduced the survey, and why City CarShare is interested in understanding more about members' familiarity with and perceptions regarding PEVs. There are no survey questions included in Section 1.
- **Part 2: Familiarity and Overall Opinion of PEVs.** This section includes eight (8) questions that focus on members' familiarity of PEVs and then transitions into their opinion regarding PEVs.
- **Part 3: Knowledge of PEVs**. This section focuses on members' familiarity with the technical aspects of PEVs, including issues such as vehicle range or factors that impact vehicle range. This section includes five (5) questions.
- **Part 4: City CarShare PEV Awareness & Interest**. This section focuses on the specific aspects of the PEVs in City CarShare's fleet, and the general members' interest in using a PEV as part of the City CarShare fleet. This section includes four (4) questions.
- **Part 5: Background Information**. This section includes basic demographic information from survey respondents (e.g., gender and age), and also seeks to understand how the respondent's vehicle ownership might change should s/he not have access to City CarShare. This section includes four (4) questions.

The following sections review the responses to each question with some conclusions drawn where appropriate.

Part 2: Familiarity and Overall Opinion of Plug-in Electric Vehicles

Part 2 of the survey asked respondents about the familiarity and overall opinion of PEVs.

Q1: Overall, how familiar are you with [plug-in] electric vehicles?

Generally, survey respondents had some familiarity with PEVs.

Level of familiarity	Percent
very familiar	8%
somewhat familiar	39%
slightly familiar	37%
not at all familiar with EVs	16%

Q2: When you think of [plug-in] electric vehicles, what specific model names come to mind?

When asked what specific EV models come to mind, respondents came up with 55 different vehicles and companies. Note that 27% of survey respondents left the question blank. The top four names were the Nissan LEAF, Chevy Volt, Toyota Prius PHEV, and Tesla Motors as shown in Table 1. Note that respondents identified multiple vehicles, so the percentages do not sum to 100%.

Table 50. Most Popular EVs

	Vehicle	Responses	Percentage
1	Nissan LEAF	470	40%
2	Chevy Volt	450	39%
3	Toyota Prius PHEV	277	24%
4	Tesla Motors	227	20%
5	Other	251	22%
	TOTAL	1,675	

One of the interesting findings was people's perception of a PEV. For instance, about 1 out of 5 respondents to this question identified a vehicle that was not a PEV, most notably hybrid electric vehicles (HEVs) such as the Toyota Prius or the Honda Insight. In many cases, survey respondents would include some combination of the Toyota Prius, Chevrolet Volt, and the Nissan LEAF. The challenging aspect about interpreting the survey results is that many respondents specifically identified the Toyota Prius Plug-In, whereas others simply put Toyota Prius. It is difficult to ascertain if the respondent is referring to the standard HEV or the new PHEV. On the other hand, there were many respondents who simply wrote Prius Hybrid, Insight Hybrid, or some combination with Hybrid in the response. This indicates that there is still considerable confusion in the market regarding the differences between hybrids and PEVs. Furthermore, there is some confusion about small or fuel efficient cars such as the Smart Car or Fiat – both of which are neither HEVs nor PEVs. Rather, they are small, urban-friendly vehicles that a small fraction of consumers identify as PEVs.

Q3 and Q4: Have you ever driven or ridden as a passenger in a battery electric vehicle (BEV) (Q3) / plug-in hybrid electric vehicle (PHEV) (Q4) that uses only electricity? (no gas, so this does not include hybrid cars)

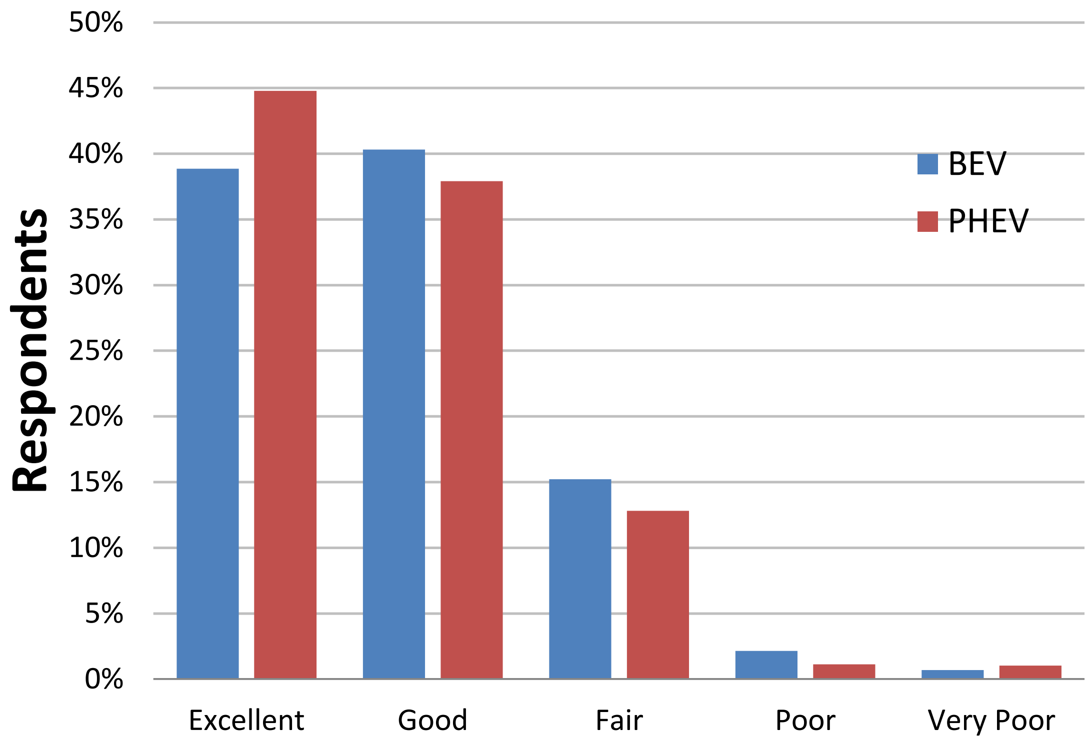
Approximately 20% of respondents had ridden in a battery electric vehicle (BEV) and 32% had ridden in a plug-in hybrid electric vehicle (PHEV).

Q5: Please indicate your opinion of battery electric vehicles as a transportation option for you.[226]

Q7: Please indicate your opinion of plug-in hybrid electric vehicles as a transportation option for you.

Generally, respondents were interested in PEVs as a transportation option (see Figure 76) – respondents identified BEVs and PHEVs as an excellent option (45% vs. 39%); good option (38% vs. 40%), or fair option (15% vs. 14%). These data do not necessarily indicate a strong favorability for either technology. And only a small portion of respondents had a negative response to PEV technology, with only 3% and 2% of respondents identifying BEVs or PHEVs as a poor or very poor option.

Figure 76. Potential for Electric Vehicle Use



[226] Note that Question 6 and Question 8 of the survey were follow-on questions regarding poor ratings assessed to BEVs and PHEVs, respectively. Question 6 received 8 responses and Question 8 received 6 responses. These responses were such a small percentage of the overall survey that they are not discussed in detail here.

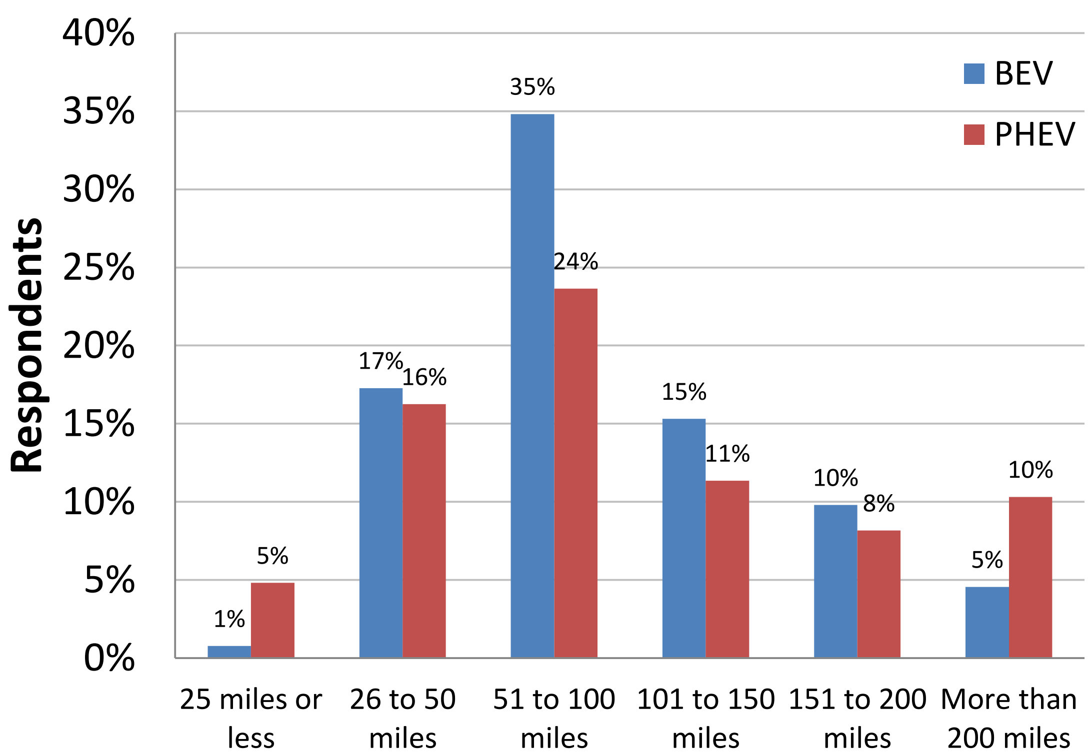
Part 3: Knowledge of Electric Vehicles

Q9: From what you may have heard, how far do you expect a battery electric vehicle can travel on a single charge?

Q10: From what you may have heard, how far do you expect a plug-in hybrid electric vehicle to travel before the battery is depleted and the car changes to gas mode?

As seen in Figure 77, the highest percentage of respondents (35%) reported that BEVs can travel 51 to 100 miles; similarly, this same range was selected by the highest percentage of respondents for PHEVs (24%). A set of respondents more familiar with PHEVs would have yielded a shift toward lower vehicle ranges for PHEVs, which have a dual powertrain architecture and generally have smaller battery capacity (associated with PEV range) than BEVs. The fact that 10% of survey respondents identified PHEVs as having a range greater than 200 miles is likely a result of respondents not reading the question in its entirety or misunderstanding the question as it was posed in the survey. Due to their hybridized powertrain, PHEVs have greater overall range than BEVs, but not greater all-electric range.

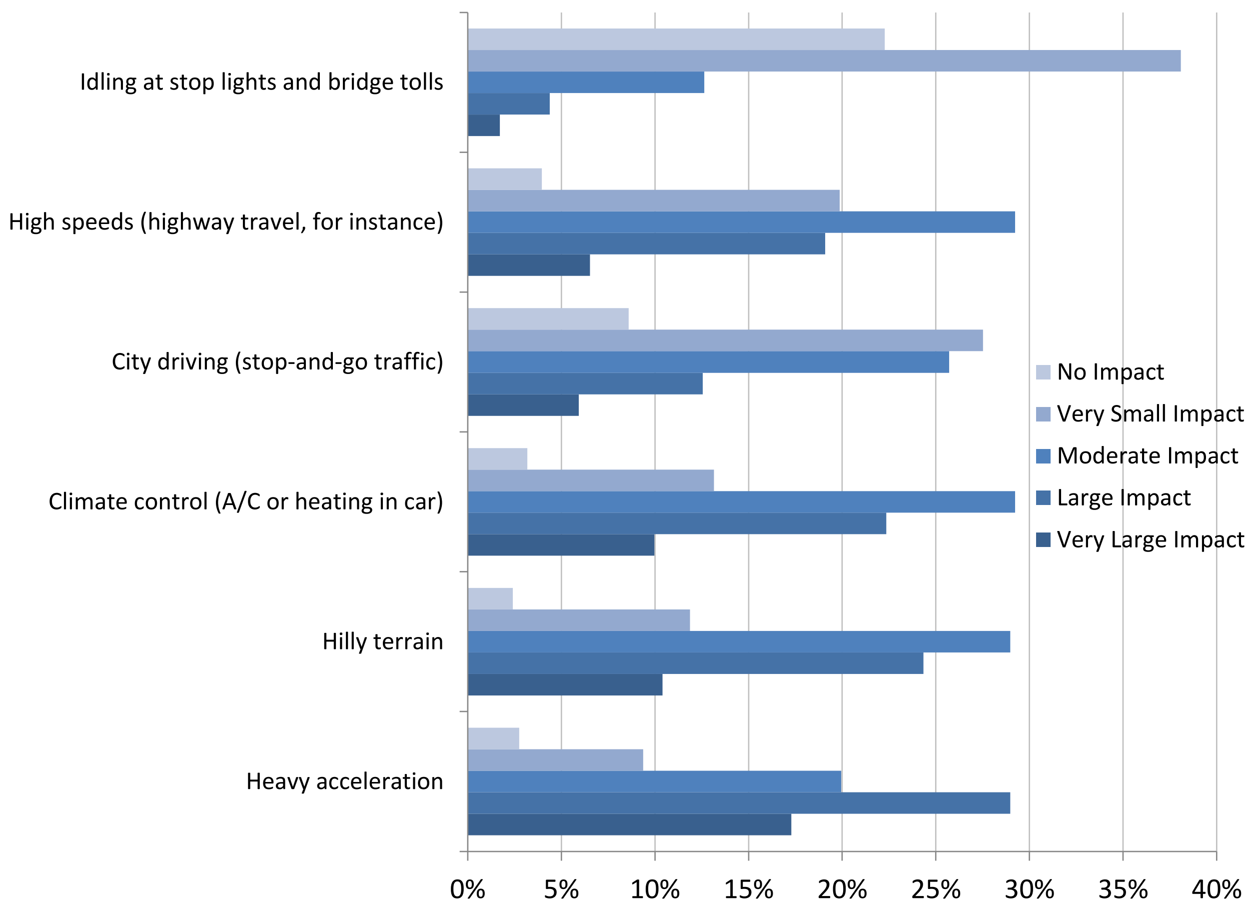
Figure 77. Perceived Electric Vehicle Travel Distance



Q11. From what you may have heard, or perhaps based on your experience driving an electric vehicle, which of the following factors will adversely affect the range of the vehicle?

In terms of which factors adversely affect the range of PEVs (see Figure 78), respondents identified heavy acceleration as having the largest impact, with hilly terrain and climate control (e.g., air conditioning in the vehicle) having the next biggest impact on vehicle range. Respondents identified high speeds and city driving as having a moderate impact, and idling at stop lights and bridge tolls as having the smallest overall impact. The respondents' collective understanding of the factors that impact PEV range is consistent with the factors that actually impact vehicle range. Note that for each question, 17-19% of survey respondents replied that they were "not sure" about the impact on range, with another 3% of respondents leaving the question blank. Despite the respondents' collective understanding of the variables that impact vehicle range, the large number of respondents (nearly 1 in 5) that answered not sure, and some other smaller inconsistencies with the level of impact that a variable will have on vehicle range, demonstrate that there are still opportunities to educate consumers about PEVs.

Figure 78. Perceived impact of parameters affect PEV range



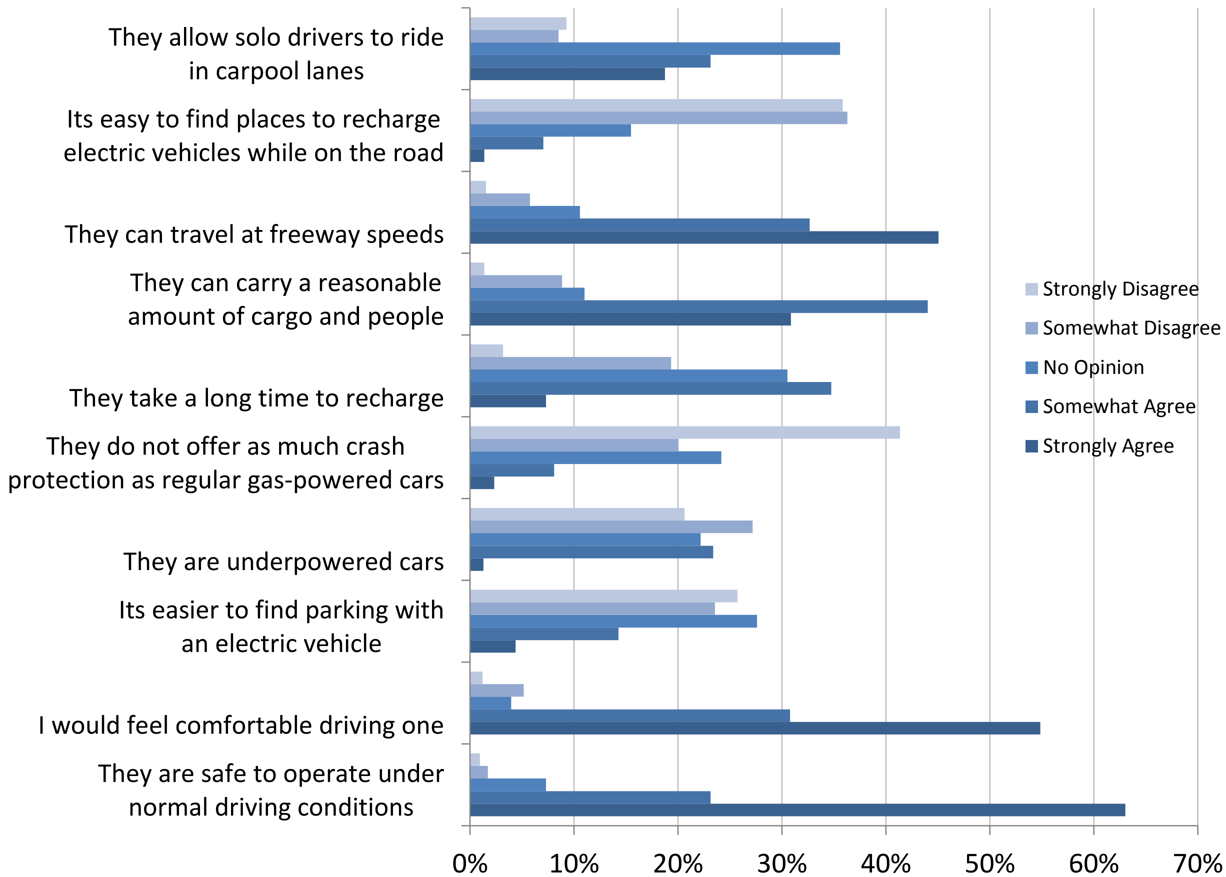
Q12. For each of the following statements about electric vehicles in general, please indicate whether you agree or disagree that the statement matches your opinion.

Respondents were asked to disagree or agree with various statements regarding PEVs, as shown in Figure 79. The statements and the corresponding responses included the following:

- *They are safe to operate under normal driving conditions*. Most respondents strongly agreed or somewhat agreed with this statement (combined 86%).

- *I would feel comfortable driving one*. The same number of respondents strongly agreed or somewhat agreed with this statement as the previous one (combined 86%).
- *It is easier to find parking with an electric vehicle*. Nearly half of the respondents disagreed with this statement (combined 49%) and another 28% of respondents had no opinion on this this matter.
- *They are underpowered cars*. Encouragingly, nearly half of the respondents disagreed with this statement (combined 48%) and a significant percentage (22%) had no opinion. Less than 25% of respondents agreed with this statement.
- *They do not offer as much crash protection as regular gas-powered cars*. The majority of respondents disagreed with this statement (61% combined) and nearly a quarter of respondents had no opinion (24%), while only 10% of respondents agreed with this statement.
- *They take a long time to recharge*. About 42% of respondents agreed with this statement and another 31% had no opinion. Less than a quarter (23%) of respondents disagreed with this statement. This indicates that many people still believe that it may take too long to recharge an electric vehicle.
- *They can carry a reasonable amount of cargo and people*. Based on this survey, the issue of cargo and capacity is not a concern: 75% of respondents agreed with this statement and only 10% disagreed, with another 11% having no opinion.
- *They can travel at freeway speeds*. Only a small fraction of respondents expressed concern about the ability of PEVs to travel at freeway speeds: 78% of respondents agreed with this statement and 7% disagreed, with only 11% having no opinion.
- *It is easy to find places to recharge electric vehicles while on the road*. The availability of charging infrastructure was clearly a concern from respondents: 72% of respondents disagreed with this statement, and only 8% agreed, with 15% offering no opinion.
- *They allow solo drivers to ride in carpool lanes*. Surprisingly, only 42% of respondents agreed with this statement, however, many respondents were clearly unsure because 36% of them responded that they had no opinion. Less than one out of five respondents (18%) indicated that they disagreed with this statement.

Figure 79. Opinions about the capabilities and characteristics of EVs



Part 4: City CarShare Electric Vehicle Awareness & Interest

Q13: Prior to taking this survey, were you aware that City CarShare offers electric vehicles to its members?

Most respondents (57%) were aware that City CarShare offers EVs to its members, however, a significant portion (40%) of respondents were not aware. This number will likely decrease over time as City CarShare continues marketing its eFleet strategy and expands its outreach to members.

Q14: Was the fact that City CarShare offers electric vehicles a major reason, a minor reason, or not among the reasons why you chose to become a member of City CarShare?

The availability of EVs is not a significant draw from members based on this survey. Only 8% of respondents listed EVs as a minor reason (6%) or major reason (2%) to become a member of City CarShare. About a quarter of respondents indicated that it was not a reason or that this question was not applicable because of when they joined City CarShare. Finally, many respondents left this question blank (43%).

Q15: How interested are you in using an electric vehicle from City CarShare in the future?

EVs definitely appeal to City CarShare members: Overall, the majority of respondents (51%) are very interested in using EV in the future. An additional 30% were somewhat interested, 11% were slightly interested, and only 3% were not interested.

Q16: What are the main reasons why you are interested in using an electric vehicle from City CarShare?

About 70% of the survey respondents provided answers to this open-ended question. Many respondents included more than one reason for their interest in using an electric vehicle. The responses were categorized into one of five areas: 1) curiosity about the technology, 2) environmental reasons, 3) to reduce petroleum or fossil fuels, 4) the potential for cost savings or fuel efficiency, or 5) an affinity for new technology. We tallied 1,009 reasons from the 803 respondents. Only 3% of responses (32) were identified as other and did not fit well within one of the five categories identified above.

- Environmental reasons were the most popular reason that respondents identified, with 43% of the responses including some references to environmental reason. These responses varied from those that were explicit, such as “better for the environment” to those that called out concerns about air quality and climate change resulting from greenhouse gas emissions. This result is not very surprising; if we assume that carshare members generally have higher environmental awareness than the general population – especially those in the San Francisco Bay Area – then it is understandable that this was the most popular reason. A smaller, but significant percentage of responses (11%) made reference to displacing petroleum or fossil fuels. We recognize that there is potentially an underlying environmental reason for displacing petroleum; however, we found it convenient to separate this because there were so many respondents who listed this as a reason. Furthermore, some respondents made specific reference to displacing petroleum or fossil fuels as an energy security strategy.
- The second and third most popular reasons were curiosity and affinity for technology. 26% of responses made some reference to the respondent’s general curiosity about the capability of electric vehicles. In some cases, respondents mentioned that they are looking to purchase an electric vehicle and would like the opportunity to learn more about them. In most cases, respondents simply listed curiosity. Another 12% of respondents made reference to being interested in the technology aspects of electric vehicles with words like “novelty” or “trying new technology”: one enthusiastic respondent even identified himself or herself as a “technogeek”. These responses suggest that there is genuine and significant interest in EVs from a significant percentage of the public – we assume that there is no reason for City CarShare members to be more curious than the general public about electric vehicles.

- A small percentage (5%) of respondents made reference to the potential for reduced costs associated with operating an EV. Many respondents made specific reference to the increasing cost of gasoline in their responses or identifying EVs as more economical.

Q17: Please indicate whether you would choose to use an electric vehicle in each of the following scenarios

The survey does show that the desire to use an EV depends on the situation. The majority of respondents would definitely choose an EV when driving less than 50 miles, when traveling with two passengers, when traveling with business associates/clients, and when traveling in urban areas. The majority of respondents would probably choose an EV when driving up to 100 miles and when traveling in hilly terrain. However, respondents would probably not choose an EV when driving up to 150 miles, when driving more than 150 miles, and when traveling to a remote, rural area.

Part 5: Background Information

Q18: Gender, Q19: Age Group, Q20: Zip code

52% of respondents were female and 47% male. The breakdown of age groups is shown in the table below. Nearly 55% of respondents were under the age of 40.

Age	18 – 21	22 – 25	26 – 30	31 – 35	36 – 40	41 – 45	46 - 50	51 - 55	56- 60	61 - 65	66
%	0.3%	6.4%	18.5%	15.7%	13.4%	11.2%	8.2%	7.4%	6.4%	4.3%	3.5%

More than 36 cities were represented in the zip codes provided by respondents, with representation largely coming from Alameda County (25%) and San Francisco County (64%). Within Alameda County, most respondents reside in either Berkeley (13%) or Oakland (7%).

Q21: How often do you have access to a personal vehicle?

A majority of survey respondents either do not (37%) or rarely (21%) have access to a personal vehicle.

When do you have access to a personal vehicle	Number	Percentage
Always	207	19%
Sometimes	259	23%
Rarely	233	21%
Never	410	37%

Q22: If carshare services were not available, would your household need to acquire an additional car?

The respondents were given three options, as shown in the table below.

Response	Number	Percentage
Yes	366	33%
No	519	47%
No, but we might get one anyway	224	20%

Appendix F: Permitting 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	

References for Appendix F

Advanced Energy, "Charging Station Installation Handbook for Electrical Contractors and Inspectors: Version 1.0," 2011, http://www.advancedenergy.org/transportation/evse/Charging%20Handbook.pdf

Pacific Gas & Electric, "Electric Vehicle Infrastructure Installation Guide," March 1999, http://ncrportal.mwcog.org/sites/surveys/EVP/General%20EV%20Reports/evmanual.pdf

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).

Appendix G: 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.

Bibliography

Electrification Roadmap, Revolutionizing Transportation and Achieving Energy Security. 2009, Electrification Coalition

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

Toyota Announces 4-layer All-solid-state Battery. 2011 [cited 2012 April 20]; Available from: http://techon.nikkeibp.co.jp/english/NEWS_EN/20101122/187553/.

Audi, BMW, Daimler, Ford, GM, Porsche and Volkswagen to unveil combined charging system, in Eurocarblog.com. 2011, Eurocar.

Annual Energy Outlook, E.I. Administration, Editor. 2011.

Cleantech matters: moment of truth for transportation electrification, in 2011 Global Ignition Sessions Report. 2011, Ernst & Young.

Plug-in electric vehicles: Changing perceptions, hedging bets. 2011, Accenture.

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

Charging Station Installation Handbook for Electrical Contractors and Inspectors: Version 1.0. 2011, Advanced Energy.

Transportation Electrification: A Technology Overview. 2011, EPRI.

SAE J1772. 2012 [cited 2012 April 20]; Available from: http://en.wikipedia.org/wiki/J1772.

Connector on the side of a DC charging stand for EV (conforming to CHAdeMO specifications). 2012 [cited 2012 April 20].

Application for Electrical Permit, D.o.B.a. Safety, Editor. 2012: Los Angeles.

Electric Vehicle Charger Installation Guidelines, B.a.S. Division, Editor. 2012: Riverside.

Ordinance No. 2964-11. 2012: City of Sunnyvale.

Realizing the Potential of the LA EV Market. February 2011, Indiana University.

Final Express Terms for Proposed Building Standards of the Department of Housing and Community Development, D.o.H.a.C. Development, Editor. January 2010: California.

Electric Vehicle Charging Station Program and Installation Guidelines. July 2011: Sonoma County.

Filing of Information in Response to Administrative Law Judge's Ruling. March 2011, PG&E.

Residential, Public, Private and Workplace Charging Stations, EV Charging Business Models, and Vehicle to Grid Technology. May 2009, Pike Research.

Accessibility and Signage for Plug-In Electric Vehicle Charging Infrastructure. May 2012, California PEV Collaborative.

Ready Set Charge California, A Guide to EV-Ready Communities. November2011, Association of Bay Area Governments, Bay Area Climate Collaborative, Clean Fuel Connection , EV Communities Alliance, LightMoves Consulting.

Sion Power Receives DOE grant to Enhance Lithium Sulfur Batteries. November 2009; Available from: http://sionpower.com/pdf/articles/Sion%20Power%20DOE%20Press%20Release_11-10-09.pdf.

Axsen, J. and K.S. Kurani, Anticipating plug-in hybrid vehicle energy impacts in California: Constructing consumer-informed recharge profiles. Transportation Research Part D, 2010. 2010: p. 212-219.

Barnett, B., et al., PHEV Battery Cost Assessment. June 2010, TIAX LLC.

BC3Bay and BAC, Electrify Your Business: Moving Forward with Electric Vehicles, A Bay Area Business Guide. April 2011, Business Council on Climate Change and Bay Area Council.

Botsford, C., The Economics of Non-Residential Level 2 EVSE Charging Infrastructure, in EVS26: Great Minds Think Electric. 2012: Los Angeles.

Botsford, C. and A. Szczepanek, Fast Charging vs. Slow Charging: Pros and cons for the New Age of Electric Vehicles, in EVS24. 2009: Stavanger, Norway.

Bowermaster, D. (EPRI). *How Much Electric Vehicle Charging is Needed?* California Plug-in Electric Vehicle Collaborative Meeting, August 2012.

Butler, AB 475. Vehicles: offstreet parking: electric vehicles. 2011.

CALSTART, Detailed Infrastructure Planning Checklist for E-Truck Fleets. 2012.

CARB, ZEV Regulation 2010, Staff Proposal. 2010.

CARB, Appendix B, Draft Environmental Analysis for the Advanced Clean Cars Program. 2011.

CARB, Proposed Regulation to Implement the Low Carbon Fuel Standard Volume I Staff Report: Initial Statement of Reasons. March 2009.

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

Chhaya, S. and M. Duvall, Impact of Plug-in Electric Vehicle Technology Diffusion on Electricity Infrastructure, Preliminary Analysis of Capacity and Economic Impacts. December 2008.

Corbett, Senate Bill 880, Common interest developments: electric vehicle charging stations. 2012.

CPUC, Order Instituting Rulemaking to Consider Alternative-Fueled Vehicle Tariffs, Infrastructure and Policies to Support California's Greenhouse Gas Emissions Reductions Goals. August 2009.

Crosby, M., P. Skala, and J. Fitch, Light-Duty Vehicle Electrification in California: Potential Barriers and Opportunities, CPUC, Editor. May 2009.

DeForest, N., et al., Impact of Widespread Electric Vehicle Adoption on the Electrical Utility Business – Threats and Opportunities. August 2009, Center for Entrepreneurship & Technology (CET), UC-Berkeley.

Dinger, A., et al., Batteries for Electric Cars: Challenges, Opportunities, and The Outlook to 2020. 2010, The Boston Consulting Group.

DOE, Federal & State Incentives and Laws, in State of Pennsylvania. 2012, Alternative Fuels & Advanced Vehicles Data Center.

Dubin, J., et al., Realizing the Potential of the LA EV Market. May 2011, University of California, Los Angeles.

Duleep, G., et al., Impacts of Electric Vehicle, Deliverable 2: Assessment of electric vehicle and battery technology. April 2011, ICF International and Ecologic Institute.

ECOtality, EV Project EVSE and Vehicle Usage Report: 3rd Quarter 2011. 2011, The EV Project.

ECOtality, EV Project EVSE and Vehicle Usage Report: 2nd Quarter 2011. 2011, The EV Project.

ECOtality, First Responder Training, in Lessons Learned. 2011, The EV Project.

ECOtality, Accessibility at Public EV Charging Locations in Lessons Learned. 2011, The EV Project.

ECOtality, EV Project EVSE and Vehicle Usage Report: 1st Quarter 2012. 2012, The EV Project.

ECOtality, EV Project EVSE and Vehicle Usage Report: 4th Quarter 2011. 2012, The EV Project.

ECOtality, The EV MICRO-CLIMATE® Planning Process, in Lessons Learned. 2012, The EV Project.

ECOtality, DC Fast Charge - Demand Charge Reduction, in Lessons Learned. 2012, The EV Project.

ECOtality, Battery Electric Vehicle Driving and Charging Behavior Observed Early in The EV Project in Lessons Learned. 2012, The EV Project.

ECOtality, A First Look at the Impact of Electric Vehicle Charging on the Electric Grid in The EV Project, in Lessons Learned. 2012, The EV Project.

EEI, The Utility Guide to Plug-In Electric Vehicle Readiness. November 2011, Edison Electric Institute.

EPRI, Impact of Plug-in Hybrid Electric Vehicles on Utility Distribution Systems. August 2009, EPRI.

Everett, A., et al., Initial Findings from the Ultra-Low Carbon Vehicle Demonstrator Programme. 2011, Technology Strategy Board.

Graham, R.L., J. Lieb, J. Sarnecki, R. Almazan, B. Neaman. 2012. Wise Investment in Electric Vehicle Charging Infrastructure through Regional Planning. EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium.

Hadley, S.W., et al., Plug-in Hybrid Electric Vehicle Value Proposition Study. July 2010, Oak Ridge National Laboratory.

Hensley, R., S. Knupfer, and D. Pinner, Electrifying cars:How three industries will evolve, in McKinsey Quarterly. November 2009, McKinsey and Co.

Humphrey, J., et al., Drive Green 2020: More Hope than Reality? November 2010, JD Power and Associates.

Kempton, Willett, Francesco Marra, Peter Bach Andersen, and Rodrigo Garcia-Valle. "Business models and control and management architectures for EV electrical grid integration ." In *Electric Vehicle Integration Into Modern Power Networks*, Chapter 4. IEEE Innovative Smart Grid Technologies Europe, 2012.

Kintner-Meyer, M., 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. 2007, PNNL.

Kromer, M.A. and J.B. Heywood, Electric Powertrains: Opportunities and Challenges in the U.S. Light-Duty Vehicle Fleet. May 2007, Sloan Automotive Laboratory, MIT.

Maitra, A., Effects of Transportation Electrification on the Electricity Grid, in Plug-In 2009 Conference. August 2009: Long Beach, CA.

MTC, Preferred Land Use and Transportation Investment Strategy for Plan Bay Area. 2012.

Myers, E., Interview with Stephanie Janczak, Barbara Rogers, and Mike Tinsky, Ford Moto Company April 2012.

Myers, E., Interview with Britta Gross, General Motors Company. March 2012.

NECA, Managing Electric Vehicle Supply Equipment (EVSE) Installations. 2011, National Electrical Contractors Association.

Neenan, B., R. Cromie, and T. Wheat, Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results. May 2010, EPRI and SCE.

Nelson, P.A., D.J. Santini, and J. Barnes, Factors Determining the Manufacturing Costs of Lithium-Ion Batteries for PHEVs, in EVS24. May 2009: Stavanger, Norway.

Nicholas, M; Tal, G; Woodjack, J; and Turrentine, T. Statewide Fast Charging Scenarios, presented at EVS26 in Los Angeles, CA, May 2012.Available online at: http://phev.ucdavis.edu/research/evs-26/EVS26%20-%20Nicholas.pdf.

Padilla, SB 859. Vehicles: records, confidentiality. 2011.

Pearre, N., et al., Electric vehicles: How much range is required for a day's driving. Transportation Research Part C, 2011. **19**: p. 1171-1184.

PG&E, Electric Vehicle Infrastructure Installation Guide. 1999, Pacific Gas & Electric.

PG&E, Electric Vehicle Penetration Study Using Linear Discriminant Analysis. June 2011.

PG&E, PG&E Smart Grid Deployment Plan: Deployment Baseline. June 2011, Pacific Gas & Electric.

Ralston, M. and N. Nigro, Plug-In Electric Vehicles: Literature Review. July 2011, Center for Climate and Energy Solutions.

Sanna, L., Driving the Solution: The Plug-In Hybrid Vehicle. 2005, EPRI.

SCE, Joint IOU assessment report for PEV notification. December 2011.

Sheehy, P. and E. Myers, Interview with Steve Schey, ECOtality. April 2012.

Sheehy, P. and E. Myers, Interview with David Patterson, Nissan North America, Inc. March 2012.

Swanson, J., R. Aslin, and Z. Yucel, Electric Vehicle Penetration Study Using Linear Discriminant Analysis. June 2011, Pacific Gas & Electric Company.

Tamor, M. and C. Gearhart. An Analytic Method for Estimation of Electric Vehicle Range Requirements, Electrification Potential and Prospective Market Size. in Rethinking Energy and Climate Strategies for Transportation. 2011. Pacific Grove, CA.

Turrentine, T., et al., The UC Davis MINI E Consumer Study. May 2011, UC Davis Plug-In Hybrid & Electric Vehicle Research Center.

Vyas, C., Executive Summary: Electric Vehicle Consumer Survey. 2012, Pike Research.

Vyas, C. and C. Wheelock, Energy & Environment Consumer Survey: Consumer Attitudes and Awareness about 13 Clean Energy Concepts. 2012, Pike Research.

Williams, B., et al., Plug-in-Hybrid Vehicle Use, Energy Consumption, and Greenhouse Emissions: An Analysis of Household Vehicle Placements in Northern California. Energies, 2011. 4: p. 435-437.