TAKING CHARGE

ESTABLISHING CALIFORNIA LEADERSHIP IN THE PLUG-IN ELECTRIC VEHICLE MARKETPLACE

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PLUG-IN ELECTRIC VEHICLE
COLLABORATIVE

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Table of Contents

EXECUTIVE SUMMARY 5

CONTEXT 10

1. The Context for a Transition to Plug-in Electric Vehicles in California 11
1.1 California's Opportunity 12
1.2 The Plug-In Electric Vehicle Challenge and Goals of this Plan 15

LANDSCAPE 16

2. Plug-In Electric Vehicle Landscape in California 17
2.1 Plug-In Electric Vehicle Technology Today 20
2.2 Charging and Today's Electricity Grid 21
2.3 Existing Policies Guide the Market 23

VISION 26

3. A Vision for Successful Market Development 27

RECOMMENDATIONS 30

4. Recommendations to Help California *Take Charge* in the Plug-In Electric Vehicle Marketplace 31
4.1 Increase Consumer Awareness and Demand for Plug-In Electric Vehicles through Public Outreach 34
4.2 Reduce Plug-In Electric Vehicle Costs 37
4.3 Simplify and Prioritize Home Charging Installations 41
4.4 Optimize Placement of Non-Residential Charging Infrastructure 44
4.5 Ensure Reliability and Safety of California's Electricity Grid 47
4.6 Maximize Job Creation and Economic Benefit in California 49
4.7 Reinforce California Policy Leadership to Guide Plug-In Electric Vehicle Markets 52
4.8 Encourage and Coordinate Local and Regional Government Efforts 54
4.9 Support Fleet Purchases of Plug-In Electric Vehicles 56
4.10 Research and Demonstrate Opportunities for Plug-In Electric Vehicles to Support California's Electricity Grid 58

FOLLOWING UP 60

REFERENCES 62

Executive Summary

Executive Summary

A new industry is blooming in response to energy and environmental needs and economic opportunities. California is *Taking Charge,* establishing its leadership in the plug-in electric vehicle marketplace.

California's long history of cultural and technological innovation, particularly around automotive lifestyles, makes it well suited to lead a transition to electric-drive transportation and plug-in electric vehicles. With an eager consumer base, ongoing technology and policy leadership, and a clean electricity grid, the state is well-positioned to provide a leading example of successful plug-in electric vehicle (PEV) market growth for other regions to follow. Such a transition can help bring energy security, air quality, climate change, public health, and economic benefits to California. PEV technology is already enhancing California's competitiveness in the global marketplace and providing for the state's sustainable growth in the 21st Century.

The state has an opportunity to continue demonstrating cultural leadership and capitalize on the coming PEV market. It has the economic, political, social, and technological wherewithal to shape the market, affect desired outcomes, and position itself as an economic center for PEV industries.

But developing a sustained market for PEVs in California will take concerted effort. Multiple stakeholders are already working to create a strong foundation for the PEV market. This plan leverages their ongoing and extensive activities and recommends new actions that require their coordination. Their collaboration will help California *Take Charge* in the global transition to PEVs.

This plan aspires to facilitate PEV market growth so that, by the end of the decade, hundreds of thousands of PEVs are sold annually in California and the market contributes significantly to California's ongoing economic, energy, and environmental policy objectives. Its strategic focus intends to solidify California as a technological, manufacturing, economic, and policy leader that benefits from — and shapes — the global PEV market for decades to come. If the six goals outlined on page 7 are achieved by the end of this decade, this plan will be a success.

SIX GOALS FOR CALIFORNIA'S PLUG-IN ELECTRIC VEHICLE MARKET THROUGH 2020

1. Consumer experiences with PEVs are overwhelmingly positive
2. Ownership costs of PEVs are competitive with conventional vehicles
3. PEV charging integrates smoothly into an increasingly clean, efficient, reliable, and safe electricity grid
4. PEVs advance energy security, air quality, climate change, and public health goals
5. Early strategic action creates jobs and economic benefits in California
6. The PEV market moves beyond early adopters to mainstream consumers

Plug-in Electric Vehicle Landscape

Today, major automakers have begun commercial production of PEVs for the first time, and many are targeting California cities as early markets. All major automakers have announced plans to produce PEVs by 2015. As PEVs enter California markets, utilities, municipal governments, PEV charging service providers, and other organizations are working together on infrastructure rollouts to support charging at homes and in public.

Today, a suite of policies in California provides a strong foundation to support a growing market for clean PEVs fueled by electricity. These policies reduce the environmental impact of transportation and improve energy security by reducing vehicle greenhouse gas emissions, promoting clean fuels (including electricity), and improving mobility while reducing passenger vehicle travel.

A Vision for Success by 2020

This plan proposes a vision, in three phases, through which sustainable PEV markets emerge by the end of the decade.

MARKET LAUNCH

California begins to transform its vehicle and energy systems over the next few years, and stakeholders work together to provide a model market designed for long-term success. Within two years, automakers sell several thousand PEVs annually to early adopters, and California accounts for 20% to 30% of PEV sales in the United States. Early adopters' experiences with PEVs meet or exceed their expectations. They become strong advocates for the technology and eagerly show off their PEVs to family, friends, neighbors, and co-workers. California initiates a comprehensive PEV consumer education program, and businesses and municipalities incorporate PEVs into fleets, exposing their workers to the technology. Altogether, these efforts lead to an ever-increasing awareness of PEVs and growing market demand among Californians. Infrastructure efforts focus on home charging. Early market research on consumer needs and vehicle usage shapes future plans.

MARKET GROWTH

A successful initial launch leads to substantial *Market Growth* within a few years. Encouraged by the overwhelmingly positive experience of California's early adopters, automotive companies continue their vehicle rollout, offering new models, more advanced batteries, and second-generation designs. Consumer markets expand in response to new vehicle offerings, innovative financing that leverages operating cost savings to reduce upfront costs, and ongoing education, outreach, and visibility. Annual PEV sales grow to tens of thousands, and PEVs become a common sight in California communities. New and adjusted local and state policies continue to support and guide PEV market growth.

The installation process for home charging equipment is simple and well-established. A data-driven master plan for public charging in California ensures connectivity throughout the state, extends the market reach of PEVs, maintains grid reliability, avoids stranded assets, and maximizes energy and environmental benefits. Utilities carefully monitor initial charging behavior and vehicle electricity consumption to encourage off-peak charging and integrate this new load into the evolving electricity grid.

MARKET TAKEOFF

By 2020, a sustainable electric transportation system is ready to emerge. As significant economic, energy, public health, and environmental benefits begin to accrue in California, the PEV market is ready for takeoff. Annual PEV sales in California are in the hundreds of thousands, and double-digit sales growth continues. Automakers offer a wide range of vehicle models, as PEVs enter multiple market segments. Vehicles, charging infrastructure, and a clean electricity grid are fully integrated in a robust, scalable PEV market system. Mass-production of, and continued improvements in, automotive batteries bring PEV purchase prices down. Lifetime PEV costs are clearly competitive with conventional alternatives. PEVs are now mainstream.

Recommendations

To realize the vision of success and achieve the goals of this plan, stakeholders must coordinate and act to overcome challenges. Key challenges include consumer education and outreach; reducing PEV costs and building markets; providing sufficient charging infrastructure; developing effective policy actions; and ensuring the safe, reliable, and efficient integration of PEV charging with the electricity grid. Stakeholder actions should foster market conditions that attract private investment, innovation, and new business models that can drive mass market adoption of PEVs through cost reduction and improved consumer experiences.

This plan provides recommendations and suggested actions to realize the six goals for PEV market success. They are summarized in Table ES 1 on the following page.

Following Up

Suggested actions identified for the *Market Launch* phase deserve immediate attention. Some of the work has already begun. Stakeholder working groups should become responsible parties to address and implement various recommendations. The PEV Collaborative will help facilitate all actions that support a robust California PEV market.

PEVs will help California meet its environmental and energy goals

Table ES1: *Recommendations to help California Take Charge in the PEV marketplace*

SECTION	RECOMMENDATIONS	SUGGESTED ACTIONS	GOALS
4.1	Increase Consumer Awareness and Demand for PEVs through Public Outreach	Institute a broad-based communications campaign	**1, 6**
		Provide opportunities for all Californians to experience PEVs	**1, 6**
		Create a trusted information clearinghouse	**1, 2, 3**
		Lead by example	**1, 6**
4.2	Reduce PEV Costs	Capitalize on existing incentives and explore new non-monetary incentives to support PEV ownership	**2, 6**
		Explore government policies and regulatory reform that encourage innovative business models to reduce PEV purchase prices and maximize private investment	**2, 5, 6**
4.3	Simplify and Prioritize Home Charging Installations	Reduce costs of installing home charging stations	**2, 3**
		Streamline the installation process	**1, 3**
		Develop general consumer and stakeholder awareness programs	**1**
		Develop charging solutions for multi-dwelling units	**3, 6**
4.4	Optimize Placement of Non-Residential Charging Infrastructure	Guide workplace charging	**3, 4**
		Adopt a strategic and data-driven approach to guide type and placement of public charging stations	**2, 3**
		Maximize private investment	**2, 5**
		Connect charging stations and drivers	**1, 3**
4.5	Ensure Reliability and Safety of California's Electricity Grid	Develop effective utility notification measures	**3**
		Structure electricity prices to encourage off-peak charging	**2, 3, 4**
		When upgrading distribution infrastructure, consider PEVs	**3**
4.6	Maximize Job Creation and Economic Benefit in California	Promote job creation and economic growth in California	**5, 6**
		Support ongoing workforce training programs	**5**
		Leverage California's academic institutions to expand degree and research programs	**5, 6**
4.7	Reinforce California Policy Leadership to Guide PEV Markets	Develop an action plan for relevant state agencies to prepare for PEVs	**1, 6**
		Adjust PEV incentives as the market grows	**4**
		Address long-term economic, energy, and environmental issues	**3, 4, 5**
4.8	Encourage and Coordinate Local and Regional Government Efforts	Coordinate, collaborate, and lead	**3, 6**
		Attract federal dollars to local government	**1, 3, 5, 6**
		Ensure local priorities are met	**4, 6**
4.9	Support Fleet Purchases of PEVs	Educate and inform fleet operators and organization decision makers	**2, 6**
		Develop targeted policies for fleets	**6**
		Leverage fleet purchasing power	**2, 6**
4.10	Research and Demonstrate Opportunities for PEVs to Support California's Electricity Grid	Investigate future opportunities for PEV charging to include demand response and consumer choice for renewables	**1, 2, 3, 4, 6**
		Test secondary applications for PEV batteries	**2, 3, 4, 6**

KEY FOR PHASES

Market Launch
Market Growth
Market Takeoff

KEY FOR GOALS

Consumer Experience	**1**	Total Costs	**2**	Charging Integration	**3**
Energy & Emissions	**4**	Jobs	**5**	Market Growth	**6**

Context

1. The Context for a Transition to Plug-In Electric Vehicles in California

California is well-positioned to lead the transition to plug-in electric vehicles in order to conserve its resources and ensure prosperity for future generations.

Mobility underlies much of our social and economic development. Modern transportation has raised living standards and yielded a highly interconnected global economy. For the past century the reliable internal combustion engine, fueled by relatively cheap petroleum, has powered transportation. But societal costs of petroleum-based transportation are becoming more evident. Foremost among these growing concerns are:

- **AIR QUALITY AND PUBLIC HEALTH.** Transportation is a primary source of carcinogenic particulate matter, air toxins, and smog. Despite vast reductions in vehicle emissions, air pollution levels exceed the health-based air quality standards in southern California more than 100 days a year. Air pollution endangers public health and shortens life expectancy in California.

- **CLIMATE CHANGE.** The transportation sector is the greatest source of greenhouse gas emissions in California, the second-largest source of such emissions in the nation, and one of the fastest-growing sources globally. Passenger vehicles account for 29% of greenhouse gas emissions in California.

- **ENERGY AND ECONOMIC SECURITY.** The United States imports more than 60% of its petroleum, leaving the economy vulnerable to price fluctuations and supply disruptions on the global market. In 2009, the U.S. petroleum trade deficit topped $200 billion, more than 40% of its total trade deficit. In 2008, when California gasoline prices spiked to $4.61 a gallon, market volatility increased Californians' expenditures on gasoline by more than $6.5 billion over the previous year.

The risk is clear. Unless we transition to alternative fuels, California's air quality and public health will continue to suffer, climate change will continue to threaten the state's ecosystems and economy, oil imports will continue to exacerbate trade deficits, and the economy will remain vulnerable to petroleum price spikes. In a competitive global economy, California can no longer afford to depend so highly on distant, unreliable fuel supplies.

1.1 California's Opportunity

California's long history of cultural and technological innovation, particularly around automotive lifestyles, makes it well positioned to lead a transition to electric-drive transportation and plug-in electric vehicles (PEVs). California consumers have a history of adopting new and "green" technologies. Innovative state policies provide a clean transportation model for other states and the country by promoting advanced vehicle technologies, clean fuels, and smart growth. In particular, the state has adopted passenger vehicle regulations to move the transportation sector away from petroleum dependence and toward clean, sustainable fuels such as advanced biofuels, electricity, and hydrogen. State policy continues to push down greenhouse gas emissions and criteria pollutants by increasing the fraction of renewable generation in the electricity grid mix and prohibiting new long-term contracts with conventional coal-fired power plants.

Now the state has an opportunity to continue demonstrating cultural leadership and capitalize on the coming PEV market. It has the economic, political, social, and technological wherewithal to shape the market, affect desired outcomes, and position itself as an economic center for PEV industries.

Successful PEV Markets Expected in California and Elsewhere

Projecting PEV market penetration in 2020 for California, U.S., or global markets has become a popular exercise. Figure 1 compares a wide range of potential market futures. Despite significant variations, each forecast suggests some market success, and many suggest great success. But replacing the existing vehicle fleet will be a slow, decades-long process, and PEVs face many market challenges. For reference, conventional hybrid vehicles took 10 years to reach 5% sales penetration in California.

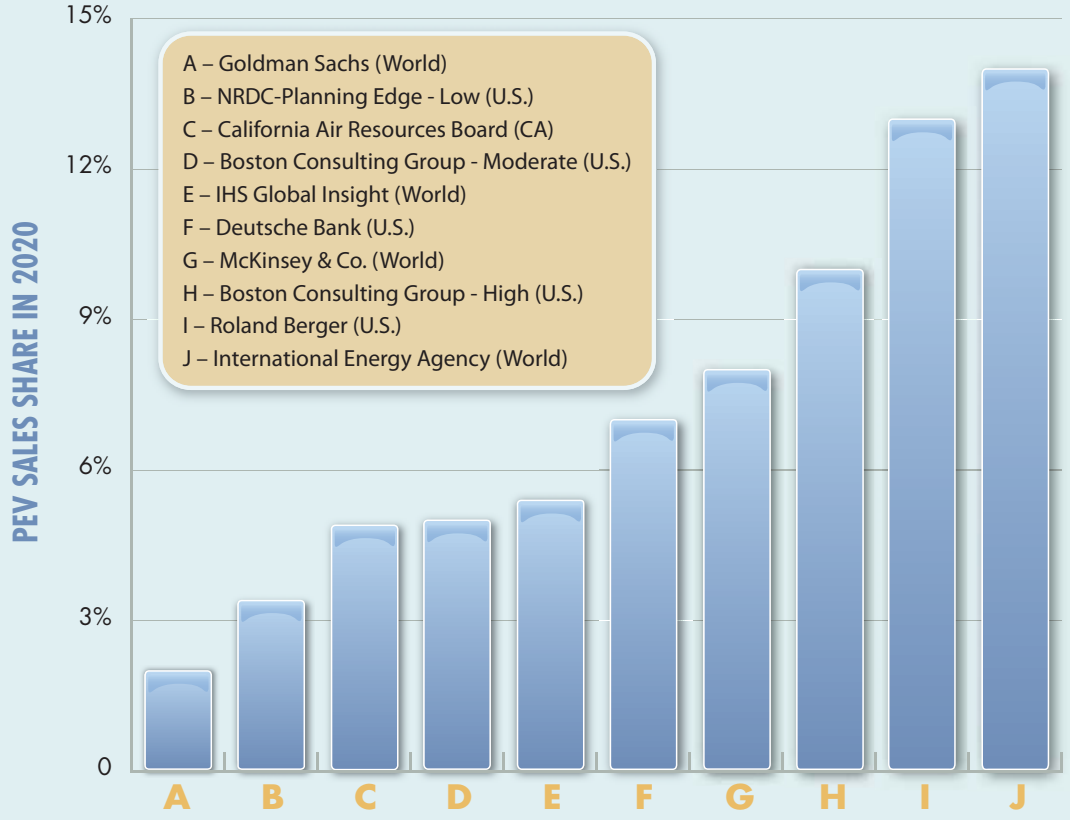

Figure 1. *An example of PEV market projections for 2020*

Private business, innovators, and research institutions clearly see opportunity in developing California as an initial PEV market. Many automakers are targeting California consumers with their first PEV offerings. A number of automakers, charging equipment manufacturers, PEV charging service providers, and technology companies are engaging with local governments to deploy charging infrastructure and provide a range of innovative services to support the PEV rollout. The state's innovation, technology, and venture capital hubs are developing business models to support PEV markets. Universities, research institutions, and national labs in California are planning for a future with PEVs. The excitement around PEVs is leading to new jobs and economic growth opportunities in California.

Economics, energy, environment, jobs, lifestyle, and values: These are reasons why California should lead another cultural and technological transition, this time, to PEVs and a clean, secure transportation future.

California by the Numbers*

- NEW CAR SALES: The California market accounts for 11% of U.S. annual new car sales and over 20% of U.S. hybrid sales. Californians buy more than 1.1 million cars per year. The market is projected to grow by about 50% to 1.7 million by 2020.

- TOTAL ON-ROAD VEHICLES: In 2010, there are over 22 million registered automobiles in California. This is likely to increase to 25 million to 30 million vehicles by 2020.

- GREENHOUSE GAS EMISSIONS: California's electricity grid is very clean. Charging and using a PEV in the state significantly reduces greenhouse gas emissions associated with transportation. A battery-electric vehicle reduces greenhouse gas emissions by 75% compared to a conventional gasoline vehicle, and by 55% compared to a hybrid vehicle. A plug-in hybrid electric vehicle with 20 miles all-electric range reduces greenhouse gas emissions by 60% compared to a conventional vehicle, and by 30% compared to a hybrid vehicle.

- JOBS AND ECONOMIC GROWTH: Since 2006, California has attracted $11.6 billion in clean technology venture capital investment, representing 24% of the global total, according to Next 10. In the first two quarters of 2010, the state attracted 40% of global clean technology investment, as venture capital investments in California increased by two-and-a-half times over the first half of 2009. California leads the United States in clean technology and battery patents. By reducing energy use and greenhouse gas emissions per unit of economic output, California companies continue to free up money for additional investment.

*See Chapter 6 for assumptions and references.

California's Zero Emission Vehicle Program: A Policy Whose Time has Come

In 1990, the California Air Resources Board adopted an ambitious Zero Emission Vehicle (ZEV) Program, requiring ZEVs to account for 2% of major automakers' new vehicle sales in 1998, increasing to 10% by 2003. While those goals were not achieved, the program fostered development in ZEV technologies, including PEVs, that has helped the market launch today. When the program was initially implemented, the only available PEVs were battery electric vehicles. They provided a functional alternative for some early adopters, but technology and market conditions were not ready for wide-scale adoption. Twenty years later, adjusted ZEV targets continue to push technology development, and today, several indicators point to success:

- The number of invested and committed stakeholders has grown significantly
- The federal government has joined California in establishing significant purchase incentives for PEVs
- Lithium-ion batteries are superior to those used previously
- Hybrid vehicles and plug-in hybrid electric vehicles have been introduced, increasing consumer awareness and options
- Uniform charging connector standards exist for PEVs
- Oil spills and price spikes, along with wars in the Middle East, are now at the forefront of American consciousness
- The dangers of air pollution and climate change are well established in the public dialogue

PEVs will help California tackle air pollution and climate change impacts and enhance its energy security

1.2 The Plug-In Electric Vehicle Challenge and Goals of this Plan

Despite the promise of PEVs outlined in the previous section, developing a sustained market for PEVs in California faces serious challenges. Obstacles include retooling the auto manufacturing industry, creating new component and PEV battery industries, reducing battery and PEV costs to compete with conventional vehicles, developing charging infrastructure, managing PEV charging loads intelligently to maintain or improve reliability of the electricity grid, and educating a new generation of buyers about these technologies. Overarching these challenges is the need for rapid action to address energy security, air quality, climate change, and public health concerns.

Multiple stakeholders are already working to overcome these challenges and create a strong foundation for the PEV market. This plan leverages their ongoing and extensive activities and recommends new actions that require their coordination. Their collaboration will help California *Take Charge* in the global transition to PEVs.

This plan aspires to facilitate PEV market growth so that, by the end of the decade, hundreds of thousands of PEVs are sold annually in California and the market contributes significantly to California's ongoing economic, energy, and environmental policy objectives. Its strategic focus intends to solidify California as a technological, manufacturing, economic, and policy leader that benefits from — and shapes — the global PEV market for decades to come. If the following six goals are achieved by the end of this decade, this plan will be a success.

SIX GOALS FOR CALIFORNIA'S PLUG-IN ELECTRIC VEHICLE MARKET THROUGH 2020

1. Consumer experiences with PEVs are overwhelmingly positive
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3. PEV charging integrates smoothly into an increasingly clean, efficient, reliable, and safe electricity grid
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5. Early strategic action creates jobs and economic benefits in California
6. The PEV market moves beyond early adopters to mainstream consumers

Landscape

2. Plug-In Electric Vehicle Landscape in California

With its ongoing policy leadership and clean electricity grid, California provides an ideal market for plug-in electric vehicles.

California's introduction of battery electric vehicles in the 1990s created a population of motivated entrepreneurs, consumer activists, and early adopters eager to purchase a PEV. Many battery electric vehicles from the 1990s and early 2000s remain in operation, and today, major automakers have begun commercial production of PEVs for the first time. Additionally, new market entrants have begun to produce or have announced plans to mass-produce PEVs within the next few years. Table 1 on page 18 lists PEVs coming to market in model years 2010, 2011, and 2012.

As PEVs enter California markets, utilities, municipal governments, PEV charging service providers, and other organizations are working together on infrastructure rollouts to support charging at homes and in public. About 1,300 public charging stations were installed to serve the first wave of PEVs ten years ago. The California Energy Commission is upgrading much of this legacy equipment to meet new industry standards and accommodate new PEVs. In all, the Commission is helping to fund over 4,000 residential and public charging stations through AB 118 funds. Funding from the U.S. Department of Energy is supplementing the vast majority of investment for those charging stations, which will be installed mostly in San Diego, Los Angeles, the Bay Area and Sacramento. Separate Department of Energy funds are paying for installation of another 500 to 700 charging stations in Los Angeles, and the Bay Area Air Quality Management District is tentatively planning to deploy at least 3,000 residential charging stations, 50 fast charging stations and as many as 2,000 public charging stations.

A suite of California policies provides a solid foundation on which to build the state's PEV market. The federal government has also stepped forward to offer manufacturer, infrastructure, and consumer incentive policies that support the market.

PEVs are Coming!

All major automakers have announced plans to produce PEVs by 2015. Several have announced plans to release PEVs in a wide range of vehicle configurations and target market segments over the next two years, as shown in Table 1.

MAJOR MANUFACTURERS

VEHICLE	MANUFACTURER	VEHICLE TYPE	ELECTRIC RANGE	BATTERY SIZE	MODEL YEAR
LEAF	Nissan	BEV	100 mi	24 kWh	2011
VOLT	GM	PHEV	40 mi	16 kWh	2011
ActiveE	BMW	BEV	120 mi	32 kWh	2011
Transit Connect Electric	Ford	BEV	80 mi	28 kWh	2011
Focus Electric	Ford	BEV	100 mi	24 kWh	2011
i-MiEV	Mitsubishi	BEV	75 mi	16 kWh	2011
Prius Plug-in Hybrid	Toyota	PHEV	14.5 mi	5.2 kWh	TBA
Smart ED	Daimler	BEV	70 mi	16 kWh	2012
RAV4-EV	Toyota	BEV	100 mi	~35 kWh	2012

NEW MARKET ENTRANTS

VEHICLE	MANUFACTURER	VEHICLE TYPE	ELECTRIC RANGE	BATTERY SIZE	MODEL YEAR
Roadster	Tesla	BEV	245 mi	53 kWh	2010
Karma	Fisker	PHEV	50 mi	20 kWh	2011
Coda Sedan	Coda	BEV	100 mi	37 kWh	2011
F3DM	BYD	PHEV	62 mi	13.2 kWh	2011
e6	BYD	BEV	250 mi	72 kWh	2011
Think City	Think!	BEV	120 mi	24 kWh	2012
Model S	Tesla	BEV	160–300 mi	42–95 kWh	2012

BEV = Battery Electric Vehicle
PHEV = Plug-in Hybrid Electric Vehicle

Table 1. *PEVs coming to market*

Prius Plug-in Hybrid

2012 Smart ED

2011 Chevrolet VOLT

2011 BMW ActiveE

2011 Mitsubishi i-MiEV

2011 Ford Focus Electric

2011 Nissan LEAF

2010 Tesla Roadster

2.1 Plug-In Electric Vehicle Technology Today

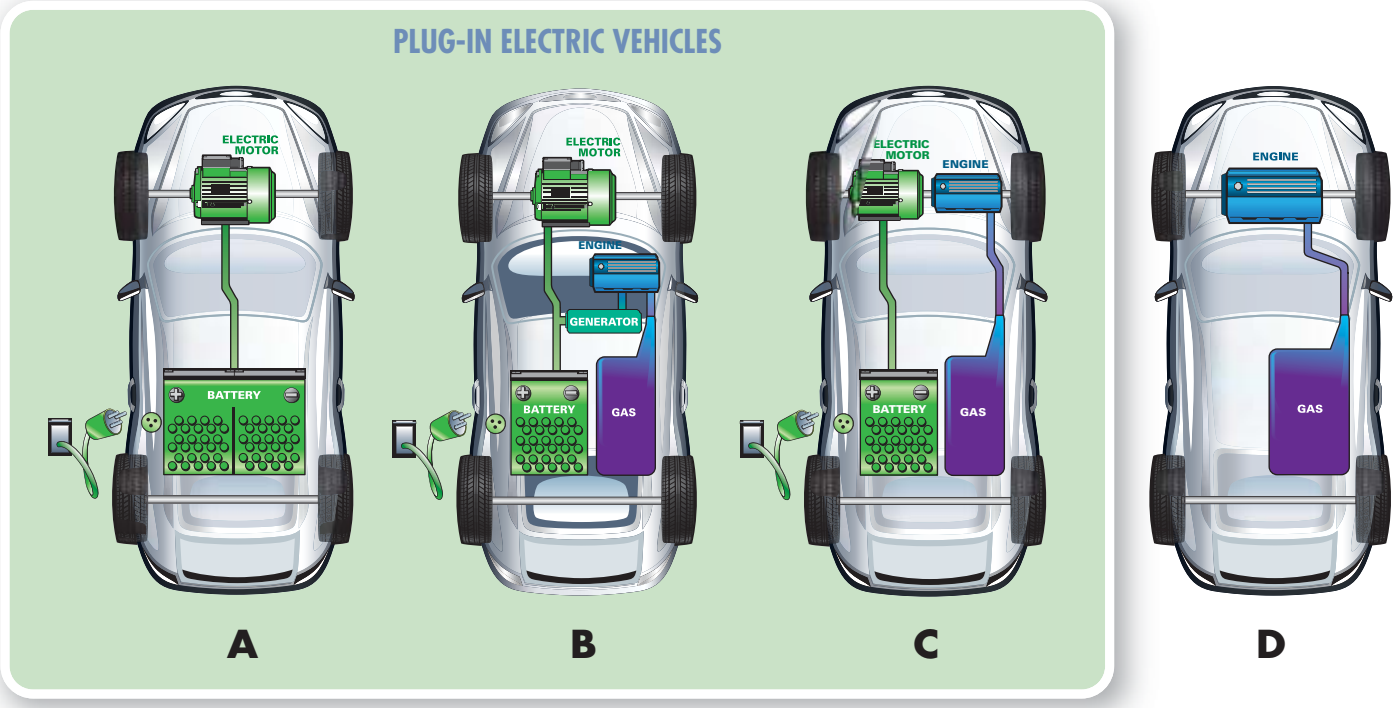

Figure 2. *A comparison of PEV and conventional vehicle configurations. (A) battery electric vehicle, (B) series plug-in hybrid electric vehicle, (C) parallel plug-in hybrid electric vehicle, and (D) conventional internal combustion engine vehicle. (Courtesy Southern California Edison)*

PEVs employ various drivetrain configurations that use grid-supplied electricity to provide some or all of their fuel. In a PEV, batteries supply energy to electric motors, which offer improved efficiency and performance compared to internal combustion engines.

Figure 2 compares several PEV technologies with conventional vehicle technologies. In a battery electric vehicle (A), a battery pack and electric motor replace the gas tank and internal combustion engine of a conventional vehicle (D). Battery electric vehicles rely entirely on electricity for fuel and their range is limited by the size of the battery pack.

A plug-in hybrid electric vehicle combines both a battery pack and electric motor with an internal combustion engine to extend the vehicle's range and provide the option for quick refueling on longer trips. These vehicles may reach broader market segments initially and may take two primary configurations. In a series configuration (B), only the electric motor drives the wheels directly, and a gasoline-powered engine serves as a generator to provide additional electricity to the motor. In a parallel configuration (C), both the gasoline engine and the electric motor can directly power the wheels.

2.2 Charging and Today's Electricity Grid

Over the next decade, electricity demand from PEV charging is unlikely to require new power plant or transmission line capacity. But even in small numbers, PEVs could stress local electricity distribution networks. Under certain circumstances, a cluster of PEVs in a particular neighborhood could overload or shorten the life of a local transformer and require equipment upgrades. As recommended in Sections 4.1 and 4.5, these concerns can be alleviated through effective consumer outreach, utility notification protocols, and pricing structures to discourage on-peak charging.

The electricity grid is undergoing a transition of its own, with new communications, sensors, and controls potentially enabling supply and demand resources to interact and respond to one another. These capabilities could reduce costs and improve system efficiency and reliability for all electric utility customers, not just PEV drivers. If appropriate technology and communication protocols develop, intelligent charging stations may allow PEVs to adjust their charging rate to provide additional services that contribute to increasingly efficient operation of the electricity grid. Section 4.10 suggests research and development towards this end.

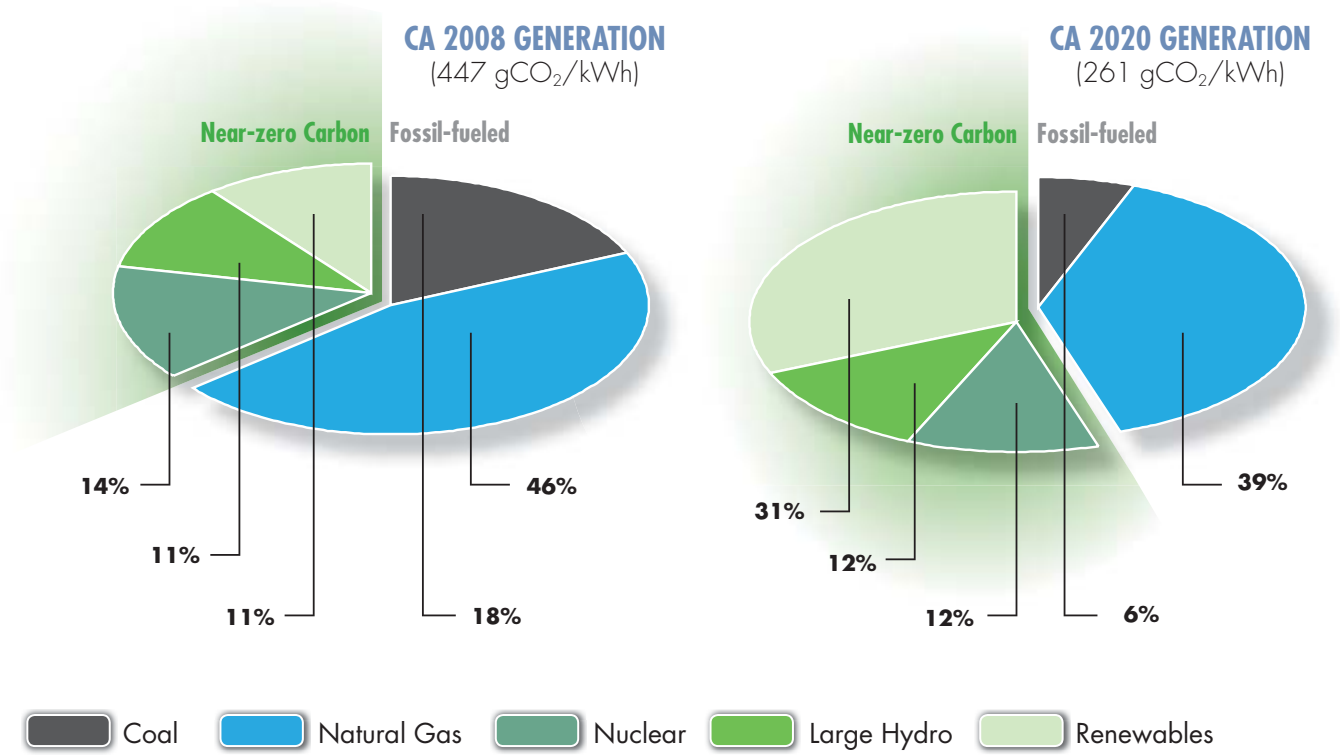

Figure 3: *California's electricity grid in 2020 is expected to have 40% lower carbon emissions than in 2008 (and California's 2008 electricity grid already has 35% lower carbon emissions than the U.S. grid). See Chapter 6 for assumptions and references.*

"Refueling" a PEV

Four different options provide various levels of service to meet consumer needs. Each has tradeoffs. Charging vehicles at higher power replenishes batteries faster, but may produce more stress on local electricity distribution networks. Higher power charging stations may cost more to install and operate. Battery switching offers intriguing possibilities, but requires significant investments and automaker commitment.

- LEVEL 1: 120V alternating current (AC), single phase, 12-16 amps continuous. This level of service is provided by a typical household outlet and is most appropriate for PEVs with relatively small battery packs, low daily mileage, or limited access to Level 2 charging. Depending on the size of the battery, Level 1 charging allows plug-in hybrid electric vehicles and small battery electric vehicles to fully charge overnight.

- LEVEL 2: 240V AC, single phase, up to 80 amps continuous, typically 12-32 amps. This level of service is appropriate to fully charge most PEVs overnight. Compared to Level 1 charging, it can cut the charge time in half. Level 2 charging may require homeowners to upgrade their electrical panel to provide a dedicated circuit for PEV charging. The same connector is used for Level 1 and 2 charging and most new PEVs are compatible with both voltage levels.

- DC CHARGING: A permanently installed charging station converts three-phase AC electricity to direct current (DC) off-board of the PEV, delivering up to 250 kW directly to the PEV battery. DC charging is often referred to as fast charging. Near-term demonstration programs and some production PEVs incorporate this capability at a rate sufficient to charge a 24 kWh battery to about 80% capacity in approximately 30 minutes. There is currently no North American standard for uniform DC charging, although one is being developed.

- BATTERY SWITCHING: An automated process exchanges a depleted battery with a fully charged battery in less time than it takes to refuel at a gas station. Battery switching is currently being demonstrated in various locations throughout the world.

2.3 Existing Policies Guide the Market

Today, a suite of policies in California provides a strong foundation to support a growing market for PEVs fueled by clean electricity. These policies reduce the environmental impact of transportation and improve energy security by reducing vehicle greenhouse gas emissions, promoting clean fuels (including electricity), and improving mobility while reducing passenger vehicle-miles traveled. Table 2 on pages 24 and 25 summarizes important California policies that affect PEV markets today.

Federal policies also provide strong support for growing PEV markets. Federal agencies in 2010 finalized national greenhouse gas emission standards for new passenger vehicles that were modeled after California's rules. And together, federal and California agencies are collaborating on new standards. Federal PEV tax credits, up to $7,500 per vehicle for the first 200,000 PEVs from each automaker, provide a significant financial incentive for new car buyers and important market certainty for automakers developing multiple models and generations of PEVs. The federal government has also funded $8 billion in low-interest loans to spur investment in domestic manufacturing of batteries and advanced vehicles, and has provided $2.4 billion in grants to dozens of additional PEV projects.

Finally, many local policies support PEV markets and infrastructure development in early market communities throughout the state.

California's Historical Policy Leadership

California has led many policy movements, particularly regarding transportation, energy, and the environment. In 1967, California began regulating smog-forming emissions from vehicles. The state's efforts provided a model for the federal government when it adopted the Clean Air Act in 1970, which still provides California with unique authority to continue to set its own emissions standards. In 1990, California expanded its leadership in vehicle emissions policy when it adopted the first Zero Emission Vehicle (ZEV) Program. In 2002, California passed Assembly Bill 1493, which was the first law in the United States to regulate greenhouse gas emissions from any source, including vehicles. Under AB 1493, California adopted standards for passenger vehicles for model years 2009–2016, and it will soon propose standards for model years 2017–2025.

California has aggressively pursued energy efficiency since the 1970s, successfully breaking the perceived link between economic growth and per-capita energy consumption, while saving consumers more than $56 billion. In that same timeframe, air quality management districts have dramatically reduced criteria air pollution from power plants. More recently, the state has also taken steps to reduce greenhouse gas emissions from power plants by adopting aggressive renewable portfolio (or energy) standards and greenhouse gas emissions limits on new, long-term power plant contracts.

California's collection of policy efforts set the stage for an economy-wide greenhouse gas policy passed in 2006, the Global Warming Solutions Act (AB 32). AB 32 has led to additional policies to address greenhouse gas emissions in the energy, manufacturing, and transportation sectors. With these polices and others, California is poised to lead PEV market development.

FUELS AND ELECTRICITY POLICIES

POLICY	YEAR	DESCRIPTION
AB 2076	**2000**	Requires state agencies to set goals for reducing petroleum consumption in California.
AB 1007	**2005**	Establishes a statewide alternative fuels plan and a goal to reduce petroleum consumption in California by 15% by 2020.
Executive Order S-03-05	**2005**	Sets an economy-wide target to reduce greenhouse gas emissions 80% below 1990 levels by 2050.
AB 32	**2006**	Sets an economy-wide limit on greenhouse gas emissions to 1990 levels by 2020 and directs the California Air Resources Board to adopt regulations and implement market mechanisms to achieve the target.
SB 1368	**2006**	Limits long-term investments in baseload generation by the state's publicly owned utilities to power plants that meet an emissions performance standard that is equivalent to the emissions rate from a natural gas-fired combined-cycle plant.
SB 1078	**2006**	Known as the Renewable Portfolio Standard, requires 20% of electricity generation to come from renewable resources by 2010. The California Air Resources Board has adopted a standard to require 33% renewable electricity by 2020.
Low Carbon Fuel Standard	**2009**	Sets performance standards for reducing transportation fuel carbon intensity by 10% in 2020 and recognizes electricity as a low-carbon fuel.
SB 17	**2009**	Requires the California Public Utilities Commission, in consultation with other state agencies, to develop a smart grid deployment plan that integrates the storage technologies of PEVs.
SB 626	**2009**	Requires the California Public Utilities Commission to develop rules to overcome barriers to widespread use of PEVs in California. The Commission is currently developing those rules under OIR 09-08-009. The Commission's rulemaking will provide much of the regulatory framework that will shape the PEV marketplace in California, including metering, rate structure, charging protocols, and other issues.
SB 1340	**2010**	Includes residential charging stations in Property Assessed Clean Energy (PACE) programs.

Table 2. *Major California policies guiding the PEV market*

VEHICLES POLICIES

POLICY	YEAR	DESCRIPTION
Low Emission Vehicle (LEV) Program	**1990**	Sets performance standards for emissions of criteria pollutants and greenhouse gases in new light-duty vehicles. An update expected in 2011 will set requirements through 2025.
Zero Emission Vehicle (ZEV) Program	**1990**	Requires a percentage of new vehicles sold in the state to have zero tailpipe emissions. An update expected in 2011 will set requirements through 2025.
AB 118	**2007**	Provides $1.4 billion in incentives through 2015 for loans or rebates on advanced vehicles purchases, alternative fuels infrastructure, manufacturing, and research and development. In 2010 and 2011, $4.1 million has been set aside for consumer PEV rebates of up to $5,000 per vehicle.
SB 71	**2009**	Authorizes the California Alternative Energy and Advanced Transportation Financing Authority to approve sales and use tax exemptions through 2020 on manufacturing equipment for PEVs and other advanced or alternative transportation or energy technologies.
SB 535	**2010**	Allows certain PEVs access to carpool lanes regardless of the number of passengers, until 2015.

RELATED POLICIES

POLICY	YEAR	DESCRIPTION
SB 375	**2008**	Requires the California Air Resources Board to adopt regional greenhouse gas emissions targets that will influence urban growth and planning.
SB 1455	**2010**	Requires the California Public Utilities Commission and the California Energy Commission to maintain a public website with links and information specific to PEVs.

Vision

3. A Vision for Successful Market Development

Annual plug-in electric vehicle sales in California may reach hundreds of thousands by 2020, an important milestone in building a sustainable market.

What are the stages of successful PEV introduction in California? How do we reach the six goals outlined in this plan?

The ambitious path presented on the following pages represents only one of any number of ways that successful PEV markets could develop in California over the next decade and provides context for the recommendations in Chapter 4.

Market Launch describes possible market conditions and stakeholder actions as the first wave of PEVs come to market, during the next few years. *Market Growth* describes how those markets may evolve as second-generation PEV models begin to appear and consumers continue to shape this transition in the automotive industry. Finally, *Market Takeoff* describes a future towards the end of the decade, when PEVs are part of the mainstream.

Market Launch

California begins to transform its vehicle and energy systems over the next few years, and stakeholders work together to provide a model market designed for long-term success. Within two years, automakers sell several thousand PEVs annually to early adopters, and California accounts for 20% to 30% of PEV sales in the United States. Despite the relatively small number of PEVs on the road, the broad range of drivetrain configurations among available models provides valuable lessons for stakeholders. Research on early adopters' experiences improves understanding of consumer preferences and market challenges. The state and federal governments maintain existing financial incentives and develop non-financial incentives to guide and support the early market.

Early adopters' experiences with PEVs meet or exceed their expectations. They become strong advocates for the technology and eagerly show off their PEVs to family, friends, neighbors, and co-workers. Consumers see both solar power and PEVs in their daily lives; some link the two as an example of how individual action can lead to a cleaner, more secure energy future. California initiates a comprehensive consumer education program that helps people imagine how a PEV might meet their needs. Businesses and municipalities incorporate PEVs into fleets and expose their workers to the technology. Altogether, these efforts lead to an ever-increasing awareness of PEVs and growing market demand among Californians.

Infrastructure efforts focus on ensuring easy, ready access to home charging for new PEV owners. California businesses as well as local, state, and federal governments install public charging infrastructure in high-traffic areas that drivers can locate using online databases, vehicle navigation systems, or smart phones. Utilities carefully monitor initial charging behavior and vehicle electricity consumption to encourage off-peak charging and prepare for integration of this new load into the evolving electricity grid. New business models emerge that support the PEV market through infrastructure and PEV charging service models.

Market Growth

A successful initial launch leads to substantial *Market Growth* within a few years. Encouraged by the overwhelmingly positive experience of California's early adopters, automotive companies continue their vehicle rollout, offering new models, more advanced batteries, and second-generation designs. Consumer markets expand in response to new vehicle offerings, innovative financing that leverages operating cost savings to reduce upfront costs, and ongoing education, outreach, and visibility. Annual PEV sales grow to tens of thousands, and PEVs become a common sight in California communities. New and adjusted local and state policies continue to support and guide PEV market growth.

Thanks to collaboration among stakeholders during *Market Launch*, the installation process for home charging stations is simple and well-established. A data-driven master plan for public charging in California ensures connectivity throughout the state, extends the market reach of PEVs, maintains grid reliability, avoids stranded assets, and increases electric driving to maximize energy, air quality, climate, and public health benefits. Workplaces offer charging station access for their employees, and apartments and condominiums begin to offer charging stations for their residents. Privately financed, publicly available infrastructure expands, and with it, applications and markets for PEVs.

The vast majority of PEV charging occurs off peak, based on price signals that encourage consumers to charge when it is least expensive and most beneficial for the electricity grid. Optional renewable energy programs are available for consumers who want to charge with even more renewable energy than California's clean electricity grid provides. Using data gathered from *Market Launch*, utilities, consumers, and other stakeholders begin integrating PEVs and home appliances with a smarter grid. New programs establish the potential for PEVs to provide demand response and support the electricity grid and renewable power generation.

Market Takeoff

By 2020, significant economic, energy, environmental, and public health benefits begin to accrue in California. The PEV market is ready for takeoff. Annual PEV sales in California are in the hundreds of thousands, and double-digit sales growth continues. Automakers offer a wide range of PEV models in multiple market segments.

Effective consumer education, infrastructure planning and development, and improved vehicle range have alleviated consumer concerns. The master-planned public charging infrastructure is well utilized and meets consumer needs and preferences. New, successful businesses that offer charging and additional services to PEV drivers create jobs and enhance California's competitive edge.

Successful management of PEV charging load, coupled with demand response, energy efficiency, and renewable power, allow PEV charging to integrate smoothly into the evolving electricity grid and maximize energy and environmental benefits. California's grid has become even less carbon intensive than it was at *Market Launch*, as utilities meet the state's 33% renewable energy targets by 2020. Consumers take pride in knowing that their PEV contributes to a cleaner energy future.

Mass production and continued improvements in automotive batteries bring PEV purchase prices down. The total costs of PEV ownership decline and become comparable to conventional vehicles, reducing the need for financial purchase incentives, which begin to retire. After careful research and development, secondary vehicle battery opportunities begin to emerge, providing additional value for PEV owners. Lifetime PEV costs are clearly competitive with conventional alternatives. PEVs are now mainstream.

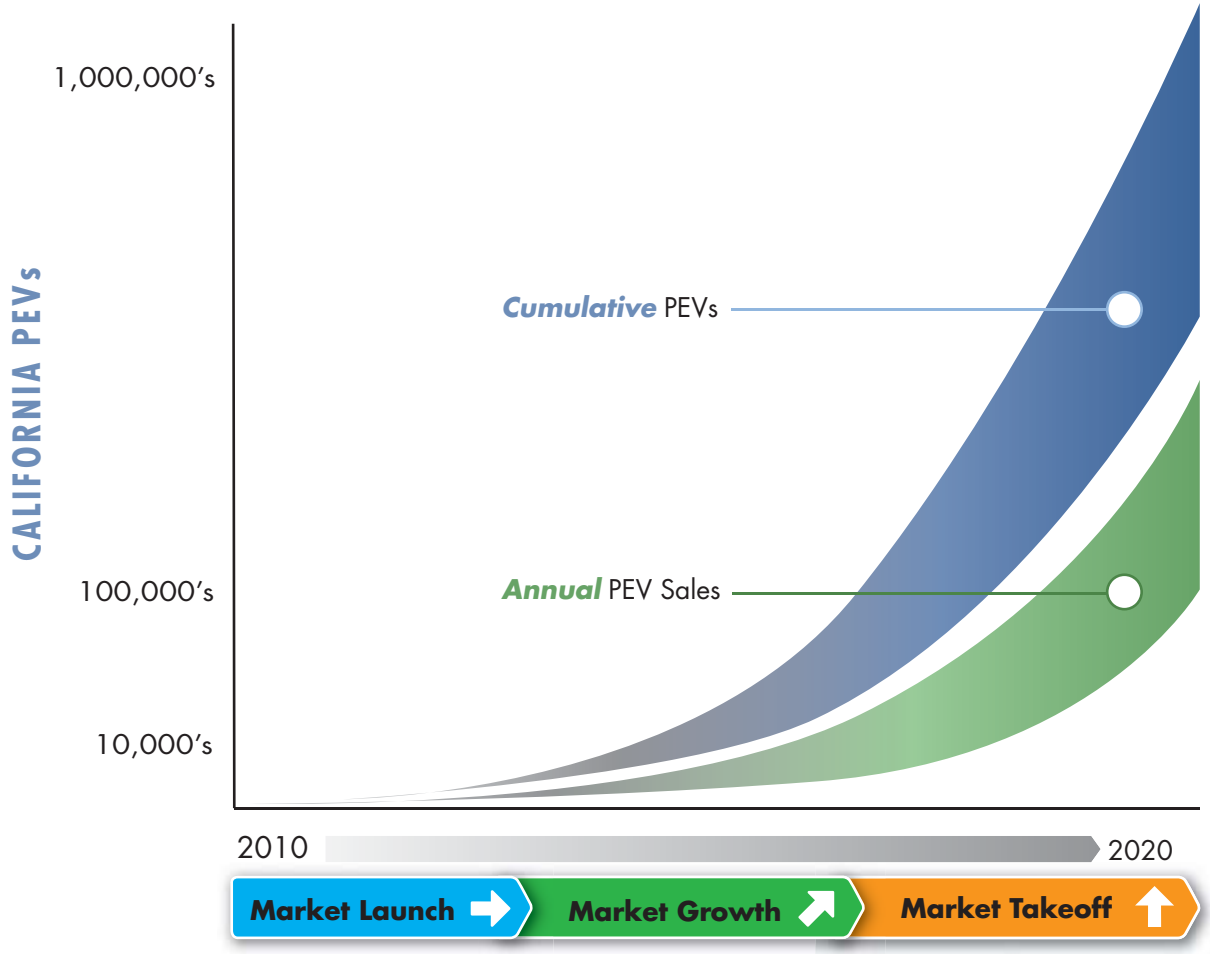

Figure 4. *A vision for sustained PEV market expansion in California*

Recommendations

4. Recommendations to Help California *Take Charge* in the Plug-In Electric Vehicle Marketplace

Achieving the goals of this plan requires stakeholders to coordinate and act to overcome challenges.

Realizing the ambitious vision for PEVs in California described in Chapter 3, or one similarly successful, requires concerted effort to build the market. Key challenges include consumer education and outreach, reducing PEV costs and building markets, providing sufficient charging infrastructure, developing effective policy actions, and ensuring the safe, reliable, and efficient integration of PEV charging with the electricity grid. Stakeholder actions should foster market conditions that attract private investment, innovation, and new business models that can drive mass market adoption of PEVs through cost reduction and improved consumer experiences.

The sections that follow detail several of these challenges and provide ten key recommendations to overcome them. Each recommendation includes suggested actions that promote at least one of the six goals of this plan.

Table 3 on pages 32 and 33 summarizes the recommendations, actions, and example outcomes, and prioritizes them by market phase. Recommendations for *Market Launch* deserve immediate attention, while those during *Market Growth* or *Market Takeoff* should help the market as it develops further.

SIX GOALS FOR CALIFORNIA'S PLUG-IN ELECTRIC VEHICLE MARKET THROUGH 2020

1. Consumer experiences with PEVs are overwhelmingly positive
2. Ownership costs of PEVs are competitive with conventional vehicles
3. PEV charging integrates smoothly into an increasingly clean, efficient, reliable, and safe electricity grid
4. PEVs advance energy security, air quality, climate change, and public health goals
5. Early strategic action creates jobs and economic benefits in California
6. The PEV market moves beyond early adopters to mainstream consumers

SECTION	RECOMMENDATIONS	SUGGESTED ACTIONS	EXAMPLES	GOALS
4.1	Increase Consumer Awareness and Demand for PEVs through Public Outreach	Institute a broad-based communications campaign	Ad Council-supported TV advertisments	**1, 6**
		Provide opportunities for all Californians to experience PEVs	PEV loaner programs	**1, 6**
		Create a trusted information clearinghouse	Lifetime vehicle cost calculator	**1, 2, 3**
		Lead by example	Encourage local leaders in community to drive PEVs	**1, 6**
4.2	Reduce PEV Costs	Capitalize on existing incentives and explore new non-monetary incentives to support PEV ownership	Reduce PEV registration fees	**2, 6**
		Explore government policies and regulatory reform that encourage innovative business models to reduce PEV purchase prices and maximize private investment	Low-interest loans for manufacturing	**2, 5, 6**
4.3	Simplify and Prioritize Home Charging Installations	Reduce costs of installing home charging stations	Offset costs with funding from AB 118 or regional air districts	**2, 3**
		Streamline the installation process	Consolidate steps to reduce home visits	**1, 3**
		Develop general consumer and stakeholder awareness programs	Share best practices through information clearinghouse	**1**
		Develop charging solutions for multi-dwelling units (MDUs)	Grant funding for pilot MDU and curbside charging program	**3, 6**
4.4	Optimize Placement of Non-Residential Charging Infrastructure	Guide workplace charging	Educate business regarding existing incentives	**3, 4**
		Adopt a strategic and data-driven approach to guide type and placement of public charging stations	Collect and analyze early market data	**3, 2**
		Maximize private investment	Charging infrastructure should have capability to directly bill end-users	**2, 5**
		Connect charging stations and drivers	Develop software tools for consumers	**1, 3**
4.5	Ensure Reliability and Safety of California's Electricity Grid	Develop effective utility notification measures	Financial incentives to encourage consumers to notify utilities	**3**
		Structure electricity prices to encourage off-peak charging	Reward consumers with low off-peak electricity rates	**2, 3, 4**
		When upgrading distribution infrastructure, consider PEVs	Allow variable power levels for charging	**3**
4.6	Maximize Job Creation and Economic Benefit in California	Promote job creation and economic growth in California	Outreach to potential manufacturers regarding incentives	**5, 6**
		Support ongoing workforce training programs	Advertise and support electrician training programs	**5**
		Leverage California's academic institutions to expand degree and research programs	Develop market research programs	**5, 6**
4.7	Reinforce California Policy Leadership to Guide PEV Markets	Develop an action plan for relevant state agencies to prepare for PEVs	Create a state working group to implement action plan	**1, 6**
		Adjust PEV incentives as the market grows	Fine-tune AB118 award criteria according to performance-based metrics	**4**
		Address long-term economic, energy, and environmental issues	Establish working group to explore post-2020 grid carbon limits	**3, 4, 5**
4.8	Encourage and Coordinate Local and Regional Government Efforts	Coordinate, collaborate, and lead	Create regional infrastructure placement plan(s)	**3, 6**
		Attract federal dollars to local government	Share resources and collaborate on grant applications	**1, 3, 5, 6**
		Ensure local priorities are met	Plan infrastructure to maximize shift to electric vehicle miles traveled	**4, 6**
4.9	Support Fleet Purchases of PEVs	Educate and inform fleet operators and organization decision makers	Promote positive leadership image and operational benefits	**2, 6**
		Develop targeted policies for fleets	Allow purchase criteria other than just vehicle price	**6**
		Leverage fleet purchasing power	Coordinate purchase cooperatives	**2, 6**
4.10	Research and Demonstrate Opportunities for PEVs to Support California's Electricity Grid	Investigate future opportunities for PEV charging to include demand response and consumer choice for renewables	Develop pilot programs for automated demand response from PEVs	**1, 2, 3, 4, 6**
		Test secondary applications for PEV batteries	Test secondary-life applications for PEV batteries	**2, 3, 4, 6**

Table 3: *Recommendations to help California Take Charge in the PEV marketplace*

KEY FOR PHASES

- Market Launch
- Market Growth
- Market Takeoff

KEY FOR GOALS

Consumer Experience	**1**
Total Costs	**2**
Charging Integration	**3**
Energy & Emissions	**4**
Jobs	**5**
Market Growth	**6**

4.1 Increase Consumer Awareness and Demand for Plug-In Electric Vehicles through Public Outreach

Effective outreach can inform consumers, drive demand for PEVs, facilitate installations of home charging equipment, and guide use of PEVs. In addition, outreach helps to maximize consumer satisfaction, electricity grid benefits, and progress towards energy and environmental policy goals. Active education efforts throughout the state and across all media platforms can create an informed public eager to purchase PEVs and use them in a way that makes the most of their beneficial attributes.

CHALLENGES

Initial market demand may be tempered by consumers' lack of direct experience with or knowledge of PEVs. Most consumers have never seen a PEV, much less driven one, and the technology is unfamiliar to them. First-hand experience is necessary to expand the consumer base for PEVs, avoid misperceptions, improve understanding, and generate excitement.

Before purchasing a PEV, consumers should understand the technology and the private and societal benefits it provides. To ensure a positive experience with PEVs, consumers must understand the type of vehicle that best matches their lifestyle and the process and cost associated with installing charging stations at home. They also need to understand the implications of vehicle use and charging levels on range, charge times, and cost. Throughout the market, consumers need accessible education and outreach.

SUGGESTED ACTIONS

INSTITUTE A BROAD-BASED COMMUNICATIONS CAMPAIGN. Private and public stakeholders should cooperate to develop a broad campaign that delivers consistent messaging. Such a campaign should include a multi-media approach, including web-based resources, social media, billboards, broadcast public service announcements, and coordination with groups such as the Ad Council. Direct benefits such as the convenience of home charging, the cost of electricity compared to gasoline, and available incentives, along with the energy, environmental, and public health benefits should be highlighted. Clearly articulating charging options and renewable energy programs that might be available to consumers may be important for those who choose a PEV primarily to minimize their personal impact on the environment.

An Information Clearinghouse for Consumers

An online PEV clearinghouse with information specific to California markets could include the following:

- Best practices for local governments, fleet operators, and first responders
- Calculators to compare total costs of ownership of different vehicles
- Classroom materials
- Descriptions of electricity metering and rate structure options
- Explanation of energy and environmental benefits of PEVs
- List of suppliers and contractors for charging stations
- Maps and links to public charging availability
- Purchase incentives for vehicles and charging equipment
- Recommended charging behaviors
- Testimonials from PEV owners

PROVIDE OPPORTUNITIES FOR ALL CALIFORNIANS TO EXPERIENCE PEVS. Automakers, government, utilities, and other stakeholders can collaborate to provide a wide range of opportunities for Californians to use PEVs in real-life settings and understand how they drive, charge, and generally feel. Beyond "ride 'n drive" events, creative promotions could incorporate PEVs into business, carsharing, rental, taxi, and driver education fleets. Stakeholders could consider developing programs that place PEVs in disadvantaged communities to ensure that a broad outreach campaign reaches all Californians. As more PEVs become available, it will be important to demonstrate the variety of choices available to consumers.

Driving 100 miles with:
Battery Electric Vehicle = $2.50
Plug-in Hybrid Electric Vehicle = $5.75
Conventional Hybrid Vehicle = $6.50
Conventional Gasoline Vehicle = $11

Figure 5. *PEVs can cut fuel costs by 80%. PEV fuel savings are an important consumer benefit that should be part of public outreach messaging. Analysis assumes a gasoline price of $3/gallon, electricity price of $0.10/kWh, and a plug-in hybrid electric vehicle with 20 miles all-electric range (see Chapter 6).*

CREATE A TRUSTED INFORMATION CLEARINGHOUSE. Stakeholders should collaborate to develop a website with comprehensive and impartial PEV information for California consumers and other stakeholder audiences. Under SB 1455, the California Energy Commission, in consultation with the California Public Utilities Commission, is developing one such website. Existing web resources, such those operated by the California Air Resources Board and the Electric Drive Transportation Association, should also be utilized and referenced.

LEAD BY EXAMPLE. If government, business, and cultural leaders drive PEVs, interest and confidence in the technology will develop. A "lead by example" philosophy could permeate throughout the state to make PEVs more visible every day. Award and recognition programs that publicize such leadership could help encourage leadership efforts and promote PEV market development.

The GPS on the Nissan LEAF constantly updates the driving range on current state of charge

The Chevrolet VOLT dashboard display provides real-time energy consumption information to the driver

4.2 Reduce Plug-In Electric Vehicle Costs

Reducing and restructuring PEV costs can enable large, sustainable markets to develop. New business models and potential revenue streams can cut costs of mobility and reduce purchase and operating costs for consumers. As costs of PEV ownership decline, PEV market segments will expand to reach a broader set of consumers.

CHALLENGES

Reducing PEV costs for consumers requires purchase prices to decline, operating cost savings to fully materialize, and robust resale markets for PEVs to develop. Lower battery costs and continuous improvement in performance will be critical. Figure 6 on page 39 emphasizes the scale of cost reductions that are possible. Increased production volumes will help reduce battery and PEV costs, but scaling up manufacturing can be challenging. PEVs share some, but not all, parts with conventional hybrid vehicles, and those supply chains need to expand, as well. In addition to bringing down the purchase price of PEVs, consumers must come to value ongoing operating cost savings in their purchase decisions.

SUGGESTED ACTIONS

CAPITALIZE ON EXISTING INCENTIVES AND EXPLORE NEW NON-MONETARY INCENTIVES TO SUPPORT PEV OWNERSHIP. Stakeholders should work to maximize the benefit of existing financial incentives on PEV market growth. To build on existing state and federal PEV purchase incentives and others, government agencies can consider additional monetary and non-monetary incentives — such as access to carpool lanes, reduced bridge tolls, provisional insurance, and favorable vehicle registration fee structures — to restructure and reduce costs of PEV ownership. State or federal grants can be leveraged to offset local fiscal impacts from PEV incentives. Where possible, government vehicle purchase incentives should be administered at the point of sale, providing consumers convenience and immediate cost savings. Incentive policies specific to PEVs should diminish and retire as technology costs decline.

EXPLORE GOVERNMENT POLICIES AND REGULATORY REFORM THAT ENCOURAGE INNOVATIVE BUSINESS MODELS TO REDUCE PEV PURCHASE PRICES AND MAXIMIZE PRIVATE INVESTMENT. Innovative business models such as third-party battery ownership or subscription-based electric mileage plans can help reduce upfront vehicle costs. Low-interest loans and innovative financing may help stimulate PEV sales and associated "green" industries in California. Some innovative financing models that leverage ongoing operating cost savings to reduce up-front investments already exist, such as for energy efficiency improvements or solar power. These types of models could be extended to include PEVs. Recommendations for bringing down battery and PEV costs over a longer timeframe are discussed in Section 4.10.

Nissan LEAF battery pack cutaway

Under the hood of the Chevrolet VOLT

Incentive Concepts to Build the PEV Market

Many types of incentives can encourage PEV sales and use. The following examples have costs and benefits that policymakers and other stakeholders must weigh before adopting.

Marketing Incentives

- Revenue-neutral programs that provide incentives to support sales of highly efficient and alternative-fueled vehicles (including PEVs) that reduce greenhouse gas emissions and energy consumption
- State purchase incentives to encourage sales of larger quantities of PEVs
- Offsets for increased sales tax due to higher purchase price of PEVs compared to similar gasoline vehicles
- Lower fees on PEV rental cars, by passing purchase incentives through to consumers, so consumers can get real-life experience with PEVs ("try-before-you-buy")
- Loaner cars or carsharing program membership for times when a PEV doesn't fulfill customer needs
- Separating battery ownership from the vehicle purchase price, perhaps through subscription-based business models or separate lease agreements
- Incentives for home charging infrastructure and permitting requirements (see Section 4.3), to defray initial costs of PEV ownership

Operating Incentives

- PEV use incentives (carpool lane access, free parking, bridge tolls, or access to county, state, or national parks)
- Offsets for incremental vehicle registration fees due to higher purchase prices for PEVs compared to similar gasoline vehicles
- Innovative insurance plans for PEVs: pay-by-the-mile or reduced liability on multiple vehicles in a household when one is used infrequently

Battery Costs are Expected to Decline

Battery costs will come down with high-volume production and manufacturing efficiencies gained over time. Many forecasts expect that the cost of a PEV battery pack will be cut in half in 5 to 10 years. Figure 6 illustrates how battery costs might come down for three types of PEVs, (A) a battery electric vehicle with a 30 kWh battery pack, (B) a plug-in hybrid electric vehicle with 30 to 40 miles of electric range and a 15 kWh battery pack, and (C) a plug-in hybrid electric vehicle with 10 to 15 miles of electric range and a 5 kWh battery pack. The retail price shown includes a 1.45 X markup of production costs (see Chapter 6 for assumptions and references). Additional PEV cost savings, which are not depicted here, may come from downsizing or removing internal combustion engines and secondary battery use or re-use applications (see Section 4.10).

Figure 6. *Battery cost comparison by PEV type*

Lithium and Rare Earth Metals: Sufficient to Safely Supply Growing PEV Markets

Much of the world's petroleum supply is concentrated in a few countries, threatening global energy security. Similarly, today, the rare earth metals that are used in electric motors and batteries are almost all mined in China, raising concerns about trade control. And supplies of lithium carbonate for lithium batteries are concentrated in ancient salt brine lakes in high, evaporative plains in Afghanistan, Argentina, Bolivia, Chile, China, and a few other parts of the world, raising questions of world resource levels.

Are we trading one security threat for another, and exchanging one limited resource for another? Likely not.

A recent U.S. Department of Energy study finds that world lithium deposits are sufficient to supply batteries for decades. Beyond China, rare earth metals can be found around the globe – and some of the largest deposits are in the United States. Congress is encouraging development of rare earth element sites inside the country, including one in San Bernardino County, California. In response to the growing demand for these rare elements, that site will become an operational mine in 2012.

Uyuni Salt Flats, Bolivia, home to the world's largest lithium deposit

4.3 Simplify and Prioritize Home Charging Installations

The convenience of charging at home is one of the most appreciated benefits of PEV ownership. By simplifying the installation process for residential charging stations, stakeholders can bring down upfront costs for consumers and ensure positive purchase and use experiences with PEVs. Positive early consumer experiences will proliferate and push the market forward.

In most cases, residential charging offers easy access to off-peak charging, which saves money for consumers and supports grid reliability and efficiency. In California, which uses relatively little coal power, off-peak generation comes mostly from low-carbon sources, such as nuclear, geothermal, wind, small hydro, and efficient natural gas-fired power plants.

CHALLENGES

Installing home charging stations presents potential inconvenience and an extra cost that consumers do not face when purchasing a conventional car. Homeowners and prospective PEV buyers may not understand that upgrading electrical circuits might be necessary to install a Level 2 charging station and better accommodate their lifestyle and PEV use patterns. The installation process can be slow and complicated, requiring homeowners to coordinate with automakers, charging equipment providers, electricians, inspectors, permit providers, and utilities in a multi-step process. And while most early PEV market development efforts focus on single-family homes, where PEV owners generally have dedicated parking and authority to upgrade electric circuitry, many potential PEV buyers live in apartments, condominiums, and other multi-dwelling units that do not provide reserved parking or access to electricity outlets. Multi-dwelling units present unique home charging challenges and limit the reach of the early PEV market.

Many stakeholders are already working to simplify and prioritize home charging installations. Some local governments have taken steps to simplify paperwork and inspections, and automakers have formed partnerships with charging equipment providers, installers, and utilities. But additional collaboration among stakeholders can further educate consumers, streamline and expedite the process, reduce costs, and minimize inconvenience to homeowners.

SUGGESTED ACTIONS

REDUCE COSTS OF INSTALLING HOME CHARGING STATIONS. Take advantage of federal, state, and local incentives to offset costs of installing residential charging stations. Under SB 1340, local and state governments can incorporate home charging investments into Property-Assessed Clean Energy (PACE) programs. To the extent possible, incentives should be bundled, and offered as rebates at the time of PEV purchase or infrastructure installation. Stakeholders can work to modify building codes or state Title 24 building standards to require upgrading electrical circuits in new and renovated garages to accommodate a Level 2 charging station. This change in codes and standards can dramatically decrease the cost of future charging station installations.

STREAMLINE THE INSTALLATION PROCESS. Stakeholders should support ongoing efforts to streamline and expedite the installation process for home charging equipment to minimize connection time from the point of PEV purchase and reduce the number of customer interfaces and home visits.

An example of today's Level 2 residential charging equipment

DEVELOP GENERAL CONSUMER AND STAKEHOLDER AWARENESS PROGRAMS. Community groups, regional government entities, and utilities should develop, use, and disseminate best practices and training protocols to PEV industry stakeholders to ensure that consumer needs are being met at reasonable cost and with equitable treatment of taxpayers and utility customers in mind. Impartial certification, training, and consumer surveying will improve consumer confidence and satisfaction. PEV customers should have a choice among PEV charging service providers, even if preferred vendor agreements are in place.

DEVELOP CHARGING SOLUTIONS FOR MULTI-DWELLING UNITS. Local and state governments should consider adopting policies that facilitate charging equipment installations and common access for consumers living in multi-dwelling units and those without dedicated parking. Government agencies can help apartment complexes reach out for targeted grant funding for communal or curbside charging infrastructure. Effective public charging infrastructure and planning can accommodate some of these potential consumers, as well (see Section 4.5). Shared-ownership of charging stations, parking spaces, or PEVs may provide access to the PEV marketplace in certain cases.

Figure 7. *Alternative solutions can meet consumers' home charging needs*

Streamlining Installations of Home Charging Equipment

Stakeholders agree that expediting and simplifying the installation process for residential charging equipment is a priority near-term action item that must be addressed to enable market growth. In addition to recommendations made elsewhere in this section, the following examples illustrate some actions that can help streamline the process.

- Coordinate among auto dealers, electrical contractors, utilities, and local authorities to minimize red tape
- Designate local contacts to respond to consumer questions about PEV charging
- Develop automated inspection reporting executed at the time of inspection
- Develop clear installation procedures and disseminate widely using the clearinghouse and other mechanisms
- Develop online applications for local inspections and permitting
- Establish 24-hour phone or Internet-based scheduling for inspections
- Establish set fees and consolidate inspections
- Prioritize applications for residential charging equipment in the permit review process
- Provide customers information about installation incentives, costs, options, and trade-offs through an information clearinghouse or other mechanisms, such as PEV consultations
- Seek compliance from nationally recognized testing laboratories (such as Underwriters Laboratory, Inc.) for dual-meter adapters

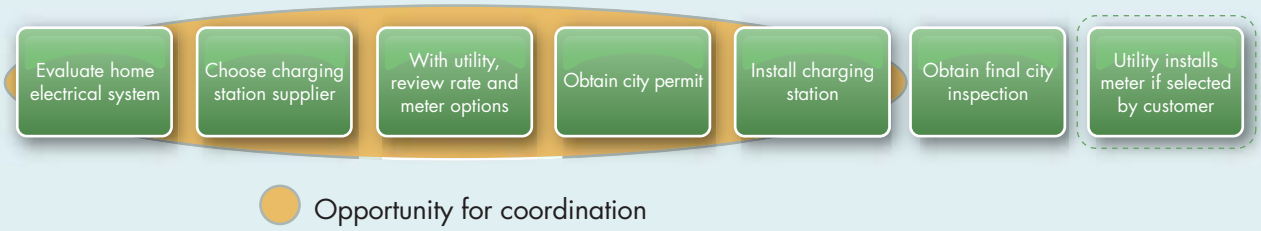

Figure 8. *Installation steps for a Level 2 home charging station*

4.4 Optimize Placement of Non-Residential Charging Infrastructure

Availability of charging stations outside of the home may play an important role in developing PEV markets. Well-placed non-residential (public) charging stations at workplaces, businesses, curbsides, destination or transit station parking lots, highways, or elsewhere, would provide added visibility for PEVs, convenience and value for PEV drivers, and an important solution for people in multi-dwelling units and without access to home charging. Public charging can provide a safety net and comfort for early adopters and extend the range and utility of PEVs, broadening their market reach. It may also allow drivers to increase electric driving and the associated energy security and environmental benefits of their PEV.

California companies are developing innovative business models and bringing venture capital investments and jobs to the state based on providing PEV services to drivers. Other businesses, including retailers and restaurants, may see value in providing charging stations to attract customers and promote a green image.

CHALLENGES

Business opportunities around public charging remain uncertain, and the extent to which PEV drivers will value and use public charging remains unknown. The impact public charging stations will have on PEV sales and use is also uncertain. While private investment should be encouraged throughout the PEV market system, some public investment in charging stations may be necessary, but should be prudent, equitable, and well-planned. Poorly planned public charging investments could lead to stranded assets or negative public perception. If left to chance, public charging could potentially have negative impacts on the electricity distribution system, and as PEV sales increase, contribute to peak electricity demand (see Section 4.6). Information about consumer charging patterns and travel destinations is needed to carefully expand and optimize public charging infrastructure to support the developing PEV market.

SUGGESTED ACTIONS

GUIDE WORKPLACE CHARGING. After home charging, workplace charging may be the preferred charging location for many PEV drivers. Regional planning agencies should coordinate with businesses and state and federal regulators to develop workplace charging programs that encourage PEV use and help to reduce commute emissions. Such programs can help regions achieve air quality and greenhouse gas emission targets, such as those under SB 375. Outreach efforts should educate businesses about obtaining incentives, such as those available under South Coast Air Quality Management District Rule 2202, or obtaining Leadership in Energy and Environmental Design (LEED) certification. While most workplace charging will occur during morning hours and midday, some could occur during on-peak hours. Clear price signals and billing PEV drivers accordingly could help to minimize peak demand.

ADOPT A STRATEGIC AND DATA-DRIVEN APPROACH TO GUIDE TYPE AND PLACEMENT OF PUBLIC CHARGING STATIONS. Early market data on PEV charging and travel behavior will provide valuable information to inform infrastructure planning and policy. Data sharing among government agencies, employers, equipment manufacturers, and PEV charging service providers can optimize public charging access and minimize unnecessary investment. Research using early market data can improve understanding around the impact of public charging on PEV sales, electricity demand, and the electricity distribution system. Additional research and analysis can assess the need for infrastructure corridors that may connect adjacent urban regions and key destinations with charging infrastructure.

Better Place charging stations in Denmark

MAXIMIZE PRIVATE INVESTMENT. Strategic, data-driven planning of public charging infrastructure should incorporate private sector business models and facilitate regional coordination among government agencies and private investors. In the near term, public-private partnerships, which have already led to significant investment in home and public charging stations, can continue to support infrastructure installations and maintenance at appropriate locations and can minimize public investment and private sector risk. Low- or zero-interest financing options could be considered for businesses that are installing charging stations in public areas. Publicly funded charging stations, including those at government fleet operations, where appropriate, should be accessible to all and have the ability to bill drivers or vehicle owners directly. Stakeholders should account for ongoing operation costs and assign responsibility for infrastructure maintenance, so that stations do not become stranded investments.

CONNECT CHARGING STATIONS AND DRIVERS. Consumers must be able to find — and use — charging stations. Information regarding the location, type, availability, cost, and other attributes of stations should be shared among stakeholders and updated in real time, so that software tools may be developed to provide consumers with the convenience and reliability they demand.

Managing a PEV charge from a smart phone

Public charging stations, such as these Blink Level 2 charging stations by ECOtality, will come to retail locations

Planning Regional Charging Infrastructure

As the PEV market launches, data on public charging behavior will help inform future investments in and placement of charging infrastructure. While data-driven planning can help guide infrastructure rollouts, some element of judgment will enter into future decisions. For example, it may make sense to have public charging well-represented in beach communities or tourist destinations that attract visitors from many miles away, as well as along adjacent travel corridors. On the other hand, shopping centers and malls often attract people who live nearby and have little need to charge their PEV. Placing charging stations in those locations may be less supportive of PEV drivers' needs.

Coulomb Technologies ChargePoint charging station, San Jose, Calif. (Courtesy Rob Sturgill)

4.5 Ensure Reliability and Safety of California's Electricity Grid

Regardless of where charging occurs — in public or at home — it is important to avoid adverse impacts on the electricity grid and associated costs for utility customers. Effective planning and collaboration among stakeholders can minimize on-peak charging and associated impacts on local distribution infrastructure. Ultimately, as technology and communication protocols develop, PEV charging may provide valuable services to the electricity grid that could improve reliability in the future (see Section 4.10).

CHALLENGES

In some circumstances, charging during local peak demand periods can contribute to overloading distribution infrastructure, creating reliability problems and shortening the life of equipment. Widespread on-peak charging could create additional demand for expensive, inefficient peaking power plant capacity and generation, which adds costs and emissions to the electricity grid. Utilities can plan infrastructure upgrades appropriately, given advance notice, but additional outreach and appropriate communication protocols are needed to encourage consumers to engage with utilities ahead of time. Additionally, consumers may be unaware of potential impacts of charging on electricity grid reliability. Effective communication tools and strategies will help consumers understand how their charging decisions can affect the grid and the prices they pay for electricity, while helping utilities and other stakeholders ensure grid reliability.

SUGGESTED ACTIONS

DEVELOP EFFECTIVE UTILITY NOTIFICATION MEASURES. Early notification enables utilities to plan for and prepare local distribution infrastructure for PEV charging. Stakeholders should develop protocols and mechanisms to facilitate early communication among automakers, consumers, PEV charging service providers, and utilities as soon as consumers expect or know that they will be charging a PEV at home. Utilities and other stakeholders should also begin to develop longer-term, scalable solutions to consolidate and simplify the notification process and address inevitable market activities such as the resale or relocation of existing PEVs. Consumer outreach, vehicle purchase incentives, PEV service offering, and electricity rates that include low off-peak prices can encourage new PEV buyers to consent to notify their electric utilities before they add PEV charging to the local electricity grid. Utilities should actively participate in a data-driven public infrastructure planning process to help avoid distribution-level impacts of public charging.

STRUCTURE ELECTRICITY PRICES TO ENCOURAGE OFF-PEAK CHARGING. Utilities, regulators, local governments, and consumer representatives are collaborating to develop and demonstrate pricing options, including time-of-use rate structures that convey the supply and demand of electricity. Sharing and clearly communicating pricing information with consumers can reward them with low-cost electricity for off-peak charging. Peak pricing that reflects the real costs of charging during peak demand periods and passes those costs on to station owners or PEV drivers can discourage charging during on-peak hours.

WHEN UPGRADING DISTRIBUTION INFRASTRUCTURE, CONSIDER PEVS. When upgrading or adding distribution infrastructure, utilities, planners, and regulators should consider potential impacts of PEV charging and adopt cost-effective, data-driven measures to support the reliable, safe, and efficient operation of the electricity grid. Infrastructure providers can offer low-cost charging solutions using existing circuits or accommodating 20-, 30-, or 40-amp charging in the home so that consumers can charge at lower power levels, when it is helpful for the grid and appropriate for their needs.

TEPCO DC fast charge station, Vacaville, Calif.

Near-term Impacts of PEV Charging on Electricity Demand? Minimal.

Figure 9 shows a hypothetical electricity demand forecast for a typical summer peak demand day in 2020 with optimal, overnight charging of 1 million PEVs. If 1 million PEVs were to be on California's roads by 2020, not only would it amount to a very successful early market, but charging from those vehicles would account for less than 1% of total electricity demand. If price signals and infrastructure planning ensured the vast majority of PEV charging occurred off peak, PEV charging would not significantly contribute to statewide electricity demand peaks.

PEV charging is expected to increase electricity demand at night, when demand is low, improving utilization of existing and future electricity grid resources, including intermittent renewable resources such as wind.

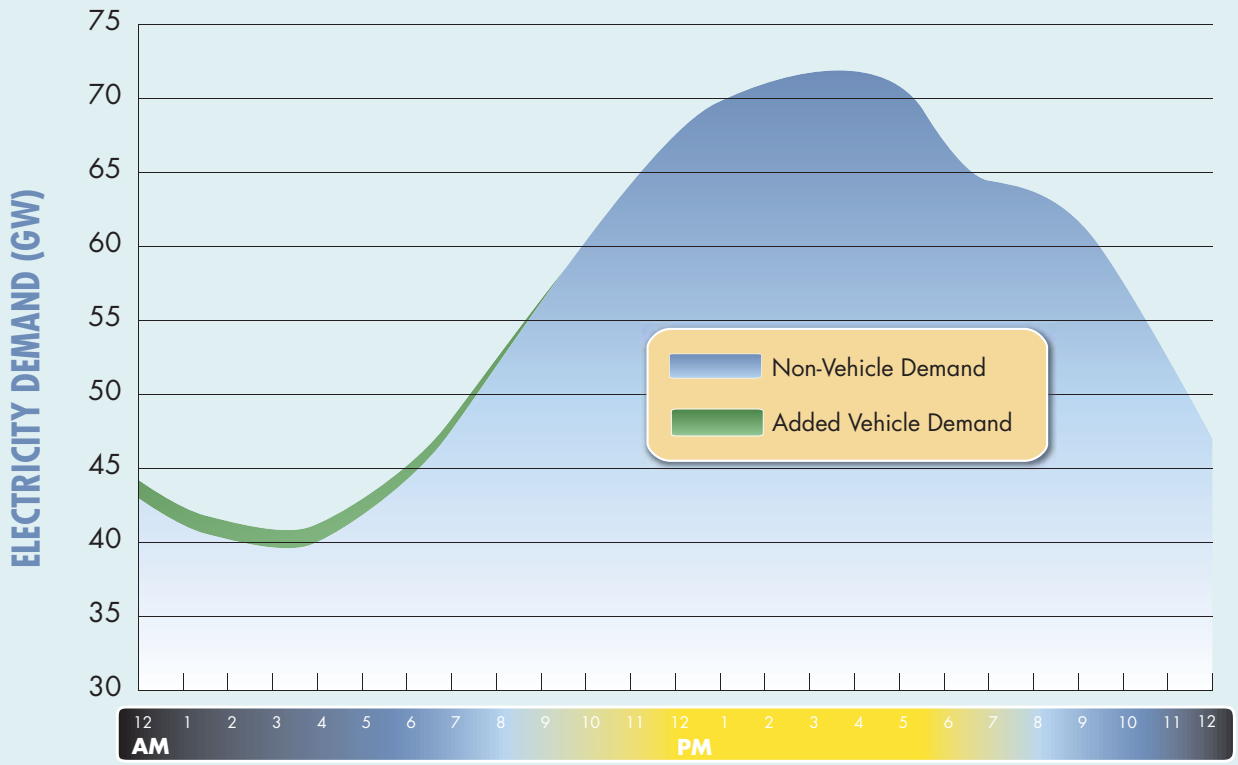

Figure 9. *Hypothetical California summer electricity demand, 2020, with 1 million PEVs charging off peak*

4.6 Maximize Job Creation and Economic Benefit in California

The confluence of California's consumer base, policy efforts, and technology and innovation centers make it a hub of PEV and other clean technology businesses. Similar to the emergence of the high-tech sector and its concentration in California's Silicon Valley, companies supporting PEV markets are clustering in California. Three of the largest PEV charging service providers and three emerging PEV automakers are California companies. By pushing PEV and related markets forward, California can support these growing businesses and attract investment. This investment creates jobs and sustainable economic growth, and gives the state a competitive advantage, which in turn enables it to shape and capitalize on future PEV market opportunities.

CHALLENGES

As this plan is developed, California and global economies are slowly emerging from deep recession, and economic, political, and regulatory uncertainty continues to hinder job growth. California policy, consumers, and voters have sent a clear signal that the state is eager to support PEV markets and related industries, but some market uncertainty persists. The state has a skilled workforce and currently faces high unemployment, but additional workforce training is needed to prepare employees for the burgeoning "green" economy and attract PEV-related manufacturing to the state.

SUGGESTED ACTIONS

PROMOTE JOBS CREATION AND ECONOMIC GROWTH IN CALIFORNIA. California policy should continue to support and encourage innovation and private sector investment in PEV technologies and services. Sustainable job growth in the PEV sector will come largely from industry supply chains, including PEV design and manufacturing; component and subcomponent part design and production; charging infrastructure development, installation, and maintenance; research and software development for smart charging; and supplier services. California businesses, cities, and state agencies should apply for available federal grants and collaborate to bring federal investment into the California economy. Stakeholders should encourage manufacturers to take advantage of existing state incentives. Among those incentives are competitive grants and loans under AB 118 and sales and use tax exemptions on green manufacturing equipment authorized under SB 71. SB 71 specifically targets alternative energy and advanced transportation technology investment that creates new, permanent jobs in California and produces quantifiable reductions in energy use and greenhouse gas and criteria pollutant emissions. Additional funding is available for workforce training through AB 118 and, potentially, through the U.S. Department of Energy's Clean Cities Program.

SUPPORT ONGOING WORKFORCE TRAINING PROGRAMS. Workforce training to support growing PEV markets should be incorporated into current training programs using existing partnerships. Unions have established an apprenticeship program, which can be used to train electricians for installing charging stations and electric circuit upgrades. Other initiatives can be leveraged, as well, such as California's Green Collar Jobs Council or the Center for Energy Workforce Development, a non-profit consortium of electric utilities that works with contractors, educators, and unions to train and place workers in the industry. Partnerships with junior colleges and vocational schools will be crucial to train and certify electrical contractors, mechanics, and others to support the PEV market in California.

LEVERAGE CALIFORNIA'S ACADEMIC INSTITUTIONS TO EXPAND DEGREE AND RESEARCH PROGRAMS. Sustainable job growth comes from a healthy business ecosystem, which is intertwined with intellectual capital at universities, colleges, and vocational schools. California's academic institutions provide an educated workforce that is prepared to support this nascent industry. For example, San Francisco City College offers three courses on PEV technology and repair. In turn, the growing industry supports research and education at the state's academic institutions. Increasingly, collaborations among public, private, and academic research programs cluster and share resources to support technology development.

Plug-in Electric Vehicles Revive Former NUMMI Facility

The former New United Motor Manufacturing, Inc. (NUMMI) plant in Fremont, Calif. is the only automobile manufacturing facility on the west coast. The first joint venture between General Motors and Toyota, the plant rolled off thousands of Chevrolet Novas, Geo Prisms, Pontiac Vibes and Toyota Corollas and Tacomas between its 1984 opening and April 2010 closing.

In October 2010, Tesla Motors, a California company and new entrant in the automotive marketplace, purchased and reopened the Fremont facility. This time, the plant will produce PEVs, which will be sold in the state and elsewhere. Several automakers have invested in Tesla, exchanging knowledge of battery technology and automotive production. Tesla leveraged California's SB 71 tax exemption and will produce its second-generation vehicle, the Model S PEV, at the revived facility. Tesla's effort could create more than 1,000 green jobs in California.

California Senator Dianne Feinstein greets Tesla CEO Elon Musk at the re-opening of the former NUMMI plant, October 2010

California Attracts Innovative Regional PEV Programs

Two large programs exemplify the commitment to PEVs in California and successful partnerships among stakeholders. These collaborations support California businesses and job growth, along with the growing PEV marketplace in the state.

In October 2010, the Bay Area Metropolitan Transportation Commission (MTC) awarded $14 million in PEV grants, including $7 million to build the first battery switching PEV network in the region. The funds enable Better Place, with many regional partners, to deploy four battery switching stations and 61 battery switchable PEV taxis in San Francisco and San Jose.

Successful partnerships in San Diego led Nissan to choose the city as a launch market for 1,000 Nissan LEAF PEVs in 2011. ECOtality is developing charging infrastructure in the region to support the rollout, co-funded by the U.S. Department of Energy and the California Energy Commission. San Diego Gas and Electric, the San Diego Association of Governments (SANDAG), and the UC Davis Plug-in Hybrid and Electric Vehicle Research Center are also partnering on the project. A similar partnership has developed for Los Angeles, and will involve an additional 1,000 Nissan LEAFs and 1,000 Chevrolet VOLTs from General Motors.

Tesla is building and supplying the battery, as well as other related parts, for the 2012 Toyota RAV4-EV

4.7 Reinforce California Policy Leadership to Guide Plug-In Electric Vehicle Markets

The potential for PEVs to dramatically reduce petroleum use and emissions is clear and justifies significant investment and consumer outreach. Every mile traveled in a PEV and fueled by the electricity grid in California improves air quality and public health, mitigates climate change effects, reduces petroleum consumption, and increases energy and economic security. As the PEV market matures, California can continue providing policy leadership to shape it in such a way as to maintain grid reliability and ensure that these energy and environmental benefits fully materialize. As it has done before, California policy can guide the transition to PEVs and provide an example for the country and world to follow.

As it has done before, California policy can guide the transition to PEVs and provide an example for the country and world to follow.

CHALLENGES

Existing California policies provide a foundation for reducing petroleum consumption and emissions from the transportation sector. These policies have helped advance the PEV market to its current stage. Going forward, California policy will have to adapt to changing PEV market conditions while staying focused on the desired outcomes in order to provide a model for others to follow.

Ongoing challenges face the transportation sector over the long term, as well. Already, the federal Highway Trust Fund, which finances highway maintenance and new transportation infrastructure projects with fuel taxes, is underfunded. As conventional cars continue to become more efficient and PEVs enter the product mix, a more robust revenue-generating solution will be needed. California must also continue to reduce life-cycle greenhouse gas emissions from passenger vehicles, the electricity grid, and all other sources if it hopes to meet its 80% greenhouse gas emission reduction targets by 2050. Achieving long-term greenhouse gas emission reduction targets will take a transformational, shared effort from businesses, consumers, and policymakers in California and throughout the world.

State Capitol, Sacramento, Calif.

SUGGESTED ACTIONS

DEVELOP AN ACTION PLAN FOR RELEVANT STATE AGENCIES TO PREPARE FOR PEVS. More work is needed to ready state agencies for their role in PEV commercialization. Agencies such as the Division of Measurements and Standards, Department of Insurance, State Treasurer, Caltrans, State Fire Marshal, various state building agencies, Department of General Services and many others have a role to play. Similar efforts have occurred for other alternative fuels, and should be repeated for and customized for PEVs. Stakeholders should also prepare state agencies to incorporate PEVs into their ongoing operations.

ADJUST PEV INCENTIVES AS THE MARKET GROWS. As PEV markets develop and total costs of ownership decline, PEV incentives, such as access to carpool lanes or reduced fees or tolls, should eventually sunset. Incentives and sunset levels can be established based on performance-based outcomes, rather than dates, to ensure continual market growth but avoid ongoing subsidy. For example, the federal PEV incentive is based on the number of vehicle sales per manufacturer. Incentives and sunsets should carefully consider impacts on the PEV market and equitable treatment of all Californians.

ADDRESS LONG-TERM ECONOMIC, ENERGY, AND ENVIRONMENTAL ISSUES. California should reinforce its policy leadership and continue to provide a model for others to follow by tackling ongoing, long-term, social issues – especially climate change. Policymakers should ensure that market signals inform consumer choices that lead to continued reductions of greenhouse gas emissions from PEVs and throughout the economy. In anticipation of PEVs becoming mainstream, the state should consider policies that recognize and address increasing integration of the transportation and electricity sectors, so that aggregate solutions may be developed to achieve the state's AB 32 and longer term 2050 climate goals. Ongoing policy leadership should also address financing issues for transportation and other infrastructure. Potential solutions include an increased fuel tax that is expanded to non-petroleum alternatives to set equitable rates for all fuels, fees based on vehicle-miles traveled, or congestion pricing on major roadways.

Climate change threatens California's coast

4.8 Encourage and Coordinate Local and Regional Government Efforts

Local governments operate on the "front lines" of PEV markets – where consumers live and markets form. Pioneering local and regional government action has played a critical role in launching PEV markets. Coordination among local governments can streamline residential charging installations and build useful public charging infrastructure that provides value for PEV drivers and connects communities at minimum public cost. Continued action can bring important benefits to communities, supporting new car buyers and bringing economic activity, jobs, and environmental benefits.

CHALLENGES

Efficient and effective government action requires leadership, education, and resources, all of which benefit from collaboration among public sector leaders. Elected and appointed officials must champion PEV market development and prioritize efforts to support it. Engaging stakeholders at the local level is especially important to ensure community priorities are considered in broader planning. Federal, state, and local leaders need to coordinate planning efforts to meet multiple objectives.

SUGGESTED ACTIONS

COORDINATE, COLLABORATE, AND LEAD. Local governments, regional planning agencies, state and federal agencies, and quasi-government entities such as the U.S. Department of Energy's Clean Cities Program, California League of Cities, or government trade associations, can coordinate to implement many of these recommendations. They should collaborate to develop broad, consistent education and outreach messages and employee training programs, to optimize placement of public charging infrastructure and streamline infrastructure codes, permitting, and installation.

ATTRACT FEDERAL DOLLARS TO LOCAL GOVERNMENTS. State and federal resources are available to support regional and local PEV initiatives and infrastructure programs. State agencies should advertise grant opportunities to local governments, communicate "best practices" for grant applications, and facilitate collaboration among local governments to win federal, state, and air quality management district grant money.

ENSURE LOCAL PRIORITIES ARE MET. Stakeholders, including regional planning agencies, businesses, and local governments, should coordinate to ensure that their local planning priorities incorporate opportunities involving PEVs. For example, PEVs can play a role in strategies to reduce daily commute emissions and can help regions achieve air quality and greenhouse gas emission targets, including those required by SB 375. Regional governments should take a leading role in developing public charging infrastructure strategies.

As California communities grow, policies will be needed to address increased energy consumption and vehicle travel

Local and Regional Governments are Leading the Way

From north to south, local and regional governments in California are *Taking Charge* to ready their communities for PEVs.

Regional air quality management districts (AQMDs) are providing funding for charging stations to support PEVs and improve local air quality. The Bay Area AQMD has allocated $5 million help fund home and public charging stations. These incentives will build upon a previous $1.3 million initiative that helped to install 400 Level 2 charging stations, six DC fast charging stations, and a battery switching station.

San Francisco is working to streamline installations of residential charging stations and demonstrate projects for charging in multi-dwelling units. The city is also working to install more than 100 Level 2 charging stations, place fast charging stations at select locations, and incorporate PEVs into car-sharing programs and taxi fleets, including some that will utilize battery switching (see Section 4.6). Many of these projects are part of the broader Bay Area AQMD infrastructure incentive program.

Sonoma County has built charging infrastructure to support PEVs through the Local Governments Electric Vehicle Partnership. The county aims to convert its government fleets to PEVs and provide charging stations for the public to use. Through grants and direct purchases, the county expects to install 129 charging stations for fleet and public use by mid-2011.

The South Coast AQMD has a history of assisting with clean fuels infrastructure and providing vehicle incentives, including a program completed in 2005 that provided $100,000 to upgrade PEV charging stations. Recently, it committed more than $700,000 to augment California Energy Commission AB 118 funds for developing charging infrastructure in the region. South Coast AQMD has partnered with other stakeholders to seek additional funding and initiate education and outreach workshops.

4.9 Support Fleet Purchases of Plug-In Electric Vehicles

Business and government fleets may provide attractive early markets for PEVs and a critical bridge to commercialization. Fleet managers have close networks that propagate best practices quickly. Targeted efforts could lead to rapid expansion of PEVs in fleets, which could catalyze other PEV markets.

Fleets account for a significant number of light-duty vehicle sales in the United States and a disproportionate share of total vehicle-miles traveled; PEVs in fleets could provide more emissions and energy savings than PEVs in other market segments. Many fleet vehicles travel along regular, fixed routes and are parked at a single location. These vehicle applications might be ideal candidates for PEVs, given their predictable electricity demands, reduced operating costs, and ability to charge overnight in a central location. Charging infrastructure for government fleets can be made available to the public at large, to maximize utilization of publicly funded charging stations.

Incorporating PEVs into fleet operations may also provide valuable outreach opportunities and experience with PEVs for employees and customers. PEVs in business fleets allow companies to market an image of green leadership. Government fleets with PEVs allow civic leaders to lead by example and promote public policy initiatives. Rental fleets with PEVs offer a unique product and expose customers to electric driving. Finally, incorporated into carsharing fleets, PEVs can reach consumers without access to off-street parking or home charging, potentially expanding PEV markets.

CHALLENGES

While representing very promising market segments for PEVs, fleets have unique characteristics that require directed outreach and policy focus. Fleet managers are generally risk-adverse buyers, who operate on tight, fixed budgets. Government fleets are not directly eligible for PEV purchase tax credits, although credits can be passed on to them through Safe Harbor Tax Benefit Transfer Lease agreements and, perhaps, other means. Some fleets must adhere to strict purchase requirements that may not allow for new technologies or vehicles with higher upfront costs.

Ford is targeting fleets for its Transit Connect Electric

SUGGESTED ACTIONS

EDUCATE AND INFORM FLEET OPERATORS AND ORGANIZATION DECISION MAKERS. Through existing fleet networks and communication practices, automakers should inform fleet managers of the benefits, costs, infrastructure needs, maintenance requirements, and operating limitations of PEVs. In addition to the recommendations outlined in Section 4.1, outreach efforts for fleets could include driver and mechanic training workshops, discussion forums to share best practices, and disseminating data and experiences through trade publications. To the extent that executives and other leaders in an organization influence the purchase decisions of fleet managers, outreach efforts should extend beyond the fleet manager to those responsible for promoting a positive, leadership image.

City of Santa Monica RAV4-EVs

DEVELOP TARGETED POLICIES FOR FLEETS. Local government agencies can remove purchase restrictions, including requirements to purchase specific vehicle makes or models based on sticker price or other criteria. California law already requires state fleets to use a comprehensive method of vehicle selection that includes consideration of petroleum consumption and greenhouse gas and criteria pollutant emissions. All fleets should consider following this model. Fleet managers can consider basing purchase decisions on a robust assessment of total costs over the duration of ownership, rather than solely on purchase price. Performance-based budgeting can provide financial incentives for fleets that reduce ongoing costs and contribute to policy goals.

LEVERAGE FLEET PURCHASING POWER. A coordinated effort to orchestrate multi-organization, large-scale PEV purchases or buying cooperatives can reduce capital costs for new vehicles, infrastructure, and other parts. Creative financing mechanisms may be needed to reduce costs and risks for fleet purchases of new vehicles and charging stations. Shared inventory of replacement equipment can help to reduce maintenance costs and PEV downtime.

A PEV Fleet Success Story

For more than 20 years, Southern California Edison has championed the use of PEVs in fleets. The utility leads by example, with the largest private fleet of PEVs in the United States. Its fleet includes 287 PEVs, mostly Toyota RAV4-EV battery electric vehicles, which are assigned to meter readers, field representatives, and security officers. The vehicles have collectively accumulated more than 19.2 million miles and reduced greenhouse gas emissions by more than 10,000 tons, smog-forming pollutants by more than 2,300 tons, and gasoline consumption by more than 963,000 gallons. Southern California Edison's PEV fleet drives 100,000 electric miles each month and has allowed the company to avoid 3,850 oil changes (saving 19,300 quarts of oil), 1,790 smog checks, and over $2 million in fuel costs. Avoiding oil changes and smog checks, alone, have saved the company $197,400.

4.10 Research and Demonstrate Opportunities for Plug-In Electric Vehicles to Support California's Electricity Grid

While California's smart grid, reliability, and renewable energy goals are independent from its PEV efforts, integrating PEVs, other forms of energy storage, and increasing fractions of renewable generation onto the electricity grid may prove synergistic.

Emerging technologies and communications between the grid and PEVs could enable consumers to opt into programs that allow for demand response from PEV charging. Under such scenarios, charge rates could increase or decrease to match intermittent renewable generation and optimize the use of power plants and local electricity distribution systems. These demand response programs, which might allow consumers to charge their PEVs based on utility price and energy availability signals, can provide load predictability, which may help balance intermittent wind generation, optimize the use of thermal power plants, and may have net cost benefits.

Likewise, automotive-grade batteries, in use onboard a PEV or in stationary applications, may represent a significant, flexible load that could potentially help to optimize the use of grid resources. When PEV batteries retire from vehicles, up to 70% of their original storage capacity may remain, and they may be repurposed for stationary storage applications. Developing and proving clear, valuable secondary applications for PEV batteries may help to reduce end-of-life costs, expand the battery markets and reduce production costs, and improve the resale value of PEVs. In turn, PEV lease rates would likely decline, along with lifetime costs of PEV ownership. Though unlikely to fully materialize before *Market Takeoff*, second-use battery applications may also help bring down battery costs for consumers, and benefit the electricity grid and all electric utility customers.

CHALLENGES

The rollout of the smart grid requires standardized development and coordination from all stakeholders, including grid operators, utilities, automakers, PEV charging service providers, and consumers. The shape that the smart grid may take remains unknown. Also unknown are the cost and durability of vehicle batteries, their ability to compete in electricity markets, and the impact that battery second-use applications would have on grid reliability. Appropriate technology, standards, and communication protocols still need to be developed to enable these potential applications. Additional research and initial demonstration projects are needed to establish the case for, and guide, secondary use and life applications for PEV batteries. Many potential markets for secondary use of vehicle batteries will not materialize until the first generation of PEVs begins to retire, perhaps at the end of the decade.

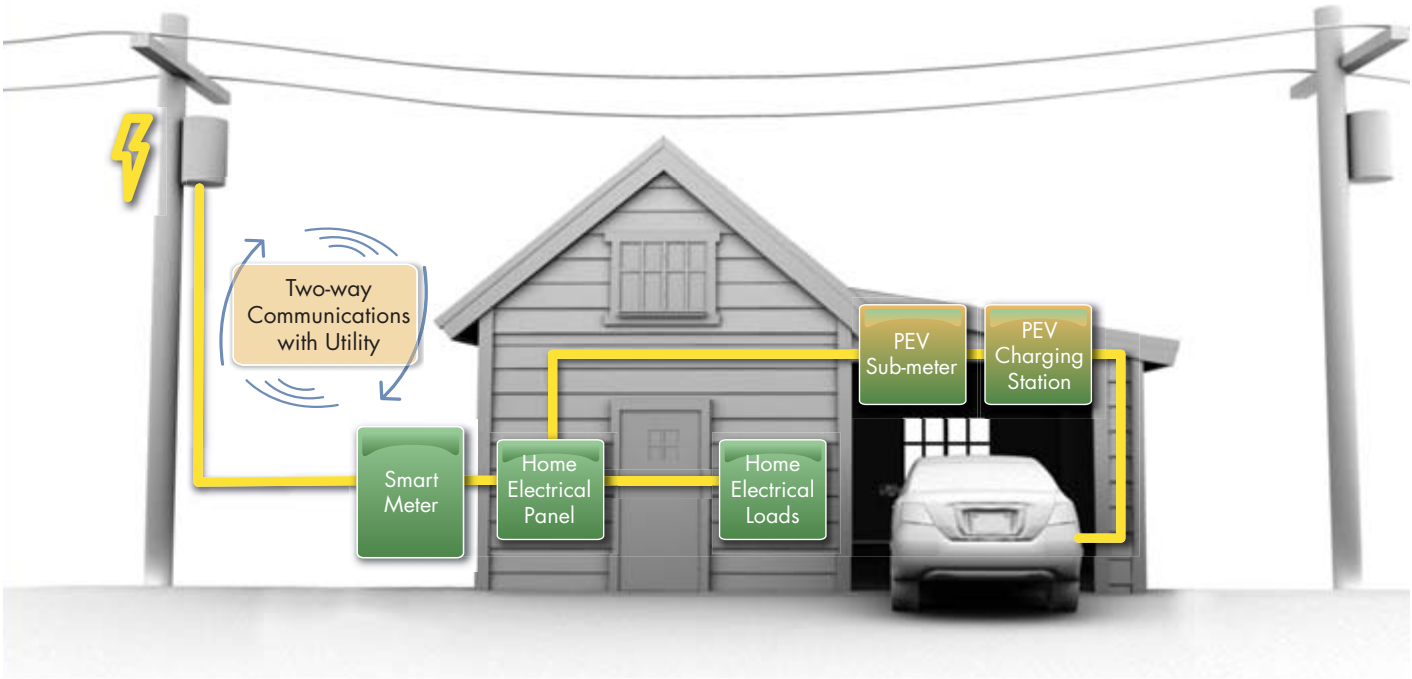

Figure 10. *Connecting PEVs to the home and grid of the future. This illustration shows one of many options for how a PEV might connect to the grid of the future and charge from home. A sub-meter allows the PEV to take advantage of time-of-use electricity rates. Two-way communications between the utility or PEV charging service provider and the resident, which will likely come in the future, is partly enabled by a smart meter. The PEV charging station may be able to respond to price signals from the utility, enabling charging when it is least expensive, most beneficial to the grid, or when it accommodates renewable generation elsewhere.*

SUGGESTED ACTIONS

INVESTIGATE FUTURE OPPORTUNITIES FOR PEV CHARGING TO INCLUDE DEMAND RESPONSE AND CONSUMER CHOICE FOR RENEWABLES. Incorporating payment, pricing, communications, and other controls into residential and public charging stations may help integrate PEV charging into the future electricity grid. The future grid could enable PEV charging to balance demand elsewhere or match the intermittent pattern of renewable generation, so consumers could choose to charge their PEV when excess generation is available or when renewables, such as off-peak wind power, are most abundant. Utilities, grid operators, and PEV charging service providers can work together to develop technology standards, protocols, and pilot programs that use cost-effective strategies to allow charging to respond to price signals and grid conditions.

TEST SECONDARY APPLICATIONS FOR PEV BATTERIES. Automakers and other stakeholders should expand collaboration on pilot programs to clarify the value of secondary use for PEV batteries and seek federal and state funding for demonstration projects.

Following Up

5. Following Up: Ensuring Plug-In Electric Vehicle Market Growth Continues and Benefits Accrue in California

Continued collaboration will help maintain momentum of the plug-in electric vehicle market in California.

The PEV Collaborative can help implement these recommendations and actions, while monitoring and communicating progress towards achieving the goals outlined in this plan. To keep the plan updated and relevant, the recommendations should be periodically reviewed, assessed, and adjusted for relevance and efficacy as the PEV market advances. Success of the PEV Collaborative and this plan can be measured by the extent to which progress is made toward these goals. Success will also be measured by the extent to which they enable actions and follow-through, analysis of critical questions, and adaptability among stakeholders and in the market.

The dialogue fostered by the creation of the PEV Collaborative and development of this plan has already facilitated cooperation and coordination among stakeholders. Their enthusiasm to address identified challenges demonstrates a shared commitment to building and supporting a robust PEV market in California. During the six months that this plan has been under development, several stakeholder initiatives have already begun to address high-priority suggested actions, such as utility notification procedures and streamlining of the home charging infrastructure installation process.

The PEV Collaborative will continue to convene stakeholders, coordinate, and support such initiatives. The following are examples of suggested actions that would benefit from near-term collaborative efforts:

- Analyzing public charging use to help government agencies plan for growth
- Communicating best practices among local governments
- Developing a comprehensive public education program with many facets
- Maintaining an information clearinghouse for PEV consumers and interested parties
- Promoting common charging and installation protocols for single and multi-dwelling residential units and workplaces
- Sharing the California plan with other state, national, and international jurisdictions

By continuing to facilitate coordination among stakeholders to address ongoing market challenges, the PEV Collaborative and this plan can work to ensure that California remains a leader in the PEV marketplace, and provides a leading example for others to follow.

References

6. References

References are listed in the order that they are used in the text. For a list of additional reports, web resources, and a summary of ongoing activities in PEV markets, please visit www.pevcollaborative.org.

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