CENTER FOR CLIMATE AND ENERGY SOLUTIONS

An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid

Final Report by the PEV Dialogue Group convened by the Center for Climate and Energy Solutions

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An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid

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The PEV Dialogue Group

The PEV Dialogue Group convened by the Center for Climate and Energy Solutions developed this plan collaboratively. Each group member participated by providing valuable input that was instrumental in shaping the Action Plan. The Plan's recommendations reflect the input from the group as a whole, not necessarily those of individual organizations.The participants will continue their collaboration in Phase II of the PEV Deployment Initiative, focusing on Action Plan implementation.

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Executive Summary

Americans purchased almost 18,000 plug-in electric vehicles (PEVs) in 2011, a strong first year for these transformative vehicles. Recently, private industry and government have invested valuable resources in developing, promoting, and deploying PEVs. These vehicles offer an uncommon opportunity to address energy security, air quality, climate change, and economic growth. However, market growth is uncertain due to policy, economic, and technical challenges, and other advanced vehicle technology may prove more popular with consumers over time. There are steps that can be taken now, however, to meet some of these challenges and ease adoption of PEVs nationwide. In *An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid*, the PEV Dialogue Group lays out some of these critical steps needed to enable a robust national PEV market.

With PEVs' important opportunities and challenges in mind, the Center for Climate and Energy Solutions (C2ES) convened the PEV Dialogue Group – a unique, diverse set of stakeholders composed of leaders from the public and private sectors along with non-governmental organizations. The Group developed an Action Plan to fill gaps in the existing work on PEVs using a consensus process that aimed to optimize public and private investments and avoided favoring certain PEV technology.

> *C2ES convened the PEV Dialogue Group in early 2011 to create an Action Plan that identifies many of the steps that would be necessary to integrate PEVs with the electrical grid nationwide.*

The Group believes PEVs could be an important part of the vehicle market in the United States and worldwide if they are given a fair chance to compete with conventional vehicles. The Group identified a series of market-based actions for all stakeholders that foster innovation, minimize public cost, educate consumers, and maintain electrical grid reliability.

The Group began by identifying key challenges and objectives that existing PEV efforts have not addressed adequately, such as integrating PEVs with the electrical grid. The Group did not focus on reducing vehicle upfront cost directly, since federal and state tax credits are already in place. The Group then held a series of face-to-face meetings to hash out the details of the Action Plan over the course of one year. The plan represents a unique and valuable contribution to the national conversation on PEVs by identifying practical steps that policymakers, regulators, local and state officials, private market participants, and others should consider as PEVs become more broadly available in the coming years.

The plan recommends specific actions in four categories summarized below:

1. **Create a Consistent Regulatory Framework Nationwide**: Regulations by state public utility commissions that are compatible across the countrycan help foster innovation and increase the PEV value proposition while also maintaining the reliability of the electrical grid.
2. **Optimize Public and Private Investments in Charging Infrastructure**: There are opportunities to accelerate private investment, encouraging innovative business models while also acknowledging that PEVs warrant some public investment in charging infrastructure.

3. **Facilitate PEV Rollout**: Connecting stakeholders to provide a satisfactory PEV and electric vehicle supply equipment (EVSE) purchase and home EVSE installation is a necessary step to seal the deal once a consumer commits to purchasing a PEV.
4. **Educate Consumers**: Explaining the PEV value proposition and bridging the consumer information gap about PEV technology can be accomplished through a combination of cutting-edge online resources and traditional touch-and-feel experiences.

The Action Plan represents Phase I of a larger initiative to pave the way for PEV adoption nationwide by helping level the playing field. Phase II aims to work with stakeholders “on the ground” to go about implementing the Action Plan with leaders across the country.

Figure ES-1 below provides an overview of the Action Plan, which is fleshed out in great detail in the body of the report. Next to each action component are a number of individual actions or the principles for the individual actions. Many activities for these actions can occur concurrently. Businesses, electric utilities, government, and non-governmental organizations (NGOs) will all play a role in each action component.

Action Plan Overview

Figure ES-1. Action Plan Overview.

Create a Consistent Regulatory Framework Nationwide

- 4 Principles of Utility Regulation
  - Protect the reliability of the grid
  - Minimize cost to the electricity distribution system
  - Encourage transportation electrification
  - Provide consistent treatment between PEVs and loads with comparable power requirements within each rate class
- Focus Areas for Regulatory Action (utility and other)
  - Residential & commercial EVSE installation
  - Residential & commercial electricity rate structure
  - Transportation infrastructure finance
  - Vehicle charging standards
  - Protecting consumer privacy

Optimize Public & Private Investments of Charging Infrastructure Regarding Location, Amount, & Type

- Assess PEV suitability based on consumer interest, gasoline & electricity prices, existing regulatory environment, local government & utility involvement, area geography, travel patterns, & expected environmental & economic benefits
- Estimate charging equipment & infrastructure needs based on consumer interest & travel patterns
- Estimate extent of public investment in EVSE based on consumer interest, private sector investments, & state/local government policy

Facilitate PEV Rollout

- Expedite EVSE home installation process
- Cooperatively remove local and state market barriers for PEV service providers

Educate Consumers

- Develop consumer web platform and other materials to understand PEV value proposition
  - Help consumers understand total cost of ownership (e.g., fuel & maintenance cost)
  - Estimate a broad set of benefits (e.g., fuel price certainty, environmental &energy security benefits)
- Close PEV technology information gap

The Action Plan divides the stakeholders into four categories – NGOs, Government, Electric Utilities, and Other Businesses. Specific actions the plan identifies vary as to which players are needed. The plan includes more detail on roles and responsibilities.

Create a Consistent Regulatory Framework Nationwide

- **Residential &Commercial EVSE Installation**: Stakeholders should jointly create a competitive and innovative market for residential and commercial PEV charging services. Decisions by Public Utility Commissions (PUCs), local government, and PEV service providers regarding household EVSE installation should streamline the installation process. Regulations should reflect the local characteristics of markets, potential PEV users, PEV service providers, and electric utilities.
- **Residential &Commercial Electricity Rate Structure**: Stakeholders should work together to identify electricity rate structures that maintain the reliability of the electrical grid and reward households for charging PEVs at off-peak hours. Rate structures should offer households choices,including options that better reflect the cost of electricity generation.
- **Transportation Infrastructure Finance**: Stakeholders should work together to determine how PEV owners can pay their fair share of transportation infrastructure maintenance. Permanent or temporary methods should be implemented in a way that does not affect PEV market growth before PEVs have a noticeable impact on tax revenue for a state.
- **Vehicle Charging Standards**: Voluntary standards bodies should work together, with the assistance of stakeholders, to develop vehicle charging standards and best practices related to the vehicle charging connector, PEV interconnection and communication with the electrical grid, and EVSE installation.
- **Protecting Consumer Privacy**: Stakeholders should ensure that individual identity is impossible to glean from data collected from EVSE and vehiclesreleased to NGOs, government, and other researchers while also maintaining the usefulness of these data for researchers.

Optimize Public and Private Investments in Charging Infrastructure

- **Assess PEV Feasibility**: Stakeholders should cooperatively develop a method to assessthe suitability of deploying PEVs in a geographic area and share this information with area governments.
- **Estimate Charging Equipment and Infrastructure Needs:** Stakeholders should collaborate to estimate charging equipment and infrastructure needs in a geographic area based on the expected PEVs in an area, travel patterns, and area geography.
- **Estimate the Extent of Public Investment in EVSE**: Stakeholders should work together to estimate the amount of public investment in an area that is appropriate to overcome existing market deficiencies.

Facilitate PEV Rollout

- **Expedite EVSE Home Installation**: Stakeholders should design an expedited EVSE home installation process. A locality can speed up permitting and inspection processes to reduce overall installation time. Localities can also promote training, best practices as identified by early-action cities, and guidelines for electrical contractors. PUCs and electric utilities should provide assistance when creating this process to ensure regulatory compliance. Steps should also be taken to encourage utility notification about EVSE installation.

- **Remove Market Barriers for EVSE Service Providers**: Stakeholders should cooperatively remove local and state market barriers for PEV service providers. Legal and regulatory hurdles that prevent a PEV service provider from competing in an area could exist. PEV service providers should identify local and state barriers that prevent them from introducing their product in a market. They should work together with automakers, PUCs, and local and state government to clear those barriers and facilitate new market introduction. Local and state government should encourage the training of inspectors and electrical contractors on all aspects of EVSE installation. Face-to-face meetings between PEV service provider representatives and government officials can begin this process.

Educate Consumers

- **Create Tools to Help Consumers Understand PEV Value Proposition**: The value proposition PEVs provide includes tangible operational cost savings such as lower fuel and maintenance costs throughout the vehicle's lifetime. In the short term, however, consumers may find non-financial benefits more valuable, like the driving experience or the statement driving a PEV conveys. Since consumers attain most of their information about vehicles online, stakeholders should cooperate on unbiased web tools that accurately communicate the PEV value proposition.
- **Close the PEV Technology Information Gap**:The focus of an effort to close the technology information gap should be to increase PEV publicity, develop web tools on PEV technology, and improve stakeholder outreach. Stakeholders should develop engaging and sophisticated web tools to educate consumers about the difference between PEVs, other alternative vehicles, and conventional vehicles. While consumers obtain most of their information about vehicles online, there is no replacing test drives and other valuable hands-on experiences.

Consumers will ultimately decide whether PEVs will succeed or not in the vehicle marketplace. The inaugural year indicates there is strong consumer interest, but the number of early adopters and the ability of PEVs to reach the mainstream consumer are still uncertain. The benefits PEVs provide warrant action by relevant stakeholders to level the playing field in order to provide a fair chance for these vehicles to compete with conventional vehicles. Implementing the steps laid out in the PEV Dialogue Group's Action Plan will enable a more viable transition to a nationwide PEV market.

1 Introduction

Plug-in electric vehicles (PEVs) offer a rare opportunity to save oil, and thereby address four top policy concerns in the United States today: energy security, air quality, climate change, and economic growth.Although the efficiency of and emissions from new conventional vehicles are expected to improve significantly in coming years, the U.S. passenger vehicle fleet still accounts for more than 40 percent of U.S. oil demand, emits 16 percent of U.S. greenhouse gas emissions, and continues to be a major contributor to local air quality problems. Meanwhile, the U.S. economy faces serious global and domestic challenges, including an uncertain environment of volatile oil prices. PEVs can help mitigate these problems and have sparked the interest of government, electric utilities, businesses, and consumers nationwide.

The Action Plan focuses on the steps necessary to integrate PEVs with the U.S. electrical grid using market-based solutions that foster innovation, minimize public cost, and maintain grid reliability.

PEVs are the latest alternative vehicle mass-produced by automakers in the ongoing advancement of passenger vehicles in the United States. Over the next two to three years, all major automakers – and some startups – intend to put PEVs on the road. These vehicles include battery electric vehicles (BEVs) powered only by electricity stored in batteries.PEVs also include battery-powered vehicles with extended-range capability typically leveraging a gasoline system (referred to as extended-range EVs, or EREVs), and plug-in hybrid electric vehicles (PHEVs), which enhance gasoline vehicles with a plug-in battery system. As of January 2012, Americans had purchased almost 18,000 PEVs (over 7,600 Chevrolet Volts, 9,600 Nissans LEAFs, and 350 Smart EDs). By the end of 2012, many new additional passenger PEVs will be available including the Toyota Prius Plug-in Hybrid, Ford Focus EV, Mitsubishi i, Coda Sedan, and Tesla Model S.

To capitalize on this opportunity, the Center for Climate and Energy Solutions (C2ES)[1] convened a broad and diverse stakeholder dialogue in the beginning of 2011 to develop *AnAction Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid*. The PEV Dialogue Group includes known leaders from all levels of government, the private sector, and non-governmental organizations (NGOs).This national-level assessment brings the best information and experience to bear on integrating PEVs with the electrical grid, relying on the lessons learned from active groups working together on PEV deployment at the local and state level. The aim of the Action Plan is to identify steps that would accelerate the adoption of PEVs nationwide by overcoming challenges to PEV integration with the electrical grid. The plan is not a technical specification for physically integrating PEVs with the grid. Nor is the plan a comprehensive document that looks at every aspect of the PEV market (e.g., methods to reduce the upfront cost of the vehicle). Instead, it identifies actions that would foster PEV market growth in the area of state-level regulations, public and private investments in charging infrastructure, PEV rollout, and consumer education. The Group focused on these areas because existing efforts have not addressed these challenges adequately.

To construct the plan, the Group used a **consensusprocess** that identified the intersection of stakeholder ideas and objectives. The Group also sought to **optimize private and public investments** in vehicle charging infrastructure including residential and non-residential charging. Lastly, the Group **avoided favoring certain PEV technology**, such as BEVs over PHEVs.[2]

TheAction Plan addresses the roles of various government players, NGOs,electric utilities, and other businesses, lays out a timeline for critical steps, and describes an adaptive strategy that takes into account lessons learned.

C2ES authored two papers to inform the Group during development of the Action Plan:

- **Plug-in Electric Vehicles Market: State of Play**:Identifies and explains (1) challenges of nationwide commercial PEV deployment (2) public policies in place to support PEV deployment, (3) PEV market forecasts, and (4) current PEV deployment.
- **Plug-in Electric Vehicles: Literature Review**: Summarizes (1) key externalities that PEVs might address; (2) issues related to PEVs, the electric power system, and the vehicle market; and (3) public policy options.

The Group relied on these papers, outside experts, as well as extensive input from dialogue participants including in-person meetings, to develop the details of the Action Plan. In formulating the plan, the Group considered the opportunities PEVs provide including those related to energy security, local air quality, global climate change, and the economy.

The solutions outlined in the Action Plan contain interdependencies requiring action by all stakeholders (see Figure ES-1). For instance, automakers can influence consumer interest in PEVs based on the volume of vehicles they plan to make available in a geographic area, and vice versa. Also, the amount of public investment needed for charging infrastructure depends on the degree of consumer interest in PEVs, the type of PEVs (BEVs, EREVs, or PHEVs), and PEV drivers' use patterns.

It is possible that hundreds of thousands of Americans will begin driving PEVs in the next several years. President Obama has set a national goal to deploy one million of these vehicles by 2015. Ensuring successful early adoption will involve overcoming initially higher vehicle purchase costs and ensuring there is adequate infrastructure. Success for PEVs will ultimately mean reaching mainstream consumers, and to do that, action is necessary on a number of fronts.

Thus far, PEV pilot projects across the United States, enabled through public-private partnerships, have been critical in the early stages of the PEV market. The continuation and expansion of these partnerships is needed to reach markets beyond early adopters. In doing so, applying best practices and lessons learned from these efforts is critical. However, new projects of the same scale will likely require a much larger share of private capital considering the current fiscal environment. Given that PEV deployment including electric vehicle supply equipment (EVSE)[3] must ultimately occur through markets and private enterprise, stakeholders must seek and develop viable models that can stand on their own, though public investment remains a crucial catalyst in early-stage adoption.

Soon consumers will have many choices of PEVs to purchase – including PHEVs, EREVs, and BEVs. This increase in choice is good for both businesses and consumers, though PEV market growth is uncertain.Getting the market beyond early adopters depends on the successful implementation of the elements contained in the Action Plan. It requires action by both public and private players. The number of public entities relevant for PEV sales is unprecedented in personal transportation; and no individual private company by itself can provide the electricity and support services PEV owners need. Thus, numerous public and private entities must work together to facilitate the rollout of PEVs.

2 Opportunities and Challenges of PEVs

The PEV Dialogue Group believes increasing the use of PEVs provides an opportunity to alleviate several major problems currently facing the United States. Yet, PEVs face many challenges to reaching the mass market, including the integration of these vehicles with the U.S. electrical grid. The Group developed the Action Plan to address challenges related to vehicle and grid integration that other efforts are not tackling sufficiently.

2.1 PEV Opportunities

PEVs present a transformative opportunity for the transportation sector. Since the 1930s, the gasoline-powered internal combustion engine (ICE) has dominated the U.S. vehicle market and much room exists for efficiency improvements with today's conventional vehicles. Because of new and forthcoming fuel economy standards, ICE vehicles will likely achieve many of these gains and remain a substantial part of the U.S. passenger vehicle market into the future. Vehicles powered by alternative fuels, on the other hand, have only achieved niche market status, and it is clear that conventional vehicles will continue to be tough competition. Although they face significant hurdles (see *Section2.2*), PEVs can help address four critical issues facing the United States today. Importantly, other alternative vehicles along with improvements in conventional vehicles can also help address these same issues to different degrees.

1. ***Energy Security***

   Problem Description:U.S. energy security refers to the adequacy and resiliency of the energy system as it relates to energy production, delivery, and consumption. The U.S. transportation sector relies on a global oil market dominated by an oligopoly – the Organization of the Petroleum Exporting Countries (OPEC) – as well as national oil companies more generally. OPEC's ability to constrain supplies results in oil prices higher than a competitive market would produce. Monopoly power, combined with oil price shocks (see *Appendix B*), mean that the U.S. economy loses hundreds of billions of dollars per year in productivity. Researchers at the Oak Ridge National Laboratory estimate the combined total of these costs has reached more than $5 trillion ($2008) since 1970.[4]Moreover, most experts believe that rising demand in emerging market economies coupled with supply-side challenges can be expected to lead to future volatility in oil prices, which is highly damaging for U.S. consumers and businesses.

   PEVs' Effect on Energy Security: PEVs can run on electricity, which in the United States does not rely on oil but rather a diverse set of almost entirely domestic energy sources.[5] Even when PEVs use gasoline (i.e., in EREVs and PHEVs), they use it sparingly and can accommodate many vehicle trips on only electricity.While data is lacking on the distribution of the length of individual car trips, the average car trip length in the United States is 9.34 miles, within the range of most PEVs.[6]

2. ***Local Air Quality***

   Problem Description: Smog and other vehicle-related air pollutants continue to harm human health in urban areas throughout the United States. Motor vehicles are currently responsible for one-half of smog-forming air pollutants and about 75 percent of carbon monoxide emissions, though tougher standards are continuing to improve the effects of conventional vehicles on air quality.[7]

PEVs'Effect on Local Air Quality: Already, efforts by the U.S. Environmental Protection Agency (EPA) and others in implementing the Clean Air Act, including vehicle emission standards, have mitigated health problems and saved millions of lives since 1970.[8] PEVs would further improve air quality, as they have no tailpipe emissions when operating in battery-electric mode. However, PEVs can be responsible for upstream emissions, depending how the electricity they use is generated.

3. ***Global Climate Change***
   Problem Description: Both the U.S. Department of Defense and the National Research Council (NRC) identify global climate change as a serious threat. The NRC indicates "there is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing and that these changes are in large part caused by human activities."[9] Under business as usual, weather pattern changes including drought and heavy rainfall, rising sea levels, and sea ice loss from climate change could seriously diminish economic growth. Climate change also threatens ecosystems and public health.[10] With respect to national security, climate change is one of the key factors that may "spark or exacerbate future conflicts."[11]

   PEVs'Effect on Global Climate Change: Depending on the source of electricity, PEV operation can be responsible for much lower greenhouse gas emissions than nearly all conventional vehicles available today, even after accounting for emissions from electricity generation.[12]

4. ***Economic Growth***
   Problem Description: America's reliance on imported oil leads to a U.S. trade deficit of hundreds of billions of dollars. Electricity for PEVs provides a suitable alternative that is typically less costly per vehicle mile traveled. Furthermore, as the world diversifies away from fossil fuels, the economic opportunity to lead in the clean energy industry is considerable.

   PEVs'Effect on Economic Growth: The United States can lead the world in PEV technology including advanced vehicle batteries and the overall advanced vehicle market, which could stimulate economic growth.Market growth for alternative and fuel-efficient vehicles can help revitalize U.S. manufacturing and herald a new era of American leadership in the automobile industry. While the U.S. economy has struggled to recover fully from the global financial crisis of 2008, clean energy has been one driver of the recovery. The design and manufacture of new vehicles, including PEVs, has already created thousands of jobs in the United States.

The inherent characteristics of PEVs help address all four of these issues. When powered by batteries, PEVs directly emit no greenhouse gas emissions or other harmful air pollutants through the tailpipe, and if the electricity used to charge the batteries is low-emitting, PEVs' upstream emissions are low as well.

In battery mode, PEVs also consume no oil. In 2009, about two-thirds of all passenger vehicles purchased in the United States were manufactured in North America,[13] and most PEVs sold in the near term are expected to be manufactured in the United States.[14]

2.2 PEV Challenges and Action Plan Objectives

PEV deployment faces many challenges, the largest of which is arguably the vehicles' high upfront cost compared to conventional vehicles. There are many existing policies designed to support PEVs including a $7,500 federal tax credit, which is a critical policy for PEVs to reach beyond early adopters. Several organizations are providing information to the private sector, government, and the public on how to address these challenges. Below are some notable examples:

- **California Plug-in Electric Vehicle Collaborative**: A public-private effort to stimulate the PEV market in California including the creation of an action plan.[15]
- **Rocky Mountain Institute's Project Get Ready**: Initiative targeted at municipalities intended to identify steps to achieve PEV "readiness" and publicize ongoing deployment activities.[16]
- **The Electric Drive Transportation Association's *GoElectricDrive.com***: A hub for information on owning and operating PEVs covering a wide range of topics for consumers.[17]
- **Advanced Energy's Community Planning Guide**: Introduction to PEVs along with a step-by-step guide to support PEV deployment, targeted at municipalities.[18]
- **Electrification Coalition**: A nonpartisan business-led group that promotes policies and actions that will accelerate PEV adoption.[19]
- **The U.S. Department of Energy's (DOE) Vehicle Technologies Program Alternative Fuels and Advanced Vehicle Data Center (AFDC) and FuelEconomy.gov websites**: Sponsored by DOE's Clean Cities program and EPA and produced by the National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory, these websites are comprehensive online resources for transportation-related information and tools regarding PEVs. The websites help consumers and fleets learn about petroleum reduction technologies.[20]
- **Edison Electric Institute's (EEI) Utility Guide to PEV Readiness**: EEI created a road map to support PEVs aimed at electric utilities.[21]

These and other ongoing projects are accelerating PEV deployment, but knowledge gaps in various crucial focus areas remain. The rollout of PEVs is still in the early stages and this is a key learning period for all stakeholders involved. Judgments before sufficient data is available could lead to unintended consequences. Actions are possible now, however, that will help lay the foundation for stakeholders to develop and adopt best practices. To avoid duplication, the PEV Dialogue Group identified challenges to accelerating PEV adoption nationwide that other efforts are not addressing adequately. The Group laid out the following objectives for the Action Plan:

- **Harmonize regulatory action related to electricity distribution**: There is a lack of national compatibility in the state and local regulatory environment for PEVs and PEV infrastructure.[22] Few jurisdictions have determined how they will manage PEV user demand for electricity and how the market for charging infrastructure will be regulated. Furthermore, there is a lack of action in many states. Regulators generally do not take action until consumers increase or alter their demand for electricity.

- **Determine if existing rules and regulations for use of and payment for infrastructure need revision**: While many existing rules and regulations for use of and payment for infrastructure (e.g., roads and electricity transmission and distribution) are favorable towards PEVs, others could create additionalchallenges to adding infrastructure (e.g., PEV-specific rules regarding additional electric loads).
- **Accelerate sustainable private sector investment in charging infrastructure**: Sustainable and significant private sector investment is critical to mass adoption of PEVs. Understanding the level of interest in PEVs as well as driving and charging behavior are critical missing pieces needed to create an environment that encourages PEV adoption and private sector investment.
- **Balance efficiency and equity**: It is unclear where public investment is most needed to accelerate and maintain a PEV market. For example, funding for public charging infrastructure[23] may be helpful in some circumstances but not in others. Equity issues could arise if the public perceives the distribution of investments favors relatively wealthy early adopters.
- **Define vehicle and fuel purchase process**: There is a lack of information regarding the process of purchasing a PEV and the electricity to recharge it in many geographic areas. This may include installing a home EVSE, notifying the local utility, taking advantage of off-peak electricity rates, and accessing available financial and non-financial incentives.
- **Define value proposition**: The significant upfront cost, largely due to expensive battery systems, deters consumers from considering a PEV. The value proposition of PEVs is unclear to many consumers. For instance, most consumers do not consider fuel savings over the life of the vehicle when making a purchase.
- **Bridge technology information gap**: Many consumers do not adequately understand PEV technology, and the extent to which different vehicle and fueling technologies can accommodate their current lifestyles. This includes inadequate understanding of the differences between BEVs, EREVs, PHEVs, and regular hybrid electric vehicles.

The objectives identified above are the focus areas of the Action Plan. Actions within the plan can address single or multiple challenges related to these objectives, and require action by one or more stakeholders. In addition, the plan lays out next steps since some actionsrequire future work to complete due to time constraints or lack of available information.

2.3 How the Action Plan Addresses PEV Challenges

The Group developed the Action Plan to accomplish the objectives laid out above using a consensus-driven process that was technology neutral (i.e., between BEVs, EREVs, and PHEVs). Each stakeholder will need to take action over a sustained period to successfully implement the plan and accelerate the adoption of PEVs nationwide. The Group organized the objectives identified into four solution categories as it devised the Action Plan: regulatory environment, public and private investments, PEV rollout, and consumer education. The table below summarizes the challenges identified by the Group along with actions intended to overcome or diminish those challenges.

Table 1: Objectives and Action Plan Summary.

Objective Category	Objective	Expected Leaders	Action
Regulatory Environment	Harmonize regulatory action	Electric Utilities, Other Businesses, Government, NGOs	Create a consistent regulatory framework nationwide that protects the reliability of the grid, minimizes cost to the electricity distribution system, encourages transportation electrification, andprovide consistent treatment between PEVs and loads with comparable power requirements within each rate class. Assess a broad set of existing models to use and pay for infrastructure, share knowledge, and identify best practices.
	Determine if existing rules and regulations for use of and payment for infrastructure need revision	Electric Utilities, Other Businesses, Government, NGOs	
Public and Private Investments	Accelerate sustainable private sector investment in charging infrastructure	Businesses, NGOs	Assess PEV suitability; estimate charging equipment &infrastructure needs; estimate the extent of public investment in EVSE needed
	Balance efficiency and equity	Government, Electric Utilities, NGOs	
PEV Roll-out	Define vehicle and fuel purchase process	Electric Utilities, Other Businesses, Government, NGOs	Work with all relevant public and private players to facilitate the introduction of PEVs in a geographic area
Consumer Education	Explain value proposition	Electric Utilities, Other Businesses, NGOs	Provide consumer web tools that educate consumers on the value proposition of PEVs including the total cost of ownership (TCO) compared to other vehicles
	Bridge technology information gap	Electric Utilities, Other Businesses, Government	Increase PEV publicity and customer knowledge of PEV technology through online tools, increased publicity, and enhanced stakeholder collaboration

3 Creating a Consistent Regulatory Framework Nationwide

With different pilot programs and varying incentives for PEV and charging infrastructure deployment across the United States, there is inadequate harmonization between regions developing regulations that affect PEV deployment, such as those related to electricity distribution. While progress and experimentation at the state and local level are critical to PEV market growth, without consistency, markets may develop more unevenly than they would otherwise or set precedents that will harm overall PEV deployment.

> ***"As regulators, policymakers, and the PEV industry implement policies, the Group advocates developing best practices and using accepted common standardsto guide governments and industry."***
>
> ***– PEV Dialogue Group***

This chapter first discusses the regulatory issues and then how the Action Plan addresses them. The Action Plan includes detailed actions that will lead to a consistent regulatory framework nationwide guided by best practices and accepted common standards.[24]

3.1 Regulatory Issues

The PEV Dialogue Group developed recommendations for actions to accomplish the following two regulatory objectives for PEV deployment:

- **Harmonize regulatory action related to electricity distribution**
- **Determine if existing rules and regulations for use of and payment for infrastructure need revision**

The Group focused mostly on regulatory issues related to the electricity distribution system including EVSE installation requirements and electricity rate structures for residential and commercial EVSE. In particular, the Group considered whether PEV-specific rules and regulations are necessary since existing regulations already address some EVSE installation issues. The Group also identified and addressed key regulatory problems related to vehicle charging standards,[25] protecting consumer privacy, and maintenance of the transportation system. The Group differentiated some actions based on early and mainstream PEV adopters.Regulatory issues related to safety were not the specific focus of this Group, although the Group recognizes that safety– both of the vehicle and the charging equipment—can have an important impact on PEV deployment.

The Group focused on a series of key questions to develop the framework for approaching regulatory issues related to electricity distribution, including:

Box 1. Utility Notification

Early notification of utilities by consumers of PEV purchases or home EVSE installations helps utilities plan for infrastructure improvements and upgrades. This becomes more important over time if the trend is towards higher-power charging. Notification can also help consumers learn about programs like PEV-specific electricity rates and PEV incentives. Some consumers may not notify utilities due to privacy concerns or lack of awareness of any notification requirements. Auto dealers may also be reluctant to support this additional step if it hinders the chance of a PEV purchase.

- Should homeowners pay for any electricity service or system upgrades necessary following a home EVSE installation that they would not pay for if installing other comparably demanding appliances such as air conditioners or hot tubs?
- How will PEV drivers contribute to maintenance of the transportation infrastructure?
- How will utilities manage demand from PEVs to maintain the reliability of the electrical grid?

If done correctly, mass PEV deployment nationwide provides an opportunity to maintain, and eventually improve the reliability of the U.S. electrical grid and potentially lower the marginal cost of electricity for all utility customers if charging is done during off-peak times. Strategic action by regulators could accelerate investments by the private sector. At the same time, inaction could result in some electrical grid problems in areas that see concentrated PEV adoption. In developing the Action Plan, the Group considered the short-term objectives of accelerating PEV adoption while also laying the foundation for a possible future consisting of greater PEV and grid integration.

3.1.1 Residential and Commercial EVSE Installation

Experts expect PEV owners to charge their vehicles mostly at home, although public EVSE can help address range anxiety and is being installed in locations nationwide for a variety of reasons (e.g., demonstration purposes and business opportunities).

Major issues related to EVSE installation include determining if PEVs should be treated differently from other comparable electric loads,[26] ensuring utility notification of EVSE installation (see Box 1), EVSE charging level restrictions, utility ownership of EVSE, regulatory treatment of PEV charging service providers, and addressing new technologies like vehicle-to-grid (V2G).[27]

As PEVpenetration increases, residential and commercial electricity service and infrastructure upgrades, like new transformers,may be needed.To equitably recover costs associated with the integration of new electrical loads, utilities and utility regulators rely upon a well-established set of rules included in utility tariffs. These rules do not discriminate between comparably demanding electrical loads (e.g., hot tubs or air conditioners). Any additional costs borne by the EVSE owner are a disincentive to the purchase and installation of charging stations in residential or commercial locations. If the EVSE owner does not pay, then utilities must either fold the cost into the rate base or pay out of company profits.

In the past, many utilities have paid for service extension and upgrades to accommodate air conditioning and other high-power demands in order to take advantage of the economies of scale from adding new customers or additional load from existing customers. Many utilities took these actions even if the cost of doing so exceeded the incremental benefit as long as expected net present value of future utility revenues remained positive. If incremental service extension exceeded a certain cost level, then customers paid for the difference in service extension.

Installations in multi-unit dwellings pose additional challenges including determining who pays for installation and any associated electricity service upgrades, who maintains the EVSE, who can use the equipment, and how the electricity is paid for. Other issues include insurance, damage liability, and common property use. Responses to these challenges can depend on whether the residence is a condominium or a rental property. For condominiums, co-owners will likely determine where, how, and when charging can take place, while renters are dependent on their property owners to provide charging. Many condominiums and rental properties share a master electricity meter and are not set up to accommodate additional meters without significant cost.

State regulators such as public utility commissions (PUCs), state energy offices, and local government may need to develop or revise guidance and policy. For instance, a condominium association may be able to charge its own fees for EVSE use if the equipment is in a private parking facility. Also, lowering EVSE installation cost through building codes for new or refurbished multi-unit dwellings is a key opportunity to lower the upfront cost of EVSE installation. Building codes could require that during construction or renovation, electric wiring for EVSE in parking facilities be installed, which is much less expensive than upgrading as a discrete project.

Table 2: Charging levels included in Society of Automotive Engineers (SAE) J1772 standard. See *Section 3.1.5* for more details on charging standards.

Level	Nominal Operating Voltage(V)	Max Rated Current (A)	Max Rated Power (kW)
AC Level 1	120	12/16	1.4/1.92
DC Level 1*	200-450	80	36
AC Level 2	240	80	19.2
DC Level 2*	200-450	200	90

* The SAE is currently finalizing a connector for DC charging Level 2 “fast” charging (there has been relatively little industry dialogue to date around DC Level 1 charging).

Another issue is whetherregulators should provide incentives to influence or institute restrictions on the type of charging equipment that can be installed. Table 2 identifies the different charging “levels” as they relate to power, current, and voltage.[28] The most commonly referenced charge levels for PEVs are alternating current (AC) Level 1, AC Level 2, and direct current (DC) Level 2, which is often referred to as “fast” charging. The amount of power required is the most important characteristic to utilities and regulatory bodies. Considering the average demand for power in a home is about 1.5 to 2 kilowatts (kW), home installation of a high-powered AC Level 2 charger could potentially cause reliability issues in a neighborhood. Although a passenger PEV's internal charging circuitry will not support the maximum 19.2 kW charging for the foreseeable future, grid reliability will become increasingly relevant as charge levels increase. After a year of early notification to select utilities of 3.3 kW charging for both the Nissan Leaf and the Chevrolet Volt, there were relatively few concerns with this level of charge. However, issues could arise in residential neighborhoods from PEVs increasingly capable of higher charging rates, such as 6.6 kW.[29] Additionally, some PEVs will have hardware that enables DC fast charging, which could cause surges in demand in areas with commercial EVSE.

Whether utilities are able to provide residential and/or commercial charging is another regulatory issue. Utilities have inherent advantages over third-party companies in providing PEV charging services.Utilities control thelocation of electricity infrastructure, will likely have access to information on prime charging locations, can often attain cost recovery for investments thereby eliminating risk, and have guaranteed revenues from other electricity sales. Many third-party providers, however, believe they could provide cheaper and more efficient service. They stress that a competitive marketplace will foster innovation and high-quality service.[30]Overall, numerous states are in the process of determining which entities will be allowed access to emerging PEV charging markets, and a common approach to regulating businesses thatprovide PEV services including electricity does notexist. Utilities could be asked to establish unregulated affiliates, which are subject to the same regulations and competition as other third-party providers.

Third-party charging service providers would like to be exempt from regulations placed on public utilities,such as cost-based pricing, to encourage competition, investment, and innovation. However, some rules would need to apply to all, for example, to ensure the safety and the quality of charging equipment used, since it is important to maintain grid reliability and consumer safety. In addition, electricity procured at wholesale for PEV charging should be subject to the same regulations governing the procurement of electricity for any other use.

In the future, automakers or aftermarket companies could eventually integrate technologies into PEVs that provide additional vehicles services, such as V2G. V2G could ultimatelylower the overall cost of owning a PEV by enabling owners to offer grid services competitively, while also improving the cost-effectiveness of grid maintenance. Policies implemented now could affect the motivation to implement V2G.

3.1.2 Residential and Commercial Electricity Rate Structure

Managed charging—i.e., using information technology protocols or financial incentives to require or encourage PEV charging at times of excess grid capacity—is necessary in order to maximize the number of PEVs deployed using existing electrical grid assets.[31] It is also necessary to maintain grid reliability and avoid the need for generation and distribution capacity additions to serve incremental PEV load. Though the amount of excess capacity varies by location, the time of day, and the season, a large amount of capacity exists during off-peak times in most places.[32] Thus, encouraging off-peak charging through time variant pricing is a good way to maintain grid reliability and minimize the cost of large-scale PEV deployment. Varying rates by electricity demand can encourage off-peak charging while also saving consumers money by enabling providers to satisfy demand at a lower cost.

Historically, most residents have paid a fixed rate for electricity. PUCs based these rates on the average cost of electricity delivery so electric utilities can recoup their costs and make a profit. As wholesale electricity markets and overall electricity demand have grown, PUCs introduced new rate structures across the United States. Many utilities offer electricity rate structures for households that encourage consumers to shift electricity usage to low-cost, off-peak hours through smart meter and other advanced technology efforts. The states these utilities operate in include many of the expected early PEV markets. If the PEV market grows beyond the early adopters, other regions may need to adopt similar rate structures—or special rate plans targeted to PEVs— to manage PEV electricity demand.

Like residential customers, commercial customers generally pay a fixed rate for electricity. They tend to pay more for their electricity than industrial customers, but less than residential customers. Commercial rates are lower than residential rates because the distribution and service costs are lower (i.e., fewer customers per kilowatt-hour or kWh served). Thus, the benefits of PEV charging using existing rate structures can differ by customer class. Commercial entities are also subject to demand charges, which are surcharges that occur when instantaneous power needs exceeds a threshold; such charges could increase the cost of charging PEVs at workplaces and shopping centers or could discourage EVSE installation in commercial locations.

3.1.3 Transportation Infrastructure and the Motor Fuel Tax

State transportation agencies receive a significant portion of their funding from federal and state revenue raised through the motor fuel tax. The original fuel tax was based on the historically strong link between fuel consumption and vehicle miles traveled. However, the lack of sufficient funding to maintain an efficient transportation system from this tax and other means has negatively affected economic growth for some time.[33] The federal fuel tax has not increased since 1993, and as a result, inflation has reduced the real value of the tax significantly. In addition, the decoupling of fuel use and vehicle miles traveled began in the late 1970s due primarily to vehicle fuel efficiency standards.[34]

In the short term, any comprehensive solution to this divergence between tax revenues and transportation infrastructure needs should address inflation, which is the primary driver of current deficits. In addition, rising vehicle fleet fuel economy should also be considered as new standards take effect and fleet turnover occurs.Regarding PEVs, even if President Obama's goal of one million PEVs by 2015 is met, losses due to the use of electricity as a transportation fuel will comprise about one percent of projected revenue shortfalls. Moreover, an additional tax on electricity as a motor fuel diminishes the total value proposition of PEVs, especially in the crucial early stage of development.

However, the threat of additional losses in funding due to gasoline and diesel use displacement by alternative vehicles like PEVs must be addressed before equity problems between the share of PEV and non-PEV drivers' contributions to transportation infrastructure maintenance are noticeable to transportation agencies. These shortfalls only occur for electric miles; EREVs and PHEVs can also run on motor fuel and pay the motor fuel tax accordingly.[35]States with substantial PEV adoption could see an impact sooner. To make up for the revenue shortfall, states have proposed methods such as a fixed charge or road user fees, which assess a tax on PEV owners based on miles driven per year.

PEV advocates have resisted these PEV-specific measures because they believe the fees threaten PEVs' viability. In addition, privacy advocates resist methods that require mileage-measuring devices to be installed in vehicles. There are suitable ways to track mileage, however, such as annual mileage readings, without using personal identifiable information like vehicle location. The deployment of PEVs today should have an eye towards the long-term consequences for a transportation system that obtains its funding from gasoline and diesel taxes.

Box 2. DC Fast Charging Standard

The lack of a common DC fast charging coupler could lead to consumer problems. The SAE is currently finalizing its version (DC Level 2). Meanwhile, some PEV service providers and automakers are pushing ahead with the existing CHAdeMO compliant connector. It is critical that the SAE and all PEV stakeholders agree on a coupler soon to maintain as much industry- wide compatibility as possible.

Another potential source of revenue for transportation infrastructure is the commercialization of the rights-of-way along the U.S. Interstate System (e.g., PEV charging stations at rest areas). The creation of the Interstate Highway Program prevented this in its inception in 1956.[36] Interstates built before 1960 (e.g., Interstate 95) are exempted. In general, areas with commercial offerings such as refueling stations must be located off the highway. The commercialization of interstate highway rest areas nationwide including the installation of PEV charging stations could bridge some of the funding gaps facing transportation agencies.

3.1.4 Consumer Privacy

Concerns exist about the use of data collected from PEVs and EVSE that could be used to personally identify a driver. Deployment projects sponsored by the DOE have instrumented thousands of vehicles with the goal of understanding PEV driver behavior.[37] In addition, PEV service providers are collecting data about the use of their EVSE, including residential installations.[38] Because the data being collected could be used to identify an individual driver, care must be taken to mask identifiable information when performing analysis to better understand PEV driver behavior.

3.1.5 Vehicle Charging Standards and Best Practices

Vehicle charging standards include, but are not limited to, standardized vehicle charging plug connectors (i.e., the coupler), PEV interconnection with the electrical grid, residential and commercial building codes, and international harmonization. Nationwide compatibility is critical for automakers, PEV service providers, and consumers. Adopting voluntary technical standards like the Society of Automotive Engineers (SAE) J1772, the most common PEV electrical connector standard, will ensure that PEV owners can use EVSE anywhere so long as interoperability standards are finalized.[39] These standards define physical and electrical characteristics related to power, safety, electrical interconnections, and electrical signaling. Future standards will incorporate functionality for smart grid applications.SAE has agreed upon a common, compliant coupler for AC Level 1 and Level 2 charging, but there is no industry agreement yet on the coupler for DC Level 2 fast charging (see Box 2). SAE is expected to finish the DC portion of the J1772 standard in early 2012. As a result, PEVs may contain two different connectors in the short term – the SAE J1772 for AC Level 1 and AC Level 2 and a DC fast charging connector (such as a CHAdeMO connector).[40]

Automakers may not choose to use the CHAdeMO connector once SAE finalizes a Level 2 coupler for DC. However, it is an option in BEVs on the road in 2011 and PEV service providers have already installed some CHAdeMO-compliant infrastructure. Hopefully, new infrastructure that uses the CHAdeMO connector will also be compatible with the connector for the SAE's DC Level 2 standard through relatively inexpensive modifications, but the extent of compatibility between CHAdeMO and the SAE DC Level 2 is not fully known yet.

No single standards body is responsible for all aspects of PEV charging. The number of standards bodies related to PEVs is very large. A partial list includes the SAE, federal agencies like the National Institute of Standards and Technology (NIST), the American National Standards Institute (ANSI), the International Code Council (ICC), Underwriter Laboratories (UL), the National Electrical Code (NEC), the International Association of Electrical Inspectors (IAEI), the National Electrical Contractors Association (NECA), and the Institute of Electrical and Electronics Engineers (IEEE), all of whom are actively engaged in developing PEV technical standards. SAE, NEC, and UL work on vehicle charging connector standards including the SAE J1772. ICC develops building codes while NECA and IAEI deal with EVSE installation standards. NIST and IEEE work on industry standards related to smart grid and V2G, two critical aspects of managed charging; these bodies consider the privacy issues identified earlier. All these bodies consider safety-related issues. ANSI convened the ANSI Electric Vehicles Standards Panel to address all of these issues together in April 2011; the panel plans to release the first version of its roadmap of the "standards and conformity assessment programs needed to facilitate the widespread acceptance and deployment of electric vehicles" in early 2012.[41]

3.2 Regulatory Framework Actions

"Automakers, PEV service providers, electricity providers, and government should cooperate on a consistent regulatory framework for PEVs that follows common principles for utility regulation, reflects observed best practices, and advances consumer interest in PEVs."

– The PEV Dialogue Group

The PEV Dialogue Group believes consistent electricity distribution regulations that capture best practices and are based on common standards can lay a foundation for PEVs to help improve the reliability of the U.S. electrical grid. But incompatible regulations could harm budding consumer perception of PEVs and diminish stakeholder interest in developing PEV infrastructure and services. Numerous pilot programs and consumer studies are now being conducted to identify best practices and common standards for managing consumer demand and understanding stakeholder responsibilities. In addition, several state and local governments have already defined key rules and regulations for PEV markets. As described above, a number of standards bodies are also engaged in developing common standards for PEVs and PEV charging.

Ultimately, jurisdictions do not need to issue the same regulations, but certain principles should be common. To that end, the Group identified the following four guiding principles for utility regulations:

Utility Regulation Principles

1. **Protect the Reliability of the Electrical Grid**: The reliability of the grid is paramount to PEVs' and the broader economy's success. Policies and regulations should avoid increasing the risk of grid unreliability.
2. **Minimize Cost to the Electricity Distribution System**: There is adequate capacity in the existing electrical distribution system for millions of PEVs. Policy and regulations should aim to leverage existing assets and use managed charging to handle demand on the system.
3. **Encourage Transportation Electrification**: The societal benefits provided by PEVs warrant policies and regulations that support PEV adoption while also supporting the previous two goals.
4. **Provide Consistent Treatment of PEVs with Comparable Power Requirements within each Rate Class**: Over time, homes have demanded more power from clothes dryers, air conditioning units, and flat-screen televisions. Commercial demand has also changed significantly over time. The key is to treat incremental PEV power demand no differently from other incremental electricity loads.

The Group concluded that, in some instances, policies to accelerate PEV adoption must distinguish between early adopters and mainstream users. The regulatory framework should foster a sustainable, open, and competitive marketplace where innovation is encouraged. All the while, regulators should not compromise electrical grid reliability, for example through the premature introduction of technology.

3.2.1 Residential and Commercial EVSE Actions

Electric utilities, PUCs, NGOs, state governments, auto dealers, automakers, PEV service providers, and local governments should jointly create a competitive and innovative market for residential and commercial PEV charging services. Decisions by PUCs, local government, and PEV service providers regarding household EVSE installation should streamline the installation process. Regulations should reflect the local characteristics of markets, potential PEV users, PEV service providers, and electric utilities.

Since there will be little, if any, impact of early PEV adoption on the reliability of the electrical grid, residential and commercial installations of EVSE should be treated the same as similar electric loads. As part of a larger multi-stakeholder collaboration, electric utilities could work with their local inspection or permitting organizations to develop and offer faster permitting or other services for PEV owners who self-report their vehicle purchases.

The costs of electricity service or system upgrades necessary for residential and commercial charging should follow current rules for infrastructure improvements, including any costs that are part of the electricity rate base.

The experience of early adopters should guide long-term residential requirements. Local government and state regulators should provide clarity on legal issues related to multi-unit dwellings including condominiums and rental properties. Local government should also consider building codes that lower EVSE installation cost by requiring electric wiring for EVSE in new and refurbished multi-unit dwellings where practical. PUCs shouldsupport and encourage effortsby auto dealers, EVSE service providers, Departments of Motor Vehicles (DMVs), state energy offices, permitting authorities, or utilities that encourage consumers to notify utilities before purchasing a PEV or installing a home EVSE.

Creating a competitive market place that offers affordable and wide-ranging service should be the focus of early and later charging infrastructure regulation. Relevant business models are not limited to EVSE operators, but also include V2G service providers; the introduction of common standards should guide the widespread introduction of technology that could be disruptive. State and local jurisdictions should encourage innovative business models at the outset with the goal of minimizing the cost of charging infrastructure build out to the public. Thus, applying current utility regulations to PEV service providers that are not acting like a utility could stifle innovation and the emerging PEV industry. However, PEV service providers that wish to procure electricity directly at wholesale should be subject to the same rules and regulations as any other entity with access to wholesale markets. In any case, typical consumer protections related to market competition should be enforced. Utilities wishing to act as a PEV service provider should do so through unregulated affiliates as the use of ratepayer dollars could provide utilities with an unfair competitive advantage. Further, utilities should be allowed to own and operate EVSE for internal use, for demonstration purposes, and in areas that the private market would not support otherwise.[42]

Current Examples

The following examples illustrate ways to streamline EVSE installation and maintain grid reliability:

- At part of its Clean Transportation Program, San Diego Gas and Electric (SDGE) published a breakdown of responsibilities among affected parties, with charging equipment installation cost falling to the owners of any multi-unit dwelling (e.g., condominium or leased rental properties) and classified as a “value-add.”[43]
- General Motors is working with utilities in several states on a program that allows consumers to opt in or out of notifying the local utility of their home address at the time of vehicle order.[44]

- Advanced Technology's Community Planning Guide includes a step-by-step guide to streamlining the home charger installation process.

Guided by the characteristics of their local markets, several states have already defined key regulations regarding PEV infrastructure. The lessons learned from these early movers should help in defining best practices for the larger PEV market.

- California has ruled that utilities will not be permitted to own EVSE unless a utility can demonstrate that it will be the only possible provider in a certain area.In contrast, Oregon is considering whether to open charging services to utilities, provided that the cost of these services is not included in their electricity rate increase claims.
- California has determined that providing charging services alone does not render a charging service entity subject to regulation as a public utility. However, the California PUC has also made it clear that it retains sources of authority other than direct regulation of a provider as a public utility to ensure the environmental performance and integrity of the electrical grid.
- In 2009, Delaware enacted the first V2G legislation in the country that requires utilities to buy electricity from PEV suppliers for the same price as it costs to charge the battery.

Action Summary

Key Questions Considered by the Group	**Government and Stakeholder Actions** ***Distinguished between Early Adopters & Mainstream Consumers where Noted***
How should the cost burden for PEV integration be shared?	PUCs should stay consistent with existing regulations based on comparable electric load and rate class; this includes surcharges related to high-power charging.
How should charging services be provided in multi-unit dwellings?	State and local government and PUCs should provide clarity on legal issues. Local government should define an approach for new and refurbished buildings to accommodate EVSE installation more easily.
Should utilities be notified when a new PEV is sold or an EVSE is installed?	A mechanism (e.g., state DMV, or EVSE permit application) may be advised to notify the local utility ofthe home address of a newly purchased PEV or EVSE with higher charge rates (e.g., in excess of 5 kW). Local government, EVSE commercial stores, and utilities should encourage notification at EVSE purchase time including informing consumers of existing rules on utility notification for significant new loads.
Can utilities own EVSE?	PUCs should allow utilities to provide service for demonstration purposes, for internal use, through unregulated affiliates, or for areas that the private market would not accommodate otherwise.
Should PEV service providers be regulated as utilities?	PEV service providers not acting as utilities should not be regulated as utilities, but PEV service providers that wish to procure electricity at wholesale should be subject to the same regulations as any other entity with access to wholesale markets. State and local government should

	require typical consumer protections related to market competition.
How can the groundwork be laid for V2G?	**Early Adopters**: PUCs should enable electricity power providers to buy electric power from PEV owners for demonstration purposes. **Mainstream Consumers**: PUCs should enable more widespread usage once common standards are established for V2G as it relates to EVSE, PEVs, etc.

3.2.2 Residential and Commercial Electricity Rate Structure Actions

Electric utilities, PUCs, NGOs, and state governments should work together to identify electricity rate structures that maintain the reliability of the electrical grid and reward households for charging PEVs at off-peak hours. Rate structures should offer households choicesincluding options that better reflect the cost of electricity generation.

PUCs should direct electricity providers to educate early adopters on how to maximize savings on their energy bills, which will help protect grid reliabilityand minimize infrastructure upgrades.PUCs should also authorize recovery of reasonably incurred costs associated with such efforts. Since early adopters are likely to depend on home charging, regulators should require residential rates that encourage off-peak charging.Stronger pricing incentives to encourage off-peak charging may be necessary if analysis indicates grid instability will increase with PEV adoption.

The following are measures to improve theconsumer experience:

- *Offer a variety of pricing plans* – Pricing plans that give the consumer a variety of electricity prices or consumption amounts to choose from are necessary. It should be noted these rate options can require the use of "smart" meters capable of measuring consumption in short time intervals.
    - Time-of-use (TOU) plans charge consumers for electricity used during a certain time and can be structured to favor charging at off-peak or specified times (most likely at night). Total household, separate, or sub-metered PEV TOU plans can be tailored to meet individual household preferences.
    - Dynamic pricing, similar to TOU plans, varies the electricity price to a consumer depending on overall demand for electricity and the cost of generating electricity at any given time. Typically, low demand and low generating cost are at night when PEVs are most likely to be charged. Household smart meters or EVSE equipment with meters capable of measuring electricity usage are necessary to enable dynamic pricing. In the future, the metering function could also be provided by the vehicle and commands sent through the vehicle's telematics system.
    - Subscription service plans provide consumers with a simple and convenient way to charge their vehicle by paying a fixed monthly fee that would cover all vehicle electricity

use and in some instances include the installation of the charging unit in their home. It is important for these plans to allow unlimited charging only during off-peak hours.

- *Individual rate analysis* –Providingutility analysis on individual household electricity bills so customers understand the impact of PEV charging on their budgets will likely increase customer satisfaction. The analysis should also include solutions to lower the bill such as suggested rate plan changes. Wherever possible, electricity providers that offer these analyses should share information on EVSE installation costsand any applicable metering installation costs.
- *Second meter or sub-meter installation* – Some trial programs have found favorable results for consumers who receive a second meter to measure PEV-related electricity use. However, the cost of a second meter (likely owned and managed by the utility) or a sub-meter (including on-board a PEV) can varygreatly and it is important to establish low-cost metering solutions that are attractive to PEV buyers.[45]

As PEV adoption moves beyond early adopters, electricity providers will face different demand patterns and may need to take steps to maintain grid reliability.Initial consumer pricing options include conditions that will have to be reevaluated as more PEVs are deployed:

- *Limited enrollments* – Clarify how pricing plan enrollments will change as PEV adoption grows.
- *V2G* – Future PEVs may be able to provide grid services and improve grid reliability. PUCs and utilities need to define rules and rates for purchasing electricity from PEVs.
- *Managed charging* –Managed charging programs could provide PEV drivers with additional financial benefits, improving PEV total cost of ownership and lowering the costs of PEV-grid integration.

Current Examples

The following examples illustrate special electricity rates to manage PEV charging.

- In Michigan, DTE Energy offers PEV owners two distinct rate structures when they install a separate meter and an AC Level 2 charger. The first rate structure is a flat $40 fee a month per vehicle and is only available to the first 250 customers. The second rate structure is described below.

Rate Name	Time	Price ($ per kWh)
On-Peak	9AM-11PM Monday-Friday	$0.18195
Off-Peak	All other times	$0.07695

- Georgia Power offers a PEV rate for residential electricity users. Customers may keep their standard residential rate or choose a night and weekend rate that excludes the super off-peak rate.

Rate Name	Time	Price ($ per kWh)
On-Peak	2PM-7PM Weekdays (June-September)	$0.25
Off-Peak	7AM-7PM (October-May) 7AM-2PM (June-September)	$0.10
Super Off-Peak	11PM-7AMDaily	$.06

- San Diego Gas and Electric (SDG&E) offers TOU rates with different metering options. A PEV owner can use a whole-house TOU rate or a separate PEV rate requiring a separate meter.The EV-TOU rate defines four distinct periods and four distinct rates:

Rate Name	Time	Price ($ per kWh)
Peak	12PM-6PM	$0.257
Off-Peak	5AM-12PM 6PM-12AM	$0.167 $0.167
Super Off-Peak	12AM-5AM	$0.144

Through its pilot programs, utilities should collect information necessary to identify the best practices for that particular utility in time to implement lessons learned before mainstream consumers adopt PEVs and market penetration is at a level where reliability and electric service cost impacts of PEVs are significant.

Action Summary

Key Questions Considered by the Group	**Government and Stakeholder Actions** ***Distinguished between Early Adopters & Mainstream Consumers where Noted***
How will utilities manage demand?	**Early Adopters**: PUCs and utilities should offer rates to encourage adoption and off-peak charging (e.g., whole house TOU, PEV-specific TOU) Utilities, NGOs, and state government should run education campaigns on the public and private benefits of off-peak charging. **Mainstream Consumers**: PUCs and utilities should encourage off-peak charging and pricing plans that proved effective in early adoption.

3.2.3 Transportation Infrastructure Maintenance Actions

NGOs, PUCs, electric utilities,and state and local governments should work together to determine how PEV owners can pay their fair share of transportation infrastructure maintenance. Permanent or temporary methods should be implemented that do not affect PEV market growth before PEVs have a noticeable impact on tax revenue for a state.

The loss of motor fuel tax revenues from early PEV adopters should be small for some time. Although financing the maintenance of the transportation infrastructure is the responsibility of all users, collecting tax revenue from early adopters should not be an immediate concern in most states. However, states with concentrations of PEVs may consider transitional policies such as short-term annual excise fees. States should carefully consider such fees since additional costs of PEV ownership could diminish market growth in the short term.

State and local governments should craft revenue collection plans during the early adoption phase and enact them before PEV adoption noticeably affects revenues, when technically feasible, and without stunting PEV market growth. The revenue could be collected at the vehicle charge point based on the amount of energy consumed (similar to the existing motor fuel tax) or devices could be installed on the vehicle itself to track actual vehicle miles travelled. Consumer resistance to tracking is stronger with respect to where the vehicle travels versus how many miles the vehicle has traveled, but any device installed on the vehicle could meet resistance. Since EREVs and PHEVs driven on motor fuel are subject to the motor fuel tax, additional revenue collection is only needed for the electric miles traveled by those vehicles.

Current Examples

- The Washington and Oregon state legislatures considered fees for PEV owners to cover the owner's share of transportation infrastructure maintenance costs; both proposals were unsuccessful in the 2011 legislative session.
- Oregon conducted a pilot project to fund state transportation infrastructure through vehicle miles traveled fees collected based on measuring devices installed in vehicles.
- Texas HB1669 would establish a "pilot" program allowing PEV and other alternative vehicle drivers to pay a VMT fee based on odometer readings or some electronic device placed on the car and would require the DMV to set the rate at a level comparable to the current gasoline tax.

Action Summary

Key Questions Considered by the Group	**Government and Stakeholder Actions** ***Distinguished between Early Adopters & Mainstream Consumers where Noted***
How will PEV drivers contribute to transportation infrastructure maintenance?	**Early Adopters**: NGOs, PUCs, electric utilities,and state and local government should define a suitable method for estimating or determining mileage data and payment collection that continues to encourage efficient vehicles similar to the existing motor fuel tax; consider transitional actions for some areas. Proposals should aim to minimize impact on PEV market growth in the short term. **Mainstream Consumers**: State government should enact a method based on effectiveness, consumer acceptance, and technological feasibility.

3.2.4 Vehicle Charging Standards and Best Practices Action

Voluntary standards bodies should work together, with the assistance of electricity providers, regulatory authorities, NGOs, automakers, and federal and local government, to develop vehicle charging standards and best practices related to the vehicle charging connector, PEV interconnection and communication with the electrical grid, and EVSE installation.

While some national standards (e.g., SAE charging level standards) are necessary right away, best practices and other standards are best identified over time. National organizations like NIST, ANSI, NARUC, NASEO, UL, NECA, IAEI, ICC, NEC, IEEE, and SAE can identifybest practices and national standards (e.g., vehicle-grid interconnection, smart grid compatibility) for charging infrastructure.

Current Examples

- ANSI held a workshop in May of 2011 to identify the state of play on vehicle charging standards and identify what is necessary for large-scale deployment of PEVs.
- The SAE is currently finalizing a coupler design for the DC Level 2 standard.

Action Summary

Key Questions Considered by the Group	**Government and Stakeholder Actions** ***Distinguished between Early Adopters & Mainstream Consumers where Noted***
Who will establish vehicle charging standards and best practices?	Stakeholders should work with standards bodies, such as SAE, NIST, ANSI, UL, NEC, ICC, and IEEE to develop PEV charging standards and best practices.

3.2.5 Consumer Privacy Actions

Electric utilities and other electricity providers, PEV service providers, and PEV pilot project participants should ensure that individual identity is impossible to glean from data collected from EVSE and vehiclesreleased to NGOs, government, and other researchers while also maintaining the usefulness of these data for researchers.

Consumers should have to agree to how any of their personal information is being used. Thus, data collection should be voluntary and mostly anonymous without the ability to identify individual consumers; the data collected should assist in maintaining grid reliability and optimizing charging infrastructure build out. The parties that use or collect data (e.g., automakers, PEV service providers, utilities, researchers, and governments) should store data in secure locations and prevent outside access. Wherever possible, analytical outputs should be used instead of raw data to prevent the sharing of personally identifiable information.

Current Examples

- Idaho National Laboratory, Nissan, ECOtality, and others are actively collecting data on thousands of vehicles and EVSE as part of a project funded by the American Recovery and Reinvestment Act (ARRA) through the DOE's Vehicle Technologies Program. Privacy is a top concern among the project participants and, as a result, there is limited public availability of the raw data.
- Senate Bill 859 became law in California in 2011 to authorize the CA DMV to release a PEV owner's home address to a utility solely for identifying where a PEV is registered.

Action Summary

Key Questions Considered by the Group	**Government and Stakeholder Actions** ***Distinguished between Early Adopters & Mainstream Consumers where Noted***
Who will have access to charging and driver data collected?	PEV service providers, electric utilities and other electricity providers, and PEV pilot project participants should have strict privacy agreements that (at minimum) mask individual identification from data collected while also

	maintaining usefulness to the data user (e.g., utility, research laboratory, private company, NGO).

The regulatory framework laid out in this chapter identifies several actions that will enable PEVs to be integrated with the electrical grid. The goal of the framework is to encourage regulatory compatibility across the country. Although it is unlikely that all states will adopt the same regulations for all aspects of PEVs, the growth of the PEV market depends to some extent on the degree of compatibility of these important regulations. Another key challenge is optimizing public and private investments, which the regulatory framework partially addresses. The next chapter delves deeper into this in order to accelerate private investment while also balancing efficiency and equity.

4 Optimizing Public and Private Investments in Charging Infrastructure

Public and private stakeholders have invested billions of dollars in the PEV industry thus far, and continued support will be necessary by both if PEVs are to reach the mainstream consumer. Considering the gloomy short-term outlook for public budgets across the United States, expansion of large, publicly funded pilot projects is unlikely and may not be necessary to accelerate PEV adoption. If private investors are to continue and eventually carry the PEV industry without public support, they will require a reasonable return on investment in a manageable timeframe.

> ***"Consumer interest should be the primary driver for public and private entities as they evaluate investment opportunities in charging infrastructure."***
>
> ***– PEV Dialogue Group***

The discussion in this chapter focuses on investment challenges for public and private entities that the Action Plan addresses. The actions identified will foster local and regional PEV markets by encouraging private investments and appropriate public support.

4.1 Public and Private Investment Issues

The PEV Dialogue Group developed the actions laid out in this chapter to accomplish the following two objectives related to public and private investments in PEV charging infrastructure:

- **Accelerate sustainable private sector investment in charging infrastructure**
- **Balance efficiency and equity**

The Group believes optimizing public and private investments in PEV deployment is essential to accelerating PEV adoption. Significant new public subsidies for PEV deployment are unlikely, so leveraging private capital is a necessity. At the same time, the sole use of private financing is problematic since some locations will need to incur upfront costs to accommodate charging infrastructure, such as electrical grid service and system upgrades. In these instances, business models for vehicle charging may not be profitable and may require some public subsidy to thrive in the short term.

The Group focused on three aspects of public and private investments in charging infrastructure that are specific to a geographic area:[46] the suitability of PEVs, charging type and infrastructure needs, and the extent of public investments in EVSE. Combined, the actions in this chapter will encourage private industry to enter new markets and rely on public investments only when necessary and appropriate.

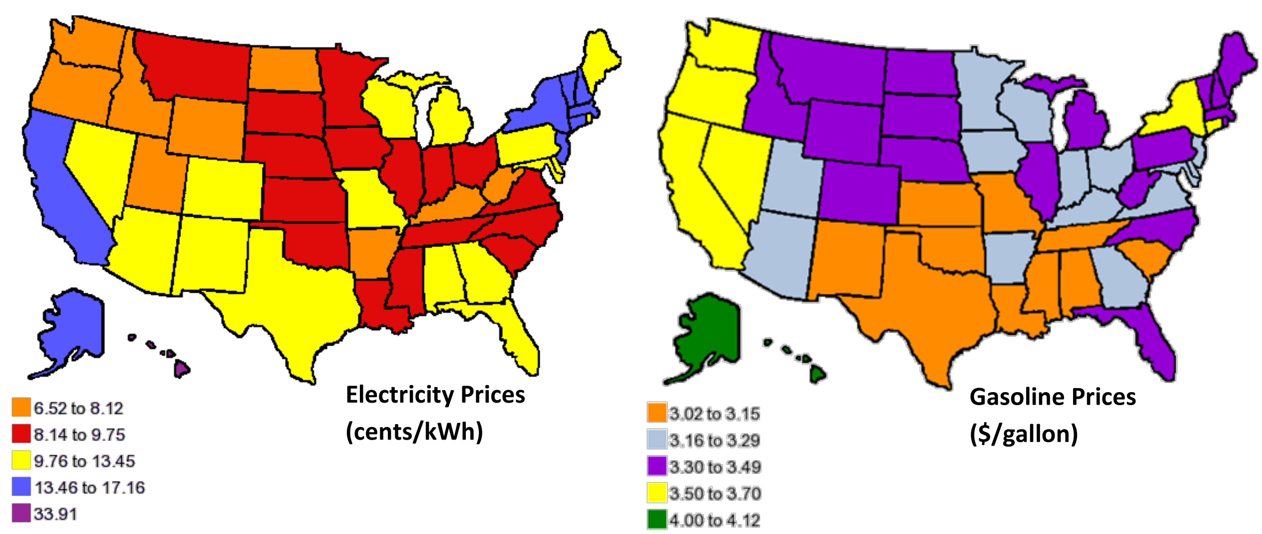
The PEV industry would not exist without the billions of dollars invested by the private sector to date. In the case of charging infrastructure, the investments have come mostly from public-private partnerships. Bringing PEVs to mainstream customers through an expansive charging infrastructure is a significant business opportunity that can also benefit the public. This chapter identifies the actions needed to help other markets grow based on lessons learned from early movers.

4.1.1 Estimating the Feasibility of PEVs

Factors affecting whether a PEV market takes hold in a geographic area include consumer interest, gasoline and electricity prices, the existing regulatory environment, degree of involvement of local and state government, local utilities, automaker and PEV service provider enthusiasm, area geography, travel patterns, and expected environmental and economic benefit provided by PEVs. A one-size-fits-all approach may miss local nuances.

Consumer Interest: The most important factor in assessing the suitability of PEVs in a geographic area is consumer interest. Demand is a function of interest in hybrid vehicles, above-average wealth (or purchasing power) and other socioeconomic factors, concern for the environment, the importance of personal image, and information availability. It is apparent that cities like San Francisco will have greater early consumer interest in PEVs than other places due to the high degree of consumer purchasing power and interest in the environment.[47] Statistical modeling techniques exist that could be useful in estimating consumer interest in an area. For example, discrete choice models can help forecast future market share of PEVs using the results of consumer preference surveys.[48]

Figure 4-1: Variation in electricity (August 2011) and gasoline (November 2011) prices nationwide.[49]



Gasoline and Electricity Prices: The regional nature of gasoline and electricity prices can influence consumers. Electricity prices vary by well over 150 percent nationwide while gasoline prices vary less than 35 percent (see Figure 4-1). Nationally, gasoline prices have been rising at a sharply faster rate than electricity prices—which have actually decreased in real terms since the early 1980s—and gasoline prices are more visible to the consumer. Thus high gasoline prices will likely act as a greater incentive for

PEV adoption than low electricity prices. Further, because PEVs are so efficient, the cost per mile of operating a vehicle on a battery fueled by electricity is typically much lower than gasoline nationwide, even if road taxes were applied to electricity.[50]

Box 3. How does an automaker decide where to sell a vehicle?

Unless an automaker produces a vehicle in very low volume, state franchise laws prevent an automaker from controlling the distribution of that vehicle within the state in order to protect a franchisee's right to do business. As a result, auto dealers must assess local interest in a particular vehicle to determine the amount to stock in their inventories. Automakers can assist dealers in making this assessment.

New vehicles like PEVs warrant special attention by auto dealers since they introduce a number of new characteristics (e.g., refueling options, range, driving experience, etc.). Consumer response is still largely unknown, so estimating the suitability of PEVs in an area is very useful to dealers.

Regulatory Environment: The degree and clarity of regulation in a jurisdiction as it relates to commercial and residential charging infrastructure can greatly influence the likelihood of private sector involvement, depending on the business model. Too much or uncertain regulation can discourage investment by some businesses by making their model unprofitable or too risky. For instance, some businesses cannot compete if a PEV service provider is treated as a utility (see *Section 3.1.1*). On the other hand, utilities may want to invest some of their profits in infrastructure to increase revenue. Other regulatory factors to consider include pricing strategies for vehicle recharging (e.g., time variant and demand charges) that may be beneficial to the PEV market.

State and Local Government Involvement: While many localities have not taken proactive steps to support PEV deployment, others have taken aggressive action including the installation of public EVSE and other incentives to support the PEV charging industry (e.g., educating electrical contractors and local and state inspectors on all aspects of EVSE). For some PEV service providers, this support is necessary and helpful to their business. Subsidies for EVSE installation deter entry into the market of subscription-based businesses that rely on offering discounted EVSE. As a result, local governments should tailor their involvement to suit the needs of their locality.

Local Utility Involvement: Without participation from the local utility, there is little likelihood that PEV deployment will be successful in a locality. Utility education and outreach efforts that describe the benefits of vehicle electrification can accelerate the market's growth. Utilities could become PEV service providers themselves, competing with other businesses (see *Section 3.1.1*). However, the utility can also stifle growth if its procedures take too long for consumers.

Automaker and PEV Service Provider Enthusiasm: Perceived interest and likelihood of success will influence automakers and PEV service providers. Although automakers cannot control where vehicles wind up (see Box 3), they can control where a vehicle is introduced initially. Automakers have a vested interest in the successful deployment of PEV charging infrastructure:achieving the right balance between too little and too much infrastructure is critical to consumer acceptance. PEV service providers will seek out places that best match their business model. A "chicken and egg" situation exists because both PEV service providers and PEV automakers need each other to succeed.

Area Geography: Climate and topology can reduce the range of a BEV, thereby directly affecting consumer interest. This is similar to the effects geography has on a conventional gasoline vehicle, but can be much stronger, for example in winter since a BEV does not have waste heat from an internal combustion engine readily available. Though the effects on a PHEV are less because of the combustion engine backup, geography can also make these vehicles less efficient. Automakers are developing ways to minimize these effects on range by offering heated seats,[51] or solar-powered fans to pre-cool the vehicle's cabin, and developing advanced thermal control systems for the battery.

Travel Patterns: PEVs typically become economical as more all-electric miles are driven. A PEV can be useful in almost any environment – suburban families can use it for errands around town and city dwellers can use it for almost all trips. The practicality of PEVs depends on consumer driving behaviors, which are largely a function of travel patterns and land use. Factors here include proximity to commercial zones, industrial zones, schools, etc. The denser the area, the more practical it is to drive a PEV since it is more likely the trip will be "all-electric." However, the fewer all-electric miles driven, the more time it takes to recoup the upfront costs of a PEV.

Expected Societal Environmental and Economic Benefits: PEVs offer societal environmental and economic benefits that warrant inclusion in any evaluation of PEV suitability in a geographic area. The environmental benefits include local air quality improvements and the mitigation of greenhouse gas emissions, which are a contributor to global climate change. When operating in zero-emission mode (which is the only mode for a BEV), a PEV directly emits no harmful air pollutants from the tailpipe and can improve local ozone levels (i.e., reduce smog). The economic benefits of PEVs include increased energy security, job creation to build out and maintain charging infrastructure, and opportunities related to PEV research, development, and manufacturing.

4.1.2 Charging Equipment and Infrastructure Needs

Best practices for PEV charging equipment and infrastructure needs are largely unknown today. The lack of real-world data on PEV driver behavior is the primary reason. Factors that affect charging equipment and infrastructure needs are similar to those that influence consumer interest including the PEVs adopted in the area, travel patterns, and area geography.

Cities and regions across the United States are actively investigating PEV charging infrastructure needs through pilot projects, public-private partnerships, and other efforts. In September 2011, DOE awarded $8.5 million in PEV deployment planning grants to 16 organizations covering 26 states.[52] In addition, the ongoing pilot deployment projects will provide valuable data on driving patterns, charging infrastructure needs, and charging equipment used for DOE grant recipients and others interested in supporting PEV deployment.

Since many consumers are not aware of their own driving patterns, it is difficult for them to assess which PEV is the best fit. The type of PEVs adopted strongly influence the charging equipment and infrastructure needs, especially at the market's outset.It is evident that PEV drivers will need access to a charger at their home– and that this is likely the primary location for all vehicle charging. It is important to note that a number of potential PEV buyers park on public streets and do not have access to a garage. The extent of the need for public charging infrastructure, however, is still largely unknown but is likely critical to expanding the PEV market beyond consumers with access to garages.

Table 3: Charging level type by site in the near term.

Site	AC Level 1*	AC Level 2**	DC Level 2***
Single Family Home	✓	✓	✗
Multi-Unit Dwelling	✓	✓	✗
Commercial Property	✓	✓	✓
Workplace	✓	✓	✗
Curbside	✓	✓	✗
Private Rest Stop	✓	✓	✓
Carpool Lots	✓	✓	✗
Public Parking	✓	✓	✗
Popular Destinations	✓	✓	✗

**AC Level 1 means low-power 1.2kW.*

***AC Level 2 means effective power levels up to 6.6 kW in commercial locations and 3.3 kW in residential locations.*

****DC Level 2 refers to fast charging at typically 50 kW.*

For charging equipment, the need for a high-power charging network largely depends on the popularity of BEVs. However, demonstration programs have shown that BEV drivers largely overcome their range anxiety and adjust their driving patterns quickly.[53]The internal combustion engine inside an EREV or PHEV overcomes this challenge by eliminating driver range anxiety. The type of charging equipment depends on the site as outlined in Table 3. For instance, DC fast charging is impractical in residential locations, but BEV owners could find them useful in many publicly accessible areas. Also, the electrical grid load profile during the day can affect what kind of charging equipment makes sense outside the home. Some electric utilities may prefer faster charging in the workplace so the PEV loads are on the grid for as short a time as possible, while others may prefer less load spread over a longer time.

For PEV drivers to maximize their electric miles, they will need access to a charger at home for all PEV types, but the charger type can vary.[54] Although PHEV owners might choose to use AC Level 2 chargers when they are available, a low-power AC Level 1 charger is suitable to recharge the vehicle's battery overnight. However, a BEV owner will likely desire an AC Level 2 charger capable of providing at least 3.3 kW of power in order to charge the battery overnight.[55]

Whether PHEVs, EREVs, or BEVs are adopted also influences public charging infrastructure layout. Although any PEV owner could use commercial EVSE, BEV drivers will likely need them to maximize their travel radius from home.

As previously mentioned, land-use patterns strongly influence charging infrastructure needs and indirectly influence charging equipment needs. The closer drivers live to where they work, the more likely they will feel comfortable with BEVs, though traveling fewer miles will reduce the value proposition that PEVs provide over conventional vehicles.[56] Similarly, area geography can affect charging infrastructure needs since PEV range is affected by topology and climate. Areas with significant elevation changes or with extremely hot or cold climates can increase the demand for charging infrastructure since these conditions decrease the expected range of electric-only travel. Other factors that limit a PEV's electric-only range, such as high traffic congestion, can also increase charging infrastructure demand.

4.1.3 Public EVSE Investments

Optimizing public and private investments in EVSE is a complex balance of social cost-benefit analysis, business innovation, and automobile market dynamics.

Strategic action by government in the form of regulatory reform and capital investments can help accelerate private involvement in PEV deployment. The benefits to society of PEV deployment warrant some public funding, but too much could stifle private investment and fail a cost-benefit assessment. This balance is not necessarily the same for all geographic areas, so there is no single, or simple, method to accelerate private investment.

Implementing a successful business model depends on a variety of factors, including a compatible regulatory framework as laid out in Chapter 3 and some public investment. Public investments in some markets can jumpstart private competition around EVSE, charging rates, and charging availability.

Currently, much of the discussion around PEVs focuses on maximizing deployment in order to improve energy security and the environment and to support nascent industries. Increasing deployment of PEVs helps the industry reach economies of scale, which can lead to significant cost reductions. There is a clear social benefit to the deployment of PEVs with respect to the environment and energy security, so some public investments are warranted. Public policy thus far has included vehicle subsidies and investments in research and development (R&D) related to battery and vehicle technology, vehicle charging infrastructure, pilot deployment programs, and manufacturing. Subsidies at the federal and state level exist to lower the upfront cost of PEVs, and some incentives exist for EVSE. Regarding EVSE installation, Chapter 3 says electrical grid service and system upgrades for PEVs should be treated like loads with similar power requirements and rate classes; meaning some sharing of costs to accommodate EVSE is appropriate.

Public-private partnerships are currently the most popular method to deploy EVSE. The two largest pilot projects today are public-private partnerships between DOE and two companies with very similar business models, ECOtality and Coulomb Technologies. DOE also provided a nearly $1 million Electric Vehicle Readiness Grant to the New York State Energy Research and Development Authority on behalf of the Transportation and Climate Initiative to support the Northeast Electric Vehicle Network, a group of eleven northeast states and the District of Columbia. Another example is the U.S. Department of Transportation awarded $2.7 million in TIGER grant funding for over 20 DC fast charging stations along key corridors in northwest Oregon.[57] Leveraging public dollars through these partnerships provides one model for nationwide deployment.

The purpose of the DOE projects is to get cars on the road and evaluate how they are used. They will also help establish best practices for home charging installation and other procedures necessary to simplify the vehicle purchase process. While the results of these projects will be incredibly useful on a number of fronts, they will not provide a large amount of data on new business models since the two major infrastructure providers use a similar approach.

In the initial stages of PEV deployment, the federal government has subsidized the installation of thousands of charging stations for demonstration purposes. In addition, some states offer subsidies for consumer purchases of EVSE. Combined, these public subsidies have helped some businesses grow, while deterring others. For instance, businesses like NRG Energy that rely on free home EVSE in return for a monthly subscription can have difficulty competing in areas that provide free home EVSE subsidized by public dollars.The private sector has invested billions so far to support PEVs, but most capital invested has thus far been in support of the PEVs themselves. Charging infrastructure accounts for a small fraction of the total invested. Companies have created new business models in hopes of capturing market share for PEV recharging, but uncertainty about profitability exists.

Depending how they are structured, public subsidies can crowd out private investment. They also can appear to favor the wealthy since PEVs cost much more than conventional vehicles today, and early adopters are likely to be relatively affluent.This perception could hold even though early adopters must bear the additional cost and time required to use new technology. Economists identify actions that are efficient in order to increase “utility” for individuals. Policymakers also temper those actions on occasion to promote equity or fairness. Equity must be a pillar of any policy framework by government, especially when the public shares in the costs of action.

Currently, a public subsidy exists for PEVs up to $7,500 for the first 200,000 vehicles produced by each original equipment manufacturer, and some states offer additional subsidies.[58] It may be difficult to justify further public subsidization of PEV deployment at the federal level beyond this public investment on equity and efficiency grounds, though this subsidy is critical to encourage PEV market development beyond early adopters. It is unclear how long state subsidies will exist given the current strain on state budgets.

There are three situations in which a good case can be made for public investments in EVSE, so long as there is sufficient consumer interest in PEVs. First, publicly financed EVSE can be useful for demonstration purposes and identifying lessons learned. Second, if the private sector is unwilling to invest in sufficient commercial charging infrastructure, such as in some small towns, then it may be prudent for public entities to support the market with the installation of some EVSE. Lastly, public charging infrastructure in densely populated areas with high concentration of multi-unit dwellings or curbside parking, or destination charging (e.g., beaches, parks, and museums) can help stimulate PEV deployment. In some cases, this could enable BEV travel between cities, though it is unlikely that BEV drivers will travel very long distances in the short term due to the time it takes to charge the battery per mile traveled.[59] The degree of support here depends on the willingness of consumers to purchase PEVs without a dense EVSE network or local businesses' willingness to allow publicly funded EVSE co-located with their businesses.

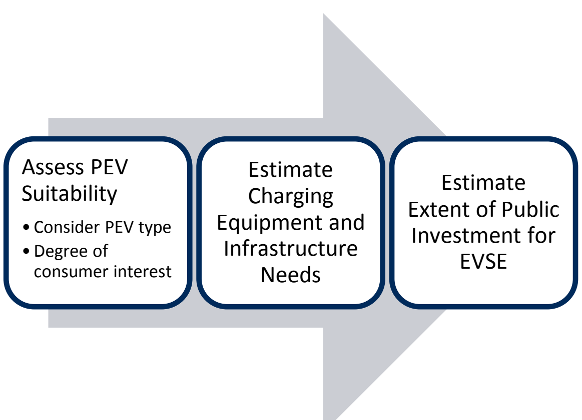
4.2 Public and Private Investment Actions

> ***"Automakers, charging infrastructure providers, electricity providers, NGOs, and government should work together to optimize public and private investments in the charging infrastructure location, amount, and type based on consumer interest and an assessment of charging equipment and infrastructure requirements."***
>
> ***– The PEV Dialogue Group***

Public and private investment in PEV charging infrastructure is a critical objective of the PEV Dialogue Group. The Group believes that optimizing these investments is a laudable goal, though it is a serious challenge in the nascent stages of PEV deployment. The fact is that some investments will not succeed while others will exceed expectations. However, there are steps that stakeholders can take to move towards optimization.

The actions in this chapter are largely location-specific since much of the growth in the early PEV market will be limited to certain regions. However, since these regions are geographically, culturally, politically, and economically diverse, early leaders can help to establish nationwide best practices related to PEV deployment and charging infrastructure installation and management.

Figure 4-2: Location-specific actions in sequential order.



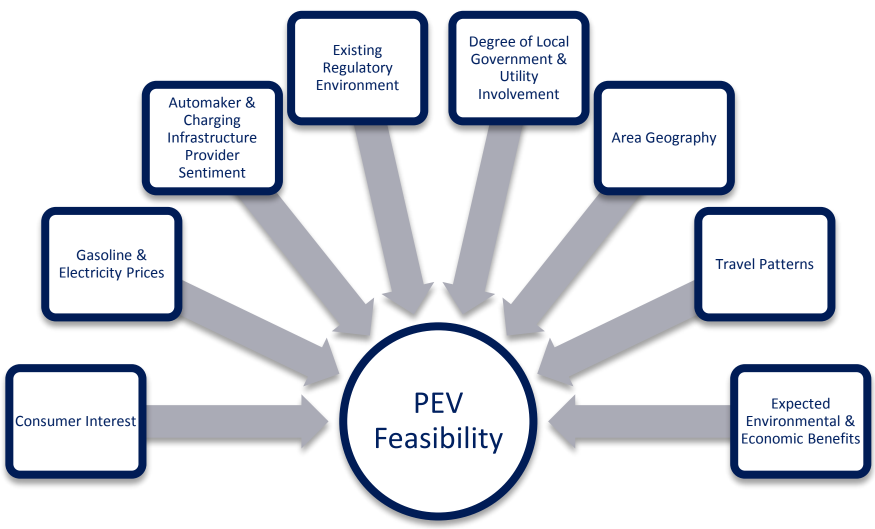
In addition, the actions in this chapter are laid out sequentially (see Figure 4-2). Thus, before estimates of public investments in EVSE or charging equipment and infrastructure needs are possible, stakeholders should assess the suitability of PEVs.

4.2.1 Assess PEV Feasibility

Automakers, auto dealers, PEV service providers, electric utilities, and NGOs should cooperatively develop a method to assessthe suitability of deploying PEVs in a geographic area and share this information with area governments.

Since the passenger vehicle and electricity markets vary greatly nationwide, evaluating the suitability of PEVs in an area is appropriate to optimize public and private investments. The evaluation should consider factors likely to influence consumer interest, including: purchasing power, gasoline and electricity prices, the existing regulatory environment, the degree of local government and utility involvement, area geography, travel patterns, and the expected environmental and economic benefits. The output of such an evaluation should provide the cost-effectiveness, PEV type (BEV versus PHEV), and the ability of PEVs to accommodate existing driving patterns.

Figure 4-3: NGOs, electric utilities, and other businessescan help estimate PEV suitability in an area.



Weighing the different attributes based on their influence on PEV suitability can help determine the likelihood of PEV adoption. While attributes that typically influence vehicle purchasing like consumer interest and fuel prices will carry the most weight, other factors will play a role as well. Regulators, state energy officials, local government, electric utilities, and businesses can increase the chance of PEV market success by taking the actions laid out elsewhere in the Action Plan.

The more criteria that an area meets, the more likely that PEV rollout will be successful. Mathematical modeling to predict the probability of success is possible, but it is not likely to be even moderately definitive until consumers have more experience with PEVs. PEV deployment efforts should incorporate the learning from ongoing PEV deployment projects, such as those being sponsored by the DOE, the Rocky Mountain Institute's Project Get Ready cities, and private-only ventures like NRG Energy's eVgo.

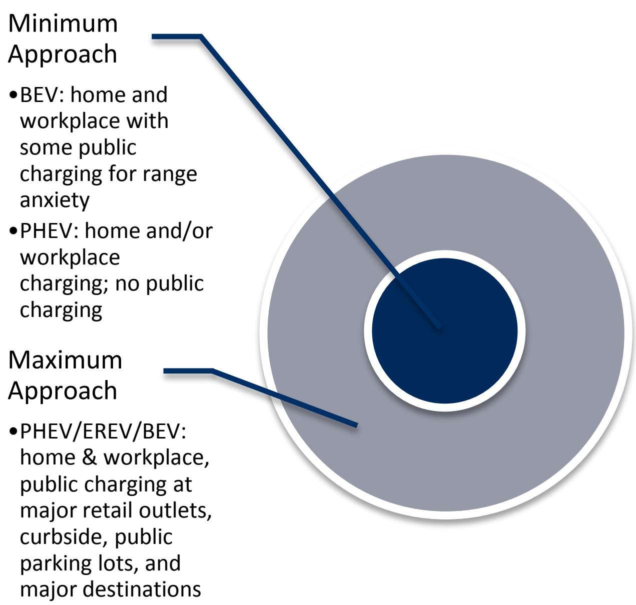
See *Appendix C* for an example scoring system to estimate PEV suitability in an area.

4.2.2 Estimate Charging Equipment and Infrastructure Needs

Automakers, PEV service providers, electric utilities and other electricity providers, and NGOs should collaborate to estimate charging equipment and infrastructure needs in a geographic area based on the expected PEVs in an area, travel patterns, and area geography.

Estimating charging equipment and infrastructure needs builds off the assessment of PEV suitability. The evaluation should help predict the kind of PEVs consumer will likely purchase, which matters most when estimating charging equipment and infrastructure needs. Thus, there are three pathways: one for BEVs, one for EREVs and PHEVs, and one for a mixed market of PHEVs, EREVs, and BEVs.

Figure 4-4: Charging infrastructure approaches.



Preferences that favor BEVs could lead to a considerably larger charging infrastructure network in terms of size and power needs than an area favoring PHEVs or EREVs. It is also likely that consumers in many areas will be interested in BEVs, EREVs, and PHEVs. Once the PEV type is considered, travel patterns and geography for an area matter most in estimating charging equipment and infrastructure needs.

With the idea in mind that BEV drivers will want ready access to power, and that EREV and PHEV drivers will want to maximize their electric miles traveled, the following are considerations for charging equipment infrastructure.

Charging Equipment Considerations

- BEV drivers will want AC Level 2 chargers (at least 3.3 kW) where they live and work to charge their battery during the workday or overnight. AC Level 1 charging may be suitable depending on the daily miles traveled.
- PHEV and EREV drivers require at least an AC Level 1 charger where they live and/or work to charge their battery either during the workday and/or overnight.
- Some targeted investment in public AC Level 2 chargers can benefit all PEV drivers.
- DC fast charging will likely only be for BEVs and is risky until the SAE finalizes its DC Level 2 coupler design, which could make some existing DC fast charging stations obsolete or expensive to retrofit.
- Consultation with the local electric utility can help resolve what kind of non-residential charging equipment ensures grid reliability.

Charging Infrastructure Considerations

Due to a lack of data on PEV driver behavior, the extent of charging infrastructure to accommodate PEV drivers is largely unknown for both early adopters and mainstream consumers. Pilot projects have provided evidence that range anxiety disappears quickly, but more evidence is needed before these kinds of concerns can be dispelled. Ongoing deployment projects, including the large deployment projects partially funded by the DOE as part of ARRA, will provide useful data on driver behavior. In the meantime, two approaches for charging infrastructure in the short term exist: a minimal approach that may only accommodate consumers knowledgeable about PEV technology and a maximum approach that aims to accommodate more drivers right away.

For the minimalapproach, BEV drivers will need home and workplace charging with some public charging to accommodate range anxiety. PHEV and EREV drivers will only need home or workplace charging; publiccharging is not necessary for PHEVs or EREVs, though it would allow these drivers to maximize electric miles traveled and thereby contribute to greater fuel savings. For the maximum approach, the approach is similar for PHEV, EREV, and BEV drivers. Home and workplace charging is necessary, and publiccharging should be considered at major retail outlets, curbside, and public parking lots.

Other factors that increase charging infrastructure requirements include:

- Land use that requires long distance driving between trips (e.g., home-to-work and shopping) will also need more charging infrastructure to accommodate daily driving needs.
- Certain kinds of area geography (e.g., topology with many elevation changes) and cold or hot climates lead to more charging infrastructure because vehicle electric-only range is reduced.
- Other factors such as areas with high traffic congestion that limit vehicle electric-only range.

4.2.3 Estimate the Extent of Public Investment in EVSE

Local and state government and NGOs should work together to estimate the amount of public investments in an area that are appropriate to overcome existing market deficiencies.

Market deficiencies like the lack of a price on greenhouse gas emissions and the failure to include external costs (e.g. military costs of securing oil) in gasoline prices, along with the desire to promote new technology development warrant some public subsidy for PEVs.[60] The existing federal and state subsidies that lower the vehicle's upfront cost can help to address these issues. Additional subsidies may be reasonable, but local and state government should carefully consider these investments only after an assessment of PEV suitability in a geographic area is completed.

As detailed in Chapter 3, upgrades to the electricity service and system for EVSE installation should be treated the same as upgrades needed by equipment with comparable power requirements within each rate class.

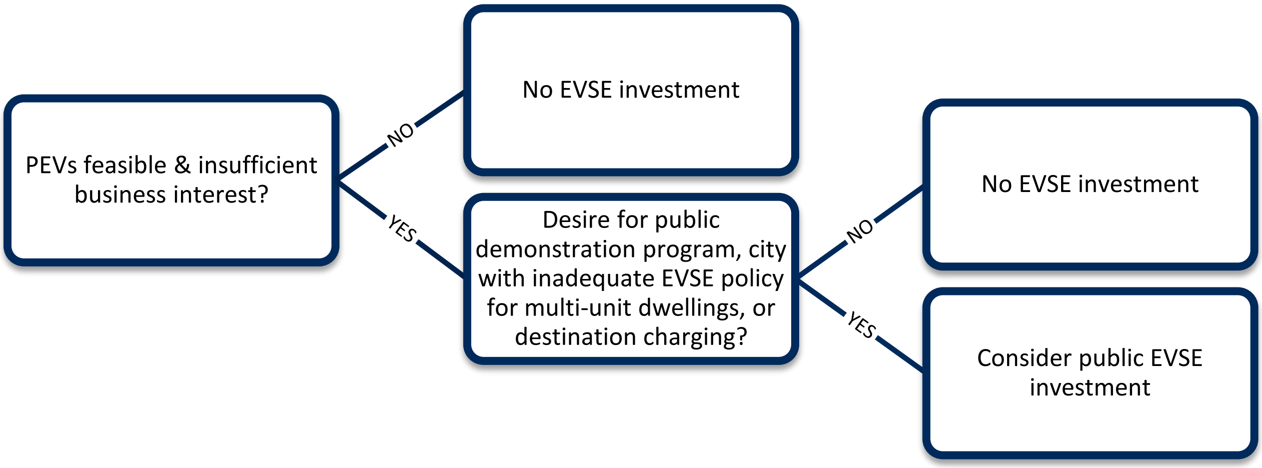
Regarding EVSE, new public investments should not be made for private EVSE. That is, government should not pay for EVSE that is not publicly available. Figure 4-5 conveys cases where local and state government should consider public investments in EVSE.

As outlined in the decision tree below, public investments only make sense if PEVs are feasible in an area and there is insufficient business interest. *Section 4.2.1*describesthe judgment of PEV suitability. Determining sufficient business interest is primarily based on the ability of the PEV service providers to build a charging infrastructure that satisfies the needs laid out in *Section 4.1.2*.

The following are three conditions that warrant the consideration of public investments in EVSE:

- **Public demonstration program**: Local governments will likely drive public demonstration programs. In the early stages of PEV deployment, publicly accessible EVSE can be a low-cost way of promoting PEV technology, raising awareness, and identifying best practices. Local governments should prioritize locations that will offer a lot of visibility and a high chance of use.
- **Cities with an inadequate EVSE policy for multi-unit dwellings**: Local governments may consider investing in publicly available EVSE for use by residents of multi-unit dwellings. In cities where the majority of residents live in multi-unit dwellings, PEV charging can be difficult as outlined in *Section 3.1*. In these places, local governments may consider public investments in EVSE to accommodate PEV drivers and overcome challenges related to condominium association policies or the actions of rental property owners.
- **Destination Charging**: Popular destinations for drivers such as parks, museums, or stadiums may be suitable locations to install public EVSE. In some cases, this could enable travel by BEVs between cities.

Figure 4-5: Decisiontree for local and state government and NGOs to estimate public investments in publicly available EVSE.



5 Facilitating PEV Rollout

The purchase process for a PEV does not stop at the auto dealer and involves an unprecedented number of stakeholders beyond those in the automotive sector. Automakers, auto dealers, electric utilities, electrical contractors, permitting offices and inspectors, and PEV service providers may all interact with a consumer during the vehicle purchase process. Beyond purchasing the vehicle, a consumer must determine whether, and how, to set up and install a home EVSE, choose from available PEV electricity rates, and access financial and non-financial incentives. Stakeholders are trying a variety of processes and new business models in the early stages of the PEV market in hopes of identifying best practices. As with the actions laid out in Chapter 4, actions here will largely depend on the geographic area.

> ***"Consumers expect a speedy PEV purchase process and should not have to interact with many different businesses before they drive a PEV off the lot."***
>
> ***– PEV Dialogue Group***

This chapter addresses stakeholder roles in supporting PEV rollout and identifies actions that will help facilitate the PEV purchase process and home installation of EVSE.

5.1 PEV Rollout Issues

The PEV Dialogue Group identified actions to increase stakeholder coordination and help accomplish the following objective:

- **Define vehicle and fuel purchase process**

In addressing challenges associated with this objective, the Group focused on purchasing and owning a PEV, vehicle charging, and accessing PEV-related incentives (both financial and non-financial). Consumers purchase a vehicle using a complex and individualized decision-making approach. The Group wants to ensure that stakeholders facilitate the purchase process to capture and enhance PEV benefits and to increase the likelihood that PEVs will fit more consumers' needs.

In developing actions to facilitate the rollout of PEVs, the Group considered the influence stakeholders have on consumer decisions and the need for stakeholder coordination. As a goal, the Group believes that consumers should be able to purchase a PEV in a comparable amount of time to a conventional vehicle. The Group also believes that transparency and consistency in how stakeholders communicate PEV-related information to consumers is critically important.

5.1.1 Purchasing and Owning a PEV

Almost all new vehicles in the United States are sold through franchised dealers, which are independently owned and serve as an extension of the automaker to the customer.[61] Automakers have worked to educate dealers about new PEVs before they are introduced to help prepare them for customer questions. However, the lack of consistency in regulations along with other issues laid out in the Action Plan makes training dealers to address all consumer issues a serious challenge that is largely location-specific.

In the short term, the PEV purchase process will be more complex than it is for a conventional vehicle.[62] The stakeholders involved in the PEV purchase process include not only the typical auto dealer and automaker, but also those that help a consumer install a home charger (e.g., electric utility, PEV service provider, and/or electrical contractor). It is possible that over time consumers will not need to install a new home charger because a compatible one may already exist. In the meantime, the auto dealer (and in some cases, the automaker) will serve as the central point that allows consumers access to a variety of stakeholders, as they might be averse to contacting many businesses separately during the PEV purchase process. Also, consumers will unlikely commit to a home EVSE, especially one provided by a PEV service provider via a service agreement, until the PEV purchase is certain.

When visiting a dealer, most consumers will be unsure of how purchasing and owning a PEV is different from a conventional vehicle. The time from an agreed sale to when a consumer can take a vehicle home can vary widely depending on the jurisdiction's PEV readiness as discussed in *Section 5.1.2*. Auto dealers' or local mechanics' ability to service these vehicles will also vary. Importantly, PEV maintenance will depend on the type of PEV; for instance, PHEVs and EREVs will still require occasional oil changes, while BEVs will not.

Much of the purchase process length depends on the coordination of the stakeholders involved. The consumer, electric utility, electrical contractor, and local government will have to coordinate to install a home EVSE, which could be facilitated by a PEV service provider or other business. Understandably, automakers and auto dealers do not want to interject themselves into this process, but they also want to ensure consumer satisfaction. To that end, automakers are forming partnerships in hopes of streamlining the purchase and EVSE home installation processes. These partnerships can help alleviate the concern identified in *Section 3.1.1* regarding electric utility notification. The following are three examples of partnerships:

- **Ford and Best Buy**: This effort represents an integrated process from the vehicle purchase and the installation of home charger provided by Best Buy's Geek Squad (and third party electrical contractors). The home charger provided by Leviton is removable. Ford estimates charging equipment and installation costs of around $1,500.[63]
- **General Motors and SPX**: General Motors is partnering with SPX to offer an AC Level 2 home charging system for $490 and approximately $1,500 for the installation), though installation costs vary widely depending on the existing home wiring. Since an AC Level 1 charger can recharge the Chevrolet Volt EREV overnight, an AC Level 2 charger is not necessarily required.[64]
- **Nissan and AeroVironment**: For Nissan's LEAF, the company is teaming with AeroVironment to provide home EVSE. Nissan charges $2,000 for a typical installation.[65]

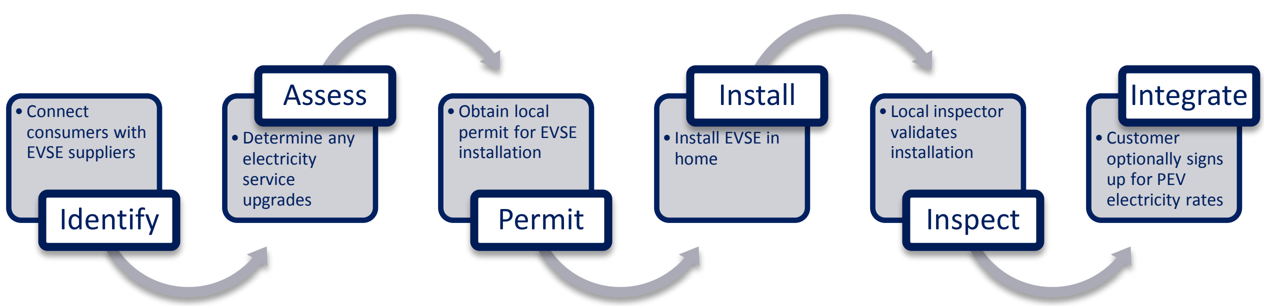
5.1.2 Vehicle Charging

If they do not use the partnerships formed by automakers, consumers will need to identify companies, including PEV service providers that install and maintain EVSE. They will also need to identify public charging stations and/or find out if workplace charging is available. Lastly, they will have to identify favorable (e.g., off-peak rate) and/or detrimental (e.g., demand charge) PEV electricity rates or additional costs associated with EVSE installation. If PUCs have not provided clarity on how PEVs are treated, some of this information may be unavailable or, worse, misleading.[66]

Consumers living in multi-unit dwellings will have to identify who, if anyone, is responsible for setting up and paying for installation. This information may not be readily available from expected sources, like condominium homeowner associations.*Section 3.1.1* further discusses the challenges related to multi-unit dwellings.

The process of installing a home EVSE will vary depending on local laws. Some proactive cities have streamlined permitting and inspection processes including Raleigh, North Carolina; Houston, Texas; and Los Angeles, California.[67] These cities can serve as models for other areas to follow. Raleigh prioritized inspections and permitting, which allows the entire installation to be done in 2 days, assuming no electricity service upgrades are necessary. Such a short process is only possible because the expected additional load on the electrical grid is small for the foreseeable future. To permit and inspect the installation of multiple EVSE, such as those that are publicly accessible, requires more analysis including expected electrical grid impacts (e.g., a distribution system impact analysis done in advance can help expedite the permitting process).

Figure 5-1: EVSE installation process (adapted from http://bit.ly/oywn6S).



PEV service providers are currently implementing different business models to accommodate home charging and beyond, since many consumers may need access to charging outside the home. Consumers will have an opportunity to pick a provider that best meets their needs.The following are examples of some business models:

- **Better Place**: Better Place has a business model to own the battery inside a BEV. By removing the cost of the most expensive component of a BEV, the company can make BEVs' upfront costs competitive with conventional vehicles today. Charging a per-mile fee similar to cellular per-minute rate plans, Better Place hopes to change the way people look at BEVs and the automobile itself. Not only will they plan to have an EVSE network, they also intend to install robotic battery swapping stations to make "fill ups" convenient. Battery swapping capability is a unique component of their network that distinguishes Better Place from competitors.

- **NRG Energy**: NRG Energy's eVgo program charges a monthly fee to subscribers, relying on this income base to build a comprehensive network of commercial and residential EVSE. The company is offering three subscription plans ranging from $49 to $89 per month with no upfront cost to install a home EVSE. For plans that include electricity usage, the eVgo charging system is in part relying on fuel (i.e., electricity) price certainty to build a customer base. AeroVironment will provide the EVSE for eVgo.
- **Coulomb Technologies**: Coulomb operates the ChargePoint Network of EVSE. In addition to its private, residential installations, Coulomb sells ChargePoint stations to commercial and public entities. The company offers AC Level 1, AC Level 2, and DC fast chargers.[68] EVSE owners set the price for using the station. Coulomb formed a public-private partnership through a grant of $15 million from ARRA to deploy its network in select locations nationwide.
- **ECOtality**:ECOtality operates the Blink Network of EVSE. Like Coulomb Technologies, the company installs both residential and commercial EVSE. ECOtality offers AC Level 2 chargers and DC fast chargers (using the CHAdeMO compliant connector). Its plan allows anyone to use a publicly available station, but provides discounts and other benefits to Blink Network members. Also like Coulomb, ECOtality formed a public-private partnership after receiving a grant worth over $100 million from ARRA to deploy its network in select cities nationwide.
- **350Green**: The modelofferedby350Green is unlike its competitors. The company installs publicly available AC Level 2 and DC fast chargers but does not provide home EVSE. 350Green offers (unspecified) pricing plans including a pay-per-use plan and a monthly subscription plan that provides access to its network.

Looking ahead, electric utilities also can make money servicing PEV load, even while holding rates steady or decreasing them. If PEVs capable of providing grid services through V2G become readily available, electric utilities may also wish to provide EVSE to consumers through business models that aim to lower grid operational costs. However, some concerns may exist about utilities providing EVSE (see *Section 3.1.1*).

5.1.3 Accessing Incentives to Support PEV Deployment

A number of jurisdictions are providing incentives for PEV drivers including favorable electricity rates; parking, high-occupancy vehicle (HOV) lane access, and other privileges; EVSE discounts; and tax credits or deductions. In the past, these incentives, especially non-financial incentives like HOV access have stimulated vehicle purchases. The financial incentives can significantly reduce total cost of ownership, but they are likely to be available only in the short term.

Electricutilities want PEV owners to charge their vehicles off-peak when the costs of services are lowest and many will offer rate plans to encourage consumers to take advantage of lower off-peak prices. These plans could lower a consumer's electricity bill below what it would be otherwiseand maximize savings relative to gasoline. To provide background and context, the table below includes a number of existing incentives along with examples.

Table 4:Policies to support PEV deployment. Many of these policies are market corrections (e.g., fuel economy and greenhouse gas standards, TOU electricity rates, and carbon price).

Policies	Level of Government			Example
	Federal	State	Local	
Financial Incentives				
Funding for R&D	✓	✗	✗	ARPA-E battery research grants
Manufacturing Incentives	✓	✓	✗	$2 billion PEV battery and component vehicle manufacturing grants from ARRA
Public Infrastructure Incentives	✓	✓	✓	Maryland offers a tax credit up to 20% of the EVSE cost.
Private Infrastructure Incentives	✓	✓	✗	ECOtality offers home EVSE at no cost partially funded by a federal grant
Purchase Incentives (tax credit, rebate, etc.)	✓	✓	✗	Utah offers a tax credit of up to $2,500 for a PEV purchase
Free Parking	✗	✓	✓	Hawaii exempts PEVs from parking fees by non-federal governmental authorities
Reduced Bridge and Toll Roads	✗	✓	✓	California allows PEVs on the HOV lane, which has a discounted bridge toll
Reduced Vehicle Registration Fees	✗	✓	✗	Washington DC offers a reduced registration fee for PEVs
Reduced Electricity Rates for Charging (TOU)	✗	✓	✗	Virginia Dominion Power provides a PEV charging rate reduction
Non-Financial Incentives				
HOV Access	✗	✓	✗	PEV drivers can use HOV lane on New Jersey Turnpike
Exemption from Vehicle Inspection	✗	✓	✗	Michigan exempts PEVs from vehicle emission inspections
Other				
Fuel Economy and Greenhouse Gas Standards	✓	✓	✗	2012-2016 federal vehicle standards
Gasoline Tax or Carbon Price	✓	✓	✗	PEVs users do not have to pay a motor fuel tax on electric miles traveled
Low-Carbon Fuel Standard	✓	✓	✗	California has a low-carbon fuel standard that will promote alternative fueled vehicles including PEVs
Zero Emission Vehicle (ZEV) Mandate	✓	✓	✗	California's ZEV Program will require automakers to sell some ZEVs including PEVs in the state
Streamline Processes	✓	✓	✓	Raleigh developed a two-day process for home EVSE installation
Facilitate Information Sharing	✓	✓	✓	DOE awarded community planning grants totaling $8.5 million and will help share results
Lead by Example – Fleets	✓	✓	✓	General Electric's commitment to purchase 25,000 Chevrolet Volts

5.1.4 Existing Efforts to Facilitate PEV Rollout

Many deployment efforts are already underway, and there is an opportunity to learn from these experiences and improve ongoing and future PEV introductions. Automakers are partnering with PEV service providers. Local governments have "get ready" projects to prepare stakeholders for the growth of the PEV marketplace. They are also working with businesses and citizens to identify convenient charging locations within their communities. The Rocky Mountain Institute's Project Get Ready also aims to prepare businesses and local governments for PEV deployment. In the case of California, the PUC has directed the utilities under its jurisdiction to conduct public education and outreach on charging as well as to the environmental and financial benefits of PEV driving. Some local governments have been proactive, largely because they are the launch cities for PEVs from General Motors and Nissan, which have led local efforts to encourage consumers to purchase their inaugural PEVs. As more automakers introduce models over the coming years, more areas will benefit from initial PEV launches.

Competing interests among the automakers can make it difficult to determine the extent to which their efforts favor their own business. Some work is clearly applicable across vehicle types and PEV service business models, but other actions could limit competition, and in some cases, increase costs to individual consumers or the public.The involvement of entities such as local government or NGOs could help avoid such cost increases.

5.2 Actions to Facilitate PEV Rollout

> ***"Automakers, auto dealers, EVSE providers, electric utilities, and government should take action to smooth the PEV purchase process, especially home EVSE installation."***
>
> ***– PEV Dialogue Group***

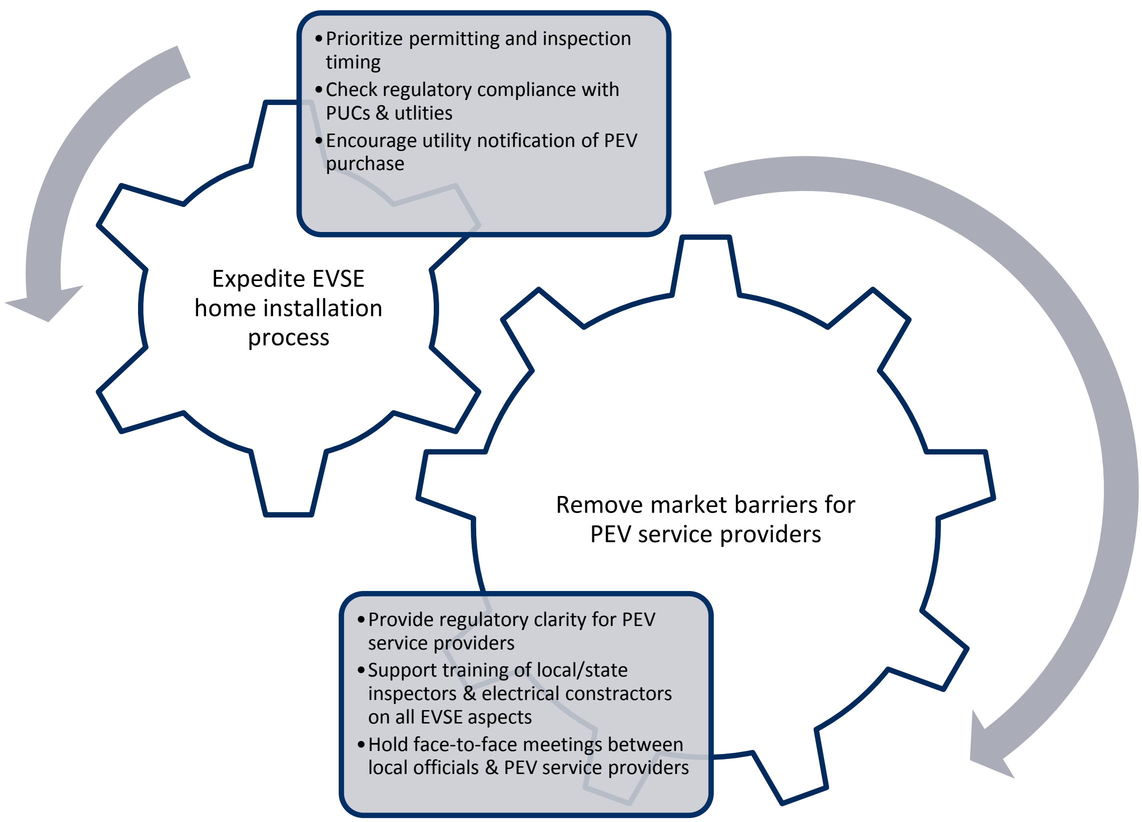
The rollout of PEVs is the culmination of activity to prepare an area for PEV introduction. The relevant businesses and government must be proactive to ensure the purchase process for consumers is as smooth and satisfying as possible. For instance, consumers may have to line up their own electrical contractor before purchasing a home EVSE, or the electric utility, EVSE provider, an automaker's third-party installation service provider, or auto dealer may help with that process.

To facilitate this process:

1. **Local government, electric utilities, and PUCs should designan expedited EVSE home installation process**: A locality can speed up permitting and inspection processes to reduce overall installation time. Localities can also promote training, best practices as identified by early-action cities, and guidelines for electrical contractors. PUCs and electric utilities should provide assistance when creating this process to ensure regulatory compliance. Steps should also be taken to encourage utility notification about EVSE installation.

2. **PEV service providers, local and state governments, and PUCs, should cooperatively remove local and state market barriers for PEV service providers**: Legal and regulatory hurdles that prevent a PEV service provider from competing in an area could exist. For instance, it may be unclear if a PEV service provider is subject to the same regulations as a utility. In addition, awareness by the public, automakers, auto dealers, and local government could also be a challenge. PEV service providers should identify local and state barriers that prevent them from introducing their product in a market. They should work together with automakers, PUCs, and local and state government to clear those barriers and facilitate new market introduction. Local and state government should support the training of inspectors and electrical contractors on all aspects of EVSE installation. Face-to-face meetings between PEV service provider representatives and government officials can begin this process.

Figure 5-2: Action by NGOs, electric utilities and other businesses, and local and state government to facilitate PEV rollout.



Current Examples

As mentioned earlier, the cities of Raleigh, Los Angeles, and Houston have developed streamlined processes that prioritize EVSE inspection and permitting. These actions include requirements for next day inspection after EVSE installation illustrating the priority of PEVs amongst city activity.

6 Educating Consumers

The PEV is a transformative automobile –some call today's PEVs the most advanced vehicles on the road. The difference between PEVs and conventional vehicles covers a vast array of what defines a car today: the vehicle's drivetrain, the technology embedded in the vehicle, the driving experience, maintenance requirements, the refueling process, and total cost of ownership (TCO). Stakeholders must work together to educate consumers on the differences between PEVs and conventional vehicles for PEVs to reach mainstream consumers.

> ***"Helping consumers understand the value proposition of PEVs is necessary to bridge the market from early adopters to the mainstream consumer."***
>
> ***– PEV Dialogue Group***

This chapter focuses on the main challenges to consumer education related to PEVs. The actions laid out in this chapter identify tools and stakeholder activities that will help consumers understand the PEV value proposition and bridge the PEV technology information gap.

One of the main challenges to PEV deployment is undoubtedly the high upfront cost of the vehicle, especially considering vehicles are already one of the most expensive purchases consumers make. In addition, the technologicallyadvanced PEVs (especially BEVs) introduced into the automotive market require consumers to learn about a number of new facets of the car-owning experience.

6.1 Consumer Education Issues

The PEV Dialogue Group identified actions that help accomplish the following objectives related to consumer education:

- **Define value proposition**
- **Bridge technology information gap**

The Grouplooked at a specific set of consumer education challenges that are especially relevant in the early stages of the PEV. The Group believes that PEVs offer a strong value proposition today; one that will grow as technology develops. The Group also believes consumers will need to rethink what it means to own and operate a vehicle. Stakeholders must help to address these challenges for PEVs to gain mainstream market acceptance.

- Consumers cannot readily estimate fuel, maintenance, and other costs over their vehicles' lifetime or other timescales (e.g., monthly).
- Consumers do not have information readily available to understand the complete value proposition provided by PEVs including non-financial benefits (e.g., energy security impacts).

- Consumers are uncertain of the differences between the types of PEVs (PHEVs, EREVs, and BEVs) and the differences between PEVs, fuel-efficient conventional vehicles, and other alternative fuel vehicles (e.g., hybrid electric vehicles and hydrogen fuel cell vehicles).

In developing solutions, the Group looked at online and offline solutions since consumers spend 60 percent of their time shopping for cars online and 40 percent visiting auto dealers and other offline activities.[69]

6.1.1 PEV Value Proposition

Unless the high cost of the battery is financed separately somehow, PEVs will cost more upfront than their conventional counterparts for the foreseeable future. But the value proposition PEVs offer goes far beyond the initial upfront cost. In fact, consumers will be more likely to purchase a PEV if they understand the benefits of electric driving, such as financial and environmental benefits.[70] The financial benefits include the PEV's TCO, which could be lower than a conventional vehicle through fuel and maintenance savings.[71] Benefits without a clear price tag include the driving and refueling experience, environmental and energy security impacts, the image driving a PEV projects, and the use of cutting-edge technology.

Automobile purchases are driven by many factors. Features like a sunroof, cup holders, and sound system are often important to consumers. Although the automobile is the second largest purchase many will ever make, the rationale behind the vehicle's purchase is often not around TCO. If consumers were only concerned with reliability and fuel efficiency, then the most fuel-efficient and reliable vehicle that accommodated the consumer's size requirement would be the most popular choice. This is often not the case.

There is a need to identify effective ways of presenting the value proposition provided by PEVs and identify the best message to educate consumers. Currently, automakers are working to identify the best practices to guide consumers in the purchase process. For example, some consumers may prefer to understand the vehicle operating cost on a monthly basis instead of TCO, and any tools created should accommodate this preference. Non-financial benefits will also require creative and concerted approaches, especially considering their importance to PEV market growth in the short term.

Understanding TCO

Some consumers purchase a vehicle using the vehicle's TCO as a guide. These consumers could purchase PEVs if TCO for a PEV is favorable to that of a conventional vehicle.

Almost all consumers know the price of gasoline, even if they do not actively drive. The visibility of gasoline's price along the road and high annual fuel costs can heavily influence consumer purchasing decisions. Meanwhile, many consumers do not know the price of electricity and are likely to be unaware of PEV-specific electricity rates.

There is evidence that consumers value fuel savings more when fuel costs spike and revert to old preferences when fuel costs return to familiar levels. Without sustained high fuel costs, the effects of fuel savings on consumer preferences are unclear, even thougha PEV driver could save over $1,000 a year depending on the price of gasoline and electricity, geographic location, and average annual mileage driven.[72] These savings can be even larger with special PEV electricity rates that capture the true cost of off-peak charging.

Automakers expect PEVs to have lower maintenance costs than conventional vehicles. Common maintenance activities like oil changes are required less often, or, in the case of BEVs, are unnecessary. Furthermore, electric drive vehicles like the extended-range Chevrolet Volt and BEVs do not have a drive shaft or a clutch. PEVs also use regenerative braking to extend the vehicle's all-electric range and lower the wear and tear on the brake system. Even vehicles with complex powertrains like the parallel PHEV Toyota Prius Plug-in Hybrid are expected to have lower maintenance costs than a conventional vehicle.[73]

Since consumers spend most of their time online when shopping for new cars, the most practical way to teach consumers about TCO for PEVs may be on the internet. Many websites offer tools and calculators that give consumers general ideas about cost-effectiveness or environmental impacts of some products. A sophisticated calculator that is tailored to an individual does not yet exist for PEVs, however.As for who is the best provider of such a service, consumers rely on third party websitesas much as on sites run by automakers.[74]

Today, consumers must collect data from multiple sources on fuel costs (gasoline or electricity), vehicle operating costs, and charging infrastructure costs to make a TCO comparison between a PEV and a conventional vehicle. Consumers must then calculate respective costs and benefits in the current and future years. Complicating this further are expected cost reductions in battery development in the coming years if manufacturers reach economies of scale.

Non-Financial Benefits

For many consumers, other factors will play a more important role in purchasing a PEV than TCO, especially in the short term. PEVs provide additional value by offering a potentially quieter and more responsive driving experience. Yet, they come with different costs as well. Many consumers may be drawn to the cutting-edge technology inside PEVs that aims to transform personal transportation. PEVs appeal to consumers who are concerned about air quality and climate change impacts of driving and to consumers who are concerned about energy security and the continued reliance on oil. Finally, some consumers will want to be the first in their communities to own and drive a PEV.

Conveying the value of non-financial benefits is challenging. Providing metrics like tons of carbon dioxide saved or barrels of oil saved likely means more to society than to individual consumers. Further, explaining the driving and refueling experience may require creative approaches such as hands-on or multimedia experiences.

6.1.2 Technology Information Gap

Technically speaking, PEVs are different from conventional vehicles. Consumers will need help in understanding the technical capabilities and limitations of BEVs, EREVs, and PHEVs. Consumers have to know the difference between these PEVs along with hybrid electric vehicles and, eventually, hydrogen fuel cell vehicles (see Table 5).

PHEVs, EREVs, and BEVs are distinct vehicle models, and consumers face unique choices.The fact is that a BEV is a fundamentally different car than a conventional vehicle, an EREV is a combination of a BEV and some of the features of a conventional vehicle, while a PHEV is a conventional vehicle with some of the features of a BEV. The distance consumers can travel in a single trip is shorter with BEVs. At the same time, driving a BEV produces no direct tailpipe emissions and can accommodate most trips.

Table 5: Current state of PEV technologycompared to other vehicle types. No hydrogen fuel cell vehicle is in mass production today, but Toyota plans to introduce one in 2015.[75]Petroleum includes gasoline and diesel, except when referring to energy security; most biofuels are produced domesticallytoday.

Category	BEV	PHEV/EREV*	Hybrid Electric Vehicle	Conventional Vehicle	Natural Gas Vehicle	Hydrogen Fuel Cell Vehicle
Engine	electric motor	electric motor,ICE		ICE		electric motor
Onboard Energy Source	battery, regenerative braking	battery, regenerative braking, petroleum or biofuels		petroleum or biofuels	natural gas	fuel cell, battery, regenerative braking
External Energy Source	electricity	electricity, petroleum or biofuels	petroleum or biofuels		natural gas	hydrogen
Electric Drive Range	75-300 miles**	10-40 miles	<1 mile	0 miles		>200 miles
Maximum Range	75-300 miles	>300 miles			>150 miles	>200 miles
Home Refueling Option	yes (AC Level 1/2)	yes (AC Level 1 or AC Level 2)	no		no	no
Refueling Time	depends on battery and charging level		<5minutes			
Energy Security Impact	nearly 100% domestic source	depends on number of electric miles	nearly half of petroleum is imported; almost all biofuels are domestic		mostly domestic source***	
Tailpipe Emissions	none	none for electric miles	greenhouse gases, ozone, etc.			None
Upstream Emissions	depends on electrical grid mix		depends on petroleum or biofuels lifecycle		depends on natural gas lifecycle	depends on hydrogen source

* When the ICE is running, a PHEV has similar characteristics to a hybrid electric vehicle. The table uses electric-only characteristics.

** The Tesla Model S available in 2012 will be able to travel from 160 to 300 miles on a charge depending on the battery system included.

*** Nearly all U.S. hydrogen comes from natural gas, a mostly domestic energy source (http://bit.ly/r6hKVy) and in the longer term could come from electrolysis or coal with carbon capture and sequestration.

The information gap that currently exists for PEV technology is substantial; a major education effort by public and private entities can create a bridge from conventional to these advanced alternative vehicles. Consumers have been slow to learn about alternative vehicle drivetrains. For instance, hybrid electric vehicles have been on the road for over a decade and many consumers are still unaware of how they differ from a conventional vehicle.

6.2 Actions to Educate Consumers

> ***"Automakers, PEV service providers, electric utilities, NGOs, and government should work together to increase consumer knowledge about PEVs' value proposition and PEV technology using an online and offline approach."***
>
> ***– PEV Dialogue Group***

The PEV Dialogue Group believes consumers will ultimately decide the success of PEVs in the United States. The Group also believes the only way for consumers to make a rational decision about purchasing and using a PEV is if they are able to recognize the PEV's value proposition and if they understand the technological differences between PEVs and other vehicles.

The actions laid out below rely on offline and online steps that require harnessing advanced technology and traditional sales and marketing activities. The Group strongly believes the internet will help inform consumers about the value and technology of a PEV, but that nothing can replace a test drive to demonstrate the satisfying, fun driving experience thatPEVs offer.

6.2.1 Create Tools to Help Consumers Understand PEV Value Proposition

The value proposition PEVs provide includes tangible operational cost savings such as lower fuel and maintenance costs throughout the vehicle's lifetime. In the short term, however, consumers may find non-financial benefits more valuable, like the driving experience or the statement driving a PEV conveys. Since consumers attain most of their information about vehicles online, stakeholders should cooperate on unbiased web tools that accurately communicate the PEV value proposition.

Unless businesses or the government offer financing schemes to lower the upfront cost of vehicles in the near term beyond tax credits already in place, consumers will need to estimate these cost savings over time (i.e., TCO) to determine if a PEV is practical for them, financiallyspeaking. Consumers will also need help in understanding PEVs' technical capabilities and limitations, the environmental and energy security benefits of electric driving, and the available public and private financial incentives.

Web-based tools could help consumers understand the value proposition of PEVs including PHEVs or EREVs versus BEVs. The tools could provide personalized results based on location, driving patterns, and local motor fuel and electricity prices, including special PEV electricity rates where applicable.A TCO tool could calculate fuel costs and estimate maintenance costs based on these inputs. The tools could also customize results based on consumers' interest in environmental protection and energy security. Results from these tools could include monetary, environmental, and energy security impacts of driving a PEV compared to a conventional or alternative vehicle.

Figure 6-1: Consumer web tools developed by NGOs,automakers, electric utilities, PEV service providers, and other businesses to estimate a personalized TCO and other factors that make up the PEV value proposition.

Current Examples

The EPA's fuel economy label for PEVs provides generic information for consumers regarding fuel savings, smog rating, and greenhouse gas rating (http://www.epa.gov/carlabel/basicinformation.htm).

GoElectricDrive.com provides acost calculator that indicates what consumers could save by driving a PEV (http://www.goelectricdrive.com). The TCO calculator portion of the web tool proposed in the Action Plan would build off this calculator by:

- Providing greater personalization
- Supporting locations nationwide
- Considering qualitative factors like driving experience and environmental benefits
- Comparing PEVs with a greater range of conventional vehicles and other alternative vehicles like hybrid electric vehicles

In sum, the Group proposes developing a toolthat would result in cost estimates with greater accuracy and provide consumers with a better sense of the total PEV value proposition than consumers can find now.

6.2.2 Close the PEV Technology Information Gap

The technological differences between PEVs and conventional vehicles warrant concerted actions by automakers, NGOs, electric utilities, PEV service providers, auto dealers, other businesses, and government to educate consumers. The information gap that currently exists is substantial; a major education effort by public and private entities can create a bridge from conventional vehicles to these advanced alternative vehicles.

The focus of an effort to close the technology information gap should be to increase PEV publicity, develop web tools on PEV technology, and improve stakeholder outreach. The tactics should involve work that is both online and offline. While consumers obtain most of their information about vehicles online, there is no replacing test drives and other valuable hands-on experiences.

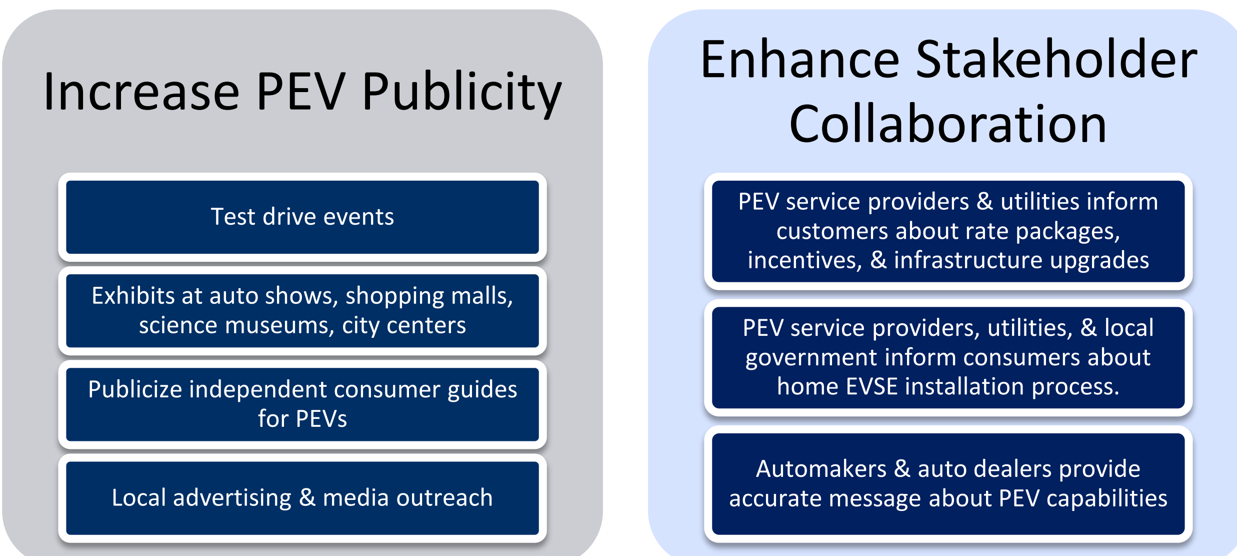
Online Tools

Stakeholders should develop engaging and sophisticated web tools to educate consumers about the difference between PHEVs, EREVs, BEVs, other alternative vehicles, and conventional vehicles. Focus areas should include the vehicle drivetrain, refueling method, manufacturing process, maintenance process, driving experience, vehicle range, and a method to evaluate a PEV's ability to satisfy existing driving needs.Interactive tools that harness the latest web technology can more easily teach consumers about complex topics than reading materials or television commercials.

Offline Efforts

Figure 6-2 provides an overview of the offline actions that will increase PEV publicity and enhance stakeholder collaboration. The actions below are already happening in areas where automakers are introducing PEVs. For example, General Motors and its auto dealers have collaborated with electric utilities and local government to ensure a smooth introduction of the Chevrolet Volt. For these vehicles to be successful nationwide, similar activities must be replicated appropriately.

Figure 6-2: Steps byNGOs, automakers, auto dealers, electric utilities,PEV service providers, otherbusinesses, and local government to bridge the PEV technology information gap for consumers.



Current Examples

The Action Plan builds off the programs illustrated below relying on technology-neutral information and in-person events. The proposed actions will provide consumers with additional unbiased information and hands-on experience.

- *GoElectricDrive*'s website provides information for consumers about owning and operating PEVs including consumer incentives, public EVSE locations, and an overview of vehicle technology(http://goelectricdrive.com).
- PluginCars.com provides a lot of useful information about PEV technology(http://www.plugincars.com).

- Southern California Edison (SCE) offers a checklist called “Before Bringing Home a PEV” to inform consumers about home and permitting needs for PEV ownership (http://www.sce.com/powerandenvironment/pev/plug-in-ready.htm).
- General Motors has up-to-date information on the Chevrolet Volt designed to help educate consumers (http://www.chevroletvoltage.com).
- Ford has an interactive webpage where consumers can decide which kind of PEV is best for them after answering a series of questions (http://www.ford.com/technology/electric/evforme).

7 Next Steps

The Action Plan, created by the PEV Dialogue Group, is an attempt to lay out the steps necessary to integrate PEVs with the electrical grid nationwide. The Action Plan is Phase I of the PEV Deployment Initiative (PEVDI), a unique effortled by C2ES aimed at accelerating PEV adoption nationwide.

While the Action Plan takes a broad look at the challenges related to PEV-grid integration, it is not a complete blueprint. Considering the immense breadth of this effort, the Group avoided duplicating other worthwhile, ongoing efforts. The Action Plan aims to complement these efforts using the unique skills provided by the Group.

The Action Plan suggests roles for businesses, electric utilities, government, and NGOs in PEV deployment, and it identifies needed actions fora compatible regulatory framework, public and private investment, PEV rollout, and consumer education.

Throughout this project, the Group identified additional gaps in addressing challenges related to PEV deployment that went beyond the scope of this initial effort. Phase II of PEVDI will constitute the implementation of the Action, including the following four projects:

- **Connect PEV Leaders around the Country:** Convene PEV leaders to foster state-level action, specific to the needs of transportation agencies and PUCs, through peer exchanges and educational workshops. Be the connective tissue for disparate efforts nationwide to encourage the sharing and development of best practices, and to ensure that actions taken at state and local levels are compatible with each other.
- **Advise Individual PEV Efforts**: Provide strategic advice to state and local PEV planning efforts. Focus on regulatory issues, optimizing public and private investments, and facilitating rollout.
- **Driver Behavior Analysis**: Conduct research on PEV driver behavior as it relates to vehicle charging infrastructure needs, grid reliability, transportation system financing, and maximizing electric miles traveled.

  Consumer Education Strategy: Create and promote a web platform to educate consumers on the PEV value proposition and PEV technology.

With Phase II,C2ES intends to work with the PEV Dialogue Group toimplement the Action Plan. C2ES will lead efforts to advocate for implementation of the Action Plan with businesses, stakeholders, and officials at the local, state, and federal levels. The emphasis will be on solutions to key challenges including harmonizing a regulatory framework nationwide, overcoming the consumer information gap, and optimizing public and private investments. C2ES will track progress on the implementation of the Action Plan on its website and through publications.

7.1 Connect PEV Leaders around the Country

To address the major challenges of PEV deployment, coordination is needed with policymakers, regulators, the business community, researchers, NGOs, and the public.With the numerous pilot programs and consumer studies currently under way, there is a need to identify best practices and common standards for managing consumer demand and understanding stakeholder responsibilities.The Action Plan highlights the need for high-level coordination and planning among all PEV stakeholders to address complex and time-sensitive challenges.

The Group will complete the *Connect PEV Leaders around the Country* by producing a common set of materials, leading and facilitating monthly meetings, coordinating initiatives at all levels of government, and sharing lessons learned.The Group will work with various non-governmental and government partners to produce and disseminate these materials.

7.2 Advise PEV Stakeholders

Chapters 3 and 4 of the Action Plan identified the need for coordination and planning at the local, state, and regional levels.Various state and local governments have already implementedkey rules and regulations, and current regulatory actions are not being coordinated in ways that will assure the smooth development of the PEV marketplace.The ongoing pilot programs and future consumer studies will help determine and influence state and region-specific policies.Overall, regulations that capture best practices and adopt common standards can lay a foundation for PEVs to help maintain the reliability of the U.S. electrical grid and preserve low electricity costs to consumers.

Through *Advise PEV* Stakeholders, the Group will provide expertise on electricity and transportation regulations, the optimization of public and private investments, and the facilitation of PEV rollout. This will help ensure that stakeholder actions taken in different areas are compatible.

7.3 Driver Behavior Analysis

In Chapter 4, the Action Plan identified significant uncertainties regarding driver behavior.Key stakeholders are uncertain of both the nature and length of PEV trips and where PEV drivers charge their vehicles.As the market develops, it is critical that researchers analyze data on driver behavior and share results with relevant stakeholders.

With *Driver Behavior Analysis*, the Group will focus on driver behavior research using information available from pilot projects.By collaborating with pilot project leaders,the Group aims to identify and publicly share ways to optimize EVSE locations, maintain grid reliability, and maximize vehicle range.

7.4 Consumer Education Strategy

Chapter 6 of the Action Planidentified how successful PEV deployment will depend on educating mainstream consumers.Consumers are most likely to seek information on PEVs from thirdparty, online sources.As such, the development of a web platform that provides up-to-date information and allows consumers to make an educated choice about purchasing a PEV will be an essential undertaking.

The envisioned *ConsumerEducation Strategy* will develop, validate, and share interactive and portable tools and resources to educate consumerson the PEV value proposition and up-to-date information on the latest PEV technology.The portal willprovide analysis tools that willinform consumers about PEV benefits, TCO calculation, PEV technology, and region-specific PEV information, such as layered maps that include policy incentives and vehicle charging options.The Group will work with a variety of government and business partners to develop the portal and promote it through a variety of avenues.

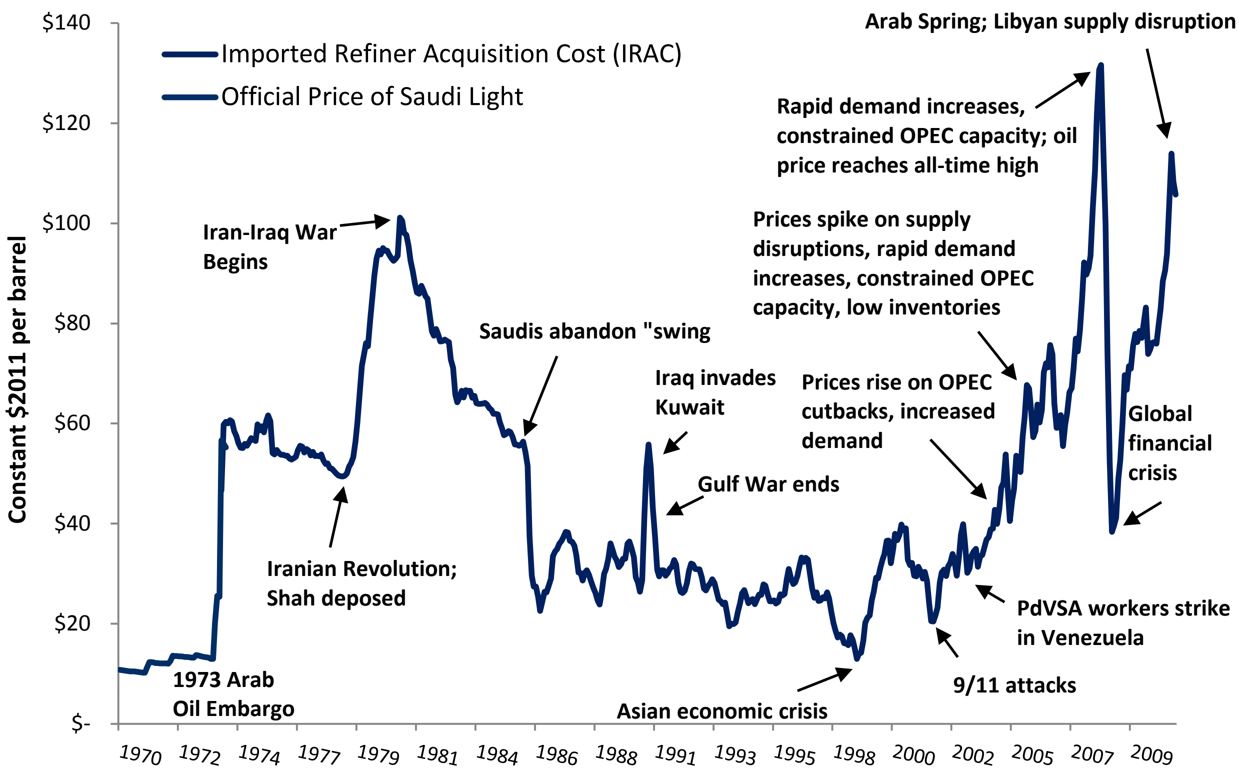
Appendix A. Action Plan Terms of Reference

The Group jointly created the terms of reference below.

1. Take into account the input of a broad and diverse set of stakeholders.
2. Accelerate PEV adoption in a manner that maximizes greenhouse gas emission reductions, energy security benefits, electrical grid reliability, and economic benefits (including job creation).
3. Consider existing efforts at all levels of government and identify reform priorities.
    a. Identify best practices from ongoing efforts, such as those by the states of California, Washington, and Michigan.
    b. Support PEV deployment by transportation agencies.
    c. Identify options for PEVs that help finance the existing transportation infrastructure.
4. Phase in over time and aim to identify and maximize short-, medium-, and long-term net benefits and emphasize new business model development, timely vehicle purchase, home charging installation, and a skilled workforce. The Action Plan should be structured to encourage innovation and be adaptive, through performance measurement, assessment, and analysis. The Plan will also examine the steps necessary to lay the groundwork for potential grid services to be provided by PEVs (e.g., ancillary services, peak shaving, and demand response).
5. Address legal, technical, and economic hurdles and risks, identify opportunities for cooperation, and lay out next steps.
    a. Address regulatory issues with an emphasis on barriers to business and technological innovation, managed versus unmanaged charging, and enabling price signals to consumers to encourage off-peak charging.
    b. Prioritize private and public investments for charging infrastructure including public policies that will support business model development

Appendix B. Oil Price Volatility

The figure below conveys the relationship of oil price volatility and events in oil producing countries since 1970.C2ES created the figure by updating data available from DOE's website (http://bit.ly/ntcraw).



Appendix C. Example Scoring System

Below is an example of how a scoring system might look including an evaluation matrix and an example community.Estimating how an area satisfies each category depends on the degree to which it meets the listed factors.

Category	Weight	Factors
Consumer Interest	Very High	High interest in the environment, high-tech, energy security; high income
Gasoline & Electricity Prices	Very High	High differential between gasoline and electricity prices; low electricity prices; high gasoline prices
Automaker & PEV Service Provider Sentiment	High	Flagship area for automaker and PEV service provider
Existing Regulatory Environment	Medium	Compatible with Action Plan utility principles; compatible with Action Plan on addressing regulations
Degree of Local Government & Utility Involvement	Medium	Active interest from local utility; active interest from local government
Expected Environmental & Economic Benefits	Medium	High smog levels; high concentration of PEV-related businesses
Area Geography	Low	Flat terrain; moderate climate
Land-use Patterns	Low	Many dense mixed-used areas; low per capita vehicle miles traveled

An Example – Electricville, Missouri

Electricville is a medium-sized city in the Midwestern United States. The land in and around Electricville is mostly flat, and the climate is mostly temperate with a few cold winter months. The city is a model for compact development with lots of mixed-use housing, low traffic congestion levels, and high transit use. The income distribution is broad – some affluent residents, but mostly middle class. Both gasoline and electricity prices are low compared to the rest of the country.

Thus far, Electricville has not been the hub of interest in PEVs by automakers, charging infrastructure, or the state, but the local government and utility believe in PEVs since a popular startup plans to manufacture vehicles there. This local involvement has sparked interest by consumers, especially because of the connection to local job creation. Thus far, no one has conducted surveys on PEV interest that could be used to forecast PEVs' market share in the future.

It is clear that Electricville meets some criteria that make for a feasible PEV market using the table above as a guide. Being able to gauge the degree to which the city is feasible for PEVs requires more investigation of consumer interest including surveying. What is clear from this initial assessment, however, is that such an investigation is warranted.

Endnotes

[1] Formerly the Pew Center on Global Climate Change
[2] There are significant differences in purchasing, owning, and operating a BEV versus an EREV or PHEV. The Action Plan considers these differences throughout, including the effects on charging infrastructure.
[3] The National Electric Code (NEC) defines EVSE as "[t]he conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle." (http://1.usa.gov/oO9Bxw)
[4]Greene, David. (2008, June 8). Costs of Oil Dependence 2008. Retrieved November 13, 2011, from U.S. DOE Vehicle Technologies Program: http://www1.eere.energy.gov/vehiclesandfuels/facts/2008_fotw522.html.
[5] The largest component of the U.S. trade deficit is the purchase of oil.
[6]http://nhts.ornl.gov.
[7]EPA.(2007, April). The Plain English Guide to the Clean Air Act. Retrieved January 18, 2012, from U.S. Environmental Protection Agency: http://www.epa.gov/air/caa/peg/peg.pdf.
[8]EPA. (2011). The Benefits and Costs of the Clean Air Act from 1990 to 2020. Washington, D.C.: U.S. Environmental Protection Agency.
[9]NRC. (2010). Advancing the Science of Climate Change. Washington, D.C.: National Academies Press.
[10]C2ES (formerly the Pew Center on Global Climate Change).(2011, January). Climate Change 101: Science and Impacts. Retrieved October 10, 2011, from C2ES: http://www.c2es.org/climate-change-101/science-impacts
[11]DOD. (2010). *Quadrennial Defense Review.* Washington, D.C.: U.S. Department of Defense.
[12] The EPA provides a close approximation of greenhouse gases from the grid at http://1.usa.gov/rASoeP.
[13]http://www.bts.gov/publications/national_transportation_statistics/html/table_01_16.html
[14] The Chevrolet Volt and the Ford Focus EV is manufactured in the United States. Nissan expects to manufacture LEAFs in the United States beginning in 2012.
[15]http://www.evcollaborative.org
[16]http://www.projectgetready.org
[17]http://www.goelectricdrive.com
[18]http://www.advancedenergy.org/transportation/resources/Community%20Planning%20Guide.pdf
[19]http://www.electrificationcoalition.org
[20]http://www.afdc.energy.gov, http://fueleconomy.gov
[21]http://www.eei.org/newsroom/energynews/Pages/20111115.aspx
[22] Many of the regulations referred to here are the responsibility of state public utility commissions.
[23] Throughout the Action Plan, public charging infrastructure refers to charging stations that are accessible by the public including those installed on private property.
[24] It should be noted that the regulatory structure for electricity markets varies across the country and what may be considered "best practice" in one state may be infeasible in another.
[25] Technical standards apply to the vehicle charging plug connector as it relates to safety and interoperability, PEV interconnection with the electrical grid such as vehicle-to-grid (V2G), and international harmonization.
[26] This includes costs related to electricity service and distribution system upgrades. The electricity transmission system refers to the high-voltage lines that carry current from power plants. The voltage is then reduced by large transformers at substations, which link the transmission system to the distribution system. The electricity distribution system refers to the low-voltage lines and equipment that deliver electricity to end users at safe

voltage levels (such as 120V for residences). Electricity service refers to the components of the distribution system that provide electricity to an individual end user including transformers, power lines, and meters.

[27] V2G is the capability of a vehicle to supply power back to the electrical grid. V2G enables PEVs to provide grid services like meeting peak demand or ancillary services like frequency regulation.Another example is technology that could start and stop battery charging depending on grid needs. Since the impacts of new uses of the vehicle battery are not yet fully understood, it is important to keep this space open for innovation.

[28]SAE.(2011). SAE Charging Configurations and Ratings Terminology. Retrieved May 26, 2011, from Society of Automotive Engineers: http://www.sae.org/smartgrid/chargingspeeds.pdf

[29] PEVs have on-board chargers capable of charging the battery at 1.2 kW, 3.3 kW, or 6.6 kW, typically. Nissan's second generation LEAF and the Ford Focus BEV will come equipped with an onboard 6.6 kW charger.

[30]A utility could become the sole EVSE provider in an area, which could potentially limit consumer choice and reduce the likelihood that new business models (that could lower the PEV total cost of ownership) would be introduced. On the other hand, utilities could provide PEV services in areas that would not be served otherwise.

[31] Today, there is spare electrical capacity to support millions of PEVs so long as charging is managed.

[32] In general, most excess capacity is available at night, allowing PEV drivers to charge their vehicles conveniently at home.

[33] Texas Transportation Institute estimates traffic congestion costs the United States $100 billion (http://bit.ly/n6zk3f).

[34]Greene, D. (2011, May 28). What is greener than a VMT tax? The case for an indexed energy user fee to finance us surface transportation. Retrieved October 5, 2011, from Transportation Research Part D: Transport and Environment: http://www.sciencedirect.com/science/article/pii/S1361920911000630

[35] This is true for miles traveled that are only powered by the vehicle's internal combustion engine.

[36]http://www.fhwa.dot.gov/interstate/faq.htm#question31

[37] Standards used for EVSE data collection are athttp://bit.ly/oG83zb.

[38] PEV service providers include businesses that supply EVSE and those that provide access to EVSE or battery swapping stations.

[39] The SAE J1772 covers the "general physical, electrical, functional and performance requirements to facilitate conductive charging of EV/PHEV vehicles in North America" (from http://bit.ly/pF3yHi). It does not cover interoperability, which is being handled separately by SAE (http://bit.ly/tjI1ZY).

[40] CHAdeMO is a DC fast charging standard created by The Tokyo Electric Power Company, Nissan, Mitsubishi and Fuji Heavy Industries. The CHAdeMO connector is available in the Nissan LEAF. The CHAdeMO connector is a different connector from the SAE J1772 connector used for Level 1 and Level 2 charging.

[41]http://www.ansi.org/edv

[42] As the PEV market evolves, PUCs may need to revisit initial decisions on this matter. For example, PUCs may have to rule on existing utility-owned EVSE assets if market conditions change.

[43]http://regarchive.sdge.com/documents/environment/multi-unit.pdf

[44]http://www.epa.gov/air/caaac/mstrs/may2011/babik.pdf

[45] Both devices accomplish the same goal; they enable a PEV owner to know PEV-related electricity usage. The difference is in the management and ownership of the device.

[46]The area could be a city or town, county, state, or region.

[47] Given PEV characteristics such as home refueling and a quiet, responsive driving experience, it is unclear if the PEV market will ultimately resemble the hybrid electric vehicle market or not.

[48]Glerum, A., Themans, M., &Bierlaire, M. (2011, July). Modeling demand for electric vehicles: the effect of car users' attitudes and perceptions. Retrieved October 7, 2011, from Transport and Mobility Laboratory: http://transp-or.epfl.ch/documents/proceedings/GleTheBie_ICMC2011.pdf .

[49]http://www.eia.gov/electricity/monthly/excel/epmxlfile5_6_b.xls, http://fuelgaugereport.opisnet.com/sbsavg.html.

[50] Federal fuel tax plus the average state fuel tax is $0.47 per gallon of gasoline. If these taxes were added to the price of electricity on a cents-per mile equivalent basis, electric drive vehicles would cost about $0.06 per mile while a conventional gasoline vehicle would cost closer $0.20 per mile (assuming electricity price is $0.10 per kWh, gas price is $3.50 per gallon including fuel taxes, fleet on-road efficiency average of 17.4 mpg, and PEVs travel 3 miles per kWh).

[51] Heated seats can save energy by reducing the need to heat the vehicle interior.

[52]http://energy.gov/articles/awards-advanced-vehicle-development

[53]Turrentine, T. S., Garas, D., Lentz, A., &Woodjack, J. (2011).The UC Davis MINI E Consumer Study. Davis: Institute of Transportation Studies at UC Davis.

[54] Those who do not have access to a garage may be able to substitute workplace charging for home charging.

[55] BEVs that travel less than 20 miles per day could be accommodated by an AC Level 1 charger.

[56] Until battery costs decline substantially, PEVs will carry a higher upfront cost than their conventional counterparts. The operating cost per mile driven is much lower for PEVs, however. Thus, the more miles driven, the more value PEVs provide.

[57] TIGER (Transportation Investment Generating Economic Recovery) is a "national competition for innovative, multi-modal and multi-jurisdictional transportation projects that promise significant economic and environmental benefits to an entire metropolitan area, a region or the nation" (see http://1.usa.gov/sbP1sN).

[58]http://www.c2es.org/what_s_being_done/in_the_states/plug_-_in_electric_vehicles

[59] BEVs traveling at highway speeds over long distances could spend about one third of the trip waiting to charge (assuming 60 mph, DC fast charging that provides 20 kWh in 25 minutes, and PEVs travel 3 miles per kWh).

[60] The presence of an oil suppliers' cartel leads to oil prices that are higher than they otherwise would be, acting as a drag on economic growth and facilitating a large wealth transfer out of the U.S. economy. For this reason, some economists and energy security experts argue that government should intervene to protect consumers and the broader economy.

[61] Through franchise laws, most states outlaw automakers from selling a new vehicle directly to consumers.

[62] The PEV purchase process described here only involves the acquisition of the PEV, even though the process begins long before a consumer enters an auto dealership. As detailed in *Section 6.1*, consumers attain most of their knowledge about vehicle purchases online. The Action Plan covers consumer education in Chapter 6.

[63]http://bit.ly/qKcLn3

[64]http://www.spx.com/en/plugged-in/

[65]http://bit.ly/n5EgX7

[66] Without PUC clarity, consumers are at greater risk of incurring surprise costs with installation and operation of their EVSE.

[67]http://bit.ly/rpG7a4

[68] No specifications were available for Coulomb's DC fast chargers at the time of this writing.

[69]R.L. Polk & Co. (2011, February). The Role of the Internet in the New and Used Vehicle Purchase Process. Retrieved October 13, 2011, from Polk.com: http://bit.ly/nYlyTC.

[70]Kurani et al. (2010). Plug-in Hybrid Electric Vehicle (PHEV) Demonstration and Consumer Education, Outreach, and Market Research Program: Volumes I and II. Davis, California: Institute of Transportation Studies, University of California, Davis.

[71]TCO takes into account the vehicle purchase cost and operational costs for fuel and maintenance. While the cost of purchasing a PEV is currently higher than purchasing a comparable conventional vehicle, lower fuel and maintenance costs could result in net savings to the vehicle owner over the vehicle's lifetime.

[72]Lipman, T., & Williams, B. (2011).Plug-In Vehicle Battery Second Life Workshop.Plug-In Vehicle Battery Second Life Workshop. Berkeley, California: Transportation Sustainability Research Center, University of California at Berkeley.

[73] See *Plug-in Electric Vehicles: Literature Review*for an explanation of the different PEV powertrains.

[74] New car buyers tend to split their time evenly amongst third party, automaker, and auto dealer websites.

[75]http://pressroom.toyota.com/releases/toyota+hydrogen+fueling+station+may+2011.htm

This report discusses actions to integrate plug-in electric vehicles with the U.S. electrical grid. *The Center for Climate and Energy Solutions (C2ES) is an independent non-profit, non-partisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in 2011, C2ES is the successor to the Pew Center on Global Climate Change.*

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