U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

A Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects

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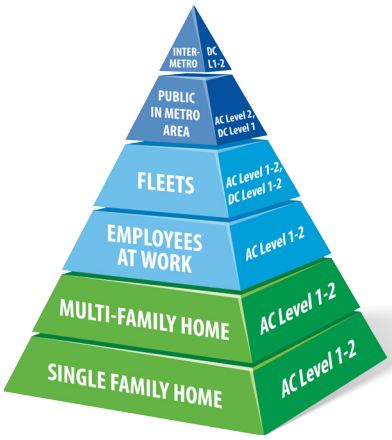

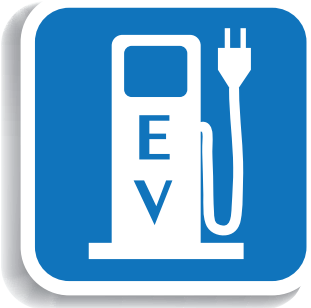

Clean Cities
U.S. Department of Energy

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This guide summarizes and synthesizes the work of a series of projects carried out by the Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure awardee organizations and partnering local Clean Cities coalitions. A full list of these organizations can be found in Appendix I of this report. On behalf of the U.S. Department of Energy's Clean Cities Program this guide was developed for the Argonne National Energy Laboratory by the Center for Climate and Energy Solutions.

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EXECUTIVE SUMMARY

This report summarizes the activities, outputs, and lessons of a series of projects that are intended to advance the deployment of plug-in electric vehicles (PEV) that was launched by the U.S. Department of Energy (DOE) in 2011. This report also serves as a roadmap to the detailed content that is available in each of the 16 PEV readiness plans that were produced by the projects.

The Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure awards were designed to help communities forge public-private partnerships to plan for and develop strategies to support the adoption of PEVs and the corresponding charging infrastructure installation. Grantees and their partners spent approximately 18 months assessing the barriers to and opportunities for PEV deployment in their regions—preparing plans to increase PEV readiness; executing some of those plans; and developing information resources for use by stakeholders, planners, and the public. Each grantee detailed their activities and outputs in a PEV readiness plan that was released by the spring of 2013.

The following is a brief overview of the findings and outputs of the readiness and planning efforts:

PEVs are one part of a suite of solutions for the challenge of providing affordable, clean, secure transportation – Unlike conventional internal combustion engine vehicles, which are powered primarily by gasoline and diesel fuels, PEVs are powered at least in part by electricity, which is generated from domestic, diverse, secure energy sources.

To document the rationale for advancing PEV readiness and to gather information for education and outreach materials, several grantees worked to identify and quantify the public and private benefits of PEVs.

The Colorado grantee performed a detailed well-to-wheels life cycle analysis to compare the emissions of PEVs with the emissions of light-duty gasoline vehicles. The Colorado grantee's study, the first of its kind in the state, concluded that the total emissions of greenhouse gases, carbon monoxide, volatile organic compounds, and nitrogen oxides from PEVs driven in the state are consistently lower than emissions from conventional vehicles.

Colorado Electric Vehicle and Infrastructure Readiness Plan, p. 94

http://denvercleancities.org/Colorado%20PEV%20Readiness%20Plan.pdf

A range of barriers stands in the way of expanded PEV adoption – As a first step in the process of constructing a plan for increasing the PEV readiness, each grantee identified the key barriers to expanded PEV adoption in the covered region and assessed its current level of readiness. Obstacles to PEV purchase and charging station installation include: lack of information, need for coordination and agreement on public policy, potential effects of PEV adoption on the electrical grid, financial issues such as incremental costs of vehicles and infrastructure, and, finally, transportation infrastructure funding.

A compilation of the hurdles to PEV adoption and charging station installation identified by the grantees is presented in Table 5, Table 6, and Table 7.

Incentives are needed to overcome the roadblocks to early PEV adoption – To reduce barriers to PEV adoption and foster early market development of PEVs, the federal government and several state and local governments offer incentives. Incentives are an important component of PEV readiness because PEVs are competing against conventional internal combustion engine vehicles, an incumbent and mature technology in an established market. Conventional vehicles have benefited from over a century of technology development, manufacturing learning-by-doing, infrastructure development, and consumer awareness and experience. Government incentives, both financial and non-financial, help to temporarily offset some of the disadvantages that PEVs face relative to incumbent conventional vehicle technologies as they are introduced into the market.

Grantees collected information about existing incentives for PEVs and charging stations, discussed which incentives might work best in their respective regions, and proposed new incentives and improvements to existing programs.

The North Carolina grantee compiled a detailed overview of PEV incentives offered in the state and throughout the country, presented survey results on the incentives that are desirable to fleet owners, and analyzed policy implications for the state.

Plug-In Electric Vehicle (PEV) Roadmap for North Carolina: Statewide Plan, p. 204 (Appendix 9)

http://www.advancedenergy.org/transportation/ncpev/state_plan_chapter.php

PEV market assessments and adoption forecasts are needed to inform planning efforts – To characterize the current state of PEV markets, for use both as a foundation for forecasting and as a source of information for incorporation into outreach and educational materials, several plans provided assessments of national, state, and local PEV markets. These included overviews of the PEV options that are currently available to consumers, assessments of the suitability of PEVs for satisfying the driving needs of consumers, analyses of the total cost of ownership of PEVs compared to conventional vehicles, and data on the current rates of PEV adoption in their study areas.

To better understand the future demand for charging infrastructure, the potential impacts on the electrical grid, and the expected economic and environmental impacts of PEV adoption, several plans included forecasts of PEV adoption. These forecasts—some quantitative and some qualitative—generally predicted PEV market growth and rising numbers of PEVs on the road, citing various drivers, including: reductions in PEV prices due to economies of scale, learning by doing, and expected battery cost reductions; state zero emission and low emission vehicle programs; federal fuel economy and greenhouse gas emissions standards; increasing public awareness and acceptance; and rising gasoline prices.

Grantees used a variety of methodologies to forecast PEV adoption. Some plans used existing forecasts from other organizations or initiatives, including the California South Coast plan which used PEV market growth projections provided by electric utilities for its service areas. Some plans, including Texas River Cities and Southeast Regional, used consumer adoption models to build scenarios that are based on high-level assumptions about total potential PEV market size, sales of PEVs to early adopters, and the spread of sales to later adopters. Some grantees simply offered a range of sales scenarios—like the Florida grantee—who based the scenarios on multiples of its first 10 years of hybrid vehicle sales.

Los Angeles (South Coast) Regional Plug-In Electric Vehicle Readiness Plan, p. 3

http://www.pevcollaborative.org/pev-readiness-reports

Texas River Cities Plug-In Electric Vehicle Initiative Regional Plan and Final Report, p. 8-2, Appendix D

http://www1.eere.energy.gov/cleancities/pdfs/texas_river_cities_readiness_plan.pdf

Electric Vehicle Adoption in the Southeast (to 2020) – Stand Alone Report, 44 pp. (Appendix included in full report)

http://www.cleancitiesatlanta.net/component/content/article/130-electric-vehicle-readiness-workbook

Drive Electric Florida Volume I: Getting Southeast Florida Plug-in Ready, p. 4-25, Appendix B-7

http://www.floridagoldcoastcleancities.com/Grant_Opportunities.html

Charging stations will be needed in a variety of settings and power levels – Consumers' "range anxiety" (concern that a vehicle has insufficient range to reach its destination) and lack of access to charging infrastructure are two of the most significant barriers to widespread adoption of all-electric vehicles (AEVs). A lack of access to charging locations is also a barrier to plug-in hybrid electric vehicle (PHEV) adoption. To assess and address these barriers while ensuring that installed charging infrastructure is highly utilized and cost-effective, grantees analyzed the future need for charging infrastructure in their regions and developed plans for charging station deployment. The number of charging stations needed, where these stations should be sited, and what level of power these stations should provide were the key considerations.

Several grantees performed geographic analyses of household travel survey data and demographic data to inform charging infrastructure investment and siting. The Southeastern Pennsylvania grantee's analysis concluded that many vehicles in its region can readily

be replaced by PEVs and that a majority of charging demand in its region can be met with residential and workplace charging.

Ready to Roll! Southeastern Pennsylvania's Regional Electric Vehicle Action Plan Volume II, p. 44

http://www1.eere.energy.gov/cleancities/pdfs/delaware_valley_readiness_plan_ii.pdf

The Northeast Regional grantee identified nine sweet-spot station location types and provided in-depth site typologies and case studies for each of these locations. This resource was designed to help public planners and private investors identify the best sites for charging station deployment in its regions and to understand the unique opportunities and challenges that are inherent in each location type.

Electric Vehicle Supply Equipment Cluster Analysis, 58 pp.

http://www.transportationandclimate.org/electric-vehicle-supply-equipment-cluster-analysis

Local governments can be powerful supporters of charging station deployment – Local governments have a critical role to play in the development of both public and private charging infrastructure due to their authority over zoning, parking, and signage; building codes; and permitting and inspection processes. Local ordinances and procedures can interfere with charging station development, which can be avoided by amending codes and streamlining processes. Local ordinances and procedures also present opportunities to proactively support or offer incentives for charging station installations.

Several grantees conducted research, developed tools, and offered recommendations to help localities in their regions support PEV adoption. The resources for local governments, which are indexed in Table 11, are flexible and diverse in their structures, content, and recommendations because localities vary significantly in their physical and built environments, administrative procedures and ordinances, resources, and desire to support PEV readiness.

The Michigan and Ohio grantees developed toolkits that provide detailed recommendations and sample code language while clearly laying out alternative approaches that communities can undertake based on their desired level of action. The California plan's toolkit provides an extensive catalog of links to existing resources and sample language for local policy development.

Plug-In Ready Michigan: An Electric Vehicle Preparedness Plan, p. 95

http://cec-mi.org/mobility/programs/pluginreadymichigan/

Electric Vehicle Readiness Plan for Ohio, p. 26

http://www.driveelectricohio.org/evplan/

A Toolkit for Community Plug-In Electric Vehicle Readiness: A Resource for Local Officials, 71 pp.

http://www.pevcollaborative.org/toolkit

Providing access to charging at multi-family residences and the at the workplace is especially challenging, and important – The two highest priority locations for installing charging stations after single-family residences are multi-unit residences and the workplace, as shown in Figure 2. At-home charging is the primary source of power for consumer PEV drivers, yet multi-unit dwellers often do not have access to dedicated garages where they can install their own charging stations. After the home, the workplace is considered to be the second most likely location where PEV drivers will want to charge, because employees spend an average of eight hours per day parked at their workplace. Workplace charging can also serve as the primary charging location for PEV drivers who do not have access to charging stations at home. Deployment of multi-unit residential and workplace charging stations can make PEV ownership viable for a broader set of drivers, decrease range anxiety for AEV drivers, and enable PHEVs and extended range electric vehicles (EREVs) to drive more electric miles.

Multi-unit and workplace charging face unique barriers beyond those faced by single-unit residential charging. To support charging station deployment at these critical, yet challenging locations, several grantees identified issues and provided resources for stakeholders to help them advance station deployment in their communities.

The Florida grantee made facilitating charging at multi-unit residences a key area of focus of its readiness plan because a relatively high percentage of housing units in Southeast Florida are multi-unit residences—41 percent—compared to the national average of 23 percent. The grantee developed fact sheets, seminars, and workshops on multi-unit dwellings with the goal of expediting multi-unit management's charging station planning and empowering residents with the knowledge to make the case for charging station installation.

Drive Electric Florida Volume I: Getting Southeast Florida Plug-in Ready, Section 6-68

http://www.floridagoldcoastcleancities.com/Grant_Opportunities.html

The Oregon grantee conducted interviews of several large employers in the state, who offer workplace charging, to understand their motivations and learn from their experiences. Based on these interviews, the grantee identified issues that are making organizations reluctant to install charging stations and recommended the development of a workplace outreach and information resource program.

Energizing Oregon, p. 31

http://www.evroadmap.us/content/energizing-oregon-plan

Electric utilities have an important role to play – Electric utilities can support charging station deployment and ensure that the electrical grid is resilient and responsive to changes arising from PEV adoption. Electric utilities can plan for potential impacts of PEV adoption on the electrical grid, including impacts on local distribution infrastructure and on the ability of existing generation capacity to meet electricity demand. To support PEV adoption and minimize potential negative effects of PEV adoption on the grid, electric utilities can work with dealers and charging providers to: track PEV adoption and charging station installations in their region; evaluate alternative electricity rate structures; plan for grid system upgrades; and clarify their role in working with third-parties to provide charging services.

The Kansas City grantee developed a model to test for weak points in the distribution infrastructure under various scenarios of PEV adoption. The analysis found that as long as PEVs make up as much as 1 percent of light-duty vehicles, there are no impacts; while at significantly higher adoption rates, such as 20 percent of light-duty vehicles, local residential distribution systems would be the first grid components to experience stress in its region.

Electrify Heartland Plan: Kansas-Missouri Community Readiness for EV and EVSE, p. 54

http://electrifyheartland.org/read-the-plan/

The Maui grantee planned a smart grid demonstration project under which 200 private, car share, and fleet PEV owner partners will interconnect with charge management systems (an electronic system that manages the timing of battery charging) and two-way communication systems, allowing project partners to gain experience with these technologies and gather information on their performance.

EVs in Paradise: Planning for the Deployment of Electric Vehicle Infrastructure in Maui County, p. 70

http://www.mauieva.org/report/

The means of funding transportation infrastructure needs to be adjusted – Over the long term, adoption of more fuel efficient vehicles and alternative fuel vehicles, including PEVs, will continue to decrease the effectiveness of gasoline taxes as a source of transportation infrastructure funding. Grantees discussed how to balance the need to adapt transportation infrastructure funding mechanisms to an increasingly fuel-efficient fleet with the desire to avoid hampering PEV early market development efforts by assessing PEV-specific fees.

The Oregon grantee noted that the state has been a leader in implementing fees based on vehicle miles traveled and is currently conducting a pilot program to evaluate alternative ways for drivers to report their miles traveled.

Energizing Oregon, p. 42

http://www.evroadmap.us/content/energizing-oregon-plan

The Kansas City grantee provided an overview of the current state of vehicle tax legislation across the country.

Electrify Heartland Plan: Kansas-Missouri Community Readiness for EV and EVSE, p. 57, 102

http://electrifyheartland.org/read-the-plan/

The Colorado plan provided a summary table outlining the advantages and disadvantages of various solutions.

Colorado Electric Vehicle and Infrastructure Readiness Plan, p. 82, Appendix 18

http://denvercleancities.org/Colorado%20PEV%20Readiness%20Plan.pdf

Public outreach, education, training, and marketing remain important – Lack of awareness of, information about, and experience with PEVs among consumers, stakeholders, and government officials are key barriers to the successful market introduction of this new technology. To reduce these barriers, grantees developed outreach, education, and training programs to connect a diverse set of audiences with the information they need to play their roles in supporting PEV readiness and adoption in their communities.

Several grantees developed and launched coordinated, multi-faceted communications programs to increase familiarity with PEVs and disseminate information. These communication efforts included organizing public events, workshops, and technology demonstrations; developing print and internet education and marketing resources; conducting phone, email, and social media marketing campaigns; and garnering local media coverage. Grantees also designed and implemented programs to train municipal personnel, first responders, electricians, automobile dealerships, automotive technicians, parking attendants, fleet managers, and the tourism industry.

Education and outreach were high priorities for several grantees and each plan encompassed a broad and diverse set of communication activities:

- The Maui grantee produced 12 episodes of a television program to inform the public about PEVs.
- The Oregon grantee staged ride-and-drive events to give consumers firsthand experience with PEVs.
- The North Carolina grantee prepared a toolkit to help other PEV advocates arrange ride-and-drive events.
- The California grantee conducted community workshops on the basics of PEV technology, ownership, and charging.
- The Kansas City grantee encouraged consumers to engage with vehicle cost-of-ownership tools to learn about potential cost savings.
- The Colorado grantee designed an interactive website aimed at consumers, businesses, and property owners.
- The Richmond grantee organized high-profile events with press conferences to garner TV, radio, and print media coverage.
- The Texas River Cities grantee developed a curriculum for PEV advocates to engage with government officials.
- The Ohio grantee designed templates for informational handouts and web resources for local communities to adapt and deploy to inform their citizens.
- The New York City grantee provided PEV information to the city's 3-1-1 non-emergency municipal services number.

Partnerships with a wide range of stakeholders are essential for advancing PEV adoption – A key goal shared by all of the PEV readiness projects was to foster an engaged network dedicated to supporting PEV adoption and charging station deployment by building lasting relationships among a diverse set of partners. By sustaining these partnerships, grantees can continue to collaborate on implementing the strategies they identified and they can preserve the momentum that was generated by the PEV readiness projects. The grantees' experiences facilitating these partnerships, as documented in their readiness plans, will also be useful to other communities who are looking to build local capacity to improve PEV readiness.

Partnerships were a high priority for several grantees and each grantee plan encompassed a broad and diverse set of communication activities:

- The Texas River Cities plan, noting that other industries, such as the natural gas industry, excel at leveraging extensive and diverse local stakeholder networks, constructed an analogous stakeholder model for the PEV industry that could be emulated by other communities.
- The North Carolina and California grantees created structures for partnership and coordination among local and regional governments and stakeholders within their states.
- The Northeast Regional grantee, whose eleven state region was the broadest of the grantees, connected government officials, planners, and PEV stakeholders across state borders to open valuable communication channels for knowledge exchange, procurement partnerships, and collaboration on regional transportation issues.

1. INTRODUCTION

Increasing passenger vehicle efficiency and reducing the use of petroleum-based fuels can reduce consumers' fuel costs, support domestic industry, minimize pollution, and increase energy security. Americans spend about $1 billion a day to import oil, with transportation accounting for more than two-thirds of U.S. oil demand. While the efficiency and emissions of new conventional vehicles have improved significantly in recent years, the U.S. passenger vehicle fleet still accounts for more than 40 percent of U.S. oil demand and 16 percent of U.S. greenhouse gas emissions.[1]

The U.S. Department of Energy (DOE) supports plug-in electric vehicles (PEVs) as one component of a suite of solutions for the challenge of providing affordable, clean, secure transportation. Unlike conventional vehicles, which are powered primarily by petroleum-based fuels, PEVs are powered at least in part by electricity, which is generated from domestic, diverse, and secure energy sources.

On September 8, 2011, Energy Secretary Steven Chu, who held the office at that time, announced the Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure awards. These awards were designed to help communities forge public-private partnerships to plan for and develop strategies to support the adoption of PEVs and charging infrastructure installation. The 16 awards, totaling $8.5 million, helped prepare U.S. communities in 24 states and the District of Columbia to adopt PEV technologies to reduce U.S. petroleum dependence and to build the foundation for a clean transportation system.

This report summarizes the activities, outputs, and lessons of a series of projects that were intended to advance the deployment of PEVs, launched by DOE in 2011. The report also serves as a roadmap to the detailed content available in each of the 16 PEV readiness plans that were produced by the projects. The 16 projects, listed in Table 1, cover a wide range of communities, from those with considerable experience with PEV planning to those eager to plan for PEVs, but without sufficient resources to begin. The geographic areas covered under each project range from the single city, to the state, to the multi-state region, as shown in Table 1 and Figure 1. For convenience, the table's first column is a shorthand way of referring to the readiness plan throughout the report.

Links to each of the readiness plans are included in the table below and can also be found at: http://www.eere.energy.gov/cleancities/electric_vehicle_projects.html.

DOE's goal was for grantees to launch a dynamic process to support the deployment of PEVs and charging infrastructure in their respective regions by engaging a broad set of partners and audiences including:

- Local policymakers and staff
- State policymakers, regulators, agencies, and staff
- Regional planners and municipal planning organizations (MPOs)
- Electric utilities and other electric power providers
- Private developers and commercial business owners
- Charging station providers
- Automobile manufacturers
- Automobile dealers
- The general public.

Grantees and their partners spent approximately 18 months assessing the barriers to and opportunities for PEV deployment in their regions, preparing plans to increase PEV readiness, executing some of those plans, and developing information resources for use by stakeholders, planners, and the public. Each grantee detailed their activities and outputs in a PEV readiness plan that was released by the spring of 2013. Finally, grantees assembled in Knoxville, Tennessee on May 1, 2013 to share their experiences, findings, and lessons learned. These presentations were recorded and can be viewed on DOE's website at: http://www.eere.energy.gov/cleancities/electric_vehicle_workshop.html.

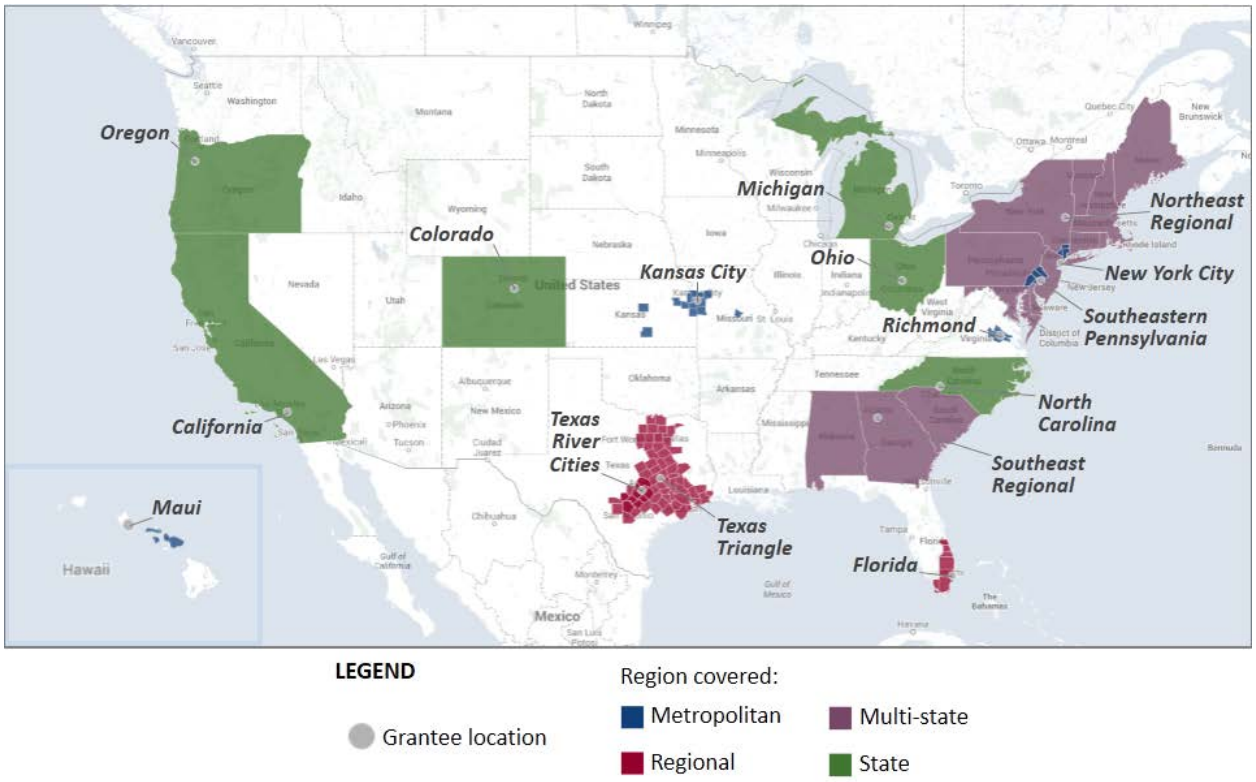
TABLE 1: Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure Awardees

SHORTHAND DESCRIPTION OF REGION	REGION COVERED IN READINESS PLAN	AWARDEE	AWARD AMOUNT
California	California, with individual plans covering the Bay Area, Central Coast, Sacramento, San Diego, San Joaquin, and South Coast regions	South Coast Air Quality Management District	$1,000,000
Colorado	Colorado	American Lung Association of the Southwest	$500,000
Florida	Southeast Florida region, with consideration given to statewide policy and planning	South Florida Regional Planning Council	$500,000
Kansas City	Greater Kansas City Kansas & Missouri area with consideration given to state policy and planning	Metropolitan Energy Information Center, Inc.	$441,178
Maui	Maui, Hawaii with consideration given to statewide policy and planning	University of Hawaii	$299,693
Michigan	Michigan	Clean Energy Coalition	$500,000
New York City	New York City	New York City and Lower Hudson Valley Clean Communities, Inc.	$418,612
North Carolina	North Carolina, with individual plans covering Greater Ashville, Greater Charlotte, Greater Triangle, Piedmont Triad regions as well as a statewide plan	Centralina Council of Governments	$500,000
Northeast Regional	Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the District of Columbia	New York State Energy Research and Development Authority	$994,500
Ohio	Ohio	Clean Fuels Ohio	$500,000
Oregon	Oregon	Oregon Business Development Department	$485,000
Richmond	Richmond region, with consideration given to Virginia statewide policy and planning	Virginia Department of Mines, Minerals and Energy	$429,051
Southeast Regional	Georgia, Alabama, South Carolina	Center for Transportation and the Environment	$545,400

Southeastern Pennsylvania	Five counties of Southeastern Pennsylvania (Bucks, Chester, Delaware, Montgomery, and Philadelphia)	Delaware Valley Regional Planning Commission	$387,698
Texas River Cities	Central Texas region, including the greater Austin and San Antonio communities, with consideration given to statewide policy and planning	City of Austin, Austin Energy	$499,782
Texas Triangle	Texas Triangle region including Dallas-Fort Worth, Houston-Galveston, and San Antonio-Austin urban areas, with consideration given to statewide policy and planning	Center for the Commercialization of Electric Technologies	$500,000

FIGURE 1: Locations of Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure grantees and regions covered

The 16 grantees covered 24 states and the District of Columbia. An interactive version of this map with links to each of the readiness plans can be found at http://www1.eere.energy.gov/cleancities/electric_vehicle_projects.html.



1.1 CONTEXT OF DOE WORK

DOE advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum use in transportation through its Clean Cities program and related deployment activities. DOE has designated 84 locally based Clean Cities coalitions that represent an area where 80 percent of the U.S. population resides. DOE's vehicle technologies deployment program works together with local communities to reduce U.S. reliance on petroleum in transportation by:

- Designating and supporting local Clean Cities coalitions of public- and private-sector stakeholders who are committed to reducing petroleum use and identifying and addressing barriers at the local level
- Providing funding opportunities for deployment projects
- Developing information resources that educate transportation decision makers about the benefits of using alternative fuels, advanced vehicles, and other measures that reduce petroleum consumption
- Reaching out to large fleets that operate in multiple states—as well as smaller ones—to help them reduce petroleum use
- Providing technical assistance to fleets deploying alternative fuels, advanced vehicles, and idle reduction
- Analyzing data from industry partners and fleets to develop tools and information for the Alternative Fuels Data Center and fueleconomy.gov web sites that help stakeholders reduce petroleum consumption.

More information about DOE's Clean Cities program and the locally based coalitions can be found at http://www.eere.energy.gov/cleancities/index.html.

1.2 OVERVIEW AND DEFINITIONS OF PEVS AND CHARGING STATIONS

A PEV is any vehicle that draws electricity from another power source, stores that electricity in a battery, and uses that electricity to power the vehicle's drivetrain, at least in part. The types of PEVs available to consumers and their differences are presented in Box 1.[2]

Box 1: There are different types of plug-in electric vehicles and the differences matter

The PEV choices currently available to consumers fall into general technological categories based on whether they power movement with energy from sources other than batteries and, if so, how the other fuel (generally gasoline) delivers power.† It is useful to differentiate between these technologies because they have different electric-only ranges, total ranges, charging needs, and fuel use.

All-Electric Vehicles (AEVs) power movement exclusively with electricity stored in a battery. Extended Range Electric Vehicles (EREVs) and Plug-In Hybrid Electric Vehicles (PHEVs) power movement entirely with electricity stored in a battery until the electric charge is low. When electric charge is low, EREVs use an internal combustion engine to run a generator and the vehicle operates as a hybrid to extend its range. PHEVs deliver less electrical power than AEVs or EREVs and as a result, PHEVs often use both an electric motor and an internal combustion engine to power the vehicle. Among PHEVs, electric-only top speed capabilities vary. PHEVs also generally store less electric energy than EREVs. In turn, EREVs store less energy than AEVs.

Because AEVs rely exclusively on electricity stored in a battery, they require more extensive charging infrastructure than EREVs or PHEVs to enable comparable driving services — particularly on occasional long trips.

† The concepts of energy and power are distinct. Energy refers to the capacity to do work. In the case of a vehicle, energy is stored in a fuel or in a battery. Power refers to the rate at which work is performed by expending energy. In the case of a vehicle, power refers to how quickly stored energy is expended to propel that vehicle.

Unlike conventional internal combustion engine vehicles, which are powered primarily by gasoline and diesel fuels, PEVs are powered at least in part by electricity, which is generated from domestic, diverse, secure energy sources. Because they offer energy security—in addition to climate, environmental, and public health benefits—PEVs are one part of a suite of solutions to the challenge of providing affordable, clean, secure transportation. This suite includes the use of other alternative fuels for light and heavy duty vehicles—including biodiesel, ethanol, other biofuels, hydrogen, natural gas, and propane—as well as vehicle efficiency technologies. Additional information on many of these solutions can be found at DOE's Alternative Fuels Data Center http://www.afdc.energy.gov.

One critical component of PEV readiness is ensuring that existing and potential PEV drivers will have access to suitable charge points (in technical literature referred to as electric vehicle supply equipment [EVSE]) which are described in Box 2.

Box 2: Charging levels

Three general levels of charging infrastructure that are commercially available are compared in Table 2. Level 1 AC (Alternating Current) charging is the cheapest option because it consists simply of plugging an electric car into a socket at the standard household voltage. Level 1 AC is also the slowest charging level and can charge most PHEVs overnight or while at work, but fully charging an empty AEV at Level 1 can take longer than one night. Level 2 AC, which runs at a higher voltage and draws more current than Level 1 AC, charges more rapidly, but requires the purchase of dedicated charging equipment and usually requires installation by a licensed electrician. Level 2 AC generally can fully charge an AEV from empty overnight, so it is often recommended for installation at residences of AEV owners. For daytime charging, Level 2 AC is commonly installed where vehicles park for a relatively short duration. For workplace chargers, the relative desirability of Level 1 versus Level 2 AC stations, or the most desirable mix of these levels, is still being debated.

Level 1 DC (Direct Current) or Level 2 DC chargers, often referred to as "DC fast chargers," are the fastest charging methods, but are also the most expensive to purchase, install, and maintain. Except in extreme temperature conditions, a Level 2 DC charger can charge typical AEVs to 80 percent capacity within 20 minutes. This level is recommended for stations offering rapid charging to many vehicles, such as fast-charging consumer stations for light-duty AEVs along highways or at shopping centers, or for supplemental daytime charging stations for some fleets of heavy-duty electric vehicles.

TABLE 2: Comparison of PEV Charging Levels

CHARGE LEVEL	VOLTAGE	CURRENT	POWER	POWER SIMILAR TO…	TIME TO FULLY CHARGE AN AEV †
Level 1 AC	120 V	8-12 amps	1.0-1.4 kW	Toaster	8–24 hours
Level 2 AC	240 V	15–100 amps	3.6–19.2 kW	Clothes dryer	4–8 hours
DC Fast-Charger	480–600 V	80–120 amps	20–72 kW	5–10 Central air conditioners	30 minutes

† AEV refers to a vehicle with a usable battery capacity of approximately 24 kWh.

Individuals and planners face two key considerations when evaluating PEV charging station investment: power level and location. Driver surveys and research on the charging behavior of early PEV adopters indicate a general order of priority for types of charging station locations, based on where drivers are most likely to need and use them, and charging station power level based on how quickly charges are needed.

This order of priority is represented visually in the literature as The Charging Pyramid (Figure 2). Broadly speaking, the needed charging infrastructure in descending order of priority includes: (1) single-family residential charging stations, (2) multi-family residential charging, (3) workplace charging stations, (4) public and private fleet charging stations, (5) opportunity charging stations within a metro area, then (6) inter-metro charging stations along major transportation corridors. For residential, workplace, and some fleet charging, AC Level 1 or 2 can cost-effectively accommodate charging needs. For public charging, especially stations on highways between metro areas, faster charging stations are needed to deliver significant charges within typical travel schedules.

FIGURE 2: The charging pyramid representation of charging infrastructure expected use

In this figure, the most critical charging infrastructure (AC Level 1 or 2 charging in single family homes) is represented as the base of the pyramid. The remaining categories of charging infrastructure are listed upwards in approximate descending order of installation priority.

Source: Argonne National Laboratory, 2012

2. LESSONS LEARNED AND RESOURCES PRODUCED

Each section of this chapter provides an overview of one topical area of grantee activity and describes the activities, analyses, findings, and recommendations that are presented in the 16 PEV readiness plans. Each section concludes with a table cataloging the content of the readiness plans to direct the reader to the detailed information that is most useful to them.

2.1 ASSESSING THE BENEFITS OF PEVS

To document the rationale for advancing PEV readiness and to gather information for education and outreach materials, several grantees worked to identify and quantify the public and private benefits of PEVs.

Enhanced energy security – Unlike conventional internal combustion engine vehicles, which are powered primarily by gasoline and diesel fuels, PEVs are powered, at least in part, by electricity. While the energy sources used to generate electricity vary throughout the country, in all regions electricity is generated from largely domestic sources including varying proportions of coal, natural gas, petroleum, nuclear power, and renewable energy. According to the U.S. Energy Information Administration (EIA), petroleum accounted for less than 1 percent of electricity generation in 2012. The South Florida Regional Planning Council, the Florida grantee, highlighted the energy security benefit of electric

vehicle adoption in its region, noting that the primary electric utility in the Southeast Florida study region currently generates approximately 87 percent of power from largely domestic fuel sources—natural gas and nuclear power—and less than 1 percent from oil. The American Lung Association of the Southwest, the Colorado grantee, constructed an electricity dispatch model based on the Western Electricity Coordinating Council's projections of the generating fleet serving Colorado customers in 2020, and estimated that the extra electricity dispatched to charge PEVs would be generated from a mix made up of 44 percent natural gas, 32 percent wind, and 24 percent coal.

PEVs are also more energy-efficient than conventional vehicles, consuming less energy to drive an equivalent distance, although the vehicles themselves do require more energy to produce. A lifecycle analysis of vehicle operation and fuel use performed by the Colorado grantee found that PEVs require about 40 percent less energy per mile, well-to-wheels, than conventional vehicles.

For these reasons, PEVs offer the benefits of reduced reliance on imported fossil fuels and increased resilience to energy price volatility. Throughout the United States, the diverse and domestic energy sources used to generate electric power offer energy security advantages over reliance on oil for transportation fuels.

Lower greenhouse gas emissions, better local air quality, and public health benefits – Because they are powered at least in part by electricity, PEVs offer the benefit of lower tailpipe emissions relative to conventional vehicles. AEVs, because they are powered by electricity alone, have zero tailpipe emissions. Due to their lower tailpipe emissions and greater fuel efficiency, PEVs offer the potential benefits of lower greenhouse gas emissions, better local air quality, and improved public health.

To estimate these potential benefits in its region, the Colorado grantee performed a detailed well-to-wheels lifecycle analysis to compare the emissions of PEVs with light-duty gasoline vehicles. Because the emissions from battery-powered travel occur in association with the generation of the electricity, a full comparison of the fuel emissions from PEVs and conventional vehicles requires a lifecycle analysis from the energy well to the vehicle wheels. This study, the first of its kind in the state, was especially valuable because of high levels of ozone (commonly known as smog) in the Denver metro area. The analysis concluded that the total emissions of greenhouse gases, carbon monoxide, volatile organic compounds, and nitrogen oxides from PEVs driven in the region are consistently lower than emissions from conventional vehicles, even when taking into account the emissions from the associated electricity generation.

Emissions in other regions vary in part because of the differences in the mix of fuels and technologies used to generate electricity across the country. However, emissions from electricity generation have tended to decline as cleaner energy sources and technologies have been adopted in the power sector. If this trend continues, well-to-wheels emissions of PEVs will also continue to fall.

Economic benefits – PEV adoption and PEV readiness also offer potential economic benefits to PEV owners and local communities.

For owners, PEVs offer the prospect of fuel and maintenance savings relative to conventional vehicles. The amount of fuel savings depends on the relative prices of electricity and gasoline in a given region, but grantees reported that in many regions PEV drivers pay only one-quarter to one-third as much to fuel their vehicles as owners of conventional vehicles. More information on the cost of fueling an electric vehicle versus a gasoline vehicle can be found at http://energy.gov/maps/egallon. PEVs, however, cost more than conventional vehicles. For discussion of the total cost of ownership of PEVs relative to conventional vehicles, see the PEV Market Assessments and Forecasts section.

For communities, reduced expenditures on gasoline offer potential local economic benefits. Clean Fuels Ohio, the Ohio grantee, analyzed the local economic impacts of fuel savings from PEV adoption in the state and determined that out of every dollar spent on gasoline, only 16.4 cents continues to circulate in the Ohio economy. The Ohio grantee also found that there was a $1,300 economic benefit per PEV adopted in the state, in part because saving money on gas allows consumers to spend more locally. The grantee also asserted that the campaign to promote

electric vehicles in the state could facilitate broader economic development and job creation in Ohio's automotive sector, both manufacturers and suppliers.

PEV readiness alone, independent of fuel savings, may also provide economic benefits for local businesses. South Coast Air Quality Management District, the California grantee, noted that PEV-ready communities might attract PEV owners and environmentally conscious individuals to shop or live in the area, stimulating the local economy. However, the level of these benefits remains uncertain.

Opportunities to leverage renewable energy sources – PEV adoption offers opportunities to leverage renewable energy sources that can further enhance energy security and emissions benefits. Renewable electricity is often generated domestically and produces zero emissions. Some early adopters of PEVs, motivated by the environmental benefits, may be interested in further reducing their personal emissions by charging their vehicles with renewable energy sources. The California grantee noted that 39 percent of PEV owners in the state also invested in residential solar energy systems. California's Bay Area plan suggested that electric utilities could incorporate renewable energy options into existing or future PEV rates. This could include directing PEV owners to information about how to purchase renewable energy credits or implementing programs that link PEV charging behavior to renewable energy availability and price. California's Central Coast plan noted that distributed renewable generation, such as home solar panels, coupled with battery storage, could enable stored renewable power to substitute for high-emitting and sometimes more expensive power from the grid.

Electric utility benefits – In the future, PEVs may offer electrical infrastructure benefits by interconnecting with building energy systems or the electrical grid to charge when electricity demand is low or to deliver stored electricity when it is most needed. Vehicle integration into building energy systems, referred to as Vehicle-to-Building (V2B), and vehicle integration into the electrical grid, referred to as Vehicle-to-Grid (V2G), are emerging technologies. As the City of Austin and Austin Energy (the Texas River Cities co-grantees) noted, V2B and V2G technologies could help electric utilities maintain operational reliability, provide better energy information and energy management tools for customers, and facilitate the integration of renewable energy resources into the electric grid.

TABLE 3: Selected Content on Benefits Assessment Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Benefits of PEV Readiness to Local Communities	Toolkit p. 7
	Recommendation: Provide Renewable Energy Options for PEV Drivers	Bay Area Plan p. 50
	Connecting PEVs and Photovoltaics	Central Coast Plan p. 32
Colorado	Benefits of PEVs to Property Developers	Appendix 14
	Study of Emissions Changes from Electric Vehicle Use in Colorado	p. 94, Appendix 24
Florida	Energy Security Benefits of PEV Adoption	Volume 1 Section 3-15
North Carolina	Benefits of Plug-in Electric Vehicles	Asheville Area Plan p. 9
Ohio	Analysis of the Local Economic Impacts PEV Fuel Savings	p. 7
Southeast Regional	Vehicle Lifecycle Greenhouse Gas Emissions	Section 1 p. 27

2.2 PEV MARKET ASSESSMENTS AND FORECASTS

Assessing the current PEV markets – To characterize the current state of PEV markets, for use both as a foundation for forecasting and as a source of information for incorporation into outreach and educational materials, several plans provided assessments of national, state, and/or local PEV markets. These included overviews of the PEV options that are currently available to consumers, assessments of the suitability of PEVs for satisfying the driving needs of consumers, analyses of the total cost of ownership of PEVs compared to conventional vehicles, and data on the current rate of PEV adoption in their study areas.

A growing number of PEV choices are now available to consumers with considerable variation in electric range, total range, charging rate, luxury, and price. Commercially available PEV offerings are on the smaller end of the vehicle size class spectrum, ranging from mini-compact up to the compact- sport utility vehicle (SUV) class. Several plans collected and synthesized data on the PEV options currently available to consumers. These data demonstrate the early market development of PEVs, provide information with which to assess the suitability of current PEV market offerings for consumer needs, and can be incorporated into materials developed for public education and outreach efforts.

Early sales of PEVs represent a small fraction of total new vehicle sales, but sales are growing. According to the Electric Drive Transportation Association, PEV sales in the United States grew from 345 vehicles in 2010, to 17,735 vehicles in 2011, to 52,835 vehicles in 2012. Most recently, in 2013, 97,193 PEVs were sold, comprising 0.63 percent of new light-duty vehicle sales.

Several plans gathered data, from state Departments of Motor Vehicles (DMVs) and other sources, on the rate and location of PEV and hybrid vehicle sales in their regions to inform forecasts of future PEV adoption and where those adopters are most likely to live.

Forecasting PEV adoption – To better anticipate the demand for charging infrastructure, the potential impacts on the electrical grid, and the expected economic and environmental impacts of PEV adoption, several plans included forecasts of PEV adoption.

These forecasts, some quantitative and some qualitative, generally predicted PEV market growth and rising numbers of PEVs on the road, citing various drivers including: reductions in PEV prices due to economies of scale, learning by doing, and expected battery cost reductions; state zero emission and low emission vehicle programs; federal fuel economy and greenhouse gas emissions standards; increasing public awareness and acceptance; and rising gasoline prices.

Grantees used a variety of methodologies to forecast PEV adoption. Some plans used existing forecasts from other organizations or initiatives, including the California South Coast plan which used PEV market growth projections provided by electric utilities for their service areas. Some plans, including those by the Center for Transportation and the Environment (the Southeast Regional grantee) and the Texas River Cities grantee, used consumer adoption models to build scenarios based on high-level assumptions about total potential PEV market size, sales of PEVs to early adopters, and the spread of sales to later adopters. Some grantees simply offered a range of sales scenarios like Florida, who based the scenarios on multiples of the first 10 years of hybrid vehicle sales.

Projections of the average rate of growth in the number of PEVs over the next decade varied, as did the timing of market penetration. The U.S. Energy Information Administration's (EIA's) 2013 Annual Energy Outlook Reference Case Scenario projects that PEVs will climb from 0.06 percent of national new car sales in 2012 to 3.2 percent by 2025. The University of Hawaii, the Maui grantee, noted that Hawaii was forecasted by Pike Research to experience the highest market penetration of PEVs in the country – 12.3 percent of new vehicle sales by 2020. The Texas River Cities plan, on the other hand, noted that adoption in Texas might lag the national adoption averages based on state sales data to date.

Several forecasts differentiated between PEV types, including AEVs, EREVs, and/or PHEVs. The future relative market performance of electric vehicle types is uncertain and may vary by region. EIA's 2013 Annual Energy Outlook Reference Case Scenario projects that national sales of PHEVs and EREVs together will be seven times higher than AEVs in 2025, but the previous year EIA predicted AEV sales to outnumber PHEV and EREV sales. Some forecasts, including the Florida

grantee's, predict PHEV adoption to exceed AEV adoption over the next two decades while others, including the Colorado grantee, predicted that AEVs will comprise a higher fraction of sales. Since PHEVs and EREVs do not require as extensive or as high-powered charging infrastructure, the implications of PEV adoption by vehicle type are significant for charging infrastructure planning.

Geographically detailed projections are useful because they can indicate which regions are likely to have the greatest need for charging infrastructure. Some plans used historical hybrid vehicle sales data, existing PEV sales data, and/or purchaser demographic data to estimate the geographic distribution of future PEV adopters. The Delaware Valley Regional Planning Commission, the Southeastern Pennsylvania grantee, summarized the findings of California surveys and data from automobile manufacturers to identify the demographic characteristics of early adopters of PEVs. The research identified the following characteristics about early adopters of Nissan Leafs in California: (1) the majority have an annual household income greater than $150,000; (2) 96 percent own their homes, with an average home value of $640,000; (3) greater than 95 percent live in a single family home; (4) nearly all own at least one other vehicle; and (5) more than one-third are current or previous owners of hybrid vehicles. Projections of PEV adoption by the Clean Energy Coalition, the Michigan grantee, include maps of the distribution of owners based on demographic data. The Ohio grantee projected adoption, based on historical hybrid and PEV sales and total vehicle sales forecasts, and used demographic data to identify specific city neighborhoods where early adopters of PEVs are likely to live. The New York State Energy Research and Development Authority, the Northeast Regional grantee, noted that in its region, nearly all PEV ownership was outside of urban cores, perhaps because single-family homes offer an easier way to accommodate home charging.

Several plans broke down PEV adoption forecasts by vehicle owner type, including privately-owned, private fleets, and public fleets. Centralina Council of Governments, the North Carolina grantee, broke down current PEV ownership by personal versus fleet-owned and noted that fleet adoption of PEVs may be expected to grow faster than personal adoption due to fleet managers' typically rational assessment of lifecycle cost savings. New York City and Lower Hudson Valley Clean Communities, Inc., the New York City grantee, focused on actions to promote PEV use in taxi and truck fleets, both because of the economic viability of these applications and the desire to promote PEVs in applications with little potential to increase the number of passenger vehicles on the road.

Grantees used PEV adoption forecasts to inform charging station needs assessments and deployment plans, which are discussed in the Charging Station Deployment Plans, Siting, and Design section.

TABLE 4: Selected Content on PEV Market Assessments and Forecasts Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Bay Area PEV Deployment Forecast up to 2025	Bay Area Plan p. 14
	Description of Southern California Plug-in Electric Vehicle Atlas	South Coast Plan p. 3
Colorado	PEV Market Penetration Scenarios in 2015 and 2025	p. 35
Florida	PEV and Charging Infrastructure Forecast to 2022	Volume 1 p. 4-25, Appendix B-7
Kansas City	PEV Vehicle Deployment	p. 13
Maui	Discussion of Future EV Deployment	p. 35
Michigan	Projection of PEV Distribution to 2016 and 2020	p. 26
North Carolina	Projections of Personal and Fleet PEV Deployment to 2030	p. 38
Northeast Regional	Assessment of Current EVSE and EV Deployment	Stand-alone report
Ohio	Forecasts of Total EV Ownership to 2030	p. 11
Oregon	Landscape of future PEV and charging infrastructure deployment	p. 19
Richmond	Identification of Primary PEV Growth Areas in Richmond	p. 16
Southeast Regional	Electric Vehicle Adoption in the Southeast (to 2020)	Stand-alone section
Southeastern Pennsylvania	EV Market Segment Overview ; EV and Charging Station Deployment	Volume 2 p. 32, 38, 46
Texas River Cities	Adoption Model for Electric Vehicles in San Antonio	p. 8-2, Appendix D

2.3 IDENTIFYING KEY BARRIERS AND ASSESSING COMMUNITY READINESS

As a first step in the process of constructing a plan for increasing PEV readiness, each grantee identified the key barriers to expanded PEV adoption in its region and assessed the current level of readiness. This section provides an overview of the grantees' efforts to identify these barriers and catalogues the barriers that the grantees identified.

Surveys of and interviews with consumers, government officials, and stakeholders – Several grantees conducted original surveys to better understand the level of readiness for PEV adoption and the key obstacles. These efforts produced critical information about the perspectives, level of awareness, and challenges in the grantees' regions. The surveys also serve as a valuable resource for communities looking to design and implement their own survey programs

Surveys of current and prospective PEV owners provided valuable information about consumer awareness of and attitudes towards PEVs, consumer charging station habits and preferences, and the holdbacks to consumer and fleet PEV purchase. The Oregon Business Development Department (the Oregon grantee) and the Texas River Cities and

Florida grantees conducted surveys of consumers, fleet managers, and current PEV owners. Most surveys and interviews supported the finding that cost concerns are of paramount importance to consumers, although access to charging is also a concern. The particular challenge of providing charging at multifamily housing and at workplace parking lots was underscored. Some grantees, including the California, Colorado, and Oregon grantees, reported that environmental stewardship was a significant motivator for early PEV adopters in their regions.

Surveys of local government officials by the Michigan, Ohio, and California grantees indicated that lack of experience with PEVs, uncertainty about zoning and planning best practices, and the cost of providing public charging infrastructure were significant barriers. Many officials were interested in taking steps to promote PEV adoption, including potentially adopting new master plan and building code language. Local governments expressed interest in technical and financial assistance, as well as public education and outreach assistance.

Interviews with industry stakeholders including automobile manufacturers, charging station manufacturers, and electric utility representatives conducted by the Center for the Commercialization of Electric Technologies (the Texas Triangle grantee) and the Texas River Cities and Oregon grantees revealed difficulty in planning for uncertain PEV market growth, difficulty among automakers in coordinating with dealerships, and uncertainty about effects of PEVs on the electrical grid.

Key barriers to readiness for expanded PEV adoption – Each grantee identified roadblocks to readiness for expanded PEV adoption in their region based on original surveys like those discussed above as well as literature reviews, expert consultations, and stakeholder and public engagement.

A summary of the key barriers collectively identified by the grantees is presented in Table 5, Table 6, and Table 7 below. Barriers to readiness for expanded adoption of PEVs fall into three general categories: PEV purchase, charging station installation and utilization, and those associated with the effects of PEV adoption.

Barriers to the purchase of PEVs, presented in Table 5, include financial, information and coordination, and public policy barriers.

PEVs are generally more expensive to purchase than conventional vehicles, even after tax incentives. Despite the fuel and maintenance cost savings that PEVs offer relative to conventional vehicles, consumers tend to weigh upfront price more heavily than future savings when making purchasing decisions. There is an expansive and evolving body of academic research on how deeply consumers discount future cost savings from efficiency investments. A rule of thumb employed in the PEV industry is that consumers generally will not consider future fuel savings unless they cover the electric vehicle price premium within three years.[3]

Assessments of the lifetime cost of ownership of PEVs as compared with a conventional internal combustion engine vehicle vary significantly, depending on assumptions used in the analysis. The North Carolina and Ohio grantees presented results from the Electric Power Research Institute's ongoing analysis of total cost of vehicle ownership, which indicate that, despite a higher upfront price after tax incentives, lower fuel costs and maintenance costs make PEVs cost competitive with average conventional internal combustion engine vehicles within 2-10 years of ownership.[4] The Colorado grantee found that PEVs can provide significant financial benefits over conventional vehicles within two years of ownership and can yield between $8,000 and $18,000 in net savings over a ten-year period of ownership. The Northeast Regional grantee performed an analysis using the DOE's Alternative Fuels Data Center Vehicle Cost Calculator and found that the long-term ownership costs of PEVs and conventional vehicles can be comparable, but only after more than 10 years. The Texas River Cities grantee calculated that AEVs currently on the market do not reach a break-even point with comparable conventional vehicles within 9-12 years of ownership.

Despite any potential for cost savings, the higher upfront price of PEVs presents a barrier to widespread adoption because consumers often do not consider the total cost of ownership when making vehicle purchase decisions.

TABLE 5: Summary of Barriers to PEV Purchase Identified by the Grantees

BARRIERS TO PEV PURCHASE	

Financial	• High upfront cost of PEVs
	  o New technology
	  o Production has not yet reached volumes that offer economies of scale
	  o Uncertain potential for future cost reduction in batteries
	• Consumers more sensitive to higher upfront price of PEVs than total cost of vehicle ownership that includes potential fuel and maintenance savings

Information and coordination	• Potential vehicle owners unfamiliar with PEVs
	  o Consumers not aware of available vehicles types and their attributes
	  o Consumers harbor misconceptions about PEV performance and safety
	  o Consumers not aware of potential fuel and maintenance savings
	  o Consumers not aware of available government incentives for PEVs
	  o Real and perceived concerns about battery degradation and potential cost of replacement
	• Range anxiety, due to factors including
	  o Consumers unaware that range is not an issue for EREVs and PHEVs
	  o Consumers overestimate daily range needs
	  o Consumers unaware of existing public charging stations
	  o Insufficient public charging infrastructure in local communities and along major transportation corridors (see Table 6: Summary of barriers to charging station installation and utilization identified by the grantees)
	  o Range of AEVs insufficient to meet the occasional long-distance needs of nearly all drivers
	• Dealerships not educated about PEVs and not motivated to spend additional time selling PEVs over conventional vehicles
	• Automotive technicians not trained to service PEVs
	• First responders not trained on unique aspects of PEVs such as de-energizing the vehicle battery
	• Policymakers not familiar with PEVs
	  o Policymakers unaware of the economic and environmental benefits of PEV adoption
	  o Policymakers unaware of the policy and market barriers to PEV adoption and the options for increasing PEV readiness
	• Efforts to promote PEVs not fully leveraged due to lack of communication and coordination among potential partners

Policy	• Poorly designed or inadequate government incentives provided to support appropriate early market development • Public or non-profit fleets not benefiting from tax credit incentives • Additional fuel cost savings from lower electricity rates during overnight charging unavailable to consumers without time-of-use (TOU) rate structures • Limited and/or outdated PEV options included on state bid lists for public fleets • Policy barriers to charging station installation and utilization (see Table 6: Summary of barriers to charging station installation and utilization identified by the grantees)

TABLE 6: Summary of Barriers to Charging Station Installation and Utilization Identified by the Grantees

BARRIERS TO CHARGING STATION INSTALLATION AND UTILIZATION	

Financial	• Home charging equipment often not sold or financed with AEV purchase at the dealership
	• Cost of home charging equipment, installation, and permitting
	• Difficulty establishing a profitable business case for charging stations
	  o Charging stations experience low utilization rates during early PEV market development
	  o Low margins on electricity sales relative to upfront costs and maintenance costs of charging stations
	  o Demand charges by electric utilities for fast charging, especially in less populated areas
	  o Difficulty establishing the terms under which charging providers can offer service in regulated markets
	• Lack of established public or private funding for the purchase and/or maintenance of charging infrastructure

Information and coordination	• Difficulty providing charging stations at multi-unit residential, workplace, and other shared parking sites (i.e., cost, fairness, ownership, administrative, and legal issues) • Consumers unaware of existing public charging stations • Long charge times inconvenient for drivers, especially where public charging stations are highly utilized and drivers may have to wait for others to finish • Uncertainty among public planners and private investors about the future intensity and location of demand for public charging stations • Uncertainty about the optimal level of charging power to install at public stations given the tradeoffs between speed of charging and station cost, as well as uncertainty about demand from AEVs (higher power needs) versus PHEVs (lower power needs) • Lack of compatibility among charging station payment methods, communications, and fast-charging standards • Uncertainty about best practices for planning parking sites with public charging stations, including Americans with Disability Act (ADA) compliance • Efforts to support charging station installation not fully leveraged due to lack of communication and coordination among potential partners
Policy	• Insufficient signage directing PEV drivers to charging stations and non-uniform charging station signage • Expensive, complex, protracted, and/or non-uniform permitting and inspection procedures for residential and workplace charging station installation • Local zoning rules vague or arduous for charging station siting • Charging-only use of public charging spaces cannot be enforced without new ordinances

TABLE 7: Summary of Barriers Associated with Potential Effects of PEV Adoption Identified by the Grantees

BARRIERS ASSOCIATED WITH THE POTENTIAL EFFECTS OF PEV ADOPTION	
Electrical grid effects	• Uncertainty about the potential for high-power electricity demand to strain electrical infrastructure, particularly in residential neighborhoods with clusters of PEV adoption or at fast-charger locations • Electric utilities unaware of or uncertain about the numbers and locations of future PEV owners • Uncertainty about how successful time-of-use (TOU) electricity rates will be at mitigating electricity demand spikes from PEV charging • Challenge of planning for, developing, and deploying the technology and infrastructure needed to enable Vehicle-To-Building (V2B) and Vehicle-To-Grid (V2G) benefits of PEVs
Transportation infrastructure funding effects	• Long-term concern that consumer adoption of more fuel efficient vehicles, including PEVs, will decrease the effectiveness of gasoline taxes as a source of transportation infrastructure funding • Misconception that PEVs will contribute substantially to reduction in gasoline tax revenue in the short-term
Equity concerns	• Concern that public financial subsidies and other incentives, including HOV lane access and dedicated parking spaces for PEVs, will be used disproportionately by higher income individuals and households

Many consumers and fleet managers are also generally unfamiliar with PEVs, and therefore, they lack information about available PEV models, PEV performance and safety, fuel and maintenance cost savings, and government incentives for PEV purchase.

When considering the purchase of a PEV, many consumers are deterred by anxiety about the lower electric-only range of AEVs relative to conventional vehicles, EREVs, and PHEVs. Range anxiety is not an issue for EREVs or PHEVs, because the consumer can rely upon the gasoline engine when the battery runs low. While apprehension about AEV range is justified for some drivers, many consumers actually overestimate their daily range needs and could in fact satisfy the vast majority of their travel needs with AEVs and home charging. Several plans determined that the daily commuting distances of most consumers are well within the range of currently available AEVs. For example, the Ohio plan noted that 70 percent of drivers in Cleveland and Columbus commute less than 20 miles round trip each day, and an additional 10 percent of drivers commute 20 to 50 miles. On the other hand, some plans noted that the shorter range of AEVs would require more careful planning of long trips and greater awareness of fuel levels than drivers of conventional vehicles are accustomed to. The real and perceived constraints imposed by the shorter range of AEVs can also be eased by expanding fast-charging infrastructure, ensuring vehicle compatibility with emerging fast-charging standards, and organizing public outreach, which are discussed in subsequent sections. Consumer range anxiety is also reinforced by both real and perceived insufficiency of public charging infrastructure. The barriers to charging station installation and utilization are discussed below.

Lack of information about PEV adoption is not limited to consumers. Many dealerships are not educated about PEVs and are not motivated to spend additional time selling PEVs over conventional vehicles. Automotive technicians require additional training to service PEVs. Emergency first responders require training on the unique aspects of PEVs.

Existing policies may also present barriers to consumer and fleet adoption of PEVs. Government incentive programs, including financial subsidies and non-financial incentives, may not provide sufficient support for the early market development of PEVs. State lawmakers and regulators also have a role to play

in establishing electricity rate programs that can persuade consumers to adopt PEVs by enabling additional fuel cost savings. In jurisdictions where financial incentives are available in the form of tax rebates, these incentives are not accessible to potential purchasers that do not have sufficient tax liability, such as public or non-profit fleet managers. Public fleet managers may be further deterred from purchasing PEVs in cases where only limited and/or outdated PEV options are included on state bid lists.

Barriers to charging station installation and utilization, presented in Table 6, include financial, information and coordination, and policy barriers.

Purchasing home charging equipment can be an additional source of confusion and financial cost for PEV adopters. Home charging equipment often is not sold or financed with the PEV purchase at the dealership. Installation of home charging can be subject to expensive, complex, protracted, and/or non-uniform local permitting and inspection procedures and zoning rules. In some locations, the installation of charging stations may require unanticipated electrical system upgrades that could add considerable expense to the installation cost.

Providing charging stations at multi-unit residences, the workplace, and other shared parking sites can be particularly challenging due to circuit installation cost, access, liability, and coordination issues.

Ensuring the adequate and efficient deployment of public charging stations to enable travel along major transportation corridors and ease range anxiety for potential and existing PEV adopters also faces barriers. Establishing a profitable business case for private investment in charging infrastructure is difficult for several reasons. Upfront capital and maintenance costs of charging stations are difficult to recover given expected electricity sales revenue, especially as charging stations experience low utilization rates during early PEV market development. In addition, the potential for incurring demand charges[5] for fast charging as well as uncertainty regarding the terms under which charging providers can resell electricity in regulated markets further complicate the business case for private infrastructure investment.

Public investment in charging infrastructure also can be challenging. It may be difficult for budget-constrained local and state governments to secure public funds and staff resources for purchasing and maintaining public charging stations. In some cases, even if public funding is available, it may be difficult to find private property owners who are willing to host and maintain public charging stations.

Uncertainty among both public planners and private investors about the future intensity and location of demand for public charging stations presents another challenge to deployment. Furthermore, at a given charging station site, there remains uncertainty about the optimal level of charging power to install given the tradeoffs between speed of charging and station cost. Project planners also face uncertainty about best practices for site design, including compliance with the Americans with Disability Act (ADA).

Even once deployed, charging stations may be challenging for PEV drivers to use. Charging stations can be difficult to locate due to insufficient signage directing PEV drivers to charging stations and non-uniformity of signs at charging stations. Parking spaces designated specifically for use by charging PEVs may be blocked by parked conventional vehicles and enforcement of charging-only spaces may require the enactment of new traffic ordinances. Lengthy charge times can be inconvenient, especially where public charging stations are highly utilized and drivers may have to wait for others to finish.

PEV drivers also may face challenges interfacing with public charging stations due to a lack of compatibility among technical, payment, and communication standards. On the technical side, while nearly all automakers use Society of Automotive Engineers (SAE) J1772 AC connector for Level 1 and Level 2 charging, the standards for DC fast-chargers are still evolving, with three different connectors being adopted by automakers and charging station providers. The CHAdeMO connector, developed by the Tokyo Electric Power Company is for DC fast-charging only and requires a separate port from the SAE J1772 AC connector. Separately, SAE developed a "Combo" connector, which includes the standard SAE J1772 AC connector along with two high-current DC pins. Finally, Tesla Motors has also deployed a private network of charging stations that use its own proprietary connector.

Barriers associated with effects of PEV adoption, presented in Table 7, include concerns about transportation infrastructure funding and equity as well as the need for electrical grid planning.

As PEVs are adopted, electric utilities are uncertain about the potential for high-power electricity demand to strain electrical infrastructure, particularly in residential neighborhoods with clusters of PEV adoption or at fast-charger locations. Electric utilities are unaware of or uncertain about the numbers and locations of future PEV owners in their service areas. Many utilities are also uncertain about how effective time-of-use (TOU) electricity rates can be at smoothing out electricity demand load by encouraging charging at night. Over the longer term, there is also the challenge of planning for, developing, and deploying the technology and infrastructure needed to enable PEV batteries to serve as distributed electricity storage through V2B and V2G interconnections.

PEVs also raise concerns about transportation infrastructure funding in some areas. Over the long term, consumer adoption of more fuel-efficient vehicles and alternative fuel vehicles, including PEVs, will continue to decrease the amount of gasoline taxes collected to fund transportation infrastructure. In addition, it may be of concern that efforts to promote PEV early market development can be hampered by PEV-specific fees motivated by the misconception that near-term PEV markets contribute substantively to decreases in gas tax revenues.

Some consumer advocates question the fairness of providing financial subsidies and other incentives, including high-occupancy vehicle (HOV) lane access and dedicated parking spaces for PEVs. Early PEV consumers tend to be higher-income individuals and households, so the benefits may accrue disproportionately to them.

Several grantees identified barriers that were especially important in their particular regions, enhancing the local value of their plans. For example, the New York City grantee faced the challenge of promoting vehicle electrification without promoting increased personal automobile use. The Colorado grantee reported struggles with public misperceptions that altitude negatively impacts battery performance as well as the real challenge posed by the need of some drivers for powerful vehicles to handle mountainous terrain. Hawaii cited the relatively high price of electricity in the state as a disincentive to PEV adoption. The Center for Transportation and the Environment, the Southeast Regional grantee, cited the limited local availability of vehicles because automakers had not targeted the region for sales or pilot programs.

Finally, a critical cross-cutting obstacle is that ongoing efforts to promote PEVs are not being fully leveraged due to lack of communication and coordination among potential partners. The central goal of each of the PEV Readiness grantees was to engage a broad set of partners and audiences to collaboratively address each of the key barriers to PEV adoption.

Quantitative assessment of PEV readiness – Identifying the specific barriers to PEV adoption facing a given region is a practical way to characterize the PEV readiness of the community. Building on the knowledge of these barriers to develop ratings of PEV readiness can provide a helpful framework for communities to understand their readiness, set goals for increased readiness, track progress towards those goals, and recognize communities for being PEV friendly. The North Carolina grantee assigned a numerical score to each of the partnering sub-regions in the state based on the level of progress towards each of 11 readiness areas. The Texas Triangle plan itemized a menu of activities and corresponding point values that communities can use to score their level PEV readiness. The Michigan plan assigned qualitative community readiness levels of accepting, encouraging, and assertive to its own recommendations and tools to enable communities to score their own level of current and aspirational PEV readiness. DOE's Clean Cities program has also developed a Plug-In Electric Vehicle Readiness Scorecard tool that enables local and regional leaders to evaluate a community's PEV readiness, receive feedback and suggestions, and track progress towards PEV readiness. This tool can be accessed at https://www.afdc.energy.gov/pev-readiness.

Reducing barriers to PEV adoption – Identifying the key barriers to expanded adoption of PEVs and assessing readiness was a first step for each grantee. The subsequent chapters of this report describe the activities grantees undertook to reduce these impediments.

TABLE 8: Selected Content on Readiness Assessment and Identification of Key Barriers Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Summary of Barriers to Adoption and Proposed Solutions	Bay Area Plan p. 11
	Overview of Barriers and Solutions to Deployment of PEVs	Central Coast Plan p. 11
	PEV Building Permit Process Survey	Sacramento Plan p. 19
Colorado	PEV Market Assessment and Ownership Business Case	p. 15
Florida	Common Barriers to Widespread Adoption of Electric Vehicles	Volume 1 Section 3-2
	Vehicle Fleet Owner Survey and Outreach	Volume 1 Section 6-108
Kansas City	Barriers to Consider and Recommended Mitigation Plan	p. 15
Maui	Barriers to EV Readiness	p. 21
Michigan	Survey of Local Government Officials	Appendix B
	Barriers to PEV Adoption	p. 26
North Carolina	Community Readiness Assessments	Statewide Plan p. 26, Appendix 1
	PEV Market Assessment and Total Cost of Ownership	Statewide Plan p. 30
Northeast Regional	Technical Barriers to PEV Adoption	Assessment of Current EVSE and EV Deployment p. 9
Ohio	Ohio Survey of Local Governments	Stand-alone report
	Total Cost of Ownership Analysis	p. 4
Oregon	Surveys of Existing and Potential PEV Owners and Stakeholders	p. 18, 24, 51
Southeastern Pennsylvania	Barriers and Recommendations for EV and EVSE Deployment in Southeastern Pennsylvania	Volume 1 p. 13
Texas River Cities	Regional Survey of PEV Owners	p. 2-2
	Comparison of Conventional and Electric Vehicles	Appendix D p. 38
Texas Triangle	Local Barriers to PEV Readiness	Volume 2 p. 14
	Survey of Electric Utilities	Volume 3 Appendix 4A
	Texas PEV-Friendly Community Program to Assess PEV Readiness	Volume 2 p. 23

2.4 DEVELOPING AND IMPLEMENTING SOLUTIONS TO OVERCOME BARRIERS

2.4.A. Incentives for PEVs and Charging Stations

To reduce barriers to PEV adoption and foster early market development of PEVs, the federal government and many state and local governments offer incentives to support PEV adoption. Incentives are an important component of PEV readiness because PEVs are competing against conventional internal combustion engine vehicles, an incumbent and mature technology in an established market. Conventional vehicles have benefited from over a century of technology development, manufacturing learning-by-doing, infrastructure development, and consumer awareness and experience. Government incentives, both financial and non-financial, help to temporarily offset some of the disadvantages that PEVs face relative to incumbent conventional vehicle technologies as they are introduced into the market. Financial incentives will become less necessary as PEV costs are reduced through technological innovation, scale of production, and learning-by-doing. Purchase incentives may also become less necessary as consumers gain awareness of and experience with PEVs and are reassured by build-out of refueling infrastructure.

As part of their activities to support adoption of PEVs, grantees collected information about existing incentives for PEVs and charging stations, discussed which incentives might work best in their regions, and proposed new incentives and improvements to existing programs.

This section provides an overview of the types of incentives offered by the federal government, states, and municipalities, as well as ideas for revising or expanding incentive programs proposed by the grantees. A detailed database of currently available state and federal incentives can be found on DOE's Alternative Fuels Data Center website at http://www.afdc.energy.gov/laws/.

Incentives for PEVs – Incentives for PEVs include both financial incentives that lower the cost of vehicle purchase and operation and non-financial incentives that provide other benefits, such as convenience, to PEV owners.

The largest and most direct financial incentives for PEVs are vehicle purchase price incentives. The federal government currently offers an income tax credit of up to $7,500 to purchasers of qualifying PEVs. States and municipalities offer a variety of additional vehicle purchase incentives, including: state income tax credits or rebates for vehicle purchases; reduced state sales taxes or exemption from taxes; reduced emissions inspection fees or exemption from emissions inspections; and reduced vehicle registration fees. Some states and municipalities offer incentives for the adoption of heavy-duty electric vehicles as well, such as purchase vouchers that lower the cost of electric and hybrid short-haul and delivery trucks and urban buses. The California grantee, noting that as of October 2012 approximately one-quarter of all PEVs sold in the United States were purchased in the state of California, attributed much of this market uptake to significant state and regional vehicle incentives. The Colorado plan cited a Nissan analysis of sales data showing that, compared to states with no PEV incentives, consumers are more than twice as likely to buy a PEV in states with at least one PEV incentive and three times as likely in states with two PEV incentives.

While vehicle price incentives have proven to be a critical support for early consumer adoption of PEVs, some grantees maintained that changes to the structure of these incentives could improve their effectiveness. One issue is that organizations without sufficient tax liability, such as public or non-profit fleets, cannot take advantage of tax credit incentives. Even entities with some tax liability may not have sufficient tax liability to claim the full value of tax credit incentives. The Colorado plan recommended that state and federal tax credit programs allow recipients to sell credits to entities that have a sufficient tax liability, such as tax equity investors.

Another issue is that tax incentives do not directly reduce the upfront vehicle purchase price at the point of sale, which both diminishes the visibility of the incentive to the consumer at the time of purchase and requires that the full retail price of the vehicle be financed. The Virginia Department of Mines, Minerals and Energy, the Richmond grantee, recommended converting the federal tax credit to a rebate, noting that this would allow any organization or individual to access the incentive, increase visibility of the discount to purchasers, and decrease the amount that is

necessary to finance.

States and municipalities also offer various incentives that promote PEV adoption and use by reducing operational costs and increasing convenience for PEV owners, including: access to HOV lanes, reduced tolls, and preferred or discounted parking. Convenience and reduced fee incentives like these offer high-visibility opportunities to promote PEV adoption and can cost less than tax-based incentives. On the other hand, some grantees noted that establishing these incentives was not possible in their region due to a lack of HOV lanes or limited public parking for which to offer incentives. The Florida plan noted that HOV lane access incentives are effective in areas with more traffic but less effective in less congested areas. These incentives also may also elicit equity concerns. The Southeastern Pennsylvania grantee noted that highly visible convenience incentives for early adopters of PEVs, who tend to be relatively affluent, may elicit public resentment of PEVs.

In addition, some electric utilities offer time-of-use (TOU) electricity rates to PEV owners which can increase PEV adoption by lowering fuel costs. While time-of-use rates may lower the cost of vehicle operation, they are not PEV subsidies per se nor are they necessarily intended to be temporary, because the rate structures are primarily designed to motivate PEV owners to charge overnight when total electricity demand is low. TOU rates are discussed in detail in the Power Grid and Electric Utilities Policies and Planning section of this report.

Incentives for charging stations – Incentives for charging station installation include both financial and green development certification incentives. These incentives cover a broad spectrum of charging station types and locations including home chargers, workplace chargers, publicly-accessible charging stations in local communities, and fast-charging stations along highways.

The federal government provided tax credits of up to $1,000 for residential consumers and $30,000 for businesses for alternative fueling infrastructure, including electricity charging stations, installed prior to December 31, 2013.[6]

States and municipalities offer a variety of additional financial incentives for charging station installation. For example, Los Angeles, California offers up to a $2,000 rebate on residential charging station installations. In Texas, some electric utilities offer incentive programs that rebate operational costs to businesses who install charging stations.

Sustainable building programs, such as the Leadership in Energy and Environmental Design (LEED) certification program, also offer incentives for charging station installation in the form of credits towards certification. The Florida plan provides an overview of the LEED program and other green building certification programs in the state and a detailed list of the charging station incentives these programs offer.

Local zoning policies can also be used to incentivize charging station deployment, which is discussed in the Local Ordinances and Administration: Zoning, Parking, and Signage; Building Codes; and Permitting and Inspection section.

In addition to providing incentives to consumers and businesses for charging station installation, federal, state, and local governments also directly fund public charging infrastructure installations, in many cases as part of research or demonstration programs. Deployment of public charging infrastructure is discussed further in the Charging Station Deployment Plans, Siting, and Design section.

Establishing, expanding, and sustaining incentives – Several grantees recommended establishing PEV incentives in their region or extending or expanding existing programs, and noted that the information, partnerships, and awareness generated from the readiness plan efforts comprised a solid foundation on which to build support for incentives. The Ohio grantee, for instance, noted that its state was alone among neighboring states in not providing tax incentives, grants, or rebates for PEVs or charging infrastructure and expressly sought in its plan to make the case and lay the groundwork for establishing PEV incentives. The North Carolina grantee, in a supplemental report to its readiness plan, provided a detailed overview of state PEV incentives offered throughout the country, presented survey results on what incentives matter to fleet owners, and analyzed policy implications for the state. The grantee prepared a table that prioritizes potential state PEV incentives

based on effectiveness and feasibility, concluding that incentives that reduce the upfront cost of PEVs are the most attractive to consumers and may be more cost effective.

Finally, while strong incentives can provide critical support for early market development, they can only be effective if consumers, fleet operators, businesses, and dealers are aware of their availability. Several grantees, noting that awareness of incentives is limited in their regions, conducted outreach and education campaigns which are discussed in the Outreach, Education, Training, and Marketing section. The Southeastern Pennsylvania plan suggested that incentives are most likely to sway consumers who are already familiar with PEVs and that expanding the market for PEVs will require broader education and awareness campaigns.

TABLE 9: Selected Content on Incentives for PEVs and Charging Stations Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Overview of Federal, State, and Local Incentives	Bay Area Plan p. 45
Colorado	Menu of Policy Strategies and Actions, Including Incentives	p. 76
Florida	Financial and Non-Financial Incentives for PEVs and EVSE	Volume 1 p. 6-51
	Building Incentives for PEV Charging Readiness, including LEED and State Programs	Appendix A-5
Kansas City	EV Benefits and Incentives Promotion Plan	p. 48
Maui	Discussion of State and Federal Incentives	p. 28
	Incentives for Off-Peak Charging	p. 68
Michigan	Charging Station Installation Incentives and Time-of-Use Rates	p. 40
North Carolina	Detailed PEV Incentives Analysis and Options for North Carolina	Statewide Plan Appendix 9
Northeast Regional	EV Adoption Incentives in the Northeast	Assessment of Current EVSE and EV Deployment p. 23
Ohio	Statewide PEV Policy Considerations, Including Incentives	p. 37
Oregon	Information on State Incentives for Fleets and Heavy Duty Vehicles	p. 27
Richmond	Policies and Incentives	p. 32
Southeast Regional	Federal, State, and Local EV and Charging Station Incentives	Section 1 p. 22
Southeastern Pennsylvania	Best Practices for Incentives and Programs to Enhance Demand	Volume II p. 123

2.4.B. Charging Station Deployment Plans, Siting, and Design

Range anxiety and lack of access to charging infrastructure are two of the most significant barriers to widespread adoption of AEVs. A lack of access to charging locations is also a significant hindrance to PHEV and EREV adoption. To assess and address these barriers while ensuring that installed charging infrastructure is highly utilized and cost-effective, grantees analyzed the future need for charging infrastructure in their regions and developed plans for charging station deployment. The number of charging stations needed, where these stations should be sited, and what level of power these stations should provide were the key initial considerations. Each grantee began their assessments of charging infrastructure needs based on scenarios of PEV adoption in their regions, which are discussed in the PEV Market Assessments and Forecasts section.

Residential, workplace, and fleet charging stations – Charging stations that are primarily only privately accessible, including single-family residential, multifamily residential, fleet, and workplace charging stations, are the most critical for enabling PEV adoption, as shown in Figure 2.

While residential, fleet, and workplace charging stations are outside the scope of publicly-accessible infrastructure deployment plans, understanding the proportion of charging that is likely to be met by private stations is critical to planning public charging station deployment. Several grantees performed geographic analyses of household travel survey data and demographic data to inform publicly-available charging infrastructure investment and siting.

The Southeastern Pennsylvania grantee's analysis revealed that approximately 80 percent of the vehicles in its region traveled less per day than the electric-only range of the Chevy Volt and approximately 97 percent traveled less than the range of the Nissan Leaf. Therefore, the grantee concluded, Level 1 at-home charging can satisfy most charging needs for PHEV/EREV drivers, and Level 2 at-home charging can satisfy most charging needs for AEV drivers. In addition, the grantee found that because 74 percent of drivers parked vehicles at work for at least 7 hours, workplace charging can further satisfy daily local charging needs. As a result, the Southeastern Pennsylvania grantee concluded that a majority of charging demand in its region can be met with residential and workplace charging.

The Southeast Regional grantee's analysis of the charging behavior of a projection of 100,000 PEVs in Alabama, Georgia, and South Carolina yielded similar results, indicating that the majority (57 percent) of charging will occur at home, followed by the workplace (26 percent). The grantee concluded that only 17 percent of charging would occur at public charging stations. Several grantees also performed geographic analyses of where residential charging stations are likely to be installed. Based on these analyses, grantees produced maps of neighborhoods whose demographics make them likely to host clusters of PEV adopters. These analyses are helpful because they provide information on potential future electricity demand for electrical grid planners (discussed further in the Power Grid and Electric Utility Policies and Planning section) and because they identify communities whose government and business leaders should be targeted for engagement.

The barriers to installation of privately-accessible charging stations are distinct from those faced by publicly-accessible stations and are discussed in the following sections: Incentives for PEV Purchase and Charging Station Installation; Local Ordinances and Administration: Zoning, Parking, Building Codes, Permitting, and Inspection; and Providing Charging Stations at Multi-Unit Dwellings, Shared Parking Areas, and the Workplace.

Publicly-accessible charging stations in local communities – Publicly-accessible charging stations in local communities are an important component of PEV readiness because they can (1) extend the electric range of PEVs by offering opportunity charging, (2) increase public awareness of PEVs, (3) decrease AEV range anxiety, (4) provide charging access to PEV owners who do not have access to home charging.

Public and private investors in local publicly-accessible charging infrastructure face the challenge of planning for the number, location, and power level of charging stations to be deployed.

Grantees performed geographic and demographic analyses to identify neighborhoods where public

charging stations would likely be in highest demand. The Ohio grantee, for example, performed a geographic analysis of PEV adoption together with data on popular destinations. The grantee estimated that by 2030, the Cleveland and Columbus areas will require over 50,000 non-residential charging stations to serve PEV drivers. The grantee also prepared a charging station deployment model demonstrating where stations could be located to provide 95 percent of Ohio's population with access to a charging station within 10 miles of home.

Siting analyses were performed by some grantees to identify locations for public charging stations using survey data, traffic data, employment data, and data on popular destinations. The Southeastern Pennsylvania grantee performed an analysis of traffic data, employment data, and major destinations to identify public charging infrastructure site targets. The California grantee identified suitable sites for charging stations based on (1) estimated future PEV demand including the number of vehicles adopted and the charging and range characteristics of those vehicles; (2) assumptions about how PEVs are operated including the purpose and distance of trips taken and the rate of home charging adoption and utilization; and (3) the characteristics of candidate sites including the destination type, who owns the parking site, and the parking lot attributes that affect installation cost estimates.

The Northeast Regional grantee took a different approach in part due to the size of and diversity within its study area. Rather than identifying specific target locations for charging stations, the grantee identified nine sweet spot station location types and provided in-depth site typologies and case studies for each of these locations. This resource was designed to help public planners and private investors identify the best sites for charging station deployment in their regions and understand the unique opportunities and challenges of each location type. The nine deployment locations (or clusters) identified, described, and evaluated were: downtown, multi-family, retail, commercial office, higher education, medical campus, regional transportation, fleet, and freight. The grantee concluded that charging stations were under-deployed in key locations, such as multi-family housing sites; that few deployment location types are interested in proactively deploying charging stations without outside funding despite marketing and branding opportunities associated with offering charging; and that municipalities should continue to lead charging station deployment.

The efficient level of charging power to provide at a particular location depends on how long drivers typically remain parked at that location. The California grantee prepared a table that demonstrated the range of parking durations and recommended charging types for different locations. For example, Level 2 or DC fast-chargers are appropriate at shopping centers where drivers park for an average of 0.5 to 2 hours. On the other end of the spectrum, Level 1 or Level 2 charging are appropriate at hotels where guests usually remain parked for 8 to 72 hours.

There remains uncertainty about the optimal amount of publicly-accessible charging infrastructure to provide. The California grantee noted that local governments have little information about how much demand there will be for charging stations, and that creating requirements for charging station installation or pre-wiring could drive up the cost of new building development or lead to underutilization of stations.

Several grantees expressed concern that charging infrastructure deployment that results in underutilized stations could backfire by creating an appearance that PEVs are not popular in the community. Some grantees noted that a focus on the need for public charging stations shifts consumer attention away from the fact that most charging will actually occur at home.

As several plans noted, charging station deployment plans and siting analyses should be reevaluated within an adaptive framework. This will enable plans to be adjusted as the actual number and location of PEVs adopted and charging stations installed changes; as travel behavior changes; and as technology advancements, such as reduced charging times or increased energy storage in batteries, become available.

Publically-accessible charging stations along transportation corridors – The development of networks of publically accessible fast-charging stations would enable AEVs to complete long trips between metropolitan areas, easing range anxiety and enabling a greater number of travel miles to be satisfied by AEVs.

In part because public charging stations along

intercity transportation corridors are projected to experience relatively low utilization compared with other charging locations in the early PEV market, development of corridor charging stations has not been given priority in many regions. The Texas Triangle grantee noted that while private industry, with government assistance, is making significant investments in charging stations within the metropolitan areas of Dallas, Houston, San Antonio, and Austin, there is very little charging station installation being planned along the intercity corridors.

Charging infrastructure along major corridors has been given attention in several regions. One high profile PEV readiness project along a major transportation corridor is the West Coast Electric Highway, which was originally envisioned to provide charging stations along all 1,381 miles of I-5 from Canada to Mexico. So far, Washington and Oregon have given the most focus to the project and have installed DC fast charging stations every 25 to 60 miles along I-5 and other major roadways in the Pacific Northwest, enabling PEV travel from the southern border of Oregon to Canada. The Oregon grantee reported that the state continues to build charging stations along I-5, which will provide access to charging stations in the urban and suburban counties with the heaviest concentration of PEV ownership as well as expand opportunities for sustainable tourism in the state.

Several grantees prepared plans to support the development of corridor charging station projects in their regions, in many cases proposing to enable PEV travel along "triangles" of roads that connect three or more cities in their regions. The Ohio grantee included charging station installations along the I-71 corridor, which links the state's three largest cities, in its analyses of public charging station needs and barriers, citing the potential to ease range anxiety. The Metropolitan Energy Information Center, Inc., the Kansas City grantee, conducted a technical analysis to support PEV travel between Kansas City, Topeka, and Wichita, Kansas. This analysis included recording PEV energy consumption along the corridor, identifying sites where charging stations would support intercity PEV travel; discussing issues related to PEV corridor design and implementation; and developing a platform to facilitate future corridor development activities. The Texas Triangle grantee constructed a model to recommend optimal scenarios of charging station deployment along the corridors connecting Dallas, Austin, San Antonio, and Houston.

Some plans for PEV readiness along transportation corridors are multimodal and/or incorporate other vehicle efficiency technologies. The Florida grantee completed a detailed master plan for a demonstration project that would establish a car-sharing program along the US-1 corridor in Miami Dade County. The plan calls for 15 to 20 percent of the car-share vehicles to be PEVs and for charging stations to be installed at 12 mass transit stations. The goals of the plan would be to investigate the consumer response to the availability of these options, to accelerate the mainstream adoption of car sharing and PEVs, and to bolster incentives for increased use of regional transit services.

Business models for investment in charging stations – While early deployment of publicly-accessibly charging stations has been, and may continue to be, publicly subsidized, developing business models for private investment in charging infrastructure that are either directly profitable or provide justifiable value for owners will be of vital importance for large-scale future deployment.

Unlike public investment in charging infrastructure, which is evaluated based on its potential to promote the early market development of PEVs, private investment in charging stations is evaluated based on the financial viability of investment. Several grantees provided analyses of the business case for investment in charging stations, which vary considerably based on assumptions about station utilization, upfront and operating costs, and electricity rates and other electricity market regulations. The Colorado grantee's analysis determined that investors can realize payback periods of less than six years if Level 1 and Level 2 station suppliers charge at least $0.30 per kilowatt-hour (kWh) and DC fast charger station providers charge $0.60 kWh, which the grantee determined is within the consumer willingness to pay. The California grantee provided scenario analyses of the present value of charging infrastructure investments to enable retailers to evaluate the financial viability of offering charging. The grantee assumed 10 years of station operation, constant electricity costs, and a discount rate of 5 percent. These analyses, which show that under some

conditions providing charging can be financially viable, demonstrate the sensitivity of project viability to total upfront costs, station utilization, charging times, and fee structures.

For sites where high-power fast chargers may be installed or where many PEVs may charge at once, such as workplaces, multi-unit residences, or fleet refueling stations, charging station managers may face additional costs resulting from high electricity demand. Many electric utilities assess a demand charge on electricity consumers based on the highest hour of demand in a given month. The California grantee researched this issue and considered how it might impact charging station investments. The California plan notes that demand charges may be particularly high for public charging stations at retail or workplace locations where PEVs are charged during the day. The California plan concludes that site managers may choose to (1) install lower powered chargers where PEVs are parked for longer periods of time or (2) regulate charger usage times of day when demand charges are lower to reduce demand charges. This issue is discussed from the utility policy perspective in the Power Grid and Electric Utility Policies and Planning section.

The Texas River Cities grantee devoted a significant portion of its efforts to research into charging infrastructure business models, which included surveying potential charging station investors as well as developing quantitative tools to enable electric utilities and private investors to assess the business case. The grantee notes that two of the biggest barriers to infrastructure installation are the low return on investment and the disaggregated value chain of electricity supply. While the grantee concludes that it is a considerable challenge to construct a workable business model around vehicle charging or charge management, these tools allow companies to evaluate the financial return on alternative business models under various assumptions and under alternative electric utility market structures.

The New York City grantee focused specifically on benefits and economic feasibility of providing curbside electricity from existing light poles to the city's 3,000 existing food trucks and carts. The grantee concluded that providing electricity in this manner could dramatically reduce greenhouse gas and local air pollution emissions from street food vendors, could pay back investments in as little as 18 months, and could serve as a low-risk early deployment of publically accessible vehicle electricity access.

Publicly-accessible charging along major corridors may be one of the most challenging cases for private investment. The Texas Triangle grantee constructed an economic model, based on upfront cost, operating costs, and demand density, to predict the areas where private investment alone might provide charging stations along the major transportation corridors connecting Dallas, Austin, San Antonio, and Houston. This analysis determined that within the next 5 to 10 years, supplying PEV charging could be profitable enough to motivate station deployment in some sections of the corridors. However, the grantee concluded, if the public policy goal is to ensure access to charging in the short term along all of the corridors, public funding for charging stations will be necessary.

In some cases, corridor charging station business models are inhibited by federal rules that prohibit the commercialization of the rights-of-way along the U.S. Interstate System. The creation of the Interstate Highway Program prevented this in its inception in 1956, although interstates built before 1960 (e.g., Interstate 95) are exempted. Therefore, in general, commercial offerings such as refueling stations must be located off the highway. While charging stations have been installed along some interstate highways where commercial offerings are prohibited, they are not allowed to collect payment. Richmond recommended encouraging the adoption of regulations that would enable charging station providers along highways to charge for their services. In 2012, the federal surface transportation reauthorization law declared that charging station projects are eligible for federal surface transportation program funding, but asserted that commercial offerings (including charging stations) along most highways remain prohibited.

Site design and installation best practices for charging stations – Many communities have limited experience installing charging stations at public parking spots. To reduce this barrier and ensure that publicly-accessible charging stations are designed to be functional, safe, accessible, low-cost, and efficient, several grantees developed site design templates and best practice

resources for charging station deployment. The Michigan, Northeast Regional, Richmond, and Ohio grantees developed toolkits for how to best install charging stations. These toolkits include checklists for general siting and design considerations as well as diagrams and guidelines specific to installation settings (such as on-street parking, garages, and commercial lots) and parking space alignments (such as parallel, perpendicular, and angled.) The Texas River Cities grantee developed a best practices guide including a checklist of considerations as well as installation process flowcharts that detail the specific roles and responsibilities of business owners, contractors, electric utilities, and government authorities.

Design for accessibility compliant with the Americans with Disabilities Act (ADA) is of particular concern and importance for charging station providers. The Richmond and Ohio grantees supported the development of a report on electric vehicle charging for persons with disabilities that provides guidelines for ADA compliant siting and design. The Northeast Regional and Colorado grantees provided illustrations of ADA-compliant charging station designs and the Colorado grantee provided a table of specific requirements for ADA compliance.

TABLE 10: Selected Content on Charging Station Deployment Plans, Siting, and Design Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Bay Area EVSE Siting Analyses	Bay Area Plan p. 19
	Planning for Retail and Public Sector Charging	Southern California Plan p. 90
Colorado	Charging Station Deployment Plan, Including Business Case Analysis	p. 39
	Requirements for ADA compliance and illustrations of ADA- compliant design	p. 70, A17
Florida	US-1 Corridor Pilot Project	Volume II
	Deploying Public Charging Infrastructure	p. 6-78
Kansas City	Corridor Charging Station Development	p. 111
Michigan	Toolkit for Charging Station Siting and Installation	p. 113
North Carolina	Analysis of Future Charging Infrastructure Needs	p. 70
New York City	Curbside Charging ; Fast Charging	p. 23, 28
Northeast Regional	Siting and Design Guidelines for Electric Vehicle Supply Equipment (including illustrations of ADA compliant charging station designs)	Standalone report
	Charging Station (EVSE) Cluster Analysis and Site Typologies	Standalone report
Ohio	Planning Ohio's Electric Vehicle Infrastructure	p. 11
Richmond	Electric Vehicle Charging for Persons with Disabilities, 14 pp. (Co-contributed)	
	Plans for EV Infrastructure Deployment; Inability to Collect Fees for Corridor Charging due to Federal Highway Rights of Way	p. 17, 32
Southeast Regional	Charging Station Distribution Requirements and Grid Impact	Electric Vehicle Adoption in the Southeast, p. 17
Southeastern Pennsylvania	Consumer Profiles and Geographic Distribution of Potential EV Demand in Southeastern Pennsylvania	Volume 2 p. 47, 51
Texas River Cities	New Electric Utility Business Models with Third-Party PEV Infrastructures	p. 5-1
	Charging Station Best Practices Guidelines	p. 2-13
Texas Triangle	Private Sector Corridor Charging Station Deployment Model	p. 48

2.4.C. Local Ordinances and Administration: Zoning, Parking, and Signage; Building Codes; and Permitting and Inspection

Local governments have a critical role to play in the development of both public and private charging infrastructure due to their authority over zoning, parking, and signage; building codes; and permitting and inspection processes. Local ordinances and procedures can present barriers to charging station development, which can be avoided by amending codes and streamlining processes. Local ordinances and procedures also present opportunities to proactively support charging station installation.

Several grantees conducted research, developed tools, and offered recommendations to help localities in their regions support PEV adoption. This section provides an overview of the toolkits provided by the grantees, followed by summaries of the barriers and opportunities identified in the toolkits.

Toolkits providing case studies, model ordinances, and planning guidance – Several grantees provided case studies, model ordinances, and planning guidance in toolkits to help local governments prepare for PEV adoption. The resources for local governments, which are indexed in Table 11, are diverse in their structures, content, and recommendations. Each toolkit was designed to be flexible because localities vary significantly in their physical and built environments, administrative procedures, ordinances, resources, and desire to support PEV readiness.

The toolkits are particularly relevant for localities within the region for which they were designed because localities within the same state operate under the same state policies, have the same scope of authority relative to their state government, and share some similar challenges and opportunities. However, these resources are also useful for a wider audience, both because some general challenges and opportunities are broadly shared across regions and because localities and states can provide each other with alternative perspectives.

Some toolkits are especially useful to a wider audience because they are comprehensive and detailed. The Northeast Regional grantee's toolkit was designed specifically to be useful by a broad audience to meet the needs of its diverse multi-state region. The California grantee's toolkit provides an extensive catalog of links to existing resources and sample language for local policy development. The Michigan and Ohio grantees' toolkits both provide detailed recommendations and sample code language while also clearly laying out alternative approaches communities can undertake.

The grantees designed the toolkits to be adaptable, recognizing that it would not be helpful or appropriate to provide localities with uniform prescriptive recommendations due to their diversity and administrative authority. The toolkits offer localities flexible menus of best practices, recommendations, and model ordinances to choose from. The Michigan and Ohio grantees both designed their toolkits to enable communities to quickly select policy options based on their self-identified levels of ambition to support PEV readiness.

While seeking to avoid prescriptive recommendations, several grantees saw value in states and localities working together towards common regional zoning and development guidelines in order to reduce confusion, increase efficiency, and harmonize regional efforts for PEV readiness. Activities to promote regional cooperation are discussed in the Facilitating Stakeholder Partnerships, Implementation Plans, and Next Steps section.

To inform citizens about localities that are most suitable for PEV ownership and to reward local progress, some grantees suggested providing official recognition to communities who have taken steps to become PEV ready. Texas Triangle proposed that the state establish a PEV-Friendly Community program that would provide guidance to and recognition of localities that carry out a requisite total of best practice actions to support PEVs.

Master plan language – Adopting local Master Plan language that identifies PEVs as part of the local transportation strategy is a foundational step for communities. Master Plans are strategic documents developed by communities as a blueprint to guide long-term policymaking. Including language on PEVs provides a basis for the development of supportive zoning codes and other ordinances that foster the deployment of electric vehicle charging infrastructure. The Michigan grantee noted that only 15 percent of

communities in the state have supportive Master Plan language while a majority of local officials are both interested in advocating for charging station installation and do not think that updating Master Plan language would be challenging.

Standard definitions in local codes – As localities consider updating codes to address and support charging station installation, is it valuable to establish and codify standard definitions for PEV terms, such as vehicle types and charging levels. The Colorado grantee provided sample definitions for key terms that are relevant to local PEV administration and suitable for adoption into local codes.

Zoning ordinances – Existing zoning ordinances do not restrict charging station installation in most communities, grantees reported. However, updating zoning codes to explicitly address charging infrastructure can reduce confusion and ease the process for both installers and local government officials.

Zoning ordinances can be amended to define where charging stations are permitted, whether the nature of the permit is outright or conditional, what charging power levels are allowed in which locations, how charging stations are sited, and if new buildings and parking facilities are required to pre-wire for or install charging stations.

Clearly specifying which zoning districts permit charging station installation and at what power level can reduce confusion for property owners and public officials and foster deployment. The California, Richmond, and Colorado grantees provided sample tables that define allowed uses which could be modified and adopted by localities. Authorizing easements for on-street charging stations in public rights-of-way can also unlock opportunities for charging station access, particularly in residential areas with street parking.

Site design guidelines and standards, discussed in the Charging Station Deployment Plans, Siting, and Design section, can also be codified in zoning ordinances to ensure that charging stations are designed to be functional, safe, accessible, low-cost, and efficient. Zoning ordinances can specify criteria for charging station size, accessibility, maintenance, lighting, signage, and other site design elements in different zoning districts or in public places.

Zoning ordinances can also be amended to establish incentives or requirements for charging station installation. Zoning codes can include charging stations in the calculation for minimum required parking spaces pursuant to established zoning ordinances or provide density bonuses[7] for installation of charging stations. Zoning ordinances can also require that a percentage of parking spaces be outfitted with or prewired for charging stations in new multi-unit residential, commercial, industrial, or large parking lot construction. The Northeast Regional grantee noted that zoning policies may present interesting opportunities to encourage charging station installation but that this approach is largely untested.

Public parking regulation, enforcement, and signage – Local parking ordinances can specify the terms of use for public charging stations, standardize charging station signage, and specify how charging station rules will be enforced. Parking policies must balance the desire to support PEV adoption with equity, practicality, and budget concerns.

Charging station providers, including localities providing charging at publicly-accessible parking facilities, must plan for and regulate the terms of use, including: (1) days and hours of operation; (2) whether to provide free or reduced price parking for charging vehicles; (3) whether and how to charge fees for electricity; (4) the extent to which parking spaces equipped with charging stations should be exclusive to PEV drivers; and (5) whether to establish time limits to provide charging access to a greater number of PEV drivers throughout the day.

Once the terms of use have been established, localities must also codify the means of enforcement, potentially including fines or towing for violators. The Kansas City grantee described the competing interests in determining enforcement, noting that on the one hand enforcement is needed to ensure charging access to PEV drivers but on the other hand, heavy penalties could reduce charging station usage and generate public resentment.

Localities also must design and install clear, uniform signage to direct drivers to charging stations, identify parking spaces equipped with charging

stations, and convey parking policies. The federal government requires uniform signage for gasoline and diesel refueling station information on roads for which they provide funding but at the time of grantee activity only provided a recommendation for PEV signage. The Michigan grantee developed standardized signage for PEV charging stations and provided designs for use by local communities. Subsequently in June 2013, the U.S. Department of Transportation (DOT) expressed their intention to establish standard regulatory signage for on-street electric vehicle parking and issued recommended sign designs for use by state and local transportation agencies.[8]

Building and electrical codes – In all regions, charging infrastructure installation is subject to state and local building and electrical codes designed to establish consistent, minimum standards to ensure the functional adequacy and safety of proposed construction projects. Guideline codes are developed by standards setting bodies (such as American National Standards Institute and the National Fire Protection Association) in collaboration with industry associations (such as the National Electrical Contractors Association and the International Brotherhood of Electrical Workers) and government representatives. These codes are used by states and localities to construct policy within their jurisdictions. Grantees agreed that existing codes do not present a significant barrier to charging station deployment, but building and electrical codes do present opportunities to support charging station deployment.

There is considerable variation among local building and electrical codes and in the balance of state and local authority over these codes within each state. For this reason, the location-specific work by the grantees is especially valuable to the communities in their regions. However, several general opportunities for supporting PEV readiness by revising and updating building and electrical codes were identified by the grantees.

Many local and state building and electrical codes currently do not specifically address charging infrastructure. Amending codes to include standards and design requirements specific to charging stations can facilitate charging station deployment by clarifying design requirements and guidelines for each building type regarding charging infrastructure types, circuit specifications, and building electricity load management. As the Ohio grantee noted, this could include referring directly to national provisions, such as the National Electric Code, which specifically address charging infrastructure.

Codes can also be designed to actively support charging infrastructure deployment by recommending or requiring the installation of conduit, wiring, electrical panel capacity, and/or adequate physical space for charging station at new or renovated buildings and parking facilities. As an example, Los Angeles and San Francisco have adopted building codes requiring that all new buildings and parking facilities be pre-wired for charging stations and provide one charging station for every 1-50 spaces, two charging stations for 51-200, and four stations for larger parking areas. Several grantees, including Florida and Texas River Cities, recommended establishing local incentives or requirements to support multi-unit residential charging.

Permitting and Inspection – Installation of charging stations is in many cases subject to permitting and inspection processes to verify compliance with applicable building and electrical codes. While some grantees determined that permitting and inspection did not present a significant barrier to charging station deployment in their regions, other grantees observed that permitting and inspection processes, durations, and fees were highly variable in their regions and concluded that expediting and streamlining permitting and inspection processes is a prime opportunity for reducing costs and confusion.

Opportunities to prudently expedite or streamline permitting and inspection processes include: (1) adopting clear local ordinances, permits, and procedures to enable straightforward compliance and minimize administrative burdens; (2) reducing and standardizing permitting and inspection fees; (3) minimizing processing and inspection times by eliminating unnecessary steps and/or fast-tracking charging station projects; (4) implementing online permitting processes; (5) classifying some charger installation categories as minor work which is subject to less burdensome permitting processes; and (6) funding and supporting training for electricians.

Ensuring that permitting and inspection do not

present unnecessary barriers to charging station installation is particularly important because most charging is predicted to occur at home. Individual households may not be familiar with permitting and inspections rules and may be deterred from installing home chargers by uncertain, costly, or burdensome processes. Expedited and streamlined permitting processes must be prudently designed, however, as ensuring safe and reliable installation of charging infrastructure is also critical to maintaining public confidence in PEVs. Some cities, including Los Angeles, California; Raleigh, North Carolina; and Houston, Texas have been early leaders in streamlining permitting and inspection processes for residential charger installations.

TABLE 11: Selected Content on Local Ordinances and Administration Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	A Toolkit for Community Plug-In Electric Vehicle Readiness: A Resource for Local Officials	Standalone document
Colorado	Model code for buildings, zoning, parking and signage	Appendix 15
Florida	Developing Supportive Codes, Policies, and Ordinances	p. 6-86, p. 198
Kansas City	Updated Building Code, Permitting and Inspection, Zoning, and Parking Plans	p. 31
Maui	Local Ordinances	p. 75
Michigan	Planning and Zoning Toolkit	p. 95
	Charging Station Signage and Regulation	p. 60, 123
North Carolina	Policies, Codes, and Standards	p. 82
Northeast Regional	Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools	Standalone document
	EV-Ready Codes for the Built Environment	Standalone document
Ohio	Advancing Electric Vehicles Through Codes and Permits	p. 26
	Model Ordinance and Policy Templates	Supplemental section
Richmond	Zoning, Codes, and Permitting to Advance EV Deployment	p. 22
Southeast Regional	Codes and Policies	Section 2 p. 4
Southeastern Pennsylvania	Recommendations tailored to regional local government needs	Volume 1 p. 13
Texas River Cities	Charging Station Codes, Ordinances, and Permitting Toolkit	p. 3-1
Texas Triangle	PEV-Friendly Community program	Volume 2 p. 21

2.4.D. Providing Charging Stations at Multi-unit Residences and the Workplace

Deployment of multi-unit residential and workplace charging stations can make PEV ownership viable for a broader set of drivers, decrease range anxiety for AEV drivers, and enable PHEVs and EREVs to drive more electric miles. The two highest priority locations for installing charging stations after single-family residences are multi-unit residences and the workplace, as shown in Figure 2.

At-home charging is the primary source of power for consumer PEV drivers, yet multi-unit dwellers often do not have access to dedicated garages where they can install their own charging stations.

After the home, the workplace is considered to be the second most likely location where PEV drivers will want to charge, because employees spend an average of six to eight hours per day parked at their workplaces. Workplace charging can also serve as the primary charging location for PEV drivers without access to charging stations at home.

Multi-unit and workplace charging face unique barriers beyond those faced by single-unit residential charging. To support charging station deployment at these critical, yet challenging locations, several grantees worked to identify issues and provide resources for stakeholders to help them advance station deployment in their communities.

This section primarily addresses the barriers to deployment of charging stations at shared on-site parking facilities at multi-unit residences and workplaces. Some multi-unit residents and employees may use on-street parking. Planning for and supporting public charging stations are addressed in the section entitled Charging Station Deployment Plans, Siting, and Design.

Key considerations and barriers – Multi-unit residential and workplace charging share many of the same design and operational considerations and barriers because they both involve installation of privately-owned infrastructure in a shared parking facility where drivers regularly park for long durations.

Due to the length of time drivers spend parked at home and at the workplace, Level 1 or 2 charging stations are appropriate for these locations. The Florida grantee noted that Level 1 charging might be more feasible for the bulk of multi-unit stations as it is less expensive and is adequate for many overnight charging needs. The Southeastern Pennsylvania and North Carolina grantee analyzed household travel survey data and estimates of the average amount of time drivers spend parked at work to demonstrate the value of workplace charging and to investigate the appropriate charging power level. Both grantees determined that most workplace charging needs could be met by Level 1 charging. However, installation of faster Level 2 chargers can increase the number of PEVs that can be served by a single station and can enable faster charging for visitors. For this reason, the Florida grantee proposed the option of offering primarily Level 1 chargers, along with a smaller number of Level 2 chargers. Recent research has noted that low-power Level 2 chargers, which charge at a similar rate as Level 1 but enable more chargers to be installed on a single commercial panel, may be the most efficient option for workplaces.[9]

Several key barriers to deploying multi-unit and workplace charging infrastructure were identified by grantees. The Texas River Cities grantee conducted surveys of multi-unit residential property owners, multi-unit residents, and workplaces and identified key challenges including:

- Low early demand for charging from residents and employees
- Lack of familiarity with PEVs and charging infrastructure among property owners and employers
- Difficulty reaching consensus on who should pay for equipment, installation, and operation costs
- Balancing physical constraints and fairness around charging station site design in shared parking areas
- Difficulty establishing a viable financially self-sufficient deployment model
- Real and perceived legal restrictions on the sale of charging services.

The Northeast Regional grantee noted an additional source of planning uncertainty: how EV drivers will use shared charging stations and whether etiquette will develop around user rotation and linger time.

Stakeholder perspectives – Multi-unit residential and workplace charging stations affect a diverse set of stakeholders with different perspectives and interests including: (a) parking users interested in charging infrastructure, (b) parking users not interested in charging infrastructure, (c) owners and managers of a shared parking facility, and (d) potential funders and owners of the charging stations, which may be one of the above groups or a third-party charging service provider. Plans to develop multi-unit and workplace charging must balance the interests of all of these stakeholders.

Providing resources to help champions evaluate and implement charging station deployment – Successful initiatives to deploy charging stations at existing shared parking facilities are typically led by an internal champion either on the demand side (a resident or an employee seeking access to charging) or the supply side (a building developer, a facility manager, or an employer seeking to offer charging). Grantees prepared recommendations and developed resources to help both demand-side and supply-side champions of multi-unit and workplace charging understand stakeholder issues, make the case for offering charging stations, and design and plan for station installation and operation.

The Florida, California, and Texas River Cities grantees prepared detailed lists of considerations, recommendations, and resources for stakeholders who are interested in advancing both multi-unit and workplace charging infrastructure. Key findings about charging at new and existing multi-unit and workplace buildings are discussed below.

Advancing charging in new buildings – Developers of new multi-unit residences and commercial buildings can be encouraged to offer charging by tax credits, subsidies, zoning incentives, sustainable building program credits, or the benefits of marketing their properties as incorporating environmentally sustainable design. Building codes such as those adopted by Los Angeles and San Francisco that require that all new buildings and parking facilities incorporate a minimum number of charging stations based on the total number of parking spaces offered can also ensure charging access to multi-unit residents and employees in new buildings. However, even in communities where incentives or mandates for charging in new buildings are established, access to charging at the sizable existing stock of multi-unit residences and businesses will still need to be addressed.

Advancing multi-unit charging – Some residents may desire access to charging stations, other residents may not, and together residents can engage with property owners or managers to decide if charging will be offered in shared parking facilities, how charging stations will be sited, who will pay for and own the stations, if and how fees will be administered for charging, and the terms of charging access and operations.

Installation and equipment may be paid for by individual residents, collectively through homeowner associations, by the building owner, or by a third-party charging service provider. The Florida grantee reported that the majority of early multi-unit charging stations were funded by individual resident PEV owners. If individual residents offer to contribute to the cost of installation, ownership of the physical infrastructure must be clearly defined and agreed upon, including accountability for the costs of site restoration if the owner chooses to remove or relocate the station.

Electricity use may be charged directly to individual residents by connecting stations to PEV owners' electricity meters or stations may be connected to a common meter, in which case access fees or fees based on usage may be assessed. To help multi-unit residential communities evaluate the financial viability of fee-based models, the California grantee provided a scenario analysis of several alternative business models based on various pricing policies which show that under some conditions providing charging can be financially viable.

From the property owner perspective, offering PEV charging may increase the marketability of multi-unit residences to tenants supportive of or likely to adopt PEVs, which could encourage developers and property managers to install charging stations. The Northeast Regional grantee presented a case study of a multi-unit residential development company considering the pros and cons of installing charging infrastructure. The Texas River Cities grantee is developing an online

property listing for PEV ready properties and rentals that could help developers and property managers market these benefits to potential tenants.

Identifying communities where charging at multi-unit residences is likely to be in high demand can help PEV advocates engage with residents, homeowner associations, property managers, and developers to support station deployment. Several grantees worked to identify these communities, including the California grantee, which reported that 65 percent of prospective early PEV adopters in Los Angeles are multi-unit residents and renters, and that PEV home charging will be most concentrated in areas of the city with substantial multi-unit residence populations. On the other hand, some residents of multi-unit properties in densely-developed areas who drive relatively few miles per year may be less interested in electric vehicles due to longer vehicle payback periods.

The Florida grantee made facilitating charging at multi-unit residences a key area of focus of its readiness plan because a relatively high percentage of housing units in Southeast Florida are multi-unit residences—41 percent compared to the national average of 23 percent. The grantee developed fact sheets, seminars, and workshops on multi-unit dwellings with the goal of expediting multi-unit management's charging station planning ahead of resident demand. The grantee also sought to empower residents with the knowledge to make the case for charging station installation with management and educate legislators about smart policies for new multi-family home construction to address charging and parking concerns.

Advancing workplace charging – Workplace charging is similar to multifamily charging but can be even more complex because some employers lease office space and parking from a third party and, therefore, may need to renegotiate their lease agreements to offer charging to their employees. Employees and employers, in some cases together with a third-party parking facility manager, can work together to decide if charging stations will be installed, if charging will be a free employee benefit or a fee service, and the terms of charging access and operations.

Offering free charging may be simpler, requiring less equipment and administrative effort, and can reinforce the image of the company's commitment to clean technologies both to employees and to the broader community. On the other hand, offering free charging means that employers cannot directly recoup their equipment and installation costs. Free charging could also generate a perception of unfairness among employees who do not drive PEVs. Employers who choose to offer free charging to their employees will also need to determine whether this constitutes a free benefit or is taxable compensation. Some organizations, notably including government employers, may be prohibited from offering free charging to employees.

Payment for charging can be structured as an access fee or a fee based on usage. To help employers and employees understand and plan for the financial aspects of workplace charging, the California grantee provided scenario analyses of several alternative workplace pricing policies.

Identifying communities where employees are likely to demand workplace charging can help PEV advocates engage with employees, employers, and third-party facility managers to support station deployment. Several grantees worked to identify these communities including the California grantee, which created a map of the Bay Area overlaying the most likely commutes for PEV owners, existing charging stations, and levels of employer interest in workplace charging.

The Oregon grantee conducted interviews of several large employers in the state who offer workplace charging, to understand their motivations and learn from their experiences. The grantee found that green marketing benefits and the availability of equipment incentives were valuable motivating factors and that having an internal employee champion of the installation effort was also important. Based on these interviews, the Oregon grantee identified real and perceived issues making organizations reluctant to install charging stations and recommended the development of a workplace outreach and information resource program.

Aiming to energize the business community around workplace charging, in 2013 DOE launched the EV Everywhere Workplace Charging Challenge, under which a growing number of partner employers have committed to assess employee demand for workplace

charging, implement a plan to install charging stations, and share progress and best practices. More information about DOE's Workplace Charging Challenge program can be found at http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/workplace_charging.html.

TABLE 12: Selected Content on Charging Station Challenges at Multi-Unit Dwellings and the Workplace Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Opportunity Charging Analysis	Bay Area Plan p. 24
	Planning for Charging in Multi-unit Dwellings and at the Workplace	Southern California p. 47, 69
Colorado	Installation Plan for Multi-unit Residential Areas	p. 62
Florida	PEV Charging at Multi-Unit Dwellings	Volume I Section 6-68
North Carolina	Workplace charging	p. 59, 67, 70
New York City	Charging at shared parking areas	p. 20
Northeast Regional	Workplace and multi-family cluster descriptions and case studies	p. 26, 50
Oregon	Workplace charging survey	p. 31
Richmond	Promoting Workplace and Multi-unit Charging	p. 41
Southeastern Pennsylvania	Workplace and Private Access EVSE	Volume 1 p. 6
Texas River Cities	Workplace and Multifamily Housing Issue Identification	p. 4-1

2.4.E. Power Grid and Electric Utility Policies and Planning

Adoption of PEVs could lower the marginal cost of electricity for all electric utility customers—if charging is done during off-peak times—and eventually improve the reliability of the electrical grid, if smart grid technologies are deployed. Electric utilities have an important role to play in supporting charging station deployment and ensuring that the electrical grid is resilient and responsive to changes arising from PEV adoption. In the absence of strategic planning and policies, the electrical grid could experience reliability issues in areas that see concentrated PEV adoption.

Additionally, if high rates of PEV adoption cause electricity demand spikes during popular charging times, rates for other electricity consumers could rise during these periods. To prepare for and support PEV adoption in their service territories, electric utilities can:

- Understand and plan for PEV adoption, including understanding potential impacts on local distribution infrastructure and on the ability of existing generation capacity to meet electricity demand
- Evaluate and implement policies and technologies that support PEV adoption,

minimize local grid reliability issues, and unlock the potential reliability and cost benefits of PEVs, including:

- Notification protocols to keep electric utilities aware of PEV adoption and charging station installation in their regions
- Alternative electricity rate structures such as TOU rates
- Planning for distribution grid upgrades
- Providing charging services and/or supporting the ability of third parties to provide charging services
- Exploring emerging smart grid technologies that can avoid local grid impacts and unlock grid management benefits of PEVs.

The Texas Triangle and Oregon grantees surveyed electric utilities in their regions to assess their awareness of PEVs, preparedness for PEV adoption, and perceived issues. Both reported a wide variation in utility awareness and preparedness, particularly between larger utilities serving urban areas that have had more experience with PEVs in their service areas and smaller utilities serving rural areas.

Several grantees planned outreach programs to promote electric utility awareness of PEVs, which are discussed in the Outreach, Education, Training, and Marketing section.

Grid impact modeling – Clustering of PEV demand in particular neighborhoods could stress local distribution infrastructure, such as transformers, resulting in premature degradation of equipment and decreased reliability. At high PEV adoption rates, charging could create electricity demand peaks that make electricity more expensive to provide or require additional generation capacity to be installed.

Understanding how PEVs will affect grid management can help electric utilities plan for PEV adoption. Several grantees performed grid impact analyses based on assumptions and projections of how many drivers adopt PEVs, what type of PEVs they adopt, where those drivers live, where and when they charge and at what power levels, the capacity and condition of local electrical distribution infrastructure, and the generation capacity in the region.

The type of PEVs adopted is of particular significance when considering potential grid impacts. PHEVs and EREVs are less likely to strain distribution infrastructure and create demand peaks because they generally charge at lower power, for shorter periods, and throughout the day due to their smaller batteries and ability to run on conventional fuels. AEVs are more likely to generate grid impacts because they generally charge at higher power and may charge for longer periods when charging due to their larger batteries and sole reliance on electric power.

None of the analyses indicated that projected PEV adoption rates would cause significant grid impacts. The Kansas City grantee developed a model to test for weak points in the distribution infrastructure under various scenarios of PEV adoption and found that, even when PEVs make up as much as 1 percent of light-duty vehicles, there are no impacts. At significantly higher adoption rates such as 20 percent of light-duty vehicles, the Kansas City grantee concluded that local residential distribution systems would be the first grid component to experience stress. The Colorado grantee's analysis also concluded that PEV adoption was not likely to affect generation or transmission, but that local distribution could require electric utility attention in some areas. Analyses by the Southeast Regional, Ohio, and Southeastern Pennsylvania grantees also indicated that there are not likely to be significant grid impacts at the PEV adoption rates that are projected.

Notification systems – Putting systems in place to notify electric utilities of PEV purchases and/or charging station deployments in their service areas can enable utilities to better react to and plan for PEV adoption. Several grantees—including the Oregon, California, Colorado, Texas Triangle, and Michigan grantees—recommended establishing notification procedures and proposed details of implementation such as establishing regular communication channels with automobile manufacturers, dealers, DMVs, and PEV owners.

Rate structures – Electric utilities may consider offering alternative electricity rate programs to PEV owners that are designed to reduce the cost of PEV charging and/or minimize grid impacts.

One option is the TOU rate structure, under which electricity users are encouraged by lower electricity

rates to shift consumption to off-peak hours, typically during the evening, when demand for electricity is low. Shifting electricity use to off-peak periods reduces the generation capacity needed to meet electricity demand during peak periods. TOU rates are enabled by smart meters that can apply variable electricity prices at different times of the day. Nationally, these meters are slowly replacing old metering technology, but are in widespread use in some states, including California. Whole-house TOU rates are enabled by new smart meters being installed by many utilities. These rates encourage PEV drivers to charge during off-peak hours because the rates are generally below average residential rates.

Another option is to offer lower rates for PEV charging than for residential electricity use, regardless of time of day. However, this requires the installation of a separate meter. A third option is to offer TOU rates for PEV charging only. This requires the installation of a secondary smart meter or a sub-meter of a smart meter.

The impacts of alternative rate structures depend on many factors including prices, climate, consumer response to the prices, and other details of the electricity market in the service region. Rate programs must also balance the goal of stimulating PEV adoption with the responsibility of electricity users to pay an equitable share of generation and distribution costs.

Several electric utilities currently offer alternative rate structures, seeking to support PEV adoption and minimize grid impacts, but also to gather data on the effectiveness of such programs. Adoption of alternative rate structures by PEV owners is nascent and data on their effects are limited. Georgia Power, as an example, offers a voluntary TOU rate for PEV charging at 23¢/kWh on-peak, 9¢/kWh off-peak, and 5¢/kWh super off-peak. Alabama Power offers a whole-house off-peak rate for all residential customers. Richmond launched a TOU pilot program that offers PEV-only rates that require a separate meter and whole-house residential rates that do not require a separate meter. Maui noted that, despite the fact that its utility offers TOU rates for PEV charging, few consumers have taken advantage of these rates, potentially due to concerns about increased rates during peak times, lack of awareness of the alternative rate programs, or the cost of installing new meters. New York City updated building codes to address providing meters capable of enabling TOU rates for PEV owners. Some utilities in Michigan offer rebates to households installing a secondary meter for PEV charging and the California grantee recommended that utilities consider offering similar rebates.

Grantees worked with electric utilities to understand how TOU rates might work in their service areas, considering their effectiveness at shifting electricity consumption behavior, the associated effect on the grid, and the economic effects on ratepayers. The Colorado grantee noted that TOU rates might not be an effective incentive for overnight charging of PEVs in the state because electricity rates are already fairly low. The Ohio grantee provided analyses to show that TOU rates could backfire by leading to the formation of potentially expensive and disruptive new demand spikes during the evening if most PEV users charge at the same time. Automated or grid-integrated charging systems that allow PEVs to stagger charging times could address this potential issue.

Grantees also identified rate structure issues around demand charges. The Oregon grantee noted that most electric utilities in its service area impose an electricity demand charge, which is assessed based on the highest hour of demand in a given month. Demand charges increase the importance of understanding the effect of PEV charging on demand profiles, particularly high-power fast chargers or sites where many PEVs will be charging at once. The California grantee noted that the inverted tier electricity rates available in the state, which were designed to motivate consumers to conserve electricity by assessing higher electricity prices for consumption above certain thresholds, could penalize PEV ownership despite its environmental benefits. The grantee recommended a few alternative adjustments to rates including establishing higher baseline tiers for PEV owners or offering discounted rates to PEV owners. Implications from the perspective of facility managers, who may experience high electricity demand from PEVs, are discussed in the Deployment Plans, Siting, and Design for Publicly-Accessible Charging Stations section.

Planning for grid system upgrades – In cases where grid impacts of PEV adoption are anticipated and are unlikely to be avoidable, electric utilities can plan for

system upgrades. These upgrades are most likely to be associated with clusters of PEV adopters in low-density residential neighborhoods or with fast charging stations. The Texas Triangle and California grantees recommended that utilities proactively identify vulnerable infrastructure and plan for upgrades. The Oregon grantee recommended that utilities share best practices and seek public investment to cover the costs of getting power to critical locations where there is insufficient grid infrastructure.

Clarifying electric utility and third-party roles in providing charging services – The regulations surrounding the sale of electricity vary by region, but some grantees recommended that the roles and legal abilities of electric utilities and third-party providers to sell charging services and install charging stations be clarified to support charging infrastructure development. In many service areas, the sale of electricity is regulated in ways that may prohibit third-party charging service providers from lawfully selling electricity. The Ohio grantee prepared a written justification of why, despite uncertainty, it believes charging providers can legally resell electricity in the state. Colorado adopted legislation deregulating the sale of electricity sold as fuel for PEVs. The Kansas City grantee proposed establishing cost recovery allowances for utility investment in charging stations to enable them to provide charging services. The Richmond grantee noted that confusion regarding jurisdiction over electrical inspections for charging stations installed in the public right-of-way is creating liability issues for utilities working with third-party charging providers and recommended updates to state building codes to address this issue.

Exploring smart grid technologies – So-called smart grid technology refers to the emerging use of communication and information technologies to improve the efficiency and reliability of the electrical grid by managing supply, transmission, distribution, and demand in new ways.

PEVs can play various roles in emerging smart grid technologies due to their potentially pliable electricity demand, sizable batteries, and interconnection of storage capability with the grid. For instance, PEVs could be programmed to dynamically communicate with the grid and charge primarily during efficient times when demand is low, which is referred to as managed charging. PEVs could also deliver stored electricity from their batteries to their host building (V2B) or to the grid (V2G). V2B and V2G can enable PEVs to (1) level out demand spikes by supplying energy during peak periods; (2) deliver electricity rapidly when the grid needs it, participating in the economically valuable ancillary services markets[10]; and (3) support expanded deployment of intermittent renewable power, such as wind and solar, by acting as a battery backup.

Grantees provided information and analyses to support smart grid research and prepare for deployment. The Texas River Cities grantee developed a technical planning roadmap for PEV interoperability with the grid that: characterizes the devices and systems necessary to enable smart grid applications, identifies and prioritizes all the points where existing and future technologies must interact, and lays out a plan for facilitating smart grid development. The New York City grantee prepared an analysis of the economics of V2G and is in the process of installing longer electrical conduits to accommodate future V2B and V2G technologies.

Some grantees planned smart grid technology demonstration projects. The Maui grantee planned a project under which 200 private, car share, and fleet PEV owners will interconnect with charge management systems and two-way communication systems, allowing project partners to gain experience with these technologies and gather information on their performance. The Texas Triangle grantee planned a similar project, for a fleet of electric medium-duty trucks, to test their ability to generate extra revenue by providing frequency response services to the grid.

TABLE 13: Selected Content on Power Grid and Electric Utility Policy and Planning Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Pricing Policies for PEV Infrastructure	Southern California p. 103
	Minimizing Grid Utility Impacts	Bay Area p. 47
Colorado	Utility, Grid, and Regulatory Strategy	p. 86
Kansas City	Grid Impact Modeling and Utility Grid Plan	p. 54
Maui	Time of Use Rate Incentives and Smart Grid	p. 70
Michigan	Utility Preparedness and Grid Impacts	p. 35
New York City	Time of Use EV Metering; Vehicle to Grid / Vehicle to Building Technology	p. 50, 57; Appendix I
Ohio	Utility Readiness	p. 20
Oregon	Informing Utilities	p. 50
Richmond	Electrical Inspection Jurisdiction, Time-of-Use Pilot Program	p. 34, 38
Southeast Regional	Grid Impact Analysis	"Electric Vehicle Adoption in the Southeast" report, p. 17
Southeastern Pennsylvania	Utility Policies and Plans to Accommodate EVs	Volume II p. 135
Texas River Cities	Charging Infrastructure Interoperability Roadmap	p. 6-1
Texas Triangle	Recommendations for Utilities, Long Term Grid Considerations	p. 29, 72
	Smart Grid Demonstration Project	p. 83

2.4.F. Ensuring Support for Transportation Infrastructure

Over the long term, adoption of more fuel efficient vehicles and alternative fuel vehicles, including PEVs, will continue to decrease the effectiveness of gasoline taxes as a source of transportation infrastructure funding. PHEV and EREV drivers currently pay less in gasoline taxes per mile driven than conventional vehicles because these vehicles drive some of those miles using electricity instead of gasoline. AEV drivers do not pay any gasoline taxes because these vehicles are entirely powered by electricity. Current transportation infrastructure funding shortfalls are only trivially due to PEVs, which comprised merely 0.63 percent of new light-duty vehicle sales in 2013. Instead, shortfalls are the result are the result of steady increases in the average fuel economy of conventional vehicles on the road outpacing increases in gasoline tax rates. However, PEVs are a highly visible symbol of

how owners of efficient vehicles contribute fewer gasoline taxes to support infrastructure, which is viewed by some as unfair. Furthermore, in the long term, PEVs could contribute significantly to funding shortfalls if they become popular among consumers.

In some communities, PEVs have become a focal point of attention in the debate over transportation infrastructure funding, with some states enacting fees specifically on PEVs to ensure that they contribute adequately. Washington and Virginia enacted annual fees for drivers of hybrid vehicles and PEVs, and North Carolina and several other states are considering similar legislation. Grantees discussed how to balance the need to adapt transportation infrastructure funding mechanisms to an increasingly fuel-efficient fleet with the desire to avoid hampering early PEV market development. The Oregon grantee argued that the solution should equitably obtain money from all road users and not single out PEVs. The Colorado grantee suggested gradually phasing in fees on PEVs to allow the early market to develop. The Kansas City plan provides an overview of current state vehicle tax legislation across the country. The Colorado plan provides a summary table outlining the advantages and disadvantages of various solutions.

Several grantees suggested that assessing fees based on vehicle miles traveled (VMT) would be a fuel-neutral way to fund transportation infrastructure. There has been limited political support for VMT fees, however, in part due to privacy concerns about monitoring or reporting vehicle travel. Oregon has been a leader on implementation of VMT fees and is currently conducting a pilot program to evaluate alternative ways for drivers to report their miles traveled.

Revenue for infrastructure could also be raised through electric utility rate structures. The Colorado grantee suggested assessing sales or excise taxes on electricity used to charge PEVs. This solution could be politically and logistically simpler than a VMT fee, but would require metering PEV charging separately and diverting revenue from general funds into transportation infrastructure funds.

TABLE 14: Selected Content on Ensuring Support for Transportation Infrastructure Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
Colorado	Fuel Tax Strategy	p. 82, Appendix 18
Kansas City	Road Tax Issues, Electric Vehicle Tax Legislation	p. 57, 102
North Carolina	Road Taxes for PEVs	p. 101
Ohio	Revenue Considerations	p. 40
Oregon	Road User Fee	p. 42
Richmond	Transportation Funding	p. 35

2.4.G. Outreach, Education, Training, and Marketing

Lack of awareness of, information about, and experience with PEVs among consumers, stakeholders, and government officials are barriers to the successful market introduction of this new technology. To overcome these barriers, grantees developed outreach, education, and training programs to connect a diverse set of audiences with the information they need to play their roles in supporting PEV adoption in their communities.

Communications programs to heighten awareness and disseminate general information – To make informed choices about PEV ownership, charging station deployment, and local support for PEV readiness, consumers, businesses, and governments need reliable information. This information includes: what PEVs are; currently available PEV models; the extent to which PEVs can satisfy driving needs; the economic value proposition of PEV ownership; available incentives; the technical and procedural aspects of charging and home charging station installation; local public charging station availability; and the energy, environmental, public health, and local economic benefits of PEVs.

Several grantees developed and launched coordinated, multi-faceted communications programs to increase familiarity with PEVs and disseminate information. These communication efforts included organizing public events, workshops, and technology demonstrations; developing print and internet education and marketing resources; conducting phone, email, and social media marketing campaigns; and garnering local media coverage.

These communication programs were a priority for several grantees and each program encompassed a broad and diverse set of activities. For example:

- The Maui grantee produced 12 episodes of a television program to inform the public about PEVs
- The Oregon grantee staged ride-and-drive events to give consumers firsthand experience with PEVs
- The North Carolina grantee prepared a toolkit to help other PEV advocates arrange ride-and-drive events
- The California grantee conducted community workshops on the basics of PEV technology, ownership, and charging
- The Kansas City grantee encouraged consumers to engage with vehicle cost-of-ownership tools to learn about potential cost savings
- The Colorado grantee designed an engaging website aimed at consumers, businesses, and property owners
- The Richmond grantee organized high-profile events with press conferences to garner TV, radio, and print media coverage
- The Texas River Cities grantee developed a curriculum for PEV advocates to engage with government officials
- The Ohio grantee designed templates for informational handouts and web resources for local communities to adapt and deploy to inform citizens
- The New York City grantee provided PEV information for the city's 3-1-1 non-emergency municipal services number.

These outreach efforts helped to inform a broad audience of consumers, businesses, and governments about PEVs. The California grantee noted that over 500 local planning officials and members of the public attended their PEV readiness workshops and 75 percent of survey respondents indicated that sessions on local PEV readiness were very helpful. The Colorado grantee estimated that their website educates approximately 1,500 users per month.

In addition, the communication plans themselves could be very helpful to other communities who are looking to conduct similar campaigns.

Training municipal personnel – Local government officials and personnel play a critical role in establishing a supportive policy environment for PEVs and in implementing those policies. Grantees prepared extensive resources to inform localities about the steps they can take to enhance PEV readiness, which are discussed in the section Local Ordinances and Administration: Zoning, Parking, and Signage; Building Codes; and Permitting and Inspection. In addition, some grantees conducted outreach events with local governments to educate on PEV basics and actively encourage enactment of supportive policies.

Training first responders – PEVs are not more dangerous than conventional vehicles in emergency situations, but training first responders ensures that personnel are aware of the differences between PEVs and conventional vehicles in such situations. Training includes topics such as how to identify PEVs, how to disable electrical systems and confirm that the vehicle is turned off, where batteries are located, and fire control considerations. The Colorado and North Carolina grantees designed and conducted training programs for first responders in their communities. The grantees plan to provide information and recommendations to other communities who are looking to implement similar programs.

Training electricians – Providing specific training on charging station installation to electricians can raise awareness that charging equipment is covered under existing national electrical codes and prepare electricians to safely and efficiently install the equipment. The Colorado and Kansas City grantees recommended electrician training and provided links to helpful presentations and course materials.

Training automobile dealerships – Many dealerships are not educated about PEVs and are not motivated to spend the additional time that is often needed to sell a PEV over more familiar conventional vehicles. Dealership training can prepare dealers to: answer consumer questions about PEVs, instruct consumers to take advantage of available incentives, provide information on home charging station installation, and engage with state public fleet managers to ensure that currently available PEV models are eligible for public purchase. Working with dealerships was a priority for the Oregon grantee, which engaged with them through dealer associations, auto shows, and dedicated dealer training workshops. The Richmond grantee recommended working with dealers to explore including home charging station costs in vehicle financing arrangements.

Training automotive technicians – As PEV adoption accelerates, an increasing number of automotive technicians will need to know how to safely and effectively service and repair PEVs. The Kansas City and Richmond grantees highlighted work with community colleges to develop curricula for PEV technician training programs. The Kansas City grantee recommended that an automotive service authority establish a standard for PEV service certification and planned to engage the automotive service community to this end.

Training for parking attendants – As PEV ownership increases in urban areas, parking garage attendants will increasingly be required to take custody of PEVs and, in some cases, charge them for owners. The New York City grantee developed a training manual for parking attendants that covers PEV operation and charging and used this manual to conduct training sessions.

Outreach to vehicle fleet managers – Although individual consumers have so far been the largest market for PEVs, public and private fleets are also promising markets because fleets have known and predictable range and duty needs, are analytical about the total cost of ownership, and can efficiently use private charging stations with multiple vehicles.

Several grantees reached out to fleet managers to support adoption of PEVs into public and private fleets. The New York City grantee investigated the feasibility of fast-charging taxi fleets and worked with managers of car share and retail delivery vehicle fleets to incorporate PEVs into their fleets and raise the visibility of these projects. The Oregon grantee is working on financing options for public and non-profit fleets that cannot access tax incentives. The grantee proposed a program to loan PEVs to fleet managers to raise awareness and enable them to determine if PEVs could be incorporated into their fleets. The Ohio grantee recommended that governments implement procurement policies requiring that PEVs comprise a percentage of all new vehicle purchases for public fleets. The Florida grantee discovered that many state vehicle purchase lists did not include up-to-date PEV options and should be updated. The Texas Triangle grantee planned a demonstration project to test the ability of a fleet of electric medium-duty trucks to generate extra revenue by providing electricity to the grid when it is needed.

Outreach to the tourism industry – In regions with a significant tourism industry, especially where travelers may be environmentally minded, incorporating PEVs into the travel experience as part of a sustainable tourism program could raise awareness of PEVs,

reduce environmental impacts of tourism, and support local charging station deployment. The Oregon grantee, noting that most leisure travel in the state was by car and that most tourists to the area consider themselves environmentally conscious, worked to develop a PEV tourism experience by producing maps and apps directing travelers to charging stations, installing charging stations at local attractions, and working with local car rental agencies to provide PEV options. Similarly, the Maui grantee worked to promote PEVs for sustainable tourism as part of a smart grid demonstration project.

TABLE 15: Selected Content on Outreach, Education, Training, and Marketing Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Training, Education, and Outreach	Final Report: South Coast Air Quality Management District (SCAQMD) California PEV Readiness Project p. 1; Bay Area Plan p. 41, 45; Sacramento Plan p. 6; San Diego Plan p. 35, 39; San Joaquin Valley Plan p. 39, 43; Southern California Plan p. 164; Toolkit for Community Plug-In Electric Vehicle Readiness p. 42, 50
Colorado	Education and Outreach	p. 51
Florida	Creating Education and Outreach Opportunities	p. 6-116
Kansas City	Plans for Communication, Education, Training, and Promoting Incentives	p. 41-48
Maui	Outreach and Education	p. 83
North Carolina	Education and Outreach Plan and Ride-And-Drive Toolkit	p. 104, Appendix 7
New York City	Mission Electric and Public Engagement	p. 7
Ohio	Marketing Plan	p. 42
Oregon	Outreach and Communications, including fleets and sustainable tourism	p. 27, 33, 38, 40, 45
Richmond	Education and Outreach	p. 43
Southeastern Pennsylvania	Education, Outreach, and Marketing Plan	Volume 2 p. 107
Texas River Cities	Communications Plan	p .7-1
Texas Triangle	Consumer Education Plan	p. 65

2.4.H. Facilitating Stakeholder Partnerships, Implementation Plans, and Next Steps

A central goal shared by all of the PEV readiness projects was to foster an engaged network dedicated to supporting PEV adoption and charging station deployment by building lasting relationships among a diverse set of partners. These partners include:

- Local policymakers and staff
- State policymakers, regulators, agencies, and staff
- Regional planners and municipal planning organizations (MPOs)
- Electric utilities and other electric power providers
- Private developers and commercial business owners
- Charging station providers
- Automobile manufacturers
- Automobile dealers
- Vehicle fleet or operations managers.

By sustaining these partnerships, grantees can continue to collaborate on implementation of the strategies they identified and they can preserve the momentum that was generated by the PEV readiness projects. The grantees' experiences facilitating these partnerships, as documented in the readiness plans, will also be useful to other communities who are looking to build local capacity to improve PEV readiness.

This information will also enhance the local actions of the nearly 100 Clean Cities coalitions across the country. These coalitions work with the DOE to advance the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum use in transportation. A national network of nearly 100 Clean Cities coalitions brings together stakeholders in the public and private sectors to deploy alternative and renewable fuel technologies, idle-reduction measures, fuel economy improvements, and emerging transportation technologies. Local Clean Cities coalitions were critical partners in each of the 16 community readiness projects.

Coordination at the local, state, and multi-state scale – The scales of the areas covered by each of the 16 PEV readiness projects and the partnerships forged through these efforts ranged from county/multicounty-level, to statewide, to multi-state regions (see Table 1 and Figure 1). As a result, the readiness plans prepared for these regions and the partner engagement processes to develop these plans were diverse.

Working at the multicounty scale, the Texas River Cities grantee noted that other industries, such as the natural gas industry, already excel at leveraging extensive and diverse local stakeholder networks. So, the grantee constructed an analogous stakeholder model for the PEV industry that could be emulated by other communities. The Richmond grantee reported that forging new stakeholder partnerships in the community had spread the message to fresh and helpful audiences, such as the local chamber of commerce.

For their state-level plans, the North Carolina and California grantees both created structures for partnership and coordination among local and regional governments and stakeholders within their states. Both grantees empowered regions within their states to produce their own regionally differentiated readiness plans. The grantees noted that fostering these relationships strengthened the collaborative platform for implementing their recommendations, increased local buy-in, and may result in partnerships on new grants and initiatives to promote PEVs. The Maui grantee developed an alliance of stakeholders that continues to collaborate on engagement and education efforts throughout the state of Hawaii.

The Northeast Regional readiness plan covered the broadest region of the grants, including 11 states, each with different legal and administrative structures and approaches to PEVs. While this presented a challenge to developing a single unified PEV readiness plan, the process connected government officials, planners, and PEV stakeholders across state borders, opening valuable communication channels for knowledge exchange, for partnering on procurement, and for collaboration on regional transportation issues.

Implementation plans and next steps – The PEV readiness plans provide roadmaps for implementation in the regions for which they were written. The plans also provide information for other communities

looking to facilitate PEV deployment. The Colorado and North Carolina grantees produced assessment tools that provide metrics to track progress towards PEV readiness at the state, local, or organizational level. The North Carolina and Texas River Cities grantees developed tables of recommendations for PEV readiness and identify next steps for partners. The California grantee is working with state partners to implement follow-up actions as part of the Governor's Zero Emission Vehicle Action Plan. Some communities are already implementing next steps including the Ohio grantee, which is now applying the PEV marketing strategy it designed as part of its readiness plan.

By laying out strategies for ongoing work, forging and sustaining partnerships, and involving a growing number of communities, the efforts that have begun across the country under these grants will continue to enable more effective PEV deployment for years to come.

TABLE 16: Selected Content on Facilitating Partnerships, Implementation Plans, and Next Steps Available in Readiness Plans

PLAN	CONTENT	WHERE TO FIND THIS CONTENT
California	Description of Statewide Communication	Final Report: SCAQMD California PEV Readiness Project p. 1
Colorado	Stakeholder Commitments and Metrics to Monitor Performance	p. 98, Appendix 23
Florida	Project Approach	p. 2-10
Kansas City	Electric Vehicle Planning Team and PEV Readiness Index	p. 8, Appendix A
Maui	Stakeholder Representation and Participation	p. 15
Michigan	Planning Process	p. 15
New York City	Project Types and Challenges of Public Private Partnerships	p. 12
North Carolina	Implementation Plan and Recommendations Matrix	p. 140
Northeast Regional	Moving EV-Ready Planning Forward	Creating EV-Ready Towns and Cities p. 32
Ohio	Summarized Recommendations	p. 2
Oregon	Project Overview, Partnerships, and Capacity Building	p. 10
Richmond	Process Overview and Key Recommendations	p. 8, 11
Southeast Regional	Stakeholder Roles	Section II
Southeastern Pennsylvania	Stakeholders and Partnerships	Volume I p. 25
Texas River Cities	Key Themes, Recommendations, and Next Steps	p. 1-4, Appendix A
Texas Triangle	Recommendations and Considerations for Implementation	p. 85

APPENDIX I: LIST OF READINESS PLAN PUBLICATIONS

TABLE 17: List of Publications from Each Readiness Plan

Each publication can be accessed through DOE's website at http://www.eere.energy.gov/cleancities/electric_vehicle_projects.html.
(*) denotes the primary publication output for each grantee, to which this report simply refers by page or section number, unless otherwise specified.

SHORTHAND NAME	REGION COVERED IN READINESS PLAN	AWARDEE	PARTNER CLEAN CITIES COALITIONS	PUBLICATIONS
California	California, with individual plans covering the Bay Area, Central Coast, Sacramento, San Diego, San Joaquin, and South Coast regions	South Coast Air Quality Management District	• Central Coast Clean Cities Coalition • East Bay Clean Cities Coalition • San Francisco Clean City Coalition • Silicon Valley Clean Cities Coalitions • San Diego Clean Cities Coalition • Sacramento Clean Cities Coalition • San Joaquin Valley Clean Cities Coalition • South Coast Clean Cities Coalition	• Statewide and PEV Readiness Report: Final Report to the U.S. Department of Energy from SCAQMD • Toolkit for Community Plug-In Electric Vehicle Readiness: A Resource for Local Officials Bay Area Regional Plug-In Electric Vehicle Readiness Plan • Central Coast Regional Plug-In Electric Vehicle Readiness Plan • Los Angeles (South Coast) Regional Plug-In Electric Vehicle Readiness Plan • Sacramento Regional Plug-In Electric Vehicle Readiness Plan • San Diego Regional Plug-In Electric Vehicle Readiness Plan • San Joaquin Regional Plug-In Electric Vehicle Readiness Plan
Colorado	Colorado	American Lung Association of the Southwest	• Denver Metro Clean Cities Coalition • Northern Colorado Clean Cities Coalition • Southern Colorado Clean Cities Coalition	• Colorado Electric Vehicle and Infrastructure Readiness Plan (*) • 25 Appendices to report (available by contacting American Lung Association of the Southwest)

Florida	Southeast Florida region, with consideration given to statewide policy and planning	South Florida Regional Planning Council	• Southeast Florida Clean Cities Coalition • South Florida Clean Cities Coalition	• Drive Electric Florida Volume I: Getting Southeast Florida Plug-in Ready • Drive Electric Florida Volume II: Corridor Pilot Project
Kansas City	Greater Kansas City area with consideration given to statewide policy and planning	Metropolitan Energy Information Center, Inc.	• Kansas City Regional Clean Cities Coalition	• Electrify Heartland Plan: Kansas-Missouri Community Readiness for EV and EVSE (*) • Electrify Heartland Plan: Appendices
Maui	Maui, Hawaii with consideration given to statewide policy and planning	University of Hawaii	• Honolulu Clean Cities Coalition	• EVs in Paradise: Planning for the Deployment of Electric Vehicle Infrastructure in Maui County (*)
Michigan	Michigan	Clean Energy Coalition	• Greater Lansing Clean Cities Coalition	• Plug-In Ready Michigan: An Electric Vehicle Preparedness Plan (*) • Plug-in Ready Michigan: Appendix
New York City	New York City	New York City and Lower Hudson Valley Clean Communities, Inc.	• Empire Clean Cities Coalition	• Mission Electric NYC – The New York City Electric Vehicle Readiness Plan: Unlocking Urban Demand (*)
North Carolina	North Carolina, with individual plans covering Greater Ashville, Greater Charlotte, Greater Triangle, Piedmont Triad regions as well as a statewide plan	Centralina Council of Governments	• Triangle Clean Cities Coalition • Centralina Clean Fuels Coalition • Land-of-Sky Clean Vehicles Coalition	• Plug-In Electric Vehicle (PEV) Roadmap for North Carolina: Statewide Plan (*) • Plug-In Electric Vehicle (PEV) Roadmap for North Carolina: Statewide Plan Appendices • Greater Asheville Plug-In Electric Vehicle Readiness Plan • Greater Charlotte Plug-In Electric Vehicle Readiness Plan • Piedmont Triad Plug-In Electric Vehicle Readiness Plan • Greater Triangle Plug-In Electric Vehicle Readiness Plan

Northeast Regional	Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the District of Columbia	New York State Energy Research and Development Authority	• Maine Clean Communities • Vermont Clean Cities • Granite State Clean Cities • Ocean State Clean Cities • Massachusetts Clean Cities • Empire Clean Cities • Greater Long Island Clean Cities • Genesee Region Clean Communities • Capital District Clean Communities • Clean Communities of Western New York • Clean Communities of Central New York • New Jersey Clean Cities • Delaware Clean Cites • Greater Philadelphia Clean Cities • Maryland Clean Cities • Greater Washington Region Clean Cities	• Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools • EVSE Cluster Analysis • Assessment of Current EVSE and EV Deployment • Siting and Design Guidelines for Electric Vehicle Supply Equipment • EV-Ready Codes for the Built Environment • Plug-In Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review
Ohio	Ohio	Clean Fuels Ohio	• Clean Fuels Ohio	• Electric Vehicle Readiness Plan for Ohio (*) • Electric Vehicle Readiness Plan for Ohio: Supplemental Section: Model Ordinance and Policy Templates • Electric Vehicle Readiness Plan for Ohio: Appendices • EV Charging for Persons with Disabilities
Oregon	Oregon	Oregon Business Development Department	• Columbia Willamette Clean Cities Coalition • Rogue Valley Clean Cities Coalition	• Energizing Oregon (*)

Richmond	Richmond region, with consideration given to Virginia statewide policy and planning	Virginia Department of Mines, Minerals and Energy	• Virginia Clean Cities	• Richmond Electric Vehicle Initiative: Electric Vehicle Readiness Plan (*) • EV Charging for Persons with Disabilities
Southeast Regional	Georgia, Alabama, South Carolina	Center for Transportation and the Environment	• Alabama Clean Fuels Coalition • Clean Cities – Atlanta • Palmetto State Clean Fuels Coalition	• Southeast Regional EV Readiness Workbook Section 1 • Southeast Regional EV Readiness Workbook Section 2 • Southeast Regional EV Readiness Workbook Section 3 • Southeast Regional EV Readiness Workbook Section 4 • Electric Vehicle Adoption in the Southeast (to 2020) (Appendix included in full report file)
Southeastern Pennsylvania	Five counties of Southeastern Pennsylvania (Bucks, Chester, Delaware, Montgomery, and Philadelphia)	Delaware Valley Regional Planning Commission	• Greater Philadelphia Clean Cities	• Ready to Roll! Southeastern Pennsylvania's Regional Electric Vehicle Action Plan Volume I: Planning and Policy Recommendations • Ready to Roll! Southeastern Pennsylvania's Regional Electric Vehicle Action Plan Volume II: Technology Overview, Detailed Analyses, and Appendices
Texas River Cities	Central Texas region, including the greater Austin and San Antonio communities, with consideration given to statewide policy and planning	City of Austin, Austin Energy	• Central Texas Clean Cities	• Texas River Cities Plug-In Electric Vehicle Initiative Regional Plan and Final Report (*)

Texas Triangle	Texas Triangle region including Dallas-Fort Worth, Houston-Galveston, and San Antonio-Austin urban areas, with consideration given to statewide policy and planning	Center for the Commercialization of Electric Technologies	• Houston-Galveston Clean Cities • Dallas-Fort Worth Clean Cities • Alamo Area Clean Cities	• Texas Triangle Plug-In Electric Vehicle Readiness Plan: Volume 1 – Summary and Recommendations • Texas Triangle Plug-In Electric Vehicle Readiness Plan: Volume 2 – Full Text of Plan (*) • Texas Triangle Plug-In Electric Vehicle Readiness Plan: Volume 3 – Appendices

Links to each of the readiness plans are included in the table above and can also be found at http://www.eere.energy.gov/cleancities/electric_vehicle_projects.html.

ENDNOTES

1. C2ES, 2012. An Action Plan to Integrate Plug-In Electric Vehicles with the U.S. Electrical Grid. 54 pp.

2. The activities of the grantees and the content in the readiness plans vary in the extent to which they differentiate between the types of PEVs. This is due to variation in the focus of effort for each grantee and the changing and expanding set of PEV models available to consumers.

3. The results of a recent study generally support this rule of thumb. Greene, D.L., Evans, D.H., Hiestand, J., 2013. Survey evidence on the willingness of U.S. consumers to pay for automotive fuel economy. Energy Policy 61, 1539-1550.

4. EPRI compared two PEVs (a 2012 Nissan Leaf and a 2012 Chevy Volt) with an average gas-only hybrid vehicle and an average conventional vehicle. The average hybrid characteristics were calculated based on the attributes of four hybrid models: Ford Fusion Hybrid, Honda Civic Hybrid, Toyota Camry Hybrid, and Toyota Prius. The average conventional vehicle characteristics were calculated based on four mid-size sedans: Chevy Cruze LTX, Ford Focus Titanium, Honda Civic EX, and the Volkswagen Passat. Analysis included vehicle purchase price, gasoline costs, electricity costs, maintenance costs, and battery replacement costs for the Nissan Leaf. PEV vehicle purchase prices included the $7,500 federal tax incentive.

5. Large users of electricity are charged not only for the amount of energy they use (measured in kWh) but also for the maximum rate of energy use (in kW). Operators of high powered fast-chargers may incur these additional demand charges not incurred by operators of slower chargers that draw less power. Further, even with low power charge points, fleets of PEVs charging simultaneously at many points could cumulatively push a facility past its maximum kW limit.

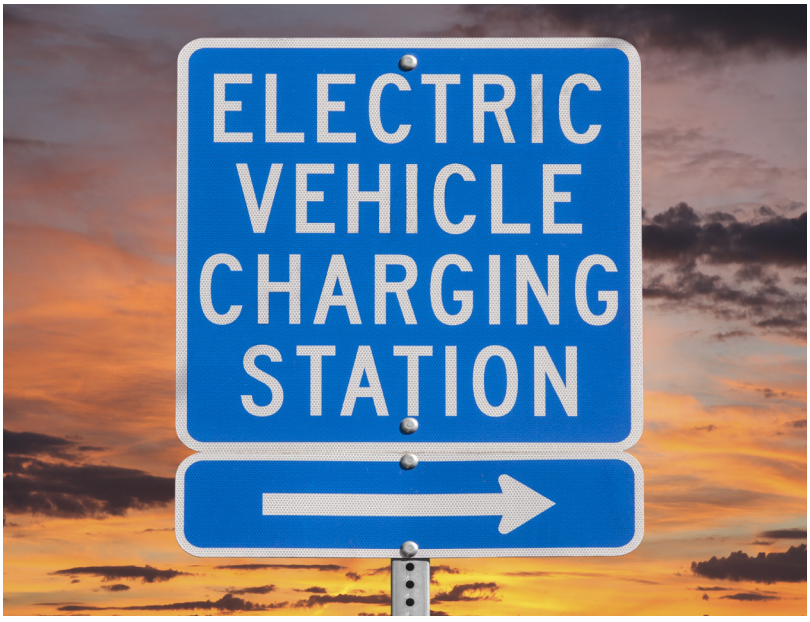
6. For additional information on this tax credit, see the Department of Energy Alternative Fuels Data Center: http://www.afdc.energy.gov/laws/laws/US/tech/3270 and the tax incentive extensions of the American Taxpayer Relief Act of 2012 (Public Law No: 112-240): http://thomas.loc.gov/home/LegislativeData.php?&n=PublicLaws&c=112.

7. Density bonuses are allowances granted to developers to exceed the maximum allowable density for the district (build more housing units) in exchange for providing some other amenity, which in this case would be the installation of charging stations.

8. Advanced Energy. 2013. Memo from U.S. DOT: Regulatory Signs for Electric Vehicle Charging and Parking | NC PEV Taskforce News. August 16. Accessed November 19, 2013: http://www.advancedenergy.org/transportation/ncpev/blog/news/?p=212.

9. Nichols, M.A., Tal, G., 2013. Charging for Charging: The Paradox of Free Charging and its Detrimental Effect on the Use of Electric Vehicles. Institute of Transportation Studies, University of California, Davis, 18 pp.

10. Ancillary services are necessary energy services that must be purchased to maintain electrical grid reliability given the need to (1) constantly balance generation with a shifting electricity demand load and (2) manage localized transmission congestion. PEVs may be well suited to provide ancillary services because the energy stored in PEV batteries can be stored from and dispatched to the grid quickly and because individual PEVs interconnect with the grid at many different places.



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