CENTER FOR THE COMMERCIALIZATION OF ELECTRIC TECHNOLOGIES

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Volume 2
Texas Triangle Plug-in Electric Vehicle Readiness Plan

Full Text of Plan

Driving on Texas Highways

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Executive Summary

This is Volume 2, the full text of the three-volume Texas Triangle PEV Readiness Plan. The Plan addresses barriers to readiness and PEV acceptance in the triangle formed by the Texas metro areas of Dallas/Ft. Worth, Houston, and Austin-San Antonio with a focus on the small and mid size cities in between. The Plan benefits the stakeholders and general public by laying out the issues and providing a set of recommendations to address these issues.

About the Authors

The Texas Triangle Plug-In Electric Vehicle Readiness Plan of the Center for the Commercialization of Electric Technologies was a collaboration between five planning teams: Plug-in Texas (state legislation and agency initiatives); Frontier Associates (electric utility issues and PEV grid interface); Southwestern Economics and CCET (local best practices to promote readiness); ECOtality North America (PEV charging infrastructure along the triangle corridors); and Dave Tuttle Consulting (consumer information program). In addition, a Technical Advisory Committee including Clean Cities coalition staff, electric utility representatives, and cognizant state agencies provided review of the work products. Finally, Southwest Research Institute provided key technical review and valuable insights into the implications of the economic change from a petroleum-based to an electricity-based transportation system.

Acknowledgements and Disclaimers

Opinions expressed in this report, as well as any errors or omissions, are the authors' alone. The examples, facts, results, and recommendations summarized in this report represent our interpretations. Nothing herein is intended to provide a legal opinion. The recommendations are voluntary except to the extent that governing bodies may decide to enact them in the form of legislation or ordinance. The plan may not be copied, reproduced, modified, distributed, sold, broadcast, stored or otherwise used without the express permission of CCET or the original copyright holder or the authors.

Electric vehicles first made their entry into the transportation systems early in the last century only to disappear under the market pressure of the internal combustion engine and Henry Ford. But in my life time the electric vehicle "ride" has been for not-so-energetic golfers and two-wheeled scooter enthusiasts. But that's about to change. Modern electric vehicles offer all the comfort, safety and convenience of their gasoline counterparts, save one thing--range limitations. Our Texas efforts will provide leadership to the nation in developing the needed infrastructure to support electric vehicle travel among our major cities, and we'll clean up smog along the way.

Milton Holloway, President & COO of CCET

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Chapter 1 Introduction

This chapter provides the background of the Texas Triangle Plug-in Electric Vehicle (PEV) Plan (Plan), its purposes, method for its development, and organization.

As used in this Plan, the *Texas Triangle* is defined by its northern apex, the Dallas-Fort Worth Metroplex, its southeastern corner, the Houston-Galveston area, and its southwestern corner, the San Antonio-Austin urban area. The backbones of the Texas Triangle are Interstate Highways 45 (connecting Houston with Dallas), 35 (connecting San Antonio with Austin, Dallas, and Ft. Worth) and 10 connecting San Antonio with Houston.

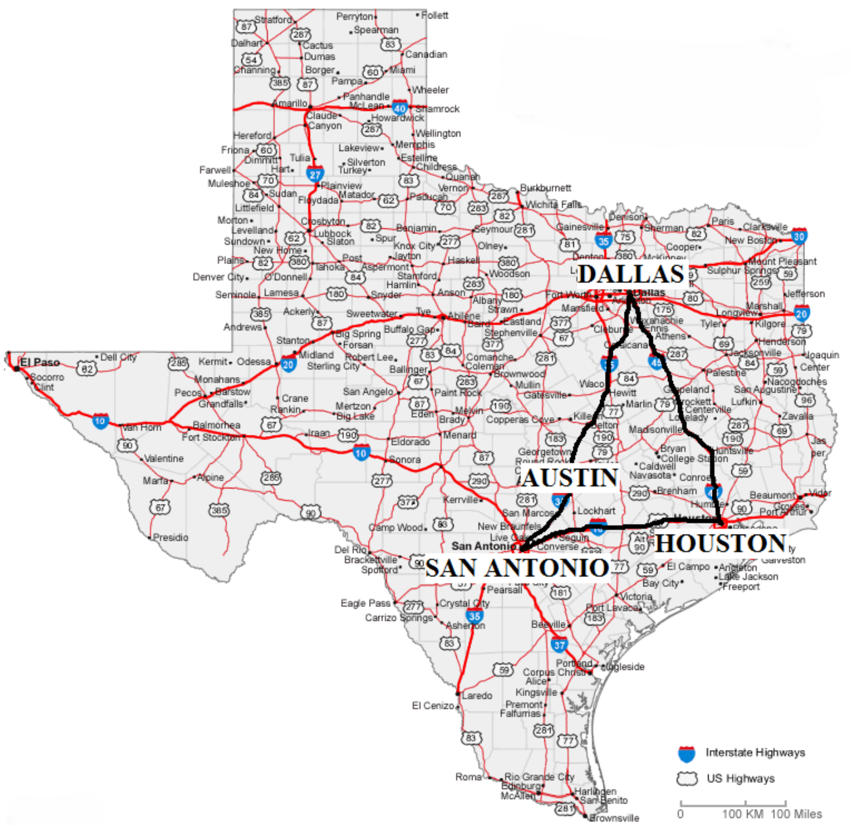


Figure 1-1
The Texas Triangle is the area bounded by the Dallas/Ft. Worth region at the apex, San Antonio and Austin in the southwest and the Houston area in the southeast.

PEV advocates contend that PEVs offer the promise of significantly reducing U.S. dependence on foreign oil over the long term (thus addressing both national security and economic concerns), improving air quality, and providing a means to better use the abundant wind resource in Texas through managed charging of PEVs during periods when the wind is most available and overall demand for power is down.

Subsidies from the federal government to PEV battery manufacturers, electric vehicle supply equipment (EVSE) vendors, and auto makers, have spurred the development of several PEV models including the all-electric or battery electric vehicles (BEVs) and the plug-in hybrid electric vehicles (PHEVs). PHEVs have the capability to use gasoline when the battery is depleted thus avoiding the need for charging on longer trips.[I] This Plan consists of recommendations to address barriers to “PEV readiness” at the regional and local level in Texas.

As shown in the tables in Appendix 1A, the great majority of the PEV sales and associated planning for charging infrastructure and PEV readiness has been focused in the four metropolitan areas defining the corners of the Texas Triangle. This Plan acknowledges the considerable planning and implementation of PEV charging stations and networks in the four metro areas. (Appendix 3A describes PEV activity in some of these areas) The *infrastructure* aspects of this Plan focuses on the intercity links inside the triangle to connect the metro areas with charging stations so that an all-electric or battery electric vehicle (BEV) driver can move between cities without fear of running out of charge. Other elements of the Plan have a state-wide application because they are best addressed at that level.

The temporal focus of this Plan is on the near term which is defined as 2013-2015. The exception is Chapter 7 which looks beyond the initial “PEV readiness” focus of this Plan by delineating activities which need to be underway during the near term to meet longer term objectives.

The various Plan elements include *potential* recommendations prepared by the authors of that particular element. The Plan authors are listed in Appendix 1B. These recommendations were later modified and others added through a review process from our Technical Advisory Group. Members of the Technical Advisory Group are listed in Appendix 1C. Finally, the CCET board of directors made additional modifications resulting in the final set of recommendations listed at the end of this Volume as Chapter 8.

The recommendations are voluntary except to the extent that governing bodies may decide to enact them in the form of legislation or ordinance. The timing of Plan recommendations implementation and the urgency and seriousness given may very well depend upon international events that could create a sudden demand for PEVs. An example would be the outbreak of war in the Middle East resulting in fuel scarcity and much higher fuel prices. Therefore, this Plan also serves as a contingency plan in addition to highlighting opportunities to take advantages of the seemingly inevitable shift to electrification of transportation over the longer term.

1.1 Background

In June of 2011, the U.S. DOE issued Financial Opportunity Announcement (FOA) 451 seeking regional and community specific proposals to develop plans to remove barriers to PEV market penetration. The Center for the Commercialization of Electric Technologies (CCET)[II] was one of 17 awardees of grants from the U.S. Department of Energy in the summer of 2011.[III]

The CCET proposal to DOE included the following objectives:

(1) Develop a Texas Triangle plan that focuses on the state wide and trans-regional issues *while relying on input from three regional planning groups* and activities of state agencies *to represent a broader state-wide plan*.

(2) Develop a Texas Triangle plan that also includes *local planning elements for the smaller metro-areas within the Triangle* that leverages the on-going planning work of the four major cities along the Triangle. This would be in the form of model ordinances, manuals, uniform code recommendations, training, etc.

(3) Develop a plan that includes state-wide *electric utility issues* related to PEVs such as possible future use of PEVs in the ancillary service market, and pricing rate structures and technology to promote managed charging at corridor charging facilities and at the residences of utility customers.

(4) Develop a plan that addresses a comprehensive *inter-regional charging infrastructure and availability so* as to allow consumers with PEVs to travel along the triangle highway system without range anxiety concerns.

(5) Develop a plan for a *state-wide interactive consumer outreach program* that will address concerns of prospective PEV purchasers, such as the economic, environmental, and logistical trade-offs between conventional vehicles and all forms of PEVs, charging specifics, charging station locations, etc.

1.2 Organization of the Plan

The Plan consists of several tasks, each of which involved one or more separate authors. Each task forms an element of the Plan and each element comprises a chapter in this document. In the preparation of each element, the Plan authors looked at two scenarios based on available or likely funding level. One is a low cost or business-as-usual (BAU) funding level; the other assumes a significant level of outside funding, most likely in the form of federal implementation grants. [IV]

Chapter 2 looks at the state government proposed and enacted PEV and alternative fuel legislation. Regulations from state agencies resulting from this legislation and other initiatives are also addressed.

Chapter 3 addresses what was originally a collection of local options for readiness including model ordinances, PEV fleet initiatives, training, and possible code revisions. As this work progressed, it was evident that rather than specifying what all communities ought to be doing, a statewide program to encourage localities to select from among a variety of "best practices" would be preferable. These best practices are packaged into a voluntary program that we recommend be administered by a statewide entity with interest and jurisdiction dealing with PEVs. The *Texas PEV-Friendly Community* program would provide guidance to and recognition of cities and small towns all over the state that put together a combination of activities from a menu of options that meet a requisite point total.

Chapter 4 looks at the electric utility aspects of PEV readiness. Because the Texas electric utility is unique in many ways, any set of recommendations needs to appreciate the fact that Texas has its own electric grid. Also, the various facets of electric power generation, transmission, distribution, and retail sales have been restructured for parts of the state, but not for other parts (i.e., not in municipally owned utilities and rural electric cooperatives). PEVs can be both an *opportunity* to balance power demand or a *threat* to exacerbate shortages and black outs. This chapter looks at both and recommends actions to address them.

Chapter 5 looks at what is required to link the metropolitan areas of the Texas Triangle together with an infrastructure of PEV charging stations such that owners of BEVs can move throughout the triangle without fear of running out of electric charge.

Chapter 6 address a significant barrier to PEV market penetration—lack of a statewide, commercially neutral, continuously updated, locally relevant, PEV consumer information program.

Chapter 7 goes beyond the immediate concerns of readiness and looks to a longer term future. The recommendations contained in this "beyond readiness" chapter recommend immediate attention to issues in the form of studies, technology development, and demonstrations to best deal with longer term issues. In this sense, it fits within the near term implementation focus of the Plan.

Chapter 8 consists of the final recommendations as revised by the CCET Board of Directors. As noted earlier, there are some differences between the recommendations in each of the chapters and the final set revised by the CCET Board.

To increase the usefulness of this Plan, it exists in three volumes, electronically. Volume 1 is the Summary and includes all of the recommendations. Volume 2 is the complete Plan including the recommendations. Volume 3 contains many important appendices that are necessary to better understand and appreciate the recommended actions.

As with any new technology, there are a variety of terms and acronyms that can create confusion to the reader through ambiguity or misuse. To create as much clarity as possible, Appendix 1D sets out the terms, acronyms and abbreviations used in this Plan.

Finally, the use of end notes for both references and additional discussion contribute to a more easily read document and keeps the focus on the substance of the recommendations. Because this Plan will be circulated almost exclusively in electronic format, the existence of multiple volumes should not create an inconvenience for the reader with respect to quickly finding the appended materials.

Chapter 2 Review of Texas Legislation and Regulatory Initiatives

In order for widespread adoption of plug-in electric vehicles (PEVs) to occur in the state of Texas and for the proper and necessary infrastructure to be implemented, it is essential that the supporting political and regulatory environment exist. The purpose of this task is to examine the current status of legislative and regulatory support for PEVs that might guide recommendations for the future initiatives.

2.1 Introduction

Texas, already the nation's leader in wind power, is poised to become a leader in electric vehicles. The widespread use of electric vehicles would dramatically reduce carbon and other emissions, including ozone, particulates and greenhouse gases. In the Dallas-Fort Worth, San Antonio, Houston and Austin metropolitan areas alone, more than 40 million cars are on the road. Two of these urban centers – Houston and the Dallas-Ft.Worth Metroplex – are considered "non-attainment" areas by the Environmental Protection Agency and are under strict mandates to improve air quality. PEVs could make a significant improvement to urban area air quality.

Texas, due to its position in the oil patch, and because of its vast size in terms of travel, has traditionally been a large fossil fuel consuming state. Moreover, Texas has traditionally been a state free of regulation that impedes personal choice of lifestyle. The adaptation of public policies to advance alternative fuels in Texas has been a slower process than in other more politically progressive or other "smaller" states with shorter consumer commutes or limited vehicular transportation needs.

This section reviews past legislative and regulatory agency actions, notes what other states are doing to prepare for PEVs and makes broad recommendations for possible future public policy considerations in Texas.

2.2 Summary of Prior Legislative Actions

The 82nd Texas Legislature (2011)

In the 82nd Texas Legislature, the most recent session in 2011, ten pieces of legislation were proposed that directly supported or involved PEVs. Out of the ten bills that were proposed, three of those passed and were enacted into law. These are: HB 3272 (adding PEVs to the low income Texans' vehicle replacement grant program); SB 385 (alternative-fueled vehicle refueling infrastructure grants funded by TERP); and HB 3399 (adjusting requirements for fleet programs to receive TERP grants on alternative-fueled vehicles). Another successful piece of legislation that could indirectly advance PEVs is SB 990 (administrative bill providing additional powers to local transit authorities; local rules could possibly allow PEV access to HOV lanes).

One of the remaining seven failed and the remaining six failed to make it out of committee or be heard in a final reading by the Senate or House. Because PEVs are often linked with alternative fuels in the mind of the public and because future initiatives may tie PEVs and natural gas-powered vehicles, we felt it important to also examine legislation that we believe was related to alternative-fueled transportation or other specific types of alternative-fueled transportation. We have identified nine additional pieces of legislation worth noting, one of which has been signed into law.

When analyzing the successes and failures of proposed legislation during this session, we must consider the outside factors and general session climate that had an impact. The 2011 Texas regular legislative session was dominated by several high profile, time-consuming and often-divisive measures. More than 8,500 bills were filed including several state agencies' "sunset bills" and issues deemed as "emergency items" by Governor Perry. Electoral redistricting and the projected budget shortfall for the state's 2012-2013 fiscal year captured much of the legislators' energy. These major items dominated the five-month session, limiting debate and passage of much meaningful energy, transportation and general business legislation. The work on the sunset legislation of TXDOT, The Public Utility Commission, The Department of Insurance and The Texas Railroad Commission went until the session's final days. Social issues including voter ID, sanctuary cities, sonograms for women before abortion procedures, a federal balanced budget amendment and eminent domain protection created a very partisan House and divided Senate. Public school and healthcare funding were not concluded during the regular session, necessitating Governor Perry to call a special session, which began May 31.

The legislature had difficulty finding the funding to promote "incentive" legislation related to PEVs and most alternative fuels in general. The natural gas industry was successful with a "Pickens Plan[V]" component of natural gas long haul truck refueling stations and truck replacement funding, but the propane, solar and wind energy sectors were largely unsuccessful in advancing legislation. The free-market, anti-subsidy philosophy of the House this session constrained two priority PEV bills – HB 3310 creating modest vehicle rebates (capped at $2,500 and 2000 vehicles; failed on House floor 92-50) and HB 3308 (providing access for PEVs to HOV lanes with fewer than the number of required passengers was postponed by its author). Passage of SB 1742 (HOV access) was near, but the legislation fell victim to the deadline for Senate bills on the May 24 House Calendar.

Again, new legislation to advance PEV adoption in the state did pass including HB 3272 (adding PEVs to the low income Texans' vehicle replacement grant program); SB 385 (alternative-fueled vehicle refueling infrastructure grants funded by TERP); HB 3399 (adjusting requirements for fleet programs to receive TERP grants on alternative-fueled vehicles); and SB 990 (administrative bill providing additional powers to local transit authorities; local rules could possibly allow PEV access to HOV lanes).

Appendix 2A summarizes the PEV related legislation in the 82nd Texas Legislature. The fourth column, that discusses apparent reasons for why the bill failed or passed, is useful for understanding what kind of future legislation might be more or less acceptable in the future.

The 81st Texas Legislature (2009)

There were many discussions and expressed support for clean transportation in the 81st Legislative Session, however, only three of the 22 pieces of legislation that were identified passed and became law. There was proposed legislation to financially incentivize the purchase of PEVs (HB 2867), convert Texas fleets to PEVs (SB 1425), create a pilot program to make an evaluation of the policies regarding PEVs (SB 1821) and require state agencies to purchase PEVs (HB 629). Though none of these particular pieces of legislation were successful, strides were made to expand the use of PEVs in Texas. HB 432 extends the amount of State vehicles required to use alternative fuels and SB 1759 created the Texas clean fleet program under TCEQ and required TCEQ to conduct an alternative fueling facilities study. Please see Appendix 2A to see a listing of PEV and alternative fuel related legislation from the 81st Texas Legislature.

The 80th Texas Legislature (2007)

2007 saw some proposed legislation for state purchasing of PEVs, promoting HOV lane access and discounted tolls for hybrid vehicles, requesting studies of alternative fuels and their implementation and expansion of low-emission programs. Unfortunately, these ideas were still in early concept and none of these measures were successful. However, the 80th Legislature was successful in expanding the Texas Emissions Reduction Plan and the Low Income Vehicle Repair Assistance (LIRAP) programs through SB 12 to reduce emissions from mobile sources, increase the number of individuals eligible for grants under LIRAP and increase the amount of the grant for purchase of a new vehicle and the retirement of older vehicles with higher emissions. This session also included some hydrogen fuel related bills, which were also mostly deemed unsuccessful. Please see Appendix 2A to see a listing of PEV and alternative fuel related legislation from the 80th Texas Legislature.

2.3 Summary of Texas State Agency Actions

Texas has advanced very few public policy initiatives to promote the community readiness or driver incentives/acceptance of clean PEVs. As described in this section, little legislation (and therefore regulatory rules) has passed related to PEVs or alternative fueled vehicles. However, momentum is beginning to rise as public interest in clean transportation evolves.

Texas regulatory bodies do not often proactively advance or promulgate new rules without legislative action or guidance. Executive Orders from the Governor, to agencies, are also rare.

The Railroad Commission, Texas Commission on Environmental Quality and Comptroller of Public Accounts are the three state agencies identified as governing regulations regarding alternative-fueled transportation. The Texas Department of Transportation also has some relevance to PEV policy.

These agencies have promulgated rules on Texas Clean Fleet Program, Texas Clean School Bus Program, Natural Gas Vehicle Grant Program, LIRAP, Low Emission Diesel, Alternative Fueling Facilities Program and a Liquefied Gas Tax when used as a transportation fuel.

Appendix 2B examines existing regulatory programs that relate to alternative fuels in order to evaluate what administrative and regulatory actions have already occurred as well as the types of programs Texas already supports.

2.4 Summary and analysis of what other states are doing

The legislature has created a number of environmentally beneficial proposals, such as The Texas Emissions Reduction Plan's Clean School Bus Funding Program. It has established clean diesel research funding, has created a natural gas vehicle grant program and other meaningful alternative fuel related programs.

However, the Texas legislature is a very independent body, not necessarily embracing federal directives nor following policies advanced by other early adapting states, particularly in the environmental policy area. However, attitudes of consumers and policy makers are evolving not just in environmental benefit recognition, but also cost of ownership/consumer savings and the convenience and ease of PEV operations.

A number of states have created incentives ranging from tax credits for charging stations to direct consumer rebates. These various programs are noted below, with italicized comments analyzing Texas likelihood of same.

Twelve states have provided HOV lane access for PEVs: Arizona, California, Colorado, Florida, Hawaii, Illinois, New Jersey, New York, North Carolina, Tennessee, Utah and Virginia. *HOV lane access is likely to be contemplated by the 2013 Texas legislature. Federal Highway Administration regulations appear to permit HOV lane access with the concurrence of local transportation authorities administering HOV lanes.*

Twelve states have created tax exemptions or credits for PEV owners: Arizona, Colorado, Georgia ($2,500 for AFV/$5,000 for ZEV), Louisiana, Maryland, Michigan, New Jersey (ZEVs only), Oklahoma (up to &15,000), Rhode Island – Warren, Utah, Washington and West Virginia. *Texas currently has small grant programs for commercial charging station investments. It is envisioned this funding could expand in 2013 if funds are available.*

Four states provide direct consumer rebates for PEV purchases: California (up to $2,500), Illinois (up to $4,000), Pennsylvania (up to $3,500) and Tennessee (up to $2,500). *PEV rebates using state money were soundly rejected in the 2011 Texas legislative session.*

Ten states provide an investment tax credit for charging equipment: Arizona, California – Bay Area, Georgia, Hawaii, Louisiana, Maryland, Oklahoma, Oregon, Washington and West Virginia. *Texas does not have a personal income tax, hence this incentive may not be practicable.*

Three states reduce or exempt license or registration for PEV owners: Arizona, Washington, D.C. and Illinois. *Because of severe budget crisis in 2011, this reduced fee concept was not deemed plausible and not pursued in the session.*

Eight states exempt PEVs from state inspections and testing requirements: Idaho, Maryland, Michigan, Missouri, Nevada, North Carolina, Virginia and Washington. *Because of severe budget crisis in 2011, this reduced fee concept was not deemed plausible and not pursued in the session.*

2.5 Legislation that might be proposed in the upcoming 2013 Session

Potential legislation to advance Texas Triangle community readiness for PEVs, and to increase consumer adoption of PEVs could include:

- Expand TERP funds used to build public charging stations along the interstates bounding the Texas Triangle
- Permit TxDOT to include EVSE at the state's safety rest stops along the Texas Triangle highways

- Develop a workable, equitable road use fee for PEV owners to participate in gasoline tax-like highway funding

- Provide HOV access for PEVs regardless of vehicle occupancy in Dallas and Houston (where the only HOV lanes in the state are located)

- Place EVSE at state-owned facilities such as office buildings, parks and airports.

- Direct state agencies to increase purchases of PEVs

Chapter 3 Local Best Practices

3.1 Background

The large metropolitan areas that comprise the corners of the Texas Triangle have planned and implemented a host of PEV readiness measures at the local level. (A brief description of these activities for two of these four metro areas appears in Appendix 3A.) For the small towns and mid-size cities along the connecting corridors and inside the Texas Triangle there has been little to no such activity. The purpose of this Plan element was to lay out a program that would encourage the small towns and mid-size cities to undertake PEV readiness efforts.

Contacts with municipal staff indicate that PEV readiness is a low priority because of the pressing needs of other issues involving the economy and the normal functions of city government. The low volume of PEV sales in their local communities, and the corresponding lack of interest by their citizens in PEV-related issues are two reasons cited by local officials for this. The outreach to small towns and mid-size cities in the Texas Triangle conducted for this Plan is discussed in Appendix 3B.

If indeed the shift from *sole* reliance on gasoline and diesel fueled vehicles to electrified transportation is an inevitable one, it is important to establish a program now that will enable all cities in Texas—not just those in the Texas Triangle—to adopt measures that will make this happen when they consider the time is ripe. This matter of "ripeness" should not be driven by a timetable. Some communities will elect to adopt PEV readiness measures before others either because they perceive this to be a way to foster economic development[VI], they want to be perceived as "green" or "progressive", they feel pressure from their citizens who are beginning to purchase PEVs, and/or they fear the impacts of sole reliance on gasoline in an era of volatile gasoline and diesel prices, and concerns of its availability, given the U.S. dependency on oil imports from hostile countries.

This chapter briefly lays out the *barrier*s to PEV readiness (section 3.2) and then provides potential *options for addressing the barriers* (section 3.3). Finally, this chapter recommends a statewide program for cities and towns, regardless of size, that can promote and assist communities in overcoming these barriers to PEV market penetration. Section 3.4 recommends the Texas PEV-Friendly Program.

3.2. Local Barriers to PEV Readiness

3.2.1 Lack of reliable, timely, and thorough consumer information regarding PEVs

PEVs are a new technology. Local communities often lack a trusted information source or repository of information that is up-to-date (the technology, costs, availability of models, and ESVE options are rapidly changing) and trustworthy (commercial interests drive advertising content which may not provide the balance and lack of bias that a prospective consumer needs). *Chapter 6* of this report addresses this problem through a recommended statewide internet-based PEV consumer information website. Implementation of this recommendation will go a long way toward addressing this barrier, but even then, having an individual to consult in a local municipal office or electric utility office will still be important. This complementary need is addressed in the recommended program in this chapter as well.

3.2.2 High costs of PEV ownership

By far the single greatest barrier to increased PEV market penetration is the high front end cost of the vehicles. The lower cost of electricity per mile, maintenance savings, and the federal tax credit does not yet offset these high front end costs resulting in lengthy "payback" periods.[VII]

3.2.3 Delays, high costs, and uncertainty in installing EVSE in residences

As illustrated in Figure 3-A, the majority of the charging of PEVs by consumers will be overnight at their place of residence. In communities where PEVs have yet to penetrate the vehicle market, finding electricians who understand EVSE and city building code enforcement staff who can readily permit the installation of the EVSE can result in delays and/or high costs in being able to charge the PEV. Prospective PEV purchasers who are uncertain as to how they will be able to charge their vehicle will be less likely to buy one. For PEV owners who are content with the slower Level 1 charging, there may be no need for new wiring, permitting, or purchase of EVSE. (See Appendix 5A for a discussion of charging levels, charging times, and power requirements.)

3.2.4 Inability for multifamily dwelling residents to obtain EVSE for home charging

For residences of owner-occupied single family dwellings with garages, obtaining and installing EVSE is relatively straight forward. Complications arise if the prospective PEV purchaser lives in an apartment or condominium building and does not own a garage or have access to EVSE from a power source. If an apartment building owner—or a condominium property owner's association—does not have an interest in providing the means of PEV charging, a prospective PEV purchaser will be deterred from making that purchase. The problems posed in these circumstances represent a serious impediment of PEV readiness for this group of consumers.

ECOtality's siting guidelines for the State of Texas, prepared as a deliverable to this Plan, lists some these issues:

> Multi-family dwellings have additional considerations because the apartment or condominium owner must be involved in any siting decisions. The EV owner will prefer a site close to the dwelling, but this may not be in the best interest of the apartment owner. Special flooding or drainage conditions may apply, and lighting and vandalism are also concerns. The payment method for electricity usage must be specified and understood by EV owners. In addition, there may be insurance and liability questions. All issues should be discussed with the property owner prior to the EV purchase.
>
> If and when the EV owner later relocates, the electrical installation raceway and panel upgrades, if any, will be retained at the multi-family location. Ownership of the EVSE needs to be identified clearly. If the EV owner wants to take the EVSE when they relocate, site restoration may be required. Circuit removal or de-energizing methods should be agreed upon. Discussion with the utility is also required, since there may be metering questions or issues to be resolved. In condominiums, the HOA may be involved in approving EVSE additions and removals.[VIII]

3.2.5 Lack of Publicly Available PEV charging stations

Just as publically available gasoline service stations are open to serve drivers of conventional ICE vehicles, PEV drivers expect to have publically available charging stations. As shown in Chapter 5 and in Appendix 3A, scores of these have already been installed at strategically located places of business or publicly owned lots and garages. If the PEV is a BEV, the driver will be confined to workplace or home charging without access to publicly available EVSE. This, in turn, contributes to range anxiety and creates a disincentive to own a BEV.

3.2.6 Lack of workplace PEV charging stations

For those considering purchasing or already own a BEV and rely on a supplemental boost in charging to make the roundtrip from work to home, the lack of work place charging creates range anxiety and discourages BEV purchase decisions. Figure 3-A illustrates that most PEV charging is done at home, where the car usually remains idle overnight; second in frequency is at the workplace, where employees spend 8 to 10 hours per day; with public charging often serving as a top-off for anxious BEV drivers or as a cost saving convenience to all PEV owners.

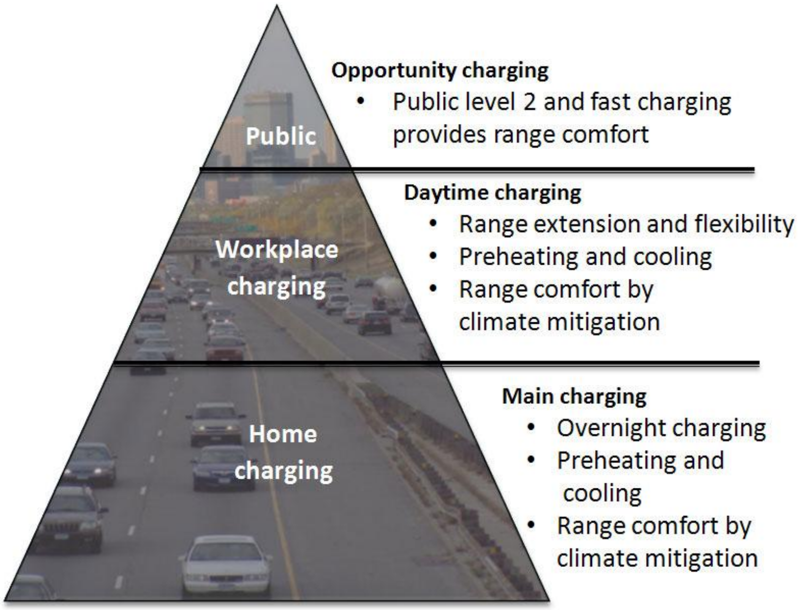


Figure 3-A – Relative Reliance on Home, Workplace, and Public Charging for PEV owners
Source: Workplacecharging.com

3.2.7 Lack of training for emergency responders, fleet managers, PEV EVSE installers, transportation and land use planners and others with niche roles in PEV readiness

In addition to generalized consumer information for prospective purchasers of PEVs, specialized information and hands-on training will be required to acquaint segments of the private and public work force of the differences that the availability and use of PEVs will make in their responsibilities. For example, if a PEV is involved in an accident it will be important for the first responder to be aware of the high voltage risks that arise when the PEV battery pack containment is breached. As noted above, training of electricians and code enforcement personnel can reduce the costs and time of EVSE Level 2 installation. The planning for electrical power to sites of possible future EVSE charging in new parking garages and parking lots may require changes in zoning and subdivision regulations to avoid costly installation of cables once the structures are completed. Understanding the particular fuel cost and maintenance advantages for fleet operators that PEVs afford will require specialized information for municipal and private fleet operators.

3.2.8 Lack of uniform signage and directions for PEV station locations

Drivers of BEVs will depend upon electronic GPS based equipment and highway signage to find locations of PEV charging equipment. If the signs are not clear or if the GPS systems are not updated to reflect new stations and those that are no longer in service, the resulting inconvenience will create a barrier to PEV market penetration.

3.2.9 Lack of interoperability of payment methods and billing in PEV charging

The Society of Automotive Engineers and other standards setting bodies are tackling the issue of interoperability of EVSE ports, plugs and systems. For a discussion of this process and remaining challenges in inoperability of charging, see *Chapter 5*. Less certain is the ability for BEV owners to find a charging station that will accept their method of payment or even allow them to use the station if they are not a paid up member of a marketing association. An analogy would be of a certain brand of gasoline could only be made to a cardholder of certain companies or to members of a particular discount club.

3.2.10 Lack of third part electricity sales in publicly owned utility service territories

Some representatives of municipally-owned utilities in Texas have expressed concern that if they allow third parties to provide PEV charging in their service territories they could lose their ability to regulate sales of electricity and would become part of the deregulated market. This concern threatens to discourage third party private EVSE vendors from providing competitively priced charging services in these publically owned service territories.

3.3. Potential Options for Overcoming Local Barriers to PEV Readiness

This section looks at the *potential options* for dealing with the barriers listed above as well as other measures that can promote PEV adoption. It also includes “lessons learned” from some of these cities that have deployed these options. As with all the recommendations coming out of this Plan, the *potential* options in all chapters are the work of the chapter author. Final recommendations were revised in several instances by the CCET Board of Directors. See Volume 1 or the summary chapter in this Volume 2 for the final list of recommended actions.

3.3.1 Incentives to offset high front end costs

The federal government has addressed the high front end costs of PEVs through a federal tax credit of up to $7500 depending upon the battery size of the PEV. [IX] As many as ten states, such as California, offer additional cash incentives of up to $2500.[X] In theory, communities can offer cash incentives although few, if any, have done so.

Other incentives including non-cash incentives include high occupancy vehicle (HOV) lane access for PEVs on freeways, waiving toll road fees, waiving state taxes on PEVs, waiving state taxes on home charging equipment, rebates on home charging equipment, parking fee exemptions for PEVs on city streets, and exemption from emission testing in areas that require this for attainment of air quality standards. More detail on these incentives can be found in Appendix 3C.

One way to reduce costs for consumers to move into a PEV is to promote the advantages of certain low cost PEVs such as Neighborhood Electric Vehicles (see Section 3.3.4 below).

3.3.2 Provision of consumer information for PEV prospective purchasers

A major barrier to PEV adoption is consumer uncertainty of this new technology along with misinformation that either accentuates problems or is misleading, inaccurate, or both. Sorting out reliable PEV data-- including tradeoffs between conventional ICE vehicles and PEVs-- can be difficult. Moreover, because PEVs are new technology their costs and features are changing rapidly.

The internet is a good place to find information on PEVs for prospective purchasers because the topic is subject to rapidly changing regulatory, technical, and marketing data. Also, prospective PEV purchasers are "internet savvy" and will often go on-line to get data. As with most topics on the internet, the quality of the data is highly variable. Even where the information is valid, it is often accompanied by a point of view-- especially commercially driven articles and information. Appendix 3D provides a listing of several websites from different types of organizations including vehicle manufacturers, EVSE providers, electric utilities, state and local governments, the U.S. DOE and other federal government sites that were used to develop the proposed consumer information program described in Chapter 6.

Because of their operating characteristics, operators of fleet vehicles comprise a special class of prospective PEV purchasers. Sites that address PEVs for fleet operators are also listed in Appendix 3D.

3.3.3 Streamlined permitting processes for EVSE installations

For the great majority of PEV owners, their principal recharging location will be at their home usually in the overnight hours. Therefore, owing EVSE is necessary. All PEVs come equipped with a charge cord that connects via a common connection (see discussion in Chapter 5 and *Appendix 5A*) to a 120V AC outlet. This may be sufficient for the owner depending upon his driving habits, availability of work place or other public charging.[XI] According to GM, about half of the Volt owners use only their 120V AC outlets for charging as opposed to the 240V AC Level 2 charging.[XII] Owners of BEVs, with their larger battery packs, will be more likely to require Level 2 charging at their homes. These chargers can be obtained from a variety of sources and now are being sold in home improvement and automotive stores. A typical cost for a Level 2 charging station exceeds $2000 including installation[XIII] and thus can be an additional barrier to PEV readiness. Often the biggest portion of this cost is providing electrical service to the EVSE including the permitting costs. Also the permitting can result in delays of several days to even weeks if inspectors face a backlog of work. Streamlining the permitting process reduces the installation costs and reduces delays in obtaining Level II charging at the home.

Despite the effort nationwide to acquaint permitting authorities with the relative straightforwardness of EVSE , there are indications that in some areas of the country the permitting process is becoming more, not less, onerous.[XIV] An essential step toward PEV readiness is the streamlining of the installation of EVSE both in the home and for commercial or public stations as well.

As described in Appendix 3E there are numerous options for streamlining the permitting process ranging from excluding EVSE from permitting to more modest means of reducing the costs. Some cities in Texas have established an expedited permitting procedure for obtaining permits to install PEV charging equipment or EVSE. San Antonio's expedited permit process has been cited by one DOE publication as an example of a "best practice". [XV] San Antonio's streamlined permitting process is described in Appendix 3F.

3.3.4 Neighborhood electric vehicle (NEV) adoption

One way to expedite the market penetration of PEVs is to ensure that the driving public is aware of a much lower front end cost of NEVs. NEVs are a form of PEVs that can be purchased for less than $10,000 or about one-third the price of full BEVs. For those who can accept the limitations of these vehicles, they provide most of the same benefits of full service PEVs. As described in Appendix 3G, Texans along with most other Americans can operate NEVs on roads and streets where the posted speed limit is 45mph or less. In dense urban areas and most suburban and small town settings this category of PEV provides the same fuel saving and environmental benefits of the larger and more expensive BEVs. Their lack of access to most highways, their limited top speeds of 30 mph, and the lack of cabin heating and cooling are drawbacks.

3.3.5 Training

One of the barriers to PEV readiness is the lack of knowledge about the advantages and disadvantages of PEVs including the very important need to understand the distinction between the two types of PEVs: the all-electric BEV and the PHEV. The need for providing best practices information can be separated into a general knowledge base with a focus on prospective PEV purchasers and a separate specialized training for segments of the public. The former is consumer information and it is dealt with in detail in Chapter 6. Following is a discussion of three types of specialized training to deal with specific audiences: electrical contractor and inspector training, first responder training, and municipal and county fleet managers training.

Electrical contractors and code enforcement personnel - High installation costs and overly burdensome permitting of PEV charging equipment may be the result of installer or inspector unfamiliarity with EVSE systems. Because of this lack of knowledge about PEVs and EVSE the installation and/or inspection and permitting process may take much longer and entail unnecessary costs. This barrier to PEV readiness can be dealt with through training programs that have been and are being developed by national organizations to educate and certify PEV EVSE installers and those who inspect and permit the installations. For purposes of this Plan we recommend the Electric Vehicle Infrastructure Training Program (EVITP), a collaboration developed between DOE Clean Cities Coalition and several industry groups. Clean Cities works with EVITP to address technical requirements, safety imperatives, and training needs for electric vehicle industry partners and stakeholders. The Electric Vehicle Infrastructure Training Program offers training around the United States at community colleges and electrical training centers. Training is open to licensed electricians in compliance with requirements of state or municipal jurisdictions. Training on local requirements supplements core training when appropriate. [XVI] See Phase I training outline provided in Appendix 3H. An internet based version of this program is also available through the Clean Cities TV Network.[XVII]

First responder training - Fire fighters, police, and emergency medical service technicians will be encountering automobile accidents involving PEVs. Although the safety risk imposed by PEVs has been overblown in news accounts, there are new and different risks that require emergency responders to understand. Appendix 3I describes resources available through the Advanced Electric Drive Vehicle Education Program , funded by a U.S. Department of Energy grant. Appendix 3I provides a description of the program.

Fleet managers training and education - Local governments own and maintain fleets of vehicles, some of which can be economically deployed as PEVs. Corporations such as Fed-Ex have begun replacing their gasoline powered vehicles with PEVs beginning with dense urban routes with lots of stopping and starting where the economics are most favorable.[XVIII] Because non-taxpaying entities are not entitled to the federal PEV tax credits, commercial fleet managers will have the most incentive initially to begin converting their fleets to PEVs. Air quality programs that focus on fleets will find an additional incentive to consider PEVs. [XIX]

The Federal Government will be leading the way in this transition of fleets to PEVs as Executive Order 13514 is implemented requiring 100% of all new vehicles in the federal fleets be alternative fueled vehicles. [XX] Appendix 3J briefly discusses other advantages to fleet managers and their concerns. This appendix also contains excerpts from the Electrification Coalition’s 2010 Fleet Electrification Roadmap. [XXI]

3.3.6 Addressing special problems with PEV charging in multifamily dwellings

There is no single approach for dealing with the multi-family dwelling charging issue because of the various attitudes and legal provisions in Home Owners Associations (HOA), apartment owner policies, etc. With good communication and coordination among the various parties (property owner, HOA, electrical contractor, PEV owner, the electric utility, and permitting agency), satisfactory solutions can be obtained for all concerned. The PEV community task force recommended in this plan can be of great benefit in these circumstances by bringing together the various parties. After a couple of precedents have been set and experience and trust have been gained, the situation becomes easier for the prospective PEV purchasers.

ECOtality produced a flow chart/decision tree that we recommend be used as guidance for dealing with these multifamily PEV charging situations. It is provided in Appendix 3L.

3.3.7 Encouraging workplace charging

According to the Electric Power Research Institute, the average vehicle is on the road for no more than two hours per day leaving 22 hours per day available for charging. Next to the overnight parking at residences, parking at the workplace usually entails 8 to 10 hours per day thus making this location second in importance to home charging. The provision of work place charging has been inhibited by a variety of issues including:

- the cost of installing Level 2 charging equipment,
- the fact that many employers lease parking and office space from a third party and thus cannot readily make available PEV charging to employees without revising lease agreements, and
- logistical and "fairness" issues such as policing abuse of the parking spots by those who are not charging or who may have already charged their vehicle and not made the spot available for other employees who want to make use of the charging location.

Appendix 3K provides a suggested approach to deal with these issues for the short term until the market provides employers with lower cost and easily administered work place charging packages.

3.3.8 Addressing uniform signage issues

Ample and uniform signage can be important for two reasons: the signs let prospective PEV purchasers know of charging availability; the signs direct current PEV owners (including those passing through the community) to PEV charging. Uniformity helps avoid confusion and allows drivers to make quick driving decisions. The federal government requires uniform signs on the roadways for which it provides funding. Appendix 3M shows federally approved signage and provides two examples of private property signage for parking lots and charging areas in Texas.

3.4. Recommendations for Implementing Best Practices

Throughout the country, those advocating PEV readiness had used two different approaches to encouraging local government and grass roots organizations to undertake best practices. One involves the "model ordinance approach" whereby a city or county ordinance is drawn up consistent with state statutes and made available to communities in hopes that they will adopt them or at least select elements for adoption. The other, which we are incorporating here, provides a flexible, point-based program similar to the LEEDs building standards program.[XXII]

3.4.1 Need for a voluntary, flexible, highly visible and incentivized program to promote PEV readiness best practices throughout the State

There is a plethora of information and programs seeking to persuade local communities to adopt a variety of PEV Readiness measures. Those developing these materials include electric utilities, automobile manufacturers, PEV enthusiasts, state governments, federal governments (including several energy, transportation, and environmental agencies), and private non-profit and non-governmental organizations. Much of the information preceding this section comes directly or indirectly from these sources and is similar in content.

Some have approached this through the development of model codes and ordinances and indeed that was our initial approach in developing this Plan. (We have included in Appendix 3N a model ordinance that has been developed under a parallel grant from DOE for the Texas River Cities Project. The value of having such a document facilitates the work of communities that want to prepare a draft ordinance without having to draft something from scratch.) Although the substantive content of the various locally available readiness measures is similar, this Plan packages and promotes the best practices concept through a proposed initiative, the *Texas PEV- Friendly Community Program* that would have the following attributes:

Voluntary - Except for measures that the Texas Legislature decides to have enacted as mandatory, this Plan takes "the carrot rather than the stick" approach. It is not only voluntary in the sense that it is up to the community to pursue, but it seeks participation by volunteers in the form of a community PEV task force.

Flexible - Given the variety of topography, economies, demographics, and attitudes across the State, it is important that local communities that choose to implement readiness programs be able to pick and choose from among a variety of options which collectively will act to promote PEV readiness and adoption. Initially we had considered setting goals or dates for implementation, but quickly realized that; here too, flexibility is important. For example, some upscale suburban communities may see considerable interest and sales of PEVs in the short term. "Early adopters" in these communities will be supportive of their local government undertaking some of the measures in the Texas PEV-Friendly program. Meanwhile, low to middle income residents in remote ranching communities may see little value in any of these measures. Thus, there is the issue of "ripeness." It could be that a couple of years from now, communities that currently express no interest in PEVs might have a complete change of mind in the face of severe fuel shortages and/or drastically higher prices for gasoline—both within the realm of possibility given the volatile political and military situation in the Middle East, Venezuela, Mexico, Indonesia and other sources of imported oil. At that time it will be important for these communities to have access to a program that will provide guidance in making them PEV friendly.

High visibility - However well-crafted a PEV Readiness program may be, if it is not visible to the public and their community leaders, it is of little value in achieving its objectives. We believe that this visibility can best be achieved by linking it to an existing state agency with some form of jurisdiction or interest in PEVs. This would need to be coupled with the Consumer Information Program recommended in Chapter 6 of this Plan. Other alternatives being considered across the country involve non-profit corporations of interested communities and stakeholders and networks of regional groups. These lack the high visibility and sense of permanence that a state agency could bring.

Candidate agencies in Texas and their jurisdictional or topical link to PEVs include:

The Texas Department of Transportation (TxDOT). PEVs will affect transportation policies in the future. Moreover, the issue of uniform signage and the prospects of using TxDOT properties along the interstates (particularly rest areas) for intercity charging involve TxDOT.

Texas Department of Motor Vehicles (TxDMV). This agency deals with vehicle owners through registration and licensing, and motor vehicle dealers through licensing and regulating.

Public Utility Commission of Texas (PUCT). PEV batteries are powered by electricity. The batteries represent both a potentially large consumer of electricity but also storage devices. Moreover, the charging of batteries can be done in a way that helps reduce likelihood of the anticipated power shortages over the next few years. PEVs can also exacerbate local electrical reliability issues when several adjacent residences begin charging PEVs at peak demand periods. The PUCT also has a well-established means of connecting with the public through its popular website, Power to Choose.

The State Energy Conservation Office (SECO) in the Office of the Comptroller is tasked with promoting energy efficiency. SECO is often the conduit for federal funds to local schools, government agencies and individuals for energy efficiency improvements. To the extent that federal funding to support PEV adoption will continue, SECO with its grant handling capabilities and ties to local government would be a good choice.

Texas Commission on Environmental Quality (TCEQ)—Given that the consumption of gasoline and diesel in vehicles is a major cause of the air quality problems in Texas, PEV adoption can be considered a significant air quality control strategy given their zero emission status when operating in an all-electric mode.[XXIII] This gives TCEQ a potential interest and role in PEV adoption.

Incentives - The recommended program described below provides low-cost incentives in the form of public recognition including signage, public awards ceremony, visibility on the agency website, etc. While costing little, the incentives could be valuable to communities seeking to foster a reputation or image that will provide it an advantage in the highly competitive world of community economic development.[XXIV]

3.4.2 Description of the proposed Texas PEV-Friendly Community Program

Despite the fact that the concept of this program developed out of the need to engage the small and mid-size cities in the Texas Triangle, it would be open to *any* community of *any* size in the State. Through an application process to the agency in charge, the community would propose or demonstrate its commitment to accomplish specific tasks or initiatives. Each task would have a maximum point total. The actual number of points from that task or initiative would be based on the degree to which the criteria are satisfied including whether the program is underway or merely planned. The role of the agency staff would be to encourage and provide guidance to the community as well as to determine point totals.

Table 3-1 provides a “straw man” program with a tentative set of points associated with the various tasks. New or revised tasks can be accommodated and points awarded changed, but the concept is to allow communities to pick and choose which areas they want to focus on. For example, a community might be composed almost entirely of single family dwellings. Therefore, the initiatives associated with multi- family dwellings (condos and apartment complexes) would not be relevant. Another community, for example, might have a couple of large employers coupled with long commutes for the workers. In this community, there would be an interest in work place charging. Another example: a community seeking to draw the local citizens as well as visitors to their historic downtown, might want to provide public PEV charging as an extra incentive to draw people to spend time downtown.

Table 3-1 below lists the ten initiatives that would be part of the menu of options. Only the first is mandatory. The formation of a core of enthusiastic and knowledgeable individuals with at least one from the municipal government is essential to the success of this program. [xxv] For purposes of illustration it is assumed that the maximum point total is 200 and that the point total level for qualifying is 100.

Initial designation of PEV-Friendly status could be based on plans and intentions, but retention of that status should be based on implementing progress, perhaps through biannual reviews.

3.4.3 Benefits of Attaining PEV-Friendly Status

Why would a community strive to attain PEV-friendly status? It is likely that most communities in Texas will not have an interest in the program, at least initially. Under current conditions, benefits would include: a designation by the Governor in an annual ceremony, a plaque or even a sign at the city limits, and inclusion in the PEV website recommended in Chapter 6 along with links to the community's or Chamber of Commerce website. These benefits largely deal with image and public relations.

However, there may be a time in the not-so-distant future when a one or more of the following developments cause city leaders to seek the information from this program in response to demands from their citizens.

- If gasoline prices were to surge in response to an international incident that disrupts—perhaps for several months or a year or more—the price and supply of crude oil, demand for reliable information on PEVs and PEV readiness in communities will increase commensurately.

- Continued improvements in PEV battery technology coupled with reduced upfront PEV costs, will result in a more gradual, but potentially large, shift in demand for PEVs and therefore PEV readiness.

- Over the past two years with the widespread use of shale fracking, natural gas reserves have increased, the price of natural gas decreased, and consequently electric power costs in Texas (which is particularly dependent upon natural gas to generate electricity) has experienced a reduction in electricity prices. Cheaper electric power combined with increasing, or static, gasoline prices will increase demand for PEVs and PEV readiness.

Table 3-1 - Menu of Optional[XXVI] Ten Initiatives for Becoming a *Texas PEV-Friendly Community*

Initiative	Additional Details	Rationale for Inclusion
1. PEV Task Force to Oversee Implementation of this Initiative Mandatory 25 points	• Should be led by a "PEV champion" (someone who is enthusiastic and knowledgeable of PEVs). • Should include at least one staff member from local government. • Should include a staff person from the local electric distribution company or an electrical contractor. • Should include at least two or more representatives from among the following: auto sales, public interest group involved in land use and environmental issues, interested citizen, or an elected official.	The experience of other communities strongly suggests that the formation of this core team or task force is critical to the success of PEV readiness.
2.Municipal fleet program to acquire PEVs when cost effective 25 points maximum	• Must conduct annual purchasing reviews based upon a program that compares ICE with PEV cost effectiveness for various types of vehicles in the city fleet. • Must have purchased at least one PEV and charging equipment for use in routine municipal functions.	PEVs in daytime service within municipalities can charge at night and in some instances are already more cost effective than internal combustion vehicles. If truly cost effective, this would be important to do for budgetary reasons alone.
3. Local Sources of Consumer Information 20 points maximum	• Each member of the PEV Task Force should be familiar with the Texas PEV Consumer Website (recommended and described in Chapter 6 of this Plan) and be able to respond to local inquiries using this and other resources. There should be at least one task force member who is the designated "go to person" for PEV questions and issues.	Lack of trustworthy unbiased consumer information contributes to consumer reluctance and/or confusion regarding advantages and disadvantages of PEV ownership and operation.
4. Up-to-date building code and streamlined permitting for	• The National Electric Code has been revised to accommodate PEV charging.	For some communities the installation of PEV charging equipment results in unnecessary delays and expenses because

Electric Vehicle Supply Equipment (ESVE) 20 points maximum	• Cities may need to pass an ordinance incorporating these revisions. • Several larger Texas cities have adopted 24-hour to 48-hour turnaround PEV charging equipment permitting. • One way to address the issue discussed above is to certify electricians who have taken the requisite training.	permitting authorities and inspectors are unfamiliar with ESVE. A "certified" private electrician will be familiar with the job and will ease the permitting and assure lower prices to PEV owners.
5. Interface with Retail Electric Providers or the local Co-op or Muni on possible future favored rates for managed PEV charging 20 points maximum	• This topic is technical and involves regulatory issues above the local level (except for municipally-owned utilities). • Nevertheless, if the PEV Task Force, which ideally would include someone from the power industry, stays aware of the developments at the state level (PUC of Texas, ERCOT) local citizens who purchase PEVs may be able to benefit from reduced electric bills where there are innovative rate structures that take PEV (time-of-day or better yet, managed) charging into account.	As the number of PEVs on the road increase, collectively they will provide an outstanding opportunity to use cheaper night time power (especially from wind turbines in west Texas). If PEV charging is managed properly power costs can be reduced by optimizing supply and demand. The competitive market can provide these opportunities now that smart meters are available.
6. First responder training 10 points maximum	• Ambulance and police must take emergency responder training and stay current (at least video viewing per year)	PEVs are unique and employ new battery technologies of which first responders should be aware.
7. Program to Publicize and Encourage Neighborhood Electric Vehicle (NEV) Use 10 points maximum	• An NEV is a PEV that meets certain highway safety requirements, but is designed to operate at a maximum of 35 mph. They are allowed to operate on all roads and streets that are posted at 45 mph or less. (But may cross roads with posted speeds above 45 mph). • Local ordinance making and maps of legal access areas would be helpful to promote NEVs.	NEVs overcome the biggest impediment to most PEVs: upfront cost. NEV use can achieve many of the same benefits of larger PEVs at much lower costs. NEVs may serve as a "gateway" to larger PEV ownership in longer term
8. Plan to allow for and encourage installation of public PEV charging stations in strategic location(s)	• Should be tied into the overall Texas Triangle PEV charging plan in Chpt 5 OR • Should be based on data showing PEV ownership and purchases in the community and therefore need-based.	- Can be an amenity - Can portray green, progressive image - Can draw through traffic to a historic downtown or other area (economic development) - If based on need (number of

25 points maximum	• The focus should be on strategic locations and providing EVSE as the need arises so as to avoid the negative image and resentment from empty PEV charging outlets taking up space in highly desirable parking areas.	PEV owners in community) will serve a public function. - Can be coupled with nocturnal fleet charging
9. Plans to facilitate ESVE for PEV owners in **- multifamily housing,** **- private commercial parking lots, and** **- restaurants and coffee shops.** 35 points (11 plus points for each subcategory) maximum	• The PEV Task Force (see Item 1 above) should address these three subcategories individually as each entails a separate set of issues and opportunities for retailers and employers. • Scoring would be conducted by each subcategory. • Initially planning will result in points, but implementation would be required to retain status.	Most plans for PEV overnight charging assume that the PEV owner lives in a single family dwelling with a garage. The issues of charging become more complicated when either (and, especially, both) of these circumstances change. In addition, there will be a need for charging during the day at shopping locations and work places, for some of the PEV owners. This is especially true for owners of BEVs who do not have the option of switching to gasoline.
10. Adoption of standard signage to direct local and through traffic to PEV charging stations 10 points maximum	• Tx DOT has responsibility for developing alternative fueling signage along the interstates. • The local community can develop a design or may be encouraged to adopt one as part of the Texas Triangle PEV.	Until PEV charging becomes more ubiquitous (e.g., similar to purchasing diesel at service stations), signage will be important to direct PEV owners, especially from outside the community, to charging stations.
200 pts maximum	The level required for Texas PEV-Friendly Community could be **100 points**.	The difference in the maximum point total available and the level required for attainment provides flexibility and assures attainment is not a burden on the aspiring communities.

3.4.4 Implementing the Texas PEV-Friendly Program Statewide

Three separate recommendations form the core of the Texas Triangle PEV Plan. These include the formation of Transportation Fuels Interagency Council through an executive order issued by the Governor (with legislation being a fall back approach). The Council would be composed of state agencies having an existing role in PEVs including energy policy, transportation policy, and economic development. This Council would consider many of the issues raised in this Plan as well as similar issues associated with natural gas-powered vehicles.

The staff for the Council could include staff from the agencies whose directors are on the Council. Ideally, the Texas PEV-Friendly Community Program discussed in this chapter and the Texas PEV Consumer Website would also be operated by Council staff. This is illustrated in Figure 3-2 below. The Clean Cities program, which funded this planning effort, includes several capable staff who have been doing work similar to the PEV Friendly program at the regional level for several years under a U.S. Department of Energy funding. This national program is being reduced in size. Thus, several of these staff might be available to serve under contract to the Council to implement the Texas PEV-Friendly Community Program as well as the Texas PEV Consumer Website.

A low end estimate of the costs involved would be two full time employee equivalents for both programs ($250,000 per year for salaries, overhead, equipment, outreach including travel).

Chapter 4 PEVs and Electric Utilities in Texas

4.1 Introduction

An essential element of PEV readiness is the degree to which electric utilities are prepared for the challenges and opportunities of this emerging market segment. This chapter addresses the impact of increased adoption of PEVs on electric utilities in the Texas Triangle. Included are rural electric cooperatives or Co-ops, municipal electric utilities, or munis, and investor-owned utilities. Through a survey (See Appendix 4A) utility respondents provided attitudes towards PEVs, ongoing planning efforts to help accommodate PEV loads, and perceived barriers to PEV penetration. These are described in the following subsections. Along with an overview of utility activities related to PEVs, a list of potential recommendations is provided to help advance the planning efforts of the utilities and encourage further growth of the PEV market. These recommendations are divided into two parts: the first assumes a business as usual (BAU) scenario, while the second (Level 2) assumes a significant increase in government funding for PEV initiatives. Actions that could be taken by the Public Utility Commission of Texas (PUCT) and the Electric Reliability Council of Texas (ERCOT) that may help utilities prepare for PEVs are also included.

4.2 Attitudes and Plans of Texas Triangle Utilities

The three types of utilities in the ERCOT market -- rural electric co-ops, municipal electric utilities, and investor-owned transmission and distribution service providers (TDSPs) -- have very diverse perspectives and levels of planning related to PEVs and associated infrastructure requirements.

The electric utility survey uncovered a wide diversity of interest level and knowledge. Utilities serving a larger, more urban customer base were more willing to participate in the survey and were much more knowledgeable regarding the impact that PEVs may have. Rural co-ops and the municipals (or munis) showed less interest in PEVs, which is unlikely to change in the near term. There are currently few PEVs in rural communities in Texas. Many survey participants from rural areas were not aware of any PEVs in their service territory. Despite expressing some interest in learning more about PEVs, the vast majority of respondents from rural co-ops and munis indicated their organization has no programs in place to support PEVs and does not anticipate the need in the future.

Ongoing planning activities occurring at utilities in the Texas Triangle seem to correlate with current and near term penetration levels in the entity's service territory. That is, the greater the interest in PEVs shown by consumers, and the greater the current adoption level, the more advanced the planning efforts. Current planning activities include:

- Passive observation - Monitoring of industry trends, market growth and regulatory decisions;

- Case-by case planning - Assisting customers with installation of charging infrastructure, focusing on enhancing customer service, customer communication, and customer education, assessing and (if necessary) upgrading distribution transformers;

- Big picture planning - Information-sharing with the utility industry and stakeholders to determine best practices for encouraging and managing PEV adoption;

- Technical planning - The largest TDSP, Oncor, is using advanced metering infrastructure to characterize load patterns and charging behavior to anticipate and mitigate impact on peak load and potential for PEV-derived ancillary services;

- Planning through forecasts - Several utilities are conducting research to determine how PEVs might impact load in their service territories, and are estimating rates of PEV adoption in order to anticipate their impact on transmission and distribution systems.

The impact of PEVs cannot yet be felt at the rural or small-town level since there are so few on the road today. Although there is some interest from utility staff in these areas, the lack of PEVs in their territories has mostly precluded any special planning efforts. Most TDSPs, which include in their service territories urban and suburban areas, are involved in PEV planning in some way, ranging from simply monitoring market conditions to evaluating transformers on a per-case basis to creating load shapes based on usage. In the near term, the majority of the utilities are not very concerned with PEVs' impact on peak load or the potential for PEVs to provide ancillary services. However, these issues become more prominent when viewed from a long-term perspective.

More pressing immediate issues are the utility's possible role in installing charging equipment and special meters for use with PEVs. There was no consensus on whether pricing programs or direct load control would be most effective in mitigating the impact of PEV charging on peak demand. Load management activities such as direct load control and pricing programs are of greater interest to Load Serving Entities (LSEs), including munis, co-ops and Retail Electric Providers (REPs) than to TDSPs. (See Appendix 4B for a brief description of the Texas restructured electric utility market and the various terminologies associated with it.)

Most utility concerns center on how costs incurred in installing infrastructure related to PEVs will be recovered. Since federal funding programs for PEV equipment may soon end, the question remains as to who bears the cost of updates to the electric system required by increased PEV penetration.

4.3. Potential[XXVII] recommendations to be considered by utilities

4.3.1 Business as Usual Scenario

The following set of recommendations includes possible actions that could be taken by the three types of utilities discussed in this report. The underlying assumption is to allow the utilities to be better prepared for a possible significant increase in the number of PEVs in their territories. Even rural areas with very limited potential for PEV penetration can benefit from simple planning efforts that might enhance customer awareness of electric vehicles while allowing the utility to become a partner in ongoing PEV development in the Texas Triangle.

This Plan element covers two possible planning scenarios: the business as usual (BAU) and significant outside funding (enhanced funding). The Plan recommendations are presented by both scenario and by utility. Within the utility recommendations, these are further divided to those utilities that have engaged in significant planning and those that have not.

Recommendations for Utilities with Minimal PEV Market Penetration or Current Planning Activities:

- Educate utility staff about the variety of electric vehicles, charging systems, and potential impacts on utility's peak load pricing strategies, and metering issues.

- Educate Consumers - Assign someone on utility staff to become the go-to person for PEV issues for customers, and be available to answer questions related to installation of charging equipment, bill impacts, and general PEV inquiries. Create a PEV link on the utility website to the statewide consumer education website recommended in Chapter 6 once it is functional, directing the customer to contact this person if they are new PEV owners, or if they are interested in learning more. This person would also serve as the point-of-contact for new PEV owners, and would be aware of any transformer upgrade issues that may arise.

- Monitor regulatory and ERCOT decisions related to PEVs, and participate in any relevant collaborative processes in the region and nationally, especially through organizations like the Texas Public Power Association. Direct the PEV point person to make contact with and develop partnerships with local PEV dealers and property owners.

- Share Information - with industry and other stakeholders to discern best practices for managing local impacts of the nascent PEV industry.

- Participate and encourage formation of Texas PEV-Friendly Communities as described in Chapter 3.

Recommendations for Utilities with Significant PEV Penetration and Advanced Planning Initiatives:

Utilities that are further along the planning process should already be undertaking the recommendations discussed above, and should additionally be beginning to move into more advanced or technical planning efforts.

- Communication with Dealerships - Utilities should initiate and maintain communication with dealerships in and near their service territories to obtain advance notification of forthcoming PEV purchases and/or installation of electric vehicle supply equipment (EVSE). The early notification process, when formalized between the automaker/dealer/EVSE installer and utility, can help utilities prepare for distribution system impacts.

- Customer Education - This should be a priority for any utility (investor-owned and otherwise) expecting PEV adoption, because customers will look to utilities as a primary source of information. As PEV market share expands, utilities should develop resources for customers interested in PEVs, including dedicated staff and web resources to help new customers understand PEV options, benefits, load impacts, requirements, and bill impacts. The utilities should direct consumers to the consumer education website described in Chapter 6 once it is functional. Customers will look to utilities for guidance and residential infrastructure assistance, and the utility should be ready to meet this expectation.

Upgrading Distribution Infrastructure - On a per-customer basis, the utility should determine whether the local distribution infrastructure needs to be upgraded or replaced. Increased use of PEVs will impact distribution transformers, especially in urban areas where "clustering" could occur, possibly shortening transformer life. Databases should be maintained that record information on PEV charging locations to determine impacts on systems, so utilities will be prepared to update distribution standards and budgets for equipment replacement.

4.3.2 Level Two Scenario

Level Two recommendations assume a much higher level of funding available for Texas Triangle utilities to further PEV readiness. These should be considered as additions to, not replacements for, Scenario One recommendations.

Recommendations for Utilities with Minimal PEV Penetration or Planning Activities:

- Purchase a PEV - Each Co-op and Muni should consider purchasing at least one electric vehicle. This would be effective in increasing public awareness, motivating the utility's customers to consider a PEV purchase. A heavy-duty PEV truck may be especially appealing to rural customers.

- Hold Public Forums - Demonstrations and informational events should be held in conjunction with public gatherings such as home and garden shows.

- Install One Public Charging Station - Studies have shown that the presence of even one well-located level 2 PEV charging station can have a significant impact on PEV adoption levels in towns and cities. A DC fast-charging station at a public location in town or along the highway would provide travelers with a place to charge, promoting local business development. It would also provide local PEV owners a public charging station, increase PEV visibility, and set the stage for additional infrastructure upgrades as time passes.

Recommendations for Utilities with Significant PEV Penetration and Advanced Planning Initiatives:

- Develop a PEV Fleet - With ample funding the utilities could purchase a fleet of PEVs for use by the utility, along with fleet charging infrastructure to increase visibility, public awareness, and speed integration.

- Develop PEV-Based Direct Load Control - This recommendation is applicable to LSEs with advanced PEV planning, such as Austin Energy or CPS Energy in San Antonio (these entities are included in the Texas River Cities Initiative and thus are not investigated in depth in this report). Investing in load control technology will strengthen the business case for PEVs served by LSEs, because of the ability to mitigate on-peak charging.

- The time of day that PEV charging occurs will have a significant impact on the wholesale energy costs of a load-serving entity, for two reasons. First, wholesale electric energy prices are typically much higher in late afternoon than middle of the night, and second, LSEs pay a transmission charge based on their total system electric demand at the time of the ERCOT system summer peaks. For example, a PEV that always charges during the hours 4 to 8 pm could cause the LSEs costs to be three times as much as for the same PEV charging from 11 pm to 3 am.

Current PEV owners are able to charge their vehicles at their discretion, and many automakers are beginning to offer mobile account management for owners, allowing them to access their account and control charging while away from the car, to benefit from advantageous rates. As PEV ownership grows, utilities may want to build in some type of load control, to mitigate the impact on peak load. Several options exist that may ease the transition (from charge-at-will to managed charging) for the customer:

- The utility can offer the customer rebates for installation of charging equipment, with the agreement that the utility may interrupt charging if necessary. The customer has the option of overriding the control, but they will be assessed a significant fee if they choose to do so.

- Another version of this agreement includes the caveat that the utility can interrupt charging provided that the vehicle will be fully charged by a certain time set by the customer. These arrangements minimize inconvenience to the customer while allowing the utility to leverage the smart grid to achieve adequate load control.

- Test products enabled by Vehicle-to-Grid (V2G) - V2G capability would be of benefit primarily to LSEs and REPs. V2G technology may allow aggregated PEVs to participate in demand response programs, dynamic pricing, ancillary services, and integration with renewables, depending on ERCOT protocols for these services. Customers would financially benefit because of the ability to take advantage of pricing programs and other demand response programs. LSEs would benefit from the ability to manage charging and mitigate charging during peak summer hours.

- Deploy Public Smart Charging Infrastructure - For utilities with more PEVs in their service territories, installing public charging stations, metering infrastructure, upgrading transformers and providing other services may help increase the market share of PEVs. Paying for these investments will necessitate some form of cost recovery. Assuming cost recovery for PEV infrastructure occurs, utilities should be well-positioned to begin expanding public infrastructure necessary for large-scale adoptions of PEVs.

- Develop Multi-family Solutions - A well-known difficulty exists in selling PEVs to residents of multi-family housing or in homes without off-street parking. Under this expanded funding scenario, LSEs would have the resources to consider offering incentives to property managers to encourage them to install PEV charging infrastructure in apartment parking lots or garages. This recommendation is particularly relevant to LSEs in urban areas, where a larger percentage of residents live in multi-family dwellings. If the managers of apartment complexes do not install PEV charging infrastructure, apartment-dwellers will, in effect, be discouraged from buying PEVs.[XXVIII] This situation would be particularly inequitable if the LSE were providing incentives to home-owners for installation of their charging infrastructure. The apartment property owner would be subject to the same PUCT sub-metering regulations as mobile home park managers, in that the owner would be prohibited from re-selling the electricity to the PEV owner at a profit.

4.4. Recommended actions to be considered by regulatory agencies

At present (mid-2012), there is no rulemaking concerning PEVs before the PUCT. The following list of recommendations attempts to address many of the utility issues described in Section 1.2. Actions by the PUCT will be instrumental in guiding utilities and breaking down barriers to further deployment of PEVs in the Triangle, particularly those related to cost recovery, metering, ratemaking issues, and standardization, and planning.

4.4.1 Business as Usual Scenario

Recommendations for the Commission assuming a business as usual funding scenario include:

- Collaboration - Assuming business as usual, the PUCT can encourage automakers and utilities to share information about where PEVs are located within their service territory, so that the utility can upgrade distribution infrastructure and deal with any reliability problems in a timely manner.

- Ownership of Charging Equipment - The PUCT will need to determine whether regulated utilities may own the residential PEV charging equipment. It will need to investigate how safety, cost, and data about PEVs location will be affected by ownership.

- Cost Recovery - Ratemaking and Facilities Charges: Utilities will incur costs when upgrading infrastructure (e.g. changing the distribution transformer to one with a higher rating) to accommodate the additional load caused by PEV charging. Utilities will need to recover this added cost either through rate increases or perhaps through a facility charge that assigns the cost directly to the PEV owner. The PUCT may decide which method of cost recovery is most efficient and equitable.

- If costs are socialized and recovered through rates, the PUCT should determine if current electric rates are sufficient to accommodate cost recovery for the utilities. If current rates are not sufficient, the PUCT should allow the utilities to include PEV-related costs in their general rate base.

- If costs are recovered on a per-customer basis (with infrastructure costs borne by PEV users only, rather than the general public), then the PUCT may want to recommend that the utilities assess a facilities charge as opposed to a rate increase. This charge would be linked to particular customers, and assessed based on potential transformer upgrades required by that customer's PEV load. The amortized share of the distribution transformer would be applied to that customer's bill each month. The concept could extend to costs incurred further upstream, including substation upgrades that may be required as PEV ownership grows.

- Customer Education Costs - Because customer education is essential to expanding PEV use, the PUCT should allow utilities to request approval for funding for costs related to customer outreach and education in coordination with the programs recommended in Chapters 3 and 6 of this Plan.

- Code Standardization - By aligning codes and standards across regions, the PUCT will help foster a national PEV infrastructure capable of supporting long-range travel. Staff should research North American standards and practices and provide a regulatory framework for effective implementation of common charging interfaces. Although standardization does not directly impact utilities, PEV interoperability will strengthen the appeal of PEVs for consumers. If more PEV are purchased, more sales will be generated for the utility.

- Clarifying Third Party Resale Rights in Public Utility Territory - Under the Public Utilities Regulatory Act (PURA), no other entity is allowed to resell or provide electricity other than the public utility. If a public utility (i.e. a municipally-owned utility or, in some cases, a co-operatively owned utility) allows another entity to provide such service, the utility may be forced into the competitive market. Some of the public utilities in the Texas Triangle would like it codified by the PUCT that they alone can determine and regulate the operation of public charging in their territories. Since public utilities are in place to serve the people and do not want to be forced into competition, they would like activity related to PEV charging to be exempt from being considered a competitive activity.

4.4.2 Level Two Scenario

In addition to the above mentioned recommendations in the BAU scenario, a Level 2 Scenario could draw upon a model for a partnership between the California Public Utility Commission and NRG, wherein the retailer has committed to investing $100 million into a comprehensive PEV charging network and is directly providing the CPUC with $20 million to help nurture PEV legislation.[XXIX] Additionally, as the PEV market expands given the additional funding, load impact may become a more serious concern. As such, the PUCT may want to obligate utilities to perform load research and forecasting as it relates to PEVs, so that future policy is as well-informed as possible. Several TDSPs within the Texas Triangle are already undergoing such studies. The PUCT may consider expanding its staff to include PEV experts as relevant rulemaking arises.

4.5 Recommended actions to be considered by ERCOT

Although there are significant obstacles, an aggregation of PEVs could arguably qualify to participate in the ERCOT ancillary services markets as a Load Resource or a Controllable Load Resource (CLR) if the vehicles have smart charging capabilities. To participate in the market as a load resource, PEVs would have to be coordinated by aggregators, who would collect enough willing participants to reach the 100 kW minimum demand response threshold specified by ERCOT.

Many of the challenges outlined below could benefit from additional study to determine the best course for resolving them and thus enabling PEVs to be integrated into the ancillary services market in ERCOT.

- Overcoming Participation Challenges - Several challenges must be overcome before PEVs can play a role in this market.

    - Since the 100 kW load must be assigned to a single transmission-level electrical bus in the ERCOT Network Operations Model, scattered PEV load may be difficult to aggregate, particularly at the residential level. Fleet vehicles being charged at a single garage may qualify more easily.

    - If a group of vehicles acting as a CLR is providing regulation service, it must be capable of primary frequency response – a nearly instantaneous response to deviations in frequency – and governor-type response to electronic signals from ERCOT. Participation in the ancillary services markets also requires special telemetry to be installed on the resource to provide real-time information on load and output. This telemetry would be prohibitively expensive for residential PEVs and likely difficult for commercial fleets.

- If the aggregated PEVs are providing Responsive Reserve Service (ERS), then the vehicles or the charging stations must have an under-frequency relay that switches off the charging if frequency drops below 59.7 Hz. This will prove cost-prohibitive at the individual vehicle level, but may be more feasible for PEV fleets.

- ERCOT's performance requirements penalize loads that fail to deliver pledged services consistent with grid reliability provisions in the ERCOT Protocols and North American Electric Reliability Corporation (NERC) standards. PEVs may pose special challenges for aggregation and consistency, and thus would be more vulnerable to these penalties.

- Revisiting Standards - ERCOT should endeavor to create a framework to allow PEVs to participate in the ancillary services market, at least at the commercial level. This may include revisiting and possibly relaxing telemetry requirements and performance standards. For example, an alternative to current telemetry requirements could be statistical sampling, in which a smaller set of telemetry sensors is used to estimate load levels for a larger set of participants. ERCOT is already studying technical issues related to PEVs[xxx], and should continue to investigate how challenges can be mitigated and how to facilitate a role for PEVs in the market.

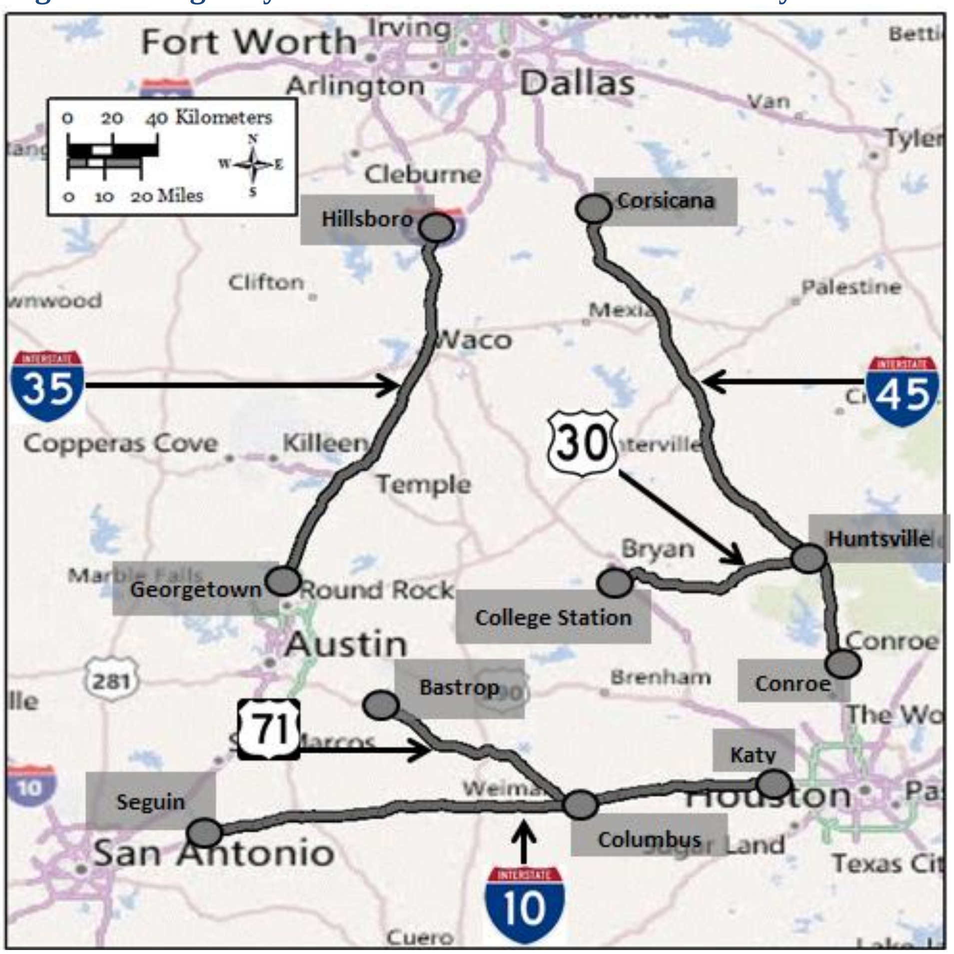
Chapter 5 Intercity PEV Charging

This chapter presents current activity and potential deployment plans for electric vehicle supply equipment (EVSE) in the Texas Triangle. While private industry, often with government assistance, is investing significantly in the deployment of EVSEs in the metropolitan areas of Dallas, Houston, San Antonio and Austin, there is currently very little EVSE installation being planned in the intercity corridors.[XXXI] These areas are made up significantly of rural areas that have been overlooked historically in the regions' transportation planning.[XXXII]

5.1 Introduction

The focus on this intercity ESVE chapter is to link the outskirts of the metropolitan areas[XXXIII] at the three ends of the Texas Triangle with each other, and to connect the Bryan College Station area with Interstate 45 and the Austin metro area with Houston via U.S. highway 71. These roadways are shown in Figure 5-1. These five highway corridors tie together the three ends of Texas Triangle plus provide an Austin-to-Houston link and tie the middle of the Texas Triangle (Bryan and College Station) to the nearest interstate.

Figure 5-1 Highway Corridors Addressed in this Intercity PEV Plan



Section 5.2 of this chapter (and Appendix 5A) describes EVSE technologies and associated business and cost issues in the context of the Texas Triangle. Section 5.3 (and Appendix 5B) describes business model considerations for the EVSE industry. Section 5.4 shows current and planned locations of EVSE in the relevant intercity highway corridors. Section 5.5 (and Appendix 5C) provides a methodology for estimating the number of EVSE stations that will be installed by companies along the highways and maps the results. This shows potential gaps where adequate EVSE coverage is less likely to be provided by private industry.

As with the other sections of this Plan, the last two sections address both a Business as Usual (BAU) scenario and a scenario assuming significant outside funding: Section 5.6 discusses potential policy recommendations and actions that can be taken to accelerate the deployment of regional EVSE and PEV adoption, regardless of the availability of significant public funding. Section 5.7 (and Appendix 5D) presents a novel optimization methodology for allocating potential public funding for EVSE across the Texas Triangle, along with maps depicting results. Appendix 5E is also included to describe the methodology for estimating the demand for PEV charging, which is applied to develop the results in sections 5.5 (and Appendix 5C) and 5.7 (and Appendix 5D).

5.2. PEV Charging Technology and Associated Issues

A discussion of the terminology and general requirements of EVSE and business plans are essential to understanding this Plan. The basic function of EVSE is to provide for the safe transfer of energy between the electric utility and a plug-in electric vehicle (PEV). There are several types of EVSEs, like there are several types of PEVs. This section summarizes information that can be found with more detailed Appendix 5A.

There are three basic models for recharging PEVs: conductive charging, inductive charging and battery swapping. Inductive charging is a method whereby electrical energy is transferred from the EVSE to the vehicle without making physical wire to wire contact. At the time of this writing, the inductive charging standard exists, but this method is not deployed by EVSE manufacturers and automotive suppliers outside some demonstration programs. Battery swapping involves removing a depleted battery from a PEV and replacing it with one that is charged. The depleted battery is then charged to be ready for placement into another PEV. Because of the significant differences between vehicle designs and, in turn, battery types used, this concept has not been deployed in the U.S. outside of small demonstrations. Therefore, battery swapping is not considered in this report. Conductive charging is in widespread use and is the focus of this report.

5.2.1 Charging Components and Terminology

The terminology for components of charging systems is described in Appendix 5A. This includes terminology for both vehicles and EVSE, and for AC and DC power supply options. It should also be noted in this report that a *site* or *location* refers to the establishment at which an EVSE is located. A *station* or an *EVSE* refers to the physical charging infrastructure, and a *port* is a single cord and connector. Therefore, a site can have multiple stations and a station can have multiple ports.

5.2.2 Basic Technical Description of AC Level 2 and Direct Current Fast Chargers (DCFC)

This section describes AC Level 2 and DC fast charge (DCFC) stations (highlighted in yellow below), which are the most relevant for the Texas Triangle corridors, since corridor drivers are unlikely to take the time required to charge with AC Level 1. AC or DC charging can be provided at several different power levels. The SAE J1772 standard, depicted in Figure 5-2, provides the current definition for AC Level 1 and AC Level 2. The current definitions provided by SAE are summarized in Table 5-1.

Table 5-1 SAE Charging LevelsXXXIV

AC Charging	Level	DC Charging
120 VAC, Single phase, 12 amp (15 amp rated circuit), 1.44 kW 16 amp (20 amp rated circuit), 1.92 kW	1	200 – 500 VDC Up to 80 amps, Up to 40 kW
240 VAC, Single phase Up to 80 amps , 19.2 kW	2	200 – 500 VDC Up to 200 amps, up to 100 kW
To Be Determined	3	To Be Determined

Table 5-2 shows *how long it takes* various PEV configurations to be fully charged from a state of near depletion. Note that most of the charging times significantly exceed the times that drivers are accustomed to stopping at a gasoline service station on a road trip. Table 5-3 shows the *distances* that a full charge will take various PEV configurations. Note also that these distances are far less than a full tank of gasoline will take an equivalent internal combustion engine vehicle. These two facts represent a challenge to intercity travel for most business and non-business or personal travel.

Figure 5-2 SAE J1772 Connector and Inlet

Table 5-2 PEV Charge Times with Depleted Battery

EV Configuration (number behind the dash is estimated mileage on battery before changing to gasoline)	**Usable Battery Capacity (kWh)**	**Circuit Size and Power in kW Delivered to Battery**			
		120 VAC, 15 amp 1.2 kW	**120 VAC, 20 amp 1.6 kW**	**240VAC, 40 amp 6.5 kW**	**480 VAC, 85 amp 60 kW**
PHEV-10	**4**	3 h 20 m	2 h 30 m	35 m	n/a
PHEV-20	**8**	6 h 40 m	5 h	1 h 15 m	n/a
PHEV-40	**16**	13 h 20 m	10 h	2 h 30 m	16 m
BEV	**24**	20 h	15 h	3 h 40 m	24 m
BEV	**35**	29 h 10 m	21 h 50 m	5 h 20 m	35 m
PHEV Bus	**50**	n/a	n/a	7 h 40 m	50 m

Note: Power delivered to the battery is calculated as follows: 120VAC x 12 amps x.85 eff.; 120VAC x 16 amps x .85 eff.; 240VAC x 32 amps x.85 eff.; 480VAC x √3 x 85 amps x .85 eff. (Limited to 60 kW maximum output.)

Another way to compare EVSE power levels is to consider what range extension may be achieved during a charge period. Table 5-3 provides a comparison based upon a vehicle efficiency of 4 miles/kWh of charge.

Table 5-3 Miles Achieved per Charge Time

Miles Achieved per Charge Time*					
Charge Time	**Circuit Size and Power in kW Delivered to Battery****				
	AC Level 1 120 VAC, 15 amp 1.2 kW	**AC Level 1 120 VAC, 20 amp 1.6 kW**	**AC Level 2 240 VAC, 20 amp 3.3 kW**	**AC Level 2 240 VAC, 40 amp 6.5 kW**	**DCFC 480 VAC, 85 amp 60 kW**
10 min	0.8	1.1	2.2	4.3	40
15 min	1.2	1.6	3.3	6.5	50
30 min	2.4	3.2	6.6	13	>50***
1 hour	4.8	6.4	13.2	26	>50***

* Vehicle efficiency 4 miles/kWh
** EVSE efficiency assumed at 85%
*** Battery is at or near full charge depending upon initial state

DC Fast Charging most nearly approximates the timing associated with gasoline fill ups for ICE vehicles. As will be noted later, the current installation and operating costs of DCFC are much higher than AC Level 2. Appendix 5A provides more details on the technical aspects and tradeoffs of the various charging options. These details are important for understanding the issues associated with whether, how, and to what extent ESVE should be provided for intercity travelers using BEVs. These details relate to the development of business models for PEV charging discussed below and in more detail in Appendix 5B.

5.3 Business Considerations for EVSE Providers

Widespread BEV adoption will require a ubiquitous EVSE infrastructure. It cannot be expected to be provided by government grants and incentives in the long run. Many programs funded by government have provided infrastructure in test areas. For EVSE infrastructure to be provided in expanding regions, a viable business for EVSE providers and charging site hosts needs to be developed. A variety of different business models have been considered recently for stimulating the growth of this infrastructure. Very few business models can exist around providing charging at no cost to the consumer. There is a cost to the host for the electricity used, for periodic cleaning and maintenance of the EVSE unit, and for the space it occupies in the parking area. Capital and operational costs need to be recovered in addition to added revenue options.

Table 5-4 Business Model Factors

Characteristic	Business Model Options
Usage Accessibility	Private, Semi-Public or Public
Active Ports per Station	Single, Dual Sequential or Dual Simultaneous
Billing Systems	Credit Card, Smart Card, RFID or Parking Meter
Cable Management	Simple or Sophisticated
Charging Level	AC Level 1, AC Level 2 or DCFC
Complementary Services	Truck stop, Post Office, Nighttime Fleet Charging or Grid Storage
Connection Type	Unidirectional or Bidirectional
Costs to Site Owner	Installation and Maintenance
Energy Provider	COOP, MUNI, REP, or Investor Owned Utility
EVSE Site Owner	Private, Semi-Public, Utility, Workplace or Government
Metering	No metering, Separate metering for station, or Use current on-site meter In vehicle
Ownership	Site Owner, EVSE Company, Utility, Government
Profit Sharing Between Site Owner & EVSE Provider	Percentage split or fixed rate to owner
Revenue Sources	Electricity, Parking, or Advertising
Type of Billing	Fixed energy rate, Fixed rate subscription, or Pay per use
Wholesale Energy Processing	Day-ahead, Intra-day, and Real-time

A list of relevant business model factors or options is shown in the table above which is in line with those investigated in previous research.[XXXV] In the case of the Texas Triangle highway corridors, the focus is on publicly accessible charging stations, to which a variety of business model options can be applied. For purposes of the estimation of the distribution of privately funded charging stations and of optimal allocation of available government funding in Sections 5.5 and 5.7, the effects of business model options on the costs of station installation and maintenance can be considered. Appendix 5B provides a detailed discussion of each of the factors and costs associated with installation and maintenance of the stations.

As discussed in Appendix 5B, the installation costs for a site with two AC Level 2 charging stations ranges from $1000 to $15,000 with considerable variation depending upon options available. The comparable costs for a DCFC site can easily be an order of magnitude higher and the operating costs can be also be higher because of the high demand charge for power.

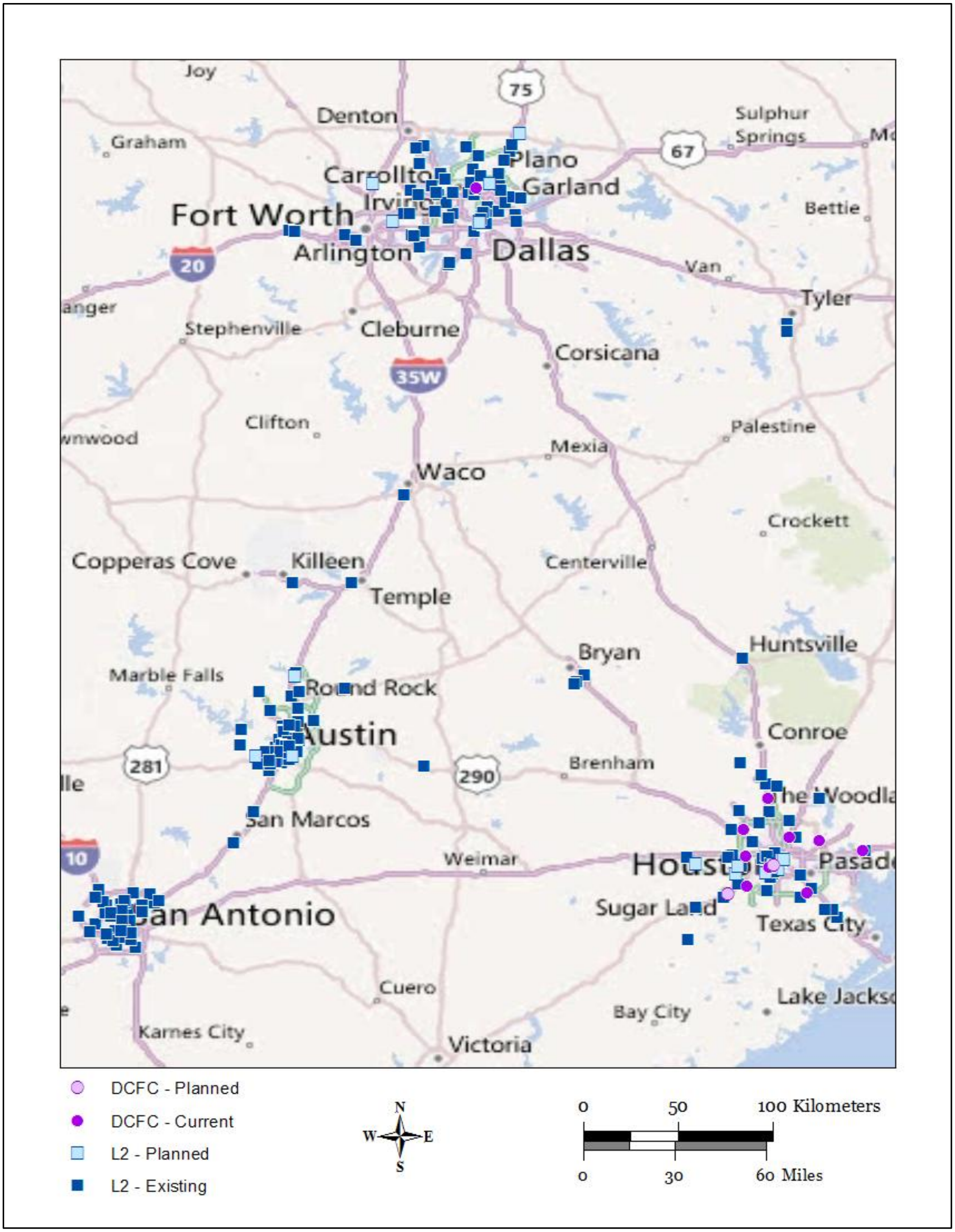
Finally, the importance of coming trends in energy considered, with a focus on possible synergies in Texas with natural gas fueling facilities. Clean Energy Fuels Corp. has identified several locations along the Texas Triangle to supply Liquefied Natural Gas (LNG) for Class-8 trucks and other heavy-duty vehicles. It is likely that Compressed Natural Gas (CNG) will also be available to support light duty vehicles traveling the Texas Triangle. With the addition and acceptance of alternative fuels as potential options found at truck stops and travel centers, and as electric vehicle sales volumes grow from the hundreds to the thousands in each metro area, it would be conceivable that these visionary truck stops would also consider a DCFC offering for the BEV driver.

5.4 Status of PEV Charging in the Texas Triangle

As noted earlier, there is considerable activity by various private companies to install ESVE in the metropolitan areas in the Texas Triangle. Figure 5-3 shows a general map of commercial and public EVSE across all corridors. This illustrates the concentration in the four major urban areas. For additional references, other sources of this type of information can also be seen in EVSE maps provided by Google Maps[XXXVI] , and three EVSE companies. These are Coulomb's ChargePoint Network[XXXVII], NRG's eVgo network[XXXVIII], and ECOtality's Blink network[XXXIX]. Each of these companies has focused on specific parts of the Texas Triangle. There are other companies providing EVSE in Texas; however, these three have provided a significant portion of stations to date.

Figure 5-3 shows that there are significant gaps in intercity EVSE corridor coverage. As of May 2012 there were few stations located along the I-35 and I-45 corridors. No stations were present along the I-10, SR-30, or SR-71 corridors. As PEV consumer adoption increases, it is expected that EVSE companies will install stations along I-35 where are there several medium-sized cities, and along parts of I-45 where there is significant intercity traffic between Dallas and Houston. However, there is likely to be far fewer privately funded stations sited along the other corridors thus leaving gaps. In addition, it is not clear that installations along I-35 and I-45 will be DCFC stations, which are needed to enable long-distance BEV travel without significant charging time. Note that PEV range varies significantly by traffic and weather conditions, making it important to provide a density of stations which provides an adequate level of comfort for drivers in the Texas Triangle.[XL, XLI]

Figure 5-3 Current Status of EVSE in the Texas Triangle [XLII]



5.5. Texas Triangle Charging Station Deployment under a Business as Usual Scenario

This section presents projections for the location of charging stations that will likely be provided by private industry under a Business as Usual scenario (i.e. absence of additional substantial government support). Section 5.5.1 describes the methodology used to model business considerations regarding placement of EVSE. Section 5.5.2 presents the results obtained from applying this methodology.

5.5.1 Methodology and Data Methodology

It is assumed that an EVSE company treats each potential station site as part of a portfolio of stations and will choose to install a station if revenues over an assumed payback period are expected to exceed costs. This simple model of competitive behavior is utilized, since the EVSE industry is still in an early adoption phase, in which potential sites along intercity corridors are typically assessed on a site-by-site basis. In turn, the number of stations that private industry EVSE providers place at a given location is estimated by the ratio of potential revenues to costs. More specifically, Eq 5.1 is utilized to estimate the density of charge ports provided by private business $s_{pjk}(x)$ at a location x along a corridor. To provide intuition on how $s_{pjk}(x)$ can be interpreted, the graphical representation of $s_{pjk}(x)$ can be seen in the figures in section 5.5.2 and Appendix 5C, which show where there are likely to be gaps in EVSE deployment. The numerator of Eq. 5.1 represents the discounted revenues over the payback period and the denominator represents the sum of capital and discounted operating costs for a station. Continuous representations of revenues and costs are used over time, since these are incurred throughout the payback period. There is of course significant uncertainty regarding demand projections for charging. Therefore, particular attention is given to the estimation of $v_{jk}(x,t)$ in Appendix 5E.

$$s_{pjk}(x) = R_{jk}(x)/C_{jk}(x)$$

$$= \left[365 \times \int_0^{\tau_f} e^{-rt} n_j v_{jk}(x,t)dt\right] \Big/ \left[c_{Ij} + \int_0^{\tau_f} e^{-rt} c_{Rj} dt\right] \qquad \text{Eq. 5.1}$$

$s_{pjk}(x)$ is the density of stations of type j, provided by private industry (ports/mile)
$R_{jk}(x)$ is discounted revenues over the payback period ($)
$C_{jk}(x)$ is discounted costs over the payback period ($)
r is the discount rate
τ_f is the length of the payback period (years)
$t \in [0, \tau_f]$ represents time
n_j revenue per demand served ($/charge-hr)
$v_{jk}(x,t)$ is the demand density for charging at location x and time t (charge-hr/[mile × year])
c_{Rj} is the upkeep cost of the station ($/[port×year])
c_{Ij} is the capital cost of a station ($/port)

Finally, it should be noted that the continuous approach taken to model the spatial distribution of station locations over the corridor has specific advantages versus other methods. In particular, this simplifies analytical derivations, and allows for a parsimonious, but effective approach to analyzing tradeoffs and costs. This is especially important for problems with significant uncertainty over long time horizons. Modeling approaches with these characteristics are thought to be useful for a wide spectrum of transportation systems[XLIII], as they allow for straightforward communication of analysis results to managers and policy makers.

Data

The types of data used in business modeling include those related to the payback time, costs, and revenues. The discount rate $r = 0$ is assumed in this report for purposes of simplicity and minimizing the number of assumptions in the models. The payback period τ_f = 5 years is assumed, which represents that the capital and maintenance costs of a station should be recouped through revenues within 5 years of installation.

Table 5-5 provides ranges for cost and revenue parameters for DCFC and AC Level 2 stations. These are in line with previous research.[XLIV] In addition, the values assumed for scenario inputs in this section and section 5.7 are shown. Significant questions still surround the development of revenue models in the EVSE industry, so no attempt is made to estimate the appropriate range.

Table 5-5 Costs and revenue parameters of EVSE

	AC Level 2		DCFC	
	Range	**Assumed Values**	**Range**	**Assumed Values**
Total Capital costs c_{Ij} ($/port)	1000-15000	5000	10000-90000	25000
EVSE ($/port)	1000-5000		10000-25000	
Grid reinforcement ($/site)	0-1000		0-20000	
Transformer cost ($/site)	0		0-45000	
Maintenance and repair costs c_{Rj} ($/year)	100-1500	250	500-9000	1250
Total Revenues n_j ($/charge-hr):		5		20

5.5.2 Results

Appendix 5C provides a series of maps that show the density of the stations that are expected to emerge under a business-as-usual scenario. Figure 5-4 and 5-5 provide maps that summarize these results for the year 2017. As can be seen, stations are expected to be primarily in cities, where they can serve demand from local and intercity drivers. The results indicate that there are likely to be significant gaps in the deployment of DCFC stations in the early years, as BEV adoption rates are still low. The only corridor with significant EVSE deployment is Interstate 35 from Georgetown to Hillsboro. If the public policy objective is to provide ready access to BEV drivers along the five corridors of interest in the short term, public funding for EVSE will be required. On other hand, these results indicate that within the next five to ten years, EVSE deployment may become profitable enough to ensure a reasonable EVSE density is provided by private industry in parts of the corridors.

Figure 5-4 DCFC Station Density due to Private Industry $s_{pjk}(x)$ in 2017

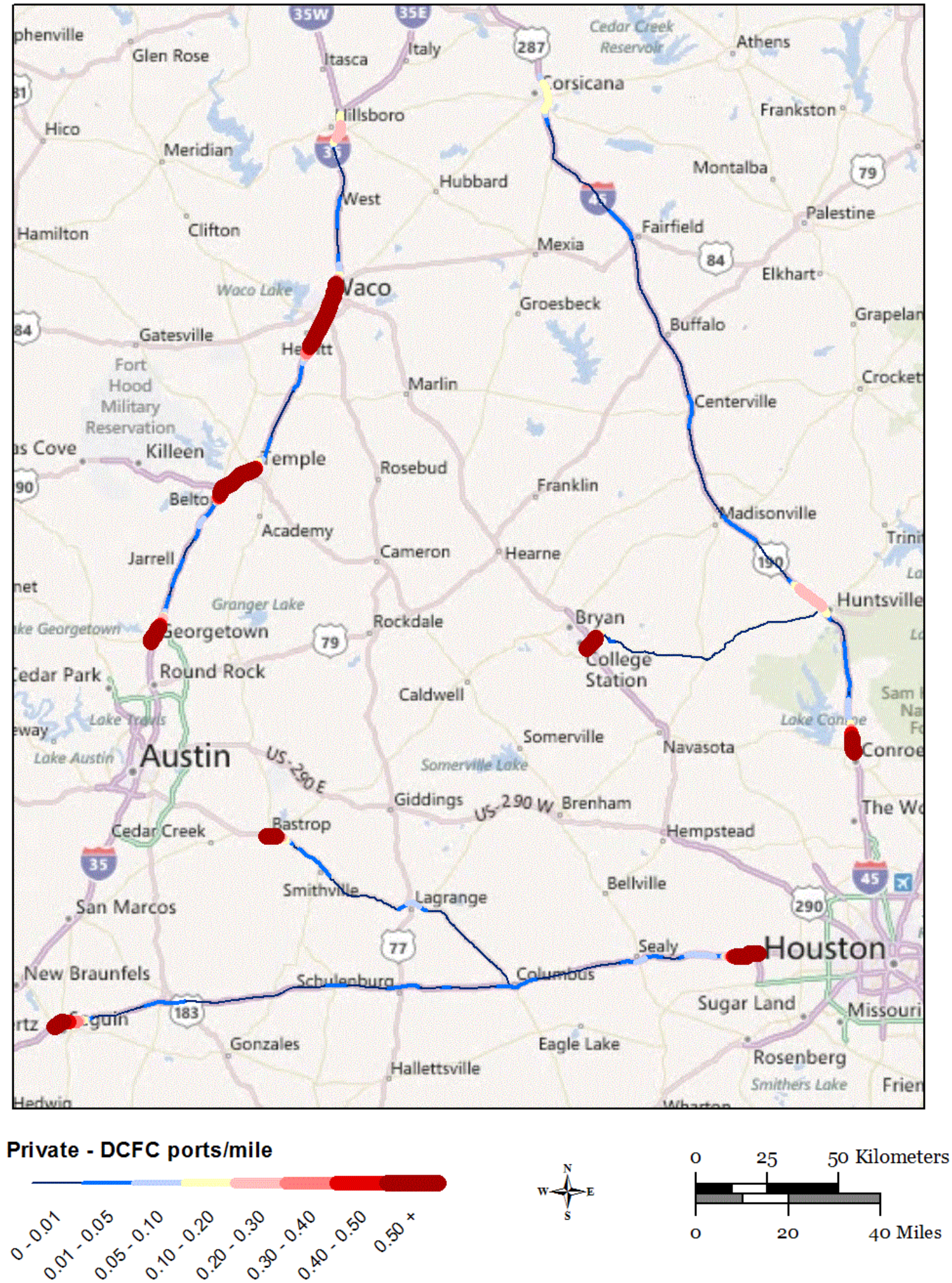
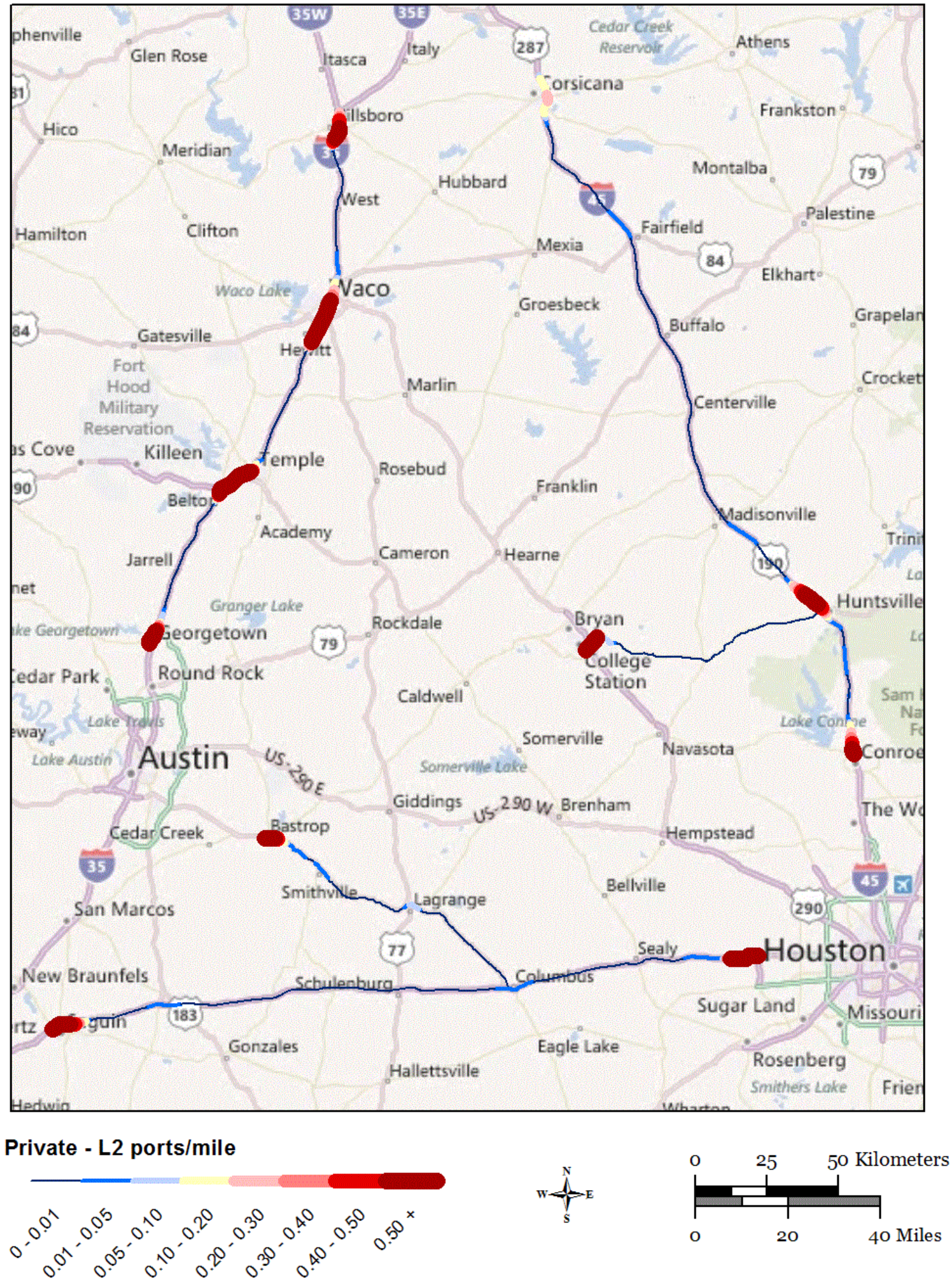


Figure 5-5 AC Level 2 Station Density due to Private Industry $s_{pjk}(x)$ in 2017



5.6. Potential Recommend Actions to Accelerate the Deployment of Regional PEV Charging Infrastructure in the Absence of Significant Federal Funding

Private industry may not provide an adequate spatial distribution of EVSE to satisfy intercity PEV travel needs. Therefore, this section provides a discussion of actions which can accelerate the deployment of regional EVSE and PEV adoption in the Texas Triangle, in the absence of federal funding specifically targeted for EVSE. The discussion in this section draws significantly from lessons learned in the EV Project[XLV], and is divided into recommendations for site characteristics, city planning and regulations, and interoperability to allow consumers to use EVSE provided by multiple companies rather than being restricted to the network of a single company. This section can also be viewed as an addition to the Texas deployment guidelines.[XLVI] The previously published guidelines focus on providing guidance for site-specific issues, whereas this section is focused more on broadly applicable approaches to encourage PEV adoption and benefit related industries in the region.

5.6.1 Recommendations for Site Characteristics

The Importance of EV Parking Location Selection within a Site -Several factors need to be considered when placing EVSE at retail or other publicly available sites. Those who are interested in motivating the public to purchase PEVs may wish to place EVSE in preferred parking locations near a facility entrance. However, experience has shown that this can actually have a negative effect. In the early days of PEV adoption, such EVSE locations may frequently be vacant, giving the impression that PEVs are not being bought by mainstream consumers. Such locations may actually frustrate ICE drivers who note that they do not get preferential treatment. In addition, placing the EVSE near the facility entrance often places it further from the electrical source which then increases the capital costs. It is more desirable to place the EVSE at a location nearer the electrical source which may not be the most preferred, but also not the least preferred parking location, as well. These tradeoffs should be considered when choosing the exact locations for PEV parking spaces.

Generally, it has been found that selecting the locations for publicly available EVSE can be a point of disagreement among those desiring to encourage PEV adoption. The motivation for the selection of a site needs to be considered. For example, if the motivation is to provide a highly visible public location that can be used as a public symbol, it may not be the best location for a highly utilized and accessible unit. If the motivation is to utilize access fees to assist in offsetting the costs of the equipment and installation, high utilization is desired and the long-term parking location at an airport is not a good selection. A park-and-ride location where residents park their vehicles to complete the commute on public transportation may also not be an ideal location if high utilization is required. Generally, such locations are relatively close to the residents' home so charging is not required and only one vehicle per day can access the EVSE. This may be a good site if the promotion of mixed transportation modes is being encouraged. This is not to say that any one motivation is more important than another, but understanding the motivations can prevent disagreements. In the absence of significant federal funding, EVSE infrastructure deployment will depend upon the business models of the EVSE suppliers and charging site hosts which will typically rely on high utilization as the primary motivation for site selection.

Accessibility - It was found when preparing for installations in the U.S. for the EV Project, there were no national guidelines for the installation of accessible equipment.[XLVII] Consequently, some EVSE suppliers and local jurisdictions, approving permits, ignored the subject. Others, wishing to be fully compliant with strict interpretations of potential requirements, created conditions where the installation of EVSE would be impossible or so cost prohibitive that no host would agree to install. As a result, several organizations initiated studies to consider what recommendations should be presented for consideration. Most of these studies and recommendations did not consider the cost to the host for compliance. In most cases where a retrofit of existing facilities is undertaken, it is acceptable to forego improvements for accessibility if it can be shown that the cost of compliance would exceed 20% of the improvement project costs. Such consideration should be applied in order to avoid the disincentive that could otherwise result which limits the availability of publicly available EVSE.

Signage -Encouraging the adoption of PEVs requires the availability of publicly available EVSE. Public availability of the EVSE means it should be available to PEV drivers when they are looking for a place to recharge. Signage should be used for "way finding" (locating) the EVSE and for usage regulation (controlling charging stall access).[XLVIII] It was found during the EV Project that selection of a common symbol is important for the public education and recognition both in way finding and in usage regulation. In the U.S., an interim symbol has been selected by several states, but not all states have concurred. This symbol should be used on streets and highways as well as at the parking stall where the EVSE is installed.

Next, it is important that the EVSE is available to the PEV driver when searching for an available station. It has been found that without regulation, ICE vehicles will not recognize the PEV symbol as restrictive and will park in the designated locations. This is particularly true when the parking location is near the facility entrance. Signs that indicate the parking stall is to be used for "PEV charging only" should be considered to reduce non PEV parking.

Note that the sign does not indicate PEV Parking only since providing a place for PEVs to park is not the incentive. It is to provide a place for them to charge. A PEV that is not charging should not be taking up the space. This also brings up the question of how much regulation to provide. While no municipality is known to have implemented punitive measures for non-PEV charging, some have considered penalties so severe as to be a disincentive for even PEVs to park at these locations. This would guarantee that the space remains vacant which, as previously mentioned, is a deterrent to the adoption of PEVs by the public.

5.6.2 Recommendations Related to City Planning and Regulations Permit Costs

The EV Project has installed EVSE in many different metropolitan areas around the U.S. Each area provides pricing for the electrical permit. In some locations, the permit is reasonably based upon similar work such as household circuits for electric clothes dryer. Other jurisdictions recognize that EVSE installation is a new source of revenue for the jurisdiction and charge fees that are up to 10 times as much as others. Such fees add to the cost of installations and may discourage the potential for PEV adoption. Therefore, it is of significant importance that permitting processes be streamlined and directed towards the avoidance of exceptionally high EVSE fees.

5.6.3 Revenue Collection in the Context of Interoperability across EVSE Providers

Revenue models for PEV charging stations will vary from one location to the next. Below are some common revenue models for commercial/public charging operations, which are also noted in Section 5.3

- Free parking and free charging. -- In this scenario, the parking lot operator would install a charging station for the benefit of its customers. An example of this would be a store or hotel installing a charging station as a means to attract customers.

- Paid parking and free charging. -- In this scenario, the parking lot operator would charge a flat rate for the parking stall which would include power for PEV charging.

- Flat rate charging fee. -- Unlimited charging for a flat fee.

- Timed rate charging -- Users charged per unit of time connected.

- Subscription charging -- Users belong to a particular subscription plan which allows for public charging as part of the plan.

Although revenue models will differ between EVSE in various locations, it is greatly beneficial to provide interoperability such that consumers can use EVSE provided by multiple companies. This greatly enhances the charging network available to the individual driver, and in turn accelerates adoption of PEVs. The following subsections present various technologies for revenue collection, and network communications systems which may be developed to allow for interoperability. This is not unlike the development of the bank ATM model.

As noted in Appendix 5B, various EVSE companies have their specific membership and payments programs. The design of the business models, back office management and control of access and authentication for the EVSE may in fact not be compatible. Several providers of networked systems have had preliminary discussions on interoperability and have agreed to work together to develop interoperability standards. The results of these development efforts cannot yet be forecasted.

The industry is new and there are several competing ideas on the business plan and approach to payment systems. Each company has invested in their own approach and the market will assist in deciding the best approach or approaches. It is expected that as greater maturity in the market is achieved, this interoperability question will be resolved. In the meantime, it is not as big an obstacle as some might suggest for a PEV driver. The PEV driver may have to carry two or three cards for the different networks in the vehicle, but that is no different from carrying two or three affinity credit cards from retail locations. While most stores accept most credit cards, customers do have to use the particular store's affinity card to get the particular benefits from that membership.

Card Readers - Several types of card readers are available that may be incorporated with EVSE. Credit/debit card readers would be simple to use and are already widely accepted by the public. The credit/debit card would record a fee for each time public charging is accessed and based upon the accessibility rather than length of time on charge. Challenges here include increased costs for ensuring privacy of consumer information during collection of information and transmittal of that information. Transaction fees are also a challenge.

A smartcard is a card that is imbedded with a microprocessor or memory chip. It can more securely store more detailed information than a credit/debit card. Smartcards can be sold in monthly subscriptions and imbedded with more information on the user. That information could be captured in each transaction and used for data recording. The smartcard could be used for a pre-set number of charge opportunities or to bill a credit card number for each time of use.

In both cases, a communication system from the reader to a terminal for off-site approval and data recording will be required. Approval received may then close a contact for power to be supplied to the EVSE. The cost of this system and its integration into the EVSE will be a design consideration. Interoperability should be accounted for in the case of smartcards in order that they can be used at the EVSE of multiple companies.

Parking Area Meters -Drivers are very familiar with parking meters used in public parking. A simple coin operated meter is an option for PEV parking areas and can be installed at the head of each EVSE parking stall. Another method in common use is for public pay parking lots where a central kiosk is used for credit card purchases. The parking stall number is identified at the kiosk and a parking receipt issued that can be displayed in the vehicle. There is little cost for the meter and a single kiosk reduces the point of service cost for the whole parking lot. This system will require an attendant to periodically monitor the area for violations. Penalties for violators will need to be determined.

RFID Subscription Service - Like the smartcard, an RFID card or fob can be programmed with user information. The RFID reader collects the information from the fob to activate the EVSE station. A monthly subscription for the user keeps the fob active and the monthly fee can be based upon the number of actual uses or a set fee. The reader is programmed for the accepted RFID or the EVSE transmits the RFID information to a network back office for authentication. As with the smartcard, interoperability should be accounted so that an RFID can be used at the EVSE of multiple companies.

5.7. Recommended Actions to Accelerate Deployment of Inter-Regional PEV Charging with Federal Funding Available

This section presents methods for assessing the quantity and locations of government-funded EVSE. Section 5.7.1 (and Appendix 5D) presents minimum EVSE quantity requirements along the corridors to facilitate intercity travel. Section 5.7.2 presents the methodology and results of analyzing optimal spatial station allocation under a government funded budget, which would complement the locations of private EVSE provision, as identified in Section 5. It should be noted that the methodology in this section is designed with maximal flexibility in mind, and therefore the input data can be adapted as needed for future analysis in the Texas Triangle.

5.7.1 Minimal EVSE requirements to enable intercity travel Methodology

This section describes the methodology used to estimate the minimum number of DCFC ports required to ensure that PEV drivers do not experience delay due to queuing at stations. In other words, this is the minimum number stations such that there is a vacant station within an assumed proximity of each driver. Eq. 5.2 presents the formula used to estimate the minimum station requirement. The term in square brackets represents the minimum daily traffic volume along the corridor, which we assume to give a reasonable estimate of intercity PEV traffic volume. Multiplying by AT_{Cj} gives the cumulative arrivals over the duration of a charging period, at the most congested time of day. We finally divide by the allowable distance a PEV can travel before a station is available η, since this provides the required charging station density.

$$s_{minjk}(t) = \frac{AT_{Cj}}{\eta}\left[\min\{Q_{Ek}(x,t)\}_{x\in[0,x_{fk}]}\right] \quad \text{Eq. 5.2}$$

$s_{minjk}(t)$ is the station density of type j required on corridor k at time t (ports/mile)
A is the fraction of PEV traffic that arrives during the peak period (1/hour)
T_{Cj} is the duration of a charge event (hours)
η is the is the maximum allowable distance that a PEV may travel to reach an open port (miles)
$Q_{Ek}(x,t)$ is the PEV traffic volume on the corridor (vehicles/day)
$x \in [0, x_{fk}]$ represents distance along the corridor (miles)
$Q_{Ek}(x,t)$ is calculated as shown in Appendix 5E.

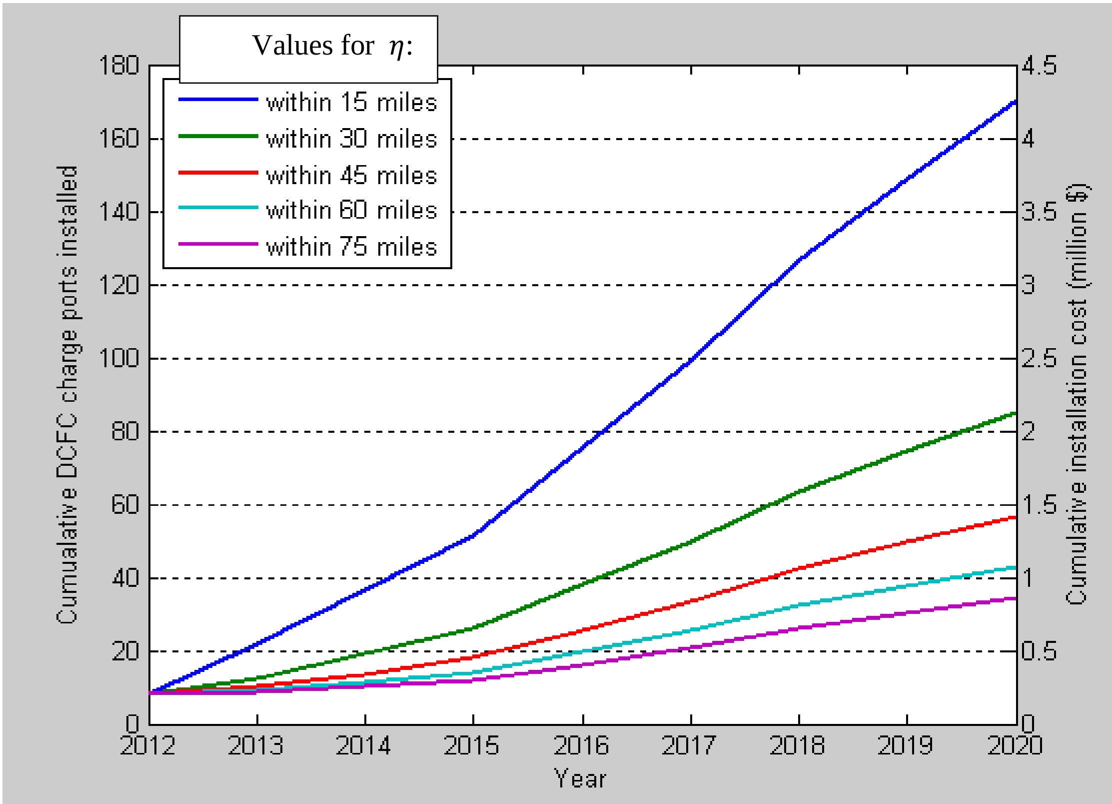
Results

Conservative values are assumed for the parameters. A is assumed to be equal to 15% of daily PEV traffic. T_{Cj} is assumed to be 25 minutes. η is varied between 15 and 75 miles. Capital costs are assumed to be $25,000 per port. $Q_{Ek}(x,t)$ is calculated according to the methods described in Appendix 5E.

Figure 5-6 shows the required cumulative DCFC station installations along all five corridors from 2012-2020, and associated costs. This represents the recommended number of future stations to accommodate future PEV intercity traffic under this minimal federally assisted funding scenario. The additional requirement that there be at least one port every 60 miles is also incorporated, to provide a minimum initial density before significant PEV traffic grows significantly. These same results are presented for other minimum initial port requirements and specifically for each corridor in Appendix 5D. As can be seen in Appendix 5D, the highest density of stations is for I-35, whereas the lowest is for SR-30, which is in accordance with the levels of PEV traffic expected on each corridor. Each line corresponds to a different assumed value of η, as shown in the legends.

Interestingly, as can be seen Figure 5-6, the costs of providing a minimal DCFC network along the corridors is relatively low. This is due to the fact that PEV traffic is only expected to comprise a small percentage of intercity traffic flow. In turn, DCFC station deployment to satisfy the needs of these drivers is fairly minimal. This indicates a relatively low investment in DCFC stations along the corridors would likely satisfy intercity travel needs during the next few years. Therefore, although charging demand may initially be quite low, it may be desirable to provide a funding level in line with the minimum requirements results in the next few years. For a relatively low cost, this would help alleviate range anxiety and enhance intercity driver comfort, and in turn encourage early adoption of PEVs in the Texas Triangle.

Figure 5-6 Total Stations and Costs for All Five Corridors, with the Requirement $S_{jk} > 1\ port\ per\ 60\ miles$ at All Locations



5.7.2 Optimization for the Spatial-Allocation of Funding Methodology

This section describes the methodology used to determine the optimal allocation of government funding for EVSE along the Texas Triangle corridors. Two steps are taken to determine optimal station locations. In the first step, the problem is formulated as a nonlinear programming problem, with a budget constraint, which solves for the optimal density of stations along the corridors. In the second step, local experts can pin down precise locations (near high demand retail, restaurants, etc.) for stations that fit the optimal density guidelines, as provided in the first step. In this report, we focus on the first step, leaving the second step to future work.

As in Section 5.5, the analytical modeling approach in this section is designed to be parsimonious but effective, to provide simple but relevant results regarding costs and tradeoffs.[XLIX] The optimization model solves for the optimal spatial density of government-funded EVSE along the Texas Triangle corridors. As previously mentioned, the resulting density can be thought of as a general solution or guideline to the question of where to locate stations.

Eq. 5.3 through Eq. 5.7 presents the basic optimization formulation for a single corridor. Eq. 5.3 is the objective function, which represents the total expected distance from charging demand to charging stations over the corridor. The unit used to describe this objective is [charge-hr × distance/station], since it represents the aggregate distance from demand points to the nearest station. This is integrated over the length of the corridor to solve for the decision variable, which is the density of publicly funded charge ports $s_{2jk}(x)$ above that required to achieve minimum density to alleviate range anxiety.

Eq. 5.4 and Eq. 5.5 represent that the sum of charging stations installed for three different purposes is equal to the total density of charge ports $s_{jk}(x)$. These three different purposes have to do with stations being provided by private industry and previously installed $s_{0jk}(x)$, government funded stations to meet the minimum density requirement $s_{1jk}(x)$, and additional government funded ports $s_{2jk}(x)$. The minimum density requirement s_{minj} is imposed to meet range anxiety concerns. Eq. 5.6 is the budget constraint, which limits the available expenditure for public infrastructure. Eq. 5.7 is the non-negativity constraint for the decision variable $s_{2jk}(x)$.

$$\text{Min} \sum_{k \in K} \sum_{j \in J} \left[\int_0^{x_{fk}} v_{jk}(x) / \left[4 s_{jk}(x) \right] \, dx \right] \qquad \text{Eq. 5.3}$$

Subject to:

$$s_{jk}(x) = \sum_{n=0}^{2} s_{njk}(x) \;\; \forall \, j \in J, k \in K, x \in \left[0, x_{fk}\right] \qquad \text{Eq. 5.4}$$

$$s_{1jk}(x) = \begin{cases} s_{minj} - s_{0jk}(x) & if\ s_{0jk}(x) < s_{minj} \\ 0 & if\ s_{0jk}(x) \geq s_{minj} \end{cases} \quad \forall\, j \in J, k \in K, x \in [0, x_{fk}] \qquad \text{Eq. 5.5}$$

$$\sum_{k \in K} \sum_{j \in J} \int_0^{x_{fk}} c_{Ijk} [s_{jk}(x) - s_{0jk}(x)] dx = B \qquad \text{Eq. 5.6}$$

$$s_{2jk}(x) \geq 0 \ \ \forall\, j \in J, k \in K, x \in [0, x_{fk}] \qquad \text{Eq. 5.7}$$

$v_{jk}(x)$ is the demand density for charging of type j on corridor k at x (charge-hr per mile)
$s_{jk}(x)$ is the total density of charging stations (ports per mile)
$s_{njk}(x)$ is the density of charging stations provided by a purpose denoted by n (ports per mile)
$n = 0$ represents stations to be provided by private industry and those that are previously installed
$n = 1$ represents government funded stations installed to meet the minimum range requirement s_{minj}
$n = 2$ represents government funded stations installed to increase station density above s_{minj}
s_{minj} is the minimum required distance between stations to ensure that intercity travel range requirements are satisfied (ports per mile)
c_{Ij} is the capital cost of each charging station ($/ports)
B is the budget for capital expenditures ($)
$x \in [0, x_{fk}]$ represents distance along the corridor (mile)

Results
This section presents optimization results for a scenario with a $5 million budget spent over five years, during the years 2013-2017. Assumed parameter values are shown in Appendix 5E for demand and Table 5-5 for EVSE costs and revenues. The optimization is executed for each year to complement previously installed stations and those to be installed by private industry during the year being assessed. The estimation of private industry provision is shown in section 5.5, with the nuance that we assume private industry only installs stations where potential revenues exceed those that would go to previously installed stations. Optimization results are presented in Figures 5-7 and 5-8. More detailed results are shown in Appendix 5D, with sequential yearly results separated by corridor.

As can be seen, DCFC and AC Level 2 stations are focused in towns and cities, where there are a significant number of candidate sites for charging stations. These locations also generally have higher traffic levels and local population living nearby. These results are especially important, since they show that charging stations should not simply be uniformly spaced along the corridors, but should be distribute in an optimal manner to maximize their potential usage. The cities and towns in the Texas Triangle are spaced relatively closely, such that stations can be placed at candidate sites while ensuring that a drivers at all locations will be within 20 miles of a station.

The optimization results are designed to complement potential deployment by private industry. However, at the assumed budget level of $1 million per year, private industry has little incentive to independently install stations for the next few years. The results do indicate that private industry deployment would affect optimal location of publicly funded stations by 2017, as noted in Appendix 5D. Considering potential variation in model inputs, a lower budget level would of course exaggerate the influence of private industry deployment of optimal public station locations. Thus, it may be ideal from a policy perspective to provide a lower budget level for the next few years, and potentially consider incremental increases depending on future demand.

Figure 5-7 Optimal Publicly Funded DCFC Charging Station Density $s_{1jk}(x) + s_{2jk}(x)$

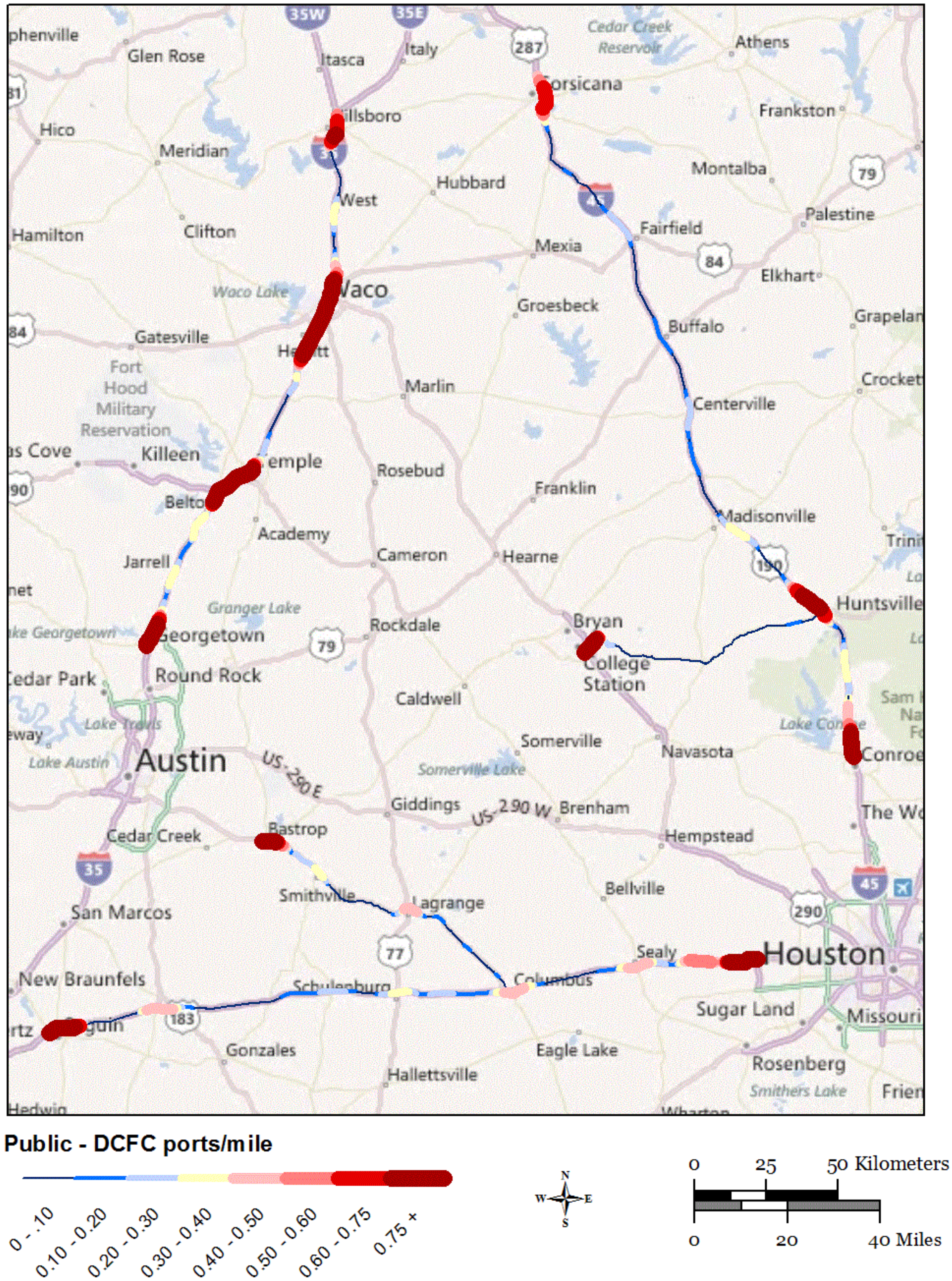
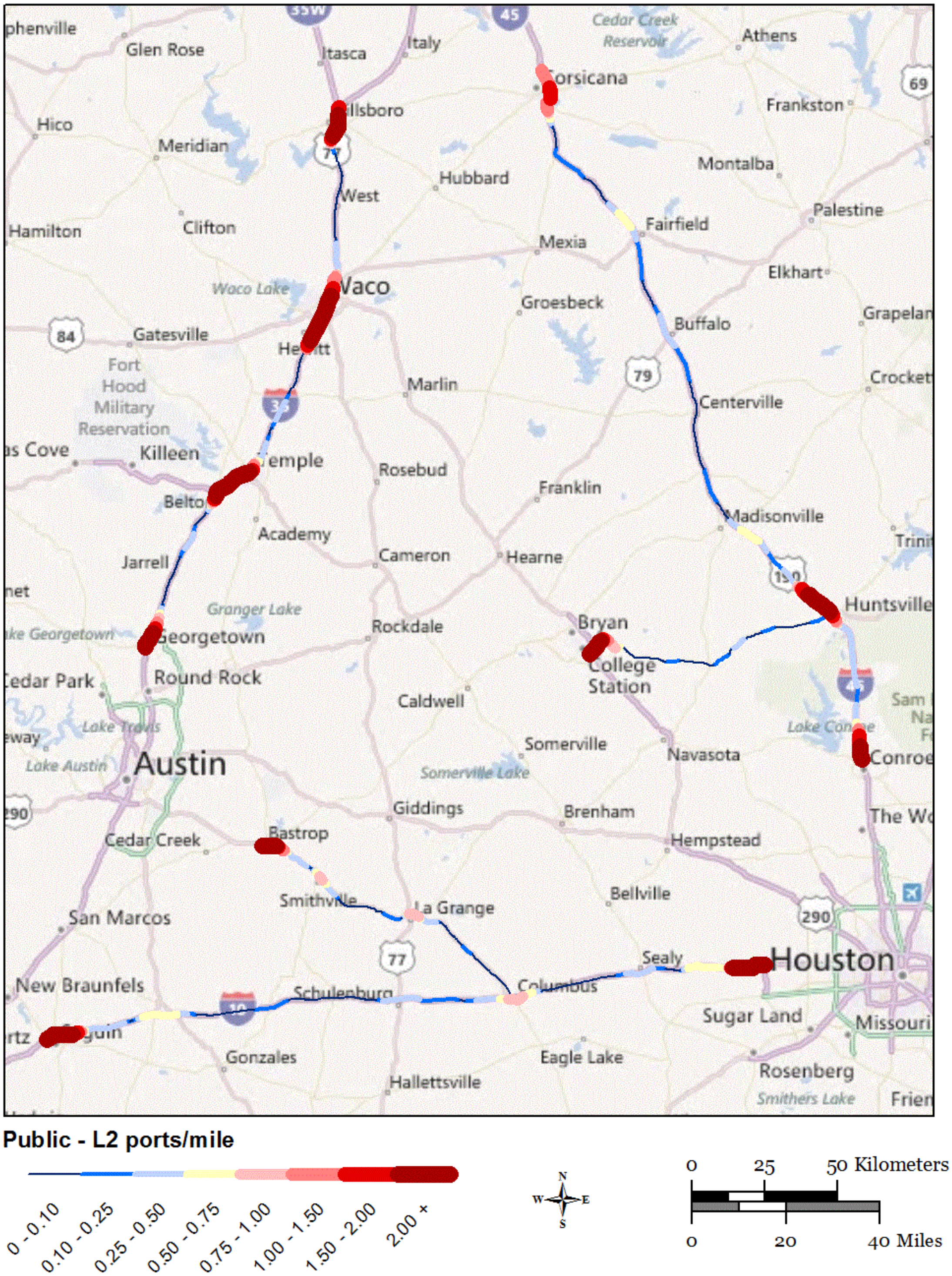


Figure 5-8 Optimal Publicly Funded AC Level 2 Charging Station Density $s_{1jk}(x) + s_{2jk}(x)$



Chapter 6 PEV Consumer Education Communications Plan

6.0 Background

One of the barriers to PEV readiness and adoption is a lack of consumer information that is:

- Credible,
- Easy-to-understand,
- Commercially-neutral,
- Reliable,
- Geographic specific,
- Easily accessible, and
- Up-to-date (through frequent updates).

To achieve these objectives, this Plan proposes the development of a website that can include as much regionally-tailored content as the budget affords. Where customization resources are not available, the site should leverage national web-based resources as a backup. This element of the Plan is summarized in section 6.2 and described more fully in Appendix 6A. The proposed consumer information program also calls for:

- Hosting and maintenance of this website by a regional entity with an interest in PEVs and the resources to host and maintain the website such as TX-DOT, Office of the Comptroller, TCEQ, or the PUCT. The alternative recommended in this Plan is to have this website be a joint effort among the various agencies proposed for the Interagency Council on Transportation Fuels.

- The periodic creation of PEV-related education material which is distributed electronically (via email or website) to co-ops, municipal utilities, and competitive energy retailers to include in their paper-based communications to their end-customers who do not have internet access or do not know where to find PEV related information on the web.

- Consideration of a more substantially resourced communications plan which would create a large amount of regionally specific content for the website to improve the communication effectiveness. Such a communications plan would probably require an investment in advertisements on radio, television, and print media to spark initial interest in PEVs and then direct the viewer to the website for additional information. Modest investments in creating visibility for the Texas PEV website on social media (such as Facebook and Twitter) should be tested as a means to improve traffic to the website.

6.1. Rationale for the Texas PEV Consumer Education Program

6.1.1 Lack of a credible, independent source of region-specific information creates a barrier to PEV Readiness and Market Penetration

There is a high degree of confusion, misunderstanding, and apprehension regarding PEVs. These concerns impede the adoption of PEVs. A plan for a statewide interactive consumer information program would allow prospective PEV purchasers to better understand the economic, environmental, and logistical tradeoffs between both conventional vehicles and PEVs including the various sub-categories of PEVs (BEVs, EREVs, and PHEVs). The existence of a trusted, easy to use, interactive program will allow prospective purchasers to make informed decisions and to be more likely to purchase a PEV by avoiding misplaced fear or a lack of knowledge.

Regionalized content would be more effective by including more specific links or instructions to find local helpful resources. This could include the provision of information on the operational performance and costs which could be expected in our specific region and climate, and communicating advantages in ways which may be better accepted by the typical Texas vehicle buyer than a national information campaign.

6.1.2 Misunderstanding that leads the public to hesitate to purchase PEVs when it may be in their best interests to do so

Many (or perhaps most) drivers do not understand the different types of PEVs and the unique advantages of each type. PEVs (Plug-in Electric Vehicles) now include pure battery electric vehicles (BEVs), extended range electric vehicles (EREVs), and plug-in hybrid vehicles (PHEVs).[L] Two examples are discussed below: inability to distinguish among PEV types and overestimating the safety risk of PEV batteries.

The 100+ year old battery electric vehicle concept is relatively simple to understand: BEVs have a large onboard battery recharged by the electric grid to power an electric motor to propel the vehicle. With modern battery technology, the typical 73+ mile range of these modern vehicles can comfortably handle the typical city commuting needs for the vast majority of U.S. drivers. However, once the battery is depleted, the driver must find a place to recharge the battery, otherwise the vehicle will be stuck on the side of the road. Solutions for BEV range anxiety include using a second family vehicle or renting a conventional vehicle for longer trips or allocating additional travel time to charge the BEV at publically available charging stations along their route.

Extended range electric vehicles (EREVs) are relatively new inventions and incorporate a unique powertrain consisting of a large electric motor, a somewhat smaller battery than a

BEV, and a gasoline engine backup which is deployed as a series hybrid to propel the vehicle once the battery is depleted. With this unique configuration, the EREV provides the high-torque and quietness of a BEV while under battery enabled driving, but once the battery is depleted the on-board computers seamlessly switch to gasoline hybrid operation which efficiently provides the overall driving range on par with today's conventional gasoline vehicles.

Plug-in hybrid electric vehicles (PHEVs) use a parallel hybrid powertrain which blends together both an electric motor and gasoline engine to substantially improve fuel efficiency while providing purely electric driving under restricted conditions (such as under light acceleration, less than 11 miles, and under 62mph). The combined blended mode and more limited electric operation allow the motor, engine, and battery to be smaller and less expensive while still providing impressive fuel economy and a driving range also comparable or superior to today's conventional gasoline vehicles. [LI]

Similarly, the public seems to have overreacted to a highly publicized battery fire incident involving a Chevrolet Volt battery pack associated with an improperly performed NHTSA crash test and may be over estimating the safety risks involved in driving PEVs.[LII]

6.1.3 Lack of trust in sources that have a commercial interest in the outcome of a consumer decision

The higher the costs of an advanced product without a long track record, the more consumers are understandably hesitant. A $30,000 to $40,000 car is a far more dear investment than a new generation $300-$400 electronic device. Independent third party evaluations or information sources are particularly important to help make potential PEV buyers comfortable that they understand the associated advantages, costs, and risks particularly given the substantial price, safety aspects, and expected long life of any vehicle. A communication plan which provides the means for consumers to easily find trusted information about PEVs is valuable and important for increased adoption.

6.1.4 A lack of region-specific information leads to confusion

By relying on national based information rather than a trusted statewide source, the public may be misled into assuming the existence of circumstances that do not apply to their specific locale. For example, they may assume that the State of Texas offers an additional subsidy for PEV purchasers, because of the well publicized program in California that does just that. Moreover, as regulatory agencies in the state begin to address PEVs, the states will diverge in some of their approaches, hence the need to develop state specific consumer information. Moreover, even within the state of Texas the practices of individual utilities (a unique mix of investor owned utilities, member owned Co-ops, and municipally owned utilities) and municipal governments suggest the need to inform the consumer of what to expect from his or her specific location.[LIII]

6.1.5 A lack of means to easily evaluate life-time costs and payback periods for our region may result in poor consumer choices

There are a number of PEV calculators and spreadsheets available on the internet for prospective buyers and fleet managers with varying degrees of complexity and usefulness. Some of these estimating tools have excellent user interfaces, others include very detailed fleet calculations, and a number are adapted for a particular region/utility. Most vehicle buyers do not perform more than a cursory analysis for the total life cycle cost of ownership of a vehicle. Experts indicate that general public most intently considers purchase price or monthly payment. Providing easy to use tools which already have regional costs included reduce the impediments for potential buyers to understand the longer term payback or advantages of PEVs.

6.1.6 Quickly evolving technological advancements in PEVs can lead to poor choices based upon dated information.

Virtually all major vehicle manufacturers either have begun selling PEVs or have announced that they will bring plug-in vehicles to the market over the next few years. While the conventional internal combustion engine (ICE) has had 100+ years of refinement, the first mass-market viable PEVs were delivered to customers in December 2010 (enabled by lithium battery technology, modern power electronics, on-board computers and software). While both PEV and internal combustion engine technologies will continue to improve, PEV powertrain technologies are at their relative infancy. It is expected that there will be substantial improvements in costs, configurations, and vehicle designs over the next few vehicle generations particularly with the many vehicle manufacturers scrambling to enter the field. This vibrant competition is likely to make PEVs progressively more attractive compared to conventional vehicles. Given these dynamics, a lack of updated and timely regionally specific information can also lead to poor choices.

6.1.7 Impediments to PEV readiness for fleet managers, utility staff, or municipal authorities

To foster PEV adoption, many fleet managers, utility staff, or municipal authorities have already created or are seeking templates to create readiness plans to address concerns. Regionally specific technical information and performance is important for fleet managers to assess the payback periods for potential PEV purchase decisions. Utility staff at co-ops, municipally owned utilities, or competitive energy retailers would benefit from having local information sources that explain the unique circumstances which may affect PEV adoption. PEV adoption would benefit from municipal authorities who create readiness plans which, for example, address building or electrical codes upgrades to facilitate lowering the cost or complexity of charging infrastructure investments, (if needed). Such a communication plan would be administered alongside the proposed Texas PEV-Friendly Community program (see Chapter 3).

6.2. Potential Recommendations under a Business-as-Usual Funding Scenario

As with the other elements in this Plan, this consumer information program element can be implemented under a minimal level of funding or can be expanded based on the availability of federal or other outside funding sources. Section 6.3 provides recommendations to meet this expanded funding scenario.

It is recommended that the communication plan be implemented on a website that is hosted by a state agency, or an interagency council or some statewide entity, to provide independent non-commercial information, address the concerns stated above, allow timely updates more often and for a lower cost than printed material, as well as provide the opportunity for as much regionalization of the information as the budget allows.

Many PEV information resources are available on the internet. The websites describe such information as the types of PEVs, advantages/limitations, and FAQs (Frequently Asked Questions). While a comprehensive list of sources has been compiled of government, industry, utility, advocacy, and vehicle manufacturer web-based resources, it would be advantageous to tailor much of this content and incorporate regional specific information hosted on a website. Issues with these existing national resources are more fully described in the next few sections.

To create an easily accessible visual outline (or storyboard), a prototype website and links was created. **Note to reader**: to see this prototype of the recommended website, click here (https://sites.google.com/site/texastrianglev2/). While this prototype is not intended to be the final website with full hosting and maintenance support, webmaster, videos, and more aesthetically attractive design, we are making it available for viewing given it has many useful links and content. As time permits, suggestions submitted to TexasPEV@gmail.com and deemed appropriate and valuable will be incorporated.

The entry page for the prototype website included three methods for a viewer to most easily navigate to the information that they wanted:

- By the group they are associated with or are seeking (e.g. PEV buyers, electricians.)
- By the topic of interest (e.g. Types of PEVs, PEV charging.)
- And by questions viewers may most often have

Once the viewer selects the group, topic or question of interest from this entry page, they are led to subsequent web pages with additional information associated with that selection. In addition, the web-based outline was created to compile and organize the list of available resources nationally.

During the course of designing this program, the scope was widened beyond end-consumers to include information which could provide important insights and education to other parties involved with PEVs (consumers of a different sort than the end PEV purchasers). Cities, utilities, and electricians are examples of other parties which would benefit from a PEV information program.[LIV]

If minimal funding is available for the communications plan, a constructive action would be to list the many links to the nationally available resources, provide as much regionally specific updates as affordable, and find an organization which would be willing to host the PEV related information on their website. Candidates for hosting the website are in section 6.2.1. A more detailed description of the communications plan and website design are included in Appendix 6A. By drawing upon the nationally available web resources, two staff level engineers can maintain the program part-time while also working part-time on the Texas PEV Friendly Community Program described in Chapter 3. A two-person team of engineers or other suitably technical persons responsible for both efforts is synergistic given the content of both the communications plan/website and the PEV Friendly Community Program are closely linked. Note: this two-employee team would be the minimal resource required to implement this program.

6.2.1 Recommended organizations for hosting the Texas PEV website

The list of non-commercial organizations considered for hosting the PEV website was narrowed down to TX-DOT (Texas Department of Transportation), TCEQ (Texas Commission on Environmental Quality), PUCT (Public Utilities Commission of Texas), and the Texas Comptroller's office. The Texas State Energy Conservation Office (SECO) in the Comptroller's office has a broad mandate that could also make them a viable candidate. If support for the website by one of these agencies is not acquired, or if an interagency council involving these staff does not materialize, then DP Tuttle Consulting will consider hosting a very basic website.

6.2.2 Steps leading to implementation and timeline

Implementation of the business as usual plan would involve securing the support for hosting, and maintaining the website during 2013 and transferring the prototype framework, list of links, and knowledge to the web designer who will create the final website, and review of the final website later in the year.

6.3 Recommendation under a Level-Two Scenario

If more resources were available, a regionally tailored website would be created to provide potential Texas PEV purchasers the best possible information on such topics as the electric vehicles available in their particular area, the electricity costs and incentives associated with their specific utility, and what they can expect in terms of electric range and performance during the different seasons, terrain, and climate in Texas.

The communications plan would ideally integrate a fully developed website with selective radio, television, web-advertising, and social media such as Facebook and Twitter. Through combined coverage and repetition, the website would gain popularity. Also, the greater he number of "hits" on the web, the higher the rank in Google searches which not only accelerate the viewing of the website, but may also reduce the need to pay for directed searches to bring viewers to the Texas PEV website.

Outreach efforts would be associated with forums such as yearly auto shows in the larger cities, green energy exhibits, renewable round-ups, or alternative fuel conferences where potential PEV purchasers would visit. PEV adoption would be increased by having experts provide face-to-face explanations of the benefits of PEVs, the unique advantages of each type of PEV, demonstrating the simplicity of home charging, and providing local PEV dealer contacts.

The budget for Level-Two plan involves:

- The development of an enhanced, regionally specific website with localized videos taken around the region: $350,000 to $400,000.
- Outreach efforts to conferences and expos within Texas: $100,000 to $150,000.
- The creation of short radio and TV advertisement themselves and procurement of the media time slots in $250,000 to $350,000.
- Development of content and procurement for web based social media advertising. $25,000 to $50,000.
- Development and printing of paper based materials: $50,000.

Note: Appendix 6B describes a proposal submitted to DOE during the summer of 2012 that would provide for both the Texas PEV Friendly Community Program and this communications plan and website, but at a funding level in between the two levels presented above.

Chapter 7 Beyond Readiness – Strategic look ahead to Long Term Transition to Electrified Transportation in Texas

While the focus of this Plan is on the near term barriers to PEV readiness in the 2013-2015 timeframe, this final chapter takes a five-to-ten year and longer look at PEVs and the challenges to developing a large market penetration of PEVs after initial rollout, primarily in Texas. Specifically, the chapter will take a look at the major opportunities that the integration of PEVs into our transportation fleet offers. In addition to the opportunities, both technical and non-technical challenges will also be presented. The intent of covering the high level opportunities and subsequent challenges is not to cover the area exhaustively, but to provide the reader a sense of the major opportunity drivers and related issues that will influence the timeline of the large scale integration of PEVs.

Following the discussion of opportunities and challenges, a future-based view of the operation of a PEV fully integrated utility grid will be presented. From the future view, a time line of the PEV industry milestones and how they are likely to occur in time will be described.

Finally, specific projects or programs that will facilitate the reaching of the referenced PEV industry milestones will each be described.

7.1 Background

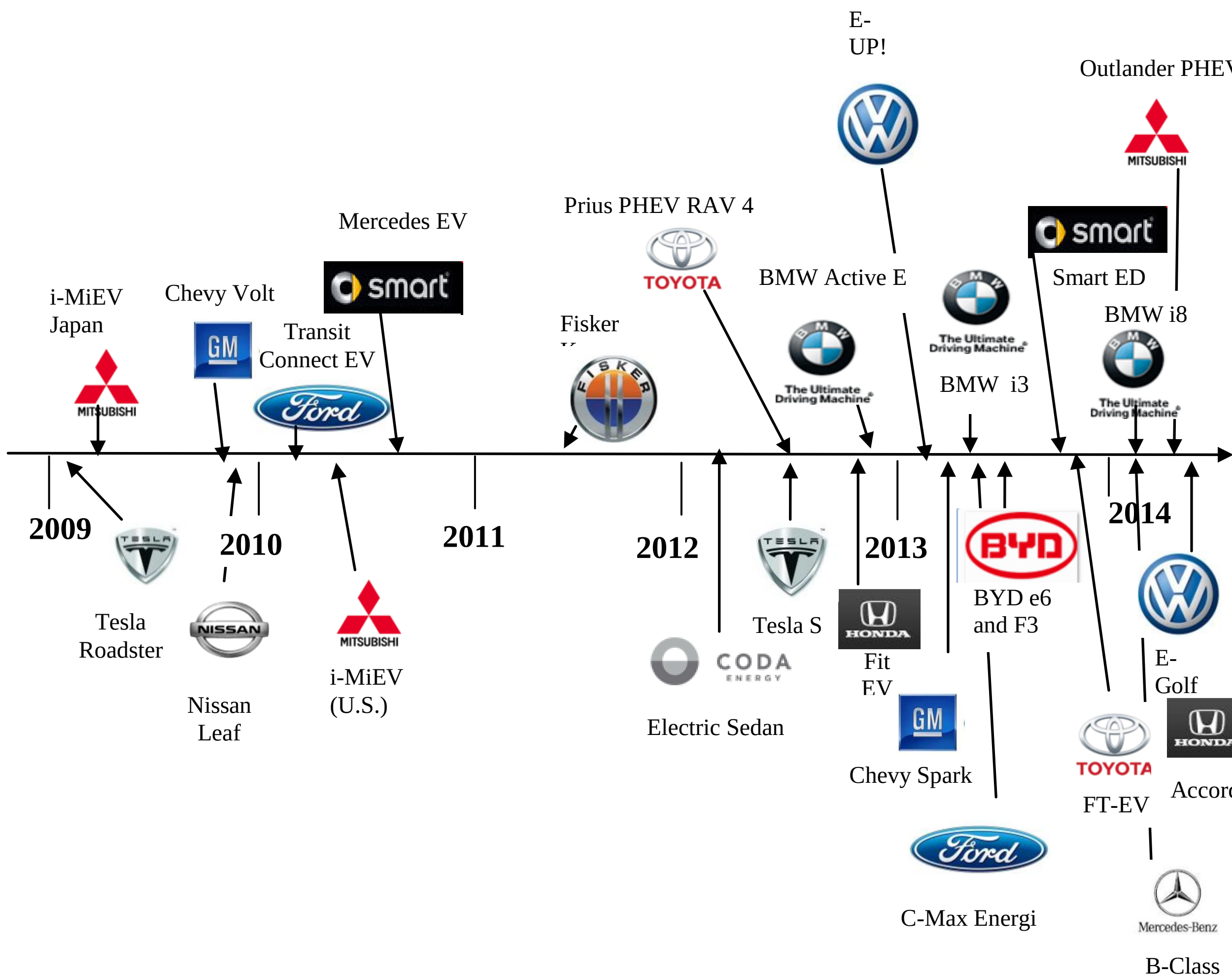
The pace of PEVs coming to the US market is accelerating.

The road to vehicle electrification started with the development of the hybrid powertrain. Three models of light duty hybrids were first introduced to the US market in the late 1990s by several automotive original equipment manufacturers (OEMs). For a number of years, these three models were the only OEM hybrid products available in the US to the driving public. Driven by the success of the early hybrids and the need for greater fuel economy, all OEMs currently have some form of hybrid based powertrains available in their vehicle model line.

The main difference between the hybrid vehicles and the current range of PEVs is in the size and type of energy storage and the rated power of the electric drive. The PEVs typically have larger batteries based on Li-Ion chemistry that are designed to hold more energy than the standard hybrid vehicle counterparts. With the additional energy and more powerful electric drive, most of today's PEVs can provide full or close to full vehicle performance on electric propulsion only[LV].

As shown in Figure 7-1 below, PEVs were first introduced to the world market in 2009 with the Tesla Roadster and the i-MiEV by Mitsubishi. These vehicles were initially only available in select markets and in small quantities. At the end of 2010, and into 2011, the release of the Nissan Leaf and the Chevrolet Volt signalled the beginning of the general availability of PEVs across the US. Currently most OEMs either have PEV models on the market or have planned releases in the next year or two.

Figure 7-1 the Accelerating Pace of mass produced PEVs



As reported for new car sales[LVI], the hybrid and PEV market continues to grow as a percentage of new car sales. In September 2012, hybrid cars sold accounted for 2.9% of new car sales in the US. Year-to-date sales were 68% greater than those in 2011. For PEVs, September sales represented 0.5% of new cars sold in the US. Year-to-date sales PEVs were 178% greater than the same period in 2011.

A number of current projections[LVII] are showing that the number of PEVs on our roads will continue to increase. According to Pike Research, Texas is projected to be one of the four states in the US leading PEV car sales. While the specific projections vary, most are projecting that there will be well over 1 million PEVs on the US roads by 2020.

PEVs are coming.

7.2 Benefits of large PEV market penetration (integrating PEVs into the grid)

As the number of PEVs on our road increase, there are a number of benefits we will realize as a result of the daily grid charging of PEVs. These benefits are to the individual car owner, the utility, the community, Texas, and the country as a whole. Mostly, these benefits fall into two categories, those benefits that can be, and are being, realized today and those benefits that will be realized in the future. To realize these future benefits, technology will need to be developed and systems will need to be put in place that do not exist today. The development of these future benefits will lead to new business opportunities and simultaneously will result in regulatory changes in how the US and specifically the Texas electricity energy markets are managed. Although not an exhaustive list, and in some cases referenced in earlier chapters, these respective benefits are summarized in the following paragraphs.

Benefits – today

Cost of transportation energy -The cost of transportation energy is typically thought of as the $/gallon of gasoline we pay at the pump. Because a PEV gets some or all of its transportation energy from the utility grid, that cost per gallon of gasoline is transferred to the $/kWhr of electricity or, considering the kWhr/mile of electrical energy used to propel the vehicle, the $/mile. Because dollars per mile is not a term typically used in the public forms today, $/mi is converted to $/gal equivalent for comparison. Depending on the specific PEV drive system and the local $/kWhr cost of electricity, a PEVs $/gal equivalent can vary. Current estimates indicate that $0.85/gal equivalent is a nominal transportation energy cost when the PEVs are operating in an electric only mode.

Although the $/gal of gasoline or diesel will vary up and down as we have seen in the last year, during that time the cost of electricity has remained relatively constant. In the next few years it is hard to say what the cost of our liquid transportation fuels will be at any given time. The general industry assumptions are that these costs will increase at a rate significantly greater than the cost of electricity[LVIII].

Environmental - With PEVs operating in electric only mode, there are no tail pipe emissions. While the generation of electricity, especially in Texas, is not without emissions, localized vehicle tailpipe emissions of PEVs do not contribute to local emissions in non-attainment areas. Furthermore in areas where there is a large resource of renewable energy such as wind, and especially in Texas, a significant amount of the energy used for charging PEV could be provided without any emissions at all. In the recent press, there has been a lot of discussion about PEVs, especially all electric vehicles, potentially have a larger carbon foot print than the conventional internal combustion engine (ICE) powered vehicle. While the specific reports and studies vary in their projections and statements, what is generally concurred is that the more a PEV is driven on the all electric mode, the lower the lifetime greenhouse gas (GHG) emissions a PEV has.

National Security - In the US, approximately 70 percent[LIX] of our oil consumption is used in the transportation sector. As transportation moves from liquid fuels to electricity our overall oil consumption will diminish and the amount of oil we have to import will also drop. For the Department of Defence (DoD), energy security is considered of strategic importance. The DoD has a number of energy security initiatives underway to reduce the amount of energy consumed on military bases, both in the US and abroad. A component of these initiatives includes PEVs[LX].

Benefits – tomorrow (through advanced grid communications, smart grid, with PEVs)

PEVs participating in the energy markets - As discussed in Chapter 4 of this Plan, in the future, PEVs may be able participate in the energy markets. The nature of the onboard battery or energy storage system gives the PEV the ability to either serve as temporary grid energy storage or to simply be a controllable load by adjusting the charge rate allowing for real-time demand management or load control. These capabilities are realized through what is typically referred to as Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) interfaces. While individual vehicles will most likely not be able to participate in the energy markets, groups of vehicles such as in commercial fleets or the aggregation of a number of individual vehicles though a third party aggregator could participate as a group by bidding and providing ancillary services. The benefits come from the economic returns and operational flexibility the real-time control of the charge and, in the case of V2G, the discharge of the PEV battery provide for the utility operator.

Charge control of PEV as a facilitator for increased penetration of renewables into the grid - Based on the ability to control when and at what rate PEV charging occurs, the large scale integration of PEVs in the grid has the ability to allow for a significant increase in the penetration of variable or intermittent renewable energy supplies such as wind and solar. One of the significant issues with renewable, especially in Texas with the West Texas wind patterns, is the ability to use the renewable power when it is available. The real-time control of PEV charging will allow the aggregate charging of vehicles to track the variability of renewables, thereby eliminating the need for conventional backup to keep match between generation and load.

7.3 Technical Challenges of large PEV market penetration (integrating PEVs into the grid)

There are several technical challenges that if not addressed will significantly delay or prevent large scale market penetration of PEVs. Several of these have been mentioned previously in earlier chapters as near-term barriers to PEV readiness and are included here as they relate to large scale PEV adoption. Although technical in nature, the result, if these challenges are not addressed or mitigated, will be to dramatically extend the timeline of the large scale integration of PEVs in the grid.

7.3.1 Charge control – minimizing on-peak charging

Studies show that the US generation assets can supply enough energy to power 73% of the U.S. transportation needs[LXI] without adding any addition power plants as long as PEVs are charged off-peak. That same energy, if added to the existing peak loads, will cause a significant short fall in generation, potentially causing rolling blackouts and adding to peak generation costs. The key to mitigating this challenge is to develop communications and control systems that will insure that the added system load of charging PEVs does not occur simultaneous to the system peaks. These new communication and control systems will need to be based on the ability for the utility or grid operator to control the charging and discharging of large numbers of PEVs. The ability to provide cost effective PEV charge control is one of the fundamental drivers for the large scale adoption of PEVs.

7.3.2 Utility distribution transformer failures (Clustering)[LXII]

In residential neighbourhoods a single distribution transformer will frequently supply power to several homes. These transformers are sized to meet the combined demand needs of all the individual homes and have the ability to rest or cool down during the non peak load times, typically at night. When these homes now include the added load of single or multiple PEVs, there is concern that the distribution transformers will be overloaded or not have the ability to cool down at night. The result may be widespread transformer failures or significantly shortened lives. The mitigation of this challenge will require advanced communications and control of individual PEV charging along with the ability to incorporate local distribution system considerations in the control strategy. As with the distribution transformer, the incorporation of grid operational needs resulting from advanced grid communications in the PEV charge control strategy will be required for large scale adoption of PEVs.

7.4 Challenges of large PEV market penetration (non-technical)

Similar to the technical challenges referenced in the previous section, there are non-technical challenges or issues that will constrain the growth of PEV adoption or extend the timeline for the large scale penetration of PEVs. Most of these have been mentioned in earlier chapter of this Plan as near term barriers. They are repeated in this section as they relate to large scale PEV adoption.

Charging infrastructure - There will need to be a charging infrastructure to enable the large scale penetration of PEVs. Unlike the near-term infrastructure requirements, the charging infrastructure required for large scale PEV adoption will require advanced communication and control capabilities that will provide for individual vehicle charge control. Without these capabilities the operational and economic benefits to large scale PEV adoption cannot be realized.

Payment/billing systems for home and non-home charging -As the proliferation of non-home charging stations are installed in public places and businesses, the need for the development of a combined payment and billing systems, such as what is used in the cell phone industry, will be required. Although not as significant for near-term PEV readiness, the interoperability in the billing and control between charging networks will be a key component to large scale PEV adoption.

Road tax collection (highway funding - New mechanisms for collecting equivalent road use taxes will need to be developed as more of the total miles travelled are driven from electricity rather than gasoline or diesel. These funds are used to support state and federal highway maintenance. With the near-term projections on the number of PEVs on the road, this will not be an issue affecting PEV readiness. It will, however, be an issue that will need to be addressed for large scale PEV adoption.

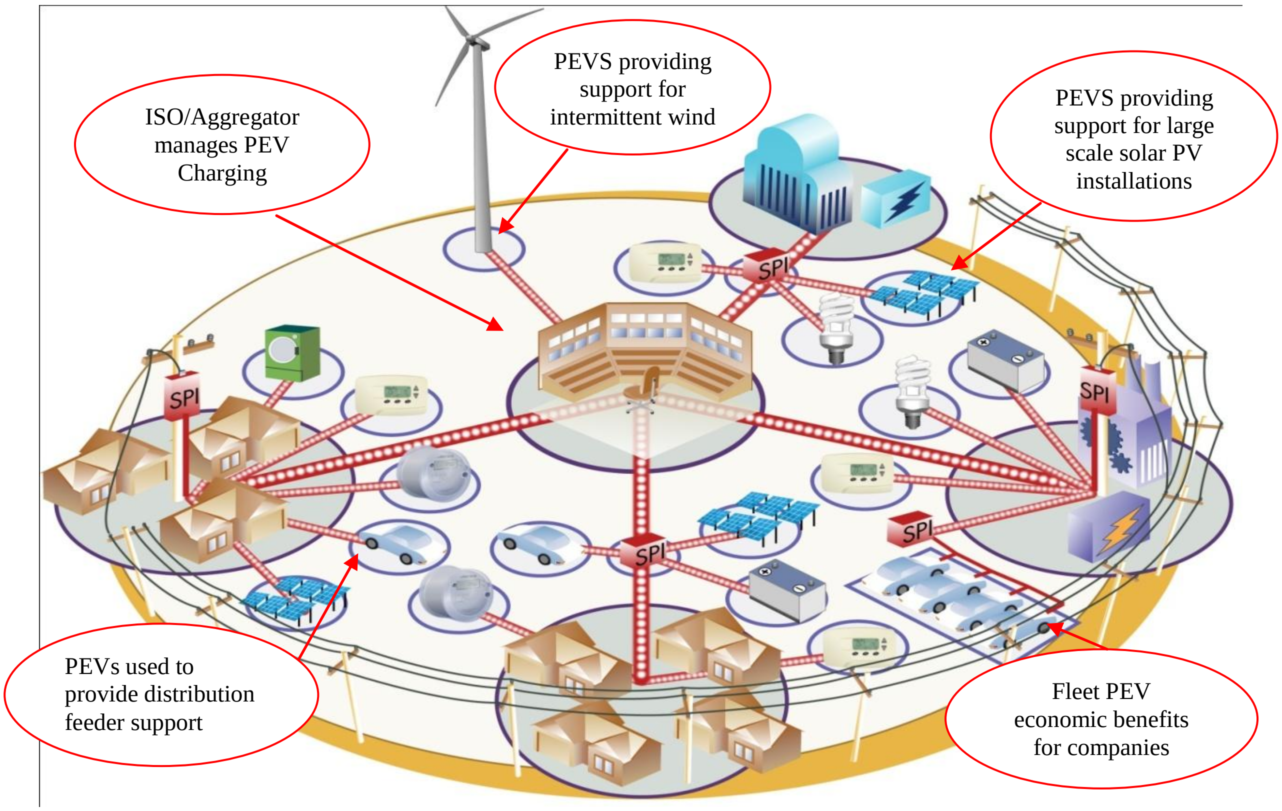
7.5 Vision of Large-scale PEV Market Penetration (PEVs fully integrated into the grid)

Given the projected market share increase of PEVs in the U.S. and Texas transportation fleet and the assumption that the technical, non-technical, and regulatory challenges to the large scale integration of PEVs will be addressed, a future where the PEV is fully integrated into the grid is not hard to envision. Figure 7-2 represents such a future where the benefits of PEVs to the grid are fully realized.

Summaries of these benefits are listed below.

ISO/Aggregator managed PEV charging -The managed charging of PEVs will allow the Independent System Operator (ISO) to be able to treat the PEVs as both a controllable load and storage resource either independently or as a aggregated whole.

Figure 7-2 Plug-in Electric Vehicles Fully Integrated into the Utility Grid



PEVs providing support for intermittent wind - The ability to control the charging of PEVs including the time and amount of energy used will allow the aggregated load following of variable wind resource. In locations such as Texas, where the wind generation of power is mostly off peak, the large scale integration of PEVs will allow a much greater penetration of wind in the generation mix.

PEVs providing support for large scale PV installations - Recognizing that PEVs will spend most of their non-driving time plugged in, the aggregation of the individual PEV batteries will serve as a grid storage asset. This will effectively be a large storage component allowing for the smoothing of variable PV outputs.

Fleet PEVs providing economic benefits for companies - Companies with fleets of PEVs will be able to directly participate in the energy markets allowing for addition revenue streams.

PEVs used to provide distribution feeder support - The ability to control and monitor the system loads down to the individual home will allow the ISO, though charge control of the PEV, to provide distribution feeder support by the real time control of the feeder loads.

7.6 Roadmap to go beyond readiness to large market penetration

In the previous section, as shown in Figure 7-4, a view is presented of a future where PEVs are fully integrated into the grid. Considering that there are a number of technical and non-technical challenges to be addressed in order to attain that future, an attempt can be made to designate a sequence of logical steps to addressing these challenges. For the purposes of this description, these logical steps are referred to as *PEV industry milestones*.

To develop the sequence of PEV industry milestones, assume the future is attained where the major milestones are realized. Looking back in time from that future view, consider what happened to allow that future to be fulfilled. The resulting activities or events then constitute the sequence of milestones. Figure 7-3 is a graphical representation of applying the above approach, where a roadmap of PEV industry milestones is depicted. These milestones are listed as successful demonstrations of specific PEV grid capabilities or general industry activities. For reference, projections of one and two million PEVs on U.S. roads are listed in the timeline.

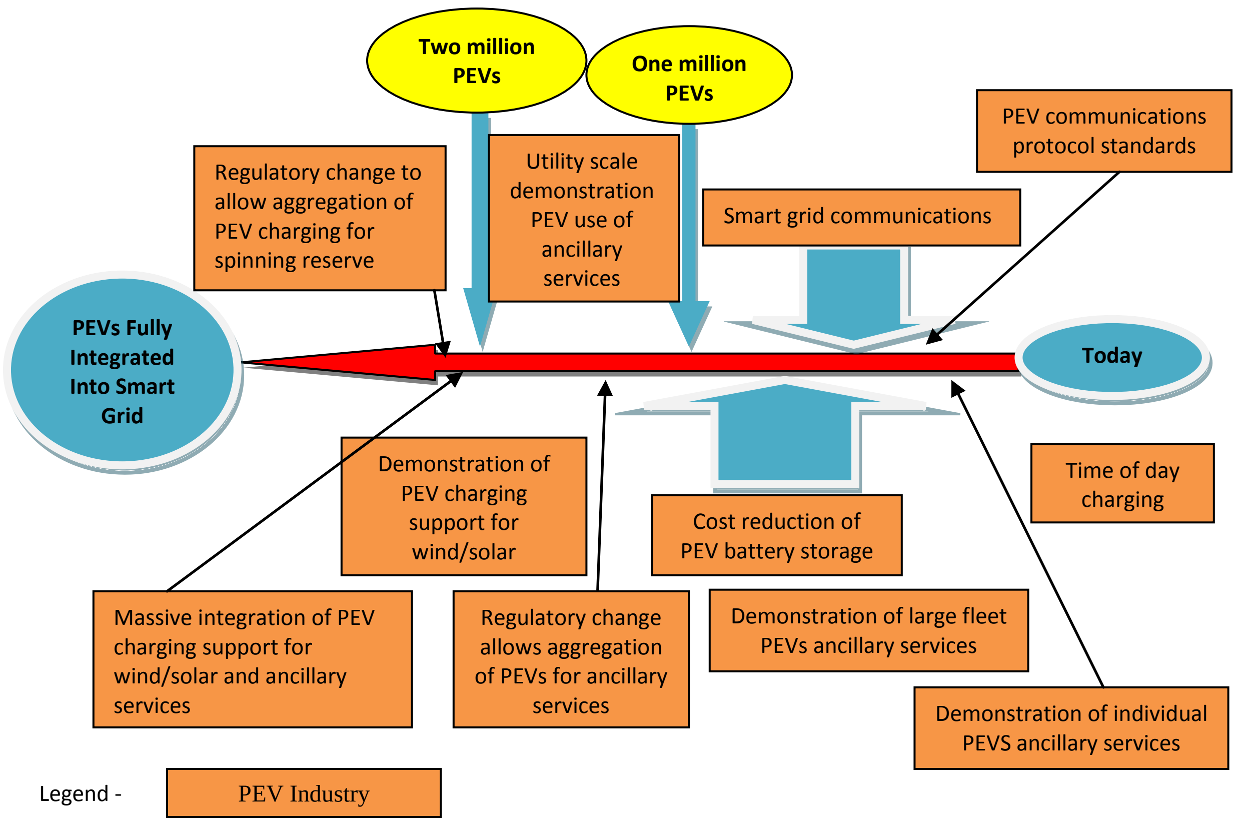


Figure 7-3 Plug-in Electric Vehicle Industry Milestone Roadmap

As described in the roadmap presented in the previous section, there are a number of key PEV industry milestones that will be a part of the large scale integration of PEVs in our transportation mix. Reaching these milestones will be in the form of having the technology or development readily available throughout the industry. That is, the milestone result would be generally available to industry in the form of standards or detailed implementation publications (rather than limited to a few companies or having the key technology by locked up in intellectual property). Even though work toward these early milestones is under way, multiple programs focusing in similar areas will provide a robust technical base to insure the results move the industry.

The DOE, the Electric Power Research Institute (EPRI), the Department of Defense, and many OEMs have programs in support of the adoption of PEVs. These organizations have activities planned or underway that can be aligned to some of the listed PEV industry milestones. One of the challenges with these programs is that they are distributed throughout the US and are generally "one-offs." A coordinated approach to milestone development with multiple programs in Texas with Texas and Federal resources would dramatically move the industry milestones forward and accelerate the large scale integration of PEVs in Texas and the country as a whole.

Listed in the following sections are the PEV industry milestones from the present until approximately one million vehicles are on the U.S. roads[LXIII]. These milestones are formatted in the structure of a project or activity. For each milestone, a brief description is provided to give a general scope of the desired activities or specific outcomes that would facilitate the achievement of the industry milestone. In addition to the description and scope, a high level view of how the program or activity would be executed under two different funding scenarios is provided. These two scenarios are a business as usual and an expanded funding level.

A business as usual (BAU) scenario is used to describe the continuation of the limited level of Texas activity by industry, local utilities, research institutes, and regulators. Generally, the BAU scenario depends on industry to self-fund the technical work associated with meeting these milestones. As the work is mostly industry funded with some Federal assistance, there are two possible negative outcomes. First, there is no assurance or incentive for the researchers to share their program results publically. Also, proprietary solutions may not be optimal. For example, interoperability may result as a private concern seeks to maximize profits and reduce competition.

The second scenario is based on expanded public funding to foster achieving each of the industry milestones on a faster schedule. Funding could be at the Texas or Federal level or a combination of both. The implication of the targeted expanded funding is that the public/private/research institution development would accelerate the execution of the roadmap and bring the needed technical solutions to the industry sooner that the BAU approach.

Specifically, targeted funding in Texas or the Texas Triangle area will result in further development of Texas leadership in this expanding area. The unique environment of Texas having its own grid (ERCOT) , a single public utility commission the breadth of the research institutional capability in Texas, the large municipal and investor owned utilities eager to promote PEVs-- all provide a compelling argument for developing these industry programs in Texas and creating Texas technology and jobs.

7.6.2 Time-of-Day Charging

A time-of-day charging program would include the development and demonstration of addressing the utility time-of-day charge control. The program would include the following components:

- Explore/characterize technical solutions for time of day charging control,
- Identify voluntary/mandatory/rate incentive strategies,
- Develop grid impact for each strategy,
- Consider strategies unique for the Texas Triangle area or ERCOT market, and
- Implement one or more solutions on vehicle(s) and capture the results.

<u>Major Tasks or activities – Business as usual</u> - Under a BAU scenario this program would consist of a technical study and subsequent analysis. The outcomes of the study would be the characterization of the current industry best practices for time of day charge control and to see where there is additional development required to enable the functionality to be realized.

<u>Major Tasks and activities – expanded funding</u> - With increased funding, the program would be able to expand beyond an industry survey and analysis. After this initial study phase, what would be added to the program is the demonstration of one or two of the leading methods for individual vehicle charge control and to capture the effectiveness and practicality of each.

7.6.3 Individual Vehicle Ancillary Services

An individual vehicle ancillary services program would include the development and demonstration of an individual PEV providing ancillary service. The program would include the following components:

- Communications protocol development,
- Control strategies response to ISO signals (ERCOT and other ISOs),
- On/off or charge rate control,

- Grid impact,
- Cost considerations/revenue recovery,
- Response rates/timing,
- Actual energy/regulation availability, and
- Evaluation of impact of V2G on vehicle

Major Tasks or activities – Business as usual - Under a BAU scenario this program would consist of a technical study and subsequent analysis. The outcomes of the study would be the identifications of the key areas where there is additional development required to enable the functionality or milestone to be realized.

Major Tasks and activities – Expanded funding - With expanded funding, the program would be able to expand beyond a technical study and analysis. After this initial study phase, what would be added to the program is the demonstration(s) of and the furthering of the current state of industry technical readiness. The demonstration(s) would consist of one or more vehicles and associated EVSE that has the functionality for providing ancillary services. Simulated or actual regulation and other ancillary services signaling would be used to capture the performance of the overall system.

7.6.4 Vehicle Communications Protocols/standards

A vehicle communications protocols/standards program would include the investigation and characterization of the developing communications technologies and protocols and, where standards are not being developed yet, actively participate in the development of those standards. The program would include the following components:

- Investigate and characterize the current OEM and other vehicle communication strategies (cell phone, Onstar, internet, other),
- Investigate and characterize the developing utility to EVSE strategies,
- Investigate and characterize the developing SAE EVSE to vehicle communication standards (actively participate in the standards development),
- Evaluate the cyber security aspects with the utility to EVSE as well as the EVSE to vehicle communications,
- Develop a communications laboratory where the different communication strategies and protocols can be developed and tested. and
- Demonstrate working laboratory level communications on a vehicle platform.

Major Tasks or activities – Business as usual - Under a BAU scenario this program would consist of a technical study and subsequent analysis. The outcomes of the study would be the characterization of the current industry best practices for utility to EVSE and EVSE to vehicle communications. Specific areas would be identified where additional development or integration is needed to provide a robust communications structure.

Major Tasks and activities – Expanded funding - With expanded funding, the program would be able to expand beyond a technical survey and analysis. A laboratory would be developed where communication development and characterization would occur. As part of the laboratory functions would be the participation in industry (SAE and IEEE) standards development. Part of the working laboratory would be the integration of the communication systems into a vehicle(s) platform.

7.6.5 Fleet Ancillary Services

A fleet ancillary services program would include the demonstration of a fleet of vehicles providing ancillary services. The program would include the following components:

- Fleet of PEVs from a single location or company,
- Commutations management (single controller/individual EVSE aggregation),
- Charge management/on-off control,
- Determination of limits of aggregation (vehicle availability/connection/battery energy level based on use), and
- V2G impact and viability.

Major Tasks or activities – Business as usual - Under a BAU scenario this program would consist of a technical study and subsequent analysis. The outcomes of the study would be the characterization of how a fleet of vehicles could be aggregated to provide a single interface to utility ancillary service command, the associated individual vehicle issues, and the design of a demonstration program to validate the design.

Major Tasks and activities – Expanded funding - With expanded funding, the program would be able to expand beyond a technical study and analysis. The designed fleet charging demonstration(s) would be implemented in a single location. Development and subsequent modification of the EVSE, the PEVs, and the creation of a master controller to allow for aggregation would be included in the effort.

7.6.6 PEV Charge Suspension during Peak Loads

A PEV charge suspension during peak loads program would include the development and demonstration of the capability to suspend PEV charging in the event of utility need. The program would include the following components:

- Technology for individual vehicle control (house/EVSE/location),

- Commutations management,
- Voluntary/mandatory/rate incentive strategies, and
- Determination of actual times of use (how often/costs/impact to utility).

Major Tasks or activities – Business as usual - Under a BAU scenario this program would consist of a technical study and subsequent analysis. The outcomes of the study would be the characterization of the current industry best practices available for charge suspension and to see where there is additional development required to enable the functionality to be realized. The focus of the effort would be on non-ancillary services equipped EVSE.

Major Tasks and activities – Expanded funding - With expanded funding, the program would be able to expand beyond an industry survey and analysis. After this initial study phase, what would be added to the program is the demonstration through a pilot program of one or two of the leading methods for charge suspension individual vehicle charge control and to capture the effectiveness and practicality of each.

Chapter 8 List of Recommendations

The following pages of tables are the final recommendations coming out of this Plan. As discussed earlier, each of the chapter authors developed recommendations many of which were based on two different scenarios. The following recommendations are those that the CCET Board of Directors agreed to. The recommendations are divided into several categories. The middle column in the table is the actual recommendation. The columns preceding and following this column are to provide some background and additional details, options, or considerations.

RECOMENDATIONS

A. Category: General

No.	Problem, Barrier or Opportunity to Promote PEVs	Recommendation	Comments
G-1	The road fuel sales tax is not adequate to fund new highway transportation needs. PEVs use state highways, but pay little or no (in the case of BEVs) taxes for the use of the roads. This exacerbates the current highway funding program. However, because the level of PEV market penetration is low, and likely to remain so for a few years, and because other fuel efficient vehicles (e.g., the hybrid) are also exacerbating the problem, careful consideration needs to be given to this issue.	**Either an interim legislative study committee or the Interagency Transportation Fuels Council (recommended below) should have a recommendation ready for enactment in the 2015 session of the Texas Legislature.**	**The recommendation should take into account the relatively lower impact of the lighter fuel efficient vehicles on roadways as well as the need for all vehicle types to share in resolving this problem.**
G-2	Given the opportunities and challenges posed by the electrification of transportation for Texas, at issue is how to pursue the various recommendations for PEV readiness and promotion listed below by category. Absent any new approach, the future will look something like the immediate past: regional activities funded largely by federal grants, ad hoc efforts, and commercial and non-profit partnerships. Many of the issues below are best pursued at the state level—either through state agency actions, legislation, and information sources. No single state agency has a clear purview of the various issues, but several have key roles. (See comments at far right)	**Establish through executive order a four-year statewide Transportation Alternative Fuels Interagency Council to implement programs and coordinate policies, contingent upon no incremental funding from the State.** State authorities (e.g., gubernatorial executive order or legislation) could establish an interagency council on alternative transportation fuels that would include both transportation electrification and use of natural gas in those vehicles best suited for LNG or CNG. The Council would include representatives from each of the agencies listed at right, plus a nonvoting member each from the environmental	To avoid the appearance (as well as the actuality) of setting up yet another bureaucracy, the Interagency Council would be strictly limited to a four-year lifetime, with any residual responsibilities assigned to one or more state agencies at the end of this time. (The Council would rely on Federal or other outside funding).) The Council could start with the PEV activities and work with the natural gas and automotive industries to include LNG and CNG vehicles and policies. Agencies with current PEV (and natural gas) related purview include: • Public Utility Commission of Texas

		community, the metropolitan planning organizations, the natural gas marketing community, vehicle manufacturing, and the electric power industry. The various programs recommended below, specifically the Texas PEV Friendly Community program and the statewide consumer information website would be run by Council staff.	• ERCOT • Texas Commission on Environmental Quality • State Energy Conservation Office • Texas Department of Transportation • Texas Railroad Commission • Department of Motor Vehicles • University research groups at state supported colleges The Clean Cities Coalition includes several dedicated professionals who have been working in this subject area for many years in Texas. They could be contracted as a temporary staff to provide immediate and cost effective expertise, especially if federal funding could be obtained for their services.

B. Category: Electric Power Industry (EPI)

No.	**Problem, Barrier or Opportunity to Promote PEVs**	**Recommendation**	**Comments**
EPI-1	Distribution utilities need a reliable means of understanding where PEV charging may be taking place in order to anticipate where their transformers and circuits may be stressed. This would permit them to upgrade the equipment before damage and an outage occurs.	**DMV notification of PEV Registration to distribution utilities.** The unique vehicle identification number or VIN assigned to each vehicle reveals the model of the vehicle being registered. If the DMV were to routinely provide notification including the addresses of the owners of models known to be PEVs to the utilities, preemptive action could be taken to avoid circuit and transformer overloading.	Temporary measures are currently in place with select vehicle manufacturers. A more reliable and permanent solution is preferred to encompass all PEVs in both the primary and secondary market. Preferably, this recommendation could be accomplished through executive action rather than requiring legislation.
EPI-2	Currently, under the Texas Public Utilities Regulatory Act (PURA), within the boundaries of a public power entity service territory, no other entity is allowed to resell or provide	**No recommendation.** Although discussed at length, the CCET Board elected to make no recommendation on the need	This issue could be one that the proposed interagency council for transportation fuels could consider in the future.

	electricity for a fee other than the public entity. If a public power entity (i.e. a municipally-owned utility or, in some cases, a co-operatively owned utility) allows another entity to provide such service, the utility may be forced into the competitive market. Some public power entities would like the ability to allow/regulate third party PEV charging, but are concerned that by doing so, they will jeopardize their status.	for clarification as to the rights and roles of public power electric utilities with respect to their ability to regulate PEV charging by third parties.	
EPI-3	In the deregulated portion of the Texas market, only registered retail electric providers (REPs) can sell electricity to customers. Given that PEV charging may be construed to be a sale of electricity, a prospective owner of PEV charging equipment who wanted to recoup his investment by charging customers for the use of the EVSE, would be required to register with the PUC of Texas and pay fees. This burden could be a barrier to public charging.	**Exempt public fee-based PEV charging stations from regulation as REPs, so long as the power has been sold once at the retail level to the charging station owner.** Owners of PEV charging stations to be exempted from the requirement to register and be regulated as a REP in the regulated portion of the Texas market.	Would likely require legislation. Rationale: Currently, owners of recreational vehicle parks are exempt from registering as a REP when they sell electricity to RV owners as part of their fee for use of the parking spot. EP3 would be analogous since the EVSE amortization is large compared to the value of the kWh sold.
EPI-4	Until managed charging to optimize PEV charging to respond to grid resources is available, a time of use (TOU) rate for PEV charging in the late night through early morning hours can help reduce peak demand and take advantage of the less expensive and more abundant wind energy resource from West Texas. At present, some REPs, such as TXU and Reliant offer such rates.	**REPs and public power entities are encouraged to voluntarily continue to offer time-of-use rate plans to promote off-peak charging by PEV owners until managed charging programs are developed to optimize PEV charging.**	TOU rates would NOT apply uniquely to PEV charging, but would help demand response peak-shifting in general. The PUCT's *Power to Choose* website could encourage REPs, for example, by s simply designating such plans as "PEV Friendly."
EPI-5	The large Transmission and Distribution Utilities (TDUs), municipally owned utilities (Muni's) and several REPs in Texas are well along the path of educating their customers and employees to the benefits, challenges, and technical aspects posed by PEVs. Our survey revealed that this is not the case for the smaller utilities.	**Utility management and staff preparation for PEV Readiness** Develop periodic utility "roundtable discussions" for sharing best practices.	This could be part of an overall CCET PEV Initiative in conjunction with the Texas Rural Electric Cooperative, the PUCT, and smaller public power groups.

EPI-6	The best way to familiarize staff and customers (e.g.., Co-op members) is first hand familiarity with PEVs and EVSE, and actually experience driving a PEV.	**Encourage Electric Co-op and Muni Internal PEV Promotion through PEV purchase and charging station installation.** The PEV would be available for employee use and could be demonstrated in annual Co-op membership meetings, for example.	The PEV owned and operated by the Co-op or Muni could be made available for drive-and-ride events discussed under Consumer Education below.
EPI-7	Fleet owners and operators are emerging as a break- through segment of PEV purchasers and users as they make use of cost-effective electrification of transportation. Electric utilities could serve as examples to the commercial and governmental fleet managers by converting their fleets to PEVs for those vehicle types that prove to be cost effective and are most appropriate for electrification. This could be justified in part as a transportation measure to achieve attainment of air quality standards in non-attainment areas.	**Encourage larger electric utilities to demonstrate use of PEVs including large bucket trucks and vehicle pool employee use vehicles.**	This could be assisted through use of Texas Emission Reduction Program (TERP) funding to offset front end costs where emission reduction benefits are demonstrated. This could be part of a CCET PEV Initiative.
EPI-8	A fleet with the capability of managing its charging rate affecting 100kW of capacity is theoretically able to participate in the ERCOT ancillary service market. The aggregation of PEV EVSE and managed charging could eventually become an important part of demand side management and grid performance.	**ERCOT should further explore the market potential for the managed charging of PEVs.** With the cooperation of a Qualified Scheduling Entity and ERCOT staff, one or more fleets would demonstrate through a pilot program how PEV charging could participate in the ancillary service market.	Note: This is one of three parts of a program proposed by CCET to DOE[LXIV]. Whether or not this application is awarded, this could also be part of a CCET PEV Initiative.
EPI-9	In addition to participating in the ancillary service market (see EPI-7 above), PEV charging can be folded into an existing demand response program including direct load control—in exchange for benefits such as the installation of a Level 2 charger, bonus payments, rate relief, etc.	**Once it has been determined that the benefits exceed the costs, public power and REPs are encouraged to voluntarily create innovative cooperative and synergistic demand response programs for their PEV customers to mitigate against peak loads.** Two options are discussed at right.	Two options: An ancillary market participant can offer the customer rebates for installation of Level-2 residential charging equipment, with the agreement that they can interrupt charging if necessary. Another version of this agreement includes the caveat that the ancillary market participant can interrupt charging provided that the vehicle will be fully charged by a certain time set by the customer.

C. Category: Consumer Education (CE)

No.	Barrier or Opportunity to Promote PEVs	Recommendation	Comments
CE-1	PEVs are viewed by much of the public as strictly utilitarian modes of clean transportation. An emerging consensus among those promoting PEVs is that the best overall consumer education technique is for prospective consumers to actually experience PEVs through driving the vehicle. The driving experience dispels the notion of PEVs as a weak sister to the internal combustion engine.	**Encourage ride-and-drive programs with cooperation from auto dealers, local utility and local PEV enthusiasts.**	This technique is part of the local best practices section below with its portfolio of 11 optional initiatives. See LBB1 through 11 below. This could also be part of a CCET PEV Initiative.
CE-2	Conflicting information about PEV safety, economy, and performance is an inherent barrier to increasing the market share of PEVs. Environmental groups and auto manufacturers tout PEVs for their own ends. Likewise, political push back against PEVs plays upon safety incidents and government subsidies. The consumer, interested primarily in the total cost of transportation, often does not know who to trust.	**Encourage the creation of a statewide website that is commercially neutral, strictly objective, and focuses on Texas related PEV issues. This program would one of the functions of the Council recommended above and therefore, its funding would be contingent upon the receipt of outside (e.g., Federal) funds.**	This is one of the seven elements in the Texas Triangle PEV Readiness Plan. It is treated in detail in Chapter 6 of the Plan.

D. Category: Intercity Charging to Address Battery Electric Vehicle (BEV) Range Anxiety (ICC)

No.	Barrier or Opportunity to Promote PEVs	Recommendation	Comments
ICC-1	The corridors connecting the metropolitan areas of the state's largest cities will eventually be served by PEV charging through "organic growth of charging infrastructure" in communities and businesses along the corridor without government funding. However, it is expected that for the next five years such	**Approach Intercity Charging as an Economic Development Opportunity** Organic growth of PEV charging can be accelerated without government funding through public charging (Level 2) to serve PEVs in the local community. Where these stations are located near amenities (restaurants, historic downtowns,	This approach is part of the Texas PEV-Friendly Community program.

	growth will be inadequate to ensure that drivers of battery electric vehicles (BEVs) will be able to comfortably make intercity trips, which is important for encouraging BEV adoption. This is especially true along I-10 connecting Houston and San Antonio and to a lesser extent between Houston and Dallas on I-45. The first link to avoid range anxiety under a Business as Usual Scenario (no additional government funding for charging stations) will be I-35 between Austin/San Antonio and Dallas/Ft. Worth.	museums, parks, etc.) out of town BEV drivers will likely spend money shopping and eating thus creating an economic development incentive for local communities to create convenient, well-marked, and well- advertised charging along the corridor.	
ICC-2	Ditto	**Inform the Public of Alternatives to Accommodate Intercity Travel and PEV Use Over the Short Term** PEV market penetration in Texas is not critically dependent upon establishing a charging infrastructure along the Texas Triangle corridors. Two interim solutions are (1) encouraging purchase of PHEVs[LXV] to avoid entirely the issue of range anxiety, or (2) encouraging two-car families to purchase a BEV or NEV[LXVI], where price and driving patterns are appropriate, in addition to their internal combustion engine "trip car."	Realization of the opportunities available to take advantage of PEVs is dependent upon a good consumer information program.
ICC-3	Ditto	**TxDOT Use of Strategically Located Rest Areas to Provide PEV Charging** The Texas Department of Transportation (TxDOT) operates several strategically located rest areas along I-10 and I-45. If TxDOT were permitted by legislation to bid out a portion of these locations to EVSE vendors for both Level 2 and DC Fast Charge, the gaps along these corridors could be closed.	The bid could be designed such that TxDOT eventually generates positive revenue. The chargers could be accompanied by a kiosk that informs the public of PEVs in general and charging locations along the corridor specifically.
ICC-4	Ditto	**Use of federal funds, if made available for the State, for Level 2 Network along interstate**	DC Fast Charging is considerably more expensive to build and operate than Level 2, but

		corridors to minimize delays and avoid range anxiety for BEV owners As noted previously, analysis done for this Plan indicates that for a subsidy of $1 million per year for the period 2013-2017 a minimal but adequate series of Level 2 and DC Fast Charging stations could be established along the connecting corridors in the Texas Triangle (including Hwy 71 from Austin to Columbus). This is an option to consider if federal funding becomes available.	it most nearly recreates the experience of refilling the tank at a service station entailing a 30 minute "delay." DCFC in adequate numbers is a response to long distance travel in BEVs. The build out assumes private sector participation through organic growth in addition to the subsidized stations. However, it should be noted that results indicate little organic growth can be expected during the initial years, since it would be difficult to compete with subsidized infrastructure. Nevertheless, within the next five years it would still be expected that organic growth would start to occur in high-demand locations, such as in the cities along I-35.

E. Category: Local Best Practices to Remove Readiness Barriers and Promote PEVs (LBP)			
No.	**Barrier or Opportunity to Promote PEVs**	**Recommendation Options**	**Comments**
LBP-0	The impetus for the Texas Triangle PEV Readiness Plan was to extend the planning and readiness activities occurring in the metropolitan regions at the corners of the Texas Triangle to the many communities along and inside the corridor. Because of the variety of towns ranging from bedroom communities to farm and ranch centers, a flexible means of adopting the various readiness measures to a community profile is important.	**Establish the Texas PEV-Friendly Community program with publically recognized communities that achieve this designation, contingent upon outside funding (e.g., Federal) to support the staff required to administer it. This program would be administered by the Council recommended in G-2 above.**	The program is voluntary with participating communities electing various options which would collectively achieve a point total that would make them eligible for the designation *PEV Friendly*. The program would be open to all communities throughout the state and would be promoted and administered by the interagency council staff recommended above.
LBP-1	The overwhelming consensus of those who have attempted to work at the community level to remove barriers to PEV readiness is that no single authority can accomplish the task. Instead, a group of PEV enthusiasts working as a core team is essential to success.	**Using "Ride and Drive" events as a kickoff, a PEV core team ideally including at least the mayor, city council member, city manager, or a city department manager serving as chair would be organized to coordinate the remaining ten initiatives.**	Other members of this core team should include a member of the local electric utility, an electrical contractor, automobile dealer, and an environmental community representative.
LBP-2	Need for fleets to consider PEV economic	**The municipality would purchase at least one**	This action will serve as an example and as an

	benefits and move to purchase PEVs when the total cost of ownership favors PEVs.	**PEV and have a program in place to determine when PEV replacements are cost effective**	ideal learning process for the municipality and other fleet operators.
LBP-3	In addition to a statewide website with a Texas focus there needs to be at least one local PEV expert	**Designate a knowledgeable, local PEV expert who is available to provide advice in an unbiased manner.**	The expert should have a very good grasp on where to go for answers and knowledge of the statewide websites and its links.
LBP-4	Local building and electrical codes may not be up to date with respect to changes made at the national level to accommodate safe PEV charging. Moreover, permitting for individuals who want to add a Level 2 charger in their home or business may be overly time consuming and expensive thus creating a barrier to PEV charging.	**Institute local code revisions by ordinance and streamline permitting activities for installation of electric vehicle supply equipment (EVSE). Provide overall training for local code enforcement and permitting authorities on PEVs.**	The training for local code enforcement personnel and electrical contractors will remove uncertainties and address concerns that would otherwise result in delays and high costs.
LBP-5	Local public power utility representatives or Retail Electric Providers in the deregulated market can provide rate plans that encourage night time rather than peak time PEV charging.	**Engage local public power utilities or REPs to ensure that rates that encourage nocturnal and off peak charging are considered as an offering to the public.**	
LBP-6	The largest single barrier to PEV market penetration is the front end cost. For many people in small towns and especially planned communities, street legal neighborhood electric vehicles can accomplish the clean air and petroleum reduction goals of PEVs at one third the front end cost of full service PEVs.	**Publicize the geographic extent of the community that can be accessed through neighborhood electric vehicles and avoid unnecessarily excluding NEVs as a transportation option for short distance and slow speed urban and suburban travel.**	NEVs can also serve as an entry level vehicle for those who cannot yet afford a full service PEV.
LBP-7	Publically available PEV charging, either free or fee based, will soon be an important service for community residents who drive a PEV. In addition, a publically available local PEV charging can reduce range anxiety for drivers of battery electric vehicles passing through the community.	**Establish at least one PEV charging station in a prominent and easily accessed location and encourage private commercial parking lot owners and retailers to consider PEV charging locations.**	The charging station can play an important symbolic role. It will be important that a variety of guidelines discussed in Chapter 3 be followed for this to be a success.
LBP-8	Home charging is proving to be the overwhelmingly predominant place that PEVs are charged. However, considerable obstacles arise where the PEV owner is a resident of an	**Engage local apartment owners and property managers to plan for and adopt one of several solutions to the problems of PEV charging at**	There are drawbacks to the various solutions to the multifamily housing PEV charging problem, but working constructively with the core team, solutions can be developed that meet community

	apartment complex or other multifamily arrangements. There are a variety of business models that have been developed to deal with these issues.	**multifamily housing properties.**	specific circumstances.
LBP-9	The second most desired location for PEV charging is the work place. Many high profile PR-conscious "green" employers have developed elaborate and expensive employee PEV charging. These are not likely to find traction with most Texas based small businesses.	**Encourage work place charging through a low cost, a low tech, and simple approach to "get the ball rolling" in this sector by allowing employee access to 120V outlets. This could involve fee-based Level 1 charging.**	A simple approach as a first step is provided in Chapter 3 of the Plan. More sophisticated (and currently more costly approaches are also available,
LBP-10	PEVs pose some high voltage electrical risks for those responding to accident scenes.	**First responder training for police, fire, and emergency medical personnel is important. Programs are already available to provide this training.**	Any consideration of risk should take into account that internal combustion engines with their gasoline fuel also pose serious risks that are absent in BEVs.
LBP-11	The Federal Highway Administration has recently developed signage specifically for PEVs. It is important for those PEV travelers passing through the towns to have uniform signage directing them to PEV charging stations.	**Establish uniform signage in the community for PEV charging stations open to the public.**	

F. Category: Direct Incentives to Purchasers to Increase PEV Market Penetration (DIP)

No.	Barrier or Opportunity to Promote PEVs	Recommendation	Comments
DIP-1	Even with the federal $7500 tax rebate, the upfront cost of a PEV is still a barrier for those who consider total cost of ownership. An additional state level direct incentive would improve the payback period and thus the incentive to buy a PEV.	**Use of up to $2.5 million in TERP funds to provide direct subsidies of $2500 to the first 1000 purchasers of PEVs in air quality non-attainment areas after the effective date of the legislation. The program could also be limited to two years.**	Ten other states have some form of state rebate or refund. This recommendation has the added advantage of helping to attain ozone air quality standard. Would probably require state legislation.
DIP-2	A direct incentive to accelerate purchases of PEVs in other states, notably CA, has been to allow PEVs access to high occupancy lanes on freeways.	**Allow PEVs access to high occupancy vehicle (HOV) lanes on expressways**	This would probably require state legislation.

G. Category: Beyond Readiness

No.	Barrier or Opportunity to Promote PEVs	Recommendation	Comments
BR-1	For the electric grid, the specific time a PEV is charged could have an impact on peak demand. In order for PEVs to be broadly adopted in the market, the issue of when vehicles are charged will need to be addressed. At this point, the technology for broad control of when a PEV is charged does not exist.	**PEV Charge Control** **Develop a technical program containing the following elements:** • **Explore/characterize technical solutions for time of day charging control** • **Voluntary/mandatory/rate incentive strategies** • **Grid impact for each strategy** • **Consider strategies unique for the Texas Triangle area** • **Implementation of one or more strategies on vehicle(s) and capture the result**	This could be part of an overall CCET PEV Initiative, in the form of a technology development program. It could be in conjunction with ERCOT, the DOE, or other state and federal funding agencies. An initial feasibility study to ascertain cost effectiveness should be completed first.
BR-2	The idea of PEVs participating in the energy services market, specifically in the area of providing one or more ancillary services has been discussed broadly. In some cases, staged demonstrations have been conducted showing that the controlled charging of PEVs can be tied to providing ancillary services. Technology development is needed to bridge the gap between a staged demonstration and robust technical solution for reliability participating in the energy market.	**Individual Vehicle Ancillary Services** **This technical program would include the development and demonstration of an individual PEV providing ancillary service. The program would include the following components:** • **Communications development** • **Control strategies response to ISO signals (ERCOT and other ISOs)** • **On/off or charge rate control** • **Grid impact** • **Cost considerations/revenue recovery** • **Response rates/timing** • **Actual energy/regulation availability** • **Consider impact of V2G on vehicle**	This could be part of an overall CCET PEV Initiative, in the form of a technology development program. It could be in conjunction with ERCOT, the DOE, or other state and federal funding agencies.
BR-3	Many players in the PEV industry, including automotive OEMs, EVSE suppliers, and	**Vehicle Communications Protocols/standards** **This technical program would include the**	This program could be conducted in conjunction with existing efforts in national laboratories or as

	utilities are working in the development of SAE standards surrounding managed charging. While this is a start, before wide spread adoption, there needs to be a migration path defined from the existing OEM unique strategies to a single solution.	**investigation and characterization of the developing communications technologies and protocols and, where standards are not being developed yet, actively participate in the development of those standards. The program would include the following components:** • **Investigate and characterize the current OEM and other vehicle communication strategies (cell phone, Onstar, internet, other)** • **Investigate and characterize the developing utility to EVSE strategies** • **Investigate and characterize the developing SAE EVSE to Vehicle communication standards (actively participate in the standards development)** • **Evaluate the cyber security aspects with the utility to EVSE as well as the EVSE to Vehicle communications** • **Develop a communications laboratory where the different communication strategies and protocols can be developed and tested.** • **Demonstrate working laboratory level communications on a vehicle platform**	a standalone effort in an independent R&D facility. The results will be critical to establishing the basis for more advanced PEV control strategies required for a much larger adoption of PEVs.
BR-4	Similar to the previously discuss EPI-7 and EPI-8; this effort would develop the technology for a PEV fleet to be aggregated. The program would utilize results developed in BR-3 or similar program as basis for expansion beyond a single vehicle to a fleet.	**Fleet Ancillary Services** **This program would include the technology development and demonstration of a fleet of vehicles providing ancillary services. The program would include the following**	This could be part of an overall CCET PEV Initiative, in the form of a technology development program. It could be in conjunction with ERCOT, the DOE, or other state and federal funding agencies.

	The technology for PEV fleet aggregation including communications and control strategies does not currently exist.	**components:** • **Fleet of PEVs from a single location or company** • **Commutations management (single controller/individual EVSE aggregation)** • **Charge management/on-off control** • **Determination of limits of aggregation (vehicle availability/connection/battery energy level based on use)** • **Determination of the limits of what ancillary services a fleet can provide.** • **V2G impact and viability**	

ENDNOTES

[I] The scope of this Plan is limited to grid-connected on-road vehicles. See Appendix 1D for more terminology, definitions, and acronyms.

[II] The Center for the Commercialization of Electric Technologies (CCET) is a Texas non-profit formed in 2005 to enhance the safety, reliability, security, and efficiency of the Texas electric transmission and distribution system through research, development and commercialization of emerging technologies. CCET brings together electric utilities, high-tech companies, research companies, and university researchers to find technology solutions to challenges facing the Texas electric power industry. Transportation electrification is one such technology.

[III] A proposal from Austin Energy that focused on the municipally owned utilities in the southwest corner of the Texas Triangle was also awarded a grant. The Texas River Cities PEV planning project has some of the same goals and objectives of this Texas Triangle PEV Plan. Both planning efforts are coordinating their activities so as to avoid duplication of effort and contradictory data and analyses. For example our Chapter 3 contains much of the same topical and actual content dealing with local best practices. Our material is packaged as menu of options and promoted as the Texas PEV Friendly Community program while the Texas River Cities Plan will include a "tool box" of measures as a way to provide a similar flexibility to municipalities seeking to promote PEV readiness.

[IV] The two-scenario approach reflects the political and economic realities that, absent a compelling and urgent need, there is unlikely to be significant state funding to implement these initiatives. Therefore, the scope of the Plan recommendations are modest. Given that the original proposed federal legislation that gave rise to the readiness grants were broken into planning grants followed by implementation grants, other recommendations are meant to serve as a pre-proposal for any federal legislation that would fund the community and regional plans. In this way we hope to provide flexibility in implementation.

[V]About the Pickens Plan: Unveiled on July 8, 2008 by T. Boone Pickens, The Pickens Plan is a detailed solution for ending the United States' growing dependence on foreign oil. That year, when oil prices reached $140/barrel, America was spending about $700 billion for foreign oil, equaling the greatest transfer of wealth in history. Today, the U.S. is still heavily dependent on foreign oil, spending nearly $1 billion a day for the commodity, enriching many OPEC nations with interests hostile to America. The plan calls for expanding the use of domestic renewable resources, such as wind and solar, in power generation, and using our abundant supplies of natural gas as a transportation fuel alternative to OPEC oil.

[VI] One means of combining economic development with PEV readiness is the concept of providing PEV charging to an existing attraction. Because Level 2 PEV charging requires at least 60 minutes or more to provide meaningful recharge for most users, the presence of PEV charging would provide an additional incentive to PEV owners to stop and enjoy the attraction (restaurants, shopping, dramatic presentation, museum, park, etc) while simultaneously recharging their PEV. Publicity (perhaps via the Texas PEV

Friendly program recommended in this chapter) along with a quality attraction and convenient co-location is all important to making PEV charging an element in economic development of a community.

VII A study published in 2011 by the Belfer Center, Harvard University, found that the gasoline costs savings of plug-in electric cars over the vehicles' lifetimes do not offset their higher purchase prices. This finding was estimated comparing their lifetime net present value at 2010 purchase and operating costs for the U.S. market, and assuming no government subidies.[43][44] According to the study estimates, a PHEV-40 is US$5,377 more expensive than a conventional internal combustion engine, while a battery electric vehicle is US$4,819 more expensive. Henry Lee and Grant Lovellette (July 2011). "Will Electric Cars Transform the U.S. Vehicle Market?". Belfer Center for Science and International Affairs, Kennedy School of Government. http://belfercenter.ksg.harvard.edu/publication/21216/will_electric_cars_transform_the_us_vehicle_market.html?hq_e=el&hq_m=1303999&hq_l=5&hq_v=4613decb42. Retrieved 2011-08-07.^ Henry Lee and Grant Lovellette (July 2011). "WillElectricCars Transform the U.S. Vehicle Market?". Belfer Center for Science and International Affairs, Kennedy School of Government. http://belfercenter.ksg.harvard.edu/files/Lee%20Lovellette%20Electric%20Vehicles%20DP%202011%20web.pdf. Retrieved 2011-08-07.Discussion Paper #2011-08.

VIII ECOtality North America, Electric Vehicle Charging Infrastructure Guidelines for the State of Texas, prepared for CCET, released May 15, 2012.

IX The Federal vehicle tax credit for PEVs and the details can be found at the federal sites linked here:

- US Federal Plug-in Vehicle Incentive = http://www.fueleconomy.gov/feg/taxphevb.shtml
- IRS Code = http://www.irs.gov/businesses/article/0,,id=219867,00.html

X California has provided an additional $2500 for zero emission vehicles such as BEVs, but the State does now include EREVs, like the Volt in the $2500 maximum. The following states currently offer vehicle incentives that are Volt-inclusive:

- ✓ Hawaii - $4,500 Rebate
- ✓ Illinois - $4,000 Rebate (Purchase only)
- ✓ Pennsylvania - $3,500 Rebate (Purchase only)
- ✓ Tennessee - $2,500 Rebate
- ✓ California - $1,500 Rebate
- ✓ West Virginia - $7,500 Income Tax Credit
- ✓ Colorado - $6,000 Income Tax Credit
- ✓ South Carolina - $1,500 Income Tax Credit
- ✓ Utah - $605 Income Tax Credit (Purchase only)
- ✓ Maryland - $2,000 Excise Tax Exemption

XI No special permitting is required to use the Level I cord set to charge, but in some rare cases, the addition of the load may be more than the service panel is equipped for (usually occurs in older homes with 60 amp service).

XII Britta Gross, VP of GM infrastructure.

XIII Costs for a Level 2 charging station were generally less than $1000 for the equipment and another $1000 for permitting and installation of 220 VAC as of mid 2012. An example of package installation is cited at http://www.metroplugin.com/faq/what-is-the-cost-of-a-level-2-charging-station-for-the-home.

XIV Kero, et al, California Plug-in Electric Vehicle Collaborative, in a report distributed by DOE, Clean Cities Coalition to CCET and other recipients of the DOE readiness grants. The report is entitled Streamlining the Permitting and Inspection Process for Plug In Electric Vehicle Home Charging Installations.

XV Bill Barker, AICP, of the City of San Antonio's Environmental Office provided the material on their program including *Municipal Deployment of Electric Vehicle Supply Equipment for Public and Fleet Charging*, DOE, Joel Danforth primary author. This report identifies the San Antonio program as a best practice for cities.

XVI http://www1.eere.energy.gov/cleancities/evitp.html is the website for the Clean Cities Coalition EVITP program.

XVII http://www.cleancities.tv/FeaturedContent/Training/EVSEResidentialChargingInstallation.aspx

XVIII http://www.fieldtechnologies.com/fedex-expanding-green-fleet-with-new-electric-vehicles/

XIX Dave Hurst, senior analyst for Pike Research. May 6, 2011 report cited in http://www.pikeresearch.com/research/hybrid-electric-vehicles-for-fleet-markets .

XX http://www.dailyenergyreport.com/2011/05/u-s-launches-1st-federal-electric-vehicle-pilot/

XXI The Electrification Coalition is dedicated to reducing America's dependence on oil through the electrification of transportation. Our primary mission is to promote government action to facilitate deployment of electric vehicles on a mass scale. The Coalition serves as a dedicated rallying point for an array of electrification allies and works to disseminate informed, detailed policy research and analysis. The EC is headed up by board chairmen and CEOs of more than 15 U.S. corporations.

XXII LEED Certification stands for Leadership in Energy and Environmental Design and is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. Certification assures that a building project is environmentally responsible, profitable, and a healthy place to work. LEED is a third party certification system by the US Green Building Council. Certification is achieved through acquisition of points thereby providing flexibility and optimizaiton.

XXIII It is often stated by PEV critics that PEVs merely redistribute air pollution by causing greater emissions from the power plants in exchange for reduced or no emissions from the vehicles. This is wrong on several counts: a) emissions from power plants are highly controlled, easily monitored, and enforced compared to vehicles; b) an electric motor is much efficient than is a gasoline engine in terms of converting energy from a fossil fuel source to automotive power; c) power plants that run on nuclear energy or natural gas are inherently cleaner than gasoline engines; and, the dispersion between a power plant stack and the population is much greater than what occurs when tens of thousands of motor vehicles are emitting at ground level in urban areas (i.e., the concentration and exposures are higher for mobile source emissions).

[XXIV] During the course of developing this Plan several individuals from different backgrounds have suggested that the Plan emphasize the economic development potential of PEV adoption in a local community. In addition to the"green" image that a community may want to project, the small towns and mid-size cities along the corridors of the Texas Triangle may want to take the disadvantage of the 30 to 60 minute charging times for PEVs traveling through their community (a disadvantage to the driver enroute to other destinations), and provide their "captive guests" with sightseeing, eating, and shopping opportunities. This in turn could have PEV owners looking forward to the excuse to spend time in the town that has provided attractions linked to intercity charging.

[XXV] Guidance material from Clean Cities Coalition and several OEMs along with anecdotal testimonies point to the essential need for a local PEV task force to oversee and promote this type of local program. Without their enthusiasm and expertise, this initiative could deteriorate into another bureaucracy. The selection of these volunteers and their level of commitment and enthusiasm is critical.

[XXVI] Of the menu of options, the first is mandatory for those communities seeking PEV-Friendly status. The reason is that the establishment of a task force or core team is essential to carrying out the other options.

[XXVII] As noted elsewhere in this Plan, the *potential* recommendations are those prepared by the author of this chapter of the Plan. The potential recommendations were revised by the Technical Advisory Group and then revised again by the CCET board of directors resulting in the final recommendations presented in the Summary.

[XXVIII] Without the ability to charge overnight at home, the PEV owner would need to have an assured means of charging at work or at parking facility equipped with EVSE.

[XXIX] Press Release, NRG Energy, March 23, 2012. Retrieved from http://finance.yahoo.com/news/nrg-energy-inc-build-unprecedented-182800086.html

[XXX] See ERCOT Planning, "2012 Long-Term Demand and Energy Forecast," December 2011; KEMA Report, "Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems," March 2010; ERCOT Emerging Technology Tracking System, Vehicle to Grid, http://www.ercot.com/gridinfo/etts/vehicle/

[XXXI] The assumption going into to this Plan was that the lack of intercity charging infrastructure for PEVs would present a barrier to PEV market penetration. Hence an essential part of "PEV readiness" would be to address the limited range of the BEV segment of the PEV market by allowing a driver of a BEV to make the more than 200 mile trip between Houston and Dallas, for example, with confidence that he could recharge along the way. It may be that the concern regarding range anxiety may be misplaced given the availability of PHEVs such as the Chevy Volt, that allow consumers to take advantage of the environmental and economic benefits of an electric vehicle for the great majority of their *intracity* travel with the flexibility of taking longer trips in rural areas without having to worry about the availability of ESVE nor the time required to recharge. If indeed the need to forge intercity links with an ESVE is less urgent than initially thought, it is still a valuable exercise to look at what such an intercity linkage would look like and how it might be accomplished as a part of the longer range electrification of transportation given the inherently lower front end costs of BEVs versus PHEVs.

[XXXII] (Prozzi and Harrison, 2007)

[XXXIII] The end points of the highway corridors represent the edges of the metro areas that are currently being addressed in the build out of ESVE infrastructure. Planning beyond these edges (i.e., east of Katy on I-10 and south of Georgetown on I-35 are within the jurisdictions of ongoing planning entities such as the regional councils of governments and/or being met through privately funded initiatives.

[XXXIV] (SAE International 2011)
[XXXV] (Kley, Lerch, and Dallinger 2011).
[XXXVI] Google 2012
[XXXVII] Coulomb 2012)
[XXXVIII] (eVgo 2012)
[XXXIX] (ECOtality 2012a)
[XL] (Cross, Pelletier, and Varhue 2008)
[XLI] (Smith et al. 2011)
[XLII] (U.S. DOE 2012)
[XLIII] (Daganzo, Gayah, and Gonzales 2012)
[XLIV] (Schroeder and Traber 2012)
[XLV] (ECOtality 2012b)
[XLVI] (Center for the Commercialization of Electric Technologies 2012)
[XLVII] (ECOtality North America 2011a)
[XLVIII] (ECOtality North America 2011b)
[XLIX] (Daganzo, Gayah, and Gonzales 2012)

[L] To reduce some of this confusion, for the most part, this Plan uses the term PHEV to include EREVs because the distinction is a technical one described in 6.1.2 and the endnote that follows this one. Both PHEVs and EREVs are not subject to sole reliance on recharging the batteries and therefore their drivers are not subject to range anxiety. See additional details in the note below.

[LI] Battery electric vehicles have the advantage of relatively simple powertrains which are expected to provide many miles of very low fuel cost, low maintenance, quiet, and enjoyable driving. They are typically more attractive to two-vehicle families whose around town commuting needs can be met with the BEV, while their longer distance driving needs can be met with their second vehicle given the range and charging speed limitations of their BEV.

Too often, however, the range limitations and higher capacity charging needs of BEVs are incorrectly associated with conventional-range equivalent EREVs and PHEVs. EREVs and PHEVs can be a family's sole vehicle, can be driven any distance by simply stopping at gas stations similar to today's vehicles, and can very simply be charged by plugging into the typical 120V electrical wall outlet that is pervasive in virtually every home in the U.S. In summary, the "range anxiety" of BEVs is non-existent with EREVs and PHEVs. This critical distinction needs to be highlighted in the proposed consumer information program.

[LII] Over the past year, the news of a fire in the battery pack of a Chevrolet Volt 3 weeks after it had been catastrophically crash tested raised concerns about the safety of the Lithium Ion batteries which are used in this newest generation of PEVs. The results of the NHTSA investigation revealed that while the gasoline tank had been properly drained after the test, the damaged Chevrolet Volt had been improperly stored after the crash without its battery properly discharged. The investigation cleared the Volt and reaffirmed its 5-star safety rating. The Chevrolet Volt and Nissan Leaf are the two most popular PEVs sold in the U.S. today and, to date, no Volts or Leafs have experienced a vehicle fire in the hands of an actual driver. It is also important for drivers to understand that over 200,000 conventional gasoline/diesel vehicles catch fire in the U.S. each year (http://www.usfa.fema.gov/downloads/pdf/statistics/v9i1.pdf). There is no evidence to date that PEVs will be any more prone to vehicle fires than today's cars and trucks.

The long term durability of the expensive lithium batteries incorporated in the recently introduced PEVs is of understandable concern. Given the demonstrated reliability of the NiMH batteries in Toyota Prius hybrid, the considerable R&D emphasis placed upon methods to ensure long term durability of Lithium batteries, and the 8 year/100,000 mile warranties on the Volt and Leaf make some experts optimistic that the batteries will have an acceptably long life.

[LIII] The Texas electricity market has a unique mix of regions with competitive retailers providing electric service offerings in large cities such as Dallas/Ft Worth and Houston, member owned co-ops (typically in rural areas, small towns, or suburban areas), and municipally owned vertically integrated utilities in such cities as Austin and San Antonio. Each one of these types of electric providers has different incentives, concerns, and interests in PEVs. Hence there will likely be unique policies, codes, rebates, or tariffs related to PEVs. For example, electric retailers in Dallas/Fort Worth/Houston may not be concerned with distribution transformer stress from PEV clustering given they do not own and are not responsible for the distribution transformers. They may, however, create special rates for off-peak PEV charging to reduce their average wholesale cost of electricity.

Vertically integrated municipal utilities which can own generation, distribution, and retail customer operations may provide rebates for residential Level-2 EVSE installation or special PEV tariff structures to enable demand response for reducing peak demand stress on the grid or PEV clustering stress on distribution transformers.

The rural co-ops may have a lack interest for many years given many of their members drive pickup trucks or SUVs, drive long distances, and may use a truck for their work needs. There may be a considerable amount of time required before cost competitive range-extended EREV/PHEV pickup trucks are available. These rural co-ops may choose to do nothing more than continue to provide flat rate electricity tariffs and ask that their members contact them to assess their transformer loading if they do buy a PEV. Co-ops serving more suburban areas may have a concern with PEV clustering as the owners of distribution systems. In summary, regionalized communications with local content would be useful in increasing awareness, clarifying the advantages of, and accelerating the adoption rate of PEVs in Texas.

[LIV] A number of insights were provided from and issues raised by our Technical Advisory Group. For example, the group posed the question: how will the communications plan provide information to consumers or other PEV interested parties if they either do not have internet access or do not know where to start their search for Texas relevant PEV information on the internet? To provide more complete coverage to as many potential PEV-interested parties, we propose having regular articles which can provide the basis for periodic announcements, background information, or articles in paper flyers which are typically stuffed in the monthly bill from an electricity provider, an electric Co-Op, or Municipally owned utility to their customers. While the end-customers of these Munis/Co-ops/Energy Retailers may not have internet access, it is reasonable to provide these potential articles to the Munis/Co-ops/Energy Retailers efficiently via a website or electronic email distribution for their use in their paper communications to their customers.

[LV] A detailed description of different PEV configurations is described in Chapter 7.1of this Plan.

[LVI] US new car sales are tracked on a monthly basis through a collaboration of HybridCars.com and Baum & Associates, see http://www.hybridcars.com/news/september-2012-dashboard-53157.html

[LVII] A number of Government agencies and private companies are making projections on the number of PEV cars on the road and new car sales through 2020. Examples are: Pike Research, Electric Vehicle Geographic Forecasts, http://www.pikeresearch.com/research/electric-vehicle-geographic-forecasts

[LVIII] Petroleum product price forecasts are made by the US Energy Information Agency. Motor gasoline prices are projected to increase at a annualized growth rate of 3.4% though 2035. http://www.eia.gov/forecasts/aeo/pdf/tbla12.pdf

[LIX] Research and Innovative Technology Admistration, Buereau of Transportation Statistics, 2010 results, http://www.bts.gov/publications/national_transportation_statistics/html/table_04_01.html

[LX] Energy security for the DoD is considered of strategic importance. There are a number of programs underway to reduce the energy consumed on military bases. One such program is referred to as the Net-Zero Base Initiative. http://energy.defense.gov/

[LXI] Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, Part 1: Technical Analysis, Michael Kintner-Meyer, Kevin Schneider, Robert Pratt; Pacific Northwest National Laboratory, http://www.ferc.gov/about/com-mem/wellinghoff/5-24-07-technical-analy-wellinghoff.pdf and Impact Assessment of Plug-in Hybrid Vehicles on the U.S. Power Grid, Michael Kintner-Meyer, Tony Nguyen, Chunlian Jin, Patrick Balducci, Thomas Secrest, Pacific Northwest Laboratory, http://energyenvironment.pnnl.gov/ei/pdf/Impact%20Assessment%20of%20PHEV%20on%20US%20Power%20Grid.pdf

[LXII] Preparing the Distribution Grid to Embrace Plug-in-Electric Vehicles, Dr. Arindam Maitra, EPRI, http://www.naefrontiers.org/File.aspx?id=35295

[LXIII] The DOE has established the date of 2015 for one million PEVs to be on the US roads. Industry projections have extended the date to beyond 2015. In the Chapter 5 analysis the Plan assumes the date would be 2017. Regardless of the calendar date, there are activities or programs required to be in place by the realization of that milestone in order to reach the PEV fully integrated grid depicted in Fig 7-2.

[LXIV] In response to DOE Financial Opportunity Announcement (FOA) 708, CCET submitted a proposal on June 14, 2012. CCET would manage the two year program, with the majority of the work being performed by Texas based Clean City Coalition staff. In addition to this fleet ancillary service pilot, the program, if funded, would help implement two other components of the Texas Triangle PEV Readiness Plan: the Texas PEV Friendly Community program and a statewide website for consumer information.

[LXV] For this Plan, the term PHEV includes extended range electric vehicles (EREVs) such as the Chevy Volt.

[LXVI] NEVs (neighborhood electric vehicles) are street legal, frequently one third the price of BEVs, and achieve the same clean air and fuel savings benefits of BEVs, where owners are willing to live with the range, speed, and comfort limitations of these vehicles.