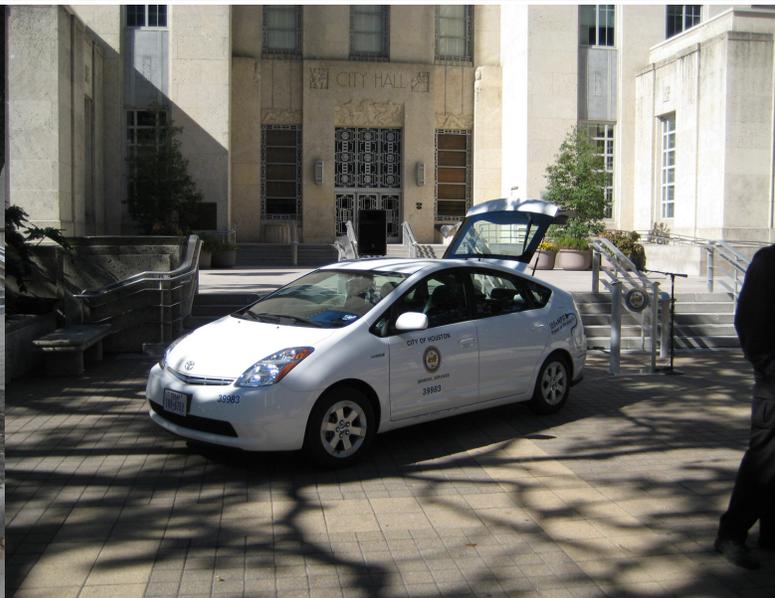




Electric Vehicle Charging Long Range Plan for the Greater Houston Area



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Acronyms

BEV	Battery Electric Vehicle—Vehicle powered 100% by the battery energy storage system available on-board the vehicle.
CCID	Charge Current Interrupting Device—A device within EVSE to shut off the electricity supply if it senses a potential problem that could result in electrical shock to the user.
EV	Electric Vehicle
EREV	Extended Range Electric Vehicle—see <i>PHEV</i>
EVSE	Electric Vehicle Supply Equipment—Equipment that provides for the transfer of energy between electric utility power and the electric vehicle.
ICE	Internal Combustion Engine
kW	Kilowatts—A measurement of electric power. Used to denote the power an electrical circuit can deliver to a battery.
kWh	Kilowatt Hours—A measurement of total electrical energy used over time. Used to denote the capacity of an EV battery.
NEC	National Electric Code—Part of the National Fire Code series established by the National Fire Protection Association (NFPA) as NFPA 70. The NEC codifies the requirements for safe electrical installations into a single, standardized source.
NEMA	National Electrical Mfg. Association—Group that develops standards for electrical products.
PHEV	Plug-in Hybrid Electric Vehicle—Vehicles utilizing a battery and an internal combustion engine (ICE) powered by gasoline, diesel, or other liquid or gaseous fuels.
REEV	Range Extended Electric Vehicle—see <i>PHEV</i>
RTP	Real Time Pricing—a concept for future use whereby utility pricing is provided to assist a customer in selecting the lowest cost charge.
SAE	Society of Automotive Engineers—standards development organization for the engineering of powered vehicles.
TOU	Time of Use—an incentive-based electrical rate established by an electric utility that Bases price of electricity on the time of day.
V2G	Vehicle to Grid—a concept of using battery storage on electric vehicles to supply power to the electrical grid.
VAC	Voltage Alternating Current often referred to simply as AC.

Executive Summary

The *Electric Vehicle Charging Long Range Plan for the Greater Houston Area* (LRP) provides a look forward at a mature electric vehicle (EV) market and the implications for creating a readily accessible vehicle charging infrastructure that is critical to success. The Plan is part of the City of Houston's *EV Project Community Plan*[™]. The report, *Recommended Electric Vehicle Charging EV Infrastructure Deployment Guidelines for the Greater Houston Area*, was prepared in the early part of this planning process in 2010. The *Guidelines* were prepared in coordination with the City of Houston, The Clinton Foundation, ECOtality North America, and the Houston EV Project Advisory Team. The *Guidelines* and *Long Range Plan* help focus stakeholders and provide a good foundation for the *EV Microclimate Short-Range Plan*.

The City of Houston is the fourth largest city in the nation with a population of 2.1 million within a metropolitan area of 5.9 million people. The area is home to the country's largest petrochemical and refining complex, the country's second-largest port, and on-road travel that exceeds 140 million vehicle miles traveled per day. Houston is also a leader in addressing the challenges of energy efficiency and air quality, including reduced greenhouse gas emissions (GHG), through initiatives such as the Emissions Reduction Plan (ERP) which set forth actions for reducing three key sources of GHG emissions: buildings and structures, waste, and mobile sources. For mobile source emissions and fuel efficiency, the City has restructured its fleet management and acquired one of the largest city hybrid electric fleets in the country. Prior to this long range planning process, the City became part of *Project Get Ready*, an EV initiative for cities, acquired funding for EVs and EV charging infrastructure, and joined the *C40 Cities Climate Leadership Group*.

The long range plan for an EV charging infrastructure is a blueprint for an accessible, effective EV network, one that provides sufficient public charging stations for the number of EVs that need to be served. The Plan addresses five key questions:

- (1) What are current travel characteristics relevant to electric vehicles and charging?
- (2) How large will the EV market be in the U.S., and the scale of electric vehicle support equipment (EVSE) to support these vehicles?
- (3) What EVSE will be needed to serve vehicle owners, which includes not only individuals, but fleets, businesses, and governmental agencies?
- (4) What will the Houston area experience in terms of vehicle sales, and in the development of supporting infrastructure (EVSE)?
- (5) How will charging infrastructure be deployed and implemented?



Nissan LEAF
Introduced in Texas in Houston



DC Faster Charger

Electric vehicles have fueling requirements that are unfamiliar to consumers. Therefore, it is important to understand how vehicles are used day-to-day, particularly the cars and trucks that most people rely on. National data show that average vehicle trips are less than 10 miles, and most trips are even shorter. Such distances are well within the capabilities of available EVs or models that will be in the market next year (80 to 120 miles). Most households have more than two vehicles providing choices for longer trips. However, the range of travel is an important concern that must be addressed in the LRP. To address this concern, the Plan establishes a guideline for public charging to be available within one-mile of every point in the 1,300 square mile urbanized area.

Electric vehicles are already available for Houston buyers including the Nissan (Leaf) and General Motors (Volt). The Ford Focus electric and other vehicles will become available late in 2011. The characteristics of various types of EVs and their charging requirements are discussed in detail in Section 4, including battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and extended range electric vehicles (EREV). Section 6 of the plan addresses the question of how many EVs will be on the road in the near term and by 2020.

U.S. market growth projections examined in the planning process range widely. The EV market share of all U.S. vehicle sales is projected to fall within a range of 2.1 to 7.4% by 2020. Many urban areas are expected to have higher market segments than nationwide projections. Houston's long range plan projections increase from 2011 with new vehicles reaching 6.7% of new vehicles purchases by 2020. The projected number of EVs on the road in 2020 would total 73,000 vehicles. Early deployment (the next one to two years) of EVSE charging infrastructure is essential for this growth to occur.

EVSE systems provide for the safe transfer of energy between the electric utility power supply and the electric vehicle. The charging process needs to be comfortable, convenient, and reliable. With the penetration of EVs into the automotive market, a corresponding penetration of this charging equipment will be required. The types of EVSE are Level 1 (110/120 v), Level 2 (220/240 v), and DC Fast Charge (440v), with DC Fast Chargers providing the shortest charging time, more like that of current gasoline refueling. Level 2 and DC Fast Chargers are the key components for public charging infrastructure. Level 2 is also likely to be the preferred EVSE for home charging.

The acceptance of EVs by the general public requires a readily available public EVSE infrastructure as part of the overall EV owner's charging patterns, which will likely include home and possibly workplace charging. The projected number and distribution of EVSE are set forth in Section 6 and 7. Projections are for 480 public charging locations in place by the end of 2012. Houston is fortunate to have NRG Energy's eVgo initiative that will place at least 50 co-located Level 2 and DC Fast Chargers in highly accessible locations with the Houston urban area during this start-up period.



eVgo charging network

The early market launch of EVs in the Houston area is helping to create a more informed public and enhanced public awareness of EVs. The LRP considers demographic factors that are indicative of potential EV markets, including single-family residences, education levels, availability of two or more vehicles, existing hybrid vehicle ownership, and travel characteristics. Houston area vehicles are driven on average 38 miles per day. The average commute time is 26 minutes (or 17 miles at 40 miles per hour). Such travel characteristics are feasible with EVs.



Location analysis for charging stations

Trip destinations are key to defining where publicly available charging will be located. The amount of time spent at destinations (dwell time) is important in selecting appropriate EVSE. Level 2 equipment is best suited for locations where EV drivers will spend 45 minutes to 3 hours. Unlike conventional fueling, these are locations that are normal part of household travel, where the charging

stations are a consumer amenity and service rather than a separate type of trip. Dwell time is less important for DC Fast Charging (Section 7), which is more like conventional fueling. These charging locations can be a destination by itself since only 15 to 25 minutes are needed to recharge.

The Houston area is also fortunate to have a relatively new and resilient electric power grid as compared with other U.S. cities. In addition, Houston's retail energy providers and electric utility companies are leaders in the deployment of smart grid technology and services that will be necessary for optimizing electric vehicles relationship with the charging infrastructure. The transmission and distribution companies are particularly aware of the need for grid reliability down to the block level where EVs will be charging. The LRP recognizes the need to coordinate and communicate among the different entities involved in deployment of EVs and EVSE into the Houston area. CenterPoint Energy will likely continue to conduct analysis and responses as EV transportation technologies become part of the Houston area market.

Local governments are also active participants in this market, with responsibilities for electrical and building codes, permits and inspections. Inspection and permitting systems must be kept up to date and responsive. For example, the City of Houston has instituted a 24-hour permitting process for residential charging equipment. Coordination and communication among local government officials and utilities will be part of implementing EV charging requirements.

As this LRP describes, Houston has a strong market for vehicles, and significant support to create a readily available EVSE infrastructure. As examples, Ecotality is providing home charging for qualifying Volt purchasers; NRGs eVgo is building a program for home and public charging; the City is deploying EVs and EVSE for its fleet, and vehicle manufacturers are looking to Houston as an early vehicle market. Therefore, Houston is well positioned to be an EV leader.

The Long Range planning process is an important step for ensuring that the Houston area has a readily available and accessible EVSE infrastructure that will support a strong EV market. The next step in this process, the EV Micro-Climate Plan, will help clarify short-term actions that will achieve the long-term goals.

1 Introduction

The City of Houston (City) is the fourth largest city in the nation, with an estimated 2009 population of 2.26 million¹. At 5.9 million people, the Houston metropolitan area is the sixth largest in the U.S. and in the last ten years has grown by more than 1.1 million people. The Houston area is home to the country's largest petrochemical and refining complex, the country's second-largest port, and on-road travel that exceeded 140 million vehicle miles traveled per day. Consequently, Houston faces significant challenges in air quality, including emissions of greenhouse gases (GHG). In response, the City has been a leader in addressing these challenges. In August of 2008, the City issued an Emissions Reduction Plan (ERP) setting forth actions on three key sources of GHG emissions: buildings and structures, waste, and mobile sources. The City has implemented and continues to implement numerous other actions to improve air quality and reduce GHG emissions.

Vehicle electrification is a key action that Houston has instituted working with the Clinton Climate Initiative, the Houston Advanced Research Center, ECOTality North America, the Rocky Mountain Institute, Texas A & M University, and the University of Texas at Austin. The Houston Electric Vehicle Initiative is building capacity within communities and working through partnerships across multiple stakeholder groups to create ongoing air quality improvements and GHG reductions. These efforts support the achievement of the City's broader environmental, economic, health, and social co-benefits.

As part of this initiative, the City has asked ECOTality North America to work with its partners and stakeholders to develop an EV Micro-Climate™ program that will help ensure that Houston is well prepared to support the consumer adoption of electric transportation. Beginning with extensive feasibility and infrastructure planning studies, the program provides a blueprint that will create a rich EV charging infrastructure in the Houston area. The program is being developed with all pertinent stakeholders, including governmental organizations, utilities, private-sector businesses, and automotive manufacturers.

The EV Project provides a continuation of the work that has been done in Houston to achieve the region's long range goals. It cannot by itself complete the necessary infrastructure but the long range plan will provide the guidance for planning this infrastructure growth and focusing on the near term for locating infrastructure.

¹ U.S Census Bureau, <http://factfinder.census.gov>

2 Driver Behavior – National Household Travel Survey

The National Household Travel Survey (NHTS) serves as the nation’s inventory of daily travel. Data are collected on daily trips taken in a 24-hour period, providing a better understanding of travel behavior. In this survey, respondents are asked to complete a diary of their travel for a 24-hour period. The survey specifies a trip date and the diary starts at 4 a.m. on that date, even if it is an unusual travel day for the respondent. This date can be any day of the week, including weekend days. The diary then continues through the destinations reached by the respondent during that day. As noted in Section 3.3 below, these destinations fall into several categories, including “Home,” since daily travel generally involves at least one trip home.

2.1 Daily Trips for All Vehicles

The following figure presents data from the NHTS survey, which has been conducted every seven years since 1969. A vehicle trip typically involves travel from home to a destination and back home, or a minimum response of two. Some trips will start away from home and return home, resulting in one reported trip. Overall, the total vehicle miles traveled on a daily basis appears has increased over time, but leveled off since 1995.

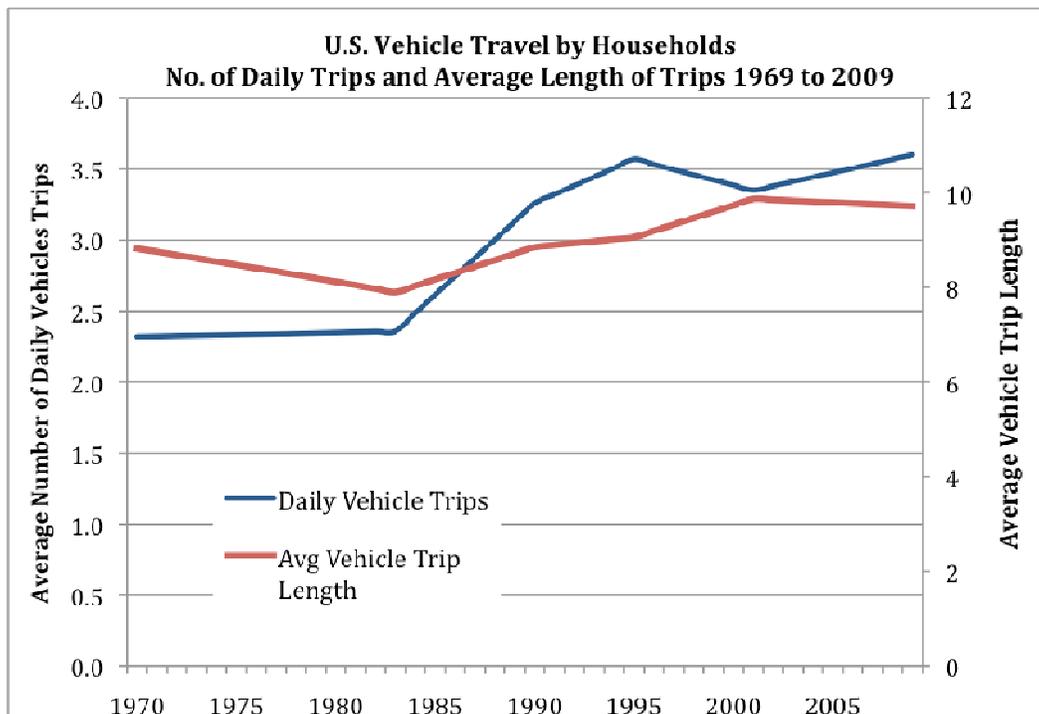


Figure 2-1 Average Daily Vehicle Trips and Trip Length for All Household Vehicles²

The average vehicle trip length for all household vehicle types has declined somewhat in recent years in response to fuel price fluctuations and economic conditions.

Combining these two averages suggests that average daily travel is approximately 35 miles, well within the range of near-term EVs. The daily travel required by individuals will be a factor in their decision to obtain an EV. Because these are average travel lengths and numbers of trips, many can be longer, publicly-available charging stations are important to potential EV buyers.

² NHTS Surveys Conducted Since 1969

2.2 Daily Trip Length by Purpose

The 2009 average weekday vehicle miles traveled by household vehicles was 9.72 miles, a decrease from 9.87 in 2001 following almost twenty years of increasing travel.³ For daily vehicle trips, Figure 2-2 identifies the percentage of trips for each of ten purpose categories. Other than the trips home, the single most common purpose of the car is for shopping or errands, followed by work and social activities. When this information is combined with that of the average number of trips per day, it shows that most drivers make several types of trips each day. Driving to and from work often involves a side trip and stops along the way, particularly on the return trip from work. Trips related to school often occur in the morning work trip. Destinations for stops are important in evaluating charging infrastructure. While vehicles spend most of their time either at home (80%) or work (4+ hours per weekday), the number and types of trips suggests that other charging opportunities are needed.

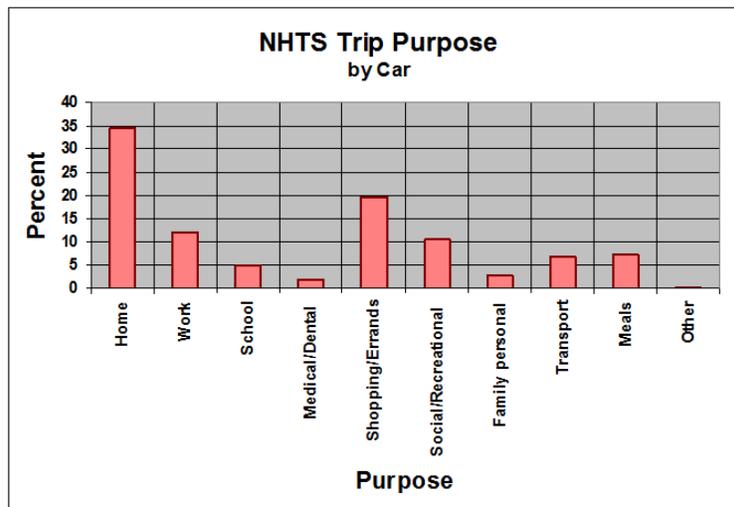


Figure 2-2 Percentage of Daily Car Trips by Purpose⁴

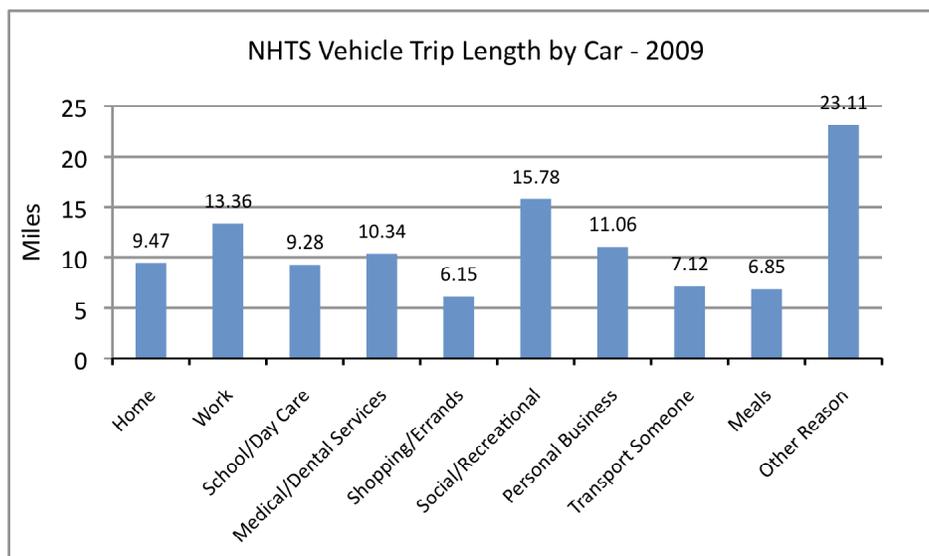


Figure 2-3 Vehicle Trip Length by Car by Purpose⁵

³ 2009 NHTS, Average Vehicle Trip Length (miles, Travel Day), Average Vehicle Trip (VT) Length by Purpose http://nhts.ornl.gov/tables09/fatcat/2009/avtI_WHYTRP1S.html

⁴ NHTS, 2009

Note: All trips reported by NHTS are "from" trips. This means that a Home trip is from home. A work trip is from work. A trip from home to work is a home trip.

Distances traveled to and from work are not necessarily the longest trips taken on a daily basis. The data show that drivers are willing to travel farther for social or recreational activities or other trips of importance. This would make the charging infrastructure at those destination points at least as important, and perhaps more important, than work locations.

2.3 Vehicle Information

Figure 2-4 identifies the two-vehicle household as the most common, with an equal percentage of households having one or three vehicles. As will be seen later, it is expected that households that will own an EV likely will have two or more vehicles. NHTS data below shows that 50.7% of households have 2 or more vehicles.

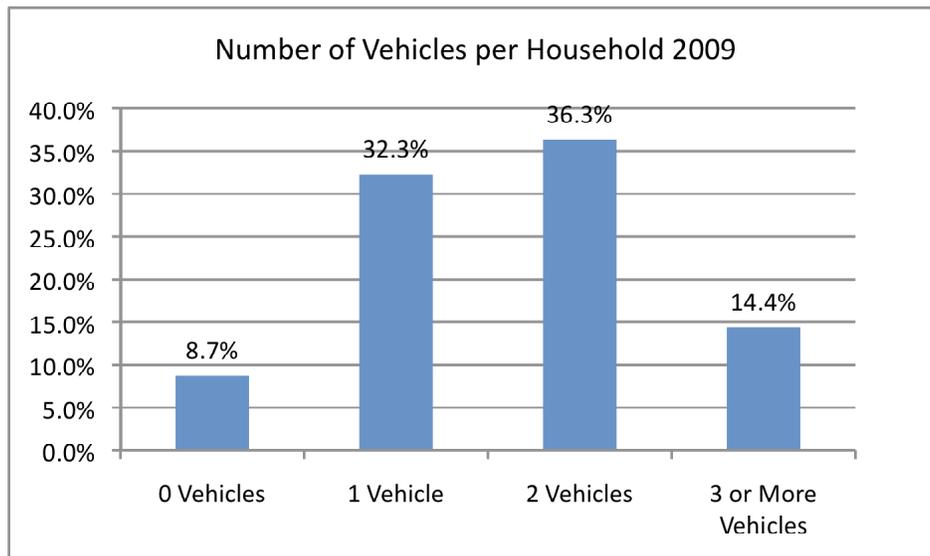


Figure 2-4 Numbers of Vehicles per Household⁶

2.4 Other Travel Characteristics

A significant percentage of vehicle traffic during peak travel times of day is not work-related travel. As seen in Figure 2-5, shopping and errands hold a greater percentage of car trips than work. While the 2009 data are not available specifically on this topic, this is similar to that reported in the 2001 data set.

The amount of travel for non-work purposes, including shopping, errands, and social and recreational activities, is growing faster than work travel. Growth in these kinds of trips is expected to outpace growth in commuting in the coming decades.⁷

In addition to this trend, a number of workers stop to shop, including getting coffee or a meal, during the commute. Commuters stop for a variety of reasons, such as to drop off children at school or to stop

⁵ NHTS, 2009 - <http://nhts.ornl.gov/2001/pub/STT.pdf>

⁶ NHTS, 2009

⁷ NHTS Brief, *Congestion: Non-Work Trips in Peak Travel Times*, U.S. Department of Transportation, Federal Highway Administration, www.nhts.ornl.org April 2007.

at the grocery store on the way home from work. Real-life examples show that trip chaining is often a response to the pressures of work and home. But the data also show that some of the growth in trip chaining has been to grab a coffee or meal (the “Starbucks effect”), activities that historically were done at home and did not generate a trip. Where vehicles actually spend sufficient time is the key factor in providing charging locations. Home locations are usually 8 hours and more and work locations are often 5 hours or more. In addition, these locations occur most days during the week. Other locations are less frequent and sporadic. There has been limited research on what these locations are, but certainly include very diverse locations.

The overall growth in travel for shopping, family errands, and social and recreational purposes reflects the busy lives and rising affluence of the traveling public. The growth in non-work travel not only is adding to the peak periods, but also is expanding congested conditions into the shoulders of the peak and the midday. See Figure 2-5.

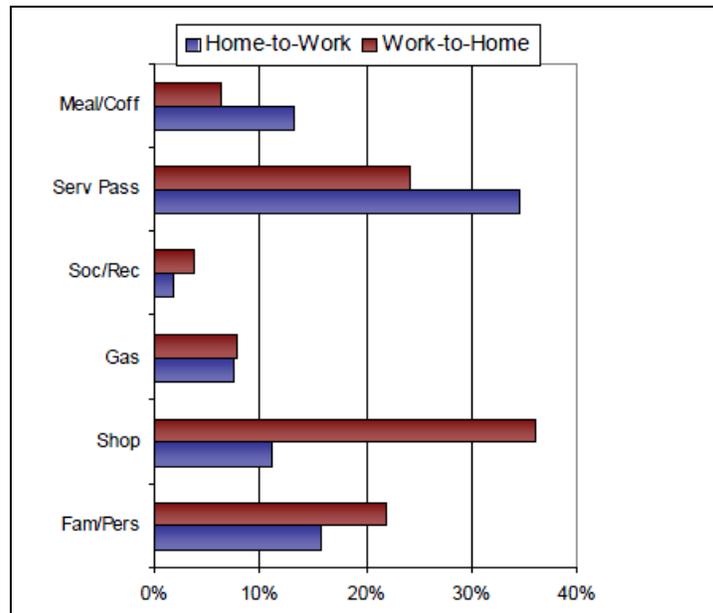


Figure 2-5 Non-Work Trips at Peak Periods⁸

In 2009, about one out of six vehicle trips used an interstate highway for part or all of a trip during an average weekday. About 44% were going to or from work, but 56% were traveling for other reasons. Trips involving the interstate are almost three times longer than other trips – nearly 28 miles on average, compared to just 10 miles for other vehicle trips.

These results suggest that the availability of EV charging stations along the interstate highway system will be important. The longer trips on the highway, coupled with the desire to keep the stops to a short duration, will increase the desire for faster charging systems (see Section 7, DC Fast Charging).

2.5 Houston Travel Characteristics

As we discussed, two factors contributing to the potential growth in EV for the Houston area are local air quality issues and vehicle market size. Houston is one of the most populous cities in the U.S. with a large number of vehicles and large number of commuters driving to work. Houston has more commuting vehicles per worker than New York or Chicago⁹. The Houston area, including Harris County, had

⁸ ibid

⁹ U.S. Census Bureau 2009

approximately 4.5 million registered vehicles in its jurisdiction in 2009¹⁰. As one of the largest urban areas, the Houston area faces congested road conditions. The 2010 Urban Mobility Report rated the Houston area as 4th among the 15 largest U.S. cities in terms of travel auto commuter delay, and 2nd for excess fuel use by auto commuters as a result of congestion.¹¹

The average travel time to work in Houston is 15.4% greater than the Texas average and 15.4% greater than the national average. Average travel time is 26 minutes. The percentage of people who take public transportation in Houston is greater than the Texas average due to availability of public transit, although this percentage is lower than many other U.S. cities. The percentage of people who carpool to work in Houston is 13.9%. The percentage of people who work from home in Houston is 8.2%, which is 22% less than the national average¹².

In 2008, the Houston annual average vehicle miles traveled (VMT) per vehicle was 14,218 miles and average daily VMT was 38.95¹³ miles, well within the range of the early EVs.

Figure 2-6, shows the result of Central Houston, Inc.'s (CHI) survey of downtown employees in March 2009 on commuting behavior. The results show 48% of downtown workers use private vehicle for their work trip. In addition, respondents travel an average of 21 miles to reach their downtown work location, spending 39 minutes getting to work and 43 minutes getting home. CHI obtained home zip codes of employees from downtown employers that commute from areas within the EV Project boundary.

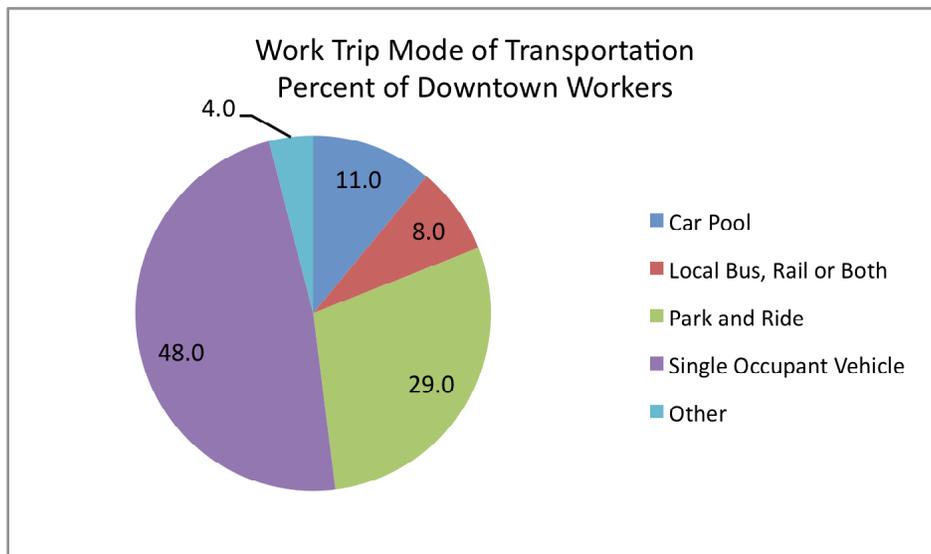


Figure 2-6 Downtown Workers Mode of Transportation¹⁴

Figure 2.7 shows the comparison of mean travel time to work from the EV Project boundary from the year 2000 to 2005-2009. Note that the travel time to work for those living in these counties has not increased in most cases.

¹⁰ ibid

¹¹ D. Schrank, T. Lomax, and S. Turner, 2010 Urban Mobility Report, Texas Transportation Institute, p. 22. Report available at <http://mobility.tamu.edu>

¹² TxDOT 2009 census journey-to-work data

¹³ Polk Data for 2008

¹⁴ 2009 Downtown Houston Commute Survey Report

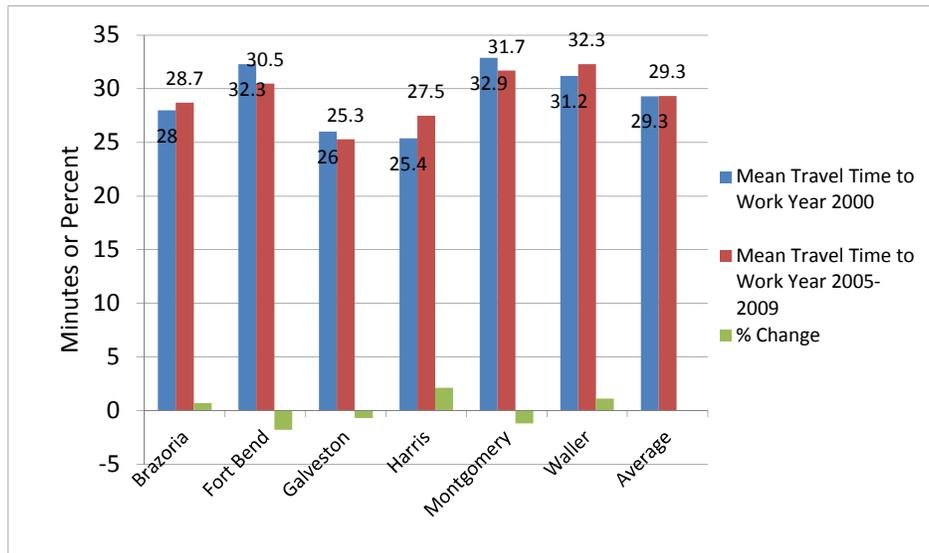


Figure 2-7 Mean Travel Time to Work – Comparison of 2000 and 2005-2009¹⁵

In Table 2.1 below, in the greater Houston area, Vehicle Trip Length by Purpose, the greatest number of trips are home based, non-work (HBNW) trips which includes shopping, going out for a meal and social or recreational. In addition, simple commutes to work (from home to work and then returning home) comprise about a quarter of all trips traveled. Other simple trips taken from the home include dropping off and picking up from school and personal business. Most of the complex chaining of trip purposes occurs for non-work trips – but over 6% is conducted during the work commute¹⁶.

Table 2-1 2009 Household Travel Survey – Motorized Trips by Purpose¹⁷

Trip Purpose	Motorized Trips	Motorized Trips%
Home Based Work	9,249	17.01%
Home Based Non-Work (HBNW)- All	29,356	53.98%
HBNW - Retail	10,389	19.10%
HBNW-Education 1 Non School Bus	8,287	15.24%
HBNW-Education 1 By School Bus	0	0.00%
HBNW-Education 2	738	1.36%
HNW Airport	94	0.17%
HBNW -Other	9,848	18.11%
Non-Home Based (NHB)-All	15,775	29.01%
NHB - Work	3,564	6.55%
NHB - Other	12,211	22.45%
Totals	54,380	100.00%

2.6 Summary

Average travel distances by Houston area drivers are well within existing EV capabilities, most households have additional vehicles for longer trips. Houston drivers make several trips to different types of destinations on a daily basis, and although the number of trips does not significantly change from weekday to weekend, the trip purposes do. These daily trips are typically shorter and can also be

¹⁵ US Census Bureau, 2009

¹⁶ TTI, 2009

¹⁷ HGAC 2009 Household Travel Survey Preliminary Result by Texas Transportation Institute

accommodated by existing EVs. These trip destinations are an important determining factor in placing publicly available charging infrastructure.

3 Electric Vehicle Projections for the United States

Long-range planning for EV infrastructure must start with an evaluation of how many EVs are expected to be deployed over the next ten years. This section develops a response to that question by beginning with the types of EVs expected and each type's characteristics. Note that the discussion focuses on sales of vehicles with the full speed and safety characteristics necessary for modern highways – not low-speed electric vehicles, which also have a role in future urban mobility.

3.1 EV Types

Battery Electric Vehicle (BEV)

Battery Electric Vehicles (BEVs) are powered 100% by the battery energy storage system available onboard the vehicle. The Nissan LEAF and Ford Focus are examples of BEVs. Refueling the BEV is accomplished by connection to the electrical grid through a connector that is designed specifically for that purpose.

Plug-in Hybrid Electric Vehicle (PHEV)

PHEVs are powered by two energy sources. The typical PHEV configuration utilizes a battery and an internal combustion engine (ICE) powered by either gasoline or diesel. Manufacturers of PHEVs use different strategies in combining the battery and ICE. Some vehicles, such as the Chevrolet Volt, utilize the battery only for the first several miles, with the ICE providing generating power for the duration of the vehicle range. Others may use the battery power for sustaining motion and the ICE for acceleration or higher energy demands at highway speeds. Frequently, the vehicles employing the former strategy gain a designation such as PHEV-20 to indicate that the first 20 miles are battery only. Other terms related to PHEVs may include Range Extended Electric Vehicle (REEV) or Extended Range Electric Vehicle (EREV). The Chevrolet Volt is an example of an EREV.

3.2 EV Batteries

Recent advancements in battery technologies will allow EVs to compete with ICE vehicles in performance, convenience, and cost. From an infrastructure standpoint, it is important to consider that as battery costs are driven down over time, the auto companies will increase the size of the battery packs, and thus the range of electric vehicles.

- **Relative Battery Capacity**

Battery size or capacity is measured in kilowatt hours (kWh). Battery capacity for electric vehicles will range from as little as 3 kWh to as high as 40 kWh or more. Typically, PHEVs will have smaller battery packs because they have more than one fuel source. BEVs rely completely on the battery pack's storage for both range and acceleration, and therefore require a much larger battery pack than a PHEV for the same size vehicle.

- **Battery Charging Time**

The time required to fully charge an EV battery is a function of the battery size and the amount of electric power (measured in kilowatts (kW)) that an electrical circuit can deliver to the battery. Larger circuits, as measured by voltage and amperage, will deliver more kW. The common 110-120 volts AC (VAC), 15 amp circuit will deliver at maximum 1.1 kW to a battery. A 220-240 VAC, 40 amp circuit (similar to the circuit used for household appliances like dryers and ovens) will deliver at maximum 6 kW to a battery. This maximum current may be further limited by the vehicle's on-board battery management system. Table 3-1 provides information on several different on-road highway speed electric vehicles, their battery pack size, and charge times at different power levels to replenish a depleted battery, assuming the onboard battery management systems allows each power level.

Table 3-1 EV Charge Times

EV Configuration	Battery Size (kWh)	Circuit Size and Power in kW Delivered to Battery			
		120 VAC, 15 amp 1.2 kW	120 VAC, 20 amp 1.6 kW	240 VAC, 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 12Amps x .85 eff.; 120VAC x 16Amps x .85 eff.; 240VAC x 32 Amps x .85 eff.; 480VAC x $\sqrt{3}$ 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 3-2 provides a comparison based upon a vehicle efficiency of 4 miles/kWh of charge.

Table 3-2 Miles Achieved per Charge Time

Miles Achieved per Charge Time*					
Charge Time	Circuit Size and Power in kW Delivered to Battery**				
	Level 1 120 VAC, 15 amp 1.2 kW	Level 1 120 VAC, 20 amp 1.6 kW	Level 2 240 VAC, 20 amp 3.3 kW	Level 2 240 VAC, 40 amp 6.5 kW	DC Fast 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

- **Trends in Battery Capacity**

As the EV industry grows, it is fully anticipated that batteries will grow in capacity, and thus the range of vehicles will grow, as well. Larger capacity battery packs will require more energy to recharge, and consequently the recharge time will be extended. Charging systems using 110 VAC circuits will become less and less relevant and higher kW chargers will become more relevant.

3.2.1 Lightweight Materials

Another recent advancement that will allow EVs to compete with ICE vehicles in performance, convenience, and cost is the introduction of lightweight materials. Since hybrid cars are built using

lighter materials, it gives them an advantage with gas mileage. The heavier a car is, the more fuel is required to power it. Lightweight cars use a reduced amount of energy which translates into fuel savings. SUVs weigh more and consequently burn more fuel. Hybrid cars using alternative fuels such as biodiesel enjoy many of the savings. Hybrid SUVs get better gas mileage than their gas burning counterparts, but it is still low compared to very lightweight passenger cars.” Source: <http://www.carsdirect.com/hybrid-cars/do-hybrid-cars-get-better-gas-mileage>

3.3 EV Sales Analysis

There is a high degree of uncertainty when projecting sales of conventional automobiles and electric vehicles. Because of the economic downturn, most automotive companies are not publishing forecasts of vehicle sales. Domestic gasoline prices over the next 10 years will serve to drive demand for more efficient vehicles, but projections are not reliable. Past trends cannot be used to predict future sales either, due to the loss in sales volumes through the past few years. Most automotive original equipment manufacturers (OEMs) have announced plans for EVs in the next few years, and the anticipated diverse vehicle inventory and subsequent out-year enhancements are expected to make EVs competitively priced, even if gasoline prices are in the sub-\$2 per gallon range. The wide range of vehicle platforms is expected to make EVs attractive for most demographic groups. Several investment firms have made projections for sales of electric vehicles, and these projections provide a range of possible penetration rates. Appendix A provides details of these projected penetration rates. The information is summarized in Section 4.4.

3.3.1 BEV and PHEV

The early hybrid vehicles that entered the automotive market were very similar to their internal combustion engine (ICE) sister models. The failure of the EVs introduced in the 1990s led some to believe that the consumer was not ready for a dramatic change in the driving experience. Hence, the hybrid was developed as a way to increase gasoline mileage without requiring a dramatic change in customer behavior. Some of that thinking continues with the PHEV. For all types of PHEV, the internal combustion engine will always provide the backup power, so consumers do not really have to change their driving behavior unless they consider the gasoline engine to be just that: a backup to the battery.

The BEV, on the other hand, operates differently from the ICE vehicles. The consumer will have to be conscious of the vehicle’s range and battery capacity, similar to the attention an ICE driver must pay to the fuel gauge. However, as new BEV drivers gain confidence (partly due to the rich EVSE infrastructure) and the vehicle range is extended with higher-capacity batteries, it will assist in a greater adoption rate of BEV. A likely scenario is a future with a multitude of technologies operating together.

In any new market, the innovators and early adopters are willing to endure some inconvenience for the privilege of enjoying the new technology. For BEVs, the lure is stronger than usual. All of the benefits of electric drive vehicles toward reducing dependence on foreign oil and increasing environmental cleanliness add to the attractiveness of the EV. For more pragmatic individuals, the reduced cost of ownership becomes important. BEV owners will quickly adapt to the changes that driving a fully electric vehicle require. These same reasons make the electric side of a PHEV much more attractive than the ICE side. It is expected that the PHEV buyer will adjust driving behavior to stay away from ICE operation as much as possible. This new learned behavior will naturally lead to the realization that the ICE is not necessary.

On the other hand, as battery capacity increases, the recharge times will be extended and even at the 60 kW charge level, restoring a battery charge may exceed the wait time comfort of some drivers. That probably will require an increase in the charging power for DC Fast Charging. For drivers taking long trips, the PHEV may still be the vehicle of choice. While projecting EV penetration is still difficult, the first major OEM to deliver mass-produced vehicles is offering a BEV. In the subsequent years, many analysts

believe that PHEV sales will dominate the market, but will be overtaken by the BEV sales by the end of the decade.

Lyle Dennis, EV enthusiast and editor of gm-volt.com, had a discussion with Mark Reuss, GM's President of North America, and quoted him as follows.

“Long-term demand (for) BEV could be higher as EREV initially leads the way with battery technology like the lithium-ion pack in the Volt...first gen,” stated Reuss. The initial EREV technology as he sees it “then feeds BEV-like vehicles.”

“While EREV will be wildly popular at first with Volt,” says Reuss, “as the technology flows down to BEV in what will be smaller cars to carry smaller packs, that may be the higher-volume play over a longer time.”

Since Reuss is in charge of GM North America sales and marketing, his opinions are likely to play a significant role in the company's strategy going forward.¹⁸

3.3.2 Consumers

The Everett Rogers Diffusion¹⁹ of Innovations theory suggests that typical market penetration of any product follows a standard distribution curve. Different segments of consumers can be identified on this curve. To clarify this, he defines these terms as part of his overall theory: Product Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. Source:

http://www.enablingchange.com.au/Summary_Diffusion_Theory.pdf

- The Product Innovators are the first to try a new product. Having the newest technology and being first is important to these consumers. They are venturesome and highly educated. Price is not as important as the innovation.
- Early Adopters are next, who again are well educated, but take a more reasoned approach where there needs to be value associated with the product.
- The Early Majority follows, where the product is selected in a deliberate manner. It meets specific needs and provides the value desired.
- The Late Majority followers, who are skeptical and prefer the traditional and standard market products.
- Finally, the Laggards are considered, who may never purchase the new product or will do so only if it becomes the only choice.

¹⁸ GM Exec: *Long Term BEV Demand will be greater than EREV*, <http://gm-volt.com>, March 2010

¹⁹ Everett M. Rogers, *Diffusion of Innovations*, Fifth Edition 2003, Free Press, New York,

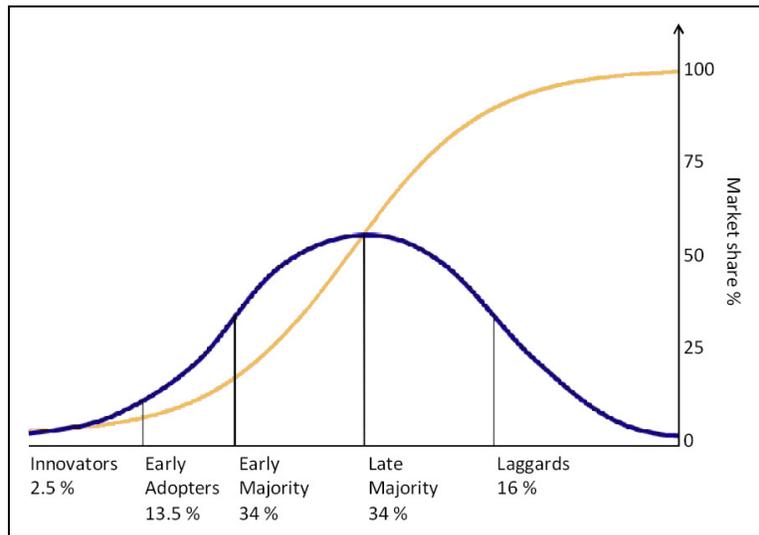


Figure 3-1 The Diffusion of Innovations According to Rogers

Deloitte suggests the Early Adopters from 2010 to 2020 will share demographics as follows:

- Similar to early adopters of hybrids
- Highly concerned about foreign oil dependency, as well as environmentally conscious.
- There are 1.3 million men and women in the US who have the demographic characteristics of the Early Majority segment.

3.3.3 Automotive Manufacturer Plans

Many OEMs have announced plans for the introduction of EVs or PHEVs in the near future. A summary table of these plans is shown in Table 3-4.

Table 3-3 OEM PHEV and EV Plans

Make	Model	All Electric Range (mi)	Battery Size (kWh)	U.S. Target Intro. Date
Plug In Hybrid Electric Vehicles				
Audi	A1 Sportback	31-62		2011
BYD Auto	F3DM	60		2010
Fisker	Karma	50		2010
Ford	Escape	40	10	2012
General Motors	Chevrolet Volt	40	16	2010
Hyundai	Blue-Will	38		2012
Toyota	Prius Plug-in	12.4-18.6		2012
Volvo	V70	31		2012
Battery Electric Vehicles				
BMW	ActiveE	100		2011
BYD Auto	e6	205		2010
Chrysler/Fiat	Fiat 500	100		2012

Make	Model	All Electric Range (mi)	Battery Size (kWh)	U.S. Target Intro. Date
Coda Automotive	Coda Sedan	90-120		2010
Daimler	Smart ED	72-90		2012
	Mercedes Benz BlueZero	120	35	2010 low vol.
Ford	Focus	100		2011
	Transit Connect	100		2010
	Tourneo Connect	100	21	2011
Hyundai	i10 Electric	100	16	2012
Mitsubishi	iMiEV	100	16	2010
Nissan	LEAF	100	24	2010
Rolls Royce	Electric Phantom			2010
SAIC	Roewe 750	125		2012
Tesla Motors	Roadster	220	56	For sale now
	Model S	160, 230, 300		2011
Th!nk	City	113		2010

There remains a strong push to bring EVs and PHEVs to market in the near future. The table above also provides valuable information on the range of vehicles that have been announced. Note that the range figures are published by the OEM and can vary dramatically with driver behavior and climatic and geographic conditions.

3.4 EV Sales Projections

Projections of EV penetration into the market vary greatly from one source to another. The vehicle manufacturers are not releasing their information to the public, other than perhaps the next year's forecast. Public acceptance is still a big question that can partly be resolved by the infrastructure, but public policy and incentives will go a long way to promote or detract from that acceptance.

President Obama has set a goal to have a total of 1 million EVs on the road by 2015. That administration goal would require the annual penetration rates shown in Figure 4-2: Annual EV Sales Projections. ETEC, dba as ECOtality has also conducted a study of EV penetration as part of the EV Project, for which the results are also shown in Figure 4.2, along with other penetration forecast described in Appendix A (page 56) Appendix A explores the current projections worthy of note, along with Morgan Stanley's and Deutsche Bank and Deloitte.

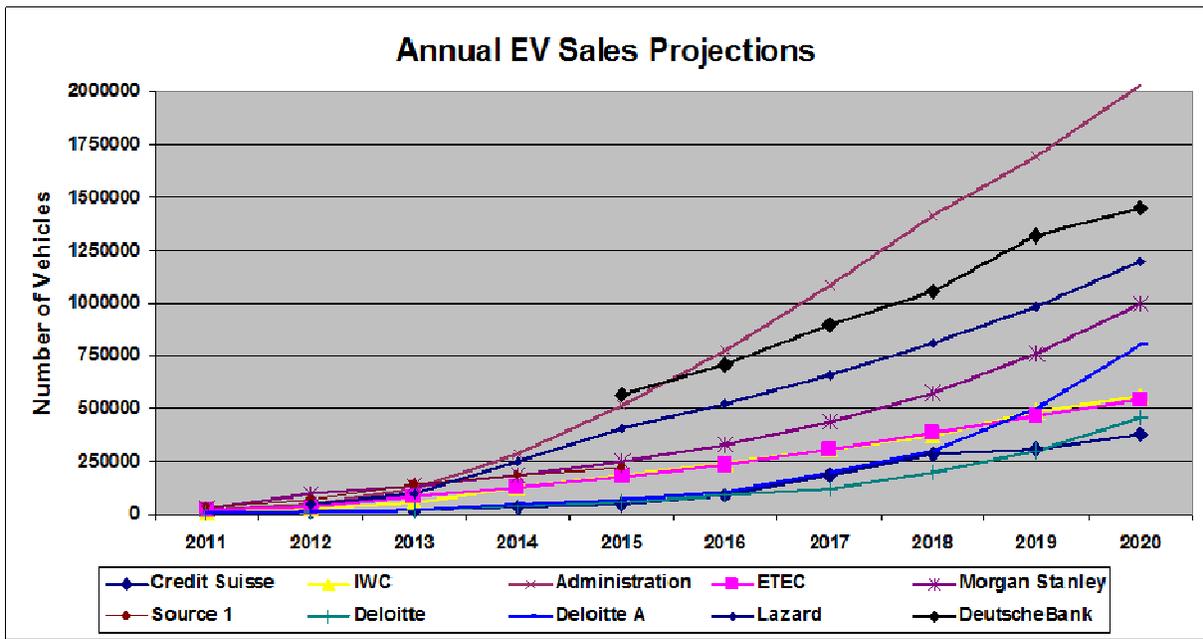


Figure 3-2 Annual EV Sales Projections – Various Sources – See Appendix A

There appears to be a fairly close agreement on a minimum sales projection of about 500,000 EVs per year by 2020. Using this as a minimum or conservative view, a more optimistic view could be that of Deutsche Bank, with the middle prediction by Morgan Stanley. This gives us a range of likely EV annual sales.

The Houston EV Project Advisory Team suggests a conservative projection that can be considered as a reasonable base for more detailed planning as adoption rates increase over time. EV penetration above the levels in this plan will provide additional incentive and demand for increased EVSE deployment. Figure 4-3 shows projected U.S. annual sales and the cumulative EV population through 2020. This would result in almost 2.5 million EVs on the road in the U.S. by 2020.

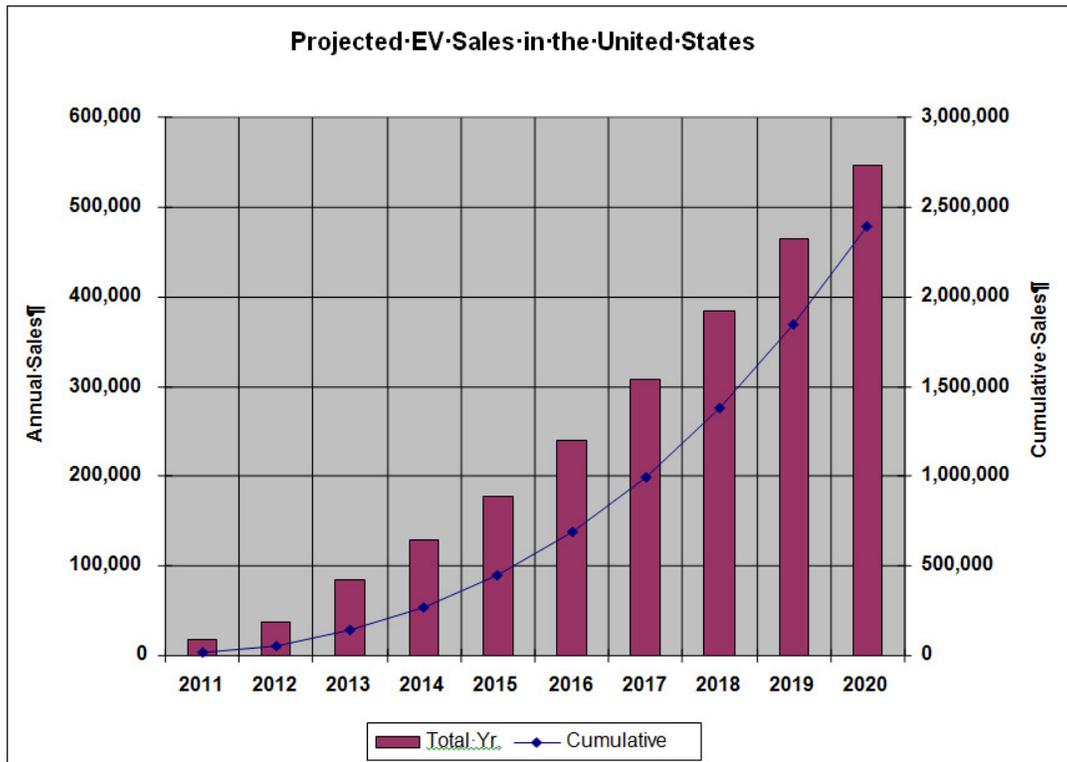


Figure 3-3 Projected EV Sales in the United States²⁰

3.5 EVs as Part of the Overall Vehicle Mix

The automotive market has been particularly slow during the economic downturn, although the most recent reports reflect a turn around. Incentives have helped spark sales, but near-term predictions remain cautious. While few are willing to make sales projections, most suggest that car sales are starting to recover in 2011 and will continue into 2012. R. L. Polk & Co. predicts a return to 15 million units in 2013, according to its most recent U.S. light vehicle forecast. Anticipating a U-shaped recovery for the U.S. light vehicle market, Polk's forecast indicates a return to more normal levels of activity by 2013. In addition to the forecast, Polk expects the market share for Japanese brands in the U.S. to stabilize, reaching 40.1% in 2013, which is similar to their current market share.

"We also expect a more even split between passenger cars and light trucks, with passenger car volume reaching 8.3 million units," reported Dave Goebel, North American forecast consultant for Polk.²¹ EVs will contribute to the overall mix of vehicles, as shown in Figure 4-3. By 2020, these EV sales will account for 3.1 to 5.6% of total new car sales.²²

The total number of passenger cars in the United States in 2007 was 135,932,930.²³ The 2.5 million cumulative EVs expected in 2020 will remain a small fraction of the total number of vehicles. However, the increasing penetration rate for EVs, coupled with the retirement of the older ICE vehicles, will maintain a positive upward trend.

²⁰ US DOT RITA Bureau of Transportation Statistics, https://www.bts.gov/publications/national_transportation_statistics/#chapter_1

²¹ R. L. Polk & Co, 2009

²² *ibid*

²³ National Transportation Statistics, Table 1-11: *Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances*, www.bts.gov, March 2010

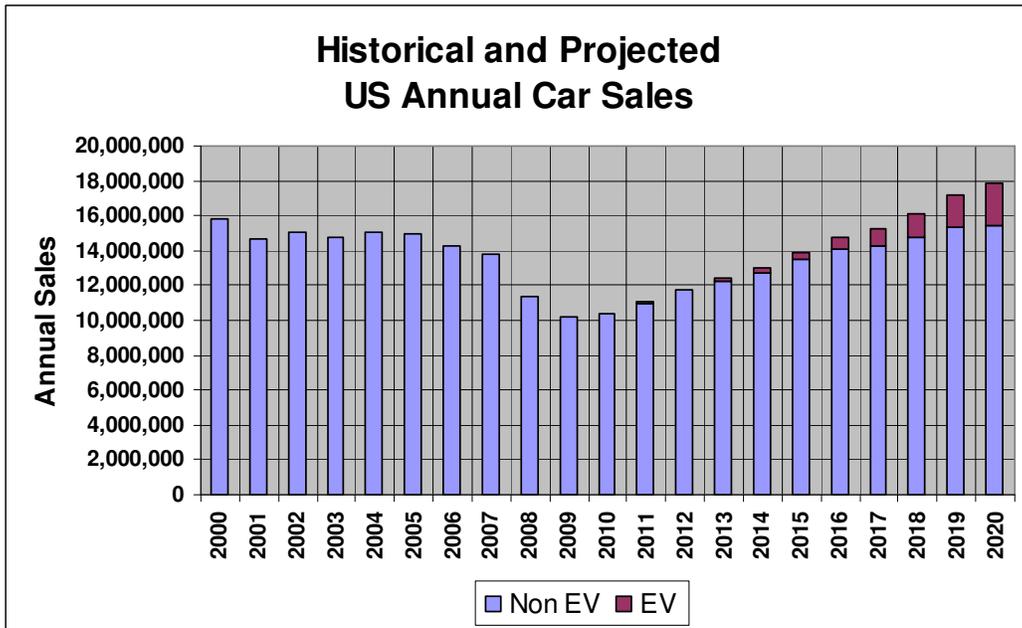


Figure 3-4 US Annual Car Sales²⁴

3.6 Fleet Vehicles

Fleet managers will have a variety of options when selecting an EV for their purposes. The capabilities of the BEV and PHEV will be well known, and vehicles can be quickly tailored for the intended vehicle mission. The range of the vehicle/battery combination required by the vehicle’s mission likely will determine the vehicle chosen. Where the usage is highly variable, a PHEV may be selected. BEVs may be chosen when specifically counting on recharging between trips.

Fleet managers are likely to be quite creative in managing their fleets, including maintaining an inventory of varying-range vehicles and providing computer programs to manage the vehicle by mission. These tools will ease the transition of fleets to EVs.

Projections of EVs selected as fleet vehicles are generally included in the total EV numbers. The percentage of fleet vehicles is expected to be higher in the early years as governmental agencies, utilities, and other major vehicle purchasers adopt EVs to encourage EV Market growth. At the end of 2008, there were a total of 4,882,000 cars in government, utility, and private fleets in the United States.²⁵ That accounts for about 3.6% of the total vehicle population at that time.

The [American Recovery and Reinvestment Act \(ARRA\) of 2009](#) included \$300 million to acquire electric vehicles for the federal vehicle fleet. This grant money is intended to assist in the early transition to EVs in fleet applications.

²⁴ ibid

²⁵ Business Fleet, 2009 Fact Book Stats, www.businessfleet.com

4 EVSE Projections in the United States

For EVs to succeed, they must provide a comfortable, convenient, and reliable transportation experience. Unless a rich charge infrastructure is in place prior to vehicle launch, EV owners will not be able to comfortably travel without experiencing “range anxiety” that the vehicle battery will run out of energy before reaching a charger, more correctly called “electric vehicle supply equipment” (EVSE).

EVSE systems provide for the safe transfer of energy between the electric utility power supply and the electric vehicle. PHEVs and BEVs require the EVSE in order to charge the vehicle’s on-board battery. With the penetration of EVs into the automotive market, a corresponding penetration of this charging equipment will be required. This section identifies the equipment that will be available and probable penetration numbers over the next decade.

The Society of Automotive Engineers (SAE) has agreed that all vehicles produced by automakers in the United States will conform to a single connector design, known as the *J1772 Standard*.²⁶ The J1772 connector and EV inlet will be used for both Level 1 and 2 charging levels, as described below.



Figure 4-1 J1772 Connector



Figure 4-2 J1772 Inlet (right side)

The Level 1 method uses a standard 120 volts AC (VAC) branch circuit, which is the lowest common voltage level found in both residential and commercial buildings. Typical voltage ratings can be from 110 – 120 volts AC. Typical amp ratings for these receptacles are 15 or 20 amps.

Level 2 is considered by many to be the preferred EVSE to meet expected consumer requirements. The J1772 approved connector allows for current as high as 80 amps AC (100 amp rated circuit); however, current amperage levels that high are rare. A more typical rating would be 40 amps AC, which allows a maximum current of 32 amps; or as another example, 20 amps AC, which in turn allows a maximum current of 16 amps. This provides approximately 6.6kW or 3.3 kW charge power, respectively, with a 240 VAC circuit. See Table 3-1 for typical recharge times at these levels.

Because charge times can be very long at Level 1 (see Table 3-1, page 12), many EV owners will be more interested in Level 2 charging at home and in publicly-available locations. Some EV manufacturers suggest their Level 1 cord set should be used only during unusual circumstances when Level 2 EVSE is not available, such as when parked overnight at a non-owner’s home. As the EV battery gains in energy density with longer range on battery only, the effectiveness of the Level 1 equipment for battery recharge will lessen and greater emphasis will be given to Level 2 and DC Fast Charging.

²⁶ While the J1772 Standard will be utilized by all automakers in the United States, it is not necessarily the standard that will be used in other countries. This standard is the subject of a harmonization project with the Canadian Codes. A common connector is also the goal of European, Asian, and North American designers.

The term Level 3 has been superseded by more descriptive terms; “DC Fast Charging” is used in this document. DC Fast Charging is for commercial and public applications and is intended to perform in a manner similar to a commercial gasoline service station, in that recharge is rapid. Typically, DC Fast Charging would provide a 50% recharge in 10 to 15 minutes. DC Fast Charging typically uses an off-board charger to provide the AC to DC conversion. The vehicle’s on-board battery management system controls the off-board charger to deliver DC directly to the battery.

4.1 Level 2 Charging

The deployment of Level 2 Charging will occur in the residential, fleet, commercial, public, and workplace/employer areas.

4.1.1 Residential

Electric utilities are tasked with providing sufficient and reliable energy. One of the challenges to be overcome is the uneven nature of daily and seasonal power usage. As demand for electricity varies throughout the day, the utility is required to add or subtract power generators to keep up. It would be more economical for utilities to reduce the peaks and fill in the valleys of this curve. The preferred method of residential charging will be Level 2 (240VAC/single-phase power) in order to provide the EV owner a reasonable charge time and to also allow the local utility the ability to shift load as necessary while not impacting the customer’s desire to obtain a full charge by morning. If EV owners charge nightly, as recommended and as needed for the electric power grid, fast charging is less important. For other PHEV owners, a dedicated Level 1 circuit may adequately meet the owner’s charging needs.

BEV owners who have the option of Level 2 charging at work or in public areas may find that the vehicle battery remains at a higher charge, meaning home charging time is not a concern and Level 1 will suffice. See Figure 3-1 (page 15) for relative battery sizes and estimated recharge times.

Even so, the EV owner will want the convenience of a rapid recharge of their vehicle battery at home, whether the vehicle is a BEV or PHEV. Deloitte research finds that only 17% of consumers are willing to charge from home when it takes eight hours for the recharge. Twice as many found home charging acceptable when the recharge required four hours. Many consumers will desire recharging to occur as fast as refilling the gasoline tank on an internal combustion vehicle, which gets into the range of the DC Fast Charging discussed in Section 6. Charging discussion seems to imply that owners will be recharging depleted batteries, rather than daily and even multiple charging during a day (keeping batteries charged up as often as possible). The Deloitte question about whether consumers would prefer 8 hours or 4 hours for charging duration misses the change in refueling behavior.

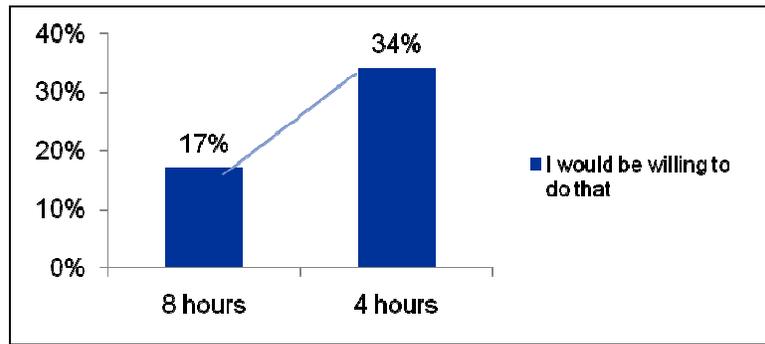


Figure 4-3 Preferences for Home Charging Duration²⁷

Analysts suggest that most recharging will occur overnight at the owner’s residence. The advantage for the owner is that most electric utilities that offer off-peak or EV special rates reduce their rates in the evening so vehicle charging can occur during the off-peak, lower-cost hours. Some electric utilities, however, designate the off-peak hours as 10 p.m. to 6 a.m., which is only eight hours. Again, the advantage of charging in less than the eight hours is evident.

Studies show that if all of the EV owners in a single neighborhood were to all set their EVSE to start when the off-peak time starts, the resulting spike could be substantial, which could potentially cause issues for the electric utility. When electric utilities begin to offer demand reduction programs to their customers and seek to balance loads for neighborhoods, new strategies probably will emerge, including rotating the charge times among neighborhoods powered off the same transformer. For example, CenterPoint determined that system-wide impacts from EVs are likely to be relatively minimal within the next decade, with additional peak load growing by no more than 5 percent. However, the localized impact of EVs, including excessive transformer loads, is of more concern. In particular, the analysis shows potential clustering of EVs which can result in high EV loads at a given transformer. Low charging levels during off-peak periods could notably limit overloading. However, as the number of EVs increases and the charging levels rise over the next ten years, transformer overloading is highly probable for certain regions of CenterPoint Energy’s territory. Careful management of EV loads could potentially mitigate such impacts. At the same time, the increasing vehicle battery capacity will require longer recharge times. EVSE will need to be capable of delivering a recharge in much less than the eight hours available at off-peak times.²⁸

In the next few years, incentive programs and consumer demographics will favor more Level 2 home installations. However, a significant number of people live in residences where a home charger may not be feasible – as an example, apartments or older urban neighborhoods with limited off-street parking. The US Census Bureau, 2005-2009 reports lists single family detached housing units as being an average of 68.8% of total housing units or 1,287,074 in the Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller counties that make up the greater Houston area.²⁹

4.1.2 Fleet

As noted in Section 4, fleet managers will have a variety of vehicles from which to choose. For PHEV users, maximizing the vehicle’s travel time on the battery is likely, since that approach will be more economical and have less impact on the environment. Consequently, the EVSE chosen will be sized for

²⁷ Deloitte Research, *Gaining Traction, A Customer View of Electric Vehicle Mass Adoption in the US Automotive Market*, January 2010

²⁸ KEMA and CenterPoint Energy Houston Electric, LLC “Electric Vehicles in Houston: Motivations, Trends, and Distribution System Impacts”, June 23, 2010

²⁹ US Census Bureau, 2000 Selected Housing Characteristics: 2005-2009

the recharge required by the vehicle mission. EVSE can easily be shared between vehicles, so some vehicles are charging while others are on the road. Some fleet managers may desire a mix of a few DC Fast Chargers with a larger number of Level 2 EVSE.

Fleet operations that currently provide a vehicle route in the morning and one in the afternoon likely will require one EVSE per vehicle to allow recharge at noon. The on-peak demand resulting from this may encourage managers to either change the route timing or select vehicles with greater range. Either way, managers will find ways to complete the mission with the least impact on electric and equipment costs. Maintaining low costs will likely result in fewer EVSE than vehicles.

Fleet managers are likely to rely on their own EVSE for the recharge of batteries, rather than depend upon the network of publicly-available EVSE. Publicly-available EVSE may not be vacant when needed or in a location suitable for the mission of the vehicle.

Fleet vehicles may include employer fleets where the EVs are purchased for the use of select employees. In these cases, the employer will determine whether an EVSE is installed at the employee's home, at the workplace, or both. Use of the company EV would likely allow private use of the EV, and thus the use of publicly-available EVSE, as well as the home base equipment.

It is expected that fleet managers will find ways to charge more than one vehicle from a single EVSE through fleet vehicle rotations or staggered shift starts.

4.1.3 Commercial EVSE

“Commercial EVSE” refers to those placed in retail or privately-owned locations (other than residences) that are publicly available. Like residential equipment, EVSE in these locations will focus on Level 2 and DC Fast Charging. Level 1 EVSE will become increasingly irrelevant. Locations sought for Level 2 will be those locations where the EV owner is likely to remain for a substantial period of time. That means that these will be destinations for the EV driver for which “purposeful” trips are made. The National Household Travel Survey found such destinations to include daycare, religious activities, school, medical or dental appointments, shopping, errands, social gatherings, recreation, family or personal, transporting someone, and meals. We could also easily add night clubs, sporting events, museums, shopping malls, theaters, government offices, attorneys’ offices, and numerous other places where people may park for one to three hours or longer. Revenue methods will be employed for retail owners to charge a fee for providing the charging service. As demand grows, good business models will expand the population of commercial Level 2 EVSE.

4.1.4 Public EVSE

“Public EVSE” refers to equipment placed on public-owned land that is publicly available. Like residential equipment, EVSE in these locations will focus on Level 2 and Level 1 EVSE will become increasingly irrelevant. These locations will be those where the EV owner is likely to remain 45 minutes to 3 hours of time, and can include government buildings, public parking lots, curbside parking, airport visitor parking, museums, etc. Public funding would be required to provide EVSE in these locations, and thus it is anticipated that the number of public EVSE installations will be substantially lower than the number of commercial EVSE installations.

4.1.5 Employer

Employers and office building managers may install EVSE to encourage employees to purchase EVs and to promote green certification of facilities. There are individuals and organizations that predict employer or workplace charging will closely follow home-based charging as the primary location for EV charging. There are a number of benefits, challenges, and questions for employers who wish to provide EVSE for employee use.

4.1.5.1 LEED Certification and Public Relations

Installation of workplace EVSE contributes to qualification for Leadership in Energy & Environmental Design (LEED) certification. LEED is an internationally-recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts.

Developed by the U.S. Green Building Council (USGBC), LEED provides building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions.³⁰

Workplace charging provides a significant corporate and public message from management on its environmental policy. Such a message encourages employees to consider their own use of EVs and thus assist in the adoption of EVs in general.

4.1.5.2 Employee Need or Convenience

Workplace charging will be important for those who may live at a significant distance or have no designated overnight vehicle parking location (see Section 4.1.5.6, page 29).

4.1.5.3 Employee Benefits

A question for the employer will be whether or not to provide free charging. The employer will either charge the employee for the use of the equipment or if providing charging at no cost, potentially create a 1099 taxable benefit.

In both scenarios, management will benefit from EVSE units that are highly functional, part of an existing network, and have a point of sale interface that provides the ability to collect specific use information for each vehicle connected or to bill the driver directly for each use.

Experience has shown that if the employer provides EVSE use without charging a fee, employees will conduct the majority of their EV charges at the workplace rather than at home.

4.1.5.4 How Many Units Should Be Installed?

There are three possible charging station installation scenarios: dedicated, open, and valet. Providing dedicated Level 2 EVSE for each employee with an EV can quickly become very expensive. Few parking facilities have electrical panels that can handle the load of numerous Level 2 EVSE before an electrical upgrade is required. One option for a dedicated parking scenario is to provide Level 1 EVSE instead. If an employee is parked for eight hours, Level 1 charging may be sufficient and this equipment is less expensive. Level 1 might be good option for employer based locations since most employers don't own their own buildings. The bigger challenge may be ensuring that charging locations don't have non-EV cars parked in them.

Providing electrical vehicle charging on an open basis will likely require that drivers move their vehicles during the day to accommodate other drivers that need a charge. Depending on the location, this could be very inconvenient and will require coordination among the drivers. Level 1 EVSE is not recommended for this scenario because of its very low charge return.

³⁰ U.S. Green Building Council, www.usgbc.org

In downtown office buildings, valet parking may be offered as a service by building management. Valet parking provides an easy means to assure an employee receives a fully-charged vehicle at the end of the day. In addition, several vehicles can be cycled through a Level 2 EVSE.

4.1.5.5 Electrical Load

Modern EVs will allow the driver to start the air conditioning or heater 20 minutes before leaving so that they have comfort on the way home without depleting the battery. It will be very convenient for people to pre-condition their vehicle before leaving work. On a wide scale, this can have a very negative impact on the electric grid, putting on a load during peak times. It is likely that in those locations, utilities likely will incentivize companies to preclude charging during peak load times.

4.1.5.6 Undesignated Parking

Undesignated on-street parking may be one of the few options available for many residences that do not have off-street parking or do not have adequate electrical service at their parking site. Some multi-family dwellings do not or will not allow private charging systems or their managers could see the EVSE as a nuisance and target for vandalism. On-street EVSE is likely to require higher maintenance because of increased exposure to traffic and vandalism.

As a result, EV enthusiasts will require alternate locations to charge their vehicles. The charging may be accomplished at nearby Level 2 retail locations or the safety-net DC Fast chargers, but could also be accomplished at the workplace. Management could provide this service and thereby increase the number of workplace chargers. Local legislation may be enacted that provides incentives to businesses and subsidizes the installation of workplace EVSE to accommodate this need.

For all of these reasons, it is difficult to predict what role workplace charging will have in the long term. It is likely that it will play a partial role in the charging of EVs, but not the significant role that some predict. The requirement to evaluate the benefits provided to employees versus the desire to avoid providing free charging will likely require fee-based charging at work that will naturally limit the access to those who actually need the charge. Supply and demand then will limit the number of EVSE stations the employer will install. It is anticipated that publicly-available charging will have a much higher impact on vehicle charging than workplace charging.

4.1.6 EVSE Requirements

The essential question raised is this: How many EVSE installations will be required to provide the necessary infrastructure? This should be viewed not only as the necessary but readily available infrastructure, where the number and availability of public charging locations results in convenient charging for EV owners. When the public sees that a high number of locations are available, they will be more receptive to entering the EV and PHEV markets. A readily available infrastructure is critical for a smooth transition from gas to electric and for consumer acceptance of electric transportation. We must stress that home charging will be a key element and first step in this direction.

The deployment of DC Fast Charge equipment will be addressed in Section 7. The remainder of this section will focus on Level 2 EVSE.

4.2 EVSE Projection Methods

ECOtality's methodology for projecting Level 2 EVSE sales over the next 10 years focuses on four major factors: geographic coverage, destination planning, refueling stations, and rich infrastructure. Section 5.2 provides the details of these projections; the four factors are summarized below.

4.2.1 Geographic Coverage

Because the cost of owning and operating EVs will become increasingly competitive, the EVs available by 2020 will appeal to a wider range of customers. This will require the available infrastructure to expand to cover an entire metropolitan area. Outlying communities, such as Sugarland and The Woodlands, are places where market conditions suggest good markets (higher income, higher education, multiple vehicles, and single family detached housing). These locations can expect to have some local infrastructure. While the highest demand will be at destination venues, additional EVSE will be required in the regions away from the city center, much in the way that gas stations are located. That geographic coverage is likely to be provided by zones that define the appropriate density of EVSE.

For urban planning, city center or specific regional destinations having the highest density of EVSE. Total projected EVSE required for the geographic coverage is that minimum needed to provide EV drivers assurance that they will not be stranded by a depleted battery anywhere in the metropolitan area.

4.2.2 Destination Planning

It was shown in the National Household Travel Survey that a significant number of trips for personal reasons to various destinations occur every day of the week. For destination planning, the metropolitan area is canvassed to determine the number of potential destinations and the number of EVSE that would be installed at each venue. The number of destination EVSE grows with the demand created by the introduction of EVs. Destinations need to be places where vehicles spend sufficient time (45 minutes to 3 hours). These may be shopping malls, restaurants, libraries, health clubs, etc., where people might spend time, including other non-employment business locations. Other locations may include golf courses, significant park areas where individuals and families spend longer amounts of time, etc. Destinations also include businesses that want to provide EVSE as part of their property or location.

4.2.3 Refueling Stations

Most studies of alternative fuels fueling stations (natural gas, propane, hydrogen) have shown that the number of conventional gas stations far exceeds what is needed to meet fueling needs. EVSE should not seek to replicate an inefficient system. EVSE planning needs to present a realistic, achievable future.

4.2.4 Readily Available Infrastructure

Analysts generally agree that the acceptance of EVs by the general public will require a readily available EVSE infrastructure. The EV owner will be comfortable with densely-distributed Level 2 equipment. Indeed, the visibility of this equipment will encourage others to consider purchasing an EV when they next choose a new car. In the early years of vehicle deployment, the ratio of publicly-available EVSE to the number of deployed EVs likely will be much higher than it might be in a mature market.

Table 5-1 provides the cumulative calculated number of EVSE installations to be deployed in residential, fleet, and public/commercial locations based upon the ECOtality methodology provided in Appendix A. This infrastructure is then identified as a percentage of total EVs. Recall that it was assumed that the number of EVSE installations for fleet applications would be two EVSE for every three fleet EVs. Also, recall that the number of residential EVSE installations is based upon assuming that 20% of HEV and BEV owners will use Level 1 at home or rely on workplace and publicly available infrastructure. It is also recognized that many EV owners may reside in locations without garages or convenient charging locations. This leads to the assumption that over time, the percentage of Level 1 users increases to 50% of EVs sold in 2020. That is, the number of Residential Level 2 users declines from 80% to 50%. ECOtality's four-factor methodology (geographic coverage, destination planning, refueling stations and rich infrastructure) was used to project EVSE, as shown in Table 5-1.

Table 4-1 Projected Cumulative EVSE Sales in the United States

Year	Vehicles Fleet	Vehicles Residential	EVSE Fleet	EVSE Residential	EVSE Public/ Commercial	EVSE Total	EVSE % EV Total
2011	3,690	14,770	2,470	11,810	41,050	55,330	300%
2015	26,370	420,540	17,670	281,760	609,780	909,210	203%
2020	86,040	2,303,860	57,640	1,151,930	2,349,940	3,559,510	149%

5 EV and EVSE in the Houston Metro Area

The nationwide projections of EVs and EVSE assist in preparing projections of EVs and EVSE that will be needed in the Houston metro area. The early market launch of EVs into the Houston Metro area helps create an informed public and enhances the public awareness of EVs. The infrastructure provided by the EV Project also creates more public awareness and interest. Houston also benefits from NRG's innovative *Project eVgo* which will provide public DC Fast Charging stations along major freeways, in shopping and business districts, at major retailers, and in multi-family community and workplace parking areas across Harris County. The projections for the Houston Area use the national projections previously described, which are modified to account for characteristics specific to the region, including the benefits of Houston's early leadership in the EV marketplace.

5.1 Long-Range Plan Boundaries

The planning boundaries focus primarily on areas in Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller counties (Figure 6-1). The boundaries are based on ZIP codes. The LRP also considers major highway systems that connect the Houston area to major population centers. The I-45, I-10, U.S. 59, U.S. 290 and I-610 corridors are of particularly high interest. Several of the proposed DC Fast Charging locations along these corridors are described in Section 7.



Figure 5-1 Houston Metro Area Long-Range EV Plan Area (based on ZIP codes)

It is expected that EVs and EVSE will be located outside of this area, but the largest concentrations are likely to be found in higher density population and employment centers.

5.2 Demographics

Development of the EV infrastructure should respond to regional demographic factors that are indicative of potential EV markets. Understanding the population densities and probable EV owner demographics, such as single-family residence and education levels, assists in determining potential EV infrastructure. In addition, operator driving behavior, existing vehicle use, travel habits, car purchases,

and population growth help define what is needed for EVSE infrastructure needs. The demographics of early EV buyers will include a narrower range of people than future EV buyers. Having a viable and accessible EVSE infrastructure will encourage the broader public to understand EVs as an attractive alternative to the conventional vehicles. The availability and visibility of these charging opportunities also reinforces the EV owners' experience with their vehicle, and helps dispel any concerns about travel range.

5.2.1 Population

According to the 2010 US Census, the major counties in the Houston EV Project's boundary increased 26.5% since 2000 adding more than 1.2 million people.³¹

Table 5-1 Population in the Houston Area 2000 to 2010 by County

County Area	2000 Population	2010 Population	% Increase*
Brazoria	241,767	313,166	29.5%
Fort Bend	354,452	585,375	65.2%
Galveston	250,158	291,309	16.5%
Harris	3,400,590	4,092,459	20.4%
Montgomery	293,767	455,746	55.1%
Waller	32,662	43,205	32.3%
Total	4,573,391	5,781,260	26.4%

*Population, percent change, April 1, 2000 to April 1, 2010

5.2.2 Single Family Residential Units

It is expected that many EV buyers will live in single-family detached residences. For example, 57% of housing units in Harris County are single-family detached. In surrounding counties, such as Montgomery and Fort Bend, these percentages rise to 67% and 84% respectively. Single-family residences are also associated with higher income level and education levels that are indicative of likely EV markets, particularly early buyers. The structures are configured in ways that are expected to make it easier to install EVSE charging (driveways and garages, rather than parking areas). Figure 5.2 illustrates year 2000 locations of single-family units, primarily those for Harris County zip codes. The EV Project Area average percent of housing units that are single family is 68.8% with total housing units of this type amounting to almost 1.3 million.³²

³¹ US Census Bureau Fact Finder, 2009

³² US Census Bureau Fact Finder, 2005-2009

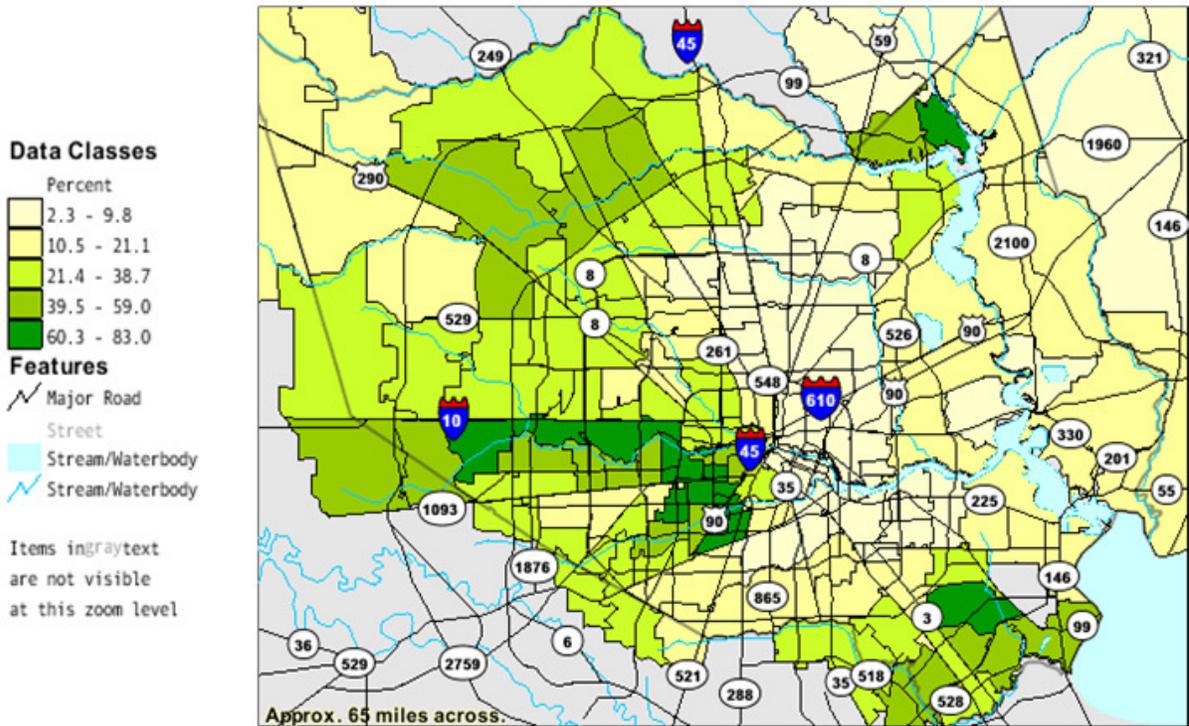


Figure 5-2 Percent of Housing Units -- One Unit, Detached: 2000³³

5.2.3 Education

In addition, the innovators and early adopters with higher education degrees are more likely to acquire EVs. Knowing market factors such as housing type and education helps identify areas where EVs are likely to be located and where publicly available charging is needed. Figure 6-3 (2000) illustrates the locations of households over age 25 with a Bachelor's degree and higher. More recent data in Table 6-4 shows Bachelor's degree or higher as a percentage of persons age 25 and older for 2009. In Harris County for example, this amounts to more than 670,000 individuals with college degrees.

³³ Census Bureau, 2000 Harris County, Texas by 5-Digit ZIP Code Tabulation Area

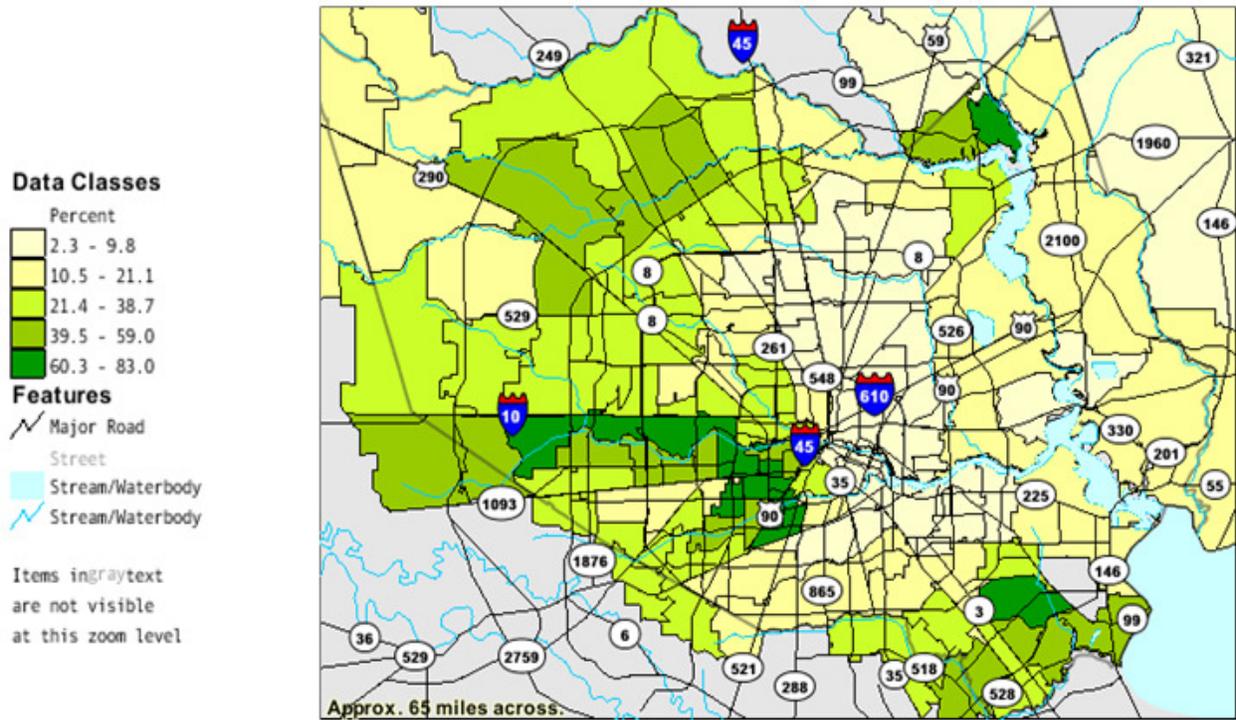


Figure 5-3 Percent of Person 25 Years with Bachelor’s Degree or Higher: 2000³⁴

Table 5-2 2009 Percent of Person 25 + with Bachelor’s Degree or Higher³⁵

County Area	% of Population with Bachelor's Degree or Higher
Brazoria	19.6%
Fort Bend	36.9%
Galveston	22.7%
Harris	26.9%
Montgomery	25.3%
Waller	16.8%
Average	24.7%

5.2.4 Vehicles

Analysts also suggest that two variables are early indicators of innovators and early adopters of EVs: households with more than two vehicles and existing hybrid electric vehicle users. Figure 5-4 shows the percent of Houston area households by the number of vehicles at that household. In 2009, 45% of households had 2 or more vehicles.³⁶

³⁴ ibid

³⁵ US Census Bureau Fact Finder, 2009

³⁶ ibid

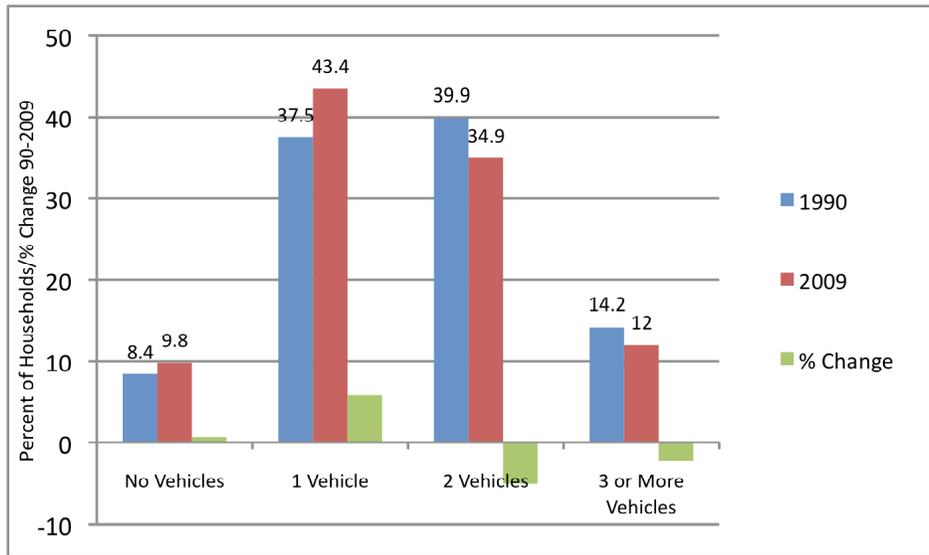


Figure 5-4 Number per Household: Greater Houston Area

Texas is among the leading states in terms of hybrid electric vehicle sales. Sales in 2009 matched those of other large vehicle markets, other than California (Table 5-5).

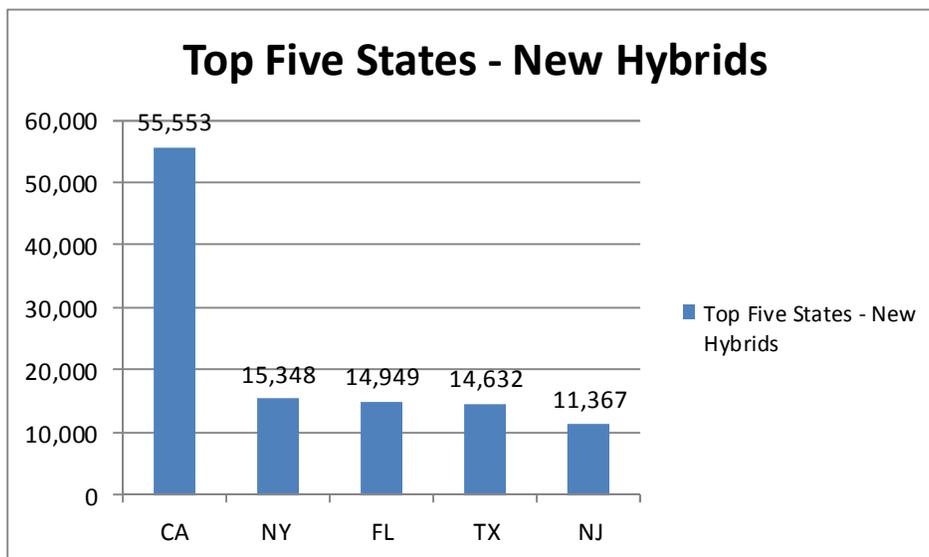


Figure 5-5 States with the Highest Hybrid Sales³⁷

Potential EV purchasers were given the opportunity to sign-up for early purchases of the Nissan Leaf EV. These potential purchasers called *Hand Raisers* came primarily from current hybrid electric vehicle owners. In the EV Project markets of Seattle, Portland, Phoenix, Tucson, Nashville and Chattanooga, almost 80% of the Nissan Hand Raisers were existing hybrid owners. To date, the Houston area has 738 Nissan Hand Raisers for the Nissan Leaf. Figure 6-7 shows the zip codes where these individuals live. Darker shades represent larger numbers of individuals.

³⁷ Hybridcars.com - December 2009 Dashboard: Year-End Tally, 2009 <http://www.hybridcars.com/hybrid-sales-dashboard/december-2009-dashboard.html>

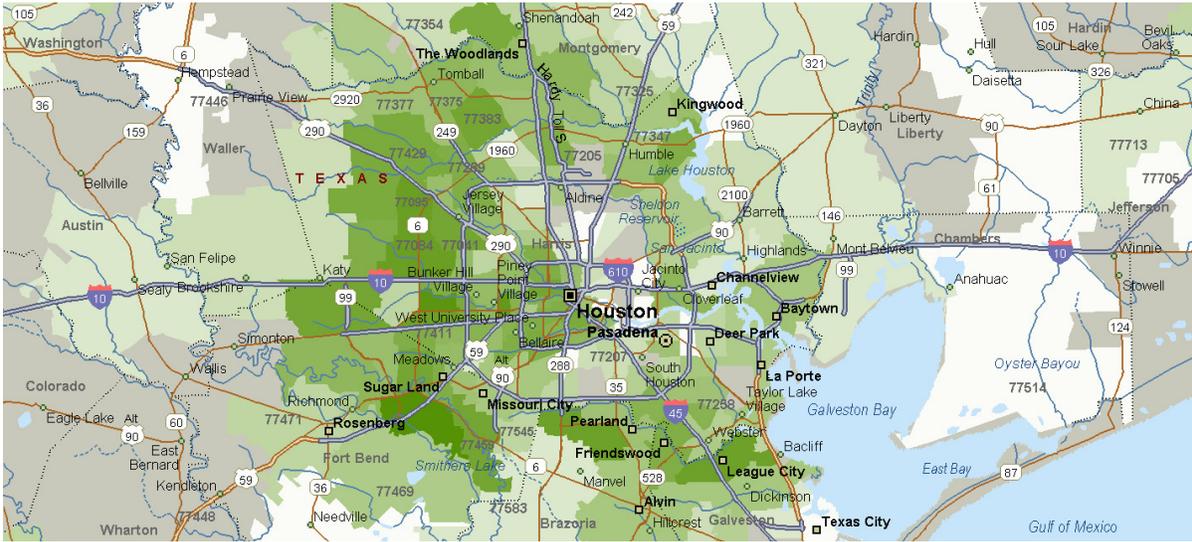


Figure 5-6 Nissan Leaf Hand-Raisers in Houston by Zip Code

5.2.5 Traffic Patterns

Significant studies have been completed that identify traffic flows and patterns on major freeways in the Houston area. More detailed, higher resolution analysis within the Houston metropolitan area will be needed to identify more specific sites where charging infrastructure might be located in the future.

As it shows in Figure 5-7, the average travel time to work in the counties representing the EV Project boundary is 30 minutes. Table 5-3 shows travel times for work trips have basically stayed the same for Houston from 2000 to 2009.

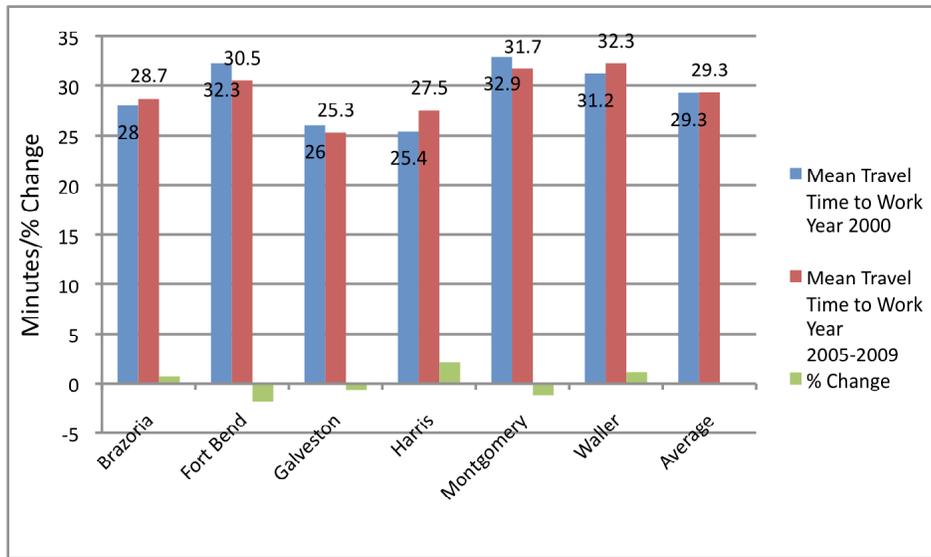


Figure 5-7 Houston Area Counties – Mean Travel Time to Work

5.2.6 Employment Centers

Major employment centers are of interest because they represent a significant destination for EV drivers. They may be an important location for employer or workplace EVSE, but being a destination, EV drivers will likely stop at other destinations between these work centers and their homes. Figure 5-8 shows HGAC’s Regional Employment Forecast in jobs per square mile for 2005 and 2035. Figure 5-9 shows projections for the area within Beltway 8.

Table 5-3 Busiest Houston Freeways³⁸

Busiest Houston Highways	Total Vehicles Peak Period	Travel Time Peak Period	Avg Speed Peak Period	Avg Speed Main lanes	Travel Time Main lanes
Total System Utilization		Minutes	MPH	MPH	Minutes
IH 10 W Katy Inbound	4,941	10.83	61.50	54.60	20.67
IH 10 W Katy Outbound	3,979	10.64	62.00	49.70	21.74
IH 45 N North Freeway Inbound	3,739	14.85	61.40	42.10	25.24
IH 45 N North Freeway Outbound	3,806	17.35	52.60	40.00	26.58
IH 45 S Gulf Freeway Inbound	2,737	12.09	58.60	41.70	16.98
IH 45 S Gulf Freeway Outbound	2,731	13.09	54.10	34.30	20.66
US 290 Northwest Freeway Inbound	3,006	12.23	60.60	37.00	21.23
US 290 Northwest Freeway Outbound	3,406	15.24	48.60	25.20	29.18
US 59 S Southwest Freeway Inbound	2,763	8.38	57.60	48.40	9.98
US 59 S Southwest Freeway Outbound	3,183	9.22	52.40	39.60	12.21
US 59 N Eastex Freeway Inbound	1,898	15.39	66.70	61.50	16.69
US 59 N Eastex Freeway Outbound	1,986	15.72	65.30	59.00	17.28

³⁸ City of Houston Study, 2009

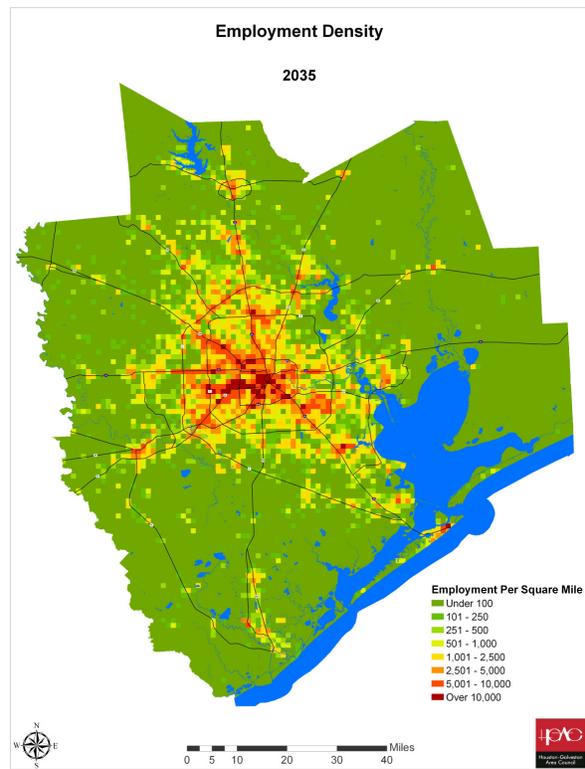
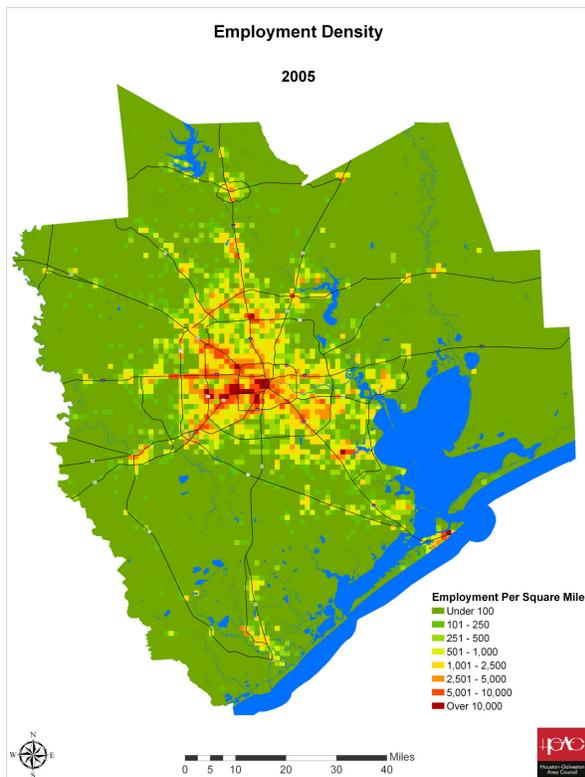
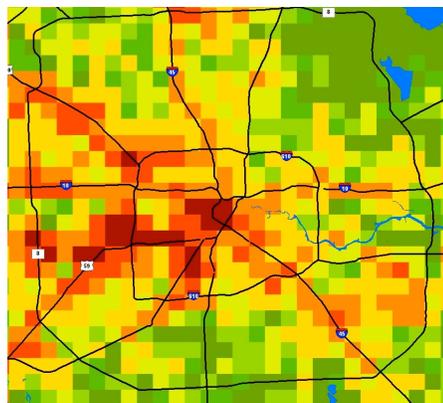
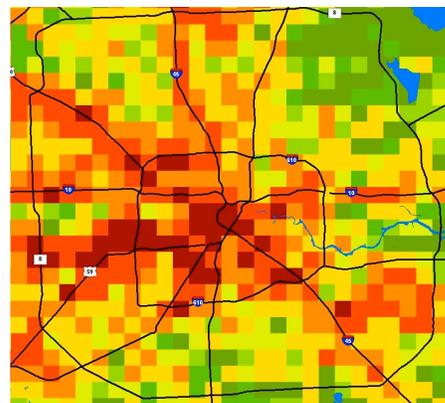


Figure 5-8 Employment Density 2005-2035 – Jobs/Square Mile³⁹



Employment Density 2005



Employment Density 2035

Figure 5-9 Employment Density Within Beltway 8: 2005-20035

5.3 EV Projections

The Greater Houston area is home to over four million vehicles⁴⁰. With a sizable vehicle market in place and an active commuting population, Houston is expected to be a large EV market. The Houston area is one of the initial market areas for the introduction of EVs in 2011. Both the Nissan LEAF and the Chevrolet Volt have been introduced into the Houston market. Other OEMs, such as Ford, will also be in the Houston vehicle market soon. Political will, public enthusiasm, utility participation, and private

³⁹ HGAC's Employment 2005-2035 Regional Forecast, April 2006

⁴⁰ Census Fact Finder, 2009

sector investments are driving the interest and motivation to bring EVs into wide public acceptance. This positions the greater Houston marketplace to be on a faster path to EV adoption.

Exemplifying such activities, NRG Energy, a wholesale power generation company, is building the country’s first privately funded electric charging network, called eVgo. It’s initial market deployment is in the Houston area with discussion for expansion into other Texas cities. NRG is offering home charging docks and a network of public available charging stations. These will be located along major roadways in Houston and at retail locations through involvement of major national and local companies.

Pike Research’s recent EV Geographic Forecast projects that sales of PEVs nationwide will total almost 359,000 vehicles by 2017. Several other national forecasts of PEV sales were reviewed carefully in the planning process. These are summarized in Appendix A. The market share for EVs projected to 2020 as a percent of all vehicle sales ranged from 2.1% to 7.4%, with an average of 4.5%. Urban areas, such as Houston, are expected to experience much higher levels of market penetration due to economic and travel characteristics of cities (higher income and shorter travel distances). Houston area projections set forth in Table 5-4 are based on reaching 6.6% market share by 2020, reflecting this higher market penetration rate and good economic conditions in the Houston area and Texas.

Table 5-4 Projected EV Sales in the Greater Houston Area

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual PEV Sales*	700	1,400	1,900	2,600	4,200	6,100	8,800	11,900	15,700	20,100
Cumulative PEVs*	700	2,100	4,000	6,600	10,800	16,900	25,700	37,600	53,300	73,400

Note: PHEV and BEV projections=Plugin Electric Vehicles (PEVs); projections are rounded to nearest 100 vehicles; % of Houston vehicle sales in 2020 = 6.65%.

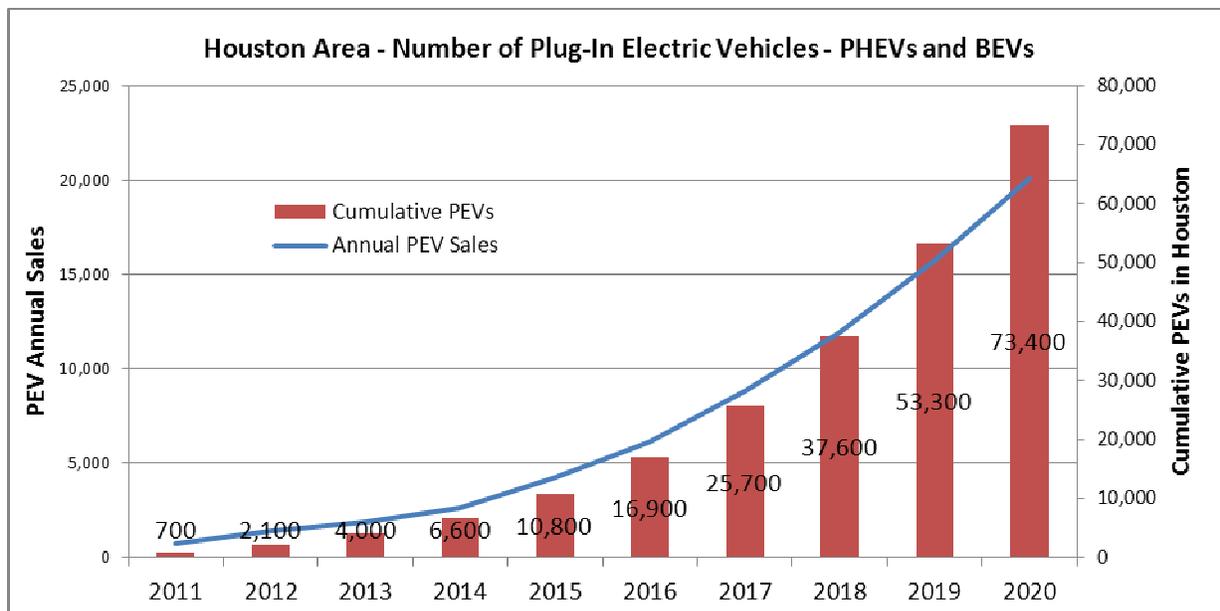


Figure 5-10 2020 PEV Sales (% of new vehicle sales) Greater Houston Area

5.4 EVSE Projections

EVSE deployment precedes EV deployment to provide the infrastructure to meet the needs of the EV owners in the Greater Houston area. Four types of charging activities are considered here in related to EVSE deployment: (1) residential, (2) workplace, (3) publicly available charging, and (4) fleets. It is

important for each of these to be addressed for the early PEV market. The distribution and density of charging locations is affected by the location, density, and intensity of associated activities. The projections are shown in Table 6-4. The factors used to develop these projections are described more fully below for each EVSE category.

Table 5-5 EVSE Projections for Greater Houston Area

Cumulative EVSE Locations¹	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential-Single Family Detached ²	600	1,600	2,900	4,600	7,200	10,900	16,000	22,500	30,700	40,700
Multi-Family ³	5	25	100	200	500	900	1,600	2,700	4,300	6,300
Workplace ⁴	5	100	200	300	500	800	1,300	1,900	2,600	3,600
Publicly Available Charging Locations ⁵	100	400	600	700	800	900	900	1,000	1,000	1,000
Fleet EVSE ⁶	100	100	200	300	500	700	900	1,200	1,600	2,100
Total EVSE	700	2,300	4,000	6,100	9,500	14,100	20,700	29,200	40,200	53,800

1. Number of Cumulative EVSE Locations: varying levels of service ranging from one plug for single family residential to several plugs at public charging locations.
2. Single Family Detached: based on vehicles sales projections; starting at 80% of EV sales, with that fraction declining to 50% as other charging options come on line and technologies change.
3. Multi-Family EVSE: based on vehicle sales, but lagging single family due to characteristics of multi-family development.
4. Workplace: based on goal to reach 10% of EVs at workplaces.
5. Publicly Available Charging: based on achieving an acceptable density of charging locations through Houston’s urbanized area; charging available within one mile of any point increasing to higher levels of availability over time.
6. Fleet EVSE: based on vehicle adoption rates and the number of EVSE needed per vehicle.

5.4.1 Residential Home-Based EVSE and Charging

Residential EVSE is the core charging location for most individually owned EVs. Vehicle travel would occur largely from the home to other destinations, and in many instances the home will be a single-family detached dwelling that is the dominant housing style in the Houston area. Most vehicle buyers will assume that they will have some level of charging available to them at their residence, either with a Level 1 or Level 2 EVSE. EV owners at multi-family dwellings will have widely varying circumstances which are discussed below.

Initial expectations are that 80 percent of EV owners will have Level 2 residential charging. The remaining 20 percent will rely on Level 1 charging or have EVSE available at their workplace or from publicly available charging. This condition may change over time as vehicles change, as EVSE becomes available at more locations, and as consumers adapt to EV characteristics.

Initially residential Level 2 EVSE will roughly equal the number of EVs in the market. For example, if there are 10,000 vehicles by 2015, an estimated 8,000 EVSE will be located at residences. In 2020, when there are more than 70,000 PEVs in the Houston area, there could be as many as 56,000 or more residential EVSEs, or as few as 35,000 EVSEs.

Assumptions and preferences for Houston on residential home charging are for nighttime, non-peak electricity use for charging residentially based EVs. This is the approach that will use the electric power grid most effectively and the approach most likely to result in lower electricity costs for the consumer. This preference is particularly true during Houston's summer months when peak electricity use is driven by air conditioning needs. In residential situations, air conditioning demand can remain high during early evening hours. As such, post-midnight EV charging provides the most advantageous option for residential EVSE.

5.4.2 Multi-Family EVSE

Multi-family EVSE projections are more uncertain than single-family residential units, which are dominated in the Houston area by single-family detached units with separate garages. Multi-family units exist in a variety of configurations from garden apartments surrounded by parking areas to high-rise complexes with parking garages. The occupants may be owners with the ability to acquire and have installed EVSE, or renters with little capability to affect decisions about EVSE availability. Owner-occupants often have homeowner or condo associations that must be involved in these decisions. The decisions on providing EVSE at will depend largely on the property owner, building management, or homeowner associations. There are also wide variations in the length of stay in multi-family rental properties, which means that EVSE will be used differently than at a single-family residence.

Nevertheless, there are reasons and incentives for multi-family dwellings to have EVSE available to tenants. In a competitive housing market, owners and managers may see the availability of EVSE as an advantage for attracting and retaining tenants. Multi-family occupants include individuals who are likely EV buyers and who will consider EVSE availability in their decision-making on where to live. Whether or not there are EVs already present at a multi-family unit, residents may choose to stay at their current location because they are considering an EV in the near future. Thus, having a charging location at a multi-family development could retain existing tenants as well as attract new tenants.

Condominium owners, another type of multi-family development, are also likely EV consumers, having demographic characteristics similar to those discussed above. Decisions on installation of EVSE will involve whatever governing body the condominium has created and the rules associated with operation of that property. Similar to rental multi-family, it may be necessary for the governing body to lease, install, or own the EVSE since parking areas are often held in common. Condominium multi-family units also have attached individual garage space that is owned by the individual condominium resident. That situation is similar to the single-family residential unit in that the owner has more control over the decision, although with some constraints due to the homeowner/condo association governance and rules.

The long-range plan needs to incorporate multi-family dwellings as an integral part of the EV marketplace. Many newer, higher density multi-family residential units are homes to residents who are prime market candidates for EVs. In addition, such units are located in multi-use areas of the region where residents may work and travel within relatively short distances. The Houston area has many such activity centers, where residential, commercial, office, and entertainment facilities are in close proximity.

In Harris County, there are over 200,000 multi-family attached residential units in structures with 20 or more units. There are another 200,000 units in structures with 10 to 19 units.⁴¹ Of these 400,000 plus housing units, some fraction could provide Level 1 or Level 2 charging for tenants or owner occupants (e.g., condominiums). Availability of at least Level 1 plugs would be feasible at some units at relatively low cost, largely depending on location of electric power in relation to parking areas and requirements

⁴¹ U.S. Census Bureau, American Fact Finder, Harris County Housing Characteristics, 2005-2009

for an electric meter. For example, a laundry adjacent to parking would provide a potential location where parking, electric power, and metering are co-located, as well as the potential for Level 2 charging.

From Harris County Appraisal District records, there are over 6,000 rental apartment properties with almost 600,000 dwelling units. Of these, approximately 6% are defined as Class A, which are newer, more costly properties. In 2009, 45 new apartment complexes were built, adding over 13,000 additional rental units.

Multi-family EVSE charging is expected to be a small fraction of the early EV market without significant encouragement of property owners, condominium/homeowner associations, and EV buyers who live in multi-family units. Types of encouragement could include outreach on benefits and challenges, third-party support such as equipment lease and finance provisions, and technical guidance on specific property installations. A checklist of requirements for EVSE multi-family could provide sufficient guidance for interested owners/managers to make an initial determination of feasibility. On-line instructions and video could supplement such decision-making. Various tax incentives and provisions in utility regulations may become available over time as the EV market grows. Such provisions would allow the multi-family EV market to grow.

Early estimates of the multi-family EVSE market include a small fraction (1 to 2 percent) of the 20 percent of EV owners who are projected to charge at non-residential locations. This fraction would increase over time as attractive solutions for multi-family EVSE are developed (EVSE technologies, third party provisions, utility solutions, financial incentives, market response, etc.). Multi-family unit growth would serve as a primary indicator of EVSE since newer development can more readily incorporate EVSE into the design, cost, and marketing of such properties.

Projections for multi-family EVSE start with achieving an initial participation level by 2012 of 2% of EVs purchased and increasing that share to 10% by 2020. EVSE multi-family locations would total 6,300 by 2020.

5.4.3 Workplace EVSE

Most Houston commuters drive to a workplace in a private vehicle where their vehicles may spend several hours parked near their jobs. From a consumer fuel cost and electric power grid perspective, charging during the day is not the preferred option suggested in the long-range plan. However, for EV owners who lack home-based charging or have travel requirements that exceed their vehicle's range, workplace charging may be essential, particularly as the EV market grows. As with multi-family EVSE, the decision to provide workplace charging is not in the hands of the individual EV owner. And similar to multi-family EVSE, the feasibility of installing EVSE also varies widely depending on specifics of the development, its parking configuration, and availability of electric power.

Most employers do not own the buildings or parking areas that are used by their employees. As such, property owners and facility managers will play a major role in decisions about EVSE even if employers are willing to pay for installation and equipment. There are also strong reasons that employers, property owners, and parking managers may choose to add EVSE as part of their operation. Employers may view the provision of on-site charging for employees as a good fit with their company's corporate goals. Property owners/developers may want EVSE as part of a development to attract and retain tenants. They may also respond to expressed interests from existing tenants for such improvements. Properties may also include commercial parking facilities that want to attract and retain customers at their operation, and EVSE offers an additional attribute to such operations.

Houston has several high density employment centers where EVSE workplace charging could fit with development objectives for the areas as well as employer goals. In addition to downtown Houston, locations include Greenway Plaza, Uptown Houston, the Energy Corridor, Texas Medical Center, The

Woodlands Town Center, and many others where high rise office buildings, multi-level parking, and major retail facilities are co-located.

Anecdotal reports on workplace charging are limited to places with high levels of early adopters, such as Silicon Valley and other technology centered employment areas. Such companies are aware that their employees are likely to purchase EVs and are often multi-family unit dwellers less likely to have home-based charging.

As part of achieving an effective and available charging network, workplace EVSE should be encouraged and supported. However, at this stage of the EV market in Houston, there is no strong basis for projecting how large this particular market segment will be. Houston employers and property owners will respond to expressed and perceived demand for EVSE charging. The likelihood of workplace EVSE is improved by the availability of support services aimed at workplace charging from NRG's eVgo and other EVSE services and products that are attracted to the Houston market. Houston has many major employers in the private and public sector who are supportive of leading edge technologies, energy concerns, and clean air.

Possible long range goals for the Houston long range plan include the availability of workplace EVSE for 10% of projected EV owners by 2020 and workplace EVSE serving 100 major employer locations. Achievement of these goals would likely lag EV market sales without the provision of programs and incentives to achieve these goals earlier.

5.4.4 Publicly Available EVSE

Publicly Available EVSE (PAE) includes any charging location that is intended for public charging that can be accessed during normal operating hours for EV charging purposes. These are equivalent in accessibility to conventional fueling at service stations, convenience stores, and other locations. Since most vehicle charging will be home-based, these locations are available for a smaller fraction of consumer needs. However, they are particularly important in addressing concerns about vehicle range and related consumer concerns. Each location would include at least Level 2 charging (DC Fast Charge discussed separately below) with one or more ports/plugs per location.

In the Houston urbanized area of 1,300 square miles, there are an estimated 1,000 conventional fueling locations. Fueling availability in U.S. cities ranges from 0.6 to 1.5 stations/locations per square mile.⁴² Urban areas with higher population densities, such as New York and Los Angeles, have more stations per square mile. Houston, with a lower population density, has roughly 0.8 stations per square mile, or an estimated 1,000 fueling stations. While there is no need to replicate the distribution of the current fueling system for EVs, this estimate provides a possible upper limit for publicly available EVSE locations.

A key consideration in this Long Range Plan is accessibility of charging stations for all EV owners. This can be accomplished with as few as 400 EVSE locations. This number of locations provides EVSE access within one-mile of every point in the Houston urbanized area.⁴³ This is 0.3 EVSE locations per square mile or roughly half the accessibility of current fueling station densities. With more than 100 locations already in the planning stages, 400 locations could be in place by the end of 2012, providing a high level of accessibility.

EVSE locations, however, will not evenly cover the Houston area due to the need to locate them in areas of high activity or in areas easily accessed by roadways. It is expected that more locations will be

⁴² "Refueling availability for alternative fuel vehicle markets: Sufficient urban station coverage", Marc Melaina and Joel Bremson, 2008, Energy Policy, available from ScienceDirect.

⁴³ A service area of one mile contains 3.14 square miles or 0.3 EVSE locations per square mile.

developed over time, rising to 1,000 locations or more by 2020. The growth in publicly accessible charging locations would be coupled with expansion of the number of places (plugs) that would be serviced at a single location. For example, a major commercial center might start with one EVSE (with two plugs), and expand to accommodate ten or more plugs (two or three EVSE, depending on specific technologies) to accommodate more vehicles at the same time, and improve customer convenience.⁴⁴

5.4.5 Fleet EVSE

The City of Houston and other public and private fleets will be adding EVs to their vehicle population in response to their needs, goals, and fleet characteristics. Projections at the national level suggest that public fleets will be particularly important in early EV and EVSE deployment. The wide range of fleets, however, makes it difficult to project with any certainty the level of deployment that will occur.

Light duty EVs such as the Nissan Leaf, the Ford Focus, and the GM Volt are good matches for many fleet applications and “company” cars. Specialty vehicles, such as the Ford Transit, are attractive options for service companies that rely on the vehicle recognition as part of their market identification; for example, Geek Squad vehicles from Best Buy, and various electrical, plumbing and related service fleets.

Public and private fleets are strongly encouraged to examine applications of EVs in their fleets as well as EVSE requirements that may be needed. Fleets are also encouraged to evaluate other opportunities for assistance with EV adaptation such as the Clean Cities program, state clean fuel fleet program, federal tax and incentives.

⁴⁴ Multiple ports/plugs will be important as customers adapt to charging availability and behavior by other customers.

6 DC Fast Charging

With the knowledge that there is a DC Fast Charging facility nearby that can deliver a significant charge in a short period of time, the driver is more comfortable using the full range of the vehicle. Without this safety net, the driver is more concerned about maintaining the vehicle battery at a higher state of charge. Thus the availability of DC Fast Charging will go a long way in the promotion of EVs. There is some question, however, whether the availability of the DC Fast Charging actually causes a higher usage of the equipment. A safety net is only needed in extreme conditions. Consequently, it may be that once established, a network of DC Fast Chargers may be sufficient for a substantial time into the long-range plan.

Fast Charging may be more of a necessary system design factor for connectivity and network design. It is reasonable extension of having PEVs and provides some support to the EV market. This section explores the design and location process for DC Fast Charging.

6.1 Design Characteristics

DC Fast Chargers require a higher power level than Level 2 EVSE units. 480-volt, three-phase AC is standard, although some equipment can use 208-volt, three-phase, and up to 575 volts AC. To provide a significant recharge, it is expected most DC Fast Chargers would be 50 or 60 kW, which would draw about 80 amps maximum at 480 volts AC. Equipment of this size can have an impact on the local electric utility grid. This equipment has two major functions: supporting the local community charging grid and providing the range extension necessary for longer trips.

6.2 Customer Usage

The rapid recharge capability of DC Fast Charging makes it ideal for locations where the consumer will stop for a relatively short period of time, typically 15 to 30 minutes. DC Fast Charging will not generally be used for completing the charge in a vehicle, but rather to provide a substantial recharge quickly. While DC Fast Charge stations may be a destination in themselves, they will likely be placed in existing locations where customers are likely to linger for this amount of time. Locations such as gas stations, convenience stores, coffee shops and rest stops serve as some examples.

6.3 Local Area Impact

The safety net provided by DC Fast Charging augments the local Level 2 publicly-available EVSE network. Its placement is strategic, but yet can present challenges.

6.3.1 Fast Charging Benefits

Table 4-1 (page 13) outlines the recharge capabilities of DC Fast Charging. It reduces the battery recharge time from hours to minutes. For many BEVs, receiving 50% battery recharge in 20 minutes is very significant. A charge opportunity lasting 10 minutes can extend the range of a BEV by 25 miles. That short a recharge time can easily be tolerated by the EV driver to gain the benefit of the range extension.

6.3.2 Electric Utility Grid Impact

The power required by DC Fast Charging is more typically available in industrial areas and may not be readily available in typical commercial or public areas. Industrial users require the higher power availability to power equipment, lights, and material handling equipment, battery charging equipment, freezers, and other very heavy electrical loads. This power is provided by the electric utility through the transformers in the area and is one reason specific areas are zoned for industrial applications. Because of the significant potential impact on the electrical grid, the electric utility company will provide vital input on DC Fast Charging locations. Grid impact would seem large for encouraging consumers to charge

during peak; again the need to charge off-peak if an EV market is as successful as proposed in this document. The equivalent of adding another few hundred thousand homes in terms of potential peak demand (400,000 PEVs charging during peak - although presumably for only a few minutes).

6.3.3 Siting of Fast Chargers

Specific locations for DC Fast Chargers depends on:

- Charging purposes; for example, charging along the way on longer trips, unplanned travel during the day, away from home EVSE, convenience.
- Site usefulness for augmenting the Level 2 publicly available charging stations; DC Fast Chargers and Level 2 can be co-located for convenience of users, and located in lower population, higher travel corridors (see below).
- Electric grid capability; sufficient capacity is needed without encountering significantly higher installation costs; this may limit the number of specific potential locations in the near term.

6.4 DC Fast Charging Along Transportation Corridors

DC Fast Charging is particularly important for transportation between major metropolitan areas. Metropolitan areas will contain the local EVSE infrastructure to support EVs within the area, but DC Fast Charging along the corridors will allow BEVs in particular the ability to traverse the long distances between metropolitan areas. DC Fast Chargers will be needed for continuity of travel and system connectivity. Having a reasonable distribution of fast charging stations provide a sense of system completeness and continuity. DC Fast Charging is more suitable than Level 2 in such locations because a customer will expect the shortest recharge time available to minimize travel time. In fact, as batteries gain in power densities and vehicle ranges are extended, power levels of DC Fast Chargers will likely be increased. DC Fast Chargers projected to be provided to support the initial rollout of EVs in 2010 and 2011 will likely be 60 kW or less. Higher power chargers have been used in the past and are certainly possible, but power availability at a site is a concern and given current battery capacities do not need these higher power levels.



Figure 6-1 DC Fast Charging (80kW) circa 2010

The Houston area will benefit from NRG's plan to install approximately 50 eVgo *Freedom Stations* by mid-2011 at major shopping and business districts, and along all major freeways from downtown Houston to approximately 25 miles from the city center. The longest stretch between stations is about 25 miles. This is approximately 25% of the total range of current EVs. For planning purposes, corridor EVSE locations should provide DC Fast Charging locations at no more than 30-mile intervals. The number of charge ports at these locations will initially be few, but more stations or more ports at existing stations can be added as demand grows.

Corridor planning should include major Houston freeways such as I-45, I-610, I-10, U.S. 59, U.S. 290, and U.S. 281, as well as the grid of major state highways connecting population centers east to west and north to south. In effect, DC Fast Charge stations can become range extenders for EVs.

6.5 DC Fast Charging Deployment Projections

The TEPCO and ECOality studies of EV infrastructure provide the methodology for determining the expected sales of DC Fast Chargers as a safety net for publicly available EVSE. The studies placed 10 DC Fast Chargers in a 50-mile square mile area, roughly the same size as the core part of Houston Micro-Climate area shown in Figure 6-1 (page 32). Per the Level 2 infrastructure analysis, this would suggest that heart of the public infrastructure should include one DC Fast Charger per 5 square mile area or one DC Fast Charger for every 90 Level 2 EVSE. For the purposes of this LRP, we are assuming EVSE location not the number of ports per EVSE. Vendors vary as to the number of ports per DC Fast Charger, currently either one or two.

The quantities of DC Fast Chargers are projected to be deployed as shown in Table 6-1. The NRG eVgo project includes 50 DC Fast Charge locations. Figure 6-2 shows the general locations for these. The average distance varies between stations and is less than 25 miles in many instances. The locations were sited at intersections of state and federal highways, as well as those leading to major residential population concentrations. Included are the most highly-traveled secondary highways in the Houston area.

Table 6-1 DC Fast Charger Projections for Greater Houston Area

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual Installations	50	30	30	40	60	70	90	110	130	140
Cumulative Locations	50	80	110	150	210	280	370	480	610	750



Figure 6-2 DC Fast Chargers in Transportation Corridors

7 EVSE Deployment and Implementation

The initial groundwork for the Houston area was established in the *EV Charging Infrastructure Deployment Guidelines*. The expected penetration of EVs and projected EVSE have been identified, including the expected growth per year. EVSE deployment is driven by projections that seek to understand how the market may respond and actual market response. The Houston long range plan is based on reasonable ranges of EVSE deployment that will meet and support actual market response.

EV innovations will diversify the types and functionality of EVs to suit many different uses and users. Most OEMs have announced initial plans for EVs; the first mass-produced EVs available for the general public are the Nissan LEAF and the Chevrolet Volt, followed soon by the Ford Focus. Both the LEAF and the Volt are on sale now in Texas. The Ford Focus will be introduced into the Houston market in late 2011.

Distribution patterns of existing hybrid ownership will assist in identifying appropriate sub-regional variation in EVSE distribution over the first several years.

The general public will observe EVs charging at the initial installations of EVSE. That will drive increased public EV interest. This interest will create demand for more EV options and expand EV driver demographics. This interest-demand loop is illustrated in Figure 7-1 below. Without outside influence, this cycle would be difficult to expand to provide more EV options. However, several additional factors can influence the desired expansion.

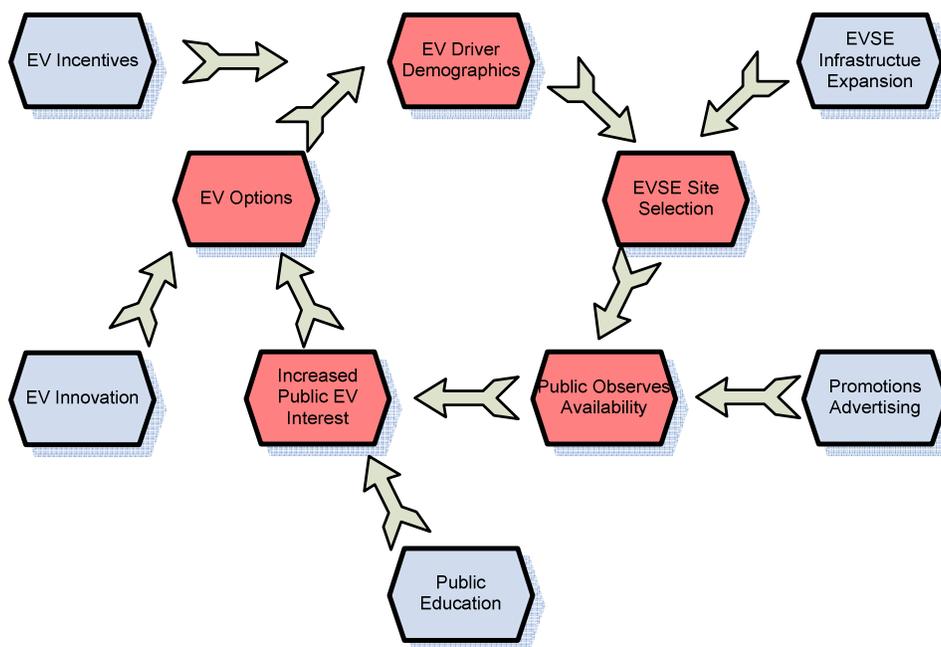


Figure 7-1 EV and EVSE Promotion

Public education can generate awareness of EV benefits such as improving air quality in the region, reducing carbon emissions, lowering day to day fuel costs, avoiding wide fluctuations in fuel prices, and reducing dependence on foreign oil. Business owners who have installed EVSE can generate public awareness through their advertising and promotions. Forward-thinking business owners and those interested in promoting EV use will be motivated to install EVSE near their businesses. Nationally known businesses will promote their image of being environmentally friendly, especially when noting their

successes in other locations. Government, non-profit organizations, and businesses can all collaborate to develop an EVSE infrastructure adapted to local community and policy needs.

7.1 EVSE Resources

Available EVSE resources are targeted at developing a readily available infrastructure – that is, community locations where charging is readily available at a variety of convenient locations. As these locations are populated with EVSE, the infrastructure deployment can be expanded outward. Additional targeted areas can be identified as demand increases. Eventually, the targets may merge and the geographic coverage expand. Once completed, owner demand will continue to drive the expansion of publicly available EVSE. The revenue systems used and business case developed for EVSE deployment will drive additional EVSE procurement to meet demand. It will be important to monitor EVSE usage to validate the expansion and placement of resources.

7.2 Venues for EVSE Deployment

Section 2 illustrated that for most drivers, a significant number of trips are for family and personal reasons to a variety of destinations every day of the week. These trips can be lengthy, as well. A review of the number of destinations in the Houston metropolitan area (approximate 30-mile radius from Houston center) reveals the following as some of the potential EVSE locations.

Table 7-1 Houston Venues for EVSE Deployment

Airports (Major)	2	Airports (Minor)	12	Amusement parks	6
Cinemas	30	Community Centers	1	Convention Centers	6
Galleries	107	Gas Stations	1,341	Golf Courses	105
Grocery Stores	664	Hospitals	74	Libraries	87
Marinas	24	Museums	45	Nightclubs/Taverns	1,243
Park & Rides	23	Parking lots	140	Pharmacies	526
Middle Schools	172	High Schools	222	Alternate Schools	123
Wineries	1	Restaurants	6,428	Shopping	64
Stadiums/Arenas	23	Theaters	31	Universities/College	61
Elementary Schools	703				

There are a total of 13,493 destinations listed above within the Houston EV Project Boundary, and all are areas where the driver might choose to stay for 45 minutes to 3 hours. Such locations will be able to support more than two EVSE, and demand will increase the quantity of EVSE. These destinations are some of the ideal locations for Level 2 EVSE.

The distribution and density of EVSE is affected by the location, density, and intensity of activity associated with each destination. Multipurpose activity areas are more likely to retain users for longer periods of time, a better fit with charging needs and duration. Malls, for example, are more likely to have longer term stays than a big box store or a standalone restaurant without related activity around it. Existing databases can contribute to locating EVSE. For example, traffic modelers use detailed household surveys on driving behavior, including trip destinations – and this information will be utilized in the future as part of the EV Project. The following information provides some basis for factors on appropriate distribution and density of EVSE:

- **Land Use Projections and Real Estate Data:** Detailed land use surveys and real estate data from tax appraisal districts classify properties in ways that can be analyzed as to their likelihood of supporting targeted destinations.
- **Travel Patterns.** Major streets, highways, and interchanges are ranked to identify areas with high levels of traffic and access to destinations.
- **Employment Density.** The number of employees, the location of their employment, and their type of business is mapped to identify targeted destinations.

Using multivariate analysis and geographic information systems (GIS), these data sets contribute to the mapping of planned distribution and density of EVSE. Initial analysis was conducted prior to beginning the long range planning process.

Additionally, planning for initial installation of EVSE will consider the demographic distribution of early adopters and destination data supplied by participating communities. The likely distribution of early adopters can be determined from zip code data for existing hybrid vehicle ownership, as well as data on the addresses of potential EV purchasers.

8.4 Public Input

From this pool of suggested locations, the initial infrastructure can take its first step from a plan to a roadmap. The next step in the Houston EV Community Plan will be the Micro-Climate Plan. This Micro-Climate Plan recommends the target areas, whereas the roadmap identifies specific sites. Ideas to establish possible locations are for EVSE are coming from:

- Houston Advisory Team members
- Public presentations
- Media announcements
- Participation in related conferences
- Direct contacts via email, web and telephone
- Community leaders
- EV drivers (ride and drive events) and others requesting information

7.3 Jurisdictional Priorities

Governmental agencies and electric utilities and private businesses are already creating priorities for EVSE infrastructure deployment. For example The Public Utility Commission of Texas has implemented a project that examines the EV Market and infrastructure issues relating to the introduction of EVs. Three workshops were held between May and October of 2010 to identify potential issues and hear strategies and proposals from the viewpoints of Transmission and Distribution Utilities and Retail Electric Providers. Source: <http://www.puc.state.tx.us/electric/projects/37953/37953.cfm>.

Public policy and incentives will create more opportunities for EVSE deployment to expand the infrastructure. Electric utilities will be monitoring the growing demand for EVs to evaluate the impact on the electric grid.

7.4 Commercial Interest

The initial availability of EVs will be attractive to fleet owners primarily for light duty passenger vehicles due to cost and availability considerations. Most governmental agencies and large employers providing pool vehicles will find these vehicles suitable for their daily vehicle mission. The promotion of EVs among their employees will generate new interest that again can expand the infrastructure deployment.

Rental car agencies and car-share programs that use EVs will help gain confidence that their users will be able to charge in publicly-available locations. Car-share programs have already announced that they will use EVs (Zipcar) and rental agencies have announced that they will acquire EVs (Hertz and Enterprise). Range anxiety and unfortunate battery discharge experiences for vehicle renters will need to be overcome through driver education and customer support services. Both the LEAF and Volt are equipped with on road emergency response as part of the vehicle design. A positive driving experience will promote EV adoption in many geographic areas.

The absorption of EVs into taxi fleets will also have a major effect on public acceptance. Taxis will have challenges using BEVs unless destination planning is included in the taxi reservation. A rider will not want to wait while the taxi is connected for charging. However, between fares, the taxi driver can make use of DC Fast Charging to prepare for the next fare. The use of EVs for taxis in Houston is much less likely than rental car share applications, but taxis have been successful fleets for HEVs. Taxis offer a good possible test bed if paired with DC Fast chargers. However, costs could be a big barrier, so major incentives would be needed.

Both the employer base and rental car companies will take advantage of the publicly available EVSE network. Their input will be useful for identifying potential locations. Like most fleet users, employer or workplace charging EVSE will be necessary to support these vehicles, but use of the publicly available EVSE infrastructure can be expected.

7.5 Level 2 EVSE Densities

Analysts for ECOtality have estimated appropriate densities of EVSE in the metropolitan regions based on destinations where EV owners will spend 45 minutes to 3 hours. Data fields for the Greater Houston Area study area considered dwell time, destination data on employment type, and traffic. The mapping in Figure 8-2 to 8-5 shows areas of high, medium, and low densities of Level 2 EVSE. High densities tend to occur near:

- High-density land use, especially areas with concentrations of commercial land uses
- High-use road corridors that provide access to adjacent businesses
- Freeway interchanges that have access to adjacent properties

Figures 7-2 to 7-5 illustrate the best places to distribute EVSE within the Houston EV Project boundary area. The maps identify typical densities of Level 2 EVSE expected by 2020. These densities are expected to “blanket” the area providing geographic coverage as well as higher densities of EVSE where the venues described in Section 8.3 above exist. The locations for the EVSE will likely consist of destinations such as shopping malls, parking garages, museums, etc. In addition, the North, South and Central maps denote areas of Level 2 Density outside the downtown areas where publicly available EVSE will be available in densities commensurate with the sale of EVs.

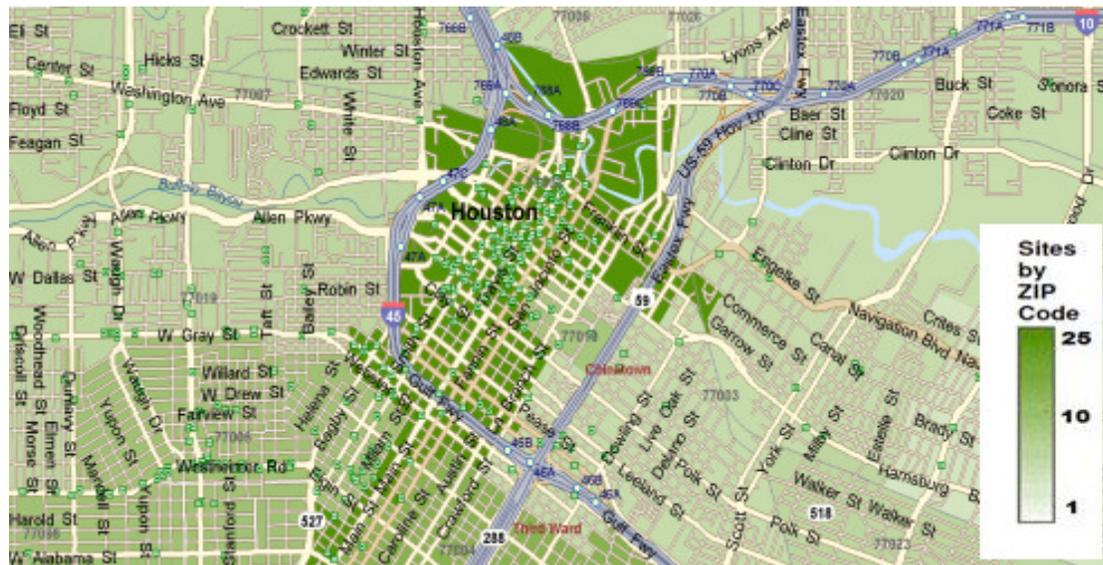


Figure 7-2 Greater Houston Area Level 2 Density - Downtown



Figure 7-3 Greater Houston Area Level 2 Location Density - North

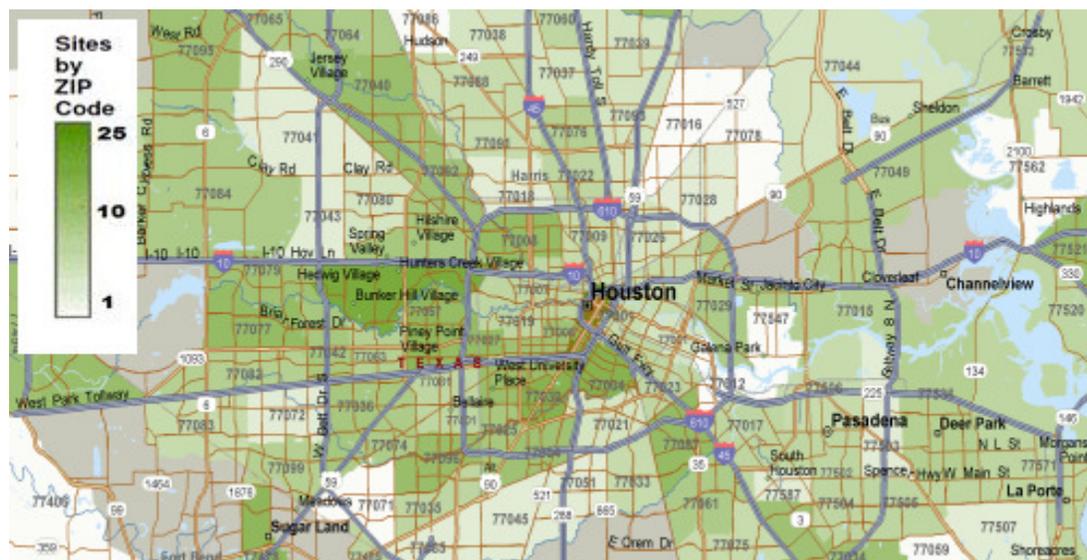


Figure 7-4 Greater Houston Area Level 2 Location Density - Central

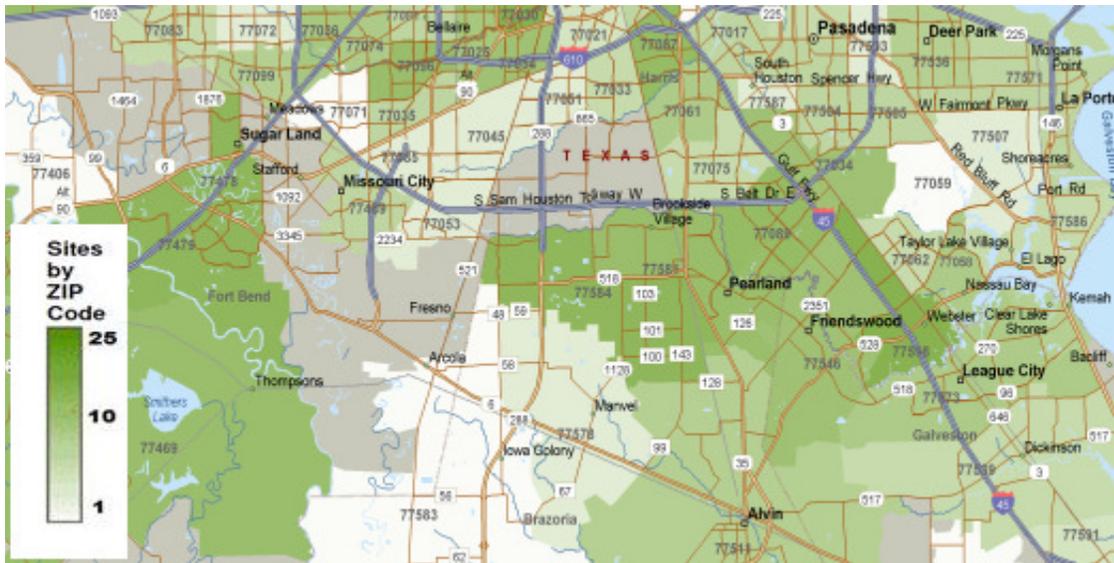


Figure 7-5 Greater Houston Area Level 2 Location Density – South

8 Summary & Conclusions

The Houston area is positioned to welcome the newest types of vehicles to reach the market – electric powered passenger cars and trucks – electric vehicles (EVs). Two major manufacturers (Nissan and GM) already have cars in the Houston area and can be ordered from dealers. More vehicles are on the way this year, and the Houston area is in planning, developing, and constructing the vehicle charging infrastructure. This long-range plan looks forward at the near term and the next ten years for ensuring that an effective, well-deployed charging infrastructure is in place.

Planning for the arrival of EVs in Houston began in earnest 2009, and gained speed and participants as it became clear that vehicles could start arriving as early as late 2010. The Houston EV Project Community Plan™ process completed the EV Charging Infrastructure Deployment Guidelines in December 2010 to organize and drive the preparations for the introduction of the Nissan Leaf, Chevy Volt and Ford Focus into the Houston market. The City of Houston organized a planning group of several key participants in the community including utilities, energy companies, and other organizations to participate in this planning process.

Range of Travel: A key issue for having a well-deployed, readily available charging infrastructure is related to EVs' range of travel. EVs, particularly all electric or battery electric vehicles (BEVs), have travel ranges that are significantly less than conventional gasoline vehicles. The Long Range Plan examines U.S. and Houston travel data to confirm that most day-to-day travel is well within the EV range, and that most early buyers will have other vehicles available to them for longer trips. Further, it was confirmed that most household vehicle trips are shorter, non-commuting trips that could be achieved without concern about range of travel. Regardless of such data, this concern will remain a consideration for most potential vehicle buyers until there is greater familiarity and experience. The experience of home charging and the accessibility of publicly available charging will help reduce this concern, but the quality of the charging infrastructure will eliminate it for the most part.

EV Market Projections: The LRP analyzes and projects the number of EVs that are expected to enter the Houston market by 2020. This analysis also provides a key indicator of what the charging needs will be in the Houston area. Several independent organizations have prepared U.S. projections of the electric vehicle market, which provided guidance for the Houston area projections. As might be expected, the national projections varied widely, and a mid-range, conservative market share was adopted for Plan projections.

The Houston area has millions of vehicles and each year another 200,000 to 300,000 new vehicles are purchased. By 2020, market projections suggest that Houston area EV purchases could total 20,000 vehicles with a cumulative total of almost 75,000 EVs. While this will be a very small fraction of the millions of vehicles, they represent a significant step for fuel efficiency, clean air, cost savings, and Texas' energy future.

Vehicle Charging Needs: EVs can be charged with various types of equipment, with the primary one expected to be a Level 2 EVSE (Electric Vehicle Support Equipment). A depleted battery system can be recharged overnight with Level 2. Most day-to-day charging will occur overnight with partially depleted batteries, more similar to cell phone or laptop charging. However, there are other types of charging that are essential for an EV charging system, not one based entirely on home charging. In fact, some vehicle owners may not have home charging as an option (for example, in multifamily townhomes or apartments).

The LRP includes five types of charging EVSEs: (1) home-based, single-family residential, (2) multi-family residential, (3) workplace charging, (4) publicly available charging, and (5) DC Fast Charge. The latter

two are particularly important plan recommendations in that they directly address concerns about non-home charging. Publicly available charging (similar to current refueling locations) includes the availability and accessibility of charging distributed throughout the Houston area. The Plan suggests that this type of charging be available within one mile of every place in the Houston area, which amounts to roughly 400 charging locations. Each location would have one or more plugs (ports). Typically public charging would be Level 2 EVSE at locations where an EV would be charged for 45 minutes to 3 hours or more. Overtime and as the number of EVs grows, the number of charging locations would increase to 1,000 or more. DC Fast Chargers, another publicly available form of charging, are capable of recharging a depleted battery system in less than 15 minutes. These are planned to be more widely distributed across the Houston area. At present, 50 Fast Chargers are planned for implementation in 2011 and 2012 with more than 700 projected by 2020.⁴⁵

The success of electric vehicles will depend on a number of variables, including a robust charging infrastructure, consumer education, and supportive public policies and investment. There are actions that federal, state, and local jurisdictions may consider over the next ten years to assist in the promotion of EVs and EVSE. This list is a starting point for consideration with some activities already underway and others under consideration.

Federal Policies

There are several federal policies and programs that are supportive of EV and EVSE development in the U.S., including an existing federal tax incentive for both EVs and EVSE.

Vehicle Tax Credit: The one most frequently mentioned is the Federal tax credit which provides a credit of up to \$7,500 for the purchase of EVs. The credit amount varies based on the vehicle's battery capacity. Detailed information on the tax credit is available on the U.S. Department of Energy's website at the following location: <http://www.afdc.energy.gov/afdc/laws/law/US/409>. The credit is referred to as the "Qualified Plug-In Electric Drive Motor Vehicle Tax Credit". The tax credit is provided to vehicles that meet the following requirements:

- Manufactured as an electric vehicle rather than converted. .
- Qualified as a motor vehicle as specified in Title II of the Clean Air Act.
- Gross vehicle weight rating (GVWR) of not more than 14,000 lbs
- Propelled to a significant extent by an electric motor drawing electricity from a battery which meets the following definition:
 - Battery capacity of not less than 4 kilowatt hours and
 - Capable of being recharged from an external electricity source
- Must be a new vehicle – vehicle use commences with the taxpayer.
- Vehicle is acquired for use or lease by a taxpayer, not for resale; credit is only available to the original purchaser of the new, qualifying vehicle. If leased to a consumer, the leasing company can claim the credit.
- Vehicle must be used primarily in the United States.
- Vehicle must be placed in service during or after the 2010 calendar year.

Existing production vehicles that qualify for the full tax credit include the Nissan Leaf, Chevy Volt, Wheego LiFe, CODA Sedan, and Tesla Motor's Roadster.

The Federal vehicle tax credit is scheduled to be phased out during 2011 based on a specified volume of vehicles sold by manufacturers. The credit applies to new EV and PHEVs purchased after December 31,

⁴⁵ NRG Energy created eVO Energy to plan and implement charging stations throughout the Houston area. These stations form the Freedom Network and will provide Level 2 and DC Fast Charging at many locations.

2009 and before December 31, 2011. The guidelines listed in the LRP reflect the current state of the tax credit. Though the infrastructure credit has been granted an extension, the full amount of the vehicle credit will be diminished after the manufacturer has sold at least 200,000 vehicles. Bills have been introduced in Congress to increase the number of vehicles.

Residential EVSE Tax Credit: A tax credit is also available for the purchase of EVSE for installation at a residence and at commercial properties. The Tax Relief, Unemployment Insurance Reauthorization and Job Creation Act of 2010 extends a tax credit for residential EVSE up to \$1,000, but no more than 30% of the total cost (to claim the maximum amount, the total EVSE cost would be \$3,333). In 2010, the tax credit was no more than 50% of the total cost.

Commercial EVSE Tax Credit: The Federal Alternative Fuel Infrastructure Tax Credit is available for costs of EVSE placed into service after December 31, 2005 and before December 31, 2011. The credit amount is currently up to 30% for equipment placed in service in 2011 with a credit up to \$30,000. Fueling station owners with multiple sites can claim credits for each location. Unused credits that qualify under general business tax credits can be carried back one year and carried forward 20 years.

Requirements for Federal Vehicle Fleets: The Energy Policy Act (EPAct) of 1992 requires that 75% of new light-duty vehicles acquired by many federal fleets must be alternative fuel vehicles (AFVs), including electric and plug-in electric vehicles. Furthermore, federal fleets are required to meet greenhouse gas reduction goals in federal fleets of more than 20 vehicles.

Requirements for State Vehicle Fleets: The Energy Policy Act (EPAct) of 1992 also requires State fleets to acquire alternative fuel vehicles, including plug-in electrics.⁴⁶ The stated purpose of EPAct is to reduce the nation's reliance on imported oil.

State and Local EV/EVSE Initiatives

There are many options that should be considered at state and local levels that will help achieve successful EV deployment in Houston and statewide. The availability of these options will further efforts for clean air, lower fuel costs, reduce impacts of volatile fuel prices, and reduced reliance on imported sources of petroleum. For Houston, reduced fuel costs for residents and businesses provides money for households and consumers that will be spent in the local economy and for local jobs.

State Initiatives

- Continue to provide incentives for EVs and EVSE to accomplish clean air and clean energy goals.
- Promote State utility policies that support EV charging infrastructure.
- Incorporate electric vehicles into state fleet programs.
- Incorporate EVSE into state energy and other regulations that affect buildings and development
- Support and deploy permit inspector training for EVSE programs.
- Assist cities and regions in conducting consumer outreach efforts for EV/EVSE deployment.
- Ensure that building code are as seamless and efficient as possible for basic EVSE installations and EVSE smart-charging standards.
- Work with utilities and EVSE providers to integrate EVs into the grid.
- Provide leadership to develop electric vehicle fast charging corridors on state highways.
- Encourage efforts to bundle EVSE with home solar or home area networks.
- Continue state provision of grants for development of EV infrastructure projects and programs as part of air quality and energy efficiency programs.

⁴⁶ Texas has redefined this requirement to apply to "clean" vehicles rather than alternative fuel vehicles.

Local Initiatives

- Update planning and zoning to incorporate electric vehicle infrastructure standards for public use, in new residential construction, and in commercial construction developments, as well as development incentives for retrofitting existing infrastructure.
- Work with the local electric utilities in area planning to identify needs for transformer enhancement at utility neighborhood substations.
- Incorporate electric transportation as part of regional and municipal transportation planning efforts
- Encourage the inclusion of EVs and associated infrastructure in neighborhood and community planning, such as livable cities, community development programs, corridor improvement plans, and regional sustainable community planning.
- Identify and train permit/code workforce on projects that incorporate EVSE; establish an expedited design review process for development and construction projects that include EVSE
- Support development of a residential EV/EVSE assessment program in cooperation with the local utility and the EVSE provider.
- Develop an online expedited EVSE permitting and inspection process in cooperation with the local utility and EVSE provider.
- Identify local capital improvement program funds or other funds that might be used to support more complex EVSE installations and panel upgrades.
- Develop community outreach and education efforts for residential and commercial EVSE residential and commercial installation.
- Include electric vehicle infrastructure in local sustainable construction/green building incentive programs.

Appendix A - Electric Vehicle Projections

As noted in the introduction to Section 4, projections of EV penetration into the market are difficult to obtain. The vehicle manufacturers are not releasing their information to the public, other than perhaps the next year's forecast. Public acceptance is still a big question that can partly be resolved by the infrastructure, but public policy and incentives will go a long way to promote or detract from that acceptance. Nevertheless, there are several projections worthy of note.

1. Electric Power Research Institute

The National Electric Transportation Infrastructure Working Council of the Electric Power Research Institute (EPRI) is a group of individuals whose organizations have a vested interest in the emergence and growth of the EV and PHEV industries, as well as truck stop electrification and port electrification. IWC members include representatives from electric utilities, vehicle manufacturing industries, component manufacturers, government agencies, related industry associations, and standards organizations.

The IWC recently completed a presentation on the effects of loading on the utility grid, presenting the EV penetration shown in Figure 3-5. This projection would provide annual sales of EVs in 2020 at about 560,000 vehicles and total EVs on the road of about 2.5 million cars.

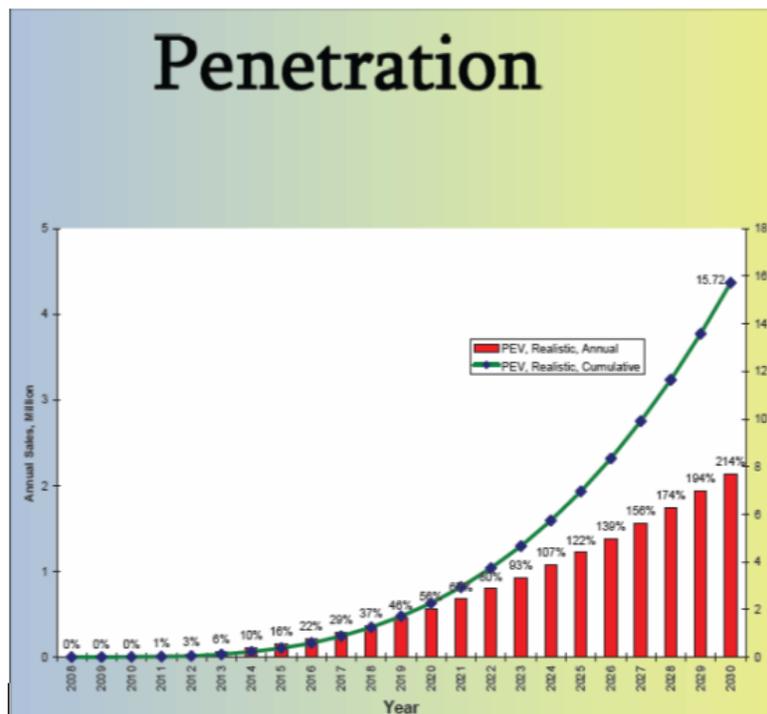


Figure A-1 IWC Realistic EV Penetration⁴⁷

⁴⁷ Plug-In 2009, Evaluation of PEV Loading Characteristics on Hydro-Quebec's Distribution System Operations, Giumento, Maitra, Kook, EPRI Sept 2009

2. Credit Suisse

Credit Suisse made the following statement:

Electric vehicles offer one of the fastest growth stories over the next twenty years. We expect automotive sales of electric vehicles to rise to over \$400 billion by 2030, with batteries rising to over \$100 billion and incremental charging infrastructure spending of at least \$170 billion. We believe that 1.1% of global vehicle sales will be electric by 2015, driven by more than \$15 billion in subsidies. That number could climb to 7.9% by 2030, hybrid electric vehicles could reach 5.9% by 2030 from 0.6% today. Nearly every auto manufacturer has plans to develop electric vehicles, with many models launching in 2011.

While we do not attempt to forecast specific HEV, PHEV, and EV sales by manufacturer, we do provide a framework that presents a hypothetical scenario for adoption rates. There are far too many moving parts to arrive at a specific forecast, as gas prices, fuel taxes, biofuel technologies, battery costs, consumer preferences, government subsidies, and policy mandates all impact adoption rates. That said, our model forecasts a potential adoption rate for PHEVs and EVs based on an economic framework.⁴⁸

Note that these projections are worldwide. Credit Suisse also projects that in 2030, U.S. sales of EV and PHEV will total 596,000 vehicles, while the world market will see 12,621,000 vehicles. The U.S. share would be about 4.72%, according to these projections.

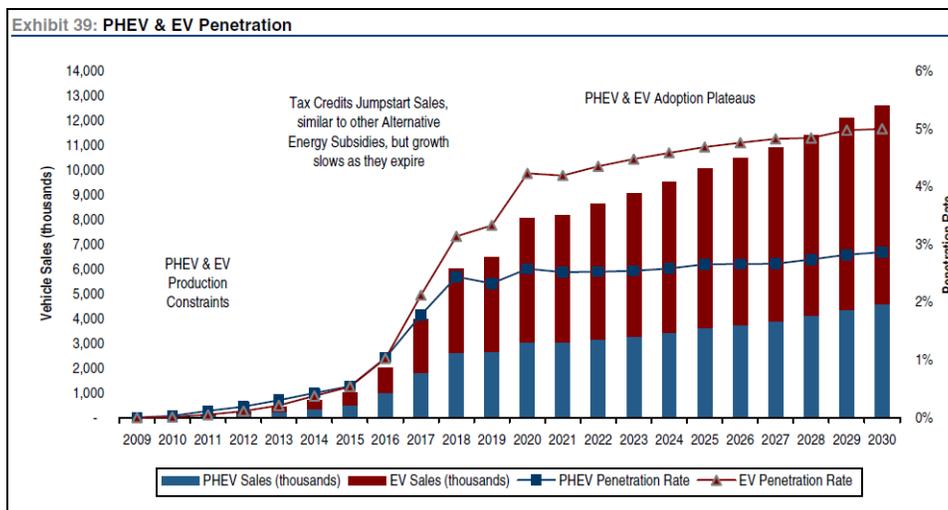


Figure A-2 PHEV & EV Penetration⁴⁹

Applying the ratio of US to world figures would suggest US EV annual sales to be approximately 380,000 vehicles in 2020.

⁴⁸ ibid

⁴⁹ ibid

3. Morgan Stanley

Morgan Stanley made the following statement:

We believe PHEVs will gain gradual acceptance with consumers and capture an increasingly larger share of HEV sales and total sales between 2010 and 2012. We see PHEV sales of a few thousand units upon launch in 2010, growing to 100K units in 2012 and 250K units in 2015. PHEV penetration will be driven by regular hybrids adding on plug-in capability.⁵⁰

US PHEV Sales year	Units
2010	5,000
2011	30,000
2012	100,000
2013	135,721
2014	184,202
2015	250,000
2016	329,877
2017	435,275
2018	574,349
2019	757,858
2020	1,000,000

Source: Morgan Stanley Research

Figure A-3 PHEV Demand Forecast⁵¹

This penetration would yield a total of 3.8 million PHEVs by 2020.

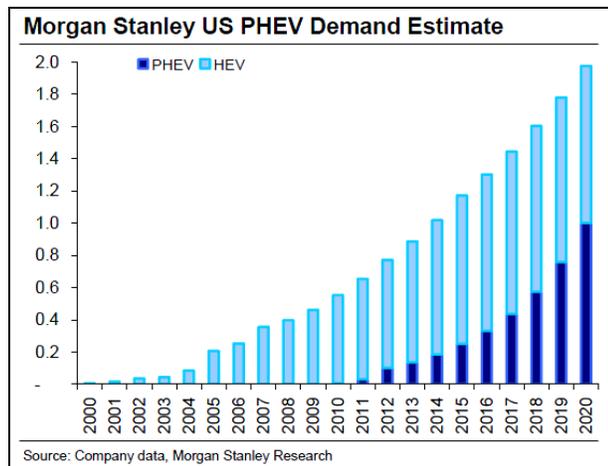


Figure A-4 PHEV & EV Penetration⁵²

⁵⁰ Morgan Stanley Research, Autos & Auto Related, March 11, 2008

⁵¹ ibid

⁵² ibid

4. Deloitte

A recent survey conducted by Deloitte of over 1,700 participants focused on electric vehicles, including fully electric vehicles, range extenders, and plug-in hybrid electric vehicles in the US market. Vehicles that do not plug into the grid were excluded.

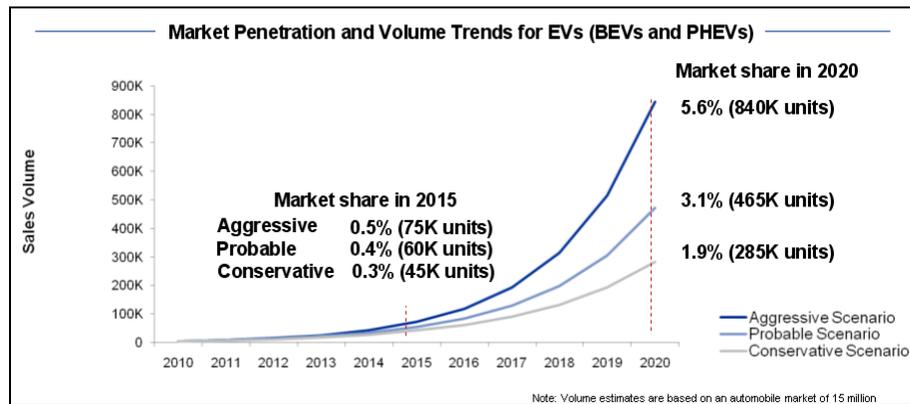


Figure A-5 Market Penetration and Volume Trends⁵³

5. Lazard Capital Market

Lazard Capital Management made the following statement:

We also believe that the launch of the Nissan LEAF as part of the eTec charging infrastructure build out will facilitate additional customer sales, due to increased customer range potential and convenience afforded by a network of charging stations.

In the US market, we assume that EV sales (PHEV + EV) reach ~ 400,000 units or 2.8% of the total market in 2015, and close to 1.1M units or 7.4% of the total market in 2020.⁵⁴

Exhibit 17. US Battery Opportunity				
	2011	2012	2015	2020
US car sales M units	13.50	13.77	14.61	16.13
% electric				
EV Sales (50% PHEV, 50% EV)	50,000	100,000	409,600	1,196,163
%	0.37%	0.73%	2.80%	7.41%
Total	55,000	155,000	980,600	5,228,938

Figure A-6 US EV Sale⁵⁵s

⁵³ Deloitte Research, Gaining Traction, A Customer View of Electric Vehicle Mass Adoption in the US Automotive Market, January 2010

⁵⁴ Lazard Capital Markets, Alternative Energy and Infrastructure, March 2010

⁵⁵ ibid

6. Deutsche Bank

Deutsche Bank made the following statement:

Automotive engineers are recognizing that it may not be possible to meet the onerous fuel efficiency targets required of them through upgrades to conventional powertrains and drivetrains. A growing number of industry executives predict that increased levels of electrification will be required.

We believe that rising fuel prices and regulatory challenges are likely to increase the electrification of the automobile – sharply. There’s another major influence here – advances in battery technology. High energy, cost effective, long lasting, and abuse tolerant batteries will be the key technical enablers for this shift, and there have been recent breakthroughs in meeting these requirements.

We find electric vehicles destined for much more growth than is widely perceived. This includes hybrid electric vehicles, plug-in hybrid electric vehicles, and even fully electric vehicles.

In the U.S. alone, 13 hybrid electric vehicle models were available in 2007, 17 are expected by the end of 2008, and at least 75 will be available within by 2011. NHTSA’s April 2008 report on proposed Corporate Average Fuel Economy Standards projected that hybrid vehicles could rise to 20% of the U.S. market by 2015, from just 2% of the market in 2007. Global Insight projects 47% hybridization of the U.S. market by 2020.⁵⁶

⁵⁶ Deutsche Bank, Electric Cars: Plugged In, 9 June 2008

7. Source 1 Research

Source 1 is a confidential source for research in the penetration of EVs.

The era of fossil fuels dominating transportation is coming to an end -- it's just a matter of when. Electric vehicles, including both plug-in hybrid electric vehicles (PHEVs) and range extended vehicles, and all-electric vehicles (EVs), also known as battery electric vehicles (BEVs) – are now the most likely candidates to someday overtake internal combustion engine (ICE) vehicles in total sales.

In addition to greenhouse gas reductions, the inexpensive cost per mile of driving with electrified transportation will drive consumer interest in EVs. In the U.S., EVs will cost approximately 75 cents per gasoline gallon equivalent to drive on electric power, a figure that could decrease by a few cents depending on advancements in battery technology.

The price of gasoline is expected to rise by approximately 65% between 2009 and 2015, while the price of electricity is likely to remain stable. This widening gap in the cost of vehicle locomotion will sustain consumer interest in EVs and encourage the expansion of charging stations so that drivers can operate on electric power as much as possible.

Should gasoline surpass \$4.00 per gallon for a sustained period of time, demand for EVs could increase dramatically, which would similarly escalate the investment in charging stations.⁵⁷

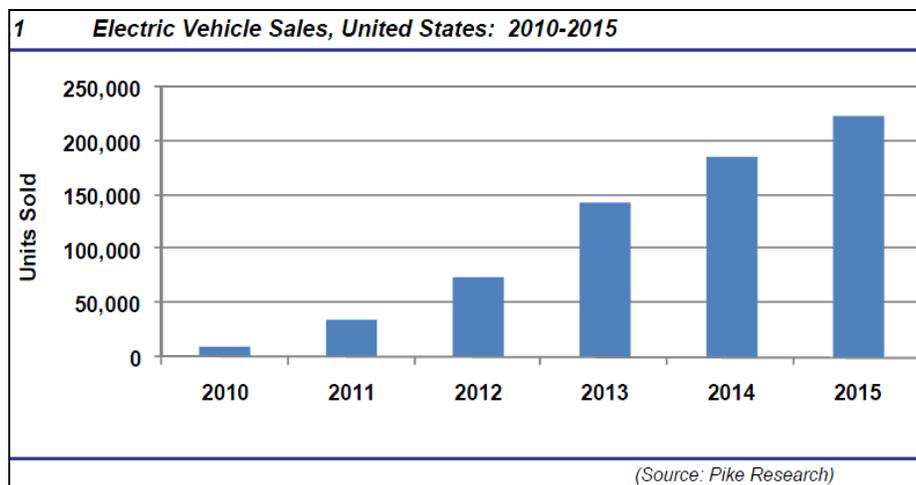


Figure A-7 Electric Vehicle Sales, United States⁵⁸

⁵⁷ Source 1 Research, Electric Vehicles on the Grid, Q2, 2009

⁵⁸ *ibid*