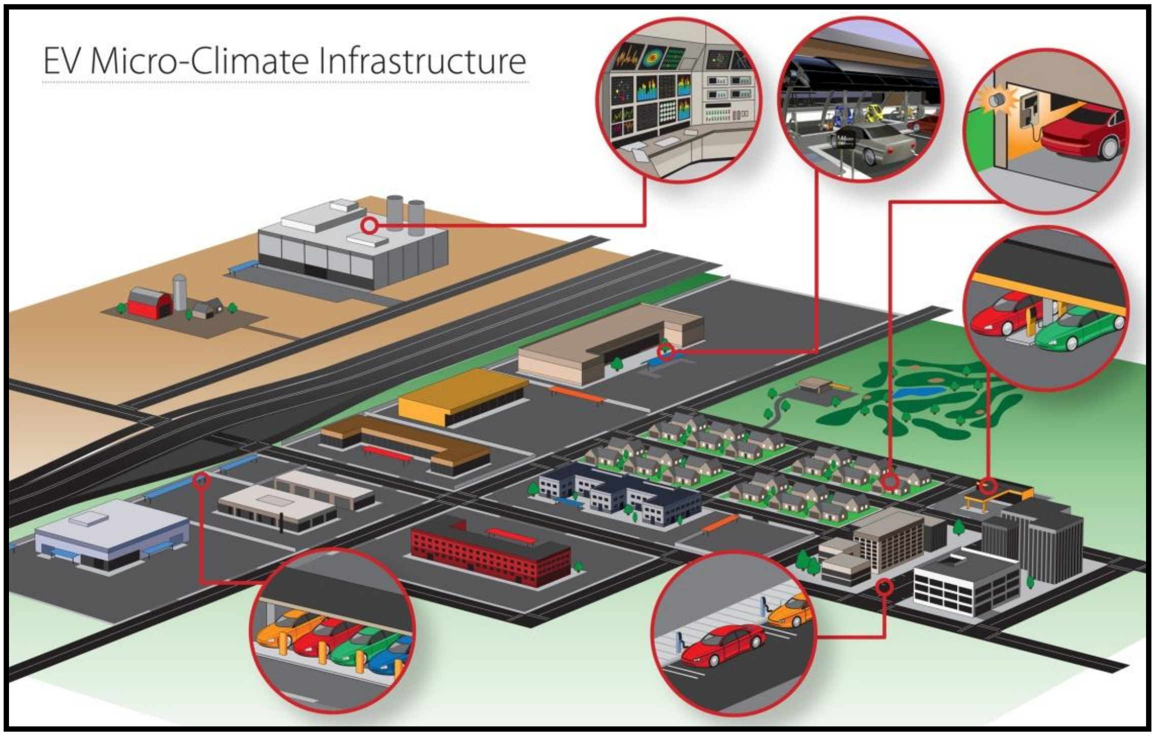
Long-Range EV Charging Infrastructure Plan for the Greater San Diego Area



October 2010

Version 4.1

ECOtality NORTH AMERICA

This material is based upon work supported by the U.S. Department of Energy under Award Number DE-EE0002194

Disclaimers
This document establishes the foundation for the initial deployment of electric vehicle supply equipment (EVSE) by Electric Transportation Engineering Corporation (doing business as ECOtality North America). Neither ECOtality NA, nor any of its affiliates:

> (a) represents, guarantees, or warrants to any third party, either expressly or by implication: (i) the accuracy, completeness, or usefulness of; (ii) the intellectual or other property rights of any person or party in; or (iii) the merchantability, safety, or fitness for purpose of; any information, product, or process disclosed, described, or recommended in this document,
>
> (b) assumes any liability of any kind arising in any way out of the use by a third party of any information, product, or process disclosed, described, or recommended in this document, or any liability arising out of reliance by a third party upon any information, statements, or recommendations contained in this document.

Should third parties use or rely on any information, product, or process disclosed, described, or recommended in this document, they do so entirely at their own risk.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately-owned rights.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Forward Looking Statements
ECOtality, Inc. (NASDAQ:ECTY), headquartered in San Francisco, CA, is a leader in clean electric transportation and storage technologies. Remarks contained in this document may contain forward-looking statements within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. All forward-looking statements are inherently uncertain, as they are based on current expectations and assumptions concerning future events or future performance of the Company. Readers are cautioned not to place undue reliance on these forward-looking statements, which are only predictions and speak only of the date hereof. In evaluating such statements, prospective users of this information should review carefully various risks and uncertainties identified in this document and the matters stated in the Company's SEC filings. These risks and uncertainties could cause the Company's actual results to differ materially from those indicated in the forward-looking statements.

Electric Transportation Engineering Corporation
dba **ECOtality North America**
430 S. 2nd Avenue
Phoenix, Arizona 85003-2418
(602) 716-9576
www.ecotalityna.com

Table of Contents

List of Figures

List of Tables

Acronyms

AC	Alternating Current
AMI	Advanced Metering Infrastructure
ARRA	American Reinvestment and Recovery Act
BEV	Battery Electric Vehicle - vehicle powered 100% by the battery energy storage system available on board the vehicle.
CCSE	California Center for Sustainable Energy
CHTS	California Household Travel Survey
DC	Direct Current
DCFC	Level 2 DC Fast Charger
DOE	U.S. Department of Energy
DR	Demand Response – mechanisms for utilities, businesses and residential customers to cut energy use during times of peak demand or when power reliability is at risk
EE	Energy Efficiency
EPRI	Electric Power Research Institute
EV	Electric Vehicle
EV-TOU	Electric Vehicle-Time of Use
EREV	Extended Range Electric Vehicle – see PHEV
EVSE	Electric Vehicle Supply Equipment – equipment that provides for the transfer of energy between electric utility power and an electric vehicle.
FHWA	Federal Highway Administration
GHG	Greenhouse Gas – a gas, such as carbon dioxide, a potential climate change contributor
HAN	Home Area Network
ICE	Internal combustion engine
ISO	Independent System Operator – creates energy and capacity markets and oversees electrical grid reliability
IWC	Infrastructure Working Council
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.
LEED	Leadership in Energy & Environmental Design, an internationally-recognized green building certification system
NHTS	National Household Travel Survey
OEM	Original Equipment Manufacturer – In this document, this term refers to automobile manufacturers.
PHEV	Plug-in Hybrid Electric Vehicle – vehicle utilizing both a battery and an internal combustion engine (ICE) powered by either gasoline or diesel.
REEV	Range Extended Electric Vehicle – see PHEV.
SAE	Society of Automotive Engineers. Standards development organization for the engineering of powered vehicles.
SANDAG	San Diego Association of Governments
SDG&E	San Diego Gas & Electric
TEPCO	Tokyo Electric Power Company
TOU	Time of Use - an incentive-based electrical rate established by an electric utility, intended to balance the load by encourage energy use during non-peak times.
U.S.	United States
U.S. GBC	U.S. Green Building Council
V2G	Vehicle to Grid - a concept that allows the energy storage in electric vehicles to be used to support the electrical grid during peak electrical loads.
VAC	Voltage Alternating Current. Public utilities generally provide electricity in an alternating current, which allows high incoming voltage to be changed by a transformer to the lower voltage required for consumer use.
VMT	Vehicle Miles Traveled

1 Introduction

The development of a public charging infrastructure is critical to the success of electric vehicles (EVs). Public education is merging with electric vehicle introduction and public policy to create an enthusiastic framework for the long-held dream of electrified, private-use transportation.

ECOtality, Inc. (NASDAQ: ECTY), headquartered in San Francisco, California, is a leader in clean electric transportation and storage technologies. Its subsidiary, Electric Transportation Engineering Corporation (eTec) dba ECOtality North America (ECOtality), is the leading installer and provider of charging infrastructure for EVs. ECOtality has been involved in every major EV or plug-in electric vehicle (PHEV) initiative to date in North America and is currently working with major automotive manufacturers, utilities, the U.S. Department of Energy (DOE), state and municipal governments, and international research institutes to implement and expand the presence of this technology for a greener future.

ECOtality designed and currently manages the world's largest EV infrastructure demonstration - the EV Project. With a budget of over $230 million, the EV Project will deploy and study Level 2 alternating current (AC) electric vehicle supply equipment (EVSE) stations for residential use, Level 2 AC EVSE stations for commercial and Level 2 direct current (DC) fast charge (DCFC) stations representing thousands of field assets, utilized in concert with the deployment of Nissan LEAF™ vehicles and Chevrolet Volt vehicles. In California, ECONA also received $8 million grant from the California Energy Commission for the EV Project.

The EV Project is a public-private partnership administered by the DOE through a federal stimulus grant, made possible by the American Recovery and Reinvestment Act (ARRA) and by the private investment of ECOtality and its partners.

The EV Project is an infrastructure study. The EV Project will deliver to ECOtality, the Government and the general public a wealth of directly-applicable technical and professional experience for jumpstarting regional EV adoption and replicating business models that lead to sustainable, market-based charge infrastructures.

The EV Micro-Climate process starts with the development of *EV Charging Infrastructure Deployment Guidelines* to organize and drive the preparations for this infrastructure. With significant input from local stakeholders, this foundation paves the way for a long-range plan.

This document examines the potential maturation of the EV market and EV infrastructure over the long term. It is difficult to achieve consensus on long-term plans due to unknowns in the economy, transportation issues, technological advances, human behavior, and related costs. However, there is wide acceptance that EVs are in fact a growing force in automotive transportation, and EV penetration is fully expected to achieve a significant market share within the next 10 years.

The actions of local communities will have an impact on EV market share. This *Long-Range EV Infrastructure Plan for Greater San Diego* provides a review of the current behavior of vehicle operators and industry projections of EV sales as a means of understanding the expected EV population in the Greater San Diego area by the year 2020. The projected EV population will require the EV infrastructure to support and encourage further increases in market share. This Plan seeks to uncover the quantities and locations of the publicly available charging systems that will do just that.

The term "EV" is used to denote all grid-connected plug-in electric vehicles, including PHEV and battery electric vehicles (BEV). At the end of 2010, Nissan dealerships in the San Diego region will begin sale of a BEV, the Nissan Leaf, and General Motors dealerships will begin sale of an extended range electric vehicle (EREV), the Chevrolet Volt. The Leaf will travel approximately 100 miles on a single charge and the Volt will travel up to 40 miles on a single charge with its range then extended another 300 miles via an onboard gasoline generator. During the 2010 – 2011 winter months, ECONA will deploy charging infrastructure in six regions of the United States (U.S.), including San Diego, as part of the EV Project.

The EV Project will collect and analyze data to characterize vehicle use in diverse topographic and climatic conditions, evaluate the effectiveness of charge infrastructure, and conduct trials of various revenue systems for commercial and public charge infrastructure. The ultimate goal of The EV Project is to take lessons learned from the deployment of these first 8,300 EV's and the charging infrastructure supporting them, to enable the streamlined deployment of the next 5,000,000 EVs.

Unlike some alternative fuels, the infrastructure for the production and distribution of electricity to power battery electric and plug-in hybrid vehicles is already in place in the form of the existing power grid and distributed energy sources like photovoltaic solar panels. According to the Electric Power Research Institute (EPRI), California's existing electricity capacity could recharge as many as 4-million plug-in hybrids if charged during off-peak hours when electricity use is relatively low.

In 2005, approximately 60 percent of California's oil supply was produced in the United States, with 20 percent of the total supply originating in Alaska and 40 percent in California. Of the remaining 40 percent that was imported from abroad, the most significant sources were Saudi Arabia (14 percent), Ecuador (10 percent), Iraq (5 percent), and Mexico (3 percent). The San Diego region does not produce any significant quantity of petroleum.

According to San Diego Association of Governments (SANDAG), daily travel demand in the San Diego region was about 16.7 million daily trips and 85 million vehicles miles traveled (VMT) as of 2006. Nearly 100 percent of these trips and vehicle miles are made with gasoline and diesel vehicles, and account for about 1.5 billion gallons of gasoline and diesel consumption. In 2007, SANDAG forecast that under a business-as-usual scenario, there will be 111 million VMT daily in 2030. Without efforts to increase deployment of alternative fuel or more fuel efficient vehicles, forecasted regional travel demand equates to annual gasoline and diesel consumption of 2.4 billion gallons by 2030.

Each Nissan EV will save as much as 436 gallons of gasoline per year compared to a comparable internal-combustion engine sedan (assuming 12,000 miles per vehicle per year). More than 90 percent of GHG (greenhouse gas) emissions in the San Diego Region come from energy. The largest contributors are on-road transportation (46 percent), electricity generation (25 percent) and natural gas end use (9 percent). Accelerating the deployment of electric vehicles will contribute to meeting the state law to reduce GHG emissions economy-wide to 1990 levels by 2020 and the long-term goal of reducing GHG emissions to 80 percent below 1990 levels by 2050.

Public and private entities in the San Diego region have been coordinating efforts and collaborating on funding proposals and planning activities. The purpose is to ensure that alternative fueling and electric charging infrastructure needs are identified and met with the unique characteristics of the region in mind. Organizations include San Diego Gas & Electric (SDG&E), SANDAG, California Center for Sustainable Energy (CCSE), Clean Fuels Coalition, local governments, universities, the regional airport and port authorities, and large businesses.

There is a general understanding that a strong regional (as well as interregional) effort will support a transition to alternative fuels. Public-private coordination and action will help communicate to the market (e.g., fuel producers and suppliers, vehicle manufacturers, potential customers, and others) that the San Diego region is committed to and seeks to attract investment in alternative fuel vehicle and infrastructure, like plug-in electric vehicles and EVSE.

In 2009, SANDAG conducted an assessment on how to accelerate deployment of alternative fuel vehicles in and around San Diego entitled the *Regional Alternative Fuels, Vehicles and Infrastructure Report*. That report recommended public – private partnerships and collaborative approaches such as forming strategic regional alliances and coordinated planning for a robust electric charging network. The region continued to support EV and EVSE deployment through recommendations in the *Regional Energy Strategy* (2009) and *SANDAG Climate Action Strategy* (2010). Local governments, SDG&E, ECONA, Nissan and SANDAG are working together to identify high priority EVSE sites, and develop consistent permitting, inspection and installation protocols and/or policies across jurisdictions. SDG&E has formed a regional advisory group to provide input into development of the experimental time of use rates that they are proposing to the Public Utilities Commission.

The EV Project provides a starting point in Greater San Diego to achieve the region's long-range goals, as over 1,500 publicly available EVSE will be installed in the region between December 2010 and June 2011. 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 EV Project resources.

This long-range plan starts in Section 2 by looking at driver behavior revealed by national surveys. Certain behavior patterns that run counter to common thought about EVs help inform the discussions in the following sections.

Before the discussion on locating charging systems can begin, the expected market penetration of EVs into this region needs to be understood. That penetration is built upon national projections described in Section 3.

The penetration of EVs into the market is tied to the availability of publicly available charging infrastructure. EV drivers must be assured that they will be able to complete their daily travel needs without depleting their battery. Likewise, the availability of charging infrastructure is tied to the quantities of EVs on the road. Businesses are unlikely to install charging stations unless there are EVs to use them. EVSE projections and their methods are discussed in Section 4.

Section 5 projects the expansion of EV and EVSE use in Greater San Diego based on the projected national growth of EV and EVSE.

The planning for the DCFC is quite different from the balance of the infrastructure but is integral to it. Section 6 is devoted to the DCFC.

Having been informed by all these factors, the detailed discussion on where and how to expand the development of the charging infrastructure can begin. Section 7 develops the approach and plan to accomplish this in Greater San Diego. Input from local stakeholders and prior work on these topics provides the support for the plan. By understanding the characteristics of the EVs and the capabilities of the charging systems along with driver demographics, an effective plan for wise deployment of available resources is possible. That is the goal of this document.

2 Driver Behavior – National Household Travel Survey

The National Household Travel Survey (NHTS) serves as the nation's inventory of daily travel. Data is collected on daily trips taken in a 24-hour period, providing a better understanding of travel behavior. Analysis of this data helps Department of Transportation officials assess program initiatives, review programs and policies, study current mobility issues, and plan for the future. 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 2.3 below, these destinations fall into several categories, including "Home", since daily travel generally involves at least one trip home.

The survey referenced in this document was conducted in 2009 and had a total sample size of approximately 150,000 households. There was an average of 1.85 drivers per household and the average age of the driver was 45 years old. The Federal Highway Administration (FHWA) analysis of the survey results from 2009 has not been fully completed at this writing, but information is available and was obtained from the FHWA website.

The survey provides for all modes of transportation, from personal car to bus to airplane to walking. The vehicles of interest for planning electric vehicle charging infrastructure are cars. Many other vehicle types may become electric vehicles, but it is our assessment that the vast majority of future electric vehicles will be cars.

2.1 Daily Trips All Vehicles

The following figures present data provided in the NHTS 2009 survey information. Comparisons are drawn from the initial survey in 1969 through the most recent NHTS survey in 2009. Figure 2-1 shows the average number of daily vehicle trips for all types of vehicles. Since a trip would generally involve from home to destination and back home, the minimum response would be about two. (Note, some may have started away from home and traveled home, only resulting in one trip.) Overall, the total vehicle miles traveled on a daily basis appears to have leveled off since 1995.

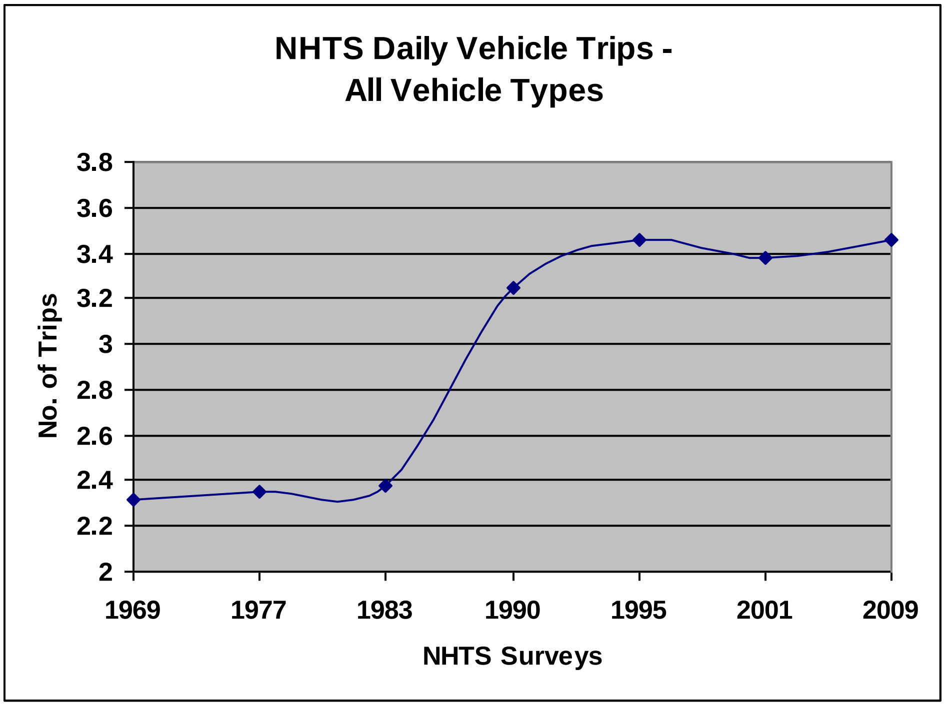


Figure 2-1 Average Daily Vehicle Trips for All Types of Vehicles from NHTS Surveys Conducted Since 1969

The average vehicle trip length for all vehicle types continues an upward climb, as shown in Figure 2.2.

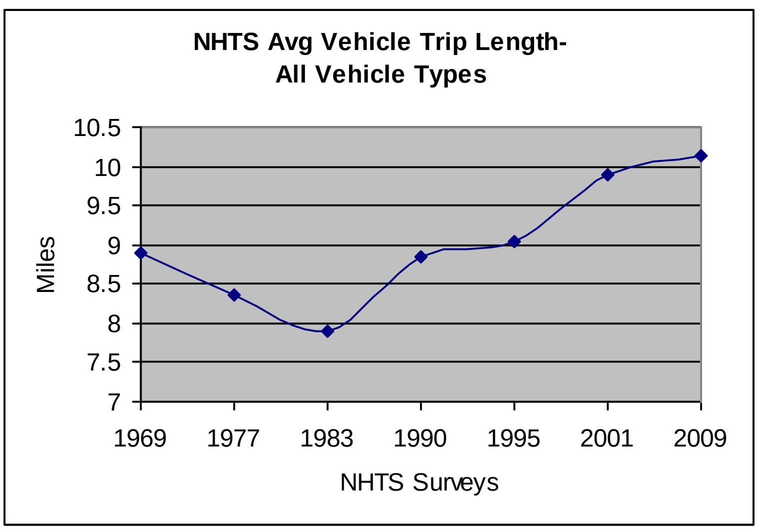


Figure 2-2 Average Vehicle Trip Lengths for All Types of Vehicles from NHTS Surveys Conducted Since 1969

Combining these two averages indicates the 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 may be a factor in this decision.

2.2 Daily Trips by Car

The 2009 average weekday daily vehicle miles traveled by cars was 31.14 miles, while the longest travel day was Thursday.

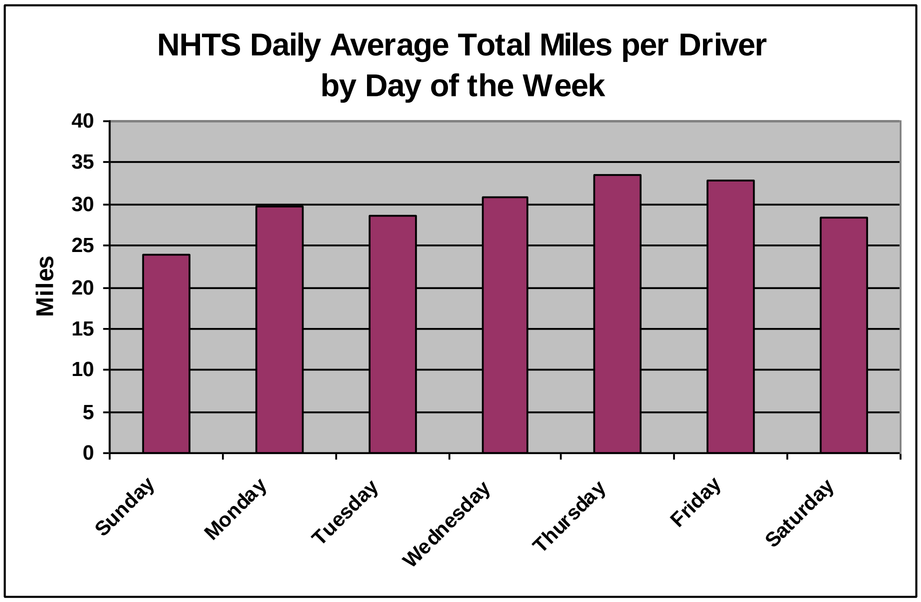


Figure 2-3 Total Daily Miles per Car Driver by Day of the Week – NHTS 2009

For the daily trips by car, Figure 2-4 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 to go shopping or run 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 stops per day. Driving to and from work also generally involves a side trip and stops along the way. Errands may also include a stop for school. Destinations for stops become important in the evaluation of charge infrastructure developed later. Intuition might suggest that charging infrastructure at home and work would be sufficient, but these data indicate otherwise.

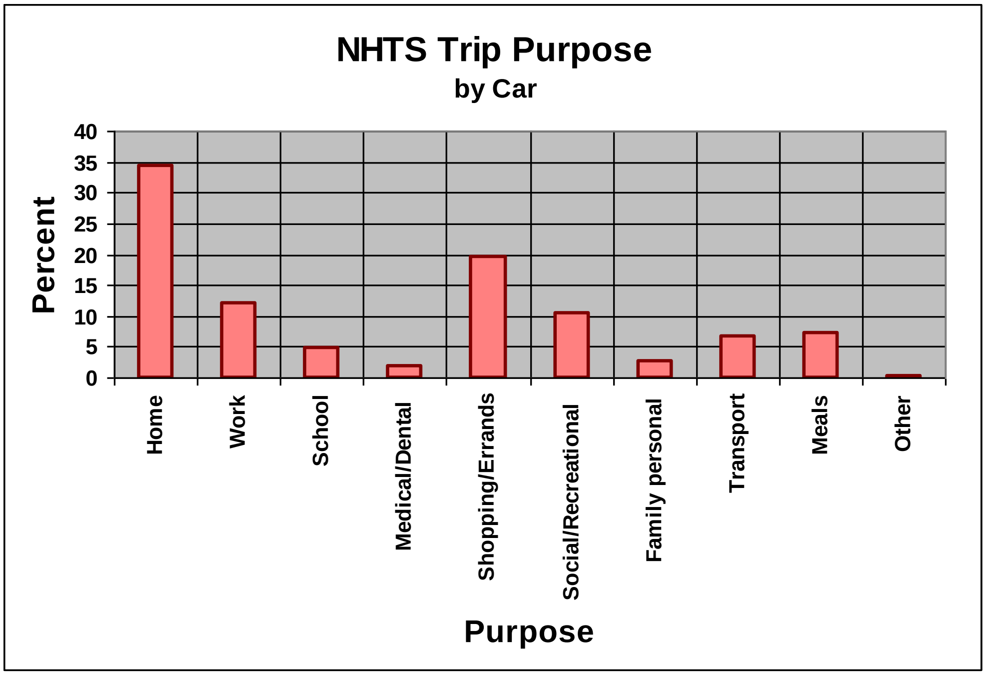


Figure 2-4 Percentage of Daily Car Trips by Purpose – NHTS 2009

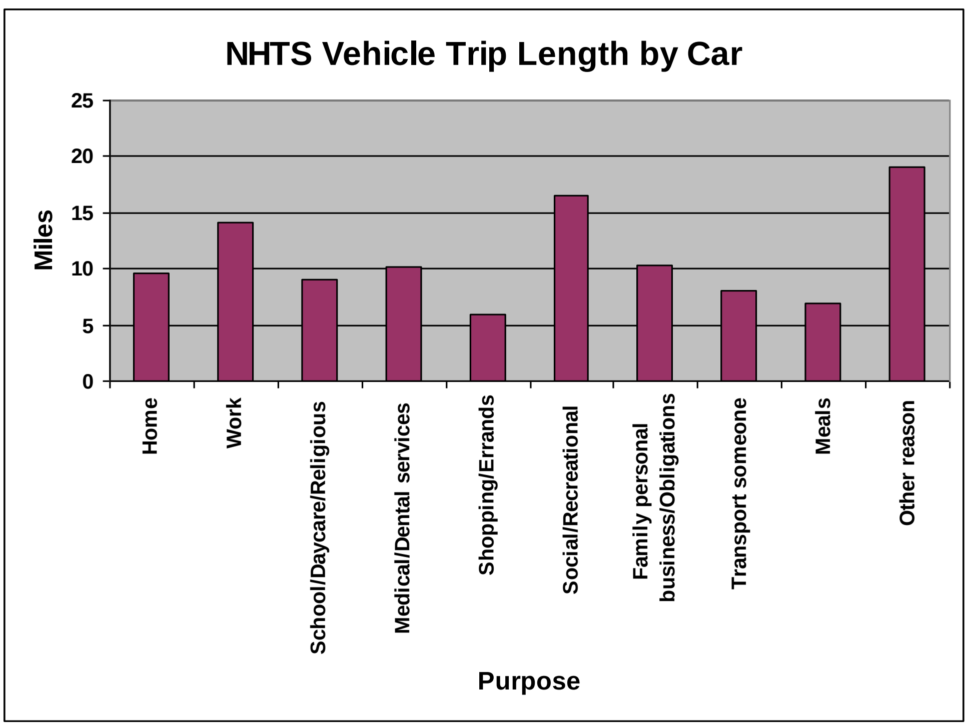


Figure 2-5 Vehicle Trip Length by Car by Purpose – NHTS 2009

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 further distances for social or recreational activities or other trips of importance. This would make the charging infrastructure at these destination points at least as important, and perhaps more important, than work locations.

2.3 Vehicle Information

Figure 2-6 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. Approximately 80% of the overall population of the United States would fit that profile.

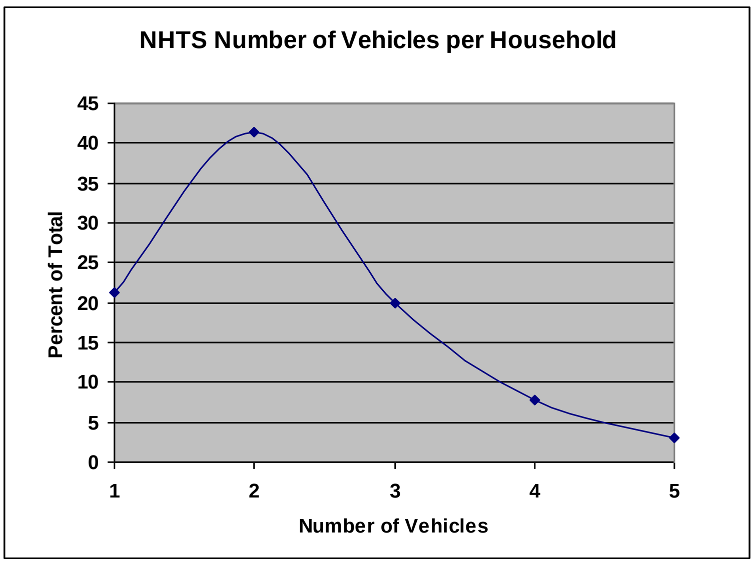


Figure 2-6 Numbers of Vehicles per Household – NHTS 2009

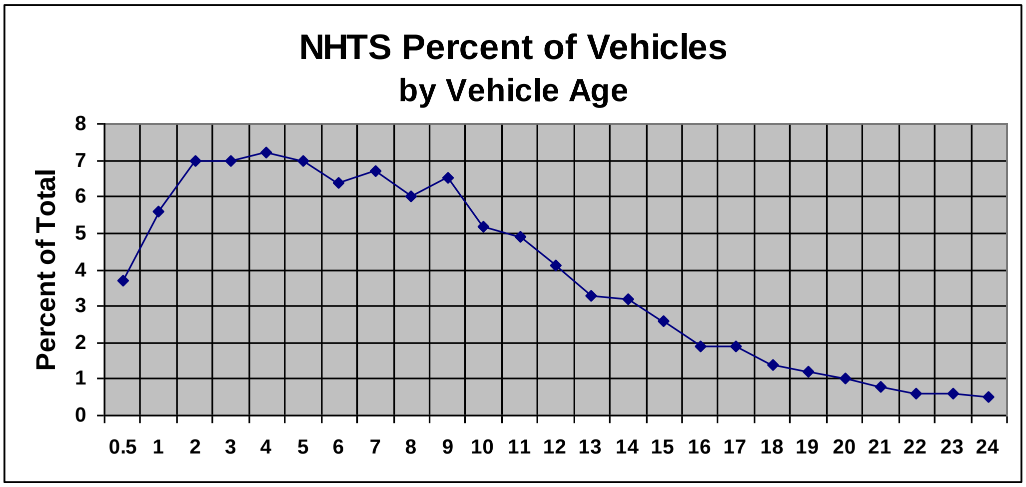


Figure 2-7 Percent of Vehicles by Vehicle Age – NHTS 2009

When looking at EV penetration rates, it is important to view not only the expected annual sales of EV, but to consider the long life of existing internal combustion vehicles. The average age of personal vehicles today is 8.3 years. A very significant number of vehicles in operation are greater than 10 years old. This will be a significant factor holding back the overall market share of EVs for a long time to come. On the other hand, the used vehicle market will likely extend the use of EVs to most demographics within the decade of the 2010s.

2.4 Other Factors

A significant percentage of vehicle traffic during peak travel times of day is not work-related travel. As seen in Figure 2-4, 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.

According to the 2001 NHTS, 85 million workers (two-thirds of all commuters) usually leave for work between 6:00 and 9:00 am, and over 88 percent of these workers travel in private vehicles. However, as shown in Figure 2-8, a significant number of non-work vehicle trips are made during peak periods.

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.[1]

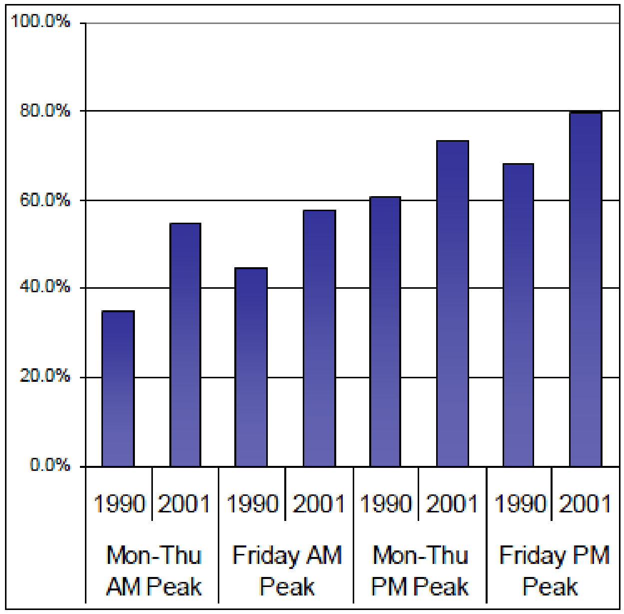


Figure 2-8 Non-Work Trips at Peak Periods – NHTS 2001

This again supports the suggestion that workplace charging may not be as important as had been expected. 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 children at school or to stop 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.

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 2-9.

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

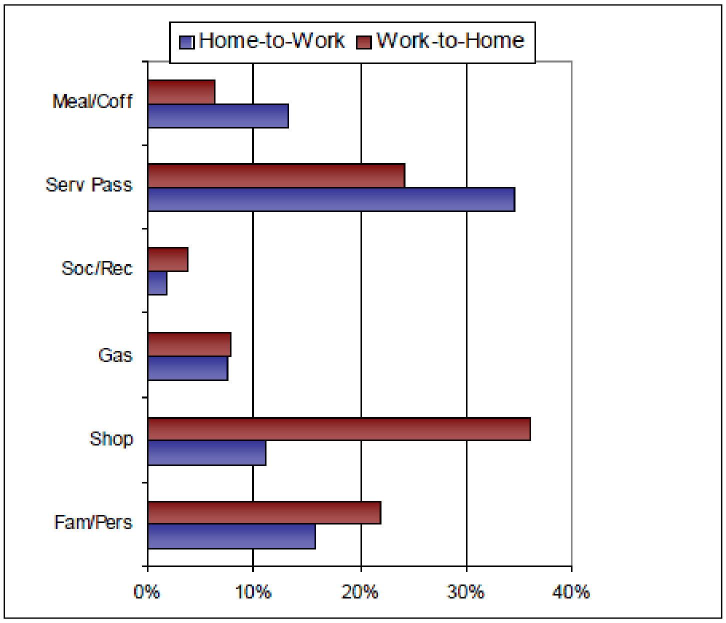


Figure 2-9 Non-Work Trips at Peak Periods – NHTS 2001[2]

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 keeps the stops to a short duration, will increase the desire for faster charging systems. See Section 6.

2.5 California Household Travel Survey (CHTS)

CHTS 2000-2001 provides additional insight into driving and commuting characteristics of California and San Diego drivers. CHTS is currently going through a 2010 update, but was unavailable at the time of writing. According to the CHTS, San Diego drivers have an average of 4.5 weekday trips / vehicle / day, and make 78 percent of their weekday trips by car. Figure 2-10 shows the breakdown of weekday trips by trip type.

[2] ibid

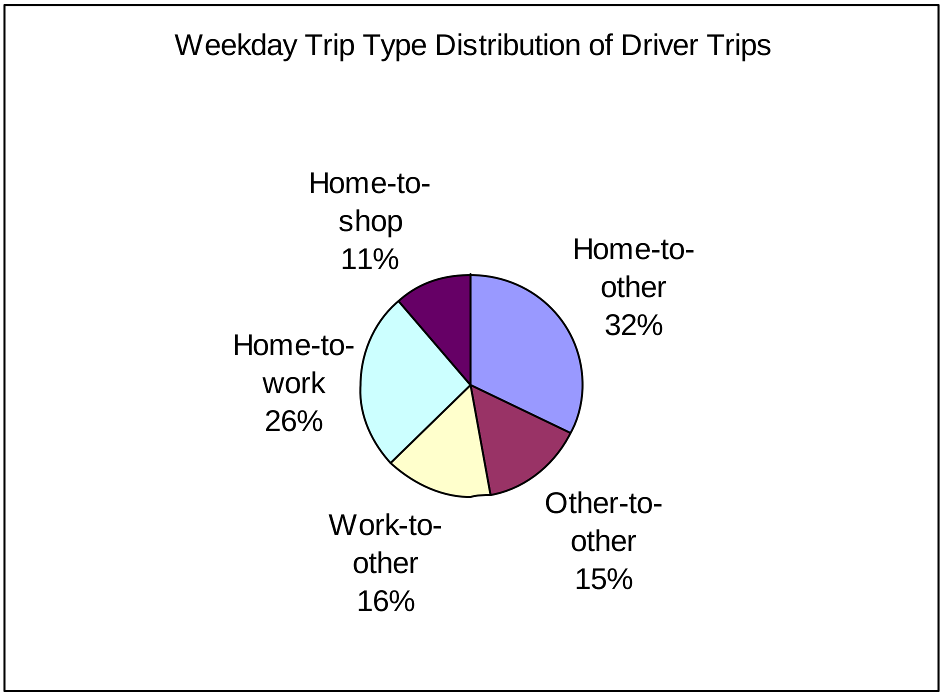


Figure 2-10 Weekday Trip Type Distribution of Driver Trips for San Diego

CHTS also shows that the number of driver trips per household per vehicle in California (and San Diego specifically) tends to increase as the household size increases and as household income increases (up to $150,000 and then it drops back off. San Diego area high is 8.7 driver trips / household / day for households with incomes of $100,000 - $149,999. U.S. Department of Transportation data shows that San Diego drivers drive an average of 23.7 vehicle miles / day (VMT/day).

2.6 Summary

Most drivers make several trips to many different destinations on a daily basis, and the number of those trips does not significantly change from weekday to weekend. The daily travel length for most drivers can easily be accommodated by the 100-mile range of the EVs expected to be available in the near term. The daily purposes of these trips can also be accommodated by these vehicles. Trip destinations will be an important factor in placing the publicly-available charging infrastructure, as discussed later in this document.

3 EV Sales Projections in the United States (U.S.)

Long-range planning for EV infrastructure must start with the 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.

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 is an example of a BEV. 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 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. It is important to note that many first generation EVs on-board Battery Management Systems may limit the effective rate of energy transfer to 3.3 kW regardless of whether EVSE is a 240 VAC 40 amp installation. Future generations of EVs may utilize the full capability of 240 VAC, 40-amp EVSE.

Table 3-1 EV Charge Times

		Circuit Size and Power in kW Delivered to Battery				
EV Configuration	**Battery Size (kWh)**	120 VAC, 15 amp **1.2 kW**	120 VAC, 20 amp **1.6 kW**	240 VAC, 20 amp **3.2 kW**	240 VAC, 40 amp **6.5 kW**	480 VAC, 85 amp **60kW**
PHEV-10	**4**	3 h 20 m	2 h 30 m	1 h 15 m	35 m	n/a
PHEV-20	**8**	6 h 40 m	5 h	2 h 30 m	1 h 15 m	n/a
PHEV-40	**16**	13 h 20 m	10 h	5 h	2 h 30 m	16 m
BEV	**24**	20 h	15 h	7 h 30 m	3 h 40 m	24 m
BEV	**35**	29 h 10 m	21 h 50 m	10 h 40 m	5 h 20 m	35 m
PHEV Bus	**50**	n/a	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 √3 x 85 Amps x .85 eff. (Limited to 60 kW maximum output.)

- **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.

3.3 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 3.4.

3.3.1 BEV and PHEV

The early hybrid vehicles that entered the automotive market were very similar to their 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, is a dramatic departure 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 become more and more apparent that having two types of technology, battery and ICE, is superfluous. For that reason, many analysts today see the PHEV as a bridge technology.

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. The next vehicle will be the BEV.

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 the DCFC. 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.[3]

3.3.2 Consumers

The Everett Rogers Diffusion[4] 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.

- 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.

---

[3] GM Exec: *Long Term BEV Demand will be greater than EREV*, http://gm-volt.com, March 2010

[4] Diffusion of Innovations (Rogers 1962)

- *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* follows, 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.

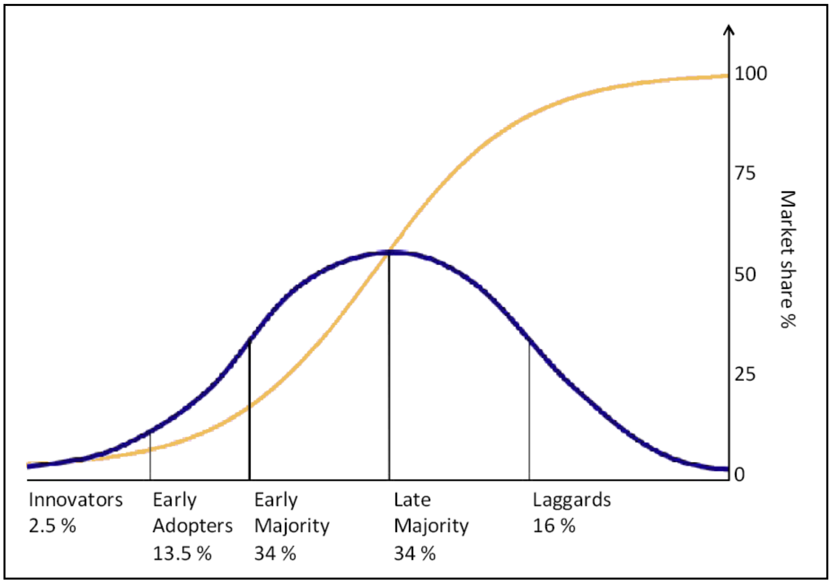


Figure 3-1 The Diffusion of Innovations According to Rogers

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

- Similar to early adopters of hybrids
- Early adoption will be concentrated around southern California, where weather and infrastructure allow for ease of EV ownership.[5]

Deloitte suggests the Early Majority will share these demographics:

- Highly concerned about foreign oil dependency, as well as environmentally conscious.

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

- There are 1.3 million men and women in the US who have the demographic characteristics of the Early Majority segment.[6]

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 3-2.

Table 3-2 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
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

[6] ibid

Make	Model	All Electric Range (mi)	Battery Size (kWh)	U.S. Target Intro. Date
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

As noted in the introduction to this section, 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. Appendix A explores the current projections worthy of note, along with ECOtality NA's projections to develop the sales estimates used here.

President Obama has set the 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 3-2: Annual EV Sales Projections. ECONA has also conducted a study of EV penetration, for which the results are also shown in Figure 3-2, along with the other penetration forecasts described in Appendix A.

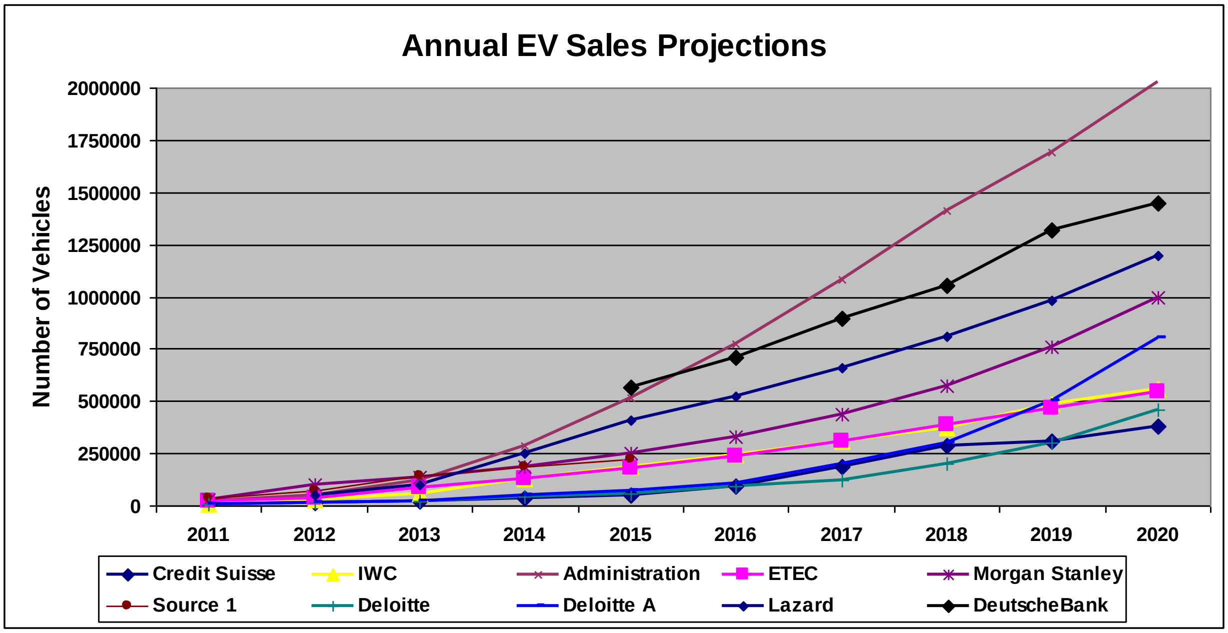


Figure 3-2 Annual EV Sales Projections in the U.S.

There appears to be 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.

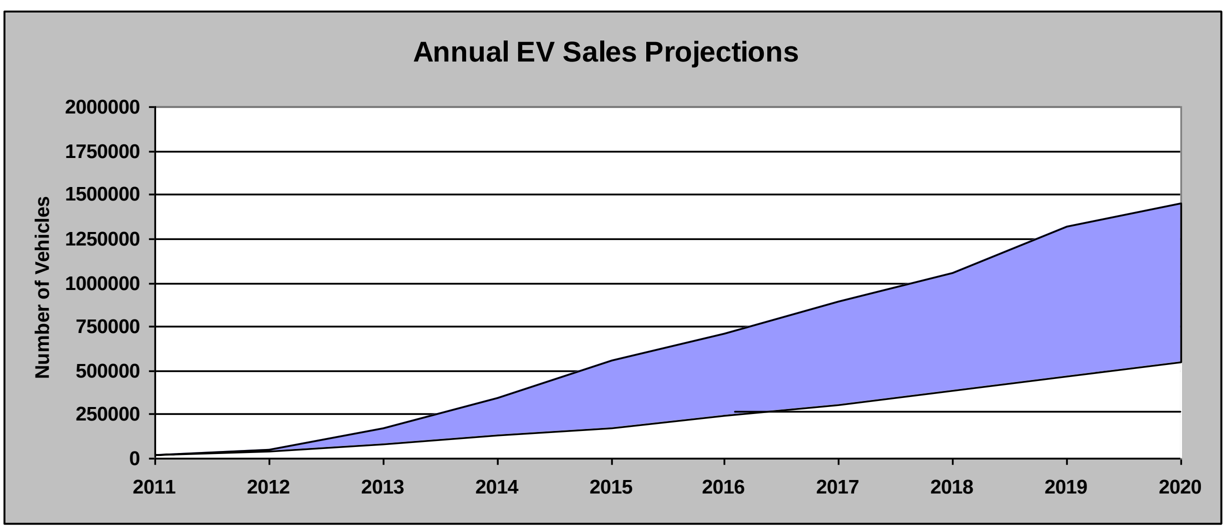


Figure 3-3 Range of Likely Annual EV Sales in the U.S.

ECONA used the lower, more conservative view for this long-term plan, but we strongly suggest that this should be considered the base for specific planning, with more rapid adoption being highly likely. EV penetration above this minimum would provide additional incentive and demand for increasing EVSE. Figure 3-4 shows this plan in annual sales, as well as cumulative sales. By 2020, a total of almost 2.5 million EVs would be in service.

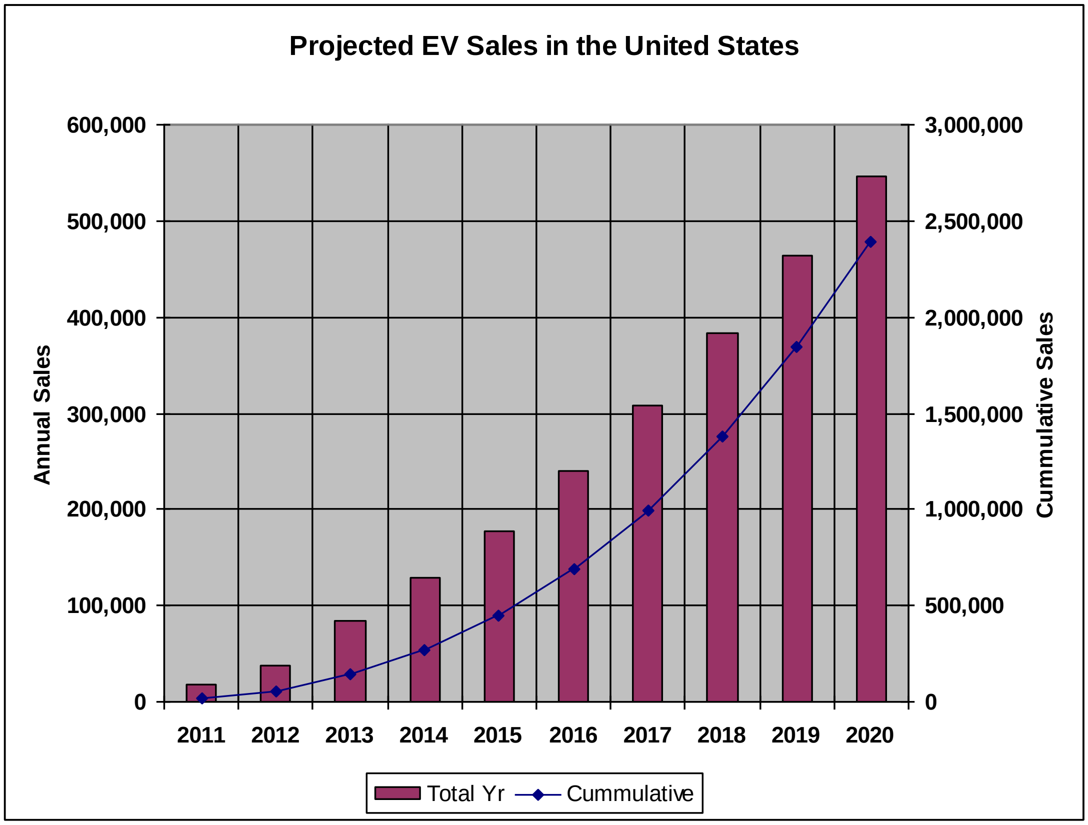


Figure 3-4 Projected EV Sales in the U.S.

3.5 EVs as Part of the Overall Vehicle Mix

The automotive market in the U.S. has been extremely slow during this economic downturn. Incentives have helped spark sales, but near-term predictions are still below average growth. While few are willing to make projections of sales, most suggest that car sales will start recovering in 2011 or 2012. EVs will contribute to the overall mix of vehicles, as shown in Figure 3-5. By 2020, these EV sales will account for 3.1 to 5.6% of total new car sales.

The total number of passenger cars in the U.S. in 2007 was 135,932,930.[7] 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.

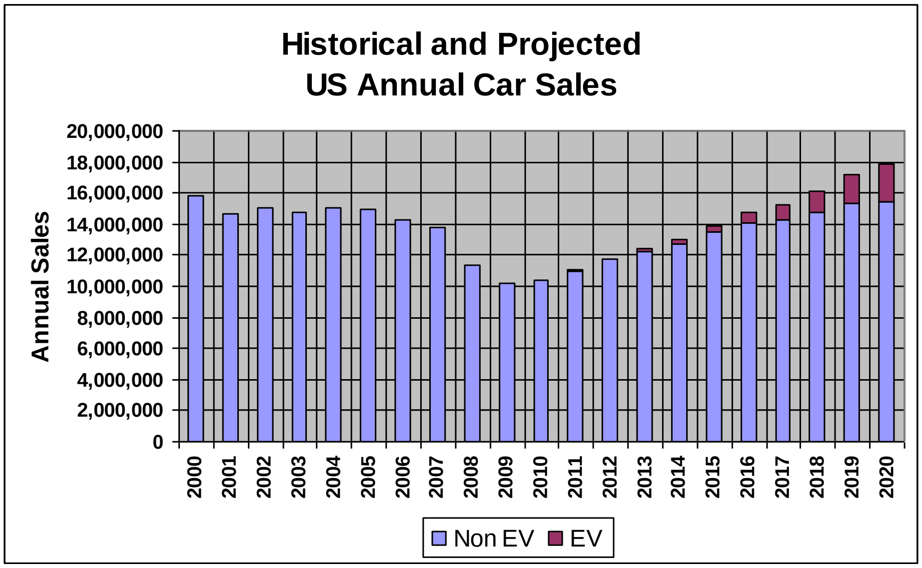


Figure 3-5 U.S. Annual Car Sales

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 widely 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.

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

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 their 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.[8] 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.

[8] Business Fleet, 2009 Fact Book Stats, www.businessfleet.com

4 EVSE Sales Projections in the United States (U.S.)

Vehicle manufacturers face many difficulties in successfully launching electric vehicles. 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. To avoid this anxiety, a charge infrastructure must be established that allows EV owners to charge where they live, work, and play. This infrastructure must be sufficiently rich to ensure that EV owners can charge conveniently. It also must include fast-charge stations that can return a substantial amount of energy in a short period of time, to make recharging at commercial locations (restaurants, stores, etc.) as simple and efficient as fueling a gasoline-fueled vehicle. A rich charge infrastructure is critical for a smooth transition from gas to electric, and for consumer acceptance of electric transportation.

These charging systems, more accurately referred to as EVSE, 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.

During the 1990s, there was no consensus on EV inlet and connector design. Both conductive and inductive types of connectors were designed and in both cases, different designs of each type were provided by automakers. At the present time, however, 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*.[9]

[9] 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.

Figure 4-1 J1772 Connector

Figure 4-2 J1772 Inlet (right side)

The J1772 connector and EV inlet will be used for both Level 1 and 2 charging levels, as described below.

In 1991, the Infrastructure Working Council (IWC) was formed by the EPRI to establish consensus on several aspects of EV charging. Level 1, Level 2, and Level 3 charging levels were defined by the IWC, along with the corresponding functionality requirements and safety systems. Since that time, the term Level 3 has been superseded by more descriptive terms; “DCFC” is used in this document.

The Level 1 method uses a standard 120 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 generally considered to be the “primary” and “preferred” method for the EVSE for both private and publicly-available facilities, specifying a single-phase branch circuit with typical voltage ratings from 220 – 240 volts AC. 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 6.6 kW 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), 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 DCFC.

DCFC 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, DCFC would provide a 50% recharge in 10 to 15 minutes. DCFC 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

For a BEV (and some PHEV owners who choose the utility time of use rates), 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. 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 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 DCFC discussed in Section 6.

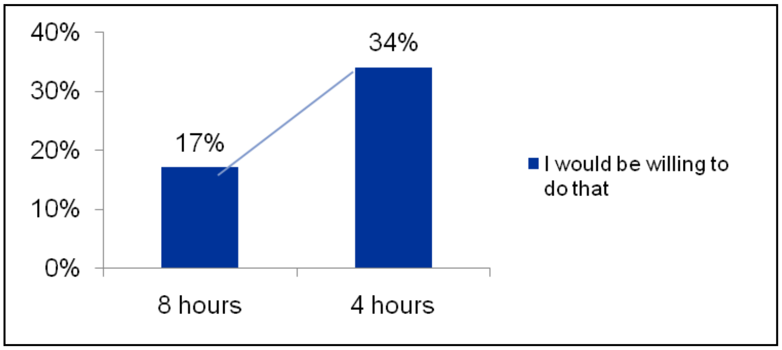


Figure 4-3 Preferences for Home Charging Duration[10]

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.

Table 4-1 SDG&E Time of Use Rate (EV-TOU)[11]

Super Off Peak Midnight – 5am	Off Peak 5am – 12pm	Peak 12pm – 6pm	Off Peak 6pm - Midnight
$.14/kWh	$.17/kWh	$.27/kWh	$.17/kWh

As the super off peak rate is less than eight hours the advantage of charging in less than eight hours is again 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, and which could potentially cause more issues. 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. At the same time, the increasing vehicle battery capacity will require longer recharge times. (See also Appendix B.) EVSE will need to be capable of delivering a recharge in much less than the eight hours available at off-peak times.

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

[11] http://www.sdge.com/environment/cleantransportation/evRates.shtml

As shown before, it is anticipated that most EV and PHEV owners will rely on Level 2 equipment where possible. In the next few years, incentive programs and consumer demographics will favor more Level 2 home use. However, the significant number of people who live in areas where a home charger may not be feasible will reduce that number, as will those consumers who buy used EVs. It is estimated that by 2020, the percentage of EV drivers with home Level 2 EVSE will be about 50% of all EV adopters.

4.1.2 Fleet

As noted in Section 3, 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 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 DCFC 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. Overall it is estimated that the population of Level 2 EVSE in fleet applications will be approximately 67% that of the EVs.

4.1.3 Commercial Publicly Available 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 DCFC. 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 NHTS 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 for a substantial period 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 are likely to install EVSE to encourage their employees to purchase EVs, to promote green certification of facilities, and to achieve organization-wide sustainability objectives. The number of EVSE provided will remain small, however, because the travel studies show that most people commute well within the range of their EV. For most employees, employer EVSE at work is a convenience, not a necessity. Major exceptions to this are employees who cannot install EV charging at their residence because of property ownership or construction limitations. Employers will need to factor the benefits provided to certain employees over others and consider the costs associated with adding numerous EVSE as the EV market grows, but they likely will find ways to maximize the benefit returned by the EVSE. It is likely that the number of employer or workplace EVSE will be less than the number of EVs, so employer strategies related to rotating EVs will be considered. Few projections of workplace EVSE have been published, and their deployment figures are not included in the projections included in this document.

Installation of workplace EVSE also contributes to qualification for Leadership in Energy and 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, CO_2 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.[12]

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 the "rich" infrastructure, where "rich" indicates that the number and availability of public charging locations results in readily available charging. 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 rich charge infrastructure is critical for a smooth transition from gas to electric and for consumer acceptance of electric transportation.

> "Even though EVs meet the daily range requirements of most drivers, range anxiety is pervasive. Customers want to be able to charge at home and have the convenience of rapid charging stations (i.e., have the same experience as buying gas)." [13]

The deployment of DCFC equipment will be address in Section 6. 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. Appendix A 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 wide demographic. This will require the available infrastructure to expand to cover an entire metropolitan area. Outlying communities 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.

---

[12] U.S. Green Building Council,www.usgbc.org

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

Multiple zones of increasing EVSE density are projected, with the city center or specific destination complex having the highest density of EVSE. The total projected EVSE required to provide this geographic coverage is considered the minimum needed to provide EV drivers assurance that they will not be stranded by a depleted battery anywhere in the metropolitan region.

4.2.2 Destination Planning

It was shown in the NHTS 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.

4.2.3 Refueling Stations

Deloitte research indicates that there is a comfort level in the public with the availability of gas stations. Their study shows that the convenience of publicly-available EVSE should at a minimum match the convenience of gas stations.

Taking the Deloitte research as a starting point, there are a number of other factors that will likely push the ratio of EVSE to EVs up or down. Operational efficiencies of networked EVSE, such as a reservation system to charge at publicly available EVSE, may exert a downward pressure on the number of EVSE needed. While the functional time it takes for an EV to charge (considerably longer than at a gasoline refueling station) will like exert an upward pressure on the number of EVSE needed. Additional factors, such as the mix of PHEVs and EREVs to BEVs may also affect the perceived and real demand for EVSE because PHEVs and EREVs are not strictly dependent on EVSE. If an ancillary market or V2G becomes attractive to EV owners this may create a greater need for publicly available EVSE.

4.2.4 Rich 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.

4.2.5 National EVSE Sales Projections

Section 3.4 illustrated the minimum expected EV sales in the U.S. With 3.6% of that expected to be fleet vehicles, Table 4-2 provides the cumulative calculated number of EVSE installations to be deployed in residential, fleet, and public/commercial locations based upon the eTec methodology. This infrastructure is then identified as a percentage of total residential EVs.

Recall that it was assumed 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 initially assuming that 20% of PHEV 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 location. 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%. eTec's four-factor methodology was used to project the publicly available EVSE, as shown in Tables 4-2 and Figure 4-3.

Table 4-2 Projected Cumulative EVSE Penetration in the United States

Year	Vehicles Fleet	Vehicles Residential	EVSE Fleet	EVSE Residential	EVSE Pub/Comm	EVSE Total	EVSE % EV Total
2011	3,692	14,767	2,474	11,814	41,053	55,340	300%
2012	7,895	48,496	5,289	37,342	113,966	156,598	278%
2013	11,308	130,048	7,577	96,235	256,194	360,005	255%
2014	17,840	252,467	11,953	176,727	416,570	605,250	224%
2015	26,367	420,536	17,666	281,759	609,778	909,203	203%
2016	34,335	652,360	23,004	410,987	815,451	1,249,442	182%
2017	43,782	951,258	29,334	570,755	1,093,946	1,694,035	170%
2018	55,166	1,323,972	36,961	754,664	1,403,411	2,195,036	159%
2019	70,031	1,772,896	57,644	1,151,930	2,349,937	3,559,511	153%
2020	86,036	2,303,860	57,644	1,151,930	2,349,937	3,559,511	149%

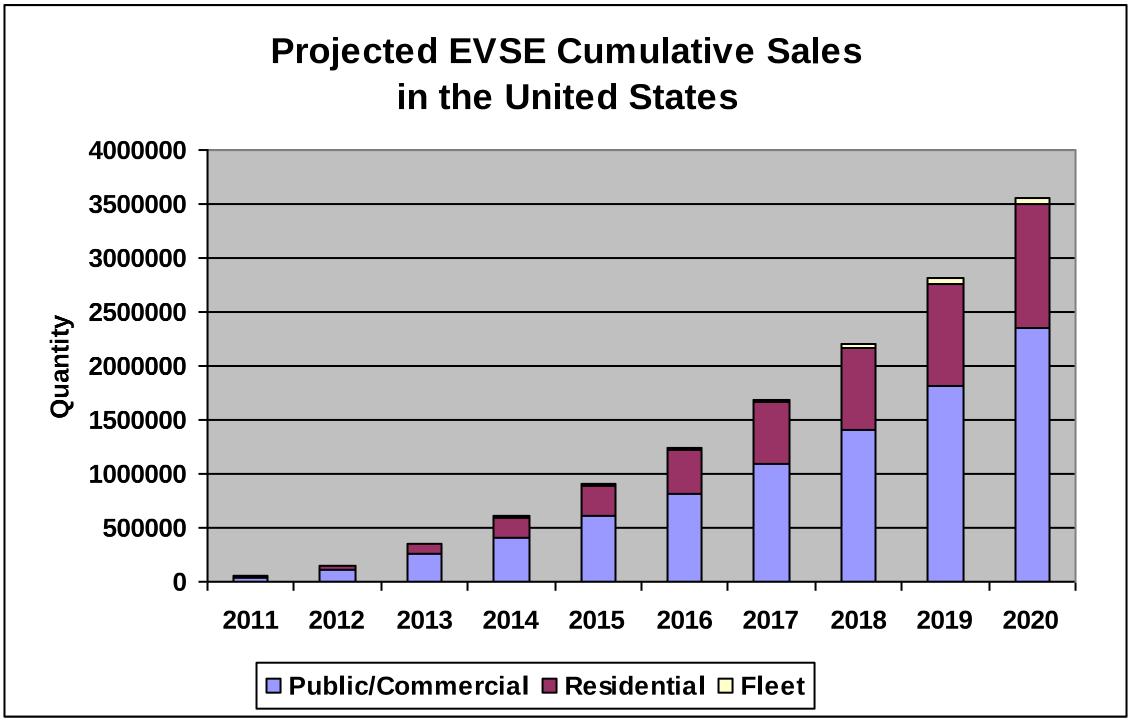


Figure 4-4 Cumulative EVSE Sales in the U.S.

5 EV and EVSE Penetrations in Greater San Diego

The nationwide penetrations of EVs and EVSE assist in providing projections of EVs and EVSE penetrations in Greater San Diego. The early market launch of EVs into San Diego will create an informed public and enhance the public awareness of EVs. The infrastructure provided by the EV Project will also create more public awareness and interest. SDG&E EV-TOU rates will create an attractive incentive to adopting EVs. Local promotional materials, incentives, and press releases encouraged by the OEMs and the EV Project also will increase vehicle penetration.

National figures are used as the basis for San Diego, with local population behavior taken into consideration. The penetration factor is increased based upon increased enthusiasm and awareness resulting from OEM and EV Project marketing. These figures are identified later in this section.

5.1 Long-Range Plan Boundaries

The planning boundary of this long range plan includes the Greater San Diego area, and the nearby markets of south Orange County. The long range plan also considers the major highway systems connecting this area to other major population centers. The I-5 corridor holds high interest in connecting the cities of San Diego, Los Angeles and all along the western coast to Seattle. DC Fast Charging along the I-8, I-5, and I-15 systems and other corridors is discussed in Section 6. The boundary selected is shown in Figure 5-1.

Figure 5-1 Greater San Diego Long Range EV Plan Boundary

This boundary is not intended to infer that EVs will not be adopted in areas outside the boundary but that the majority of EV owners will work or live within this area, based on the current and planned concentration of population and employment centers within the boundary. In addition, the boundary area should be the focus of publicly available EVSE.

5.2 Demographics

Developing the EV infrastructure should respond to demographics. Understanding the population densities, likely EV owner's demographics, operator vehicular behavior, existing vehicle use, travel habits, car purchases and growth will help understand the need for EVSE penetration. The demographics of early adopters will be much narrower in range than those of EV users 10 years from now. The rich EVSE population will encourage the general public to accept the EV as an alternative to the internal combustion vehicle. The readily available public and fast charging infrastructure will enhance the EV owner's experience and dispel "range anxiety" for those who fear running out of battery.

5.2.1 Population

The boundary area population in 2007 was 3,667,880 compared to California State population of 36,983,904[14], with 3,131,552 people in San Diego County[15]. Figure 5-2 shows the population by zip codes within the boundary area. Generally, population is concentrated nearer the coast, in the multiple city centers of the 18 cities in San Diego County, and along the major interstates and state routes throughout the region.

Figure 5-2 Population Total Persons (2007) by Zip Code[16]

---

14 Microsoft MapPoint 2010 United States

15 2050 Regional Growth Forecast, SANDAG.

16 2050 Regional Growth Forecast, SANDAG

Figure 5-3 Major Population Centers

This boundary includes all the major cities of the San Diego area, which extends to the northern boundary of the City of Oceanside, and south Orange County, as shown in Table 5-1.

Table 5-1 Major Population Centers Greater San Diego Area 2008[17]

City Area	Population
San Diego and Major surrounding Area	1,824,235
San Clemente/Laguna Niguel, etc	390,290
Carlsbad/Oceanside and surrounding area	271,442
Escondido and surrounding area	311,133
Chula Vista	230,397

5.2.2 Education

The introduction of EVs in the next ten years is expected to provide a wide range of vehicle types and capabilities. This inventory is expected to appeal to the greater population in promoting the adoption of EVs. Analysts project, however, that innovators and early adopters of EVs will generally have higher education degrees. The long range plan should involve the greater public, but the early years of adoption should consider education when placing the publicly available EVSE. Figure 5-4 illustrates the population percent by zip code of adults with college bachelor degrees and advanced degrees.

[17] http://www.citypopulation.de/USA-California.html

Figure 5-4 Percent Adults with Bachelor's Degree or Above (2007) by Zip Code[18]

5.2.3 Vehicles

Analysts also suggest that the existing hybrid vehicle users can be an early indicator of who the innovators and early adopters of EVs will be. Figure 5-5 shows locations of existing hybrid vehicles.

[18] Microsoft MapPoint 2010 United States

Figure 5-5 Hybrid Vehicles by Zip Code

It is also likely that adopters of EVs will have at least two vehicles in the household. Figure 5-6 shows locations of households with two or more vehicles.

Figure 5-6 Households with Two or More Vehicles (1990) by Zip Code[19]

5.2.4 Traffic Patterns

Significant study has already been completed on identifying traffic flows and patterns on major freeways. What is useful in identifying potential sites for publicly available EV charging infrastructure are where trips are attracted to in the greatest numbers—regional attractors. Vehicle trips points can be broken into trip origination points, typically residential areas, and trip destinations. Uses that draw trips from all over the region are regional attractors, and one type of regional attractor is an employment center, which is described in more detail in the next sub-section. Other regional attractors include retail and entertainment districts, along with recreation areas and multi-modal transportation hubs. Figure 5-7 shows major regional attractors of the use types described above.

[19] Microsoft MapPoint 2010 United States

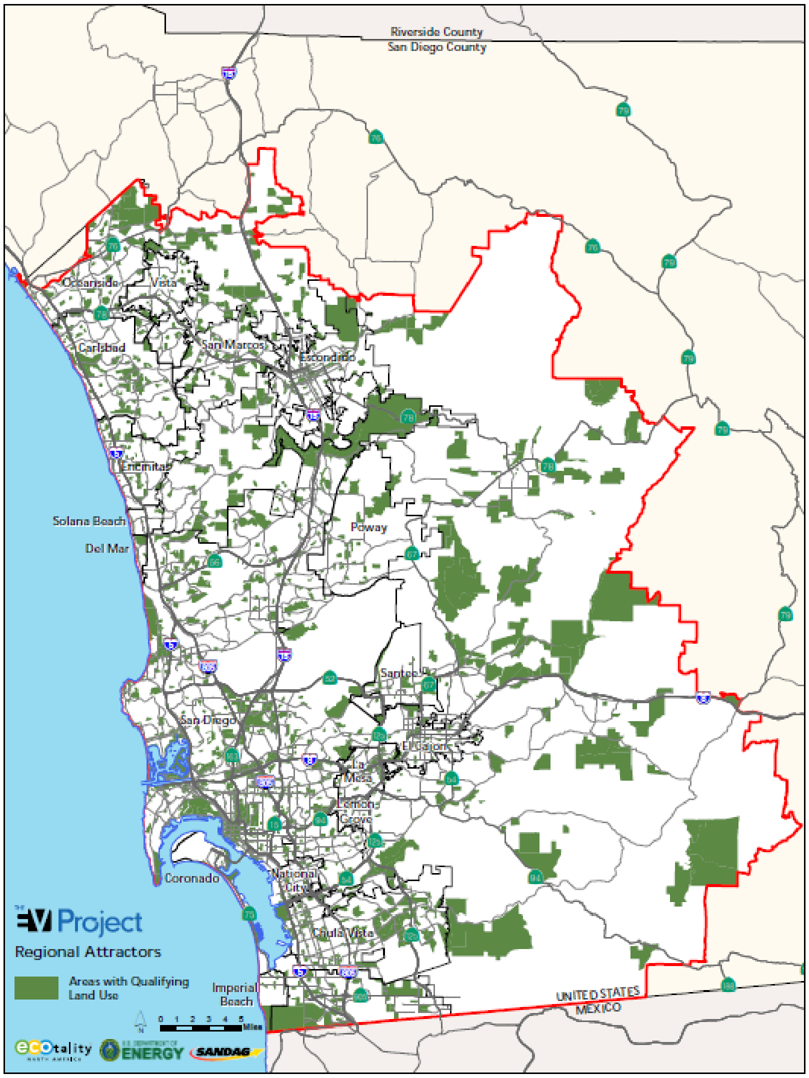


Figure 5-7 San Diego Area Regional Attractors[20]

5.2.5 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 within and around these work centers, and between these work centers and their homes.

[20] SANDAG, 2010 The EV Project

Figure 5-8 Numbers of Businesses (2007) by Zip Code[21]

Figure 5-9 Businesses per Square Mile by Zip Code[22]

---

21 Microsoft MapPoint 2010 United States

Six of the top seven areas of business density in the area are in City of San Diego city limits. They are identified in Table 5-2 and shown in Figure 5-10 below.

Table 5-2 Major Business Densities

Zip Code	City	Density Businesses/Sq Mi
92101	San Diego Center	1277
92103	San Diego Center	797
92108	San Diego North	804
92111	San Diego North	528
92110	San Diego Northwest	510
92126	San Diego Mira Mesa	487

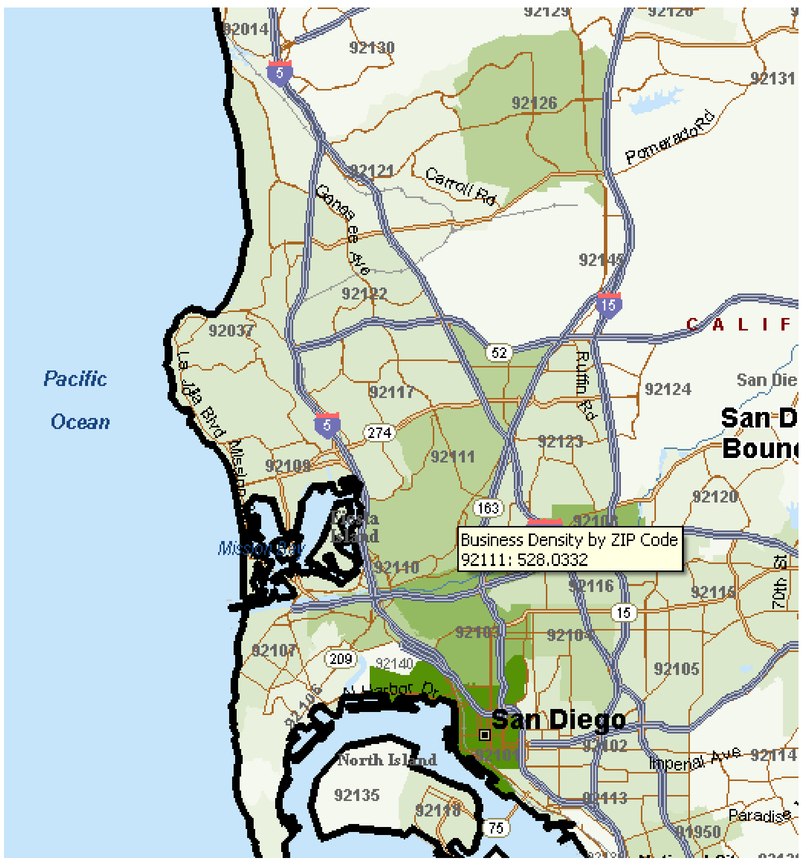


Figure 5-10 San Diego Major Business Densities

22 Microsoft MapPoint 2010 United States

5.3 EV Sales Projections

The San Diego area is one of the initial market areas for major production EVs in 2010. The Nissan Leaf and the Chevy Volt by GM are both being introduced into this market. Other OEMs will follow as well. The political will and public enthusiasm are driving the interest and motivation to draw the EVs into public acceptance. This will place the Greater San Diego Area and south Orange County on a faster path to EV adoption.

These factors can be applied to the EV market penetration projections of Section 4 to show the following projections by Metropolitan Area.

Table 5-3 Annual EV Sales Greater San Diego and South Orange County

Annual	San Diego	San Clemente	Carlsbad/ Oceanside	Escondido	Total
2011	1,282	0	0	0	1,282
2012	1,064	125	72	90	1,350
2013	1,336	157	162	113	1,696
2014	2,154	253	308	182	2,734
2015	3,620	426	553	305	4,596
2016	5,252	617	909	443	6,667
2017	7,604	894	1,424	641	9,654
2018	10,214	1,201	2,115	862	12,968
2019	13,596	1,598	3,036	1,147	17,262
2020	17,281	2,031	4,206	1,458	21,940

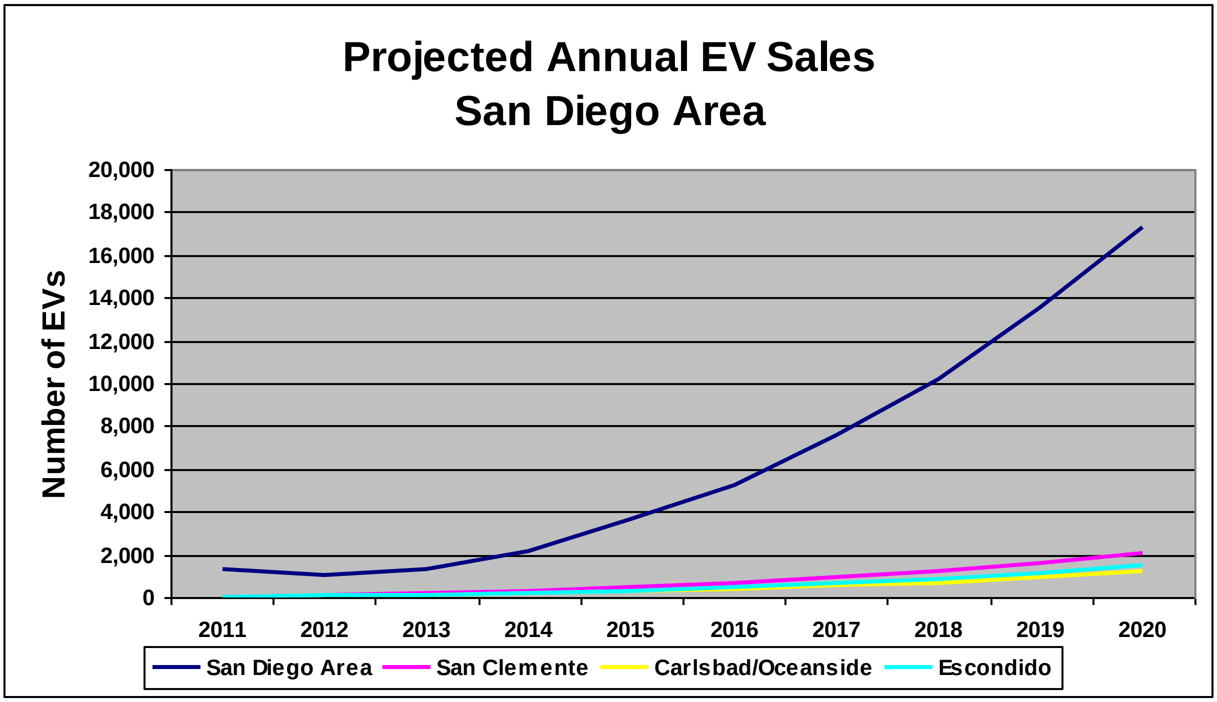


Figure 5-11 Annual EV Sales Greater San Diego and South Orange County

Table 5-4 Cumulative EV Sales Greater San Diego and South Orange County

Cum.	San Diego	San Clemente	Carlsbad/ Oceanside	Escondido	Total
2011	1,282	0	0	0	1,282
2012	2346	125	72	90	2,632
2013	3682	282	162	202	4,322
2014	5835	535	308	384	7,062
2015	9456	961	553	689	11,659
2016	14707	1578	909	1132	18,327
2017	22312	2472	1424	1774	27,981
2018	32526	3672	2115	2635	40,949
2019	46123	5271	3036	3782	58,211
2020	63404	7302	4206	5240	80,151

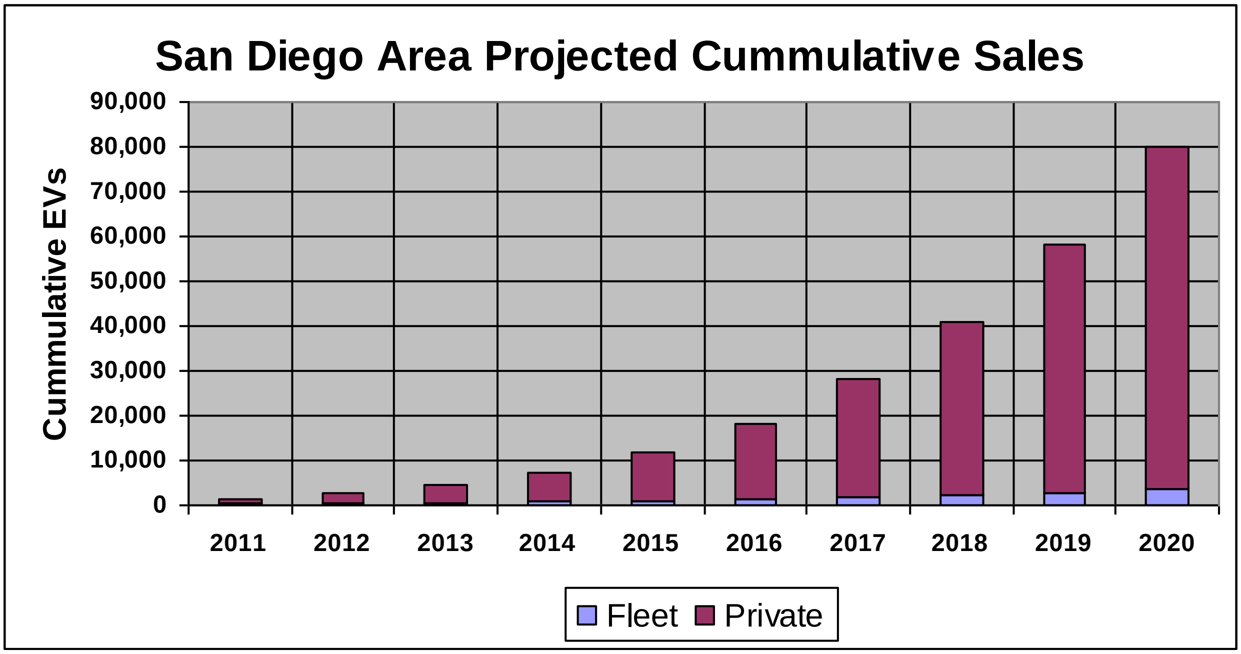


Figure 5-12 Cumulative EV Sales Projections Greater San Diego and South Orange County

5.4 EVSE Sales Projection

EVSE deployment precedes the EV deployment to provide the rich infrastructure desired. The number of EVSE is calculated as before to provide the following tables.

Table 5-5 Annual EVSE Sales Projections in Greater San Diego and South Orange County

EVSE	San Diego	San Clemente	Carlsbad/ Oceanside	Escondido	Total
2011	3,842	0	0	0	3,842
2012	3,029	356	205	256	3,846
2013	3,434	404	232	290	4,360
2014	4,834	568	327	408	6,135
2015	7,379	867	500	622	9,368
2016	9,584	1,126	649	808	12,168
2017	12,955	1,523	877	1,093	16,447
2018	16,279	1,913	1,102	1,373	20,667
2019	20,749	2,439	1,405	1,750	26,343
2020	25,763	3,028	1,744	2,173	32,709

Table 5-6 Cumulative EVSE Sales Projections in Greater San Diego and South Orange County

EVSE	San Diego	San Clemente	Carlsbad/ Oceanside	Escondido	Total
2011	3,842	0	0	0	3,842
2012	6,871	356	205	256	7,688
2013	10,305	760	232	545	12,048
2014	15,137	1,328	327	953	18,182
2015	22,516	2,195	500	1,575	27,550
2016	32,100	3,321	649	2,383	39,718
2017	45,055	4,844	877	3,476	56,165
2018	61,333	6,758	1,102	4,849	76,832
2019	82,082	9,196	1,405	6,599	103,175
2020	107,846	12,225	1,744	8,772	135,884

For each of the metropolitan areas, the individual categories of Level 2 EVSE are as follows:

Table 5-7 San Diego Area

Year	Fleet	Residential	Publicly Avail
2011	172	820	2,850
2012	79	728	2,222
2013	62	921	2,452
2014	91	1,412	3,329
2015	137	2,289	4,953
2016	160	3,158	6,266
2017	219	4,367	8,369
2018	259	5,602	10,418
2019	348	7,062	13,339
2020	397	8,344	17,022

Table 5-8 San Clemente

Year	Fleet	Residential	Publicly Avail
2011	20	0	0
2012	9	86	261
2013	7	108	288
2014	11	166	391
2015	16	269	582
2016	19	371	736
2017	26	513	984
2018	30	658	1,225
2019	41	830	1,568
2020	47	981	2,001

Table 5-9 Carlsbad/Oceanside

Year	Fleet	Residential	Publicly Avail
2011	0	0	0
2012	5	49	150
2013	4	62	166
2014	6	96	225
2015	9	155	335
2016	11	214	424
2017	15	296	567
2018	18	379	705
2019	24	478	903
2020	27	565	1,152

Table 5-10 Escondido

Year	Fleet	Residential	Publicly Avail
2011	0	0	0
2012	7	61	187
2013	5	78	207
2014	8	119	281
2015	12	193	418
2016	14	266	528
2017	18	368	706
2018	22	473	879
2019	29	596	1,125
2020	34	704	1,436

6 DC Fast Charging

Section 4.4 provided the background information on DC Fast Charging. Studies have found that the inclusion of DC Fast Charging has a significant effect on drivers in relieving “range anxiety”. With the knowledge that there is a 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. This section explores the design and location process for DC Fast Charging.

6.1 Design Characteristics

DCFCs require a higher power level than the Level 2 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 the significant recharge, it is expected most DCFCs 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 capabilities 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 DCFC 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 coffee shops, convenience stores, and rest stops, serve as some examples. These are the typical locations for the “trip chaining” discussed in Section 2.7. In addition to trip chaining, DC Fast Charging may be an integral component in an EV driver’s day if they do not have regular access to home or workplace charging, as it provides a fast and convenient way to add significant range to an EV.

6.3 Local Area Impact

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

6.3.1 Fast Charging Benefits

Table 3-1 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 all typical commercial or public areas. Industrial users require the higher power availability to power equipment, lights, material handling equipment, battery charging equipment, freezers, and other very heavy loads. This power is provided by the electric utility through the transformers in the area and is one reason areas are zoned for industrial applications. Because of the significant potential impact on the electrical grid, the electric utility company will have significant input on DC Fast Charging locations.

6.3.3 Siting of Fast Chargers

There are three major factors then in siting the DC FCs: suitability for charging purposes, suitability for augmenting the Level 2 publicly available charge infrastructure, and suitability of the electric grid capability.

6.4 Transportation Corridors

DC Fast Charging is particularly important for transportation between major metropolitan areas. The metropolitan areas will contain the local EVSE infrastructure to support EVs in the area but the corridors will allow BEVs in particular the ability to traverse the long corridors between. DC Fast Charging is more suited here than Level 2 because customer satisfaction will require the shortest recharge time available in order to minimize travel delays. In fact, as batteries gain in power densities and vehicle ranges are extended, it can be expected that the power levels of DCFCs will also be increased. DCFCs expected to be provided to support the initial rollout of EVs in 2010 and 2011 are expected to be 60 kW or less. Larger power electronics have been used in the past and are certainly possible but the power availability would be a concern and such sizes may be unnecessary given the current battery capacities.

Figure 6-1 Blink DCFC with Mitsubishi i-MiEV

6.4.1 Corridor Spacing

Research provided in Section 4.6 identified that, from a convenience standpoint, EV charging stations should be as plentiful as current gasoline stations. This translates also to corridor travel. A review of gasoline stations along Interstate 8 from San Diego to Live Oak Springs is shown in Figure 6-2.

Figure 6-2 Gasoline Stations along I-8

The longest stretch in this trip between stations is about 15 miles. This is about 15% of the range of an EV. In general for corridor travel, minimum planning should allow 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.

6.4.2 Siting of DCFCs

Corridor planning should involve the major interstates and state routes in the Greater San Diego area, as they all connect population centers in the region. The DCFC stations become range extenders for the EVs. Thus, they should also extend from the major highways into the major residential areas.

6.5 DC Fast Charging Deployment Projections

6.5.1 City Planning

Tokyo Electric Power Company (TEPCO) conducted a study of EV infrastructure in Tokyo and found significant reduction of range anxiety when DCFCs were inserted in the EVSE infrastructure. Their study placed 10 DCFCs in an 8 km by 15 km (approximately 50 square mile) area; this is also the area of the heart of a micro-climate area, as shown in Figure 4-12. Per the Level 2 infrastructure analysis, that area included 900 Level 2 EVSE. This would suggest that the heart of the public infrastructure should include one DC Fast Charger per 5 square mile area or perhaps one DCFC for every ninety Level 2 EVSE.

Based upon the quantities of Level 2 EVSE identified for the four metropolitan areas of Section 5.2.1, the quantities of DCFCs would be as indicated in the following table.

Table 6-1 Annual Deployment of DC Fast Charging per Metropolitan Area and South Orange County

EVSE	San Diego	San Clemente	Carlsbad/ Oceanside	Escondido	Total
2011	32	0	0	0	32
2012	25	3	2	2	31
2013	27	3	2	2	35
2014	37	4	3	3	47
2015	55	6	4	5	70
2016	70	8	5	6	88
2017	93	11	6	8	118
2018	116	14	8	10	147
2019	148	17	10	12	188
2020	189	22	13	16	240

Table 6-2 Cumulative Deployment of DC Fast Charging per Metropolitan Area and South Orange County

EVSE	San Diego	San Clemente	Carlsbad/ Oceanside	Escondido	Total
2011	32	0	0	0	32
2012	56	3	2	2	63
2013	84	6	4	4	97
2014	120	10	6	7	144
2015	175	17	10	12	214
2016	245	25	14	18	303
2017	338	36	21	26	420
2018	454	50	29	36	567
2019	602	67	39	48	755
2020	791	89	51	64	995

6.5.2 Corridor Planning

The guidelines above would suggest the DCFC Locations as noted on Figure 6-3 below. There are 17 DCFC locations identified. While the average distance between these stations in some cases is less than 30 miles, the stations were sited at intersections of state and federal highways as well as leading to major residential population concentrations.

Figure 6-3 DC Fast Charging Possible Locations 2020

7 EVSE Deployment Implementation

The initial groundwork was established in the *EV Charging Infrastructure Deployment Guidelines*. The expected penetration of EVs and the desired EVSE has now been identified, including the expected penetration per year. Of course, the deployment experienced could be quite different, and changes to this approach may be required. However, deployment of the EVSE should be planned now.

7.1 EVSE Deployment Cycle

Locating the Level 2 EVSE will start with the identification of available EV options. That availability will determine the likely owner demographics. These demographics will inform the EVSE site selection process. The general public will observe the EVSE and EVs charging at these stations. That will drive increased public EV interest. That interest will demand more EV options that will expand EV driver demographics. The 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.

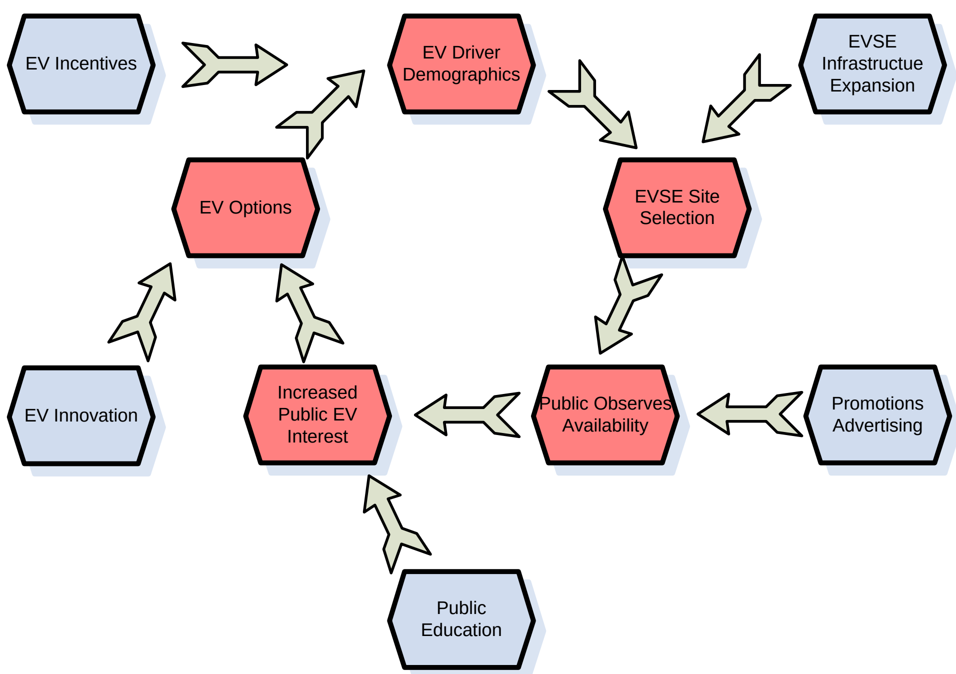


Figure 7-1: EV and EVSE Promotion

EV innovation will develop diverse models of EVs to suit many different demographics. Most OEMs have announced their plans for EVs, and increased choices will expand EV driver demographics. Public education will generate public awareness to drive public interest. Business owners who have installed EVSE will generate public awareness through their advertising and promotions. City planners and forward-thinking businesses will install EVSE beyond the developed infrastructure areas to drive the availability of EVSE.

The starting point for this EVSE infrastructure build out is EV Options. The first mass produced EVs available to the general public are the Nissan LEAF and the Chevy Volt. Both are due to be released in the last quarter 2010. The demographics of the expected buyers will help direct the initial placement of publicly-available EVSE into target areas.

The employer base and likely entertainment, shopping, and personal venues for these owners will help to focus that target. Geographic coverage as identified in Section 4.6 will be employed, with the inner circle focused on the target area. Available EVSE resources are identified along with public input on suggested locations. Mapping programs are employed to assist in demographic and target identification.

7.2 EVSE Resources

Available EVSE resources are targeted at developing a rich infrastructure – that is, community centers where charging is readily available at a variety of convenient locations. As community centers 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 expanded. Once this expansion is 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.

7.3 Venues for EVSE Deployment

It was shown in Section 2 that for most drivers, a significant number of trips for personal reasons to various destinations occur every day of the week. These trips can be of substantial length, as well.

A quick review of the major Portland metropolitan area (approximate 30-mile radius from Portland center, which includes part of Vancouver, WA) revealed the following destinations.

Table 7-1 San Diego Area Destinations

Airports (Major)	2	Airports (Minor)	5	Amusement parks	7
ATMs	919	Auto services	2039	Banks	675
Bus Stations	4	Campgrounds	26	Casinos	7
Cinemas	29	City Town Halls	152	Convention Centers	12
Galleries	99	Gas Stations	660	Golf Courses	68
Grocery Stores	450	Hospitals	34	Libraries	88
Marinas	23	Museums	52	Nightclubs	538
Park & Rides	2	Parking lots	35	Pharmacies	248
Police Stations	32	Post Offices	45	Schools	767
Shopping	39	Stadiums and arenas	10	Theaters	22
Wineries	4	Restaurants	5458		

There are a total of 8,867 destinations shown above and all are areas where the driver will likely stay for a substantial amount of time. If just two thirds of these destinations installed EVSE and there were just two EVSE at these locations by 2020, the total number of ports would be about 11,800. Note that the San Diego Level 2 EVSE population shown in Table 5-7 reaches this point in 2018. Many of these locations will be able to support many more than two EVSE and the demand will again increase the quantity of EVSE. These would represent ideal locations for possible Level 2 EVSE.

7.4 Public Input

Solicitation of ideas from public workshops, public announcements or promotions, or advertising can be used to establish a pool of possible locations. EV drivers may be queried to gain their insight and experience. Forward-thinking business owners and those interested in promoting EV use will be motivated to install EVSE near their businesses. Nationally-known businesses will be eager to promote their image of being environmentally friendly, especially when noting their successes in other locations.

From this pool of suggested locations, the initial infrastructure can take its first step from a plan to a roadmap. The plan suggests the target areas, whereas the roadmap selects specific sites.

7.5 Jurisdictional Priorities

Governmental agencies and electric utilities will also create priorities for EVSE infrastructure deployment. 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.

7.6 Commercial Interest

The initial availability of EVs will be attractive to fleet owners that are using primarily passenger vehicles. 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 will gain confidence that their renters will be able to charge in publicly available locations. Range anxiety and unfortunate battery discharge experience for renters will need to be overcome with driver education. A positive driving experience will promote EV adoption in many geographic areas.

The absorption of EVs into taxi fleets will 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.

Both the employer base and rental car companies will take advantage of the publicly available EVSE network. Their input should be sought for possible 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.

7.7 EVSE Densities

Figure 7-2 Level 2 EVSE Long-Range Plan Densities

7.8 Summary

Figure 7-2 shows the best current representation for the expected growth and densities of publicly available EVSE by 2020. There is significant overlap with these densities and the density of population, employment centers and other regional attractors. Increasing demand for EVs will continue to drive demand for publicly available EVSE beyond this point, supported by retailers who recognize the beneficial financial aspects of providing a service to EV drivers. Electric utilities may be able to more accurately forecast generation needs along with demand response actions as the industry matures.

Appendix A – EV and EVSE Sales Projections

Contents intentionally removed

Appendix B – Points of Interest for Electric Utilities

A long-range plan for infrastructure directly involves the electric utilities. Not only will the increased demand for EVs drive the demand for electricity, it can be driven during the most inopportune times for electric load management. There are many topics of interest to electric utilities that are being or will be explored during the timeframe of this long-range plan. Some of these topics are identified below. Solutions may not exist as yet, and some strategies still may be far into the future. Nevertheless, discussions on these topics are underway at this time.

B.1 Local Grid Reliability – Clustering

A potential result of the introduction of EVs in any community could be the increased interest in obtaining an EV after seeing the neighbor's new car. In a short period of time, clusters of new EVs may appear, meaning that clusters of new residential EVSE will also appear that can have a significant impact on electric utility grid operations.

The concentration of EVSE behind individual secondary distribution transformers can create conditions of excessive current flow for durations that exceed the planned duty cycles of the equipment. This will result in insufficient time for cool-down and subsequently a significant de-rating of expected life for the utility asset. The corresponding financial and operational impact to the business is very meaningful.

The electric utilities will want to prepare for this potential. They will require a proactive or even predictive tracking of where the EVs are appearing and congregating as the initial marketing launch gets underway. These data feeds also can tie into the tracking and scheduling of EVSE installations. Having this information allows utilities to proactively manage the infrastructure upgrades that will be needed in the least prepared areas. Next, the utilities need a method for deferring and distributing clustered charging into the overnight or off-peak hours so that sufficient cool-down of transformers can be achieved through tempered daily charging duty cycles. Ultimately, smart charging solutions can involve coordinated charging schedules that allow customers to tailor their individual recharging needs in an optimal "network balanced" charging solution.

This would allow the utility to better plan and defer emergency capital expenditures, as well as minimize the disruption of unplanned outages.

B.2 Peak Shaving Strategies

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. Figure B-1 shows a typical example of a daily load profile. 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. Utilities have various strategies that assist in this goal. One such strategy is to use Time of Use (TOU) rates. For utilities that use such rates, the price charged for electricity during peak times is higher than that at low demand, encouraging users to switch usage to the low-demand times.

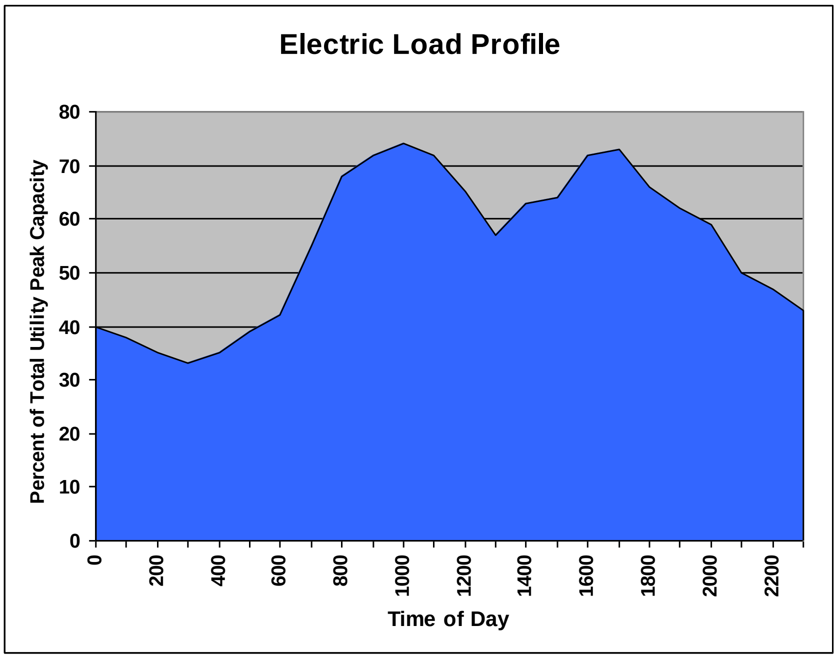


Figure B-1: Typical Daily Load Profile

Widespread adoption of EVs may aggravate this issue. Many EVs will have the feature of allowing "pre-conditioning" of the vehicle. That is, in summer, the vehicle can be programmed to start the air conditioner fifteen or twenty minutes before the end of the work day so that the car is cool when the driver leaves work. This allows the air conditioner to take power from the EVSE rather than the vehicle battery. However, if every vehicle started the air conditioner at this time, the net result would be to compound the afternoon peak. Likewise, if every vehicle were to be connected to the home EVSE when arriving home at 5:30 in the afternoon, a similar compounded peak could be seen.

Promoting an evening TOU that begins when the peak is over is one strategy to avoid the compounded peak. The EVSE can be programmed to begin the charge at the beginning of this off-peak period. But again, if all EVs were to start charging at the beginning of the off-peak time, another spike in power demand could be seen. Some suggest that this peak could be worse than having no TOU incentives at all.

In the broader picture, the coincident draw of additional aggregate power through feeder circuits servicing both home and commercial EVSE can lead to imbalances within the overall utility system. This can result in the need for either emergency or economic curtailment of load.

The two primary methods for managing the demand side of excessive load are to automatically or manually drop load or to drive consumer behavior change to shift the timing of the load. Dropping load is the extreme measure and can lead to brown-outs. Simply using TOU rates may not be sufficient to drive consumer behavior. The other choice is to bring on more generating power if available.

EVs connected to "smart" EVSE can support all three strategies. Smart EVSE is designed with communication and control equipment that allows greater utility control of the charge and discharge of the vehicle battery with the consent of the owner. Even though an EV is connected during the off-peak time, the utility may delay the start of the charge several hours for some vehicles to even out the demand. Typically the owner will not care when the EV is charged overnight, as long as it is fully charged when needed in the morning. If dropping load is required by the utility, smart EVSE can be turned off during the peak times to curtail load. Again, the owner may receive special rate incentives for consenting to this drop. Finally, the large electrical storage capacity of the EV battery may be utilized in vehicle-to-grid (V2G) strategies to augment the electric grid. Technology exists for many of these features, and testing and development continues. The advantage to the owner may be reduced electric rates in exchange for charge flexibility. The benefit to the utility is that it can avoid paying for incremental wholesale power at very high cost to satisfy load. In areas of weaker grid infrastructure, the utility can avoid voltage reduction and/or power outages.

B.3 Regulatory Activities for EVSE Penetration

Regulators are taking dramatic steps to force the utility investment and expenditure for implementing socially beneficial programs involving Advanced Metering Infrastructure (AMI), Smart Grid, and Home Area Network (HAN), as well as the corresponding Demand Response (DR) and Energy Efficiency (EE) applications this enables. In many regions, significant federal aid has initiated large-scale programs for this purpose. Specifically for EVs, regulators are seeking input from utilities on potential impacts of home and commercial charging, and their readiness with cost-effective mitigation solutions. The more aggressive utilities are seeking approval for ownership and rate basing of the EVSE infrastructure. Others are considering support from EV owners, which may allow real-time-pricing incentives to enable these applications.

The capability of smart EVSE to support Smart Grid interoperability will make this a very important part of giving regulators the confidence that utilities are implementing these types of open-standards-based solutions.

B.4 Carbon Capture Strategies

Climate change science points to the need to significantly reduce carbon dioxide emissions. The utility, industrial, and transportation sectors will be a focus for carbon reduction incentives, regulations, and penalties. What this means in an age of electric transportation is that utilities will need to meet the future higher power demand for charging EVs by adding more clean energy generating resources and increasing energy efficiency programs which in turn will allow EVs to displace increasing amounts of emissions from the fossil fuel dependent transportation sector.

Policies will be required to enable electric utilities to develop clean energy and energy efficiency while obtaining credit for EV emission reductions in the transportation sector..

B.5 Public Perception and Jobs

Stimulus funding for Smart Grid deployment and Advanced Technology demonstrations has built an expectation of job creation by the public utility companies that have received the funds. Even when there is no direct stimulus funding, the utility is typically seen as a community leader in stability and economic development, which contains an “unwritten expectation” that they will put rate-based profits back into business expansion. Coupled with the extensive publicity over the Clean Energy revolution, and the coming explosion of EVs as an industrial renaissance for the US, this is setting up a large opportunity for utility public relations.

For utilities, building out the EVSE infrastructure may be seen as sort of a “public works” program. This develops a strong sense of community responsibility fulfilled and excellent customer and regulatory relations.

B.6 Ancillary Services

Imbalances brought on by momentary differences between supply and demand on the electric grid requires regulation services to reconcile. That is, at any given moment, the amount of electric supply capacity that is operating may exceed or may be less than load. This can happen with even greater frequency when utilizing intermittent renewable resources. Regulation services, often referred to as “ancillary services”, are used for damping that difference.

Regulation services are typically provided by ISOs (Independent System Operators). They create markets for attracting participants supplying the area where regulation services are needed to balance this difference. Typically, generation is used in a “standby spinning mode” to react to the imbalances. With the advent of economical storage in batteries, this service can be provided with significantly faster response times. The control of this storage, essentially the systematic charging and discharging of aggregated batteries in response to the ISO market signal, creates a significant value stream for the participant. When logically aggregated and controlled, the batteries from hundreds or thousands of EVs can be effectively harnessed to provide these ancillary services.

Appendix C – Legislative and Public Policy Points of Interest

The success of electric vehicles will depend on a number of variables, including a robust charging infrastructure, consumer education, and government support. There are many actions that federal, state, and local jurisdictions may consider over the next 10 years to assist in the promotion of EVs and the corresponding EVSE. This list is not intended to be exhaustive, but rather a starting point for consideration. Some activities are already underway, and others are under consideration.

C.1 Federal Level

Establish coherent regulatory policies for electric drive vehicles and infrastructure.
Currently there are multiple regulatory and standard-setting bodies developing policies regarding electric drive technology, including vehicle efficiency metrics, charging and refueling equipment standards, metering, and information management protocols. Regulatory requirements developed should be in the interest of advancing clear goals for the industry.

Adopt and incorporate electric vehicle transportation into federal fleet programs.
The adoption and incorporation of electric vehicle transportation at the federal level will not only assist federal agencies in supporting federal legislation efforts to meet national environmental standards, but also expand the awareness and use of this technology to reduce dependence on foreign oil, integrate smart grid technology, and diversify alternative fuel programs.

Establish a federal grant program linking the adoption and use of electric vehicles in transportation planning and programming and carbon reduction policy goals.
Establishing a federal grant program encouraging the adoption and use of electric vehicles in transportation planning and programming to reduce pollution would provide further incentive for states, regions, local governments, and businesses to incorporate this technology in their communities.

Incorporate electric vehicle transportation in long-range environmental, energy, and transportation policy pertaining to clean air programs, alternative fuels programs, national smart grid development, and development of major transportation corridors.
There is a great opportunity for the U.S. Department of Energy, U.S. Environmental Protection Agency (Sustainable Communities), and U.S. Department of Transportation to develop interagency policy initiatives incorporating electric vehicles and infrastructure to clean air programs, alternative fuels programs, smart grid initiatives, and infrastructure improvement of major transportation corridors to meet renewable energy, environmental, and alternative transportation policy goals.

Extend and expand federal tax credit for EV charging infrastructure.
Continuing to advance the adoption and seamless deployment of electric vehicle charging infrastructure through incentives such as the federal infrastructure tax credit will assist in offsetting costs associated with its purchase and installation process.

Provide dedicated funding for research and development of electric vehicle battery and charging technology.
Investing federal funding to accelerate breakthroughs and commercialization of battery and charging technology will allow the industry to refine and enhance the performance of its products for the future and keep the industry globally competitive.

Continue dedicated funding for electric vehicle and charging infrastructure programs.
Continuing to support funding for electric vehicle and charging infrastructure programs at the U.S. Department of Energy will provide ongoing resources to improve the technology and increase its deployment.

Expand U.S. electric drive transportation-related manufacturing.
Expanding electric drive transportation-related manufacturing in the United States will provide significant job creation and help further expand the industry's pipeline of diverse electric vehicles.

Provide incentives to develop electric vehicle fast charging corridors on federal highways.
Establishing a program at the U.S. Department of Transportation to coordinate development of fast charging corridors with private industry and state agencies along major intrastate and interstate transportation corridors.

Promote outreach and education to consumers, businesses, and state and local governments, including training of first responders, to increase awareness of the benefits, safety, and requirements of electric vehicle transportation and charging technology.
Establish funding for industry outreach and education programs to support comprehensive campaigns at the state and local level.

C.2 State Level

Provide tax rebates, grant programs, and other tax incentives for EVs and EVSE for residential, public, and commercial use.

Establishing criteria for state programs to assist in offsetting costs to acquire electric vehicles and charging infrastructure will assist adoption and deployment of the technology and make it accessible to more segments of the population. For example, EV Home Charging Improvement Grants, renewable business energy tax credits, and state energy grants to provide funding for homeowners, businesses, and government entities who purchase an EV to offset costs, including pre-installation assessment, permit, and installation, associated with modifying electrical sources to include an EVSE.

Provide incentives by allowing EVs with single occupants to use HOV lanes.

Work with state transportation departments or motor vehicle departments to issue license plates or permits allowing single occupant EV drivers to use HOV lanes or toll roads for an established fee.

Incorporate electric vehicles into state fleet programs.

The adoption and incorporation of electric vehicle transportation at the state level will not only assist state agencies in supporting state legislation efforts to meet environmental standards, but also expand the awareness and use of this technology to reduce dependence on foreign oil, integrate smart grid technology, and diversify alternative fuel programs.

Incorporate EVSE into state green building standards code.

Including EVSE as a green building standard would expand the elements included for green commercial and residential construction and assist in offsetting installation costs associated with adding EVSE post-construction.

Provide funding for permit inspector training for EVSE programs.

Local municipalities have incurred dramatic cutbacks in the development services and permitting departments. Due to the novelty of this technology and the high volume associated with these installations, a program providing funding for training of permit inspectors for EVSE programs would greatly assist in increasing the knowledge base associated with this specific product and fast-tracking projects in communities.

Develop a consumer EV and EVSE outreach program in conjunction with local efforts.

Creating a statewide outreach campaign through the state's environmental, transportation, and/or energy agencies in collaboration with local jurisdictions would help expand awareness, knowledge, and benefits provided for consumers who own and operate on-road electric vehicles and charging infrastructure equipment.

Establish, where applicable, building code guidelines for seamless and expedited basic EVSE installations and EVSE smart-charging standards.

Work with state building code departments to establish guidelines to facilitate seamless and expedited EVSE installations, including model installation scenarios for panel upgrades, multi-family dwelling units, single-family dwelling units, and commercial and public infrastructure, as well as identifying standard elements of smart charging EVSE in cooperation with the requirements of local utilities.

Work with utilities and EVSE providers on integration of EVs into the grid and ongoing assessment of power plant infrastructure enhancement.

Facilitate a process by which the state energy agency works with utilities and EVSE providers to assess successful integration of EVs into the grid and monitor any future need for planning additional power plant infrastructure or a renewable energy partnership program with solar, wind, and/or other natural energy sources.

Provide incentives to develop electric vehicle fast charging corridors on state highways.

Work with state transportation departments to identify opportunities to incorporate fast charging infrastructure on high-volume state highways, including private development opportunities.

Provide incentives to bundle EVSE with home solar or home area networks.

Develop state and/or utility packaged programs offering leveraged rate and/or tax credit when combining electric vehicle infrastructure with home solar or home area network systems that reduce energy usage impact from the grid.

Provide grants for EV infrastructure projects and programs.

Continued funding from state agencies and energy commissions for research and development, infrastructure demonstration projects, grants, training, and/or community outreach and education programs associated with electric vehicles and EVSE technology will greatly assist the integration and deployment of this technology in communities across the country.

C.3 Local Level

Update building code to include electric vehicle infrastructure in sustainable construction/green building criteria.

To incentivize the use of electric vehicles in the community, enhance green building construction, and offset costs associated with EVSE installations, municipalities may update building code criteria to include smart EVSE in sustainable/green commercial and residential construction elements.

Update planning and zoning districts to incorporate electric vehicle infrastructure standards for public use, in new residential construction, and in commercial construction developments, as well as incentives for retrofitting existing infrastructure.

To enhance economic development and community redevelopment initiatives, municipal planning departments may designate special zoning overlays incorporating smart charging electric vehicle infrastructure, which may additionally enhance multimodal transportation programs in many communities.

Work cooperatively with local utility in planning districts to track usage and need for transformer enhancement at utility neighborhood substations.

Encourage developing energy infrastructure program between appropriate municipal departments and local utility in order to adequately plan and monitor neighborhood substations to address the impact of community EV energy usage on the grid.

Encourage incorporation of electric transportation in municipal multi-modal transportation planning efforts.

Municipal transportation departments would enhance transportation service in the community by incorporating electric transportation and EVSE in multi-modal transportation and transit programs. Including this technology in a municipality's overall transportation program could assist with long-term fuel costs and reduce local pollution issues.

Identify and train permit/code workforce in municipal building departments to work on projects incorporating EVSE and establish an expedited design review process for development and construction projects incorporating EVSE.

Dedicating a set of specialized, trained employees to work on projects incorporating EVSE technology will allow technical review of these projects and high-volume permitting to proceed more rapidly.

Develop a home assessment program and online expedited EVSE permitting and inspection process in cooperation with utility and EVSE provider.

Developing a home assessment program and incorporating an online expedited EVSE permitting and inspection process to be performed by specially trained and certified inspectors in cooperation with the local utility and EVSE provider, notifies consumers regarding potential incurred costs prior to purchasing an electric vehicle and provides consumers who do purchase an electric vehicle with timely customer service and installation of the technical equipment to support its use.

Dedicate a portion of local funding to support more complex EVSE installations and panel upgrades.

At times, more complex scenarios for EVSE installations will occur and the cost associated with upgrading panels may be cost prohibitive. Municipalities that include a high risk of having more complex EVSE installations, for example, where there are a high percentage of multi-family dwelling units or dedicated commercial area to accommodate retrofits, may want to dedicate a portion of local funding to assist consumers offset installation costs.

Develop a coordinated community outreach and education program regarding EVSE residential and commercial installation equipment, the installation process, and tax credit programs with the local utility and the EVSE provider.

A locally developed and coordinated community outreach and education program in cooperation with the local utility and EVSE provider will deliver a community-driven message to inform residents about programs and processes associated with electric vehicles and charging infrastructure technology.

Provide incentives to bundle EVSE with home solar or home area networks.

Develop local and/or utility-packaged programs offering a leveraged rate and/or tax credit combining electric vehicle infrastructure with home solar or home area network systems that reduce energy usage impact on the grid.