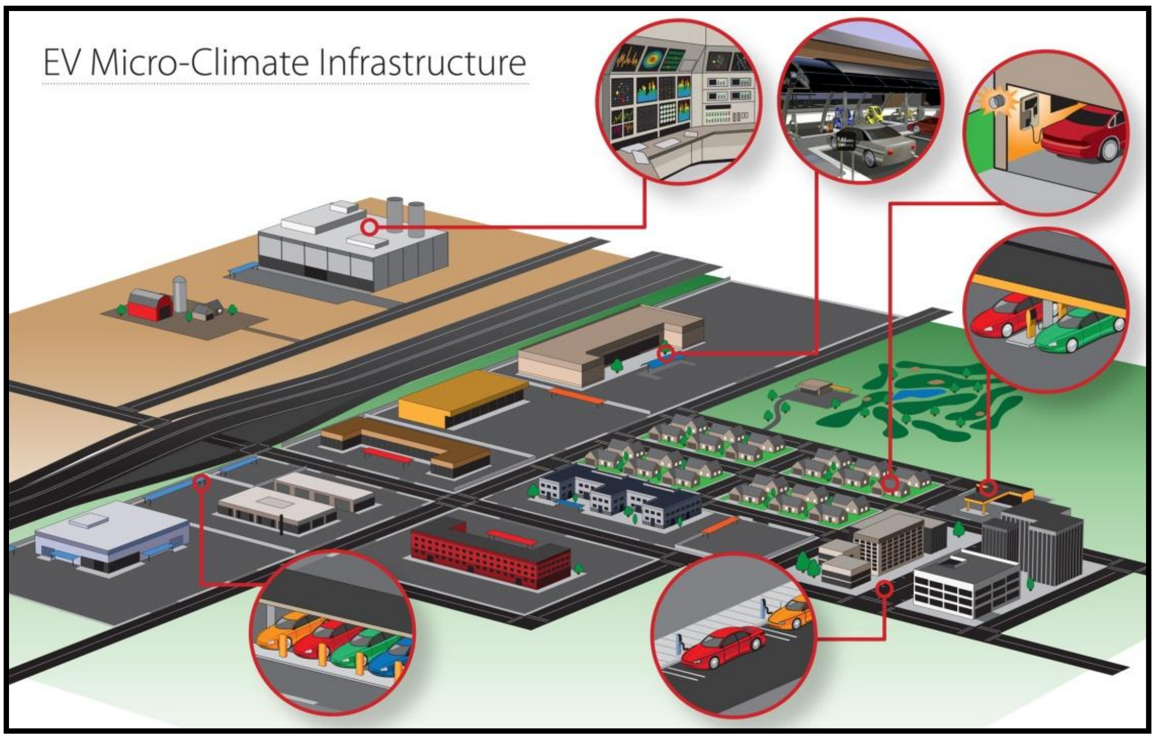
Long-Range
EV Charging Infrastructure Plan
for the
State of Arizona



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NORTH AMERICA

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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.
CCID	Charge Current Interrupting Device
DC	Direct Current
DCFC	Level 2 DC Fast Charger
DOE	U.S. Department of Energy
DR	Demand Response
EE	Energy Efficiency
EPRI	Electric Power Research Institute
EV	Electric Vehicle
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.
HAN	Home Area Network
ICE	Internal combustion engine
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.
MAG	Maricopa Association of Governments
MSA	Metropolitan Statistical Areas
NEC	National Electric Code - part of the National Fire Code series established by the National Fire Protection Association (NFPA) as NFPA 70. The NEC codifies the requirements for safe electrical installations into a single, standardized source.
NEMA	National Electrical Manufacturers Association. Develops standards for electrical products.
NHTS	National Household Travel Survey

OEM Original Equipment Manufacturer. In this document, this term refers to automobile manufacturers.

PAG Pima Association of Governments

PHEV Plug-in Hybrid Electric Vehicle – vehicle utilizing both a battery and an internal combustion engine (ICE) powered by either gasoline or diesel.

RDD Random Digit Dial

REEV Range Extended Electric Vehicle – see PHEV.

RTP Real-Time Pricing. A concept for future use whereby utility pricing is provided to assist a customer in selecting the lowest cost charge.

SAE Society of Automotive Engineers. Standards development organization for the engineering of powered vehicles.

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.

USGBC United States 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.

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.

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 Charging Infrastructure Plan for Arizona* 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 targeted area in Arizona by the year 2020. The projected EV population will require the EV charging infrastructure to support and encourage further increases in market share. This Plan seeks to uncover the quantities and locations of publicly-available charging systems that will do just that.

ECOtality is partnering with Nissan North America, General Motors, and several other companies to deploy up to 5,700 zero-emission electric vehicles (Nissan LEAF), 2,600 Extended Range Electric Vehicles (Chevrolet Volt), and thousands of charging systems to support them, in private and public locations in strategic markets in six states: Arizona, California, Oregon, Tennessee, Texas, and Washington.

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 the lessons learned from the deployment of these first 8,300 EVs, and the charging infrastructure supporting them, to enable the streamlined deployment of the next five million EVs.

The EV Project provides a starting point in Arizona to achieve the region’s long-range goals. It cannot by itself complete the necessary infrastructure, but the long-range plan will provide guidance for planning this infrastructure growth and focus 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. Information specific to Arizona is also included. 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 and Appendix A.

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 fully depleting their vehicle’s battery. Likewise, the availability of charging infrastructure is tied closely to the number 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 and Appendix A.

Section 5 projects the expansion of EV and EVSE use in Arizona, based on the projected national growth of EV adoption and EVSE infrastructure.

The planning for the DCFC is quite different from that for the rest of the charging infrastructure, but is also 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 Arizona. Input from local stakeholders and prior work on these topics provides support for this plan. By understanding the characteristics of EVs and the capabilities of the charging systems, as well as expected 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 are collected on daily trips taken in a 24-hour period, providing a better understanding of travel behavior. In this survey, respondents are asked to complete a diary of their travel for a 24-hour period. The survey specifies a trip date and the diary starts at 4 a.m. on that date, even if it is an unusual travel day for the respondent. This date can be any day of the week, including weekend days. The diary then continues through the destinations reached by the respondent during that day. As noted in Section 2.3 below, these destinations fall into several categories, including "Home", since daily travel generally involves at least one trip home.

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 going from home to destination and back home, the minimum response would be about two trips. (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.

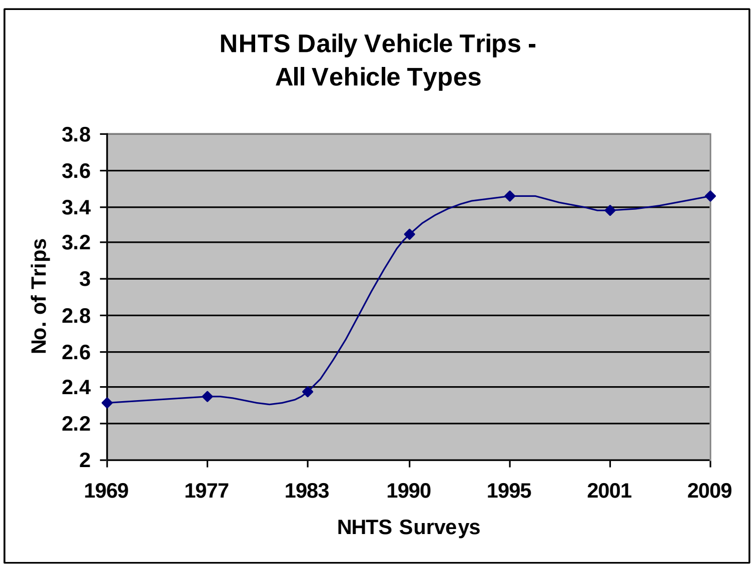

Figure 2-1: Average Daily Vehicle Trips for All Types of Vehicles

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

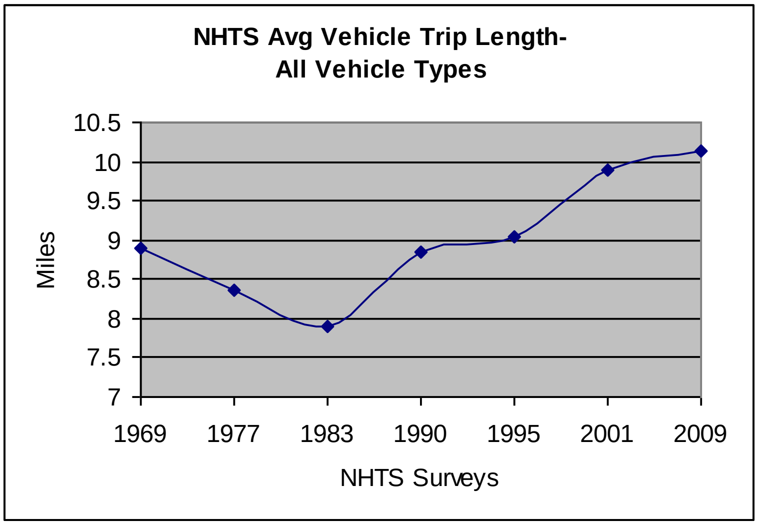

Figure 2-2: Average Vehicle Trip Lengths for All Types of Vehicles

Combining these two averages indicates that 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. For the daily trips by car, Figure 2-4 identifies the percentage of trips for each of ten purpose categories. Other than trips home, the single most common purpose for a 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 indicates otherwise.

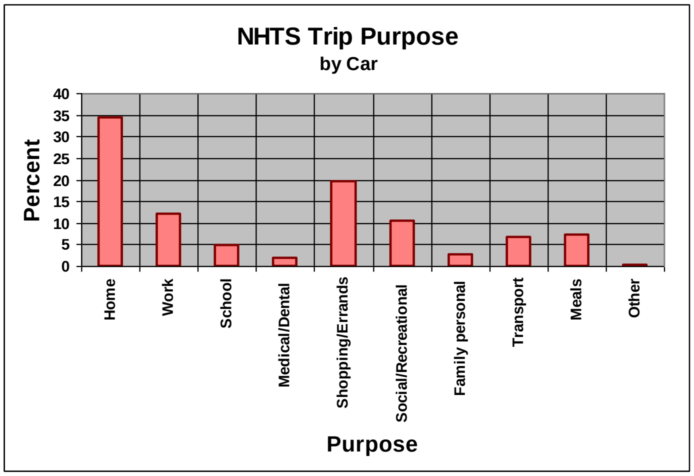

Figure 2-3: Percentage of Daily Car Trips by Purpose NHTS 2009

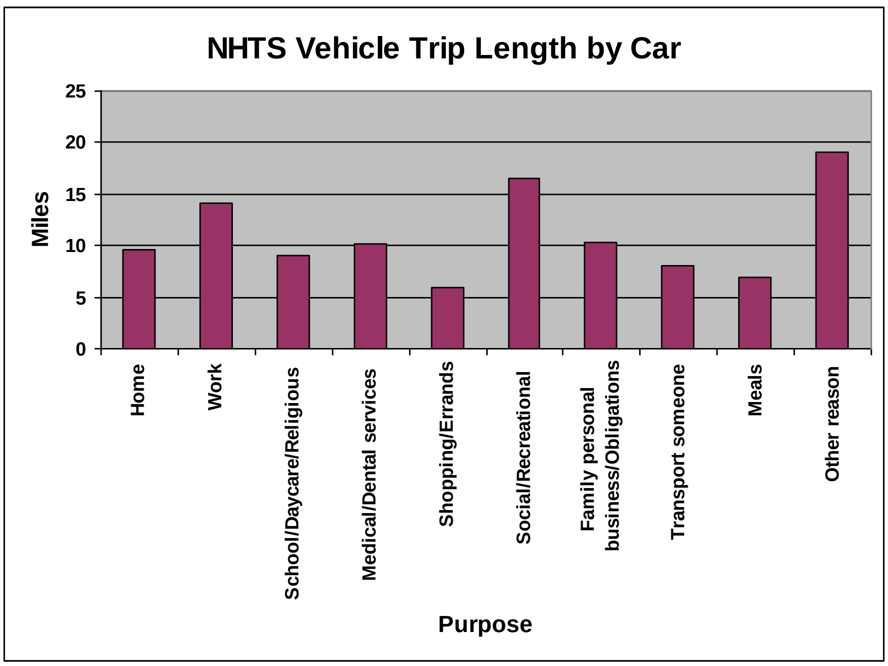

Figure 2-4: Vehicle Trip Length by Car by Purpose NHTS 2009

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

The chart in Figure 2-5 identifies that the two-vehicle household is the most common, followed by 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 would fit that profile.

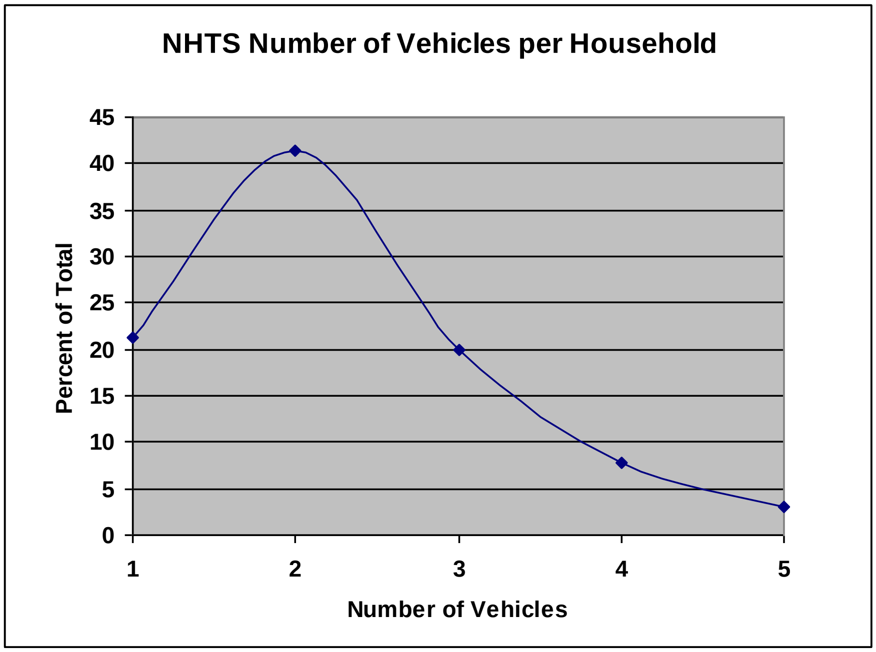

Figure 2-5: Number of Vehicles per Household – NHTS 2009

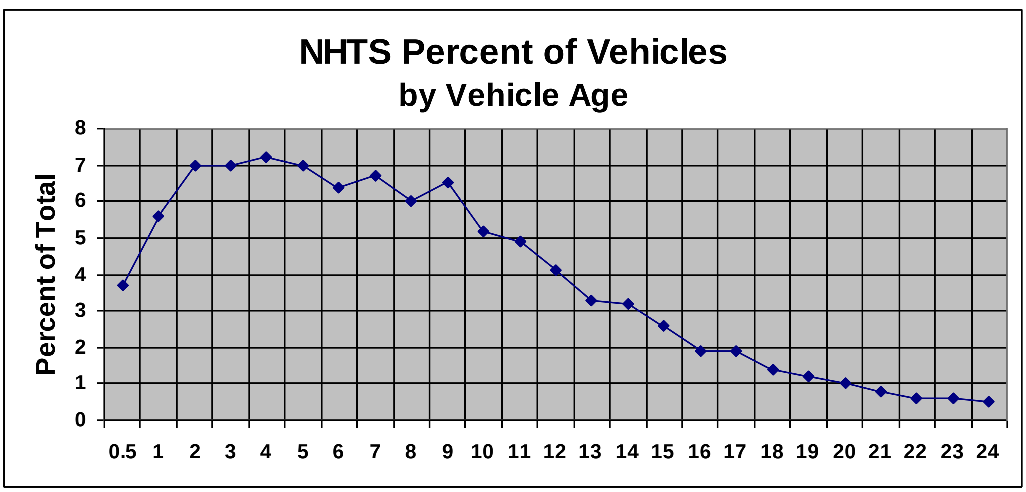

Figure 2-6: Percent of Vehicles by Vehicle Age

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 the 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.

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]

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 this *trip chaining* is often a response to the pressures of balancing work and home. But the data also show that some of the growth in trip chaining has been to pick up 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 2-7.

[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.

[2] ibid

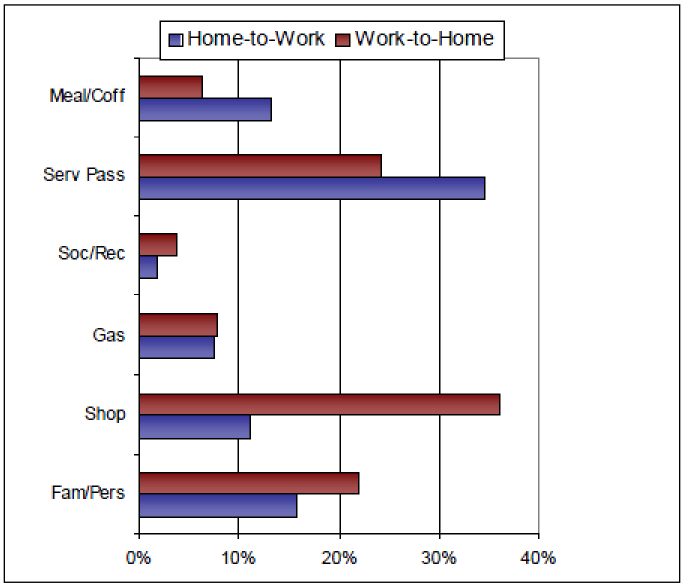

Figure 2-7: Non-Work Trips at Peak Periods NHTS 2001[2]

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

2.5 Arizona Household Travel Survey

2.5.1 Phoenix

As part of Maricopa Association of Governments' (MAG) 2001 Maricopa Regional Household Travel Survey, the 4,018 participating households reported data for 78,511 places visited and 58,484 trips. The travel behavior data includes the general type of place visited, land-use type of that location, activities at each place, travel modes, and arrival/departure times. For auto trips, the data includes number traveling in the party and how many were household members, whether a household vehicle was used, and if travel was made on any portion of a highway. The travel data is summarized in the following tables.

The Maricopa Regional Household Travel Survey includes data from households in Maricopa County and a small portion of Pinal County, which contains the city of Apache Junction. The weekday travel statistics were collected by NuStats, a survey research firm, for use by MAG. The cities in this geographic area are depicted in Figure 2-8.

[2] ibid

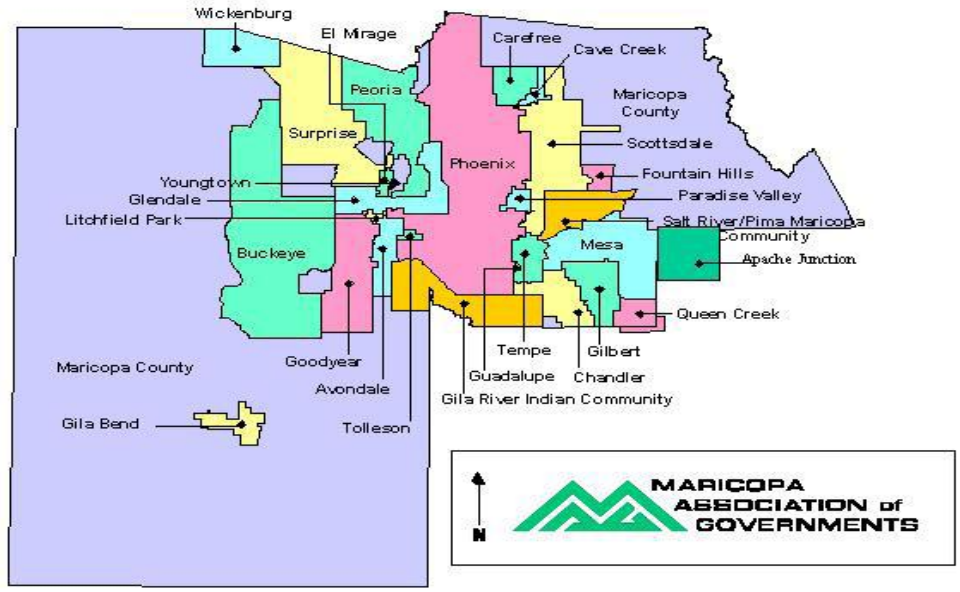

Figure 2-8: Maricopa Regional Household Travel Survey Geographic Area

The Maricopa Regional Household Travel Study was based on telephone interviews of randomly selected households from the study area. Household recruitment was based upon household size and employment status. Interviews were done assessing: household size, number of vehicles, household income, dwelling type, age, gender, and work status.

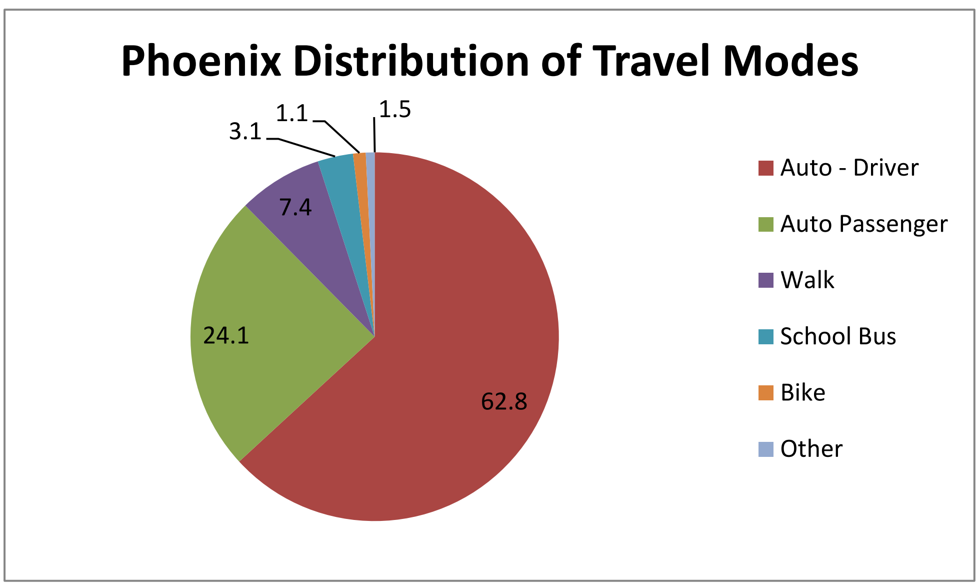

Figure 2-9: Mode of Transportation Phoenix Area

Figure 2-9 shows that the overwhelming mode of transportation for the Phoenix metropolitan area is the car. Auto drivers and passengers in autos make up almost 87% of the people surveyed. The average trip duration took just over 20 minutes per trip.

Just as the NHTS Survey indicated, the percentage of travel for non-work purposes in Phoenix, including shopping, is growing faster than work travel. See Figure 2-10.

Figure 2-10 indicates that the most frequent trip purpose throughout the week is shopping, followed by trips to work, going to school, and getting a meal. This coincides with the NTHS study that 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 also may include a stop for school and getting a meal. 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.

The study showed that almost 18% of the trip purposes on Saturday and 15% on Sunday were for shopping in the Phoenix Metropolitan area; driving to eat a meal accounted for almost 6% of weekend trips. These results would be another reason to locate EVSE at locations where shopping and dining occur.

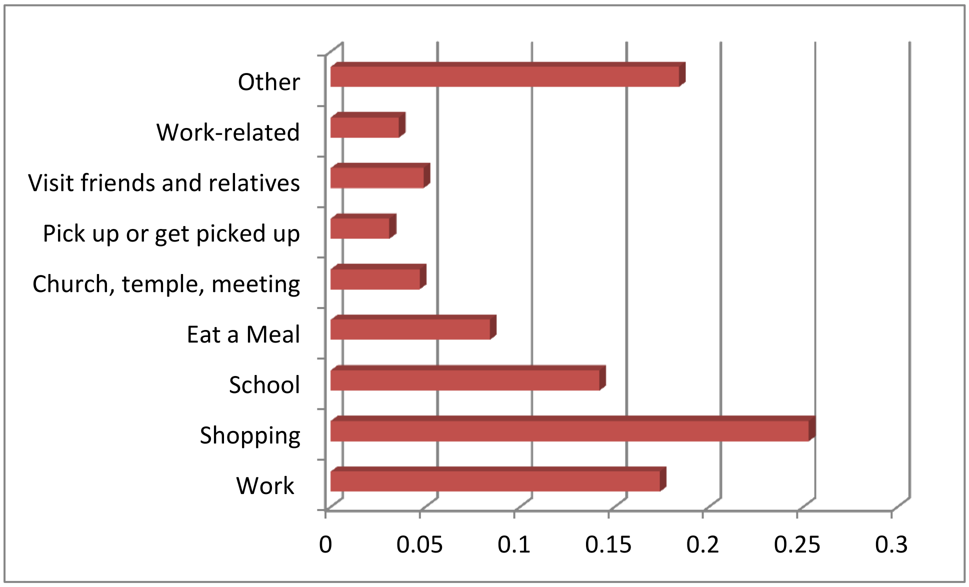

Figure 2-10: Trip Purposes for Phoenix All Days

In Phoenix and Tucson, commuters stop for a variety of reasons, such as to drop children at school, stop at the grocery store on the way home from work, and attend to other personal business. As in the NHTS survey, results show that trip chaining is often a response to the pressures of balancing work and home. But the data also show that some of the growth in trip chaining has been to pick up a meal, snack, or coffee, activities that historically were done at home and did not generate a trip. 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.

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 in the Phoenix and Tucson metropolitan areas.

2.5.2 Tucson

The objective of Pima Association of Governments' (PAG) Tucson Household Travel Survey (THTS) was to obtain data about activity behavior and travel patterns of Tucson area households. The information collected will be used for modeling travel patterns and planning transportation systems and services within the Tucson area. Specifically, THTS collected data on the activities and travel over a 24-hour period for all members of 2,076 households, a representative sample of the households in the Tucson area.

The data was collected in three steps: (1) a random-digit-dial (RDD) telephone recruitment interview to solicit participation, collect baseline information on the household, and assign an activity day; (2) mailing of an information packet with activity diaries for each household member; (3) telephone interviews the night following the activity day to collect household members' activity and travel information. The survey was pilot tested in August 2000. After minor modifications, the survey went into the field in September of 2000 and was completed in the beginning of December 2000.

The PAG Household Travel Survey includes data from households in Pima County, which contains the cities of Tucson, South Tucson, Oro Valley, Green Valley, and Marana. The weekday travel statistics were collected by MORPACE International, a survey research firm, for use by PAG.

The PAG Regional Household Travel Study was based on telephone interviews of randomly-selected households from the study area. Household recruitment was based upon household size and employment status. Interviews were done assessing: household size, number of vehicles, household income, dwelling type, age, gender, and work status.

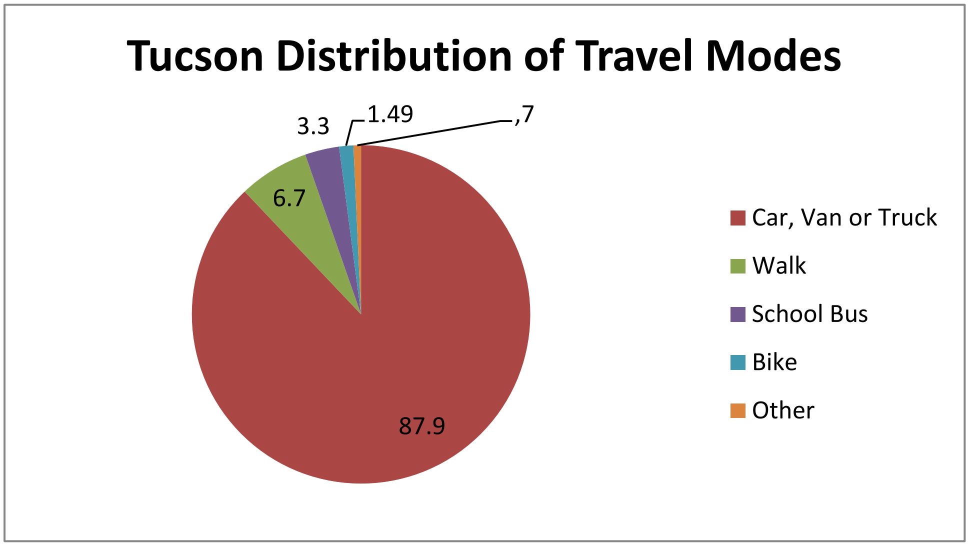

Figure 2-11: Mode of Transportation in Tucson Area

Figure 2-11 shows that the overwhelming mode of transportation for the Tucson metropolitan area is the car. Auto drivers and passengers in autos make up almost 88% of the people surveyed. The average trip duration took just over 20 minutes per trip.

In Tucson, just as the NHTS Survey indicated, the percentage of travel for non-work purposes, including Picked up/Get Picked up, Shopping, Errands, and Meals, is growing faster than work travel. See Figure 2-12: Tucson Distribution of Trip Purposes All Days.

Figure 2-12 indicates that the most frequent trip purpose for all days of the week, besides picking someone up or getting picked up, is shopping. In Tucson, trips for Personal Business and getting a meal were next in frequency. This coincides with the NTHS study that 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 this data indicates otherwise.

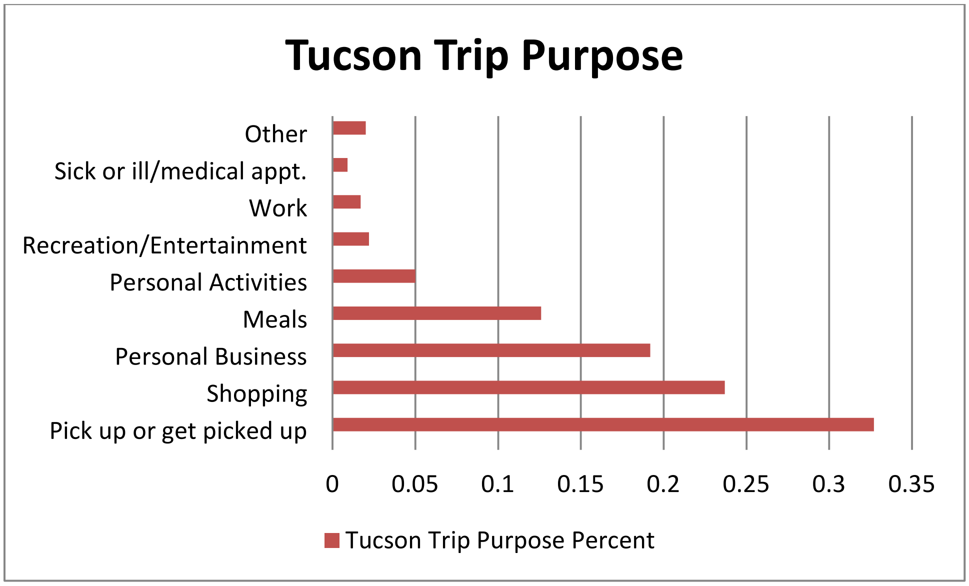

Figure 2-12: Tucson Distribution of Trip Purposes All Days

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. The 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

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 on-board the vehicle. The Nissan LEAF is an example of a BEV. A BEV is refueled by connecting it to the electrical grid via a connector system that is designed specifically for this 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. PHEV manufacturers use varying strategies to combine 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 include Range Extended Electric Vehicle (REEV) or Extended Range Electric Vehicle (EREV).

3.2 EV Batteries

Recent advancements in battery technologies will allow EVs to compete with ICE vehicles in performance, convenience, and cost.

From an infrastructure standpoint, it is important to consider that as battery costs are driven down over time, the auto companies will increase the size of the battery packs, and thus the range of electric vehicles.

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

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

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, 40 amp **6.5 kW**	480 VAC, 85 amp **60 kW**
PHEV-10	**4**	3 h 20 m	2 h 30 m	35 m	n/a
PHEV-20	**8**	6 h 40 m	5 h	1 h 15 m	n/a
PHEV-40	**16**	13 h 20 m	10 h	2 h 30 m	16 m
BEV	**24**	20 h	15 h	3 h 40 m	24 m
BEV	**35**	29 h 10 m	21 h 50 m	5 h 20 m	35 m
PHEV Bus	**50**	n/a	n/a	7 h 40 m	50 m

Note: Power delivered to battery 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)

Another way to compare EVSE power levels is to consider what range extension may be achieved during a charge period. Table 3-2 provides a comparison based upon a vehicle efficiency of 4 miles/kWh of charge.

Table 3-2 Miles Achieved per Charge Time

Miles Achieved per Charge Time*					
	Circuit Size and Power in kW Delivered to Battery**				
Charge Time	***Level 1*** 120 VAC, 15 amp **1.2 kW**	***Level 1*** 120 VAC, 20 amp **1.6 kW**	***Level 2*** 240 VAC, 20 amp **3.3 kW**	***Level 2*** 240 VAC, 40 amp **6.5 kW**	***DCFC*** 480 VAC, 85 amp **60 kW**
10 min	0.7	1	1.9	3.7	34
15 min	1	1.4	2.8	5.5	51
30 min	2	2.7	5.6	11	>50***
1 hour	4	5.4	11.2	22	>50***

*Vehicle efficiency 4 miles/kWh

**EVSE efficiency assumed at 85%

***Battery is at or near full charge, depending upon initial state

- **Trends in Battery Capacity**
  As the EV industry grows, it is fully anticipated that batteries will increase in capacity, and thus the range of vehicles will increase, 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 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 price projections are not reliable. Past trends cannot be used to predict future automotive sales either (conventional or electric), due to the loss in sales volume during 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. This information is summarized in Section 3.4, and Appendix A contains details of these projected penetration rates.

3.3.1 BEVs and PHEVs

The early hybrid vehicles that entered the automotive market were very similar to their ICE sister models. The failure of the electric vehicles 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 a 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 DCFC. For drivers taking long trips, the PHEV may still be the vehicle of choice. While projecting EV penetration is still difficult, it is noted that the first major OEM to deliver mass-produced vehicles is offering a BEV. In subsequent years, many analysts believe that PHEV sales will dominate the market, but will be overtaken by 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 in 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 newly 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 Probable Consumers

The Everett Rogers Diffusion[4] of Innovations theory identified that typical market penetration of any product follows a standard distribution curve. Different segments of consumers can be identified on this curve.

- The *Product Innovators* are the first to try a new product. Having the newest technology and being first is important to these consumers. They are venturesome and highly educated. Price is not as important as the innovation.
- *Early Adopters* are next, who again are well educated, but take a more reasoned approach where there needs to be value associated with the product.
- The *Early Majority* follows, where the product is selected in a deliberate manner. It meets specific needs and provides the value desired.
- The *Late Majority* 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.

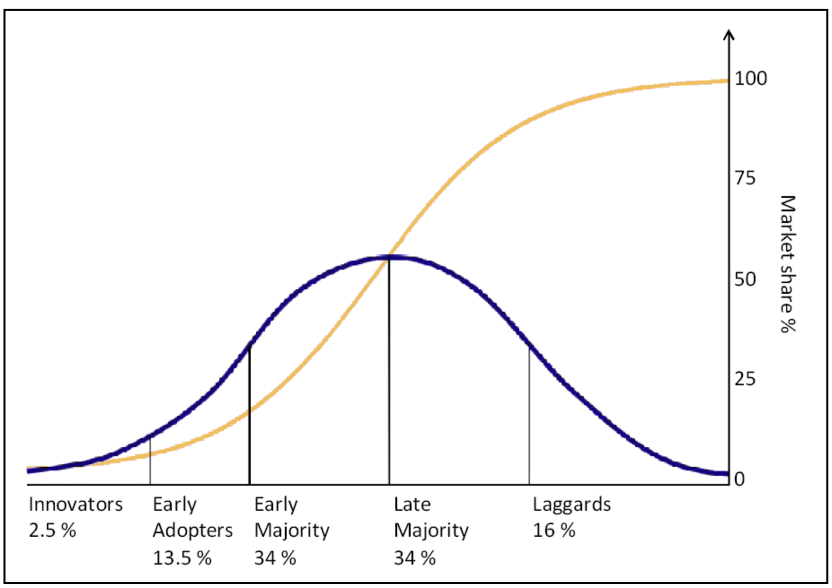

Figure 3-1: The Diffusion of Innovations According to Rogers

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

[4] Wikipedia, *Diffusion Theory*, www.wikipedia.org

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.
- 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 3-3 below.

Table 3-3 OEM PHEV and EV Plans

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

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

6 ibid

Make	Model	All Electric Range (mi)	Battery Size (kWh)	U.S. Target Intro. Date
Coda Automotive	Coda Sedan	90-120		2010
Daimler	Smart fortwo	82	16	For sale now
	Mercedes Benz BlueZero	120	35	2010 low volume
	Mercedes Benz SLS AMG E-Cell	90-130	48-60	2013
Ford	Focus	100		2011
	Transit Connect	100		2010
	Tourneo Connect	100	21	2011
Hyundai	i10 Electric	100	16	2012
Mitsubishi	iMiEV	100	16	2010
Nissan	LEAF	100	24	2010
Rolls Royce	Electric Phantom			2010
SAIC	Roewe 750	125		2012
Tesla Motors	Roadster	245	56	For sale now
	Model S	160, 230, 300		2011
Th!nk	City	113		2010
Toyota	RAV4 EV	100		2011

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 toward promoting or detracting from that acceptance. Appendix A explores the current projections worthy of note, along with ECOtality's projections to develop the sales estimates used here.

ECOtality strongly suggests that this is a conservative projection and 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 3-2 shows this plan in annual sales, as well as cumulative sales. By 2020, a total of almost 2.5 million EVs will be in service.

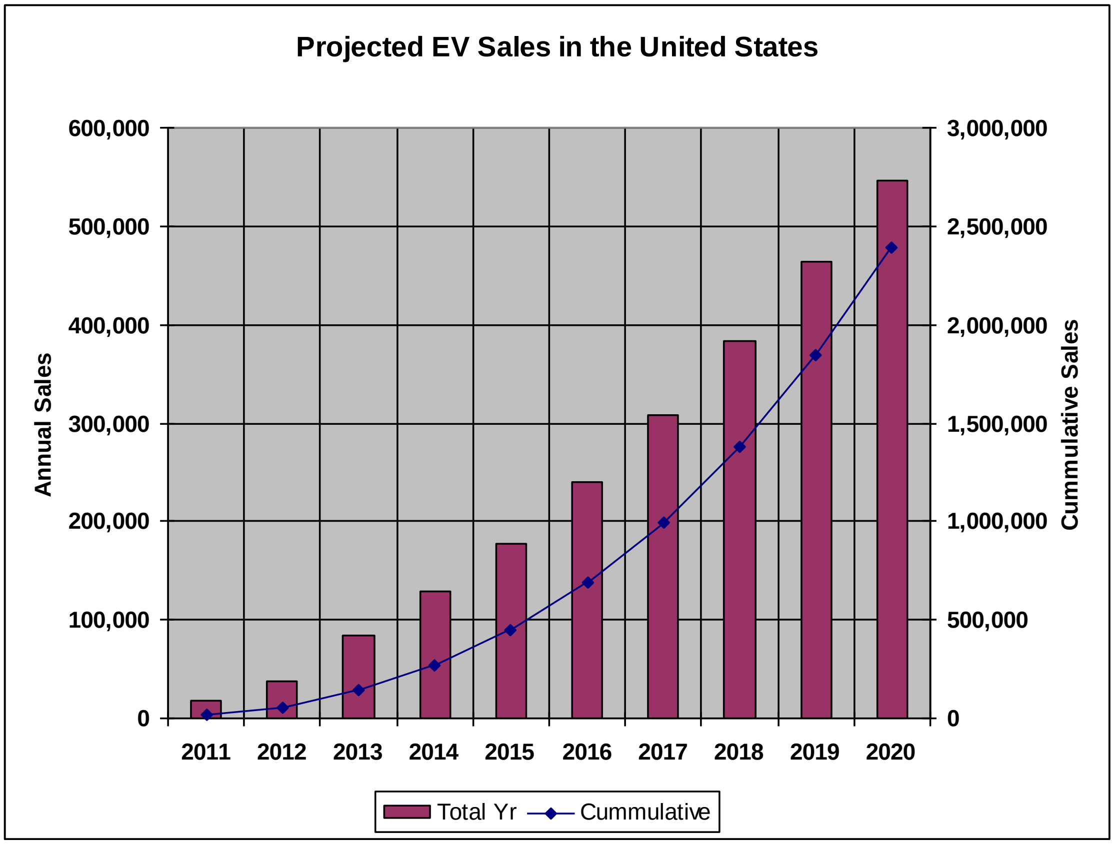

Figure 3-2: Projected EV Sales in the United States

3.5 EVs as Part of the Overall Vehicle Mix

The automotive market in the United States 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 3-3. 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 United States 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.

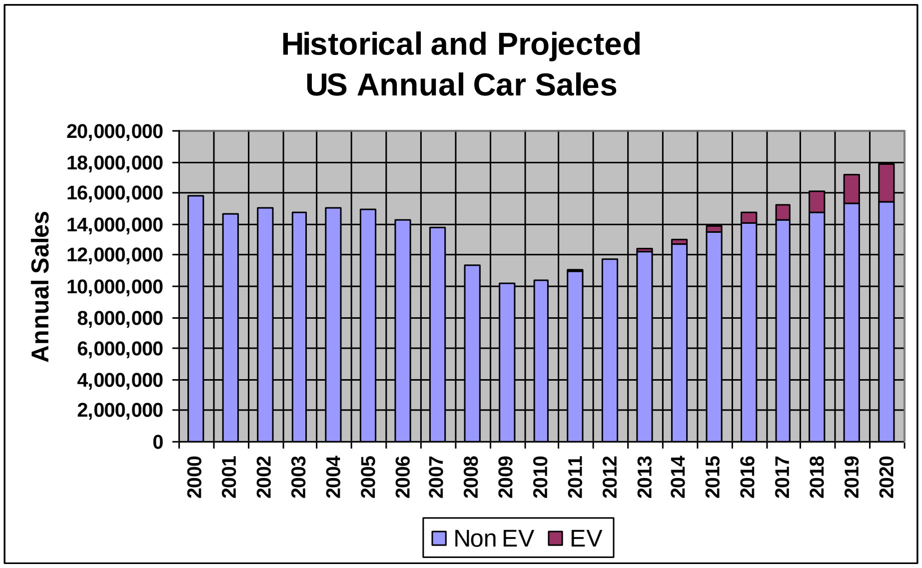

Figure 3-3: Historical & Projected US Annual Car Sales

3.6 Fleet Vehicles

Fleet managers will have a wide 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 mission is widely varying, a PHEV may be chosen. 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 included in the total EV numbers. The percentage of fleet vehicles (versus personal 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.

It should be noted here that 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

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] See Figure 4-1.

[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.

J1772 Connector

J1772 Inlet (right side

Figure 4-1: J1772 Connector and Inlet

The J1772 coupler and EV inlet will be used for both Level 1 and 2 charging levels, which are described below.

In 1991, the Infrastructure Working Council (IWC) was formed by the Electric Power Research Institute (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 2 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 VAC. Typical amp ratings for these receptacles are 15 or 20 amps.

Level 2 is generally considered to be the "primary" and "preferred" method for EVSE for both private and publicly-available facilities, and specifies 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 levels that high are rare. A more typical rating would be 40 amps AC, which allows a maximum current of 32 amps or 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 again 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, the DCFC would provide a 50% recharge in 10 to 15 minutes. The 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 EVSE Deployment

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 owner (and some PHEV owners who take advantage of 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 opportunity for Level 2 charging at work or in public areas may find the vehicle battery remains at a higher charge, and thus home charging time is not a concern and Level 1 will suffice. See Table 3-1 for relative battery sizes and estimated recharge times.

Nevertheless, 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. That gets into the range of the DCFC discussed in Section 6.

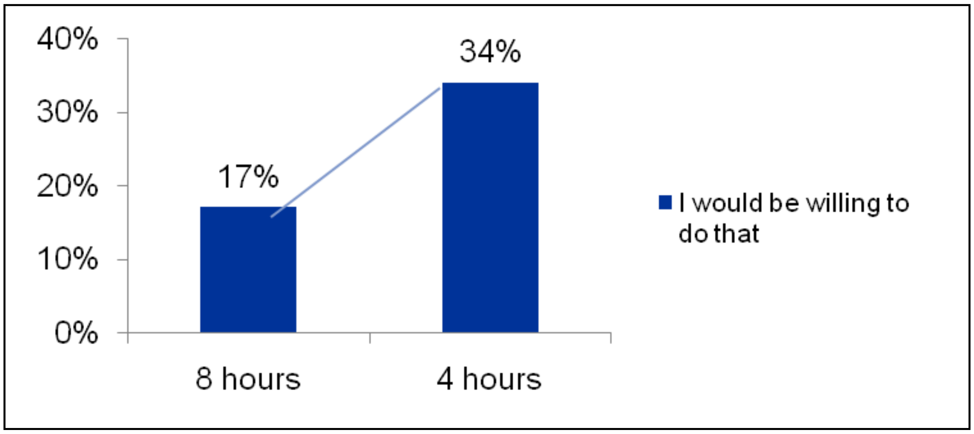

Figure 4-2: Willingness to Charge at Home for Given Number of Hours[10]

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.

Studies show that if all of the EV owners in a single neighborhood were to all set their EVSE to start when the off-peak time starts, the resulting spike could be substantial, which could potentially cause more issues. When electric utilities begin to offer load management 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 Appendix B.) EVSE will need to be capable of delivering a recharge in much less than the eight hours available at off-peak times.

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.

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

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 may desire a mix of a few DCFCs 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 be 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

Commercial EVSE refers to those units placed in retail or privately-owned locations (other than residences). Like residential equipment, EVSE in these locations will focus on Level 2 and DCFCs. Level 1 EVSE will become increasing irrelevant. Locations sought for Level 2 will be those locations where the EV owner is likely to remain for a substantial period of time. That means that these will be destinations for the EV driver for which "purposeful" trips are made. The National Household Travel Survey found such destinations to include daycare, religious activities, school, medical or dental appointments, shopping, errands, social gatherings, recreation, family 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 in the form of parking or membership fees. As demand grows, good business models will expand the population of commercial Level 2 EVSE.

4.1.4 Public

Public EVSE refers to equipment placed on public-owned land. Like residential equipment, EVSE in these locations will focus on Level 2. Again, Level 1 EVSE will become increasing 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 and office building managers may install EVSE to encourage employees to purchase EVs and to promote green certification of facilities. There are individuals and organizations that predict employer or workplace charging will closely follow home based charging as the primary location for EV charging. There are a number of benefits, challenges, and questions for employers who wish to provide EVSE for employee use.

4.1.5.1 LEED Certification and Public Relations

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

Developed by the U.S. Green Building Council (USGBC), LEED provides building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions.[11]

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

4.1.5.2 Employee Need or Convenience

Transportation studies show that most round-trip commutes are well within the projected range of EVs, so aside from those who may live at a significant distance or have no designated overnight vehicle parking location (see Section 4.1.5.6), workplace charging for most employees is a convenience, not a necessity.

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

4.1.5.3 Employee Benefits

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

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

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

4.1.5.4 How Many Units Should Be Installed?

There are three possible charging station installation scenarios: dedicated, open, and valet. Providing dedicated Level 2 EVSE for each employee with an EV can quickly become very expensive. Few parking facilities have electrical panels that can handle the load of numerous Level 2 EVSE before an electrical upgrade is required. One option for a dedicated parking scenario is to provide Level 1 EVSE instead. If an employee is parked for eight hours, Level 1 charging may be sufficient and this equipment is less expensive.

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

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

4.1.5.5 Electrical Load

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

4.1.5.6 Undesignated Parking

Home-based charging is expected to be the preferred location for charging. There are, however, several residential scenarios whereby home-based charging is not an option. A significant number of residential scenarios exist where people either park their vehicle in undesignated street-side parking or do not have a convenient location for charging at their residence. Some multi-family dwellings do not or will not allow private charging systems or will see the EVSE as a nuisance and a target for vandalism. As a result, EV enthusiasts will require alternative locations to charge their vehicles. Charging could be accomplished at nearby Level 2 retail locations or the safety net DCFCs, but could also be accomplished at the workplace. Management could provide this service and thereby increase the number of workplace chargers. It is also possible that local legislation may be enacted that provides incentives to businesses and subsidizes the installation of workplace EVSE to accommodate this need.

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

4.1.6 EVSE Requirements

The essential question raised is this: How many EVSE installations will be required to provide the necessary infrastructure? This should be viewed not only as the necessary but 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)."[12]

The deployment of DCFC equipment will be address in Section 6. The remainder of this section will focus on Level 2 EVSE.

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

4.2 EVSE Projection

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, but these 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.

Three zones of increasing EVSE density are projected, with the city center or specific destination complex having the highest density of EVSE. 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 area.

4.2.2 Destination Planning

It was shown in the National Household Travel Survey that a significant number of trips for personal reasons to various destinations occur every day of the week. For destination planning, the metropolitan area is canvassed to determine the number of potential destinations and the number of EVSE that would be installed at each venue. The number of destination EVSE grows with the demand created by the introduction of EVs.

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.

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-populated Level 2 equipment. Indeed, the visibility of this equipment will encourage others to consider purchasing an EV when they next choose a new car. In the early years of vehicle deployment, the ratio of publicly-available EVSE to the number of deployed EVs likely will be much higher than it might be in a mature market.

Table 4-1 provides the cumulative, calculated number of EVSE installations to be deployed in residential, fleet, and public/commercial locations, based upon the ECOtality methodology provided in Appendix A. This infrastructure is then identified as a percentage of total EVs.

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

Year	Vehicles Fleet	Vehicles Residential	EVSE Fleet	EVSE Residential	EVSE Pub/Comm	EVSE Total	EVSE % EV Total
2011	3,690	14,770	2,470	11,810	41,050	55,330	300%
2012	7,900	48,500	5,290	37,340	113,970	156,600	278%
2013	11,310	130,050	7,580	96,240	256,190	360,010	255%
2014	17,840	252,470	11,950	176,730	416,570	605,250	224%
2015	26,370	420,540	17,670	281,760	609,780	909,210	203%
2016	34,340	652,360	23,000	410,990	815,450	1,249,440	182%
2017	43,780	951,260	29,330	570,760	1,093,950	1,694,040	170%
2018	55,170	1,323,970	36,960	754,660	1,403,410	2,195,030	159%
2019	70,030	1,772,900	46,920	957,360	1,808,350	2,812,630	153%
2020	86,040	2,303,860	57,640	1,151,930	2,349,940	3,559,510	149%

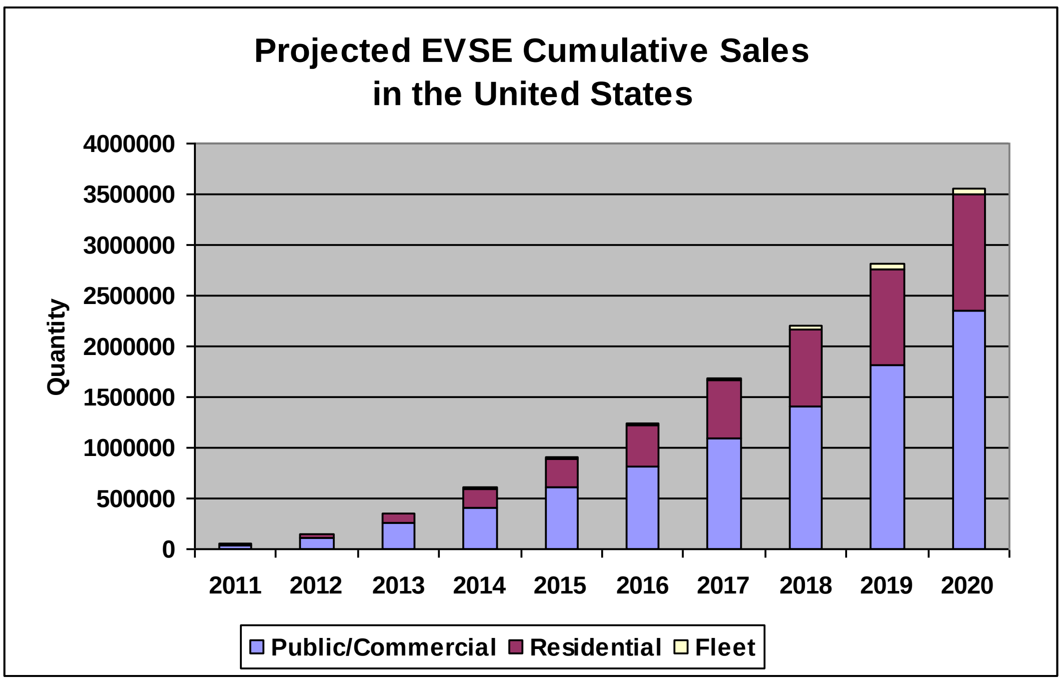

Figure 4-3: Cumulative EVSE Sales in the United States

5 EV and EVSE Penetrations in Arizona

The nationwide penetrations of EVs and EVSE assist in providing projections of EVs and EVSE penetrations in Arizona. The early market launch of EVs into Arizona 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. 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 Arizona, with local population behavior taken into consideration. This 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 entire state of Arizona, but focuses on the central area, where the majority of the state's population resides. The population centers outside this boundary could be evaluated separately. Significant driving distances separate this area from the neighboring states, which will be a challenge for EV connections. Nevertheless, the long-range plan also considers the major highway systems connecting this area to other major population centers. The Interstate 17 (I-17) corridor is in this boundary, as well, due to high interest in connecting the cities of Phoenix and Flagstaff. DCFC along the I-8, I-10, and I-40 systems and other corridors is discussed in Section 6. Figure 5-1 shows the planning boundary.

Figure 5-1: Arizona Long-Range EV Charging Infrastructure Plan Boundary

This boundary is not intended to infer that EVs will not be adopted in areas outside the boundary, but rather that the majority of EV owners will work or live within this area. In addition, the boundary area should be the focus of publicly-available EVSE.

5.2 Demographics

Development of the EV infrastructure should respond to demographics. Understanding the population densities, probable EV owner demographics, operator driving behavior, existing vehicle use, travel habits, car purchases, and population growth will help planners define what is needed 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. 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 charge.

5.2.1 Population

The boundary area population in 2007 was 5,469,675, compared to an Arizona State population of 6,248,612.[13] Figure 5-2 shows the population by zip codes within the boundary area.

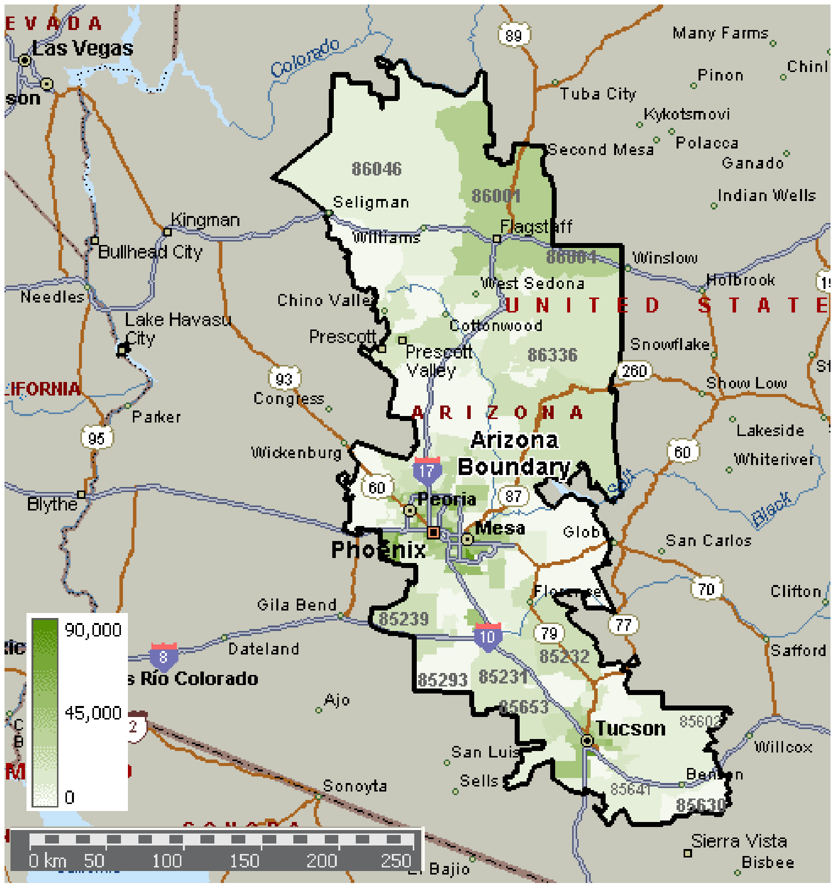

Figure 5-2: Population: Total Persons (2007) by Zip Code[14]

This boundary includes most of the major cities of Arizona, as shown in Table 5-1 below. The U.S. Office of Management and Budget combines population centers into Metropolitan Statistical Areas (MSA) where there is at least one urban core of at least 50,000 people. When there are adjacent territories that have a high degree of integration with the core, those areas are included. In Arizona, there are six MSAs.

13 Microsoft MapPoint 2010 United States

14 ibid

Table 5-1 Major Population Centers Arizona 2008[15]

City Area	Population
Phoenix Metropolitan Statistical Area	4,179,427
Tucson Metropolitan Statistical Area	967,089
Flagstaff Metropolitan Statistical Area	127,450
Prescott Metropolitan Statistical Area	212,635
Kingman/Lake Havasu Metropolitan Statistical Area	194,944
Yuma Metropolitan Statistical Area	196,972

5.2.2 Education

The introduction of EVs over 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 the innovators and early adopters of EVs will 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 5-3 illustrates the population percentages by zip code of adults with college bachelor degrees and advanced degrees.

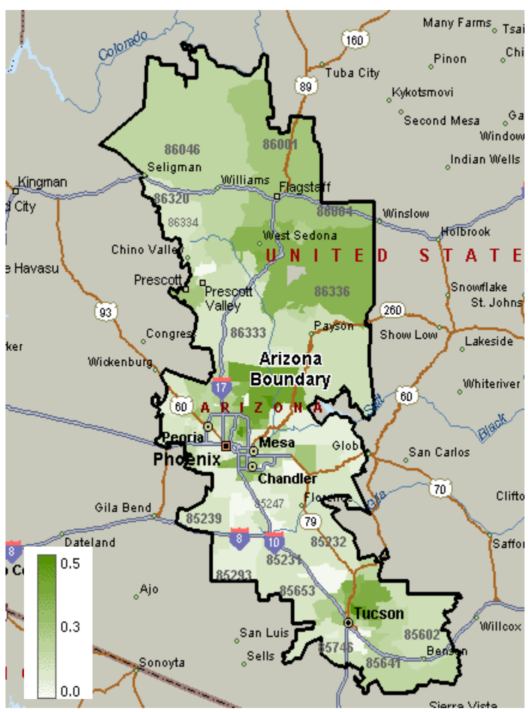

Figure 5-3: Percentage of Adults with Bachelor's Degree or Above (2007) by Zip Code[16]

15 http://www.citypopulation.de/USA-Arizona.html

5.2.3 Vehicles

Analysts also suggest that existing hybrid vehicle users can be an early indicator of who the innovators and early adopters of EVs will be. Figure 5-4 shows the locations of existing hybrid vehicles.

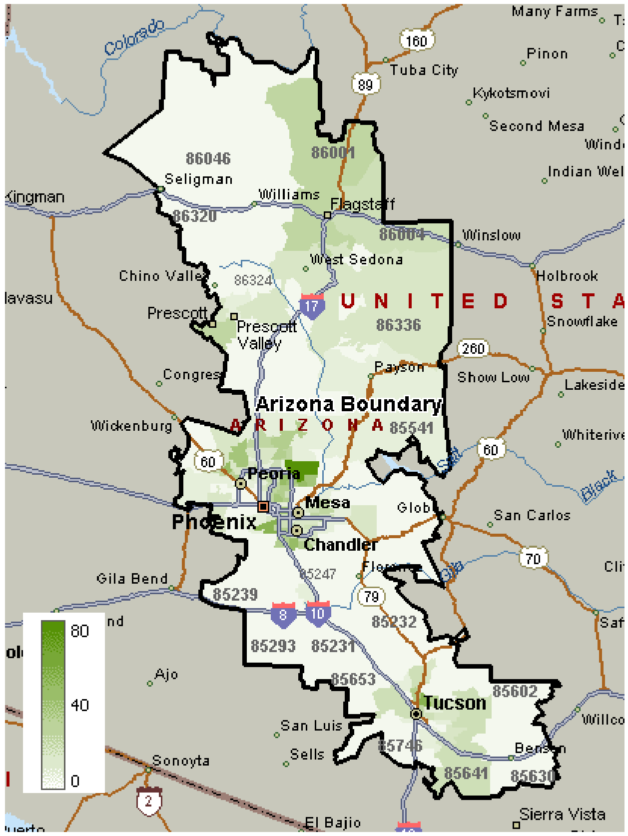

Figure 5-4: Hybrid Vehicles by Zip Code

16 Microsoft MapPoint 2010 United States

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

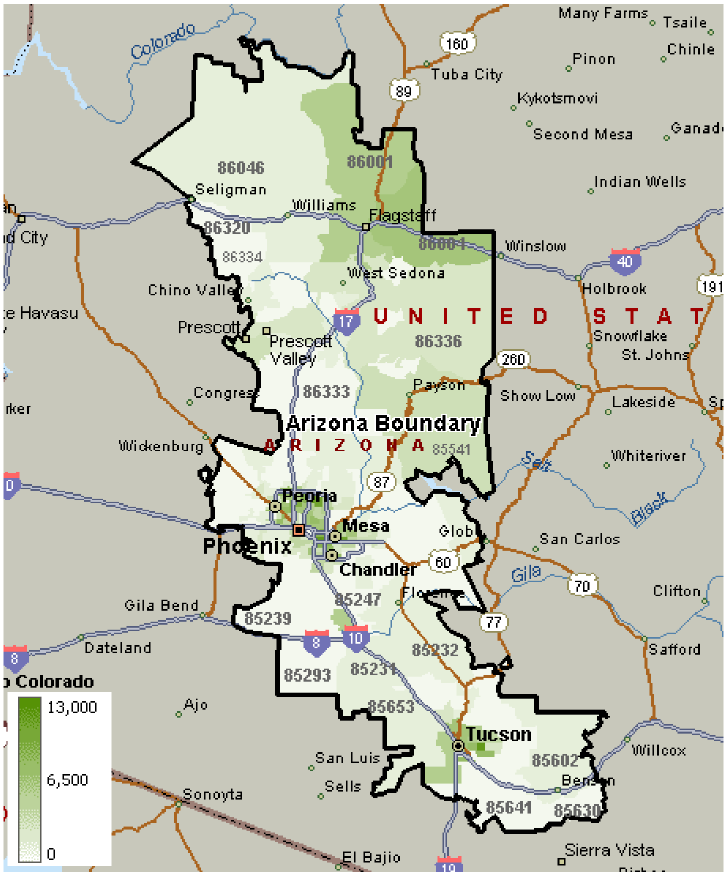

Figure 5-5: Households with 2 or More Vehicles (1990) by Zip Code[17]

5.2.4 Traffic Patterns

Significant study has already been completed on identifying traffic flows and patterns on major freeways. Additional studies in the local metropolitan areas will be useful in identifying potential sites for charging infrastructure.

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 between these work centers and their homes. The greatest densities of businesses are in the three zip codes below.

[17] ibid

Table 5-2 Major Business Densities

Zip Code	City	Density Businesses/Sq Mi
85003	Phoenix Center South	961
85012	Phoenix Center North	728
85701	Tucson Center South	865

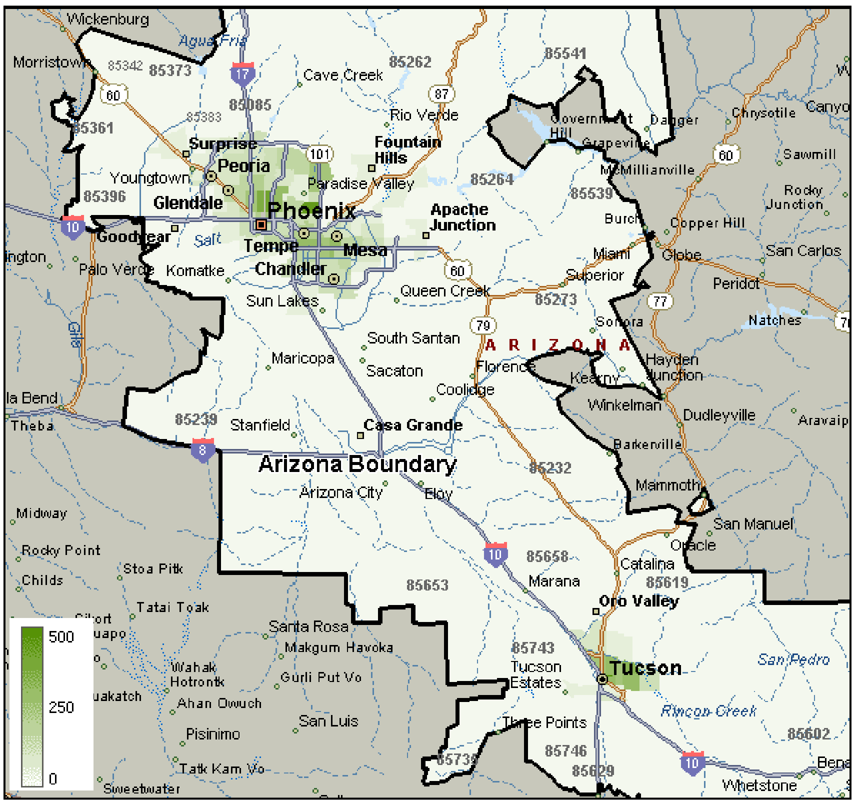

Figure 5-6: Businesses per Square Mile by Zip Code[18]

[18] ibid

The metropolitan areas of Phoenix and Tucson are shown in Figures 5-7 and 5-8.

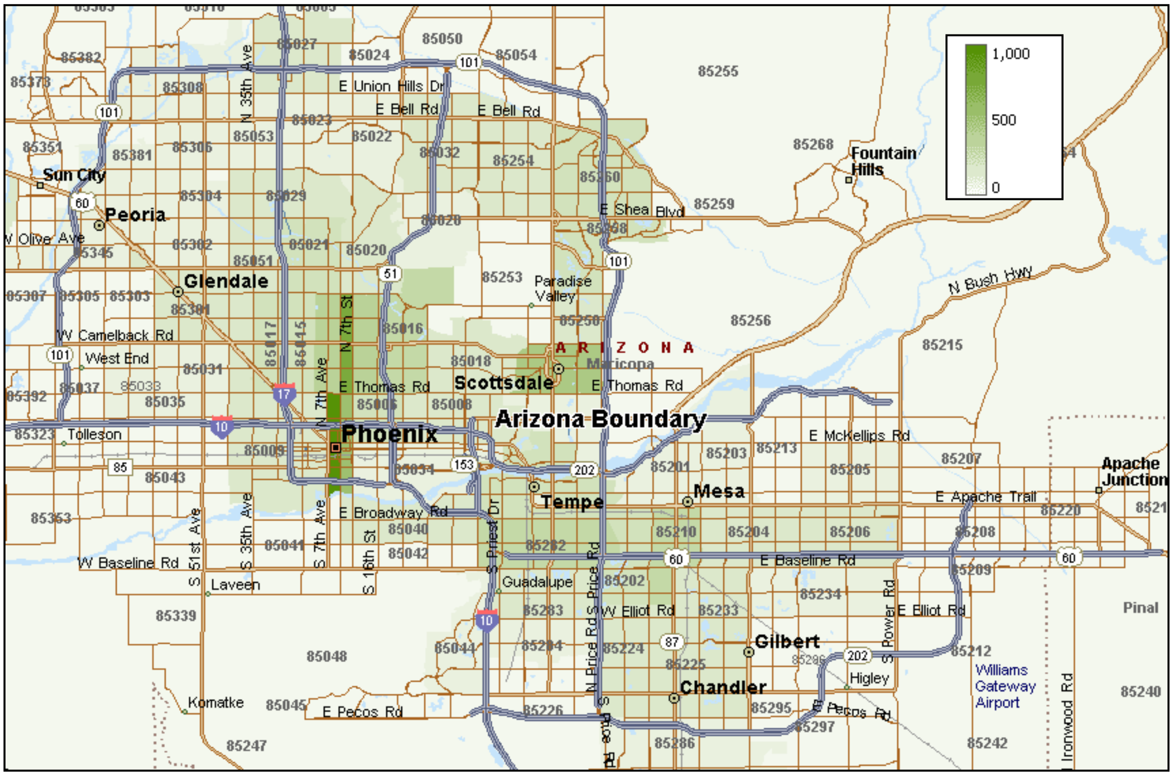

Figure 5-7: Phoenix Major Business Densities

Figure 5-8: Tucson Major Business Densities

5.3 EV Sales Projections

The Phoenix and Tucson areas are one of the initial market areas for major production EVs in 2010. The Nissan LEAF is being introduced into this market. Other OEMs will follow, as well. Political will and public enthusiasm are driving the interest and motivation to bring EVs into public acceptance. This will place the Arizona area on a faster path to EV adoption.

These factors can be applied to the EV sales projections in Section 4 to show the following projections by Metropolitan Area.

Table 5-3 Annual EV Sales Arizona

Annual Sales	Phoenix MSA	Tucson MSA	Flagstaff MSA	Prescott MSA	Total
2011	1,880	440	0	0	2,320
2012	1,860	430	60	100	2,450
2013	2,340	540	70	120	3,070
2014	3,770	870	120	190	4,950
2015	6,340	1,470	190	320	8,320
2016	9,200	2,130	280	470	12,080
2017	13,310	3,080	410	680	17,480
2018	17,880	4,140	540	910	23,470
2019	23,800	5,510	730	1,210	31,250
2020	30,260	7,000	920	1,540	39,720

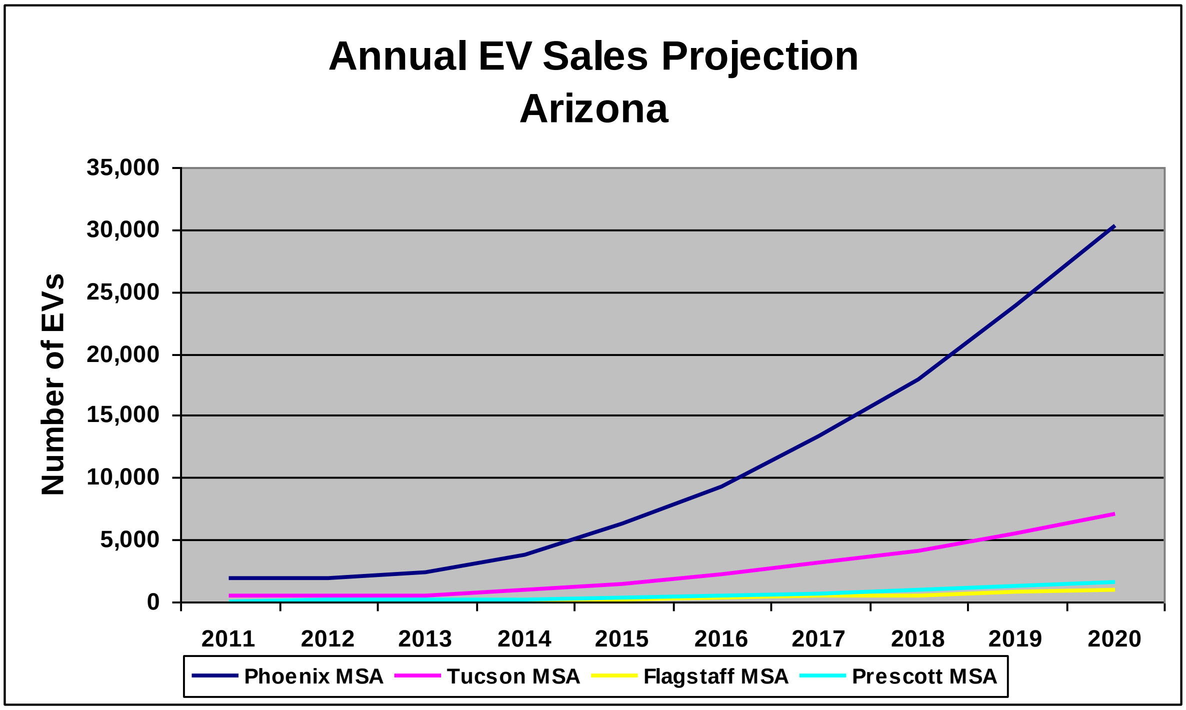

Figure 5-9: Annual EV Sales Projections - Arizona

Table 5-4 Cumulative EV Sales Projection Arizona

Cum. Sales	Phoenix MSA	Tucson MSA	Flagstaff MSA	Prescott MSA	Total
2011	1,870	440	0	0	2,310
2012	3,730	870	60	100	4,760
2013	6,070	1,410	130	210	7,820
2014	9,840	2,280	240	400	12,760
2015	16,180	3,750	440	730	21,100
2016	25,370	5,880	720	1,200	33,170
2017	38,690	8,960	1,120	1,870	50,640
2018	56,570	13,100	1,670	2,780	74,120
2019	80,380	18,610	2,390	3,990	105,370
2020	110,630	25,610	3,320	5,530	145,090

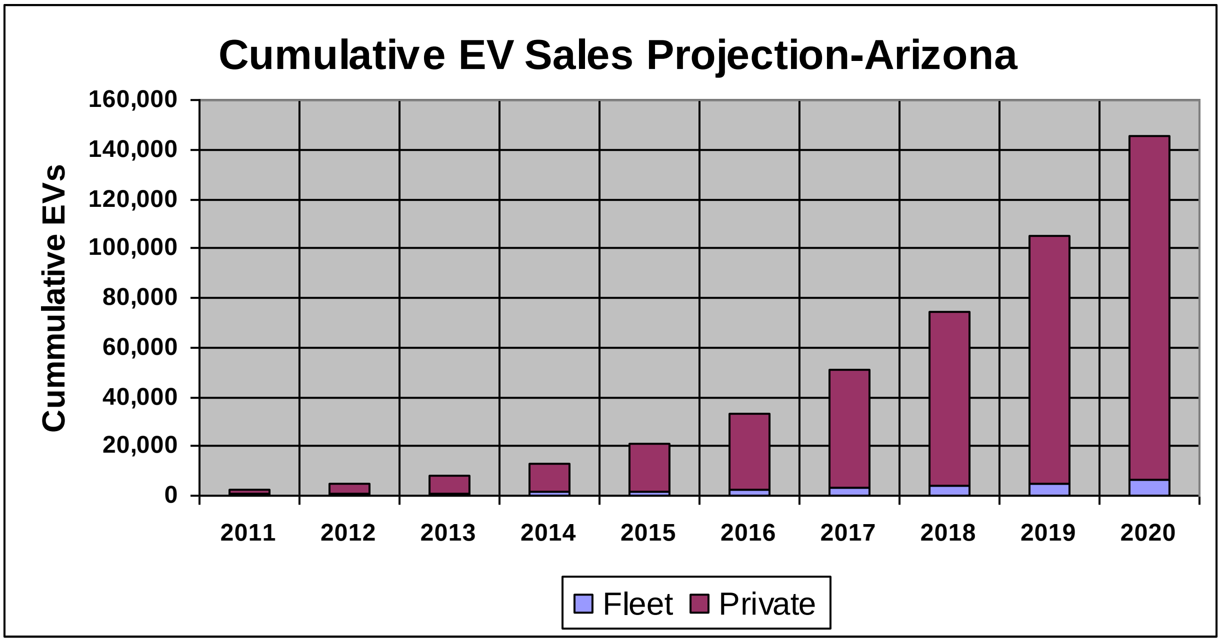

Figure 5-10: Cumulative EV Sales - Arizona

5.4 EVSE Sales Projection

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

Table 5-5 Annual EVSE Projections

Annual Sales	Phoenix MSA	Tucson MSA	Flagstaff MSA	Prescott MSA	Total
2011	5,610	1,320	0	0	6,930
2012	5,300	1,230	160	270	6,960
2013	6,010	1,390	180	310	7,890
2014	8,460	1,960	260	430	11,110
2015	12,920	2,990	390	660	16,960
2016	16,780	3,880	510	850	22,020
2017	22,680	5,250	690	1,150	29,770
2018	28,500	6,600	870	1,450	37,420
2019	36,330	8,410	1,110	1,850	47,770
2020	45,110	10,440	1,380	2,300	59,230

Table 5-6 Cumulative EVSE Projections

Cum. Sales	Phoenix MSA	Tucson MSA	Flagstaff MSA	Prescott MSA	Total
2011	5,610	1,320	0	0	6,930
2012	10,910	2,540	160	270	13,880
2013	16,920	3,940	340	580	21,780
2014	25,380	5,890	600	1,010	32,880
2015	38,300	8,880	1,000	1,660	49,840
2016	55,080	12,770	1,510	2,520	71,880
2017	77,760	18,010	2,200	3,670	101,640
2018	106,260	24,610	3,070	5,120	139,060
2019	142,590	33,020	4,180	6,970	186,760
2020	187,700	43,450	5,550	9,260	245,960

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

Table 5-7 Phoenix MSA

Year	Fleet	Residential	Publicly Avail	Total Yr
2011	250	1,200	4,160	5,610
2012	140	1,270	3,890	5,300
2013	110	1,710	4,290	6,010
2014	160	2,470	5,830	8,460
2015	240	4,010	8,670	12,920
2016	280	5,530	10,970	16,780
2017	380	7,640	14,650	22,670
2018	450	9,810	18,240	28,500
2019	610	12,360	23,360	36,330
2020	700	14,610	29,800	45,110

Table 5-8 Tucson MSA

Year	Fleet	Residential	Publicly Avail	Total Yr
2011	60	280	980	1,320
2012	30	300	900	1,230
2013	20	370	990	1,380
2014	40	570	1,350	1,960
2015	60	930	2,010	3,000
2016	70	1,280	2,540	3,890
2017	90	1,770	3,390	5,250
2018	100	2,270	4,220	6,590
2019	140	2,860	5,400	8,400
2020	160	3,380	6,900	10,440

Table 5-9 Flagstaff MSA

Year	Fleet	Residential	Publicly Avail	Total Yr
2011	0	0	0	0
2012	5	40	120	165
2013	5	50	130	185
2014	5	80	180	265
2015	5	120	260	385
2016	10	170	340	510
2017	10	230	450	690
2018	10	300	560	870
2019	20	380	710	1,110
2020	20	440	910	1,370

Table 5-10 Prescott MSA

Year	Fleet	Residential	Publicly Avail	Total Yr
2011	0	0	0	0
2012	5	60	200	265
2013	5	80	220	305
2014	10	130	300	440
2015	10	200	440	650
2016	10	280	560	850
2017	20	390	750	1,160
2018	20	500	930	1,450
2019	30	630	1,190	1,850
2020	40	740	1,520	2,300

6 DCFC

Section 4 provided background information on the DCFC. Studies have found that the inclusion of DCFC 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 the DCFC will go a long way in the promotion of EVs. There is some question, however, whether the availability of the DCFC 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 DCFCs may be sufficient for a substantial time into the long-range plan. This section explores the design and location process for the DCFC.

6.1 Design Characteristics

The DCFC requires 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 40 to 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 the DCFC makes it ideal for locations where the consumer will stop for a relatively short period of time; typically 15 to 30 minutes. DCFCs 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 2.4.

6.3 Local Area Impact

The safety net provided by the DCFC 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 the DCFC. 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 the DCFC is more typically available in industrial areas and may not be readily available in typical commercial or public areas. Industrial users require the higher power availability to power equipment, lights, 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 the DCFC locations.

6.3.3 Siting of Fast Chargers

There are three major factors when siting DCFCs: 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

The DCFC 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 metropolitan areas. The DCFC is more suitable 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 the DCFC will also be increased. DCFCs expected to be provided in support of the initial rollout of EVs in 2010 and 2011 likely will be 60 kW or less. Larger power electronics have been used in the past and are certainly possible, but power availability would be a concern and such sizes may be unnecessary, given current battery capacities.

Figure 6-1: Chrysler EPIC DCFC (90kW) circa 1997

6.4.1 Corridor Spacing

Research provided in Section 4.2.3 identified that, from a convenience standpoint, EV charging stations should be as plentiful as current gasoline stations. This holds true for corridor travel. A review of gasoline stations along Interstate 10 from Phoenix to Quartzsite shows nine exit locations where gasoline stations can be found.

Figure 6-2: Gasoline Stations along I-10

The longest stretch in this trip between stations is about 50 miles. This is about 50% of the range of an EV. In general for corridor travel, minimum planning should allow DCFC 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 freeways in the Arizona area, as well as the major state highways connecting population centers. 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 DCFC Deployment Projections

6.5.1 City Planning

Appendix A provides the methodology for determining the expected sales of DCFCs as a safety net for municipal EVSE. The estimated quantities of the DCFC to be deployed are shown in the following table.

Table 6-1 Cumulative Deployment of DCFC per Metropolitan Area

Cum. Sales	Phoenix MSA	Tucson MSA	Flagstaff MSA	Prescott MSA	Total
2011	50	10	0	0	60
2012	90	20	5	5	120
2013	140	30	5	5	180
2014	200	50	10	10	270
2015	300	70	15	15	400
2016	420	100	15	20	555
2017	580	140	20	30	770
2018	780	180	20	40	1,020
2019	1,040	240	30	50	1,360
2020	1,380	320	40	70	1,810

6.5.2 Corridor Planning

The guidelines above would suggest the DCFC locations as noted on Figure 6-3 below. There are 44 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.

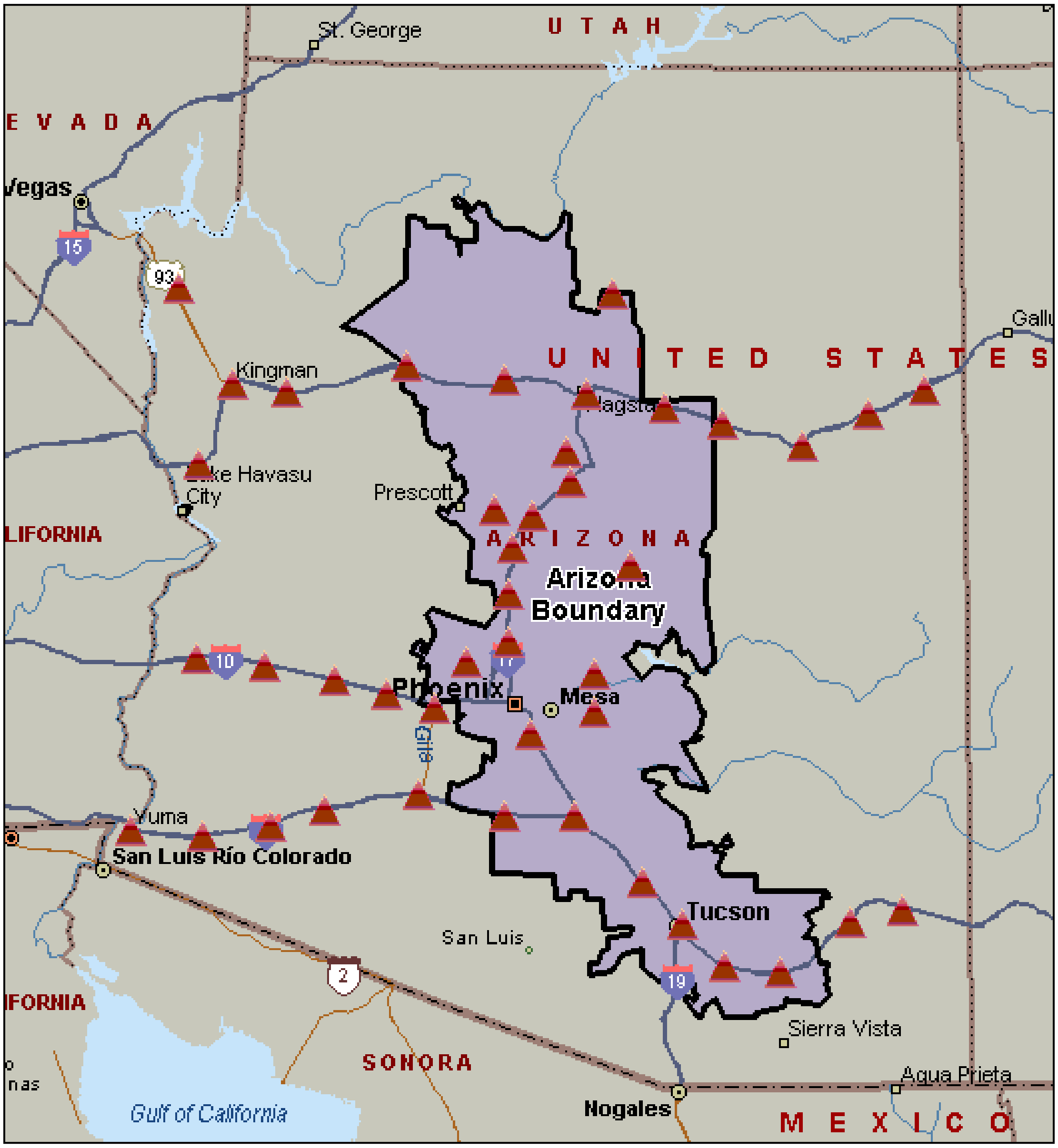

Figure 6-3: Possible Arizona DCFC Locations in 2020

7 EVSE Deployment Implementation

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

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. This 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.

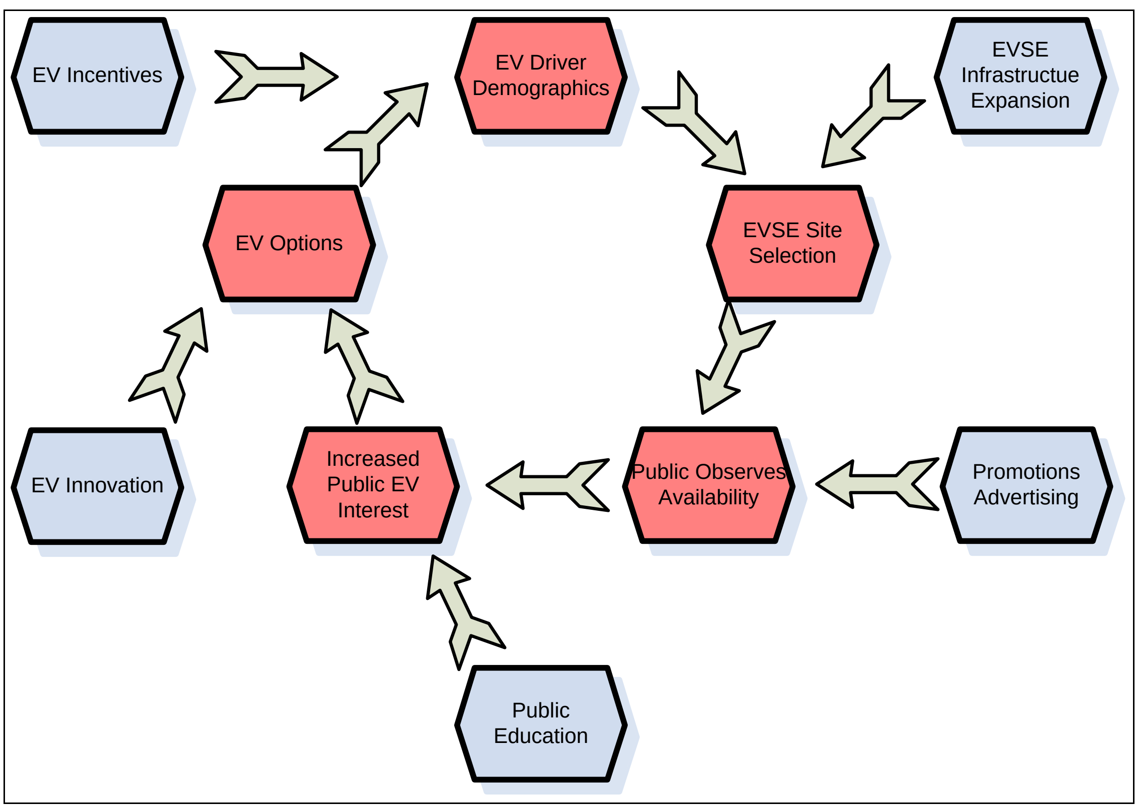

Figure 7-1: EV and EVSE Promotion

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 for the general public are the Nissan LEAF and the Chevrolet Volt. Both are due to be released in the last quarter of 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 4.2.1 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 EV Micro-Climate. As the target areas are populated with EVSE, the deployment can be expanded outward. Additional targets can be identified as demand increases. Eventually the targets may merge and the geographic coverage expanded. Once the expansion is completed, owner demand will continue to drive the expansion of publicly-available EVSE. The revenue systems used and business cases developed in the deployment of EVSE 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 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 Phoenix metropolitan area (approximate 30-mile radius from Phoenix center) revealed the following destinations.

Airports (Major)	1	Airports (Minor)	8	Amusement parks	9
ATMs	1404	Auto services	2230	Banks	828
Bus Stations	8	Campgrounds	67	Casinos	6
Cinemas	30	Community Centers	16	Convention Centers	8
Galleries	96	Gas Stations	761	Golf Courses	216

Grocery Stores	443	Hospitals	60	Libraries	46
Marinas	2	Museums	58	Nightclubs	649
Park & Rides	41	Parking lots	109	Pharmacies	361
Police Stations	35	Post Offices	40	Schools	1035
Shopping	67	Stadiums and arenas	34	Theaters	29
Wineries	1	Restaurants	5277		

There are a total of 13,975 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 18,600. Note that the Phoenix 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.

A similar review of the major Tucson metropolitan area shows 3,825 destinations. Flagstaff shows 660 and Prescott shows 800. Again, if just two-thirds of these destinations included two EVSE at these locations by 2020, the total number of ports would be about 5100 in Tucson, 880 in Flagstaff, and 1050 in the Prescott area. Here again, the projections show that these penetrations of EVSE should be reached between 2018 and 2019.

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 the DCFC 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

The following figures show the projected density maps for Phoenix and Tucson, separated by destinations listed below each map.

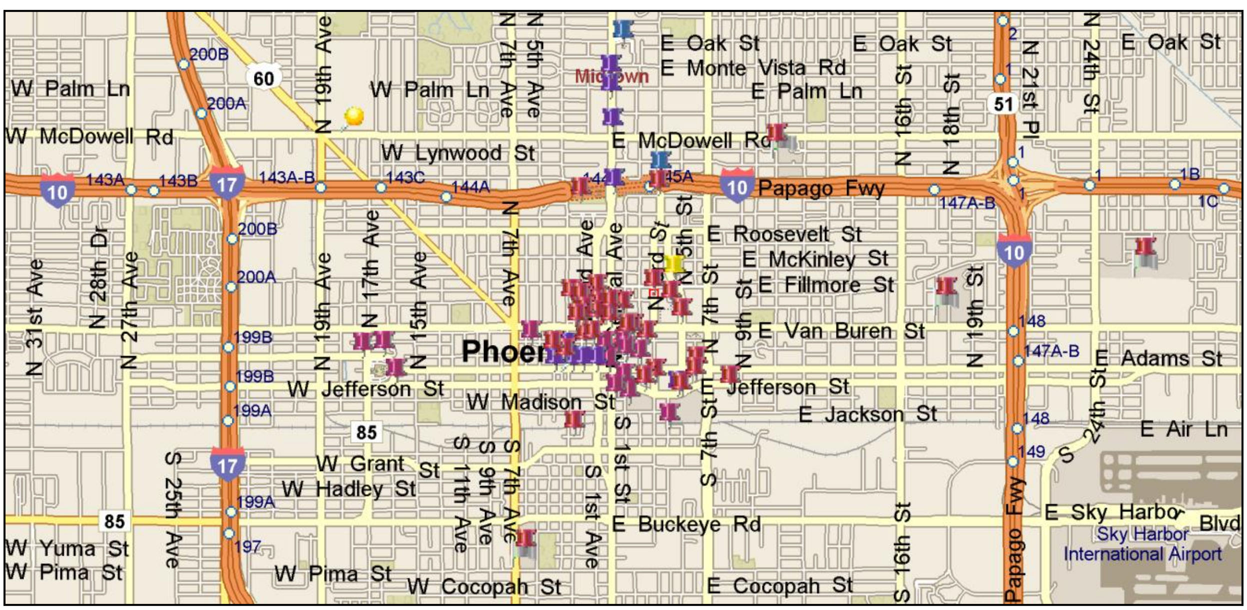

Figure 7-2: Central Phoenix Level 2 - Long-Range Plan Densities

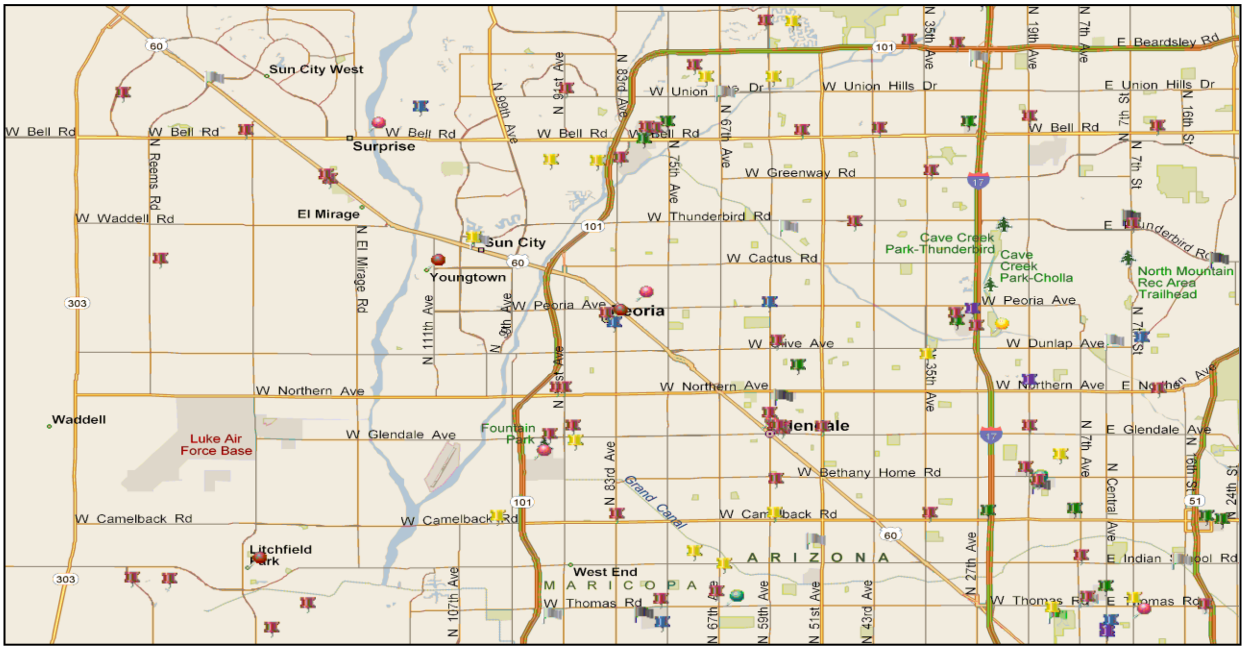

Figure 7-3: West Phoenix - Level 2 Long-Range Plan Densities

Key to Density Maps

- Museums, Theaters & Libraries - Shopping Malls, Restaurant and Amusement Parks
- Parking Garages - Movie Theaters and Golf Courses - City Halls - Hospitals

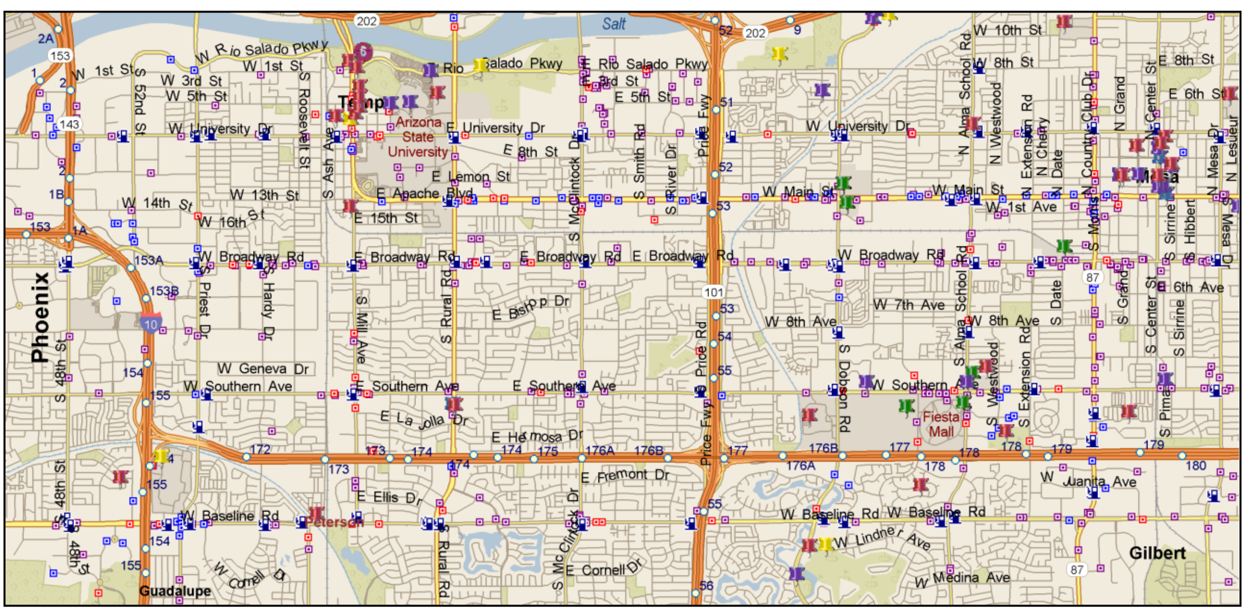

Figure 7-4: Tempe/Mesa - Level 2 Long-Range Plan Densities

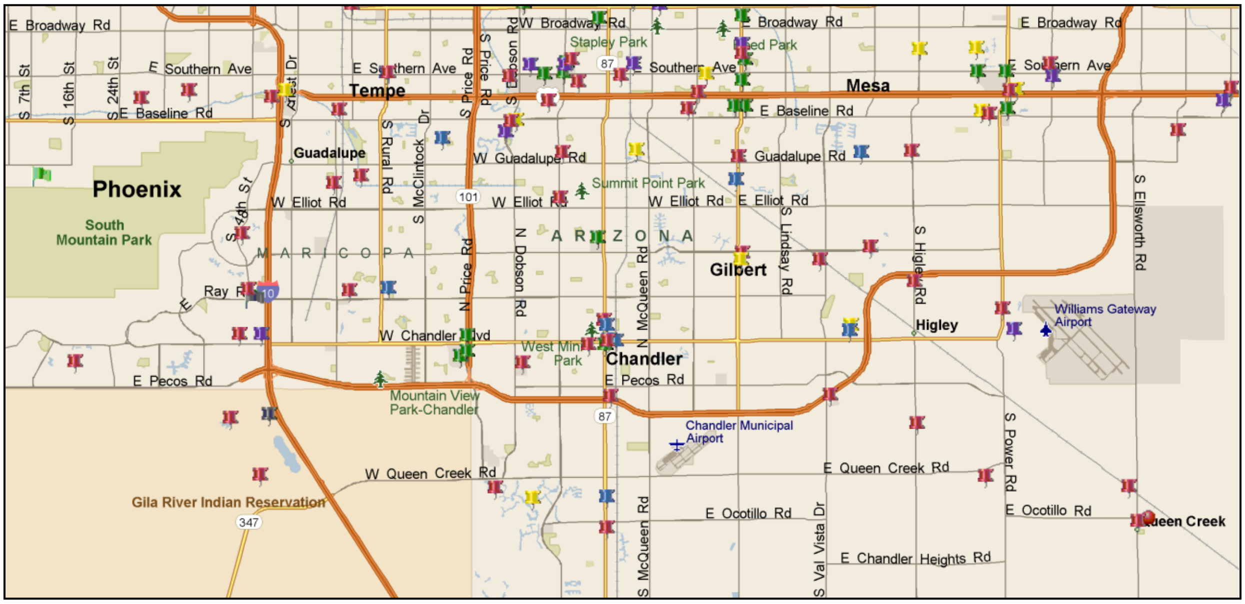

Figure 7-5: SE Phoenix Metro Area - Level 2 Long-Range Plan Densities

Key to Density Maps

- Museums, Theaters & Libraries - Shopping Malls, Restaurant and Amusement Parks
- Parking Garages - Movie Theaters and Golf Courses - City Halls - Hospitals

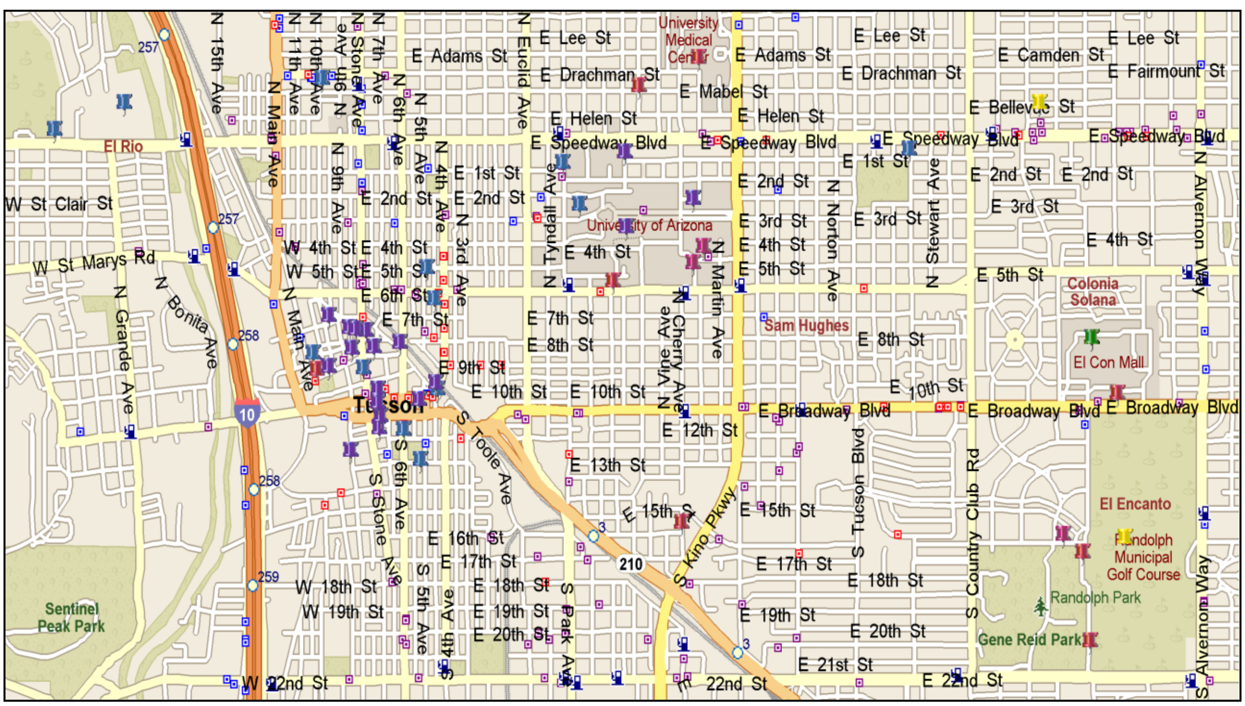

Figure 7-6: Central Tucson - Level 2 EVSE Long-Range Plan Densities

Figure 7-7: North Tucson - Level 2 EVSE Long-Range Plan Densities

Key to Density Maps

- Museums, Theaters & Libraries - Shopping Malls, Restaurant and Amusement Parks
- Parking Garages - Movie Theaters and Golf Courses - City Halls - Hospitals

Figure 7-8 below shows the MAP 2004 Average Weekday traffic study results. Data was collected in 2002 and 2003. Traffic volumes were derived from MAG, city, county, and state traffic recording devices. Most volumes were collected on a typical weekday, such as Tuesday, Wednesday, and Thursday. Interestingly, the data collected reflected an increased volume of traffic due to population growth, but there was only a slight variation in the busiest intersections and streets from the previous study in 2000.

The data collected from the study is reflected in Table 7-1 and Table 7-2.

Figure 7-8: Phoenix's Busiest Intersections and Streets

Table 7-1- Phoenix's Busiest Streets (Source: MAG)

On Map	Street	Section of Street	Average Daily Traffic	Maximum Daily Traffic
1- 2	Loop 202 - E/W	51 to I-17	234,000	291,000
3 - 4	I-10 - N/S	Warner to 51	219,000	257,000
5 - 6	I-10 – E/W	Litchfield Rd to 7th Ave.	180,000	239,000
7 - 8	Loop 202 - E/W	Loop 101 to 51	172,000	179,000
9 - 10	51 - N/S	Cactus to 202	167,000	178,000
11 - 12	Rt. 60 – E/W	Higley to I-10	164,000	210,000
13 - 14	Loop 101 – N/S	FLW to McDowell	158,000	184,000
15 - 16	Loop 101- E/W	51 to 75th Ave.	132,000	182,000
17 - 18	Loop 101 – N/S	Beardsley to I-10	128,000	146,000
19 - 20	Loop 202 - East/West	Cooper to I-10	88,000	100,000

Table 7-2- Phoenix's Busiest Intersections (Source: MAG)

On Map	Intersection	Date Collected	Average Daily Traffic*
1	Baseline & I-10	2006	58,000
1	Indian School & I-17	2006	58,000
2	27th Ave. & Indian School	2006	55,000
3	Scottsdale Road & Shea	2006	54,000
3	24th Street and Baseline	2006	54,000
4	Olive and 17th Ave.	2006	53,000
5	Scottsdale Road & Cactus	2006	50,000
5	Cactus and 35th Ave.	2006	50,000
6	24th Street and Camelback	2006	48,000
7	Indian School & 24th Street	2006	46,000
8	Camelback and 32nd Street	2006	45,000
9	Priest and Warner	2006	44,000

*Vehicles entering intersections

Figure 7-9 below shows the MAP 2004 Average Weekday traffic study results. Data was collected in 2002 and 2003. Traffic volumes were derived from MAG, city, county, and state traffic recording devices. Most volumes were collected on a typical weekday, such as Tuesday, Wednesday, and Thursday. Interestingly, the data collected reflected an increased volume of traffic due to population growth, but there was only a slight variation in the busiest intersections and streets from the previous study in 2000.

The data collected from the study is reflected in Table 7-3 and Table 7-4.

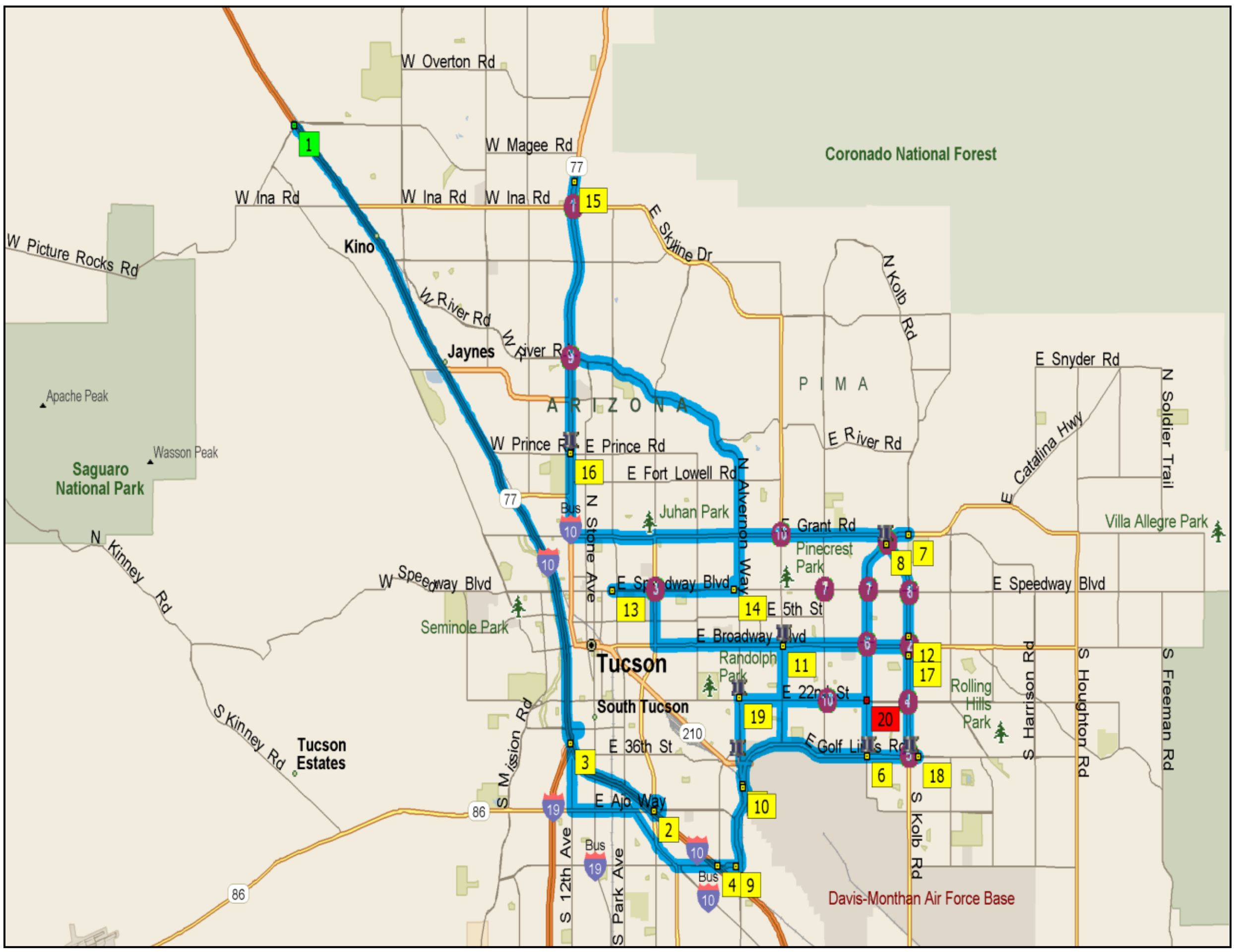

Figure 7-9: Tucson's Busiest Intersections and Streets

Table 7-3 - Tucson's Busiest Intersections (Source: PAG)

Rank On Map	Intersection	Date Collected	Daily Traffic*
1	Oracle & Ina	2006	150,000
2	Broadway & Kolb	2006	100,000
3	Speedway & Campbell	2006	98,000
4	22nd & Kolb	2006	96,000
4	Grant/Kolb & Tanque Verde	2006	96,000
5	Golf Links & Kolb	2006	94,000
6	Broadway and Wilmot	2006	92,000
7	Speedway & Craycroft	2006	91,000
7	Speedway & Wilmot	2006	91,000
8	Speedway & Kolb	2006	88,000
9	Oracle & River	2006	87,000
10	22nd & Craycroft	2006	86,000
10	Grant & Swan	2006	86,000

Table 7-4 - Tucson's Busiest Streets (Source: PAG)

On Map	Street	Section of Street	Average Daily Traffic	Maximum Daily Traffic
1 - 2	I-10	Ajo Way to Cortaro Road	130,000	169,000
3 - 4	I-19	I-10 to Irvington Road	83,000	96,000
5 - 6	Golf Links Road	Wilmot Road to Alvernon	61,000	75,000
7 - 8	Tanque Verde Road	Grant Road to Camino Pio	56,000	60,000
9 - 10	Alvernon Road	Golf Links Road to Irvington	55,000	63,000
11 - 12	Broadway Blvd.	Swan Road to Kolb Road	55,000	55,000
13 - 14	Speedway Blvd.	1st Ave. to Alvernon Way	53,000	56,000
15 - 16	Oracle	Prince Road to 1st Ave.	52,000	59,000
17 - 18	Kolb Road	Broadway Blvd. to Golf Links	52,000	54,000
19 - 20	22nd Street	Alvernon Way to Wilmot Rd.	52,000	52,000

7.8 Summary

Figure 7-2 and Figure 7-3 show the best current representation for the expected growth and densities of publicly available EVSE by 2020. 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, as well as develop demand response actions as the industry matures.

8 Appendix A – EV and EVSE Sales Projections

As noted in the introduction to Section 3, projections of EV penetration into the market are difficult to obtain. The vehicle manufacturers are not releasing their information to the public, other than perhaps the next year's forecast. Public acceptance is still a big question that can partly be resolved by the infrastructure, but public policy and incentives will go a long way to promote or detract from that acceptance. Nevertheless, there are several projections worthy of note.

8.1 National EV Projections

8.1.1 Electric Power Research Institute

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

The IWC recently completed a presentation on the effects of loading on the utility grid, presenting the EV penetration shown in Figure 8-1. This projection would provide annual sales of EVs in 2020 at about 560,000 vehicles and total EVs on the road of about 2.5 million cars.

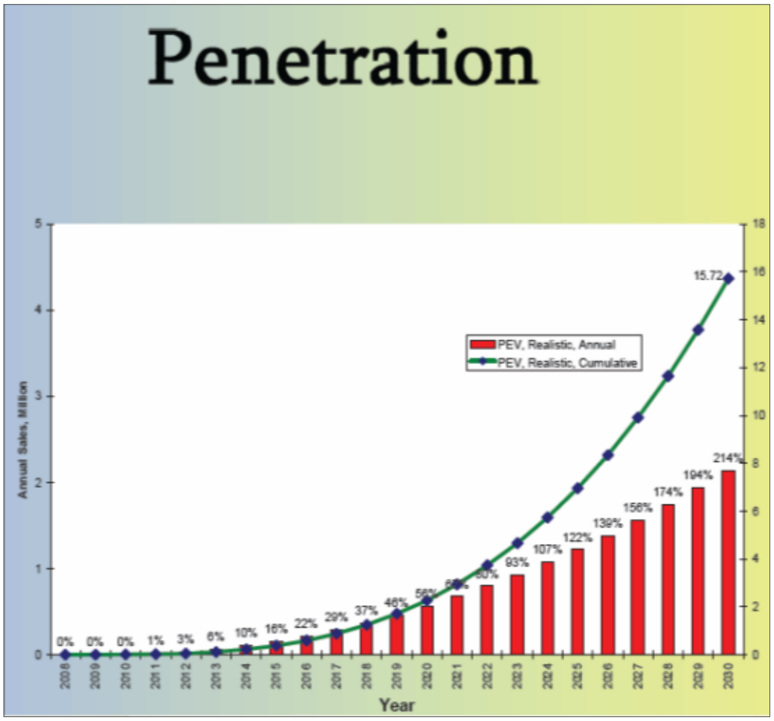

Figure 8-1: IWC Realistic EV Penetration[19]

8.1.2 Credit Suisse

Credit Suisse made the following statement:

> "Electric vehicles offer one of the fastest growth stories over the next twenty years. We expect automotive sales of electric vehicles to rise to over $400 billion by 2030, with batteries rising to over $100 billion and incremental charging infrastructure spending of at least $170 billion. We believe that 1.1% of global vehicle sales will be electric by 2015, driven by more than $15 billion in subsidies. That number could climb to 7.9% by 2030; hybrid electric vehicles could reach 5.9% by 2030 from 0.6% today. Nearly every auto manufacturer has plans to develop electric vehicles, with many models launching in 2010.
>
> While we do not attempt to forecast specific HEV, PHEV, and EV sales by manufacturer, we do provide a framework that presents a hypothetical scenario for adoption rates. There are far too many moving parts to arrive at a specific forecast, as gas prices, fuel taxes, biofuel technologies, battery costs, consumer preferences, government subsidies, and policy mandates all impact adoption rates. That said, our model forecasts a potential adoption rate for PHEVs and EVs based on an economic framework."[20]

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

[20] ibid

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

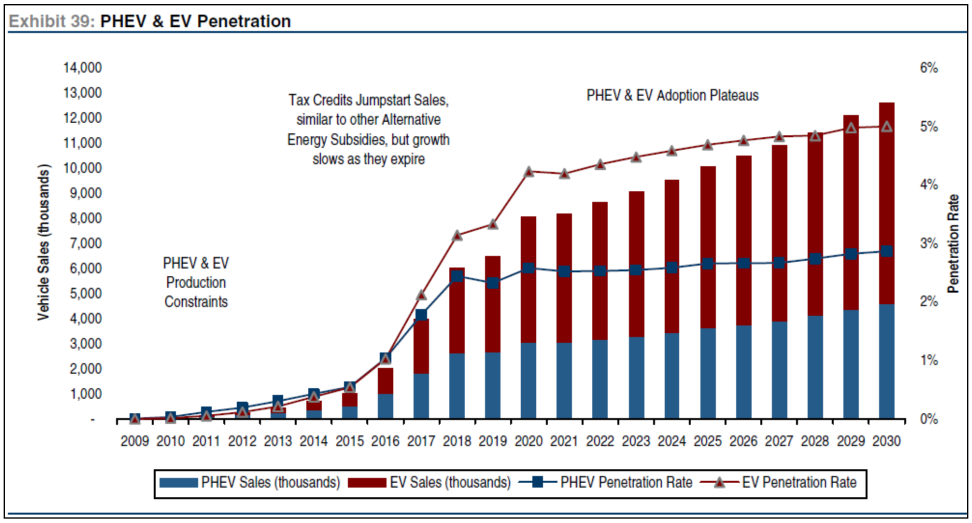

Figure 8-2: PHEV & EV Penetration[21]

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

8.1.3 Morgan Stanley

Morgan Stanley made the following statement:

> We believe PHEVs will gain gradual acceptance with consumers and capture an increasingly larger share of HEV sales and total sales between 2010 and 2012. We see PHEV sales of a few thousand units upon launch in 2010, growing to 100K units in 2012 and 250K units in 2015. PHEV penetration will be driven by regular hybrids adding on plug-in capability.[22]

[21] ibid

[22] Morgan Stanley Research, Autos & Auto Related, March 11, 2008

Morgan Stanley US PHEV Demand Forecast

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

Source: Morgan Stanley Research

Figure 8-3: PHEV Demand Forecast[23]

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

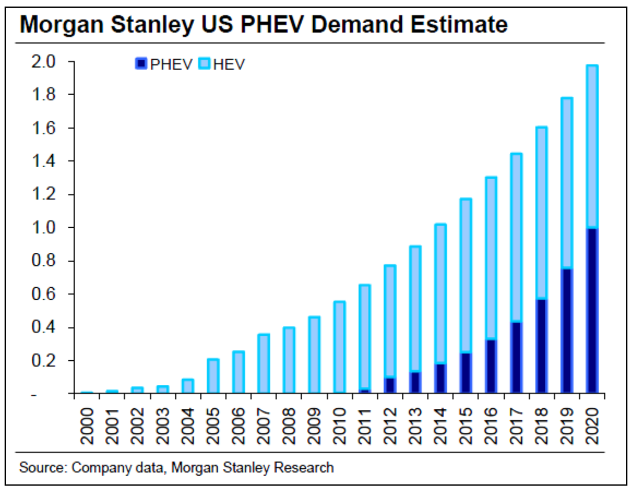

Figure 8-4: PHEV & EV Penetration[24]

8.1.4 Deloitte

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

[23] ibid

[24] ibid

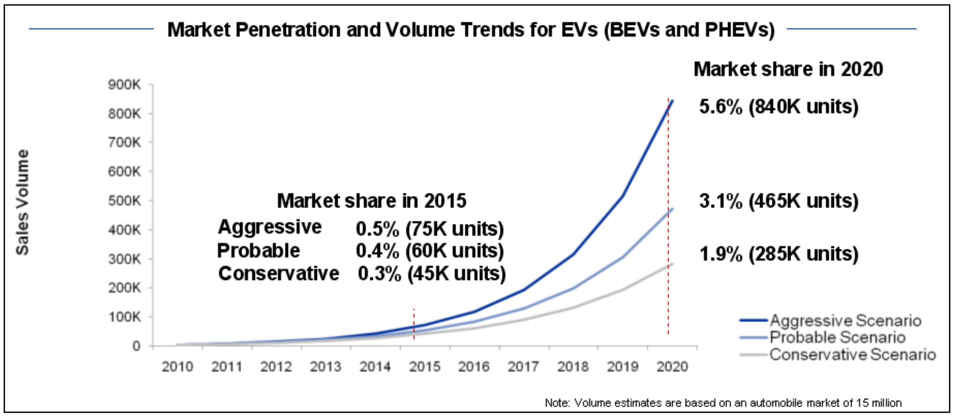

Figure 8-5: Market Penetration and Volume Trends[25]

8.1.5 Lazard Capital Markets

Lazard Capital Markets made the following statement:

> "We also believe that the launch of the Nissan LEAF as part of the ECOtality charging infrastructure build-out will facilitate additional customer sales, due to increased customer range potential and convenience afforded by a network of charging stations.
>
> In the US market, we assume that EV sales (PHEV + EV) reach ~ 400,000 units or 2.8% of the total market in 2015, and close to 1.1M units or 7.4% of the total market in 2020."[26]

Exhibit 17. US Battery Opportunity

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

Figure 8-6: US EV Sales[27]

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

[26] Lazard Capital Markets, *Alternative Energy and Infrastructure*, March 2010

[27] ibid

8.1.6 Deutsche Bank

Deutsche Bank made the following statement:

> "Automotive engineers are recognizing that it may not be possible to meet the onerous fuel efficiency targets required of them through upgrades to conventional powertrains and drive-trains. A growing number of industry executives predict that increased levels of electrification will be required.
>
> We believe that rising fuel prices and regulatory challenges are likely to increase the electrification of the automobile – sharply. There's another major influence here – advances in battery technology. High energy, cost effective, long lasting, and abuse tolerant batteries will be the key technical enablers for this shift, and there have been recent breakthroughs in meeting these requirements.
>
> We find electric vehicles destined for much more growth than is widely perceived. This includes hybrid electric vehicles, plug-in hybrid electric vehicles, and even fully electric vehicles.
>
> - In the U.S. alone, 13 hybrid electric vehicle models were available in 2007, 17 are expected by the end of 2008, and at least 75 will be available within by 2011. NHTSA's April 2008 report on proposed Corporate Average Fuel Economy Standards projected that hybrid vehicles could rise to 20% of the U.S. market by 2015, from just 2% of the market in 2007. Global Insight projects 47% hybridization of the U.S. market by 2020."[28]

8.1.7 Source 1 Research

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

> "The era of fossil fuels dominating transportation is coming to an end -- it's just a matter of when. Electric vehicles, including either plug-in hybrid electric vehicles (PHEVs) or range extended vehicles, and all-electric vehicles (EVs), also known as battery electric vehicles (BEVs) – are now the most likely candidates to someday overtake internal combustion engine (ICE) vehicles in total sales.
>
> In addition to greenhouse gas reductions, the inexpensive cost per mile of driving with electrified transportation will drive consumer interest in EVs. In the U.S., EVs will cost approximately 75 cents per gasoline gallon equivalent to drive on electric power, a figure that could decrease by a few cents depending on advancements in battery technology.
>
> The price of gasoline is expected to rise by approximately 65% between 2009 and 2015, while the price of electricity is likely to remain stable. This widening gap in the cost of vehicle locomotion will sustain consumer interest in EVs and encourage the expansion of charging stations so that drivers can operate on electric power as much as possible.

[28] Deutsche Bank, *Electric Cars: Plugged In*, 9 June 2008

Should gasoline surpass $4.00 per gallon for a sustained period of time, demand for EVs could increase dramatically, which would similarly escalate the investment in charging stations."[29]

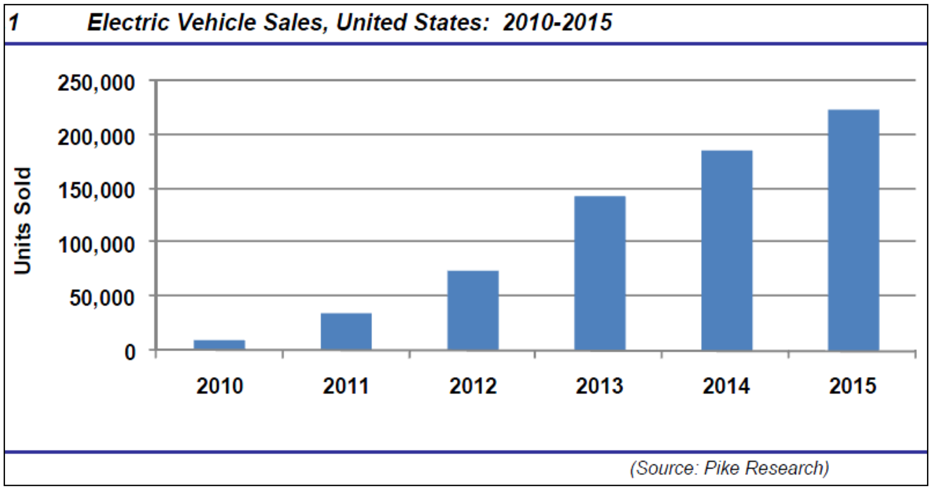

Figure 8-7: Electric Vehicle Sales, United States[30]

8.1.8 All EV Projections

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 8-8. ECOtality has also conducted a study of EV penetration, for which the results are also shown in Figure 8-8, along with the other penetration forecasts described in Appendix A.

[29] Source 1 Research, *Electric Vehicles on the Grid*, Q2, 2009

[30] ibid

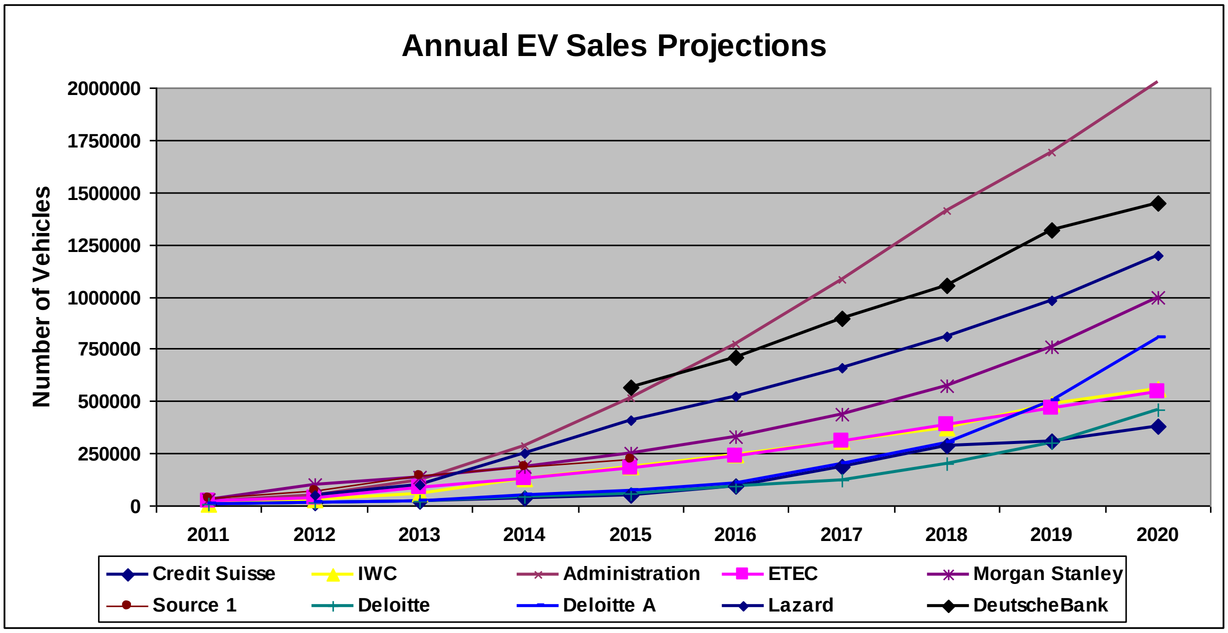

Figure 8-8: Annual EV Sales Projections in the United States

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.

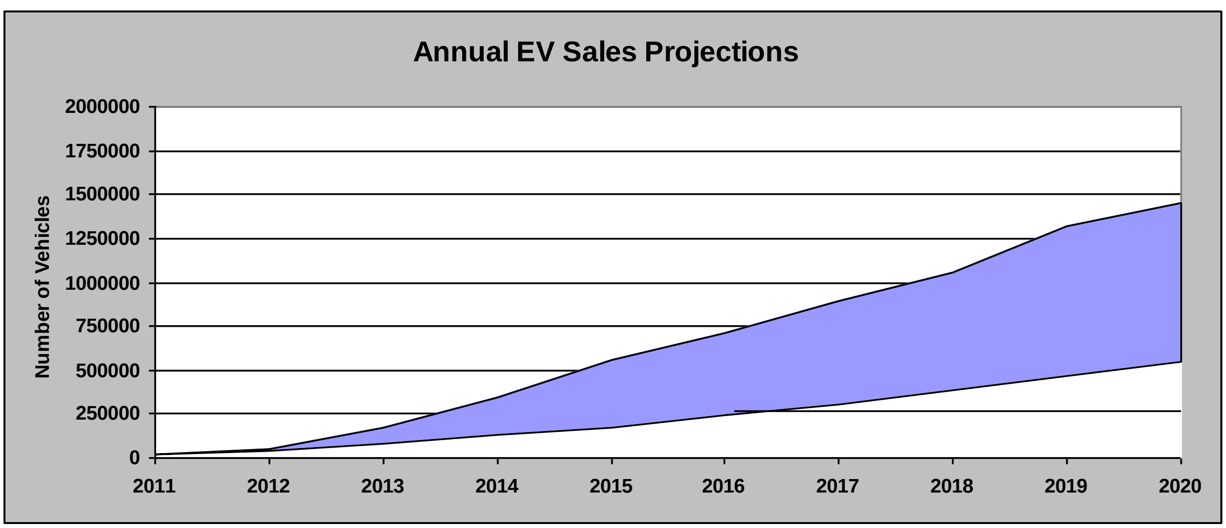

Figure 8-9: Range of Likely Annual EV Sales in the United States

ECOtality 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 8-10 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.

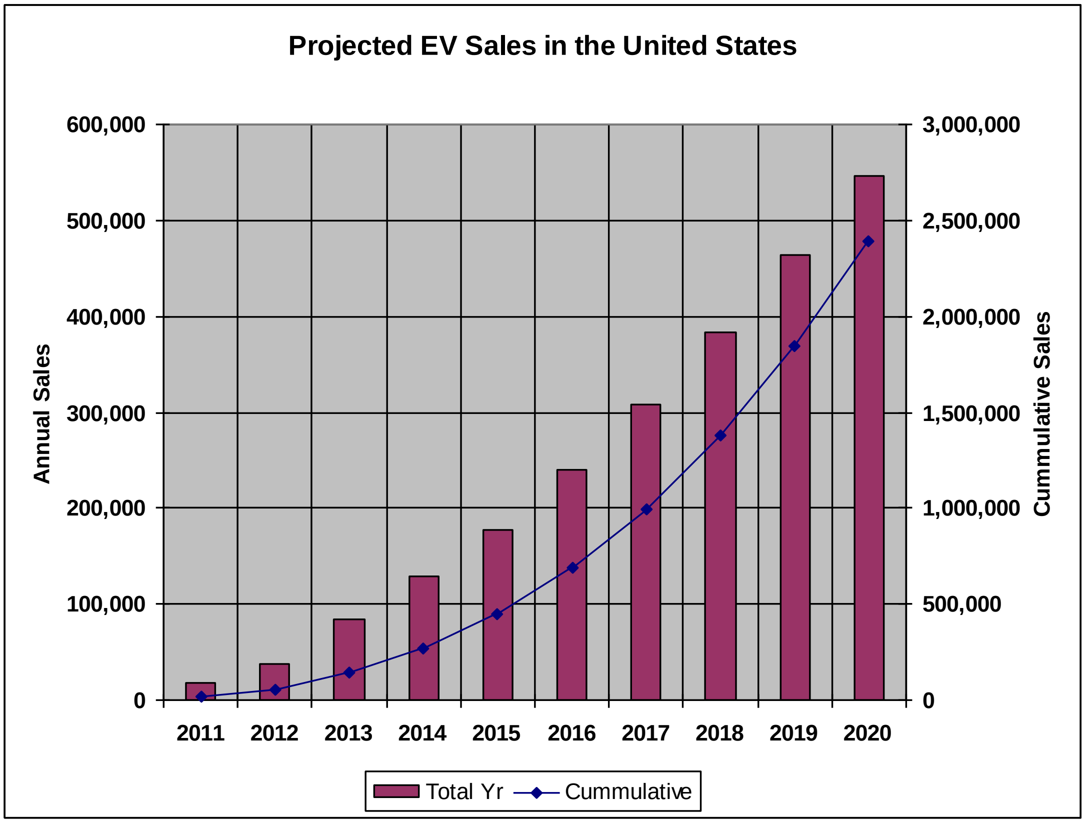

Figure 8-10: Projected EV Sales in the United States

8.2 Level 2 EVSE National Sales Projections

ECOtality's methodology for projecting Level 2 EVSE deployment over the next 10 years focuses on four major factors: geographic coverage, destination planning, refueling stations, and rich infrastructure. These factors are summarized below.

- **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.

Three zones of increasing EVSE density are projected, with the city center or specific destination complex having the highest density of EVSE. Total projected EVSE required providing 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 area.

- **Destination Planning**
  It was shown in the National Household Travel Survey that a significant number of trips for personal reasons to various destinations occur every day of the week. For destination planning, the metropolitan area is canvassed to determine the number of potential destinations and the number of EVSE that would be installed at each venue. The number of destination EVSE grows with the demand created by the introduction of EVs.

- **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.

- **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-populated 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.

Figure 8-10 illustrated the minimum expected EV sales in the United States. With 3.6% of that expected to be fleet vehicles, Table 8-1 provides the cumulative calculated number of EVSE installations to be deployed in residential, fleet, and public/commercial locations based upon the ECOtality methodology. This infrastructure is then identified as a percentage of total 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%. ECOtality's four-factor methodology was used to project the publicly available EVSE, as shown in Table 8-1.

Table 8-1 - Projected Cumulative EVSE Sales 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	46,921	957,364	1,808,354	2,812,639	153%
2020	86,036	2,303,860	57,644	1,151,930	2,349,937	3,559,511	149%

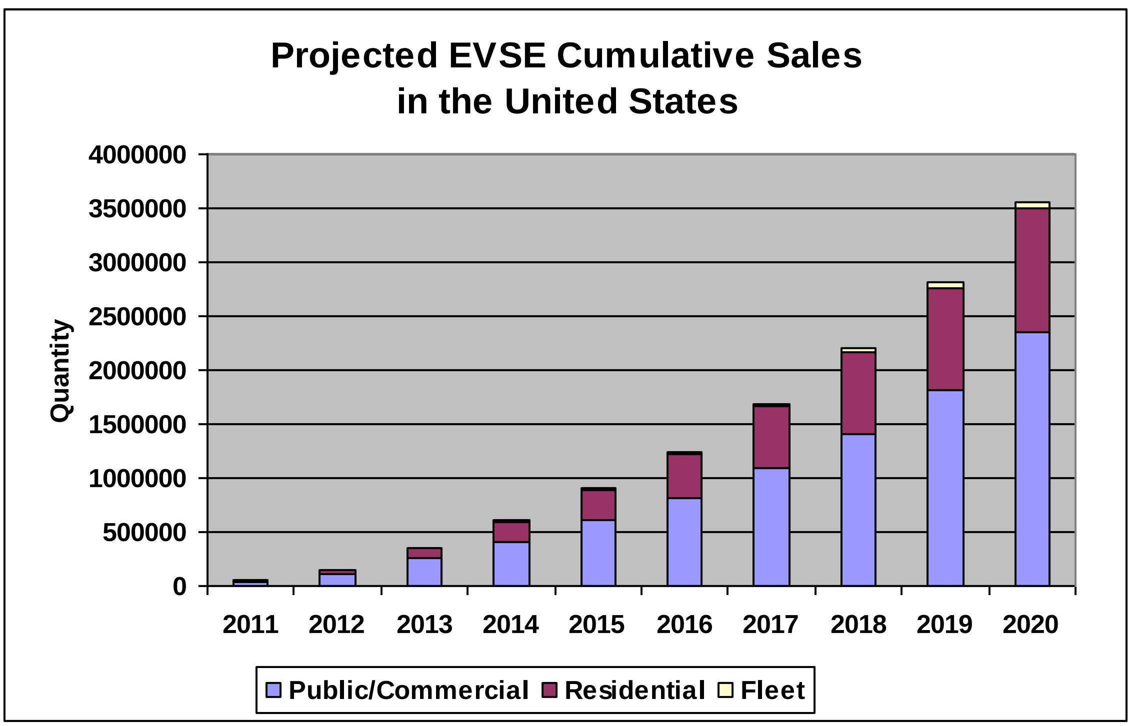

Figure 8-11: Cumulative EVSE Sales in the United States

8.3 DC Fast Charge (DCFC) EVSE National Sales Projections

Tokyo Electric Power Company (TEPCO) conducted a study of EV infrastructure in Tokyo and found significant reduction of range anxiety when fast chargers were inserted in the EVSE infrastructure. Their study placed 10 DCFCs in an 8 km by 15 km (approximately 50 square mile) area. 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 DCFC per five-square-mile area or perhaps one DCFC for every 90 Level 2 EVSE.

DCFCs will also be deployed along transportation corridors. The usage of these range extending chargers is unknown since it will depend upon the driver's tolerance for more frequent stops in travel than is currently experienced by internal combustion vehicles. Once established along the corridor, the quantities of ports will be expanded as demand grows.

A rich infrastructure may in the early years include more DCFCs but for lack of other data, it is assumed that the ratio will remain the one DCFC for every 90 Level 2 EVSE.

Table 8-2 - Projected DCFC Sales in the United States

Year	Annual Level 2 EVSE	Cumulative Level 2 EVSE	Annual DCFC	Cumulative DCFC
2011	55,340	55,340	620	620
2012	101,260	156,600	1,120	1,740
2013	203,400	360,000	2,260	4,000
2014	245,250	605,250	2,720	6,720
2015	303,950	909,200	3,380	10,100
2016	340,240	1,249,440	3,780	13,880
2017	444,600	1,694,040	4,940	18,820
2018	501,111	2,195,040	5,570	24,390
2019	617,600	2,812,640	6,860	31,250
2020	746,870	3,559,510	8,300	39,550

9 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.

9.1 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. This data feed also can tie into the tracking and scheduling of the EVSE installations. Having this information allows utilities to proactively manage the infrastructure rebuilding that will be needed in the worst-prepared areas. Next, the utilities need a method to defer and spread 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 the customers to tailor their individual recharging needs in an optimal "networked 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.

9.2 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. Appendix B Figure 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 to 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.

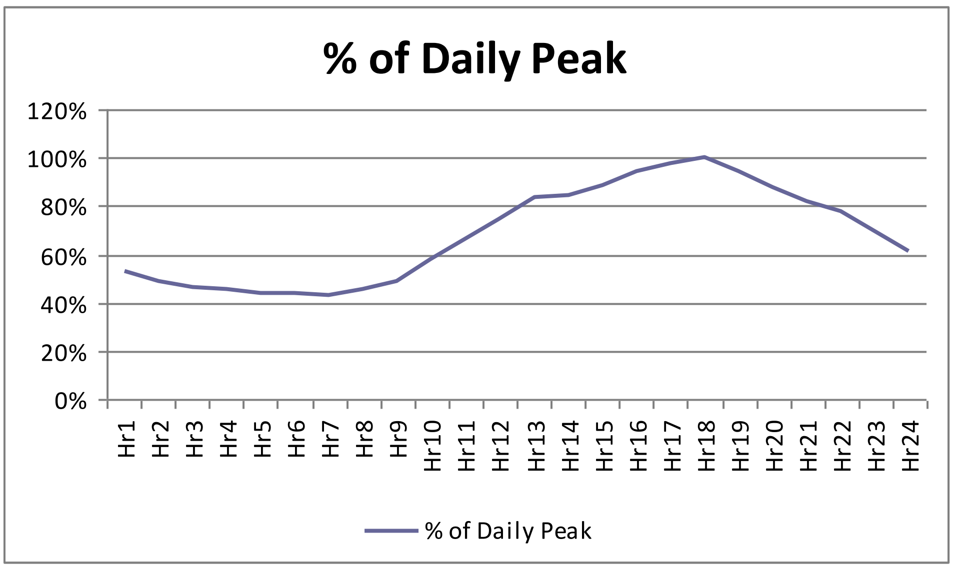

Figure 9-1- Typical Daily Load Profile

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 to allow 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 rates incentives to consent to this drop. Finally, the large electrical storage capacity of the EV battery may be utilized in vehicle to grid 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.

9.3 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.

9.4 Carbon Capture Strategies

Climate change science has precipitated a strong bias toward radical government action (tax or Cap and Trade) to curtail carbon dioxide emissions. While this is a raging debate that incorporates science, technology, health, economics, and politics, there is little doubt that government intervention in the utility, industrial, and transportation sectors is imminent. What this means in an age of electric transportation is that utilities have both a concern: higher power demand for charging the EV requires more generating resources that could produce more carbon against a benefit to claim: EVs displace even higher levels of carbon emission from internal combustion engines.

Legislation will be required to avoid having the utilities accept the penalties of the former without credit for the latter.

9.5 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 finding, 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.

10 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 EVSE infrastructure. 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.

10.1 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, integrating smart grid technology, and diversifying 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), 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 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.
Establish 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.

10.2 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.

10.3 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 is 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.