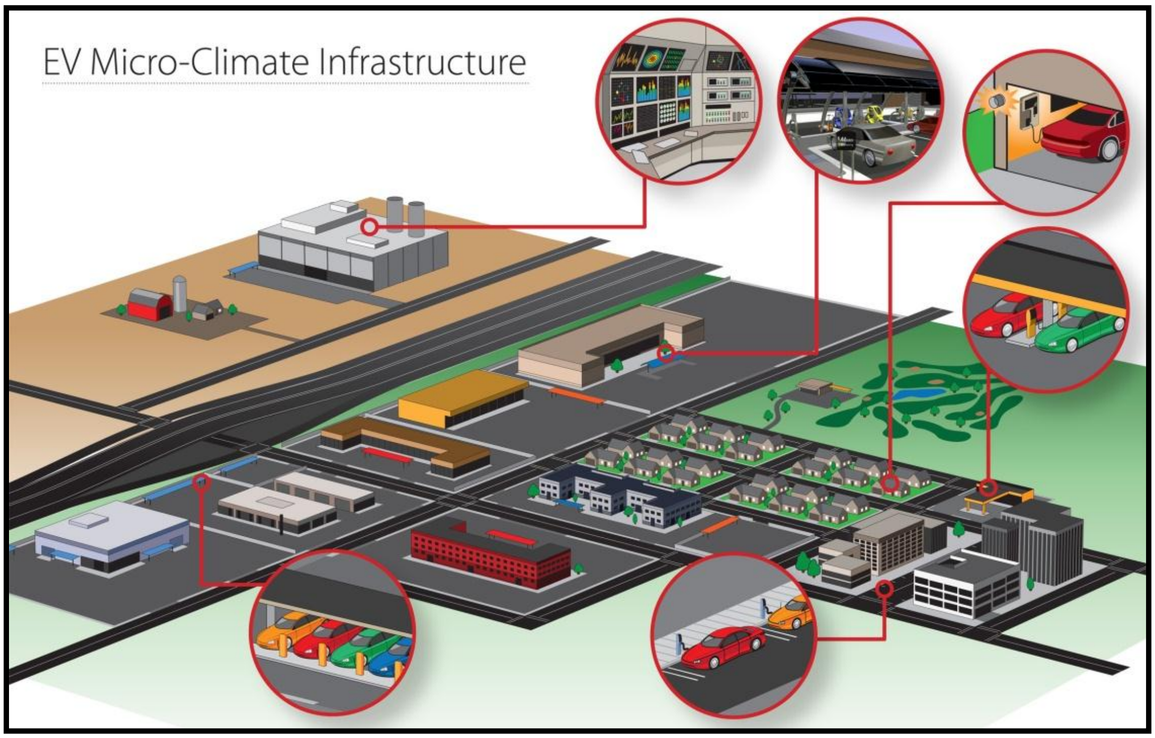
Long-Range
EV Charging Infrastructure Plan
for
Western Oregon



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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.
GIS	Geographic Information Systems
HAN	Home Area Network
ICE	Internal combustion engine.
ISO	Independent System Operators
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
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.

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

POS Point of Sale

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.

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.

VMT Miles by Vehicle

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 Infrastructure Plan for Western Oregon* 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 Western Oregon area by the year 2020. The projected EV population will require the EV infrastructure to support and encourage further increases in market share. This Plan seeks to uncover the quantities and locations of 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 Western Oregon to achieve the region's long-range goals. It cannot by itself complete the necessary infrastructure, but the long-range plan will provide the guidance for planning this infrastructure growth and focusing on the near term for locating EV Project resources.

This long-range plan starts in Section 2 by looking at driver behavior as revealed by national surveys. Information specific to Western Oregon 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.

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 battery. Likewise, the availability of charging infrastructure is tied 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.

Section 5 projects the expansion of EV and EVSE use in Western Oregon based on the projected national growth of EV and EVSE.

The planning for the DCFC is quite different from the balance of the infrastructure but is integral to it. Section 6 is devoted to 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 Western Oregon. Input from local stakeholders and prior work on these topics provides the support for the plan. By understanding the characteristics of EVs and the capabilities of the charging systems along with driver demographics, an effective plan for wise deployment of available resources is possible. That is the goal of this document.

2 Driver Behavior – National Household Travel Survey

The National Household Travel Survey (NHTS) serves as the nation's inventory of daily travel. Data 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 travel from home to destination and back home, the minimum response would be about two. (Note, some may have started away from home and traveled home, only resulting in one trip.) Overall, the total vehicle miles traveled on a daily basis appears to have leveled off since 1995.

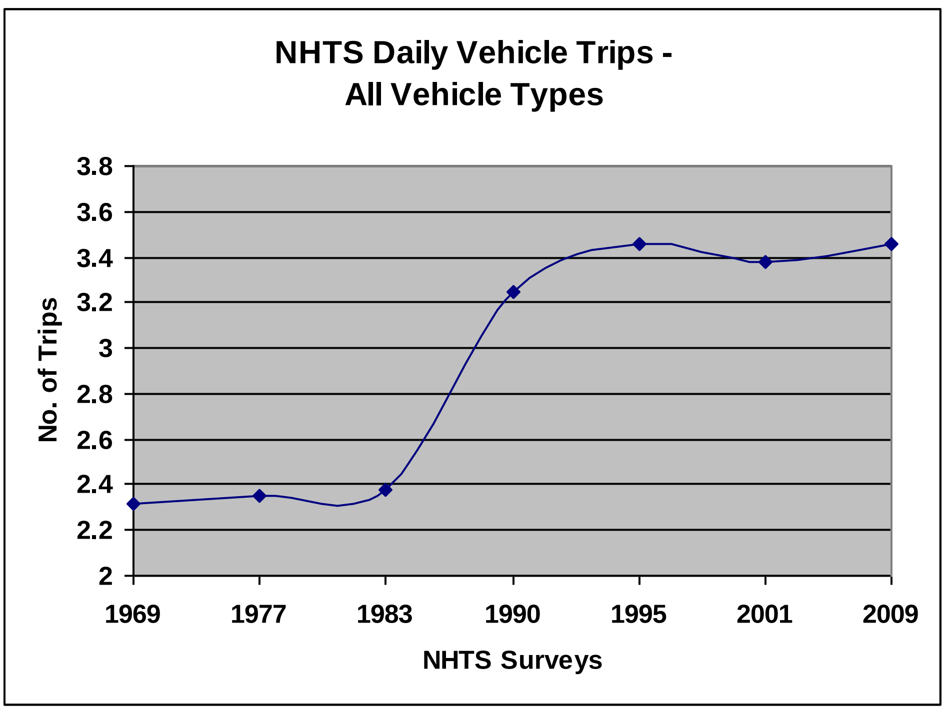

Figure 2-1: Average Daily Vehicle Trips for All Types of Vehicles

From NHTS Surveys Conducted Since 1969

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

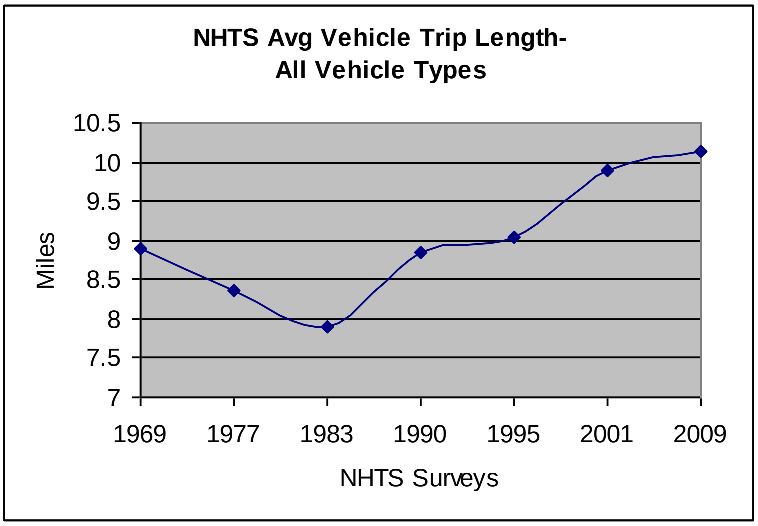

Figure 2-2: Average Vehicle Trip Lengths for All Types of Vehicles

From NHTS Surveys Conducted Since 1969

Combining these two averages indicates that average daily travel is approximately 35 miles, well within the range of near-term EVs. The daily travel required by individuals will be a factor in their decision to obtain an EV. Because these are average travel lengths and numbers of trips, many can be longer. Publicly-available charging stations 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 the trips home, the single most common purpose of the car is to go shopping or run errands, followed by work and social activities. When this information is combined with that of the average number of trips per day, it shows that most drivers make several stops per day. Driving to and from work also generally involves a side trip and stops along the way. Errands may also include a stop for school. Destinations for stops become important in the evaluation of charge infrastructure developed later. Intuition might suggest that charging infrastructure at home and work would be sufficient, but these data indicate otherwise.

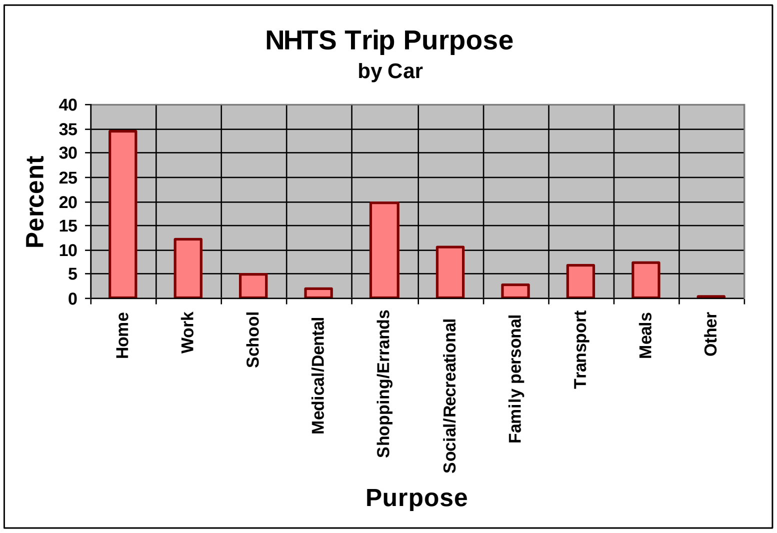

Figure 2-3: Percentage of Daily Car Trips by Purpose – NHTS 2009

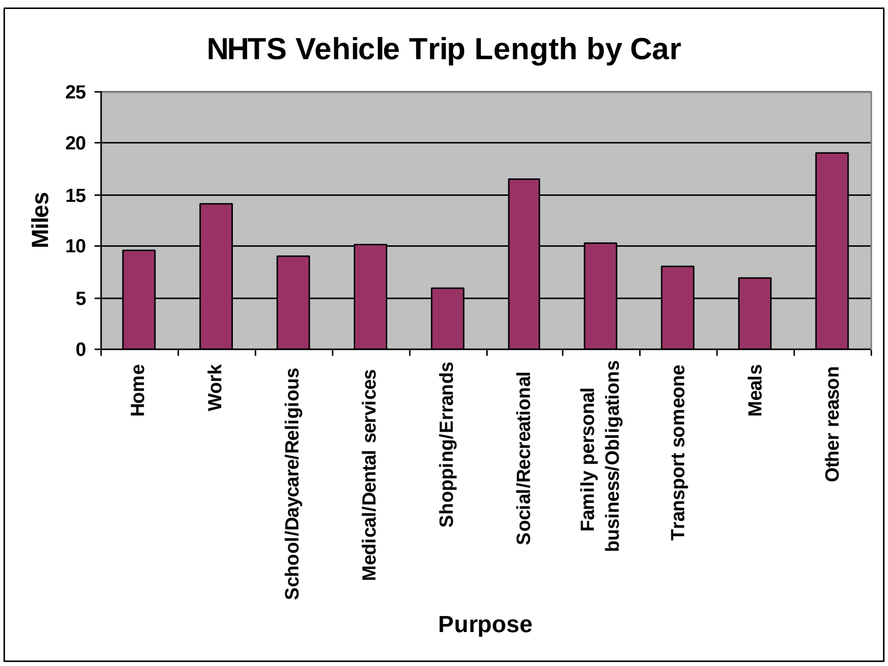

Figure 2-4: Vehicle Trip Length by Car by Purpose – NHTS 2009

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

Figure 2-5 identifies the two-vehicle household as the most common, with an equal percentage of households having one or three vehicles. As will be seen later, it is expected that households that will own an EV likely will have two or more vehicles. Approximately 80% of the overall population of the United States would fit that profile.

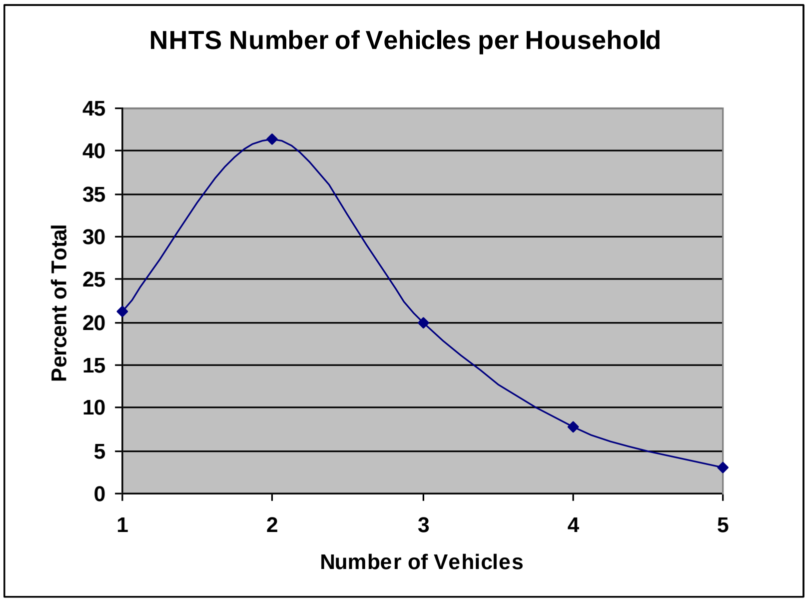

Figure 2-5: Numbers of Vehicles per Household – NHTS 2009

2.4 Other Factors

A significant percentage of vehicle traffic during peak travel times of day is not work-related travel. As seen in Figure 2-4, shopping and errands hold a greater percentage of car trips than work. While the 2009 data are not available specifically on this topic, this is similar to that reported in the 2001 data set.

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]

[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.

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 off children at school or to stop at the grocery store on the way home from work. Real-life examples show that trip chaining is often a response to the pressures of work and home. But the data also show that some of the growth in trip chaining has been to grab a coffee or meal (the “Starbucks effect”), activities that historically were done at home and did not generate a trip.

The overall growth in travel for shopping, family errands, and social and recreational purposes reflects the busy lives and rising affluence of the traveling public. The growth in non-work travel not only is adding to the peak periods, but also is expanding congested conditions into the shoulders of the peak and the midday. See Figure 2-6.

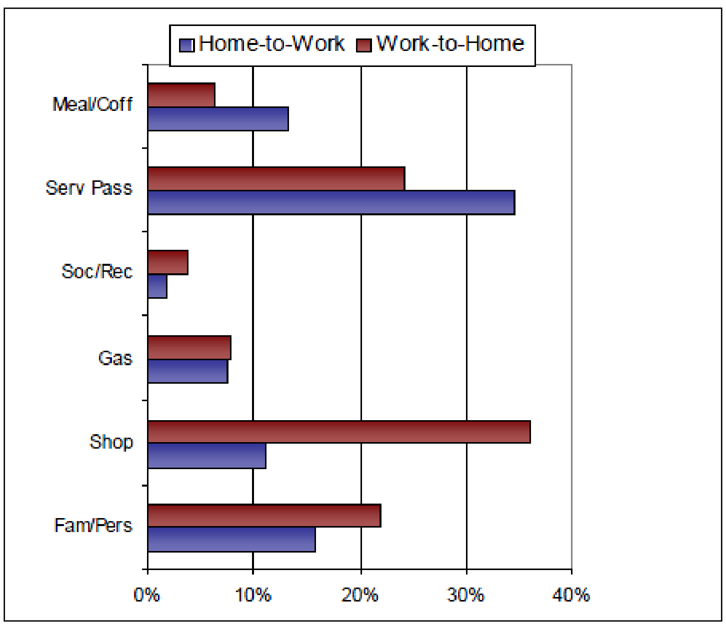

Figure 2-6: Non-Work Trips at Peak Periods – NHTS 2001[2]

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.

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[2] ibid

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 Oregon Travel Survey

Because of the metropolitan area's land use density and the fact that fewer improvements are being added to major road systems, the Portland area has congested road conditions similar to much larger urban areas like Seattle. From 1997 to 2007, congestion delay in the Portland area increased by about 4% per year.[3]

Oregonians rely on transit and non-motorized transportation more than most other places in the nation. Still, most drive alone or share a ride in an automobile to make a trip. In year 2000, 73% of Willamette Valley residents drove alone and about 12% carpooled. Oregon residents of higher-density neighborhoods travel by automobile 25% less than the national average.

Figure 2-11 below, which was prepared using ODOT 2000 census journey-to-work data[4], shows that the majority of households in Oregon travel under 50 miles per day and 80% of households travel less than 80 miles per day – within the range of the early EVs.

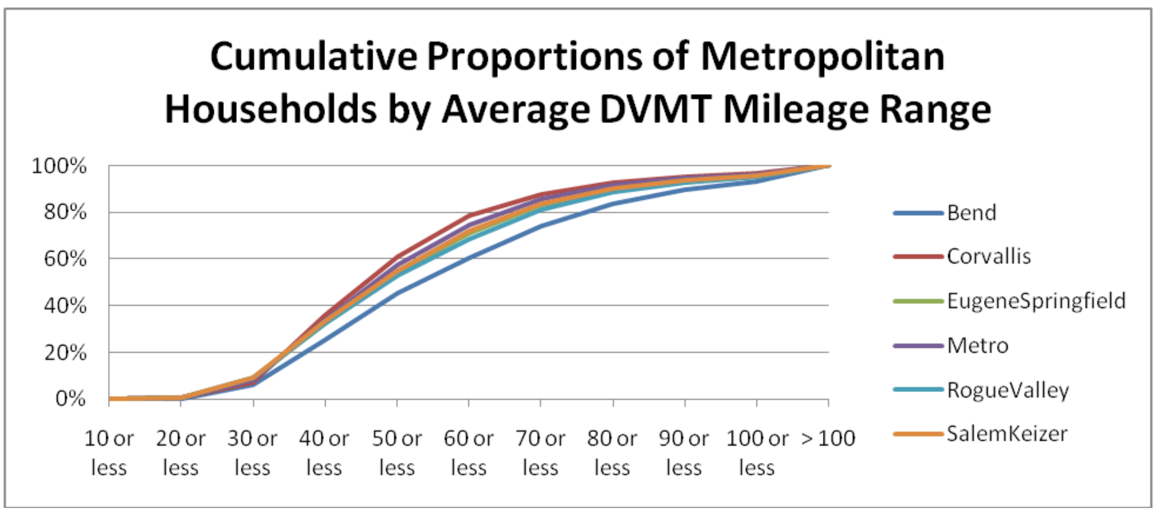

Figure 2-7: Metropolitan Area Mileage Range

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[3] Gregor, Brian; ODOT, *Analysis of Congestion and Travel Trends Reported in the 2009 Urban Mobility Study Report*, July 2009

[4] Alternative Fuel Infrastructure Working Group, *Report of the Alternative Fuel Infrastructure Working Group*, Oregon, January 2010

In 2002, Oregonians each traveled an annual average of 9,618 miles by vehicle (VMT). That calculates to 29 VMT per person per day. Portland-Vancouver numbers are lower, with daily distances of approximately 19 to 20 per capita VMT over the period of 2003-2004[5]. However, increased population has led to more Portland metropolitan area commuters spending 30 or more minutes traveling one way to work. For that period, average daily traffic for major roadways also increased.

According to a study of Portland travel characteristics, simple commutes to work (from home to work and then returning home) comprise about a quarter of all trips traveled. Other simple trips taken from the home include those to school (16%), to shopping (10%), social or recreational (9%), and personal business (9%). Most of the complex chaining of trip purposes occurs for non-work trips (18%) – but over 6% is conducted during the work commute[6]. Round-trip travel distance patterns vary across the Willamette Valley and Portland area, as shown in Table 2-1.[7]

Table 2-1 Average Round Trip Travel Distance of Workers Traveling to MPO

Workplace Metropolitan Planning Organization (MPO)	Workers Residing Inside MPO (Average Miles)	Workers Residing Outside MPO (Average Miles)	All Workers (Average Miles)
Eugene/Springfield	10	42	18
Corvallis	7	40	19
Portland Metro	13	45	18
Salem/Keizer	8	42	17

[5] Metro, *A Profile of Regional Trends and Travel Characteristics in the Portland Metropolitan Region February 2007*

[6] James G. Strathman, Kenneth J Dueker, and Judy S. Davis; *Effects of household structure and selected travel characteristics on trip chaining.* Transportation 21:23-45 1994; Kluwer Academic Publishers. Center for Urban Studies, School of Urban and Public Affairs, Portland State University, Portland, OR 97207, USA

[7] Brian Gregor, ODOT, *Supplementary Information for HB 2186 MPO Greenhouse Gas Emissions Task Meeting #2 Related to Briefing on Greenhouse Gas Emissions in the Oregon Transportation Sector*, November 2009

2.6 Summary

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

3 EV Sales Projections in the United States

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. Note that the discussion focuses on sales of vehicles with the full speed and safety characteristics necessary for modern highways – not low-speed electric vehicles, which also have a role in future urban mobility.

3.1 EV Types

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

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

3.2 EV Batteries

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

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

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

Table 3-1: EV Charge Times

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

Note: Power delivered to the battery is calculated as follows: 120VAC x 12Amps x.85 eff.; 120VAC x 16Amps x .85 eff.; 240VAC x 32 Amps x.85 eff.; 480VAC x √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	DC Fast 480 VAC, 85 amp 60 kW
10 min	0.8	1.1	2.2	4.3	40
15 min	1.2	1.6	3.3	6.5	>50***
30 min	2.4	3.2	6.6	13	>50***
1 hour	4.8	6.4	13.2	26	>50***

* Vehicle efficiency 4 miles/kWh

** EVSE efficiency assumed at 85%

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

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

3.3 EV Sales Analysis

There is a high degree of uncertainty when projecting sales of conventional automobiles and electric vehicles. Because of the economic downturn, most automotive companies are not publishing forecasts of vehicle sales. Domestic gasoline prices over the next 10 years will serve to drive demand for more efficient vehicles, but projections are not reliable. Past trends cannot be used to predict future sales either, due to the loss in sales volumes through the past few years. Most automotive original equipment manufacturers (OEMs) have announced plans for EVs in the next few years, and the anticipated diverse vehicle inventory and subsequent out-year enhancements are expected to make EVs competitively priced, even if gasoline prices are in the sub-$2 per gallon range. The wide range of vehicle platforms is expected to make EVs attractive for most demographic groups. Several investment firms have made projections for sales of electric vehicles, and these projections provide a range of possible penetration rates. Appendix A provides details of these projected penetration rates. The information is summarized in Section 3.4.

3.3.1 BEV and PHEV

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

The BEV, on the other hand, is a dramatic departure from the ICE vehicles. The consumer will have to be conscious of the vehicle's range and battery capacity, similar to the attention an ICE driver must pay to the fuel gauge. However, as new BEV drivers gain confidence (partly due to the rich EVSE infrastructure) and the vehicle range is extended with higher-capacity batteries, it will become more and more apparent that having two types of technology, battery and ICE, is superfluous. For that reason, many analysts today see the PHEV as a bridge technology.

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

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

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

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

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

Since Reuss is in charge of GM North America sales and marketing, his opinions are likely to play a significant role in the company’s strategy going forward.[8]

3.3.2 Consumers

The Everett Rogers Diffusion[9] Innovations theory suggests that typical market penetration of any product follows a standard distribution curve. Different segments of consumers can be identified on this curve. To clarify this, he defines these terms as part of his overall theory: Product Innovators, Early Adopters, Early Majority, Late Majority, and Laggards.

- The *Product Innovators* are the first to try a new product. Having the newest technology and being first is important to these consumers. They are venturesome and highly educated. Price is not as important as the innovation.
- *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.

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

[9] Diffusion of Innovations (Rogers 1962)

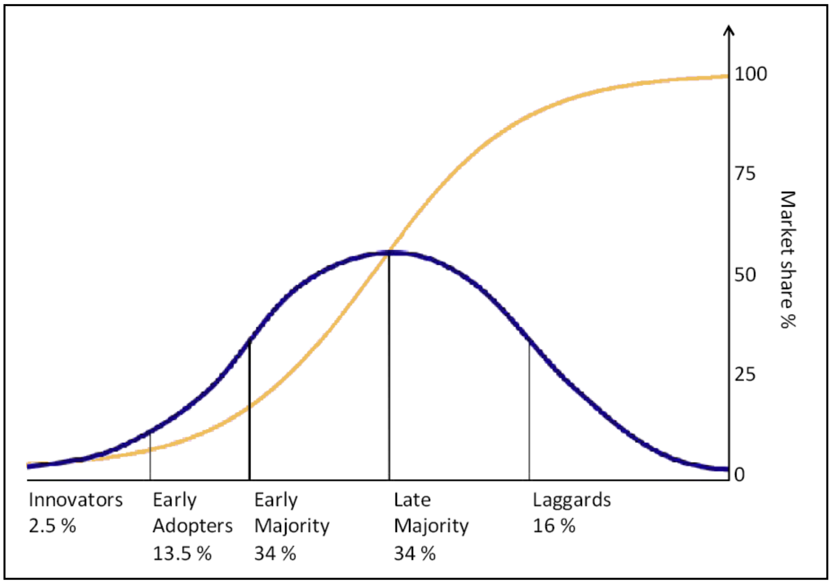

Figure 3-1: The Diffusion of Innovations According to Rogers

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

- Similar to early adopters of hybrids
- Early adoption will be concentrated around southern California, where weather and infrastructure allow for ease of EV ownership.[10]

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.[11]

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.

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

11 ibid

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

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

3.4 EV Sales Projections

As noted in the introduction to this section, projections of EV penetration into the market are difficult to obtain. The vehicle manufacturers are not releasing their information to the public, other than perhaps the next year's forecast. Public acceptance is still a big question that can partly be resolved by the infrastructure, but public policy and incentives will go a long way to promote or detract from that acceptance. Appendix A explores the current projections worthy of note, along with ECOtality NA's projections to develop the sales estimates used here.

ECOtality NA 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 deployment. 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.

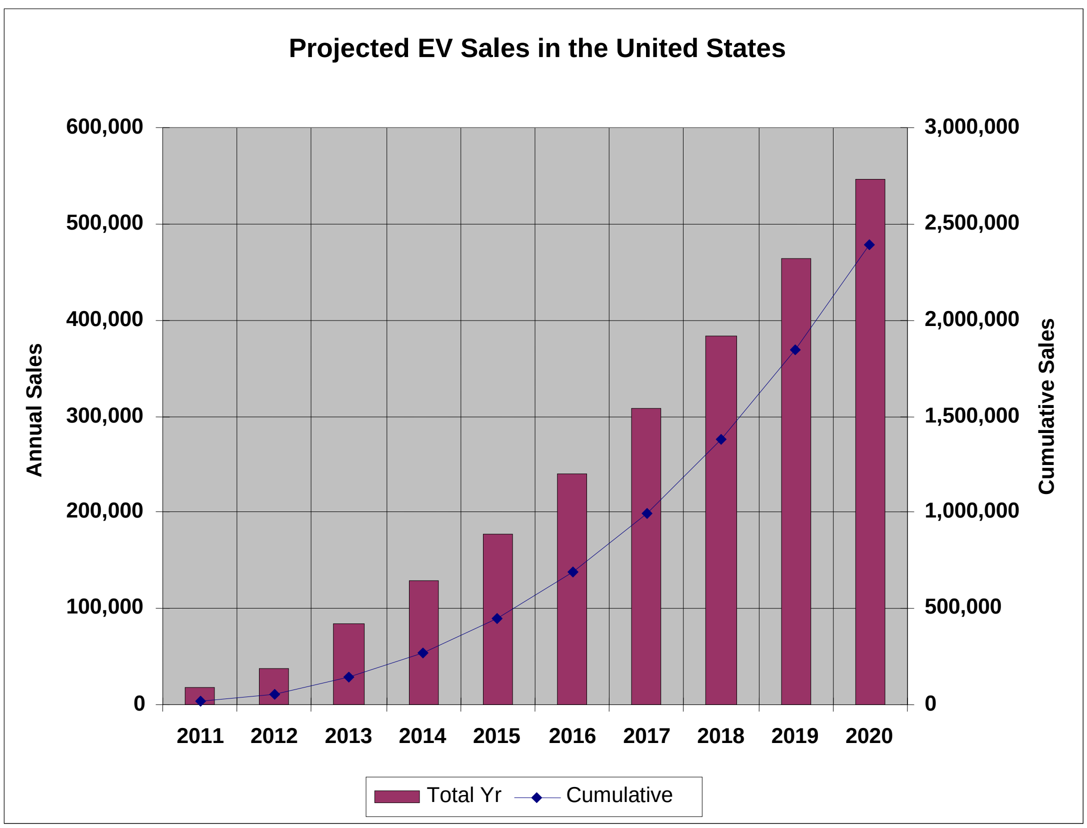

Figure 3-2: Projected EV Sales in the United States

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.[12] 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.

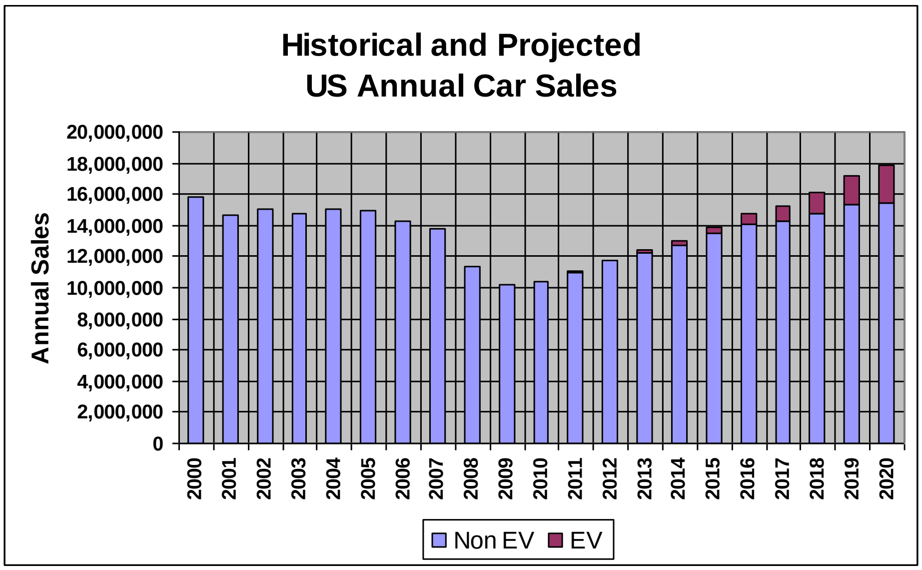

Figure 3-3: US Annual Car Sales

3.6 Fleet Vehicles

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

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

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

Projections of EVs selected as fleet vehicles are generally included in the total EV numbers. The percentage of fleet vehicles is expected to be higher in the early years as governmental agencies, utilities, and other major vehicle purchasers adopt EVs to encourage 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.[13] That accounts for about 3.6% of the total vehicle population at that time.

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

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

4 EVSE Sales Projections in the United States

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

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

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*.[14]

Figure 4-1: J1772 Connector

Figure 4-2: J1772 Inlet (right side)

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

[14] 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.

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 3 has been superseded by more descriptive terms; "DC Fast Charging" is used in this document.

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

Level 2 is generally considered to be the "primary" and "preferred" method for the EVSE for both private and publicly-available facilities, specifying a single-phase branch circuit with typical voltage ratings from 220 – 240 VAC. The J1772 approved connector allows for current as high as 80 amps AC (100 amp rated circuit); however, current amperage levels that high are rare. A more typical rating would be 40 amps AC, which allows a maximum current of 32 amps; or as another example, 20 amps AC, which in turn allows a maximum current of 16 amps. This provides approximately 6.6 kW or 3.3 kW charge power, respectively, with a 240 VAC circuit. See Table 3-1 for typical recharge times at these levels.

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

DC Fast Charging is for commercial and public applications and is intended to perform in a manner similar to a commercial gasoline service station, in that recharge is rapid. Typically, DC Fast Charging would provide a 50% recharge in 10 to 15 minutes. DC Fast Charging typically uses an off-board charger to provide the AC to DC conversion. The vehicle's on-board battery management system controls the off-board charger to deliver DC directly to the battery.

4.1 Level 2 Charging

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

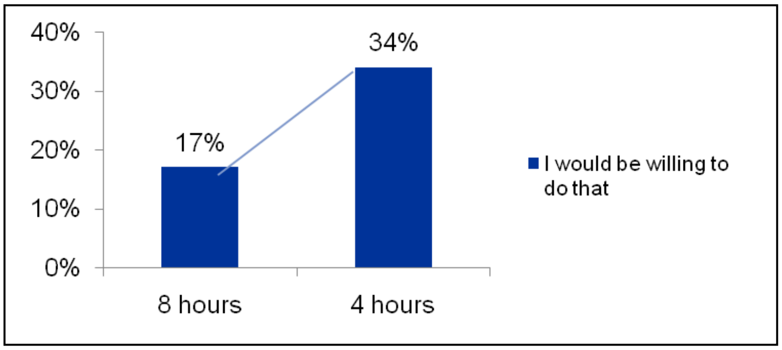
4.1.1 Residential

Electric utilities are tasked with providing sufficient and reliable energy. One of the challenges to be overcome is the uneven nature of daily and seasonal power usage. As demand for electricity varies throughout the day, the utility is required to add or subtract power generators to keep up. It would be more economical for utilities to reduce the peaks and fill in the valleys of this curve. Utilities have various strategies to assist in this goal. One such strategy is to use Time of Use (TOU) rates. For a BEV (and some PHEV owners who choose the utility time of use rates), the preferred method of residential charging will be Level 2 (240VAC/single-phase power) in order to provide the EV owner a reasonable charge time and to also allow the local utility the ability to shift load as necessary while not impacting the customer's desire to obtain a full charge by morning. For other PHEV owners, a dedicated Level 1 circuit may adequately meet the owner's charging needs.

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

Even so, the EV owner will want the convenience of a rapid recharge of their vehicle battery at home, whether the vehicle is a BEV or PHEV. Deloitte research finds that only 17% of consumers are willing to charge from home when it takes eight hours for the recharge. Twice as many found home charging acceptable when the recharge required four hours. Many consumers will desire recharging to occur as fast as refilling the gasoline tank on an internal combustion vehicle, which gets into the range of the DC Fast Charging discussed in Section 6.

Figure 4-3: Preferences for Home Charging Duration[15]



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

Studies show that if all of the EV owners in a single neighborhood were to all set their EVSE to start when the off-peak time starts, the resulting spike could be substantial, which could potentially cause issues for the electric utility. When electric utilities begin to offer demand reduction programs to their customers and seek to balance loads for neighborhoods, new strategies probably will emerge, including rotating the charge times among neighborhoods powered off the same transformer. At the same time, the increasing vehicle battery capacity will require longer recharge times. (See also Appendix B.) EVSE will need to be capable of delivering a recharge in much less than the eight hours available at off-peak times.

In the next few years, incentive programs and consumer demographics will favor more Level 2 home installations. However, a significant number of people live in residences where a home charger may not be feasible – as an example, apartments or older urban neighborhoods with limited off-street parking. It is estimated that by 2020, the percentage of EV drivers with home Level 2 EVSE will be about 50% of all EV adopters.

[15] 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 fleet managers 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 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 EVSE

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

4.1.4 Public EVSE

"Public EVSE" refers to equipment placed on public-owned land that is publicly available. Like residential equipment, EVSE in these locations will focus on Level 2 and Level 1 EVSE will become increasingly irrelevant. These locations will be those where the EV owner is likely to remain 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.[16]

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 roundtrip 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 and not a necessity.

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[16] 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 (POS) interface that provides the ability to collect specific use information for each vehicle connected or to bill the driver directly for each use.

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

4.1.5.4 *How Many Units Should Be Installed?*

There are three possible charging station installation scenarios: dedicated, open, and valet. Providing dedicated Level 2 EVSE for each employee with an EV can quickly become very expensive. Few parking facilities have electrical panels that can handle the load of numerous Level 2 EVSEs 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 will 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 to assure an employee receives a fully-charged vehicle at the end of the day. In addition, several vehicles can be cycled through a Level 2 EVSE.

4.1.5.5 *Electrical Load*

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

4.1.5.6 Undesignated Parking

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

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

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

4.1.6 EVSE Requirements

The essential question raised is this: How many EVSE installations will be required to provide the necessary infrastructure? This should be viewed not only as the necessary but 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)." [17]

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

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

4.2 EVSE Projection Methods

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

4.2.1 Geographic Coverage

Because the cost of owning and operating EVs will become increasingly competitive, the EVs available by 2020 will appeal to a wide demographic. This will require the available infrastructure to expand to cover an entire metropolitan area. Outlying communities can expect to have some local infrastructure. While the highest demand will be at destination venues, additional EVSE will be required in the regions away from the city center, much in the way that gas stations are located. That geographic coverage is likely to be provided by zones that define the appropriate density of EVSE.

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

4.2.2 Destination Planning

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

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

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

5 EV and EVSE Penetrations in Western Oregon

The nationwide penetrations of EVs and EVSE assist in providing projections of EVs and EVSE penetrations for Western Oregon. The early market launch of EVs into Oregon 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 Oregon, with local population behavior taken into consideration. The 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 focuses on the Portland area and Western Oregon. The long-range plan should also consider the major highway systems connecting the Portland area to other major population centers. The I-5 corridor is included within this boundary because of high interest in connecting these cities. DC Fast Charging along the I-5, I-84, and other corridors is discussed in Section 6. The boundary identified is shown in Figure 5-1. Note that this boundary includes remote mountainous regions that will likely not contain EVs. The areas are included to illustrate the generalized boundary.

Figure 5-1: Western Oregon Long-Range EV 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 regional 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 population of EVSE will encourage the general public to accept the EV as an alternative to the internal combustion vehicle, and will enhance the EV owner's experience and dispel "range anxiety" for those who fear running out of battery charge.

5.2.1 Population

According to the Oregon Transportation Plan, about 71 percent of Oregonians live in the Willamette Valley, including metropolitan Portland. Approximately 42 percent of the state's population lives in the Portland metropolitan area alone. The boundary area population in 2007 was 3,580,686, compared to the state of Oregon's total population of 3,725,050.[18] This boundary includes major cities in Oregon, as shown in Table 5-1 below.

Table 5-1 Major Population Centers – Western Oregon 2009

City Area	Population
Portland Area	1,462,300
Eugene/Springfield	226,030
Salem/Keizer	228,266
Corvallis/Albany	112,000
Bend/Redmond	118,450
Medford/Ashland	172,593

[18] ibid

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 5-2 illustrates the population percentages by zip code of adults with bachelor degrees and advanced degrees.

Figure 5-2: Percentage of Adults with Bachelor's Degree or Above (2007) by Zip Code[19]

[19] Microsoft MapPoint 2010 United States

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 5-3 shows the locations of existing hybrid vehicles.

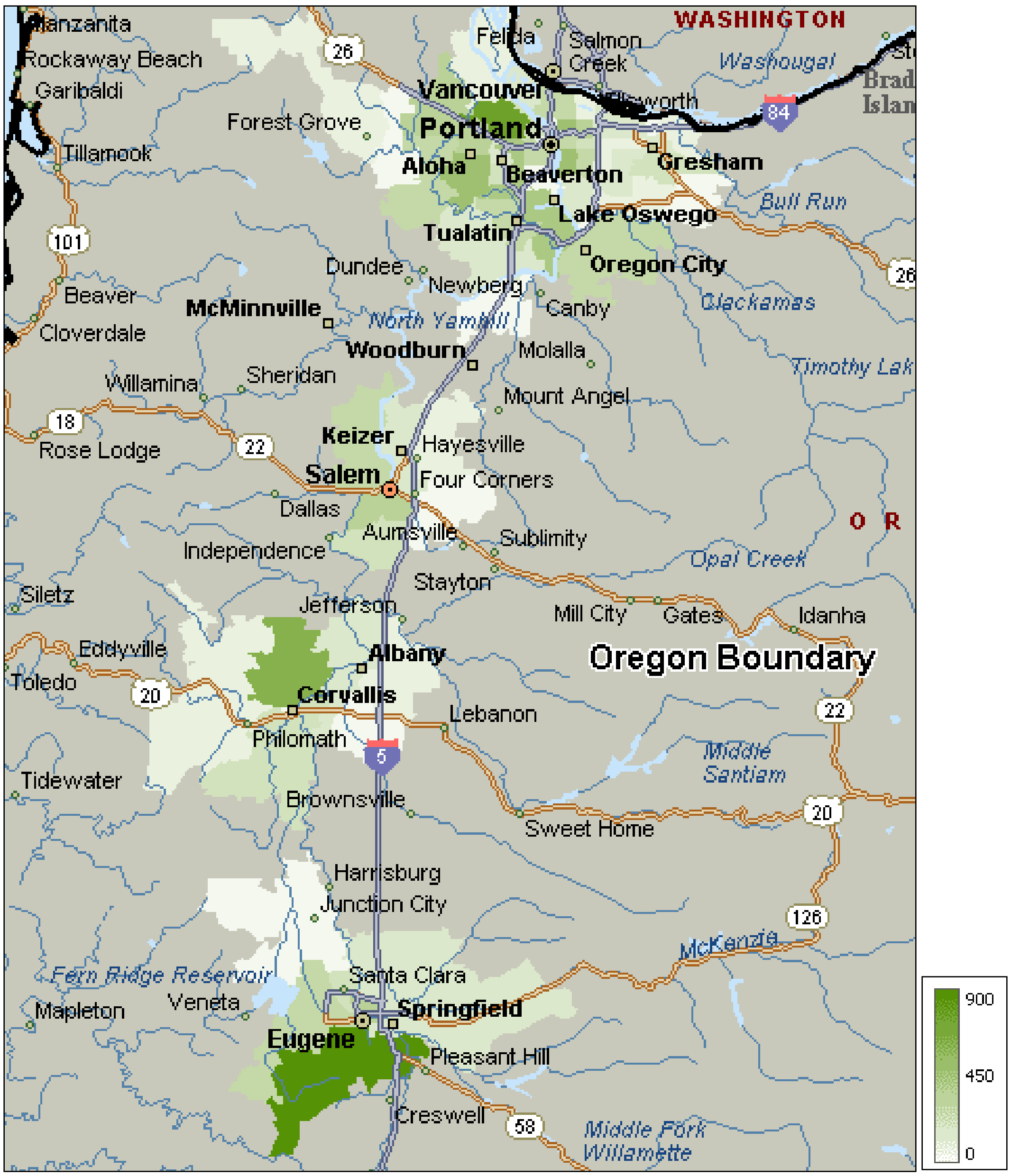

Figure 5-3: Total Hybrid Vehicles by Zip Code

It is also likely that EV adopters will have at least two vehicles in the household. Figure 5-4 below shows locations of households with two or more vehicles.

Figure 5-4: Households with 2 or More Vehicles (1990) by Zip Code[20]

20 ibid

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.

Census data reveal a number of commuting patterns in the Willamette Valley:

- Most Willamette Valley commuters who worked in a major employment center also lived in that center (e.g., West Metro or Salem/Keizer).
- The vast majority of Willamette Valley commuting between the major employment centers occurred between these four centers in the Portland metropolitan area: Portland, West Metro, Southeast Metro, and Gresham.
- Commuter flows from outside the Portland metropolitan area were minor compared to flows internal to the Portland metropolitan area.
- The number of vehicles used for commuting up the I-5 corridor into the Portland metropolitan area from counties to the south was very small compared to those used for commuting within the Portland metropolitan area. Nonetheless, Portland was the main destination for commuters using I-5.[21] Three times more commuter traffic was destined for metropolitan Portland than left the area.
- I-5 was not the dominant corridor for intercity commuting. When aggregating commuters from communities outside of Clackamas, Multnomah, and Washington Counties that might have used I-5 to reach Portland, the amount was less than 2% of the metropolitan area's total commuters. Important commuting flows occurred across the valley to major employment centers, not up and down the valley between employment centers. More people commuted into Portland from the east (27,000) and west (49,000) than commuted in from the south on I-5 (16,000) in 1990. The Salem-Keizer metropolitan area and the Albany and Corvallis urban areas showed the same patterning.[22]
- The Salem-Keizer area was a strong draw for commuters. Between Woodburn and Salem, more traffic headed southward into Salem than northward out of Salem. However, according to data from the 2000 Census Transportation Planning Package,

[21] Gregor, Brian; *Commuting in the Willamette Valley*; ODOT; May 1998

[22] Gregor, Brian; *Commuting in the Willamette Valley*; ODOT; May 1998

about 22% of workers residing in the Salem area commuted to work locations outside of the Salem area. About 6%of the Salem area workforce commuted to the Portland area.[23]

- The Eugene-Springfield area sent very few commuters to workplaces outside of Lane County and attracted commuters primarily from places within Lane County – primarily from the south[24]. Only 10% of workers from the Eugene area commuted to work locations outside of the Eugene area.[25]

Figures 5-5 and 5-6 summarize traffic volumes on major highways and also show travel time characteristics emanating from the population centers in the Portland metropolitan area and the Willamette Valley.[26]

[23] Gregor, Brian; *Analysis of Congestion and Travel Trends Reported in the 2009 Urban Mobility Study Report*; July 1, 2009

[24] Gregor, Brian; *Assessing Intercity Commuting Patterns in the Willamette Valley Using the Census Transportation Planning Package (CTPP)*; N.D.

[25] Gregor, Brian*; Analysis of Congestion and Travel Trends Reported in the 2009 Urban Mobility Study Report*; July 1, 2009

[26] Source: Metro

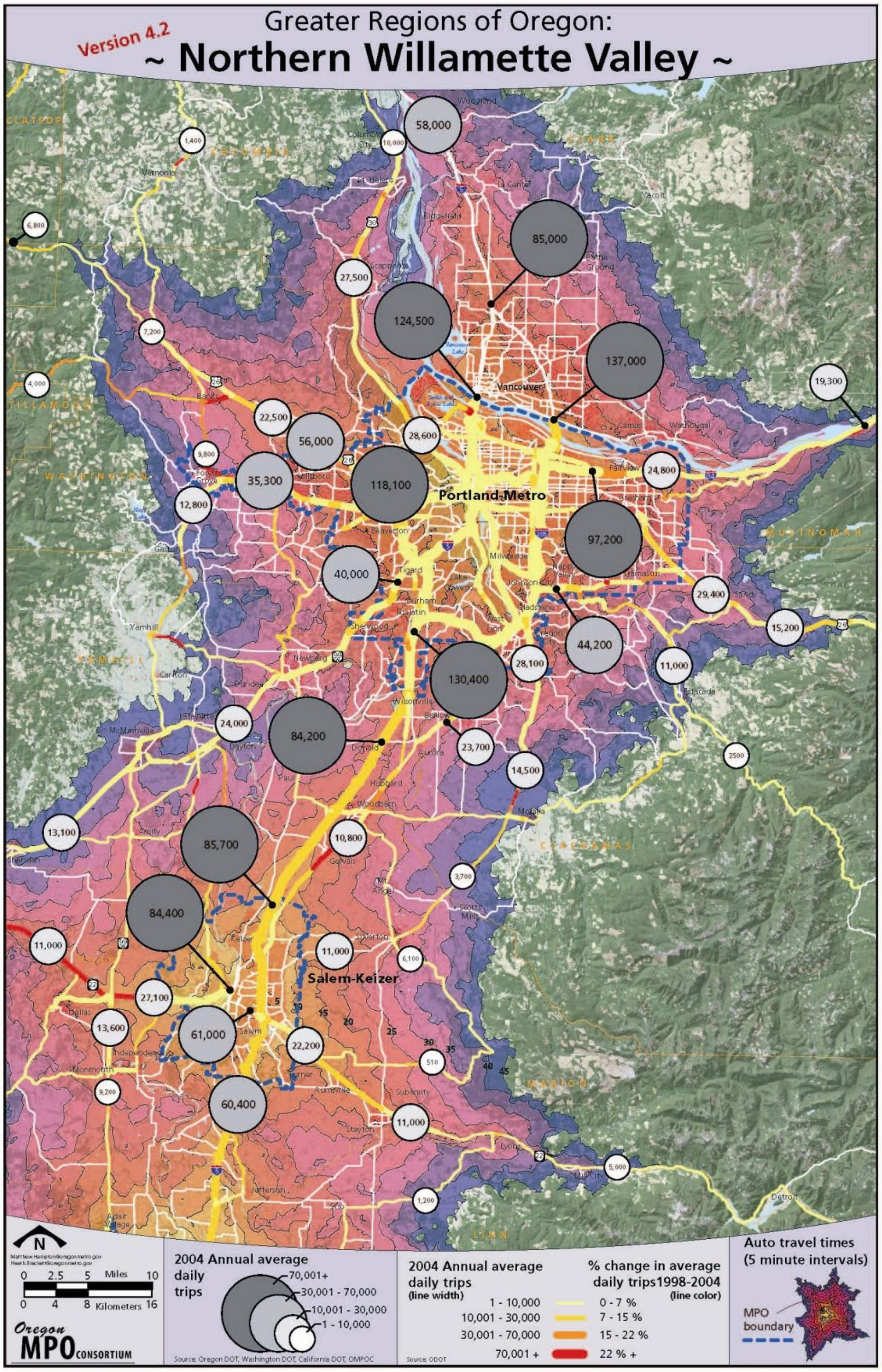

Figure 5-5: Travel Statistics Northern Willamette Valley[27]

[27] Oregon MPO Consortium

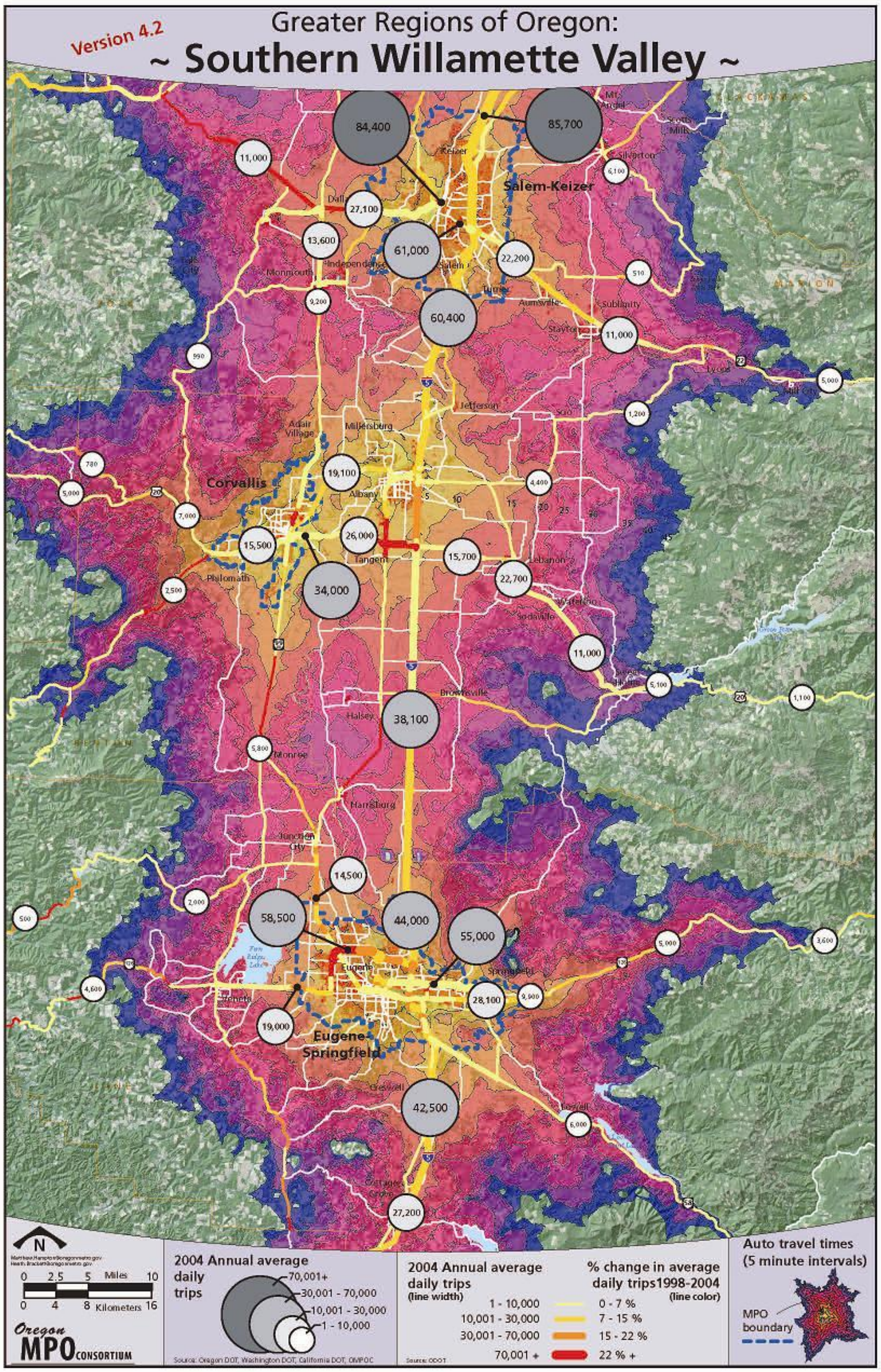

Figure 5-6: Travel Statistics Southern Willamette Valley[28]

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[28] Oregon MPO Consortium

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. Densities of businesses are shown in Figure 5-7 below.

Figure 5-7: Businesses per Square Mile by Zip Code[29]

The greatest business densities are found in the three zip codes listed in Table 5-2 and shown on Figure 5-8.

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[29] ibid

Table 5-2: Major Business Densities

Zip Code	City	Density – Businesses/Sq Mile
97204	Portland Center	4957
97205	Portland Center West	2117
97209	Portland Center North	1806

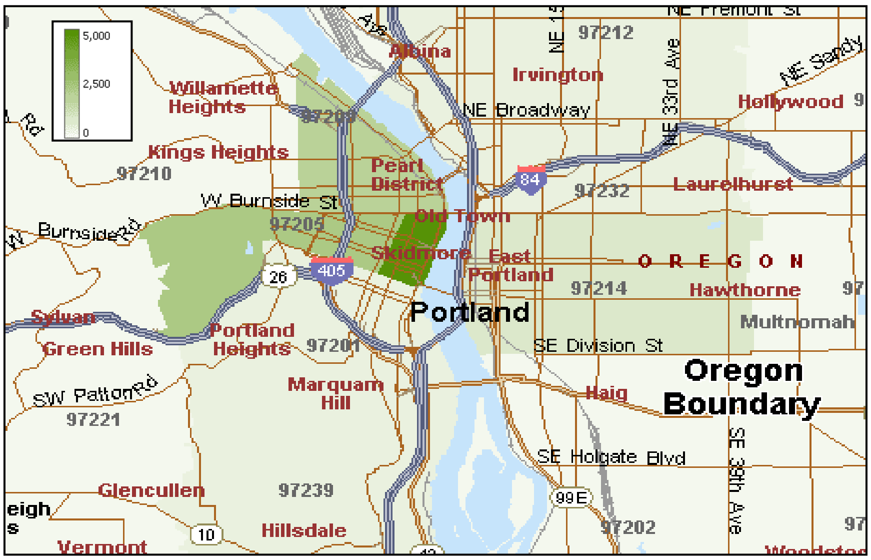

Figure 5-8: Portland Major Business Densities

5.3 EV Sales Projections

The Portland area is one of the initial market areas for major production EVs in 2010. Both the Nissan LEAF and the Chevrolet Volt by GM are being introduced into this market. Other OEMs will follow, as well. Political will and public enthusiasm are driving the interest and motivation to draw EVs into public acceptance. This will place the Western Oregon area on a faster path to EV adoption.

These factors can be applied to the EV market sales projections in Section 3 to show the following projections by Metropolitan Area.

Table 5-3: EV Sales Western Oregon

Annual Sales	Greater Portland	Salem/ Keizer	Corvallis/ Albany	Eugene/ Springfield	Bend/ Redmond	Medford/ Ashland	TOTAL
2011	780	120	60	110	50	70	**1,190**
2015	2,780	420	200	400	180	240	**4,220**
2020	13,260	1,990	980	1,890	860	1,130	**20,110**

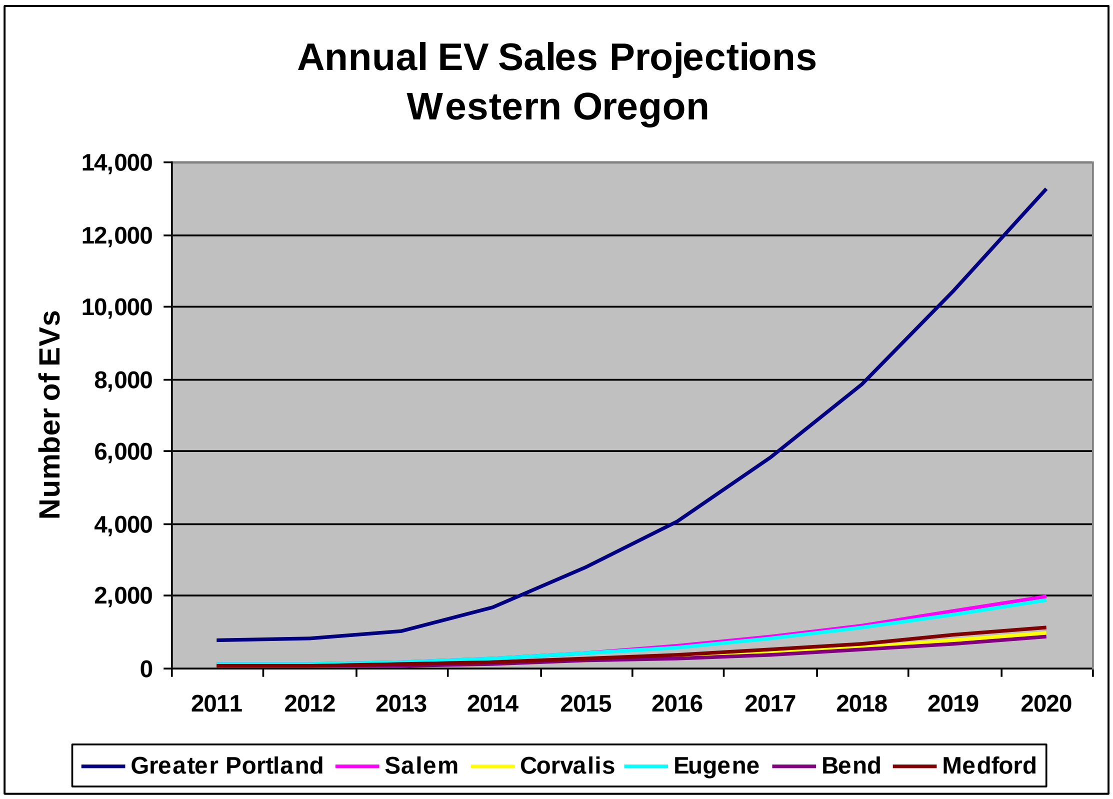

Figure 5-9: Annual EV Sales Projections – Western Oregon

Table 5-4: Cumulative EV Sales – Western Oregon

Cum. Sales	Greater Portland	Salem/ Keizer	Corvallis/ Albany	Eugene/ Springfield	Bend/ Redmond	Medford Ashland	TOTAL
2011	780	120	60	110	50	70	**1,190**
2015	7,050	1,060	520	1,000	460	600	**10,690**
2020	48,450	7,260	3,560	6,890	3,140	4,120	**73,420**

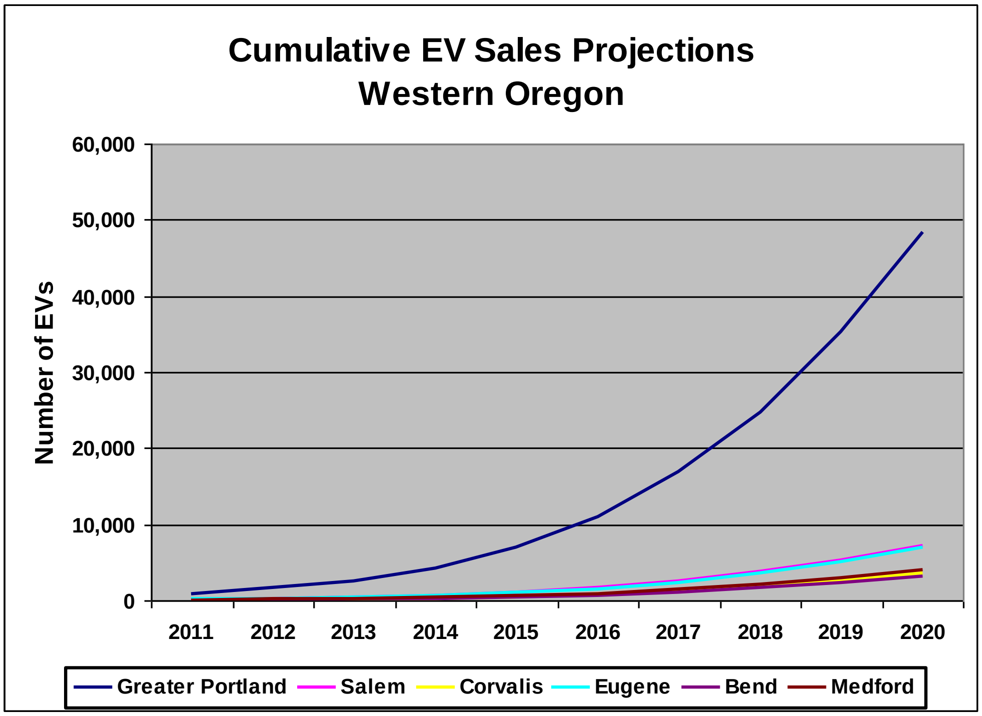

Figure 5-10: Cumulative EV Sales Projections Western Oregon

5.4 EVSE Sales Projection

EVSE deployment precedes EV deployment to provide the rich infrastructure desired. The number of EVSE is calculated as before to provide the following tables. For reasons noted in Section 4.1.5, workplace or employer-based EVSE is not included in these numbers.

Table 5-5: Annual EVSE Projections

Annual Sales	Greater Portland	Salem/ Keizer	Corvallis/ Albany	Eugene/ Springfield	Bend/ Redmond	Medford Ashland	TOTAL
2011	1,530	230	110	220	100	130	**2,320**
2015	4,560	680	340	650	300	390	**6,920**
2020	18,230	2,730	1,340	2,590	1,180	1,550	**27,620**

Table 5-6 Cumulative EVSE Projections

Cumulative Sales	Greater Portland	Salem/ Keizer	Corvallis/ Albany	Eugene/ Springfield	Bend/ Redmond	Medford/ Ashland	TOTAL
2011	1,530	230	110	220	100	130	**2,320**
2015	12,320	1,850	910	1,750	800	1,050	**18,680**
2020	72,520	10,870	5,330	10,310	4,700	6,160	**109,890**

6 DC Fast Charging

The introduction to Section 4 provided some background information on DC Fast Charging. Studies have found that the inclusion of DC Fast Charging has a significant effect on drivers in relieving “range anxiety.” With the knowledge that there is a facility nearby that can deliver a significant charge in a short period of time, the driver is more comfortable using the full range of the vehicle. Without this safety net, the driver is more concerned about maintaining the vehicle battery at a higher state of charge. Thus the availability of DC Fast Charging will go a long way in the promotion of EVs. There is some question, however, whether the availability of the DC Fast Charging actually causes a higher usage of the equipment. A safety net is only needed in extreme conditions. Consequently, it may be that once established, a network of DCFCs may be sufficient for a substantial time into the long-range plan. This section explores the design and location process for DC Fast Charging.

6.1 Design Characteristics

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

6.2 Customer Usage

The rapid recharge capability of DC Fast Charging makes it ideal for locations where the consumer will stop for a relatively short period of time, typically 15 to 30 minutes. DC Fast Charging will not generally be used for completing the charge in a vehicle, but rather to provide a substantial recharge quickly. While DCFC stations may be a destination in themselves, they will likely be placed in existing locations where customers are likely to linger for this amount of time. Locations such as coffee shops, convenience stores, and rest stops serve as some examples. These are the typical locations for the “trip chaining” discussed in Section 2.7.

6.3 Local Area Impact

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

6.3.1 Fast Charging Benefits

Table 3-1 outlines the recharge capabilities of DC Fast Charging. It reduces the battery recharge time from hours to minutes. For many BEVs, receiving 50% battery recharge in 20 minutes is very significant. A charge opportunity lasting 10 minutes can extend the range of a BEV by 25 miles. That short a recharge time can easily be tolerated by the EV driver to gain the benefit of the range extension.

6.3.2 Electric Utility Grid Impact

The power required by DC Fast Charging is more typically available in industrial areas and may not be readily available in 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 electrical loads. This power is provided by the electric utility through the transformers in the area and is one reason specific areas are zoned for industrial applications. Because of the significant potential impact on the electrical grid, the electric utility company will provide vital input on DC Fast Charging locations.

6.3.3 Siting of Fast Chargers

Site suitability for DCFCs depends on:

- Charging purposes
- Site usefulness for augmenting the Level 2 publicly available charge infrastructure
- Electric grid capability

6.4 DC Fast Charging Along Transportation Corridors

DC Fast Charging is particularly important for transportation between major metropolitan areas. Metropolitan areas will contain the local EVSE infrastructure to support EVs within the area, but DC Fast Charging along the corridors will allow BEVs in particular the ability to traverse the long distances between metropolitan areas. DC Fast Charging is more suitable here than Level 2, because customer satisfaction will require the shortest recharge time available to minimize travel delays. In fact, as batteries gain in power densities and vehicle ranges are extended, it can be expected that the power levels of DCFCs will also be increased. DCFCs projected to be provided to support the initial rollout of EVs in 2010 and 2011 are expected to be 60 kW or less. Higher power chargers 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 DC Fast Charging (90kW) Circa 1997

Research shows that from a convenience standpoint, EV charging stations should be as plentiful as current gasoline stations. This holds true for corridor travel. The exits containing gasoline stations along Interstate 5 between Medford and Eugene are shown in Figure 6-2.

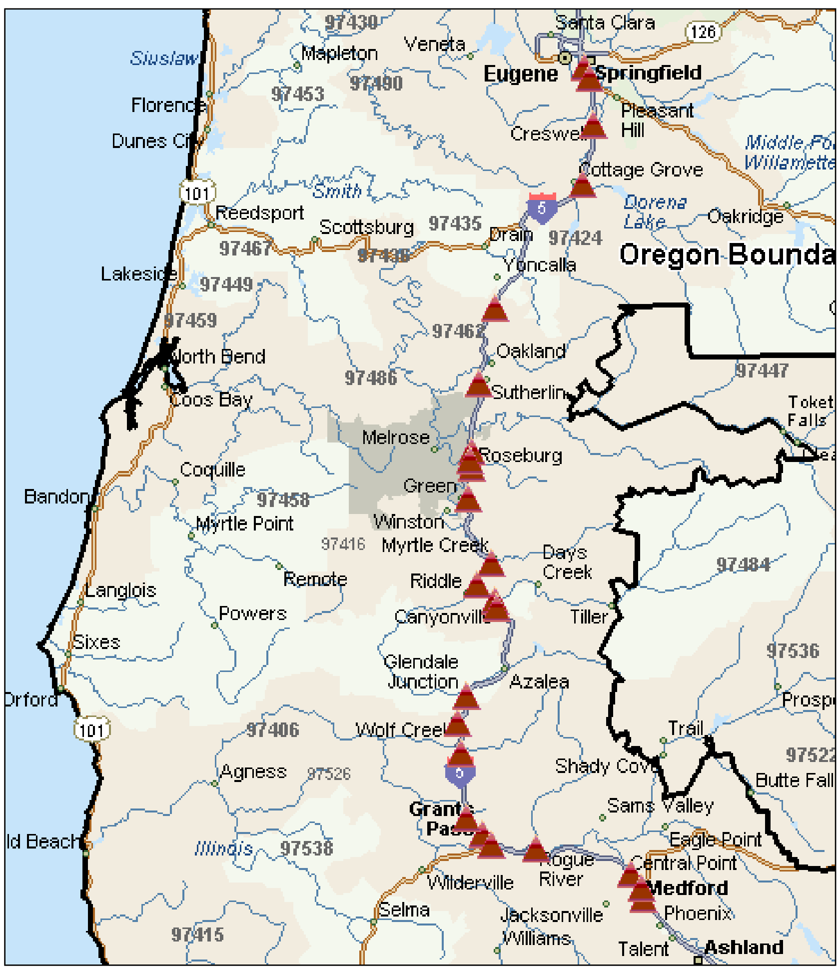

Figure 6-2: Gasoline Stations along I-5

The longest stretch in this trip between stations is about 25 miles. This is about 25% of the range of an EV. In general for corridor travel, minimum planning should allow DC Fast Charging locations at no more than 30-mile intervals. The number of charge ports at these locations will initially be few, but more stations or more ports at existing stations can be added as demand grows.

Corridor planning should involve freeways such as I-5, I-84, I-105, I-205, and I-405 in the Western Oregon area, as well as the grid of major state highways connecting population centers east-west, as well as north-south. DC Fast Charge stations become range extenders for the EVs. Thus, they should also extend from the major highways into the major residential areas.

6.5 DC Fast Charging Deployment Projections

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

Table 6-1 Annual Deployment of DC Fast Charging per Metropolitan Area

Annual Sales	Greater Portland	Salem/ Keizer	Corvallis/ Albany	Eugene/ Springfield	Bend/ Redmond	Medford/ Ashland	TOTAL
2011	30	4	2	4	2	2	**44**
2015	40	6	3	6	3	4	**60**
2020	130	20	10	20	10	10	**200**

Table 6-2 Cumulative Deployment of DC Fast Charging per Metropolitan Area

Cum. Sales	Greater Portland	Salem Keizer	Corvallis Albany	Eugene Springfield	Bend Redmond	Medford Ashland	Total
2011	30	4	2	4	2	2	**44**
2015	150	20	10	20	10	10	**220**
2020	610	90	50	90	40	50	**930**

The guidelines above would suggest the DCFC locations noted on Figure 6-3 below. There are 65 DCFC locations identified. While the average distance between these stations is less than 30 miles, the stations were sited at intersections of state and federal highways, as well as those leading to major residential population concentrations. Included are some of the highly-traveled secondary highways.

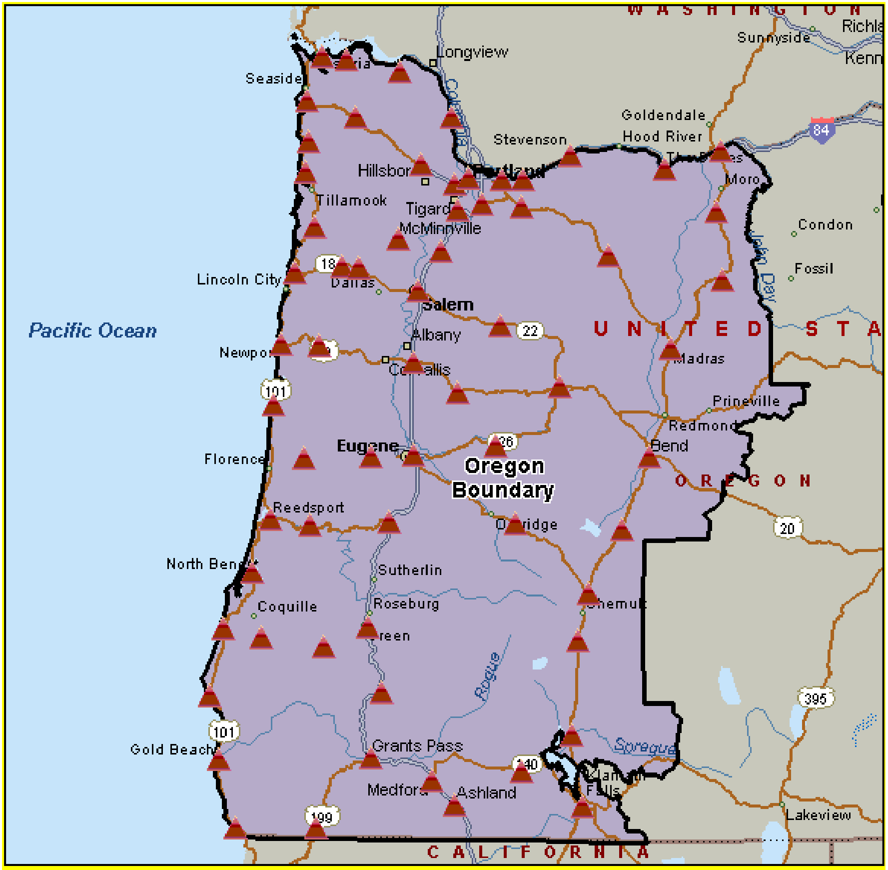

Figure 6-3: DCFCs in Transportation Corridors

7 EVSE Deployment Implementation

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

7.1 EVSE Deployment Cycle

EV innovation will develop diversity in types and functionality of EVs to suit many different uses. Most OEMs have announced their initial plans for EVs; 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.

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

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

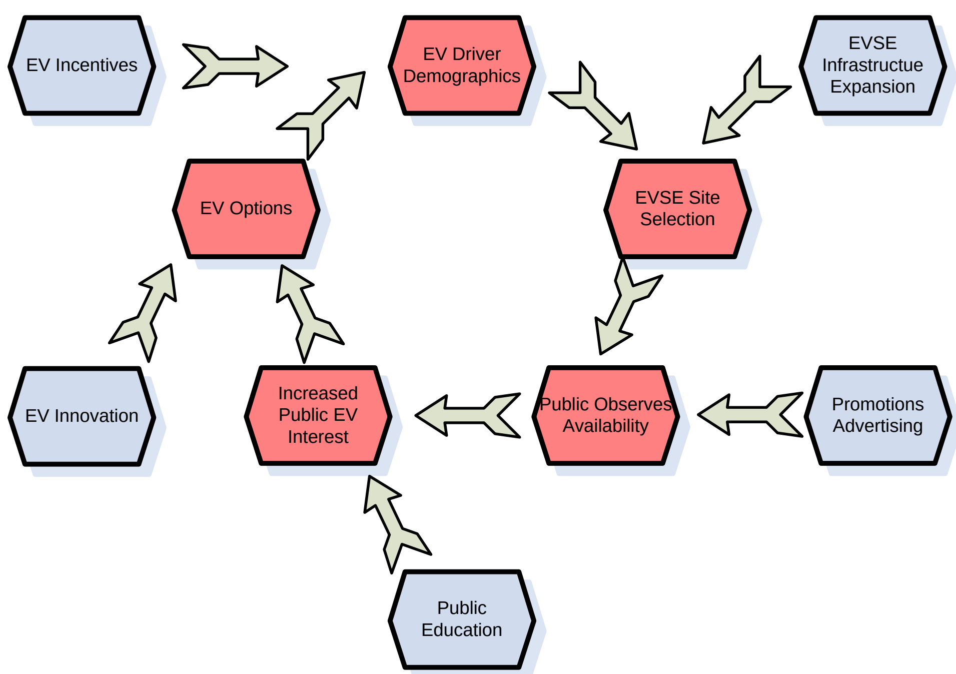

Figure 7-1: EV and EVSE Promotion

Public education can generate awareness of EV benefits such as reducing carbon emissions and dependence on foreign oil. Business owners who have installed EVSE can generate public awareness through their advertising and promotions. Forward-thinking business owners and those interested in promoting EV use will be motivated to install EVSE near their businesses. Nationally-known businesses will be eager to promote their image of being environmentally friendly, especially when noting their successes in other locations. Government, non-profit organizations, and businesses can all collaborate to develop an EVSE infrastructure adapted to local community and policy needs.

7.2 EVSE Resources

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

7.3 Venues for EVSE Deployment

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

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

Table 7-1 Portland Venues for EVSE Deployment

Airports (Major)	1	**Airports (Minor)**	13	**Amusement parks**	6
ATMs	733	**Auto services**	1,703	**Banks**	614
Bus Stations	3	**Campgrounds**	27	**Casinos**	2
Cinemas	41	**Community Centers**	12	**Convention Centers**	6
Galleries	59	**Gas Stations**	428	**Golf Courses**	68
Grocery Stores	407	**Hospitals**	34	**Libraries**	56
Marinas	26	**Museums**	53	**Nightclubs**	615
Park & Rides	63	**Parking lots**	71	**Pharmacies**	177
Police Stations	48	**Post Offices**	64	**Schools**	733

Shopping	36	**Stadiums and arenas**	6	**Theaters**	25
Wineries	76	**Restaurants**	3,785		

There are a total of 9,991 destinations listed above, and all are areas where the driver might choose to stay for a substantial period of time. Many of these locations will be able to support many more than two EVSE, and demand will again increase the quantity of EVSE. These destinations represent ideal locations for Level 2 EVSE.

The distribution and density of EVSE is affected by the location, density, and intensity of activity associated with each destination. Existing databases can contribute to locating EVSE. For example, traffic modelers use detailed household surveys on driving behavior, including trip destinations – and this information is being utilized in Washington State as part of the EV Project. However, the Oregon study area does not have a complete set of current household survey data, so the following data were utilized to help determine appropriate distribution and density of EVSE:

- **Zoning**. Zoning classifications in urban areas are ranked according to their likelihood of supporting targeted destinations.
- **Travel Patterns**. Major streets, highways, and interchanges are ranked to identify areas with high levels of traffic and access to destinations.
- **Employment Density**. The number of employees, the location of their employment, and their type of business is mapped to identify targeted destinations.

Using multivariate analysis and geographic information systems (GIS), these data sets contribute to the mapping of planned distribution and density of EVSE.

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

7.4 Public Input

Ideas to establish possible locations are for EVSE are coming from

- public presentations,
- media announcements,
- conferences,
- direct contacts via email, web and telephone,

- community leaders, and
- Oregon advisory team members.

Drivers that use or are interested in using EVs will be queried to gain their insights.

From this pool of suggested locations, the initial infrastructure can take its first step from a plan to a roadmap. The plan recommends the target areas, whereas the roadmap identifies 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 primarily using 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 and car-share programs will gain confidence that their users will be able to charge in publicly-available locations. Range anxiety and unfortunate battery discharge experiences for renters will need to be overcome with driver education. A positive driving experience will promote EV adoption in many geographic areas.

The absorption of EVs into taxi fleets will have a major effect on public acceptance. Taxis will have challenges using BEVs unless destination planning is included in the taxi reservation. A rider will not want to wait while the taxi is connected for charging. However, between fares, the taxi driver can make use of DC Fast Charging to prepare for the next fare.

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

7.7 EVSE Densities

Analysts have estimated appropriate densities of EVSE in the metropolitan regions based on appropriate destinations. Data fields for the Oregon study area considered zoning, destination data on employment type, and traffic. GIS mapping in Figure 7-2 shows areas of high, medium, and low densities of EVSE. High densities tend to occur near

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

Figure 7-2 indicates the best places to distribute EVSE within the Portland metropolitan area. In addition to I-5, other corridors show considerable traffic and access to appropriate destinations.

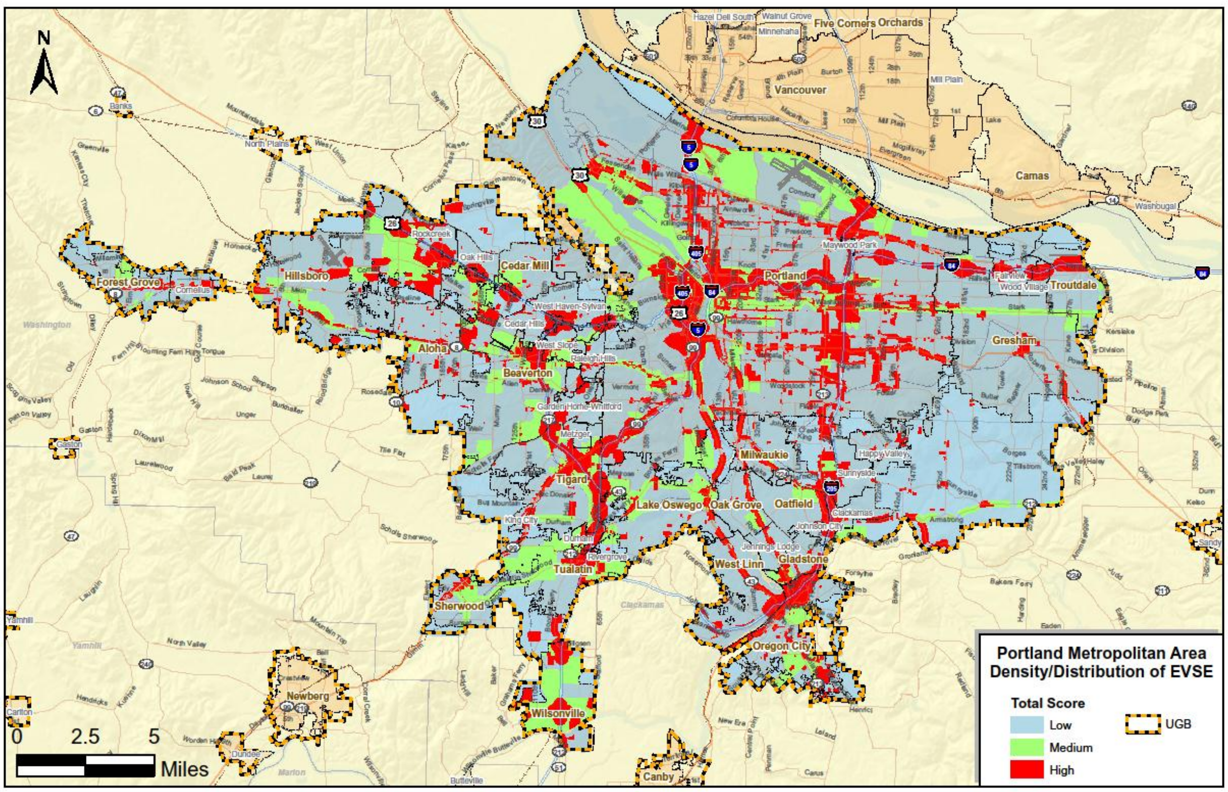

Figure 7-2: Level 2 EVSE Long-Range Plan Densities for Portland Area

Figure 7-3 shows EVSE distribution patterns for Eugene and Springfield. In some cases, the underlying zoning promotes high density of EVSE near interchanges. Downtown areas show mostly high density.

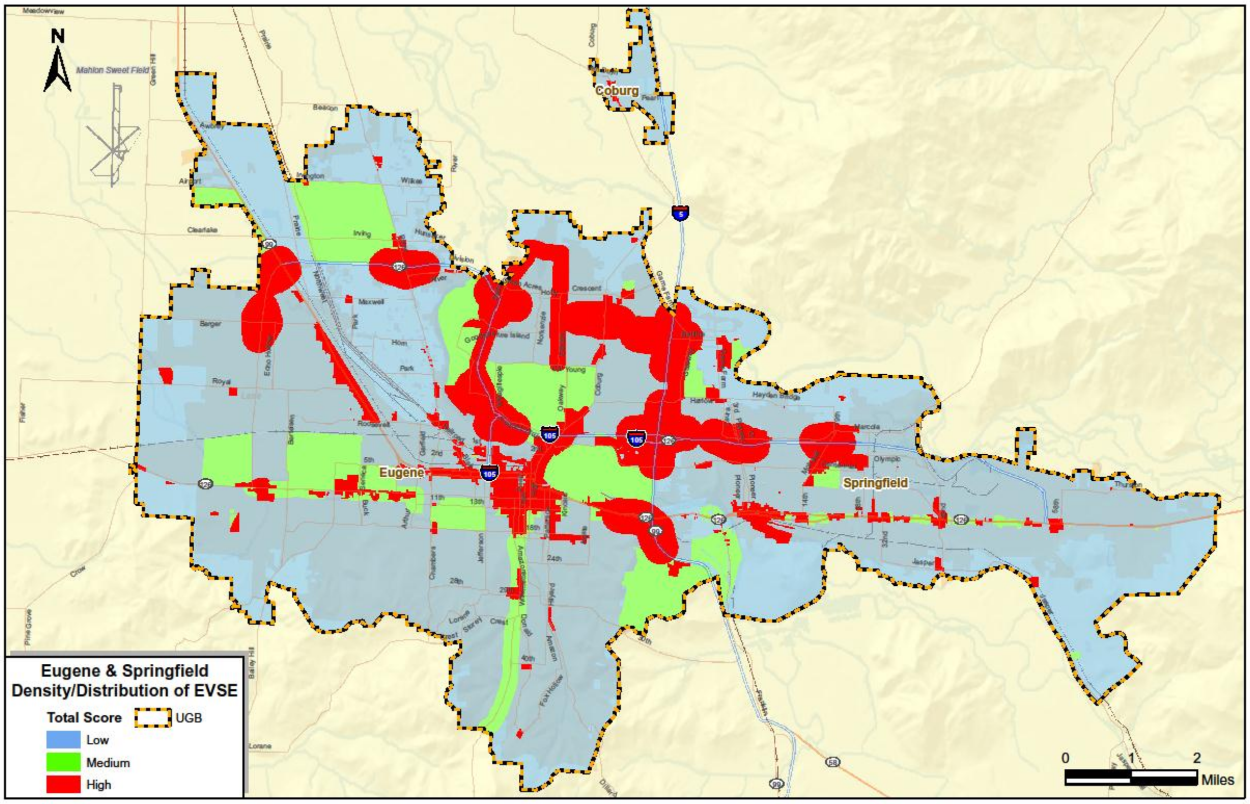

Figure 7-3: Level 2 EVSE Long-Range Plan Densities for Eugene & Springfield

Figure 7-4 showing the Salem/Keizer area indicates that high density is appropriate near I-5 interchanges, along several corridors, and also in Salem's downtown.

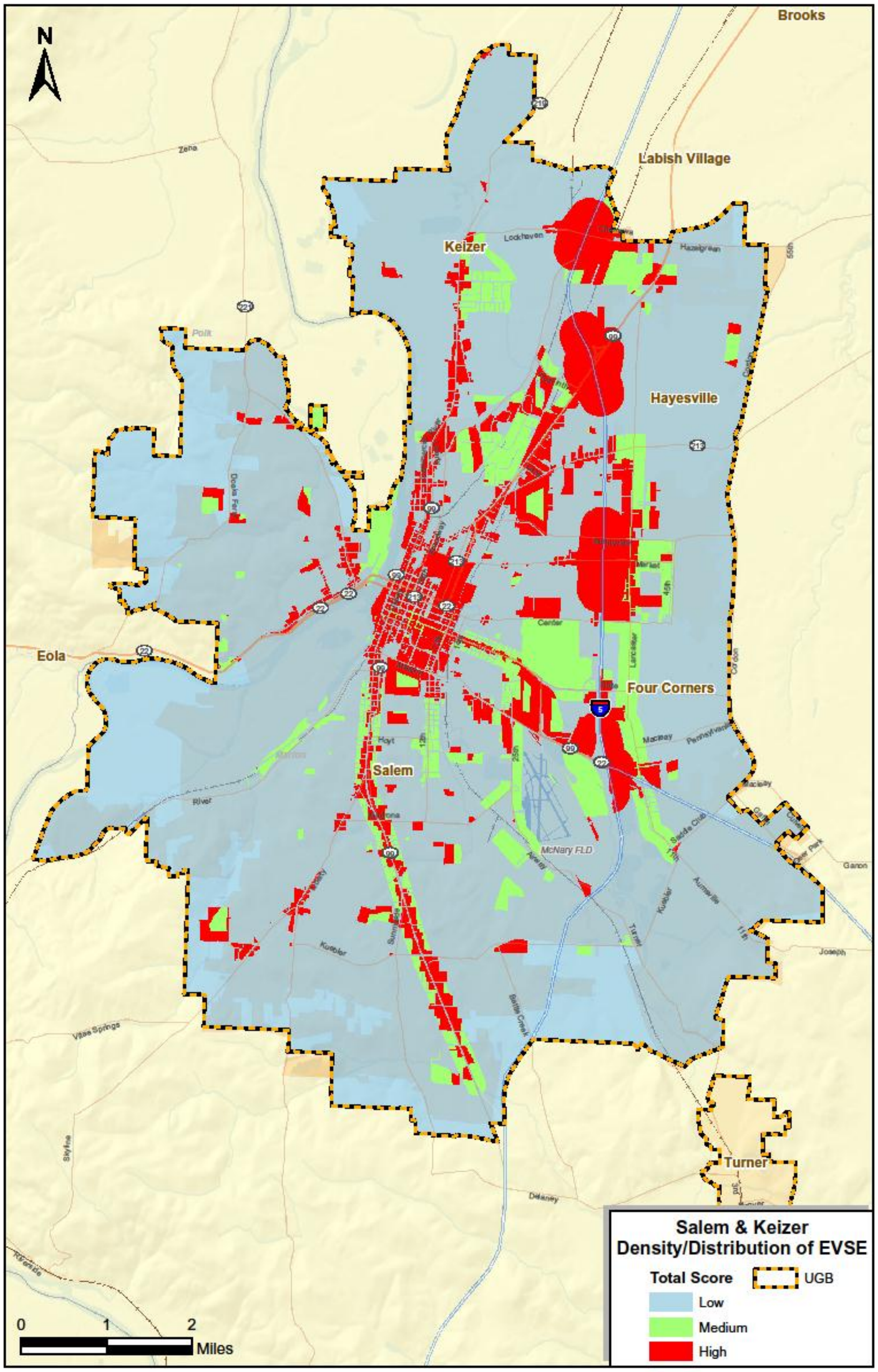

Figure 7-4: Level 2 EVSE Long-Range Plan Densities for Salem & Keizer

Corvallis, unlike the other metropolitan areas in the Willamette Valley, does not have the high levels of traffic, and thus the road corridors do not heavily influence the density recommendations. As seen on Figure 7-5, this pattern also occurs in Albany, except for some areas in proximity to I-5 that indicate high-density EVSE.

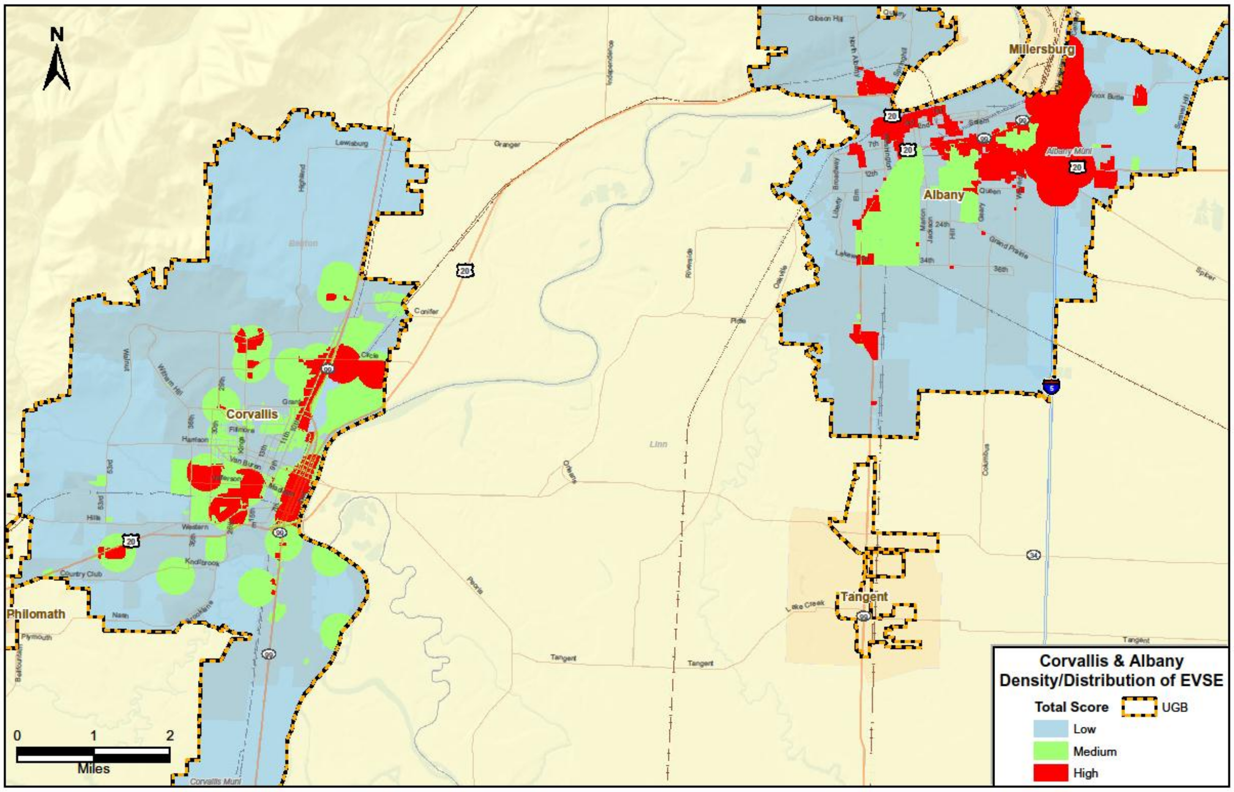

Figure 7-5: Level 2 EVSE Long-Range Plan Densities for Corvallis & Albany

7.8 Summary

Figures 7-2 through 7-5 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 along with demand response actions as the industry matures.

8 Appendix A – EV and EVSE Sales Projections

This section is intentionally omitted.

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. These data feeds also can tie into the tracking and scheduling of EVSE installations. Having this information allows utilities to proactively manage the infrastructure upgrades that will be needed in the least prepared areas. Next, the utilities need a method for deferring and distributing clustered charging into the overnight or off-peak hours so that sufficient cool-down of transformers can be achieved through tempered daily charging duty cycles. Ultimately, smart charging solutions can involve coordinated charging schedules that allow customers to tailor their individual recharging needs in an optimal “network balanced” charging solution.

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

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. Figure 7-1 shows a typical example of a daily load profile. As demand for electricity varies throughout the day, the utility is required to add or subtract power generators to keep up. It would be more economical for utilities to reduce the peaks and fill in the valleys of this curve. Utilities have various strategies that assist in this goal. One such strategy is to use 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.

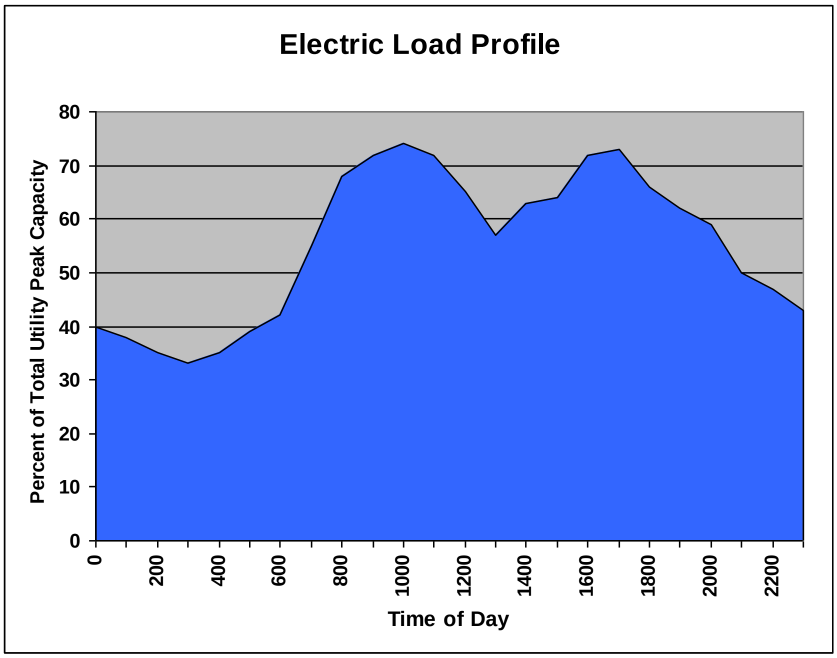

Figure 9-1: Typical Daily Load Profile

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

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

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

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 funding, the utility is typically seen as a community leader in stability and economic development, which contains an “unwritten expectation” that they will put rate-based profits back into business expansion. Coupled with the extensive publicity over the Clean Energy revolution, and the coming explosion of EVs as an industrial renaissance for the US, this is setting up a large opportunity for utility public relations.

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

9.6 Ancillary Services

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

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

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 the corresponding EVSE. This list is not intended to be exhaustive, but rather a starting point for consideration. Some activities are already underway, and others are under consideration.

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, integrate smart grid technology, and diversify alternative fuel programs.

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

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

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

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

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

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

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

Promote outreach and education to consumers, businesses, and state and local governments, including training of first responders.
This effort will increase awareness of the benefits, safety, and requirements of electric vehicle transportation and charging technology.

Establish funding for industry outreach and education programs.
This will support comprehensive campaigns at the state and local level.

10.2 State Level

Continue to incentivize EVs and EVSE.
Existing support includes a $1500 state tax credit for purchasing an electric vehicle and Business Energy Tax Credits for installation of EVSE. Legislative actions will be needed to continue existing programs.

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

Establishing state programs to assist in offsetting costs to acquire electric vehicles and charging infrastructure.
This will increase adoption and deployment of the technology and make it accessible to more segments of the population. For example, EV Home Charging Improvement Grants and state energy grants can 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. Feebates can provide a revenue-neutral method of encouraging adoption of EVs by offering rebates to EV buyers and collecting corresponding fees from purchasers of high-carbon fueled vehicles.

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.
The LEED certification process already gives points for installation of EVSE. 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.

Update building code guidelines as appropriate for seamless and expedited basic EVSE installations and EVSE smart-charging standards.

Oregon has already set a national example for improving building codes relative to EVSE installations. Additional language to further expedite the permit and inspection process is expected to be adopted summer 2010. Continue the work of the State Building Codes Division 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.

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

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 State leadership and incentives to develop electric vehicle fast charging corridors on state highways.

Work with ODOT, other State agencies, and the utilities to identify opportunities to incorporate fast charging infrastructure along 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 rates and/or tax credits 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 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 the local utility in planning districts to track usage and need for transformer enhancement at utility neighborhood substations.
Encourage the development of an energy infrastructure program between appropriate municipal departments and the local utility in order to adequately plan and monitor neighborhood substations and 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 the local utility and the EVSE provider.
Developing a home assessment program and incorporating an online expedited EVSE permitting and inspection process to be performed by specially trained and certified inspectors in cooperation with the local utility and EVSE provider, notifies consumers regarding potential incurred costs prior to purchasing an electric vehicle and provides consumers who do purchase an electric vehicle with timely customer service and installation of the technical equipment to support its use.

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

Develop a coordinated community outreach and education program regarding EVSE residential and commercial installation equipment, the installation process, and tax credit programs with the local utility and the EVSE provider.
A locally developed and coordinated community outreach and education program in cooperation with the local utility and EVSE provider will deliver a community-driven message to inform residents about programs and processes associated with electric vehicles and charging infrastructure technology.

Include electric vehicle infrastructure in local sustainable construction/green building incentive programs.
Develop local and/or utility-packaged programs offering a leveraged rate and/or tax credit combining electric vehicle infrastructure with projects such as home solar or home area network systems that reduce energy usage impact on the grid.