How Does Utilization of Non-Residential EVSE Compare Between those Installed in Oregon in Planned versus Unplanned Locations?

April 2015

Key Conclusions

- A significant planning effort for non-residential Level 2 electric vehicle supply equipment (EVSE) placement was undertaken using the EV Micro-Climate® process in the greater Portland area during 2010.
- Fully 74% of the EV Project's available EVSE were placed in the predicted high utilization zones.
- Overall, EVSE placed in the predicted high utilization zones experienced 87% greater charge events per week than those outside these zones.
- The EVSE placed in predicted high utilization zones had average vehicle connect time periods 4.4 times longer than those outside these zones.
- The charging site host venue is an important factor in EVSE utilization, both within and outside the high utilization zones.
- The EV Micro-Climate® planning process utilized in the greater Portland area was highly successful in predicting high non-residential EVSE utilization.

Introduction

The lack of public charging infrastructure for plug-in electric vehicles (PEVs) has been identified as a barrier to their widespread adoption. Federal and state grants have been awarded to promote public charging and retail businesses have an interest in installing charging infrastructure. A common question for charger installations is "Where should the chargers be placed?" One of the objectives of the EV Project was to study the interaction of PEV drivers with public infrastructure; therefore, that same question needed to be addressed by EV Project management prior to the first PEVs being delivered. The options available at that time for determining where chargers should be placed were as follows:

- Plan locations related to key attraction sites where PEV parking is anticipated
- Solicit retail and public charging hosts for random placement
- Ask early adopters where they want public infrastructure
- Identify sites near known high-traffic areas.

The EV Project chose the first option for planned deployment. This process was implemented in all EV Project markets.

To evaluate the effectiveness of the planning process utilized by the EV Project, two questions relevant were asked:

1. How well did final installation sites fit with planned locations?
2. How does utilization of non-residential Level 2 EVSE vary between those areas where it was planned versus areas where it was not planned.

The first question was addressed in a separate paper for the San Diego area,[1] where 98% of installed non-residential EVSE were installed in planned areas. Therefore, a comparison of utilization between EVSE use in and outside planned areas in San Diego is not practical. The Portland, Oregon area was selected for this analysis, because the planning approach was very similar to San Diego, but a significant percentage of non-residential EVSE was installed outside the planned areas. The details of the planning approach were included in "EV Micro-Climate® Plan for Northwestern Oregon"[2] and are summarized in Appendix A. The lessons learned during the planning process are addressed in another paper, "The EV Micro-Climate® Planning Process."[3]

Analysis Approach

The PEV charging stations or EVSE delivered by the EV Project included both residential and non-residential units. Non-residential Level 2 EVSE were installed in workplace environments, fleet applications, and publicly accessible locations near retail centers, parking lots, and similar locations. The planning process identified target areas for EVSE deployment. This process for the Portland area is summarized in Appendix A. The entire greater Portland area was mapped through a collaborative process with government, industry, and public to develop a heat map, where red indicated zones predicted to have high charger utilization, green zones indicated medium utilization, and blue zones indicated low utilization. The planning process then focused on identifying venues in the high utilization zones that would attract large numbers of PEV drivers. This planning process was completed in 2010, prior to delivery of the first PEVs to the region. In this analysis, utilization of EVSE deployed in the high utilization zones are compared to EVSE deployed in the medium and low utilization zones in the Portland area.

Plan Results

By August 2013, non-residential EVSE deployment was nearly completed, with 323 EVSE reporting data to the EV Project database. These 323 EVSE were located in 129 separate sites for an average of 2.5 EVSE per site. Multiple EVSE were typically located at a site to reduce installation costs and to ensure an EVSE is available for use at all times, even when one is already in use. Table 1 details the number of sites and quantity of EVSE.

Table 1. EVSE installations per site.

Number of EVSE	Number of Sites
1	34
2	53
3	21
4	12
5 or more	9

The actual installation sites were compared to a detailed Portland density map (Figure A1 of Appendix A). Table 2 presents the details of the deployment sites. Figure 1 presents these locations geographically. The colors match that of the predicted utilization zones.

The 129 sites represent 57 separate owners and includes public buildings, fleet, workplace, and retail locations.

Table 2. EVSE deployment in predicted utilization zones.

Utilization Zone	Quantity of Sites	Percent of Sites	Quantity of EVSE	Percent of EVSE
High	95	74%	251	78%
Medium	20	15%	44	13%
Low	14	11%	28	9%

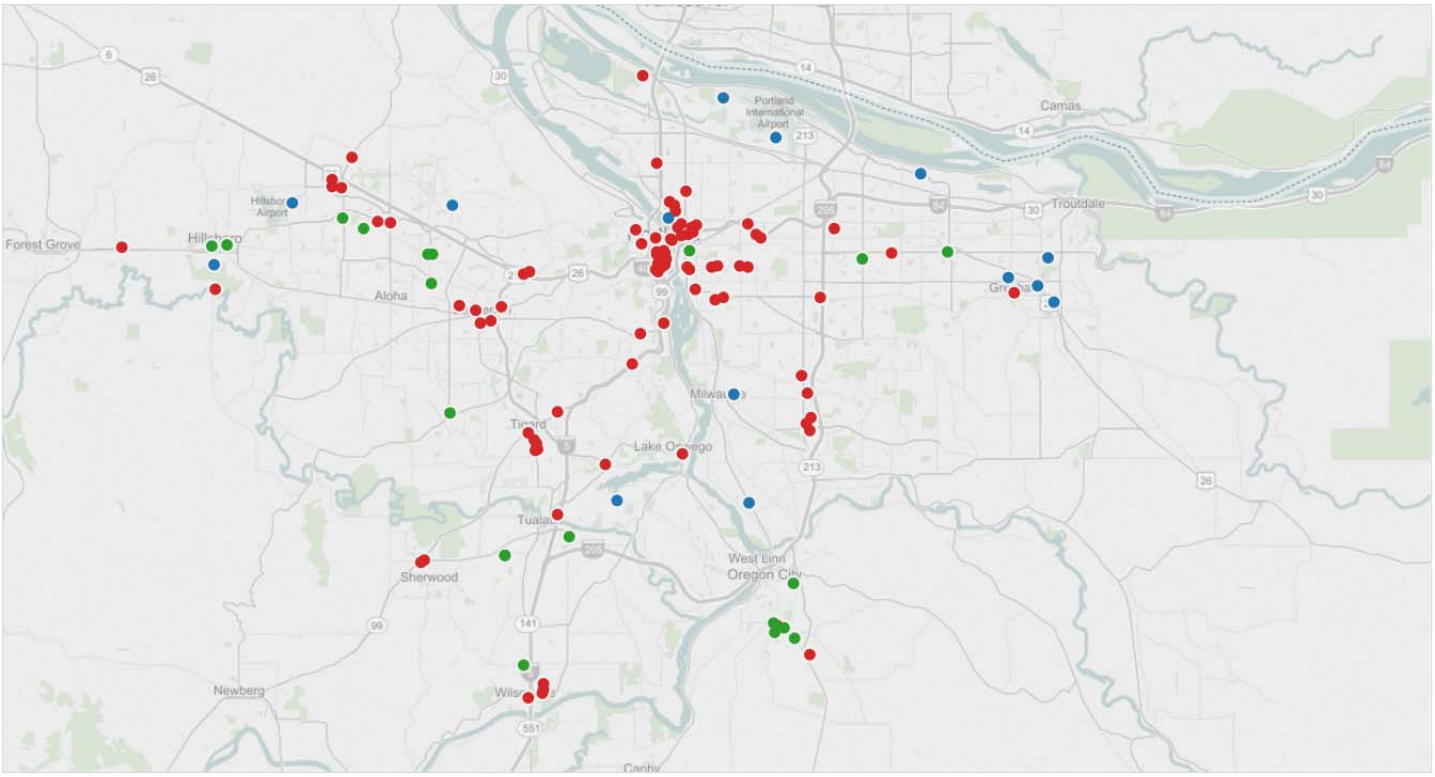

Figure 1. Non-residential EVSE installations in the greater Portland area.

Utilization Metric

The EV Project planning goal was to place all EVSE in locations where high utilization was predicted. High utilization was defined as high numbers of users and high turnover of charging events. However, the placement of non-residential EVSE requires approval of the charging site host. Because host motivations for placement of EVSE vary significantly, chargers were actually installed at a variety of locations, with varying predicted utilization.

Utilization of public EVSE units was still developing in August 2013 as PEV drivers explored the boundaries of their vehicle range. Some EVSE units were used on a regular basis, some occasionally, and others rarely. Additionally, an EVSE unit may have been used extensively one week but not used the next. Therefore, the time period over which the charger utilization is evaluated

is also important. For this paper, the primary metric selected was the average number of connect events per week since that EVSE was installed. A “connect event” is defined as insertion of the EVSE connector into the PEV charge port for at least a 1-minute duration, during which some power is actually transferred.

At locations with multiple EVSE installed, the most conveniently located EVSE was generally more highly used. Early analyses found that high-performing and low-performing EVSE, in terms of events per week, could be found at the same site. However, because it was the site being evaluated, all events for all EVSE at that site were summed in this analysis to identify the number of events per site. This metric will favor the higher numbers of EVSE only when the sites with lower numbers have maximized their utilization, which is an event that had not occurred by August 2013.

The hours EVSE were connected to a PEV were also summed and divided by the number of weeks since the EVSE was installed, producing an average weekly connect time. The total connected time at a site was divided by the total number of events and by the number of EVSE on the site to identify the average connect time per EVSE. Finally, the average amount of energy transferred per event was calculated.

Analysis Results

Table 3 compares analysis metrics for predicted high and medium/low utilization zones.

Table 3. Utilization at predicted zones as measured in average and maximum connection events per week.

Utilization Zone	Connect Events/Wk (avg/max)	Connect Hours/Wk (avg/max)	Energy (kW)/Event (avg/max)
High	3.7/48.0	34.9/887.4	6.3/16.1
Medium/Low	2.0/11.7	8.0/54.8	6.4/23.0

Clearly, the high utilization zones contained the highest average and maximum number of connect events per week. The average number of connect events per week was 87% higher at the high utilization zone than the others. In addition, these sites provided the longest connect times. The average time connected was 4.4 times longer in the high utilization zones. The amount of energy transferred per event was similar for all utilization zones. This is expected, because energy transferred depends on vehicle condition (i.e., state-of-charge) rather than location. No variation in state-of-charge was expected between vehicles charging at high utilization zones versus medium/low utilization zones.

Location in a high utilization zone was not assurance of high usage. As summarized in Table 4, 62 of the 129 sites analyzed had an average number of events per week below the average for low and medium zone usage (i.e., two events per week). Of these 62 sites, 41 were found in predicted high utilization zones, representing 43% of all high utilization zone sites.

Table 4. Sites of low utilization.

Utilization Zone	Quantity of Sites	Percent of Utilization Sites
High	41	43%
Medium	15	75%
Low	6	43%

Further Evaluation

Highly Utilized Sites versus Installation Date

Figure 2 shows the average number of charge events per week versus the number of weeks since installation of the EVSE. Again, the color of the dot represents the utilization zone where the site was located.

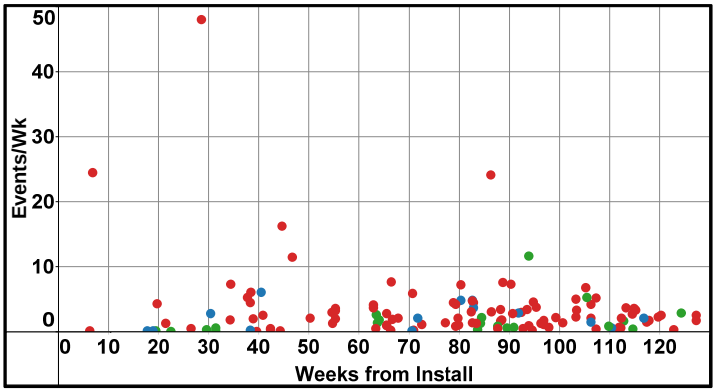

Figure 2. Site utilization versus weeks following installation.

Installations of EVSE into the predicted high utilization zones occurred throughout the active promotion of the EV Project, with no specific emphasis on installing these sites early in the EV Project. From Figure 2, there appears to be no increase in EVSE utilization over time, because the earliest installed EVSE (i.e., greatest number of weeks from installation) fare no better than others installed later. Similarly, EVSE installed most recently showed no disadvantage in utilization. Installation of EVSE in medium and low zones occurred throughout the EV Project’s active promotion, and it appears the date of installation also had no effect on their utilization.

Highly Utilized Site Locations

Eighteen sites average over 5.0 events weekly, including one in the low zone and two in the medium zone. The locations are shown in Figure 3 and detailed in Table 5. The central Portland area appears to have fared the best in

utilization. Location along major traffic routes also appears important.

Venue Classifications

Venue classifications are identified in another EV Project lessons learned[4] report. The venues associated with these 18 highly utilized sites are included in Table 5.

Event Duration per Electric Vehicle Supply Equipment

The average event duration per EVSE generally varies inversely with the number of distinct users. It is noteworthy that two highly utilized sites in the medium zones were big retailers.

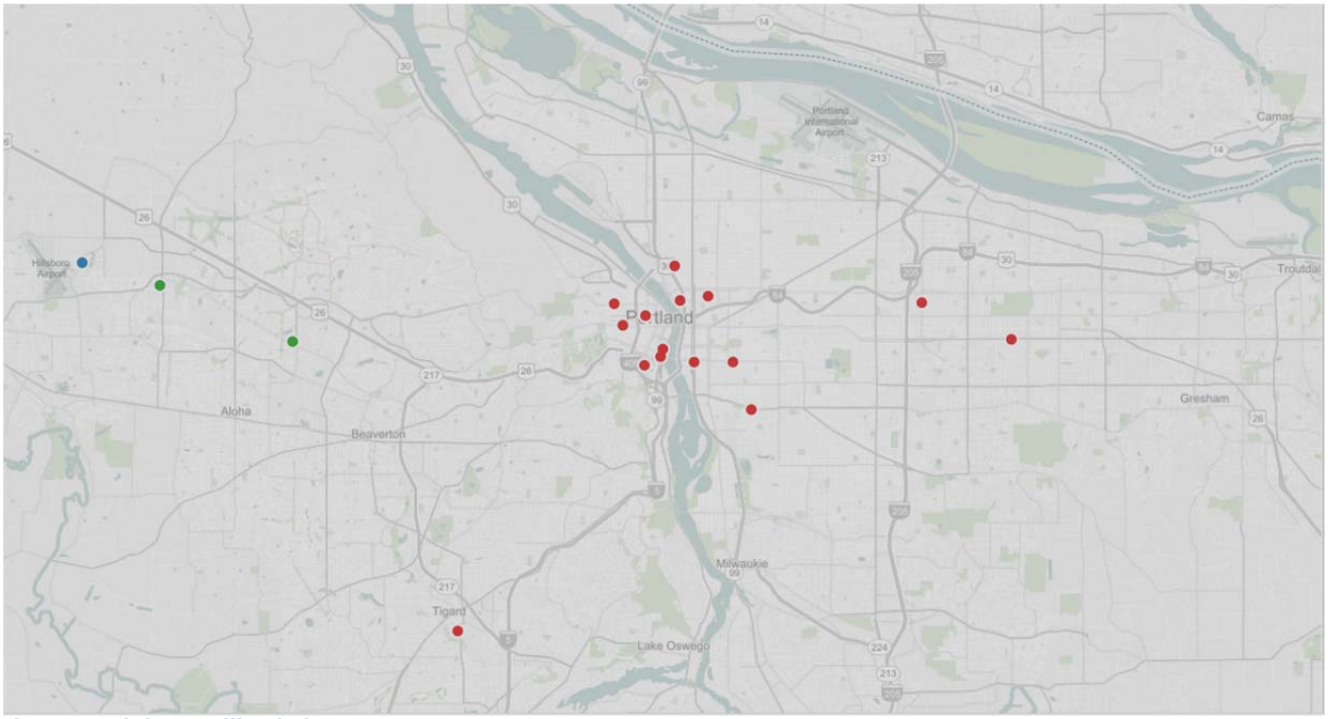

Figure 3. Highest utilized sites.

Table 5. Highest utilized sites.

Venue	Sub-Venue	Zone	Site Events/Wk	Avg Event Duration per EVSE (hours)	Number of Distinct Users
Public/Municipal	Parking Lot	High	48.0	3.7	11+
Retail	Retail – Big	High	24.5	0.5	65+
Parking lots	NA	High	24.1	2.9	36+
Fleet	NA	High	16.3	3.7	NA
Retail	Retail – Big	Medium	11.7	0.6	119+
Workplace	N/A	High	11.4	5.3	1
Retail	Retail – Big	High	7.6	1.0	182+
Medical	NA	High	7.6	1.4	113+
Medical	NA	High	7.3	1.5	63+
Retail	Retail – Small	High	7.3	2.1	8+
Leisure	Arts/Entertain.	High	7.2	0.7	114+
Retail	Retail – Big	High	6.8	0.4	324+
Fleet	NA	High	6.1	6.5	NA
Public/Municipal	Library	Low	6.0	0.6	49+
Retail	Shopping Mall	High	5.9	0.4	144+
Retail	Retail – Small	High	5.3	2.3	78+
Retail	Retail – Big	Medium	5.3	1.3	134+
Retail	Retail – Big	High	5.2	1.3	130+

It is also noted that the library listed in Table 5 is located in a low zone, but provides a significant number of programs and events.

Distinct Users

Access to non-residential EVSE varied throughout the project period. In the beginning, charging was open to all users with no access control. In 2012, access was changed to require the user to utilize a controlled access membership card. Later, fees for use were incorporated into most sites. Table 5 indicates the number of distinct users from the date of installation through August 2013 based on use of the EV Project Blink membership card. Those sites that include the "+" indicate the EVSE was utilized by PEV drivers other than those using a Blink membership card. While the number of distinct "guests" in each location is unknown, the magnitude of guest use is indicative of use by PEV drivers coming from a greater distance to use the charger. This wider draw significantly increases utilization and, from Table 5, appears to be related to large retail, medical, and entertainment venues. These are all venues that are equally accessed by local residents and by vehicles traveling from a greater distance to specifically visit that venue.

Low Utilization Sites

As noted above, location in a high utilization zone is no assurance of high utilization. Table 6 presents the 18 lowest utilized sites.

Table 6. Lowest utilized EVSE.

Venue	Sub-Venue	Zone	Events/Wk
Fleet	NA	Medium	0.04
Public/Muni.	Public Works	**High**	0.05
Workplace	Utility	Medium	0.10
Public/Muni.	Military	Low	0.11
Public/Muni.	Senior Center	**High**	0.11
Workplace	Utility	Medium	0.13
Public/Muni.	Public Building	Low	0.14
Public/Muni.	Military	Low	0.16
Public/Muni.	Parking Lot	**High**	0.16
Workplace	Utility	Low	0.18
Hotel	NA	**High**	0.20
Public/Muni.	City Hall	**High**	0.22
Medical	NA	**High**	0.24
Workplace	Utility	Medium	0.27
Workplace	Utility	**High**	0.28
Public/Muni.	City Hall	**High**	0.28
Public/Muni.	Public Services	Medium	0.31
Hotel	NA	**High**	0.38

None of these locations are involved in retail or services, thus missing the venue criteria considered important in the planning process for high EVSE utilization.

Electric Vehicle Owner Residential Locations

The EV Project's schedule enrolled vehicle owners starting in December 2010. Enrollment in the EV Project ceased at the end of January 2013. Figure 4 shows the home location of the EV Project's PEV drivers in the greater Portland area. The homogeneous distribution of locations shows that utilization of non-residential EVSE in any particular zone is not influenced by a nearby concentration of residences with PEVs.

Motivation of Host

As noted above, motivations for hosts in placement of EVSE at their locations varied, meaning low utilization of sites may not be due to its location in a low utilization zone. As can be seen in Table 6, several EVSE located in high utilization zones actually have low utilization. Examination of these sites shows that these sites typically have (1) EVSE poorly placed on the site, making it difficult to locate or use, (2) high traffic in their zone, but are located at a low traffic facility, or (3) were installed by the charging site host simply to showcase support for PEVs, without regard to utilization. These sites are not suitable at this time for high utilization.

Conclusions

The planning effort undertaken in the Portland area identified areas with predicted high utilization for non-residential EVSE. The EV Project was successful in deploying 74% of the available EVSE into the high utilization area. Data collected from these EVSE demonstrate that utilization is greater for EVSE installed in the predicted high utilization zones than for those installed in the predicted medium and low utilization zones.

Utilization data also show that placement of EVSE in the high zone is not sufficient to ensure high utilization. The venue for the charging site host, the EVSE location on that site, and the host's motivation for installing charge infrastructure are also important.

The high number of distinct users is indicative of the sphere of influence of any particular site. The two retail locations in the medium zone had a significant number of distinct users, indicating a large draw of users from outside their immediate areas.

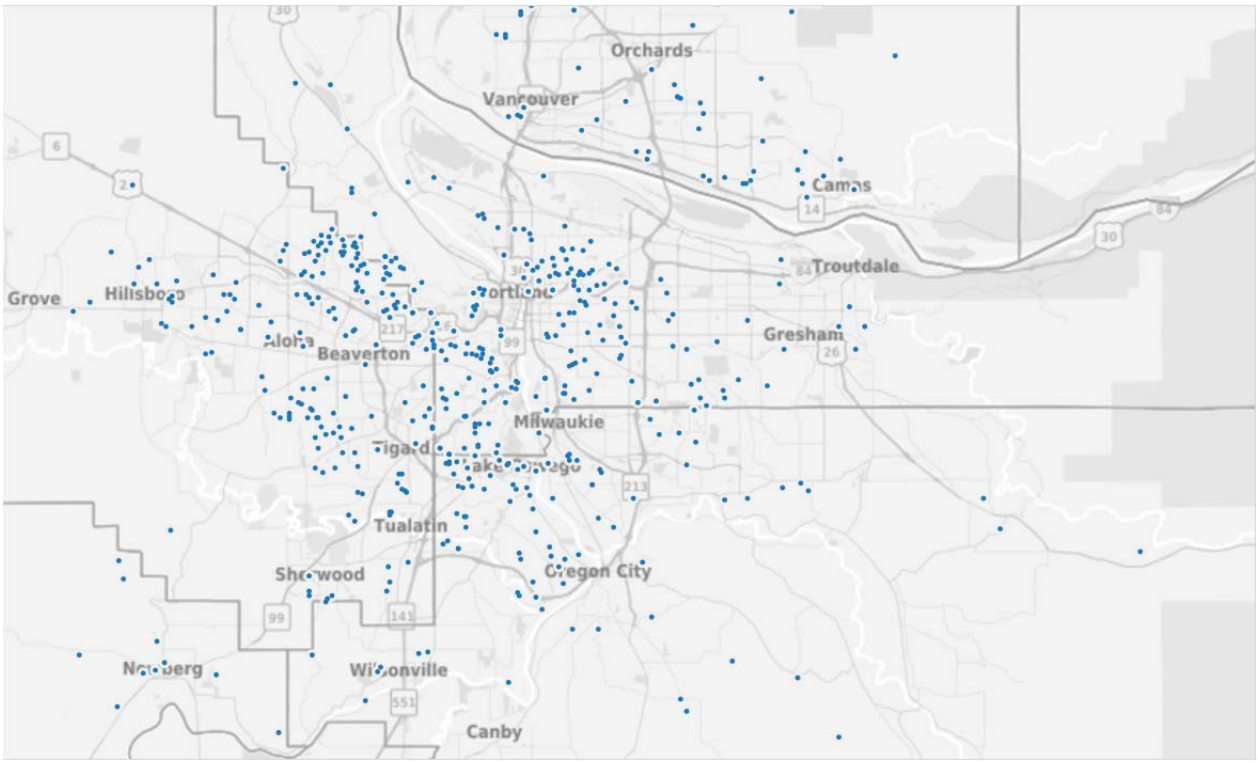

Figure 4. PEV drivers' home locations.

About The EV Project

The EV Project was the largest PEV infrastructure demonstration project in the world, equally funded by the U.S. Department of Energy (DOE) through the American Recovery and Reinvestment Act and private sector partners. The EV Project deployed over 12,000 alternating current Level 2 charging stations for residential and commercial use and over 100 dual-port direct current fast chargers in 17 U.S. regions. Project participants gave written consent for EV Project researchers to collect and analyze data from their vehicles and/or charging units. Data collected from the vehicles and charging infrastructure represented almost 125 million miles of driving and 4 million charging events. The data collection phase of the EV Project ran from January 1, 2011, through December 31, 2013. Idaho National Laboratory is responsible for analyzing the data and publishing summary reports, technical papers, and lessons learned on vehicle and charging unit use. Approximately 8,300 Nissan LEAFs™, Chevrolet Volts, and Smart ForTwo Electric Drive vehicles were enrolled in the project.

Company Profile

Idaho National Laboratory is one of DOE's 10 multi-program national laboratories. The laboratory performs work in each of DOE's strategic goal areas: energy, national security, science, and the environment. Idaho National Laboratory is the nation's leading center for nuclear energy research and development. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance.

For more information, visit avt.inl.gov/evproject.shtml.

References

[1]"How well did Non-residential EVSE Installations Match the Planned Areas in San Diego?" avt.inl.gov/evproject.shtml#Lessons Learned.

[2]"EV Micro-Climate Plan for Northwestern Oregon" avt.inl.gov/evproject.shtm#LessonsLearnedl.

[3]"The EV Micro-Climate Planning Process," lessons learned, http://avt.inl.gov/evproject.shtml#LessonsLearned.

[4]"Categorizing EVSE Venues: Describing Publicly Accessible Charging Station Locations," lessons learned, http://avt.inl.gov/pdf/EVProj/CategorizingEVSEVenuesSept2014.pdf.

Appendix A, Northwestern Oregon Public EVSE Location Planning

Approach

The EV Micro-Climate® planning process was developed during the EV Project as an integrated turn-key program to ensure an area is well equipped with the needed infrastructure to support the consumer adoption of electric transportation. Beginning with extensive feasibility and infrastructure planning studies, the program provided a blueprint to create a rich electric vehicle infrastructure.

The EV Micro-Climate process enlisted highly interested stakeholders in the region to provide local context, history, and drive for electric vehicle adoption. These stakeholders were active throughout the planning process. The Micro-Climate process focused the interests of this highly diverse group to produce three major planning documents. The evaluation of this Micro-Climate[3] planning process has been completed and is available for review.

The EV Micro-Climate process in northwestern Oregon produced three documents: "Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene" (April 2010), "Long-Range EV Charging Infrastructure Plan for Western Oregon" (August 2010), and the "EV Micro-Climate Plan for Northwestern Oregon" (November 2010). All documents are available at the same website referenced above.

Documents

The EV Infrastructure Deployment Guidelines provided indoctrination information and general guidance for starting the planning process. The Long Range Plan projected PEV population in the greater San Diego area by the year 2020, as well as the projected public charging infrastructure densities that would support this population. The EV Micro-Climate Plan for San Diego narrowed the future look to the next 2 to 3 years to provide direction for the near-term installation of publicly available EVSE provided by the EV Project.

Methodology

The stakeholders conducted a data search of state, regional, and local data that could be useful in locating EVSE. Initial inquiries included geographical information system data for the following:

- Traffic volumes (state and local)
- Employment location information by industry type
- Zoning classifications from the cities.

The three categories were used to create multiple data layers and associated values mapping. A combined, single map was then produced to show proposed density and distribution patterns for EVSE by using multivariate analysis. The analysis resulted in three categories: high, medium, and low, reflecting the anticipated utilization of non-residential EVSE to be located within those geographic areas. Figure A1 shows this density map for the greater Portland area.

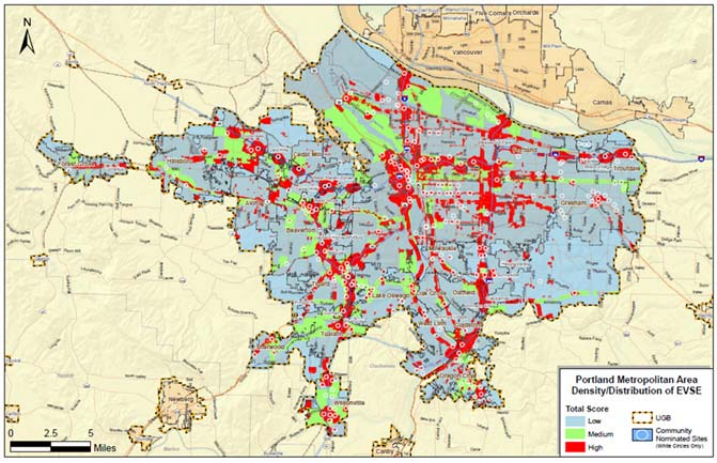

Figure A1. Greater Portland region of the EV Project.

There may be many different motivations for the host in locating public EVSE, including generation of revenue from fees, promoting a public environmental image, encouraging patronage by the PEV driver demographic, and providing range extension for PEV drivers. The stakeholders determined that optimum locations for publicly accessible EVSE would be those with the following:

- High number of users
  - Integrated into daily life
  - Available to many different users
- High frequency of vehicle turnover
  - Vehicle stay times of 45 minutes to approximately 3 hours
- Significant availability
  - Maximize the number of open days per week and per year
  - Maximize the number of open hours per day.

Following the process outlined above, a significant effort was made to solicit input from the cities and public on the map. Most suggested locations were already identified in the high or medium areas. Very few public locations were in low areas. Consequently, the map in Figure A1 was used by the regional manager as the focus for sites for non-residential EVSE.