Do Plug-In Electric Vehicle Drivers Park near Publicly Accessible Electric Vehicle Supply Equipment in San Diego but Not Use Them?

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Key Conclusions

- The EV Project installed 545 non-residential fleet, workplace, and publicly accessible electric vehicle supply equipment (EVSE) units at 164 sites in the San Diego region.
- Seven of the 139 sites reporting data accounted for 25% of all instances of plug-in electric vehicles (PEVs) participating in The EV Project parking near (i.e., within 300 ft) an EVSE installed by The EV Project and, further, accounted for 41% of all charging events at all of these sites.
- For both the Leaf and Volt drivers, approximately 3% of all away-from-home parking events were within 300 ft of an EV Project-installed EVSE and approximately 7% of all PEV away-from-home parking events included a charge event at any available EVSE.
- An average of 26% of EV Project PEVs that parked near (i.e., within 300 ft) an EVSE site installed by The EV Project actually charged at that site, with Leaf drivers charging more frequently than Volt drivers.
- An average of 6% of EV Project PEVs that parked away from home but not near (i.e., within 300 ft) an EVSE installed by The EV Project was charged by some means other than EV Project EVSE.
- The probability of a PEV charging if it parked near (i.e., within 300 ft) a non-residential EVSE in The EV Project was approximately 1 in 4.
- The EV Project's non-residential EVSE venues attracting the most parking were workplace, retail (both shopping malls and large retail chains), and parking lots. The venues attracting the most charging were workplace and shopping malls.

Introduction

PEV charging stations deployed as part of The EV Project included both residential and non-residential sites. Non-residential sites included EVSE installed in workplace environments, fleet applications, and publicly accessible locations near retail centers, parking lots, and similar locations. The EV Project utilized its Micro-Climate® planning process to determine potential sites for publicly accessible EVSE in San Diego. This process worked with local stakeholders to target EVSE deployment near areas where significant PEV traffic and parking was expected. This planning process is described in *The Micro-Climate Deployment Process in San Diego.*[1]

The EV Project issued its deployment plan for San Diego in November 2010, prior to the sale of PEVs by Nissan and Chevrolet. The project deployed residential EVSE concurrent with vehicle delivery starting in December 2010. The installation of non-residential EVSE commenced in April 2011, consistent with the original project schedule, closely following the adoption of PEVs. The residential participation portion of The EV Project was fully subscribed by January 2013 and the non-residential EVSE deployment was essentially completed by August 2013.

A prior report titled, *How Well Did Non-Residential EVSE Installations Match the Planned Areas in San Diego?,*[2] reported that 98% of the deployed non-residential EVSE were installed within the planned target areas. A comparison of EVSE utilization of those installed within and outside the planned areas was investigated; however, so few EVSE were installed outside the planned area in San Diego that a comparison would not be useful. The greater Portland, Oregon area was considered instead for this evaluation because of similar characteristics and the planning process. The *How Does Utilization of Non-Residential EVSE Compare Between Those Installed in Planned vs. Unplanned Locations?* [3] paper identified 87% greater utilization of EVSE in planned locations vs. unplanned locations and their "connect times" were 4.4 times as long. The question then remains whether vehicles actually park in significant numbers near these installed locations and whether they charge while parked there.

Analysis Approach

The EV Project participants provided consent for EV Project researchers to collect and analyze data from their vehicles and charger use. Throughout the planning process, it was assumed that EVSE would have a quarter-mile radius of influence (i.e., a person would likely walk up to 1/4 of a mile from the EVSE where their vehicle is charging to their desired destination. However, actual practice suggests that this distance may be too far. A more conservative distance of approximately 300 ft (i.e., the

length of a football field) was subsequently identified for analysis purposes. Figure 1 shows the relative size of these two distances.

Figure 1. Comparison of 1/4-mile and 300-ft radii circles.

The area shown in Figure 1 is a single 1/4-mile radius circle around an EVSE site; it includes five separate 300-ft radius circles, with four around other EVSE sites. A close inspection reveals that a person would need to walk several blocks from the EVSE to a destination a quarter of a mile away. A person would need to be highly motivated (i.e., actually needing the charge) to walk an equivalent of 4.5 football fields to and from the charge location.

Based on this information, the analysis approach involved identifying a 300-ft radius circle (i.e., EVSE zone) around each of The EV Project's installed EVSE sites, identifying the number of times a PEV participating in The EV Project parked within that EVSE zone, and determining the number of times it charged at the EVSE unit.

The period from July 1 to December 31, 2013, was chosen for the analysis because the non-residential EVSE infrastructure was essentially fully deployed and PEV drivers were well aware of the EVSE locations by that time. In addition, access fees had been in place for approximately one year; therefore, changes in fee structures would not influence the decision to charge or not.

Data collected from project participant vehicles were used to identify trip end points away from the participant's home. EV Project data correlation was used to identify which of these trip end points was near a non-residential EVSE installed by The EV Project and resulted in a vehicle charge event. The trip end point was identified by a "key-off" event; therefore, duration of the parking event was not identified. It is possible that the PEV driver decided not to charge because the stay was of a short duration and the energy received by charging would be insignificant.

In Figure 1, the yellow star identifies a non-residential EVSE, the pink dots identify vehicle trip end points that correlate with a charge event, and the green dots identify vehicle trip end points that did not correlate with a charge event.

Some of the EVSE zones overlap, placing some vehicle trip end points and charge events in more than one EVSE zone. The number of events in overlapping zones is counted and adjusted in the analysis.

An inspection of Figure 1 reveals some charge events that occur outside the 300-ft EVSE zone. These events may have occurred at EVSE not installed by The EV Project (for which no data are available) and are not included in this evaluation. Some charge events appear to be located outside the center point of the circle. This may be due to global positioning system coordinate tolerances in vehicle reporting data, which is adjusted in the analysis.

Data were segmented by Nissan Leafs and Chevrolet Volts, producing results that can be separated for analysis by vehicle type.

Data Analysis Results

Figure 2 shows the locations of deployed non-residential EVSE at 164 sites in the San Diego region. Most of these sites contain multiple EVSE.

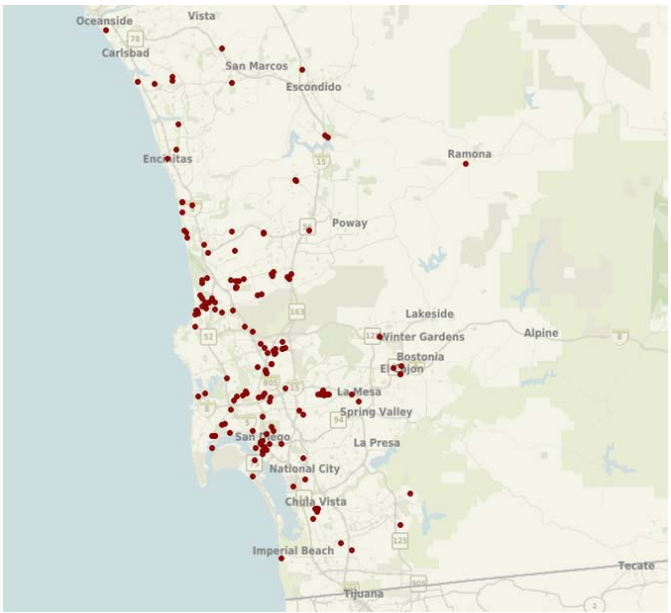

Figure 2. Non-residential EVSE locations in the San Diego region.

The data set used for this analysis contains information from 139 sites that provided data during the analysis period. Parking data points in overlapping 300-ft EVSE zones accounted for 3% of the total site events. After subtracting the overlap parking counts to eliminate double counting, the final results for this analysis are shown in Table 1.

Table 1. Vehicle parking locations.

Vehicle	Parked in Zone	Charged in Zone	Percent of Park Events Charged
Leaf	4,974	1,421	29%
Volt	3,095	705	23%
Total	8,069	2,126	26%

In summary, 26% of project participant PEVs that park within 300 ft of EVSE installed by The EV Project actually charged at that EVSE. Leaf drivers tended to charge more often when parked in a zone than Volt drivers.

During this same period, the total Leaf and Volt events away from home are shown in Table 2.

Table 2. Away-from-home charging and parking events.

Vehicle	Parked Away from Home	Charged Away from Home	Percent of Park Events Charged
Leaf	124,150	8,736	7%
Volt	107,933	7,821	7%
Total	232,083	16,557	7%

The planning process for San Diego identified target areas for deployment of non-residential EVSE. Overall, the project was 98% successful in installing EVSE in the target areas. These 139 sites are not the only locations where PEVs may park; Table 3 summarizes the away-from-home events that do occur in the EVSE zones.

Table 3. Away-from-home parking.

Vehicle	Parked Away from Home	Parked in Zone	Percent of Park Events
Leaf	124,150	4,974	4%
Volt	107,933	3,095	3%
Total	232,083	8,069	3%

Subtracting the events in the zone from all away-from-home charging yields the results of Table 4.

Table 4. Away-from-home events out of the EVSE zones.

Vehicle	Parked out of Zone	Charged Out of Zone	Percent of Park Events Charged
Leaf	119,176	7,315	6%
Volt	104,838	7,116	7%
Total	224,014	14,431	6%

In summary, 3% of the time a project participant PEV parked away from home, it parked near a non-residential EVSE installed by The EV Project. Once there, it charged 26% of the time.

All of the other times (i.e., 97%) when a project participant PEV parked away from home and not near a non-residential EVSE installed by The EV Project, it charged only 6% of the time.

Further Analysis

Top Parking Analysis

All of the 139 EVSE zones analyzed recorded at least one park event during the evaluation period. When sorting these zones by venue type, the relative contribution to parking events by venue is displayed in Figure 3.

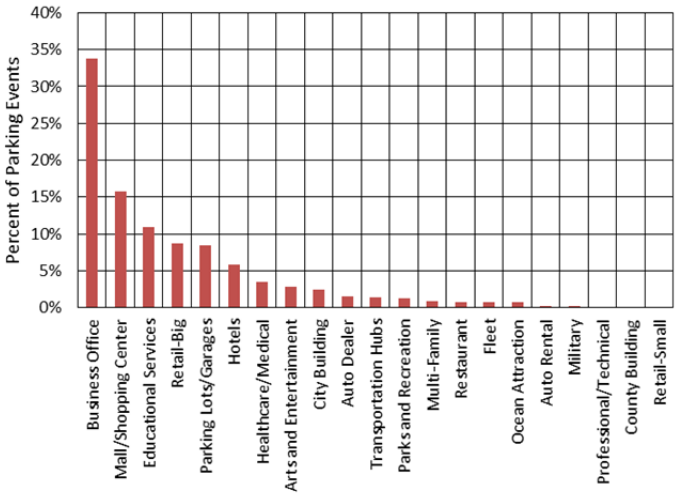

Figure 3. Distribution of parking events by venue.

While all EVSE zones had some activity, not all zones were highly utilized. The top 20 EVS zones (14%) accounted for 52% of all parking events and 51% of all charge events. Table 5 summarizes these zones by venue and overall utilization.

Table 5. Top parking location venues.

Primary Venue	Secondary Venue	Parking Events (%)	Charging Events (%)
Workplace	Business Office	21	29
Retail	Shopping Mall	9	2
Retail	Retail - Big	8	10
Parking Lot	Parking Lot	6	5
Education	Education	4	2
Public	City Hall	2	1
Leisure	Arts & Enter.	1	2
Retail	Auto Dealer	1	0

It is interesting to note that four shopping malls were included in the top zones for parking events; however, two of them had zero charge events. Similarly, the auto dealer had 98 parking events, but only one charging event.

The workplace/business office is also of interest to determine whether the high utilization is due to employee charging or public charging. Five workplace locations were in the top 20 EVSE zones. Parking information for these zones is shown in Table 6. The distinct number of vehicles indicates that many different vehicles were responsible for the parking and charging events.

Table 6. Distinct vehicles at workplace locations.

EVSE Zone	Distinct Leafs	Distinct Volts
1	15	1
2	10	4
3	18	8
4	4	1
5	11	7

Because six months of data were included in the data set, the maximum number of work days would be approximately 130. For analysis purposes, it was assumed that an employee would be involved in 104 or more parking events. (This is conservative because an employee may leave the site for lunch and return, thus, recording another site visit.) Four vehicles in the above five EVSE zones park at a particular site more than 104 times in the period. One of these vehicles charged more than 75% of the visits. Thus, these workplace locations are more frequently utilized as public charging locations than employee locations.

Top Charging Analysis

Twenty-six EVSE zones (19%) recorded an average of one or more charge events per week during the July 1 to December 31, 2013, evaluation period. Figure 4 presents distribution of all charging events by venue.

The top eight EVSE zones recorded 49% of all charge events and also represented 29% of all parking events. While parked in these eight zones, vehicles charged, on average, 57% of the time. These EVSE zones represent the venues noted in Table 7.

Table 7. Top venues for charging events.

Primary Venue	Secondary Venue	Charging Events (%)	Parking Events (%)
Workplace	Business Ofc	36	22
Retail	Shopping Mall	5	3
Medical	Healthcare	3	1
Education	Education	3	1
Parking Lot	Parking Lot	2	2

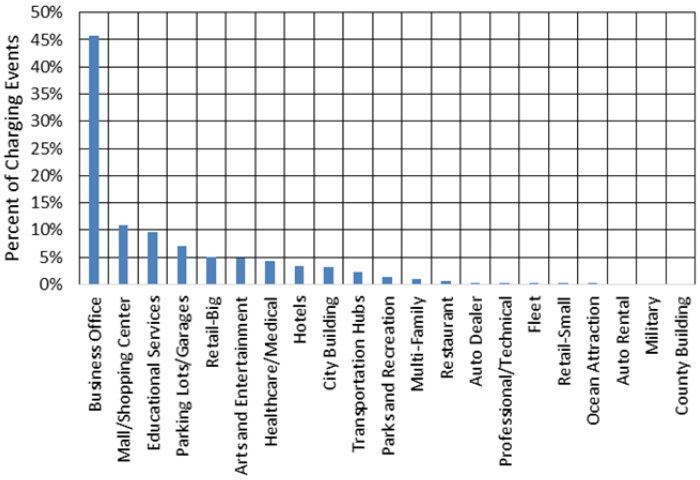

Figure 4. Distribution of charging events by venue.

Six of these eight zones were included in the top parking sites. Four workplace locations are combined in the first row of Table 7. These are also included in Table 5; therefore, charging events and parking events are related to public use rather than employee use.

Forty-seven EVSE zones (34%) recorded no charge event by project participant PEVs in the last 6 months of 2013, although there was a combined 1,326 parking events and some recorded up to 234 PEV parking events within the 300-ft zone. Seventeen different venue types are represented by these sites. The reason these sites were not attractive for charging is unknown. Reference 4 explored the attitudes of PEV drivers in charging away from home and may provide insight. In addition, the durations of the parking events are unknown and some events may have been too short to provide sufficient recharge energy to be of interest to the PEV driver.

Charging Utilization Analysis

The percentage of charging events per parking event was investigated independent of the frequency of either parking or charging. For example, an EVSE zone with one parking event that results in a charge event will have a charging percentage of 100%. While the charging percentage for zones of only one visit may not be of interest, it may be illuminating to identify the zones with both highest charging percentage and frequent charging events.

Ten sites, with nine different venues types, had more than 26 charging events and greater than 60% charging percentage (i.e., the zone averaged one or more charge events per week and more than 60% of the vehicles that parked in the zone charged there). The locations of these EVSE zones are shown in Figure 5.

The number of parking events at these EVSE zones ranged from 36 to 170. Thus, these are not the most frequented places because other EVSE zones had

significantly more parking events. Only one of these zones is included in the top parking analysis discussed above. The reason these zones are charging attractions is not known. However, this does lead to the next investigation relating to the frequency of visits.

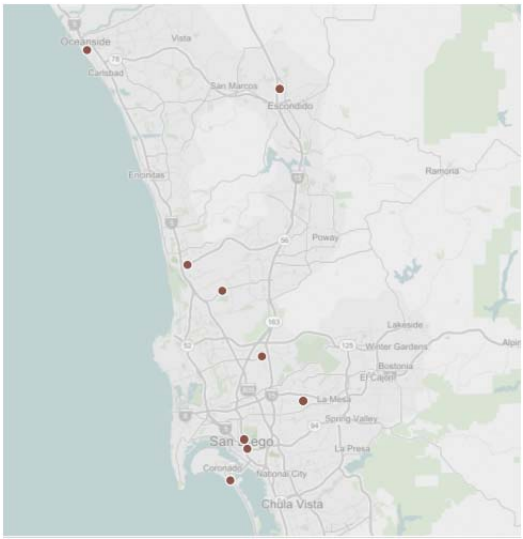

Figure 5. EVSE Zones with highest number of charge events and high charging percentage.

Results from investigating the frequency of parking events and their charging percentages are shown in Table 8.

Because there were 26 weeks of data, the number of parking events greater than 156, for example, can also be identified as those sites having an average of 6 or more parking events per week.

Table 8. Average charging percentages by parking events per week.

Number of Parking Events	Number of Sites	Average of Charging Percent
All sites	139	26%
>26	77	26%
>52	53	26%
>78	28	26%
>104	17	25%
>130	16	24%
>156	11	29%
>182	7	28%
>208	6	32%
>234	5	27%
>260	4	33%
>286	3	40%

Eliminating the top three workplace sites, it appears that the probability of a vehicle charging if it parks within 300 ft of an installed EVSE is about 1 in 4 regardless of the number of vehicles that will park in that area and regardless of the venue type.

Conclusions

Ninety-eight percent of The EV Project's deployed EVSE units are in locations that were targeted in the San Diego planning process. The process identified these sites as anticipated high vehicle parking destinations. Data show that the 300-ft zone around these EVSE sites accounted for 3% of all away-from-home parking events. (Analysis of PEV driver parking behavior away from home was reported in Reference 5.)

The planning process assumed that PEVs would charge were they parked. For the 139 sites reporting data in the last half of 2013, 34% had zero charging events recorded, although, combined, they had a total of 1,326 parking events. The PEV drivers' attitudes in using away–from-home charging are the subject of another report (Reference 4).

For vehicles that parked within 300 ft of EVSE installed by The EV Project, the vehicle charged 26% of the time. This is compared to charging 6% of the time elsewhere. Leaf drivers tended to charge more frequently than Volt drivers when parked within an EVSE zone.

For both Leaf and Volt drivers, approximately 3% of all away-from-home parking events were within an EVSE zone and approximately 7% of all PEV away-from-home parking events included a charge event.

Even though several non-residential EVSE were installed in workplace locations, they are frequently utilized as public charging locations.

About The EV Project

The EV Project was the largest PEV infrastructure demonstration project in the world, equally funded by the United States 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. Approximately 8,300 Nissan LEAFs™, Chevrolet Volts, and Smart ForTwo Electric Drive vehicles were enrolled in the project.

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.

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 and avt.inl.gov/chargepoint.shtml.

References

[1]*The Micro-Climate Deployment Process in San Diego,* Lessons Learned, avt.inl.gov/evproject.shtml.

[2]*How Well Did Non-Residential Electric Vehicle Supply Equipment Installations Match the Planned Areas in San Diego,* Lessons Learned, avt.inl.gov/evproject.shtml.

[3]*How does Utilization of Non-residential EVSE compare between those installed in Planned vs. Unplanned Locations?* Lessons learned, avt.inl.gov/evproject.shtml

[4] *How Do The EV Project Participants Feel About Charging Their EV Away From Home?*, http://avt.inl.gov/pdf/EVProj/EVProjectParticipantsAndAwayFromHomeCharging.pdf.

[5]*Characterize PEV Driver Away-From-Home Parking behavior in San Diego*, avt.inl.gov/evproject.shtml.