Are Plug-In Electric Vehicle Driver Preferences an Effective Method for Siting Publicly Accessible Electric Vehicle Supply Equipment?

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Key Conclusions

- As a partner in The EV Project, the University Of California Davis (UCD) surveyed 461 participants in The EV Project from the San Diego area and requested their preferences for locations of publicly accessible charging stations.
- Respondents provided 172 specific locations for alternating current (AC) Level 2 electric vehicle supply equipment (EVSE) locations.
- Respondents generally provided thoughtful locations that would be an attractive general plug-in electric vehicle (PEV) charging location, but which were also predicted by the planning process.
- Twelve of the participant-specific locations were not predicted by the San Diego planning process.
- Actual vehicle parking data collected during The EV Project showed that none of these 12 locations were ones where PEV drivers frequently parked.
- Asking PEV drivers to predict where they and other PEV drivers would like to have EVSE is not a replacement for an effective planning process to locate EVSE for public use.

Introduction

The lack of public charging infrastructure for PEVs has been identified as a barrier to their widespread adoption. Federal and state grants have been awarded to promote public charging infrastructure, and retail businesses have shown interest in installing charging infrastructure. A common question for electric vehicle service providers is "Where should the chargers be placed?"

In the early stages of PEV delivery to local markets, the options were as follows:

- Plan locations that are associated with destinations where PEV parking is anticipated
- Solicit retail and public charging hosts for voluntary placement
- Ask early adopters where they want public infrastructure
- Select sites near known high-traffic areas.

The EV Project chose to utilize a planning process for locating charging infrastructure. The planning process used for San Diego was the EV Micro-Climate® process.[1]

The EV Project schedule provided for development of the deployment plan in November 2010, just prior to delivery of the first Nissan Leafs and Chevrolet Volts. The project delivered residential EVSE concurrent with vehicle delivery, starting in December 2010. Installation of non-residential EVSE commenced in April 2011. This was consistent with the original EV Project plan to schedule deployment closely following delivery of PEVs.

The residential participation portion of The EV Project was fully subscribed by January 31, 2013, and the non-residential EVSE deployment was effectively completed by August 2013. Further, 98% of the installed EVSE in the San Diego area were deployed within the original plan target areas.[2]

Concurrent with deployment of these non-residential EVSE, UCD's Institute of Transportation Studies conducted participant surveys of select EV Project participant volunteers.[3] The surveys were conducted in mid-2012 and solicited input from 461 Leaf and Volt owners residing in the greater San Diego are and who were participating in The EV Project.

Some of the questions in the survey requested respondents to identify locations where they would like to see publicly accessible EVSE. By the time the results of the survey were available, installation of publicly accessible EVSE provided by The EV Project was well underway using the Micro-Climate process. Therefore, the survey participants' desired locations were not able to be considered in the final deployment plan.

The paper addresses the following issues:

1. Do the locations identified by survey participants coincide with the Micro-Climate's high priority planned locations?
2. Do the installed EVSE satisfy locations identified by survey participants?
3. Are participant vehicles parking in the locations identified by survey participants?

4. Can PEV driver preferences for desired locations be effective in siting publicly accessible EVSE?

University of California Davis Survey Summary

The survey was conducted in several parts and included San Diego and other regions of California. The San Diego results are of interest in this document.

The survey was conducted online through a web interface that enabled participants to place locations on a map. “For the most part, the web interface was a success, although the placement of common locations appeared problematic for approximately 20% of respondents. This was most probably due to the complexity and wording of the questions.”[4] The drivers’ willingness to pay for charging was not explored in the survey.

“Leaf drivers want to be able to go slightly farther with their vehicle than currently possible by placing chargers farther away than the chargers they are currently using.”[5] Two strategies for placing these EVSE were evident: (1) regional siting, where new EVSE allowed the expansion of range within the home territory and (2) trans-regional siting where direct current fast charger locations could expand range beyond the current region. An example would be to allow a driver in San Diego to drive the Leaf to locations in the Los Angeles area.

The UCD survey included driver response preferences for both AC Level 2 EVSE and direct current fast chargers. “The main desire is for quick charging. Quick chargers are wanted at regional attractors such as downtowns, large malls, airports and other regional services. Quick charging connecting adjacent regions was also indicated by respondents.”[6] Only the AC Level 2 EVSE locations are analyzed herein.

Driver Desired Locations

Figure 1, taken from the Reference 3 report, identifies PEV driver preferences for charger types and locations. Further, 1,362 chargers were desired, with only 29% totally within the San Diego area. Because only the Leaf has fast charge capability, the desire for direct current fast chargers well north of the San Diego and the Los Angeles area suggested that some Leaf drivers planned to be quite aggressive in extending the range of their vehicles.

In the Micro-Climate planning process, the geographic model was the Master Geographic Reference Areas (MGRA), which is a proprietary data unit designed and used by the San Diego Association of Governments. The 18,756 MGRAs are geographic areas roughly the size of census blocks in urban and suburban areas, and census block groups in rural areas. MGRAs are designed to nest into larger standard geographies, such as census tracts, zip codes, and municipal boundaries. MGRAs are polygon shapes rather than points, but contain the points of interest that were expected to attract PEV drivers. An MGRA may contain more than one point of interest.

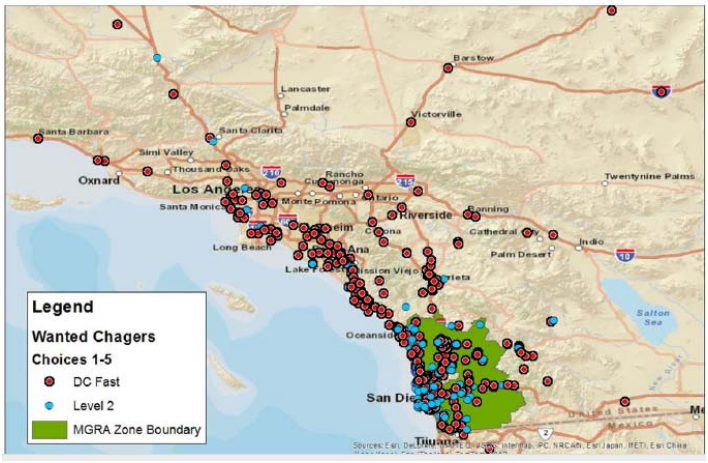


Figure 1. Charging locations wanted by San Diego PEV drivers.

Several factors were considered when evaluating the suitability of an MGRA for its attraction to PEV drivers; all MGRAs were rated. The top rated 3,333 MGRAs, of the total 18,756 MGRAs, were selected in the Micro-Climate process to be target sites. The solicitation of charging site hosts proceeded with these target locations. Reference 2 reported that 98% of the deployed AC Level 2 EVSE were placed within these target areas.

Figure 2 presents the AC Level 22 EVSE locations within only the San Diego area that PEV drivers indicated that they wanted in response to the UCD survey.

In Figure 2, the green points were identified both by drivers participating in the UCD survey and by The EV Project Micro-Climate process. The red points were identified only through the UCD survey. A total of 172 total locations were identified. The predicted versus unpredicted demand categories are defined below.

UCD compared the PEV driver desired charger locations to its top rated 1,000 MGRAs. Buffers of 1/8 mile, 1/4 mile, 1/2 mile, 1 mile, 2 miles, and 5 miles around each of the 1,000 MGRAs were analyzed. The results are presented in Figure A-1 of Appendix A and were taken from the Reference 2 report.

In summary, 20% of the PEV drivers’ desired locations were within the top 1,000 MGRAs and 73% were within 1/4 mile (440 yards) of the MGRA. The planning process assumed that a PEV driver would walk up to 1/4 mile from a desired charging location.

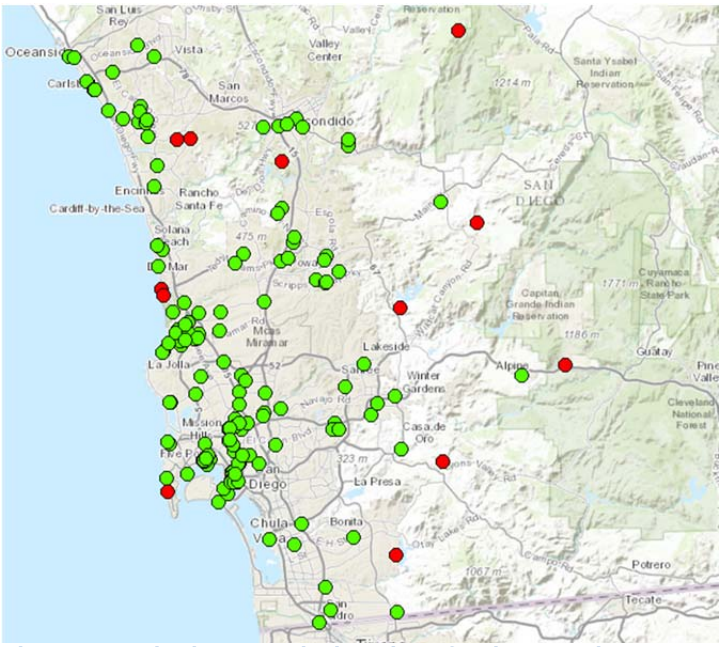


Figure 2. Desired AC Level 2 locations for the San Diego PEV driver.

The UCD analysis placed 1-mile buffers around the top 1,000 MGRAs to define "predicted" locations. The EV Micro-Climate planning process identified 1/4-mile buffers around the top 3,333 MGRAs. Thus, a comparison between the evaluations is not directly applicable. However, a detailed look at the PEV drivers' desired chargers can be examined.

Predicted Alternating Current Level 2 Demand

UCD provided the mapping interface for driver preferences. The global positioning system coordinates of the 172 responses are shown in Figure 2. It is difficult to interpret the respondents' specific intent in identifying some of these locations, because a detailed investigation of the global positioning system coordinates does not reveal any specific reason for selecting the location. For example, Figure 3 shows several driver-preferred locations in San Diego. Several identifiers are located in Petco Park, several located near Harbor Drive and the convention center, and one at Horton Plaza. All of these can be classified; however, there are three others that are near no specific attraction and are likely the desire for stations in the general San Diego region.

The paper titled, *Categorizing Electric Vehicle Supply Equipment Venues: Describing Publicly Accessible Charging Station Locations,*[7] was used where possible to categorize these driver preferences. The close evaluation of each global positioning system location suggests the following as the intent of the drivers surveyed.

General locations included areas such as San Diego, Chula Vista, Escondido, Point, Loma, and Oceanside. The transportation hub was the San Diego airport. Arts and entertainment included Petco Park, Balboa Park, and San Diego Wild Animal Park. Malls and shopping centers included Carmel Mountain Plaza, Fashion Valley, Clairemont Town Square and Westfield Mission Valley. Ten of the locations appeared to be simply the intersection of two major roadways. Finally, eleven locations were in residential, wilderness, or other locations that could not be readily classified. These could have been specific areas of interest to the respondent or indicative of the issues identified by UCD in collecting the responses (Table 1).

Figure 3. San Diego select locations.

Table 1. San Diego identified locations.

Venue	Sub-Venue	Quantity
General Location		56
Retail	Mall Shopping Center	33
Retail	Retail Big	1
Leisure	Arts and Entertainment	23
Leisure	Parks and Recreation	10
Transportation Hub		13
Education		6
Medical	Medical/Healthcare	5
Workplace	Business Office	4
Intersecting Freeways		10
Unknown		11

In general, these responses appear to be thoughtfully considered as locations of attraction to PEV drivers, with 160 of these locations being in planned demand areas where an attraction was anticipated in The EV Project Micro-Climate process.

Unpredicted Alternating Current Level 2 Demand

Twelve points represent charging locations that the PEV drivers identified as desirable but were not within 1 mile of the top 1,000 MGRAs. The following four questions were investigated for these 12 points. Note; the "FID" number is

a reference to the UCD point id.

1. Do the locations identified by survey participants coincide with the Micro-Climate high priority planned locations?

Table 2 presents the 12 locations desired by drivers participating in the UCD survey, but that were not near an attraction identified by The EV Project Micro-Climate process. Two of the locations in Table 2 are located within the original Micro-Climate planning target areas. FID locations 79 and 155 are recreation areas near the coast and may be attraction sites. While some of the remaining eight may have been intended to be general vicinity locations by the respondents of the survey, all appear to be very specific locations.

Table 2. Unpredicted driver demand locations.

FID	Location	3,333 MGRA	Comment
12	Near Escondido	No	Residential area
44	North of Lakeside	No	San Vicente Reservoir
48	Mountains east of Ramona	No	Residential area
49	Hellhole Canyon Preserve	No	Wilderness area north of Ramona
73	I-8 east of Alpine	Yes	Viejas Outlet Center
79	Coast south of Del Mar	No	Torrey Pines State Natural Reserve
84	Jamul	No	Wilderness
94	La Costa	No	Residential area
98	SW of San Marcos	Yes	Shopping area
137	West side of Lower Otay Lake	No	U.S. Olympic Training Center
155	Coast south of Del Mar	No	Torrey Pines Park
168	NSC, San Diego Point Loma	No	Naval facility

2. Do the installed EVSE satisfy locations identified by survey participants?

Of particular interest here are four attraction areas from Table 2 (shown in Table 3).

None of the installed AC Level 2 EVSE are close enough to serve these desired locations.

3. Are participant vehicles parking in the locations identified by the survey participants?

Reference 8 investigated the 21,636 distinct locations where EV Project vehicles in the San Diego area parked during the last half of 2013. Table 4 identifies whether the 12 locations desired by drivers participating in the UCD survey, but that were not near an attraction identified by The EV Project Micro-Climate process are locations where PEVs park.

Table 3. Unpredicted locations in relation to installed AC Level 2 EVSE.

FID	Location	Near Publicly Accessible EVSE	Comment
73	Viejas Outlet Center	No	18 miles away
79	Torrey Pines Reserve	No	2.4 miles away
98	Shopping area	No	3.6 miles away
155	Torrey Pines Reserve	No	2.8 miles away

Table 4. PEV parking frequency in unpredicted locations.

FID	Location	Frequent Park Location	Quantity of Parking Events
12	Near Escondido	No	0
44	North of Lakeside	No	0
48	Mountains east of Ramona	No	8
49	Hellhole Canyon Preserve	No	0
73	I-8 east of Alpine	No	40
79	Coast south of Del Mar	No	150
84	Jamul	No	3
94	La Costa	No	1
98	Southwest of San Marcos	No	60
137	West side of Lower Otay Lake	No	6
155	Coast south of Del Mar	No	20
168	NSC, San Diego Point Loma	No	140

The Reference 8 report identified 232,083 parking events in the last half of 2013. Each of the above locations contributed less than 0.06% of the parking events and would not be considered a frequent parking location.

4. Can PEV driver preferences on desired locations be effective in siting publicly accessible EVSE?

The PEV drivers participating in the UCD survey were asked where they would like chargers placed. The vast majority of the responses appear to be very thoughtful because the locations appear to be general attractors for PEV drivers. Nevertheless, the locations identified that

were outside the planned areas were not helpful in selecting sites for publicly accessible EVSE.

The preferences displayed in Figure 1 that are in the Los Angeles area and further from the San Diego region appeared quite aggressive for Leaf drivers. However, many drivers actually made these trips. The green dots in Figure 4 are trip end points of Nissan Leafs from residences in the San Diego region. These are cumulative end points by December 2012.

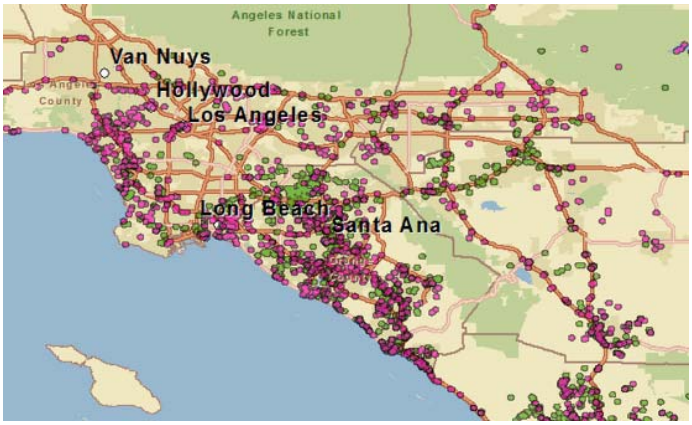


Figure 4. San Diego Leaf and Volt trip end points, December 2012.

Conclusions

The majority of the locations identified by PEV drivers participating in the UCD survey were already identified in The EV Project's Micro-Climate planning process. The drivers identified areas of attraction where PEVs are likely to park, as did the formal planning process. Asking PEV drivers where they might want publicly accessible AC Level 2 EVSE placed may not an effective method for site selection. Individuals may express locations that only apply to their self-interest rather than choosing charging locations that may benefit all PEV drivers. Careful selection of the phrasing of the questions will be important. Expectations from respondents may include anticipation that their responses will be considered in the final placement of EVSE, which may not be the case. The questions may be more relevant after the PEV drivers have experience with their PEV and the infrastructure is well established.

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 AC Level 2 charging stations for residential and commercial use and 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]http://avt.inl.gov/pdf/EVProj/EVMicroClimatePlanningProcessV1.0.pdf.

[2]"How Well Did Non-Residential Electric Vehicle Supply Equipment Installations Match the Planned Areas in San Diego?" December 2014.

[3]"California Statewide Charging Survey: What Do Drivers Want?," UCD-ITSRR-13-14, Nicolas, Tal, Woodjack, Scrivano.

[4]ibid.

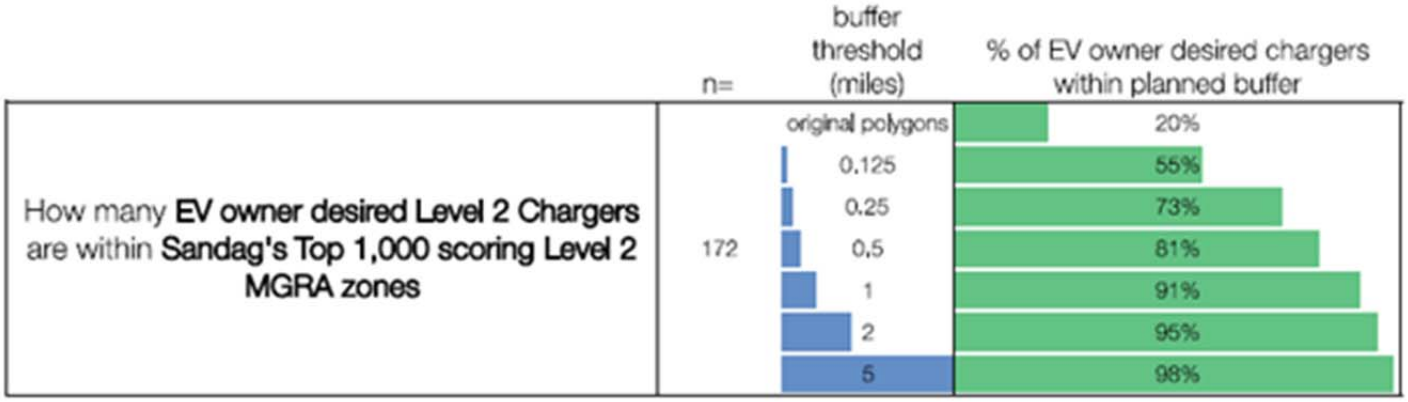
[5]ibid.

[6]ibid.

[7]"Categorizing EVSE Venues: Describing Publicly Accessible Charging Station locations," http://avt.inl.gov/pdf/EVProj/CategorizingEVSEVenuesSept2014.pdf.

[8]"Characterize PEV Driver Away-From-Home Parking Behavior in San Diego," avt.inl.gov/evproject.shtml.

Appendix A



A-1. UCD analysis of desired charger locations.

In summary, 20% of the PEV drivers' desired locations were within the top 1,000 MGRAs and 73% were within 1/4 mile (440 yards) of the MGRA.