THE EV Project

How do Residential Level 2 Charging Installation Costs Vary by Geographic Location?

April 2015

Key Conclusions

- During the EV Project, the average (mean) cost for installation of a residential Level 2 charging unit (including permit fees and service upgrades, but excluding charger cost) was $1,354.
- The median installation cost was $1,200.
- The Los Angeles market had the highest average installation cost at $1,828, while Atlanta had the lowest at $775.
- The cost of permit fees can have a significant impact on overall costs. Average permit costs varied from $49 to $206 across the EV Project markets and from 3.9% to 14.5% of overall installation costs.
- On average, EV Project participants paid $250 toward installation of their Blink home charging unit.

Introduction

One of the objectives of the EV Project was to deploy plug-in electric vehicle (PEV) Level 2 charging stations in geographically diverse markets and collect data from those charging stations. These markets were selected based on sales and marketing plans of PEV partners Nissan and Chevrolet. The individual markets were further defined by zip code boundaries in order to support the EV Micro-Climate® planning process used to target locations for non-residential (i.e., publicly accessible) charging stations to support the vehicles participating in the EV Project.

This diversity enabled the project to collect data reflecting geographic factors that impacted installation costs and use of the charging infrastructure. This paper provides an analysis of residential Level 2 charging station installation costs and discusses the geographic factors driving variations in these costs.

EV Project Residential Program

To interpret and fully understand installation cost data collected during the EV Project, one must analyze it in the context of the project's history.

In order to meet the expected enthusiasm for the introduction of the Nissan Leaf and Chevrolet Volt, the EV Project elected to limit participation to those vehicle purchasers residing in single-family homes that had a designated overnight parking location for the participating PEV. Installation costs, time required for installation, and level of effort to deploy charging units at multi-family dwellings (e.g., apartment buildings, condominiums, and townhouses) would vary significantly depending on each property's parking and management and was deemed to be inappropriate in meeting the EV Project objective of studying deployment and use of non-residential charging infrastructure.

The EV Project intended to provide "free home charging" to study participants who were willing to share the data generated by use of both their PEV and the charging infrastructure being installed at their home. This "free home charging" was to include the Blink charging unit and the cost of installing the unit in a "typical" residence.

To simplify the EV Project's administration and the appeal to new Leaf and Volt owners, a single credit amount was established across the EV Project study markets. The credit amount was determined by surveying licensed electrical contractors in all of the EV Project markets on their installation costs for various "typical" residences.

This survey of licensed electrical contractors from all EV Project markets not only determined the appropriate installation credit level, but also qualified interested electrical contractors as part of the EV Project's Certified Contract Network (CCN). This qualification included technical capabilities, experience, and the ability to work under contracting requirements imposed on the EV Project, including Davis-Bacon Act (DBA) conformance. From this process, over 30 electrical contractors were qualified as part of the EV Project's CCN and residential installation cost credit was set at $1,200.

Deployment of residential charging units began late December 2010 when the Leaf PEVs were first introduced for sale in the United States. Within the first year of infrastructure deployment, the EV Project added Volt PEVs to the project and installed residential Blink charging units in 10 diverse markets, including the following:

1. Arizona (metro Phoenix and Tucson)
2. San Diego, CA
3. Los Angeles, CA
4. San Francisco, CA
5. Oregon (Portland metro, Corvallis, Eugene, and Salem)
6. Seattle, WA (Seattle metro, Tacoma, and Olympia)
7. Tennessee (entire state)
8. Washington, DC (metro area, including homes in Maryland and Virginia)
9. Dallas, TX

10. Houston, TX.

The offer to participate in the EV Project was made to purchasers or leasers of a Chevrolet Volt or Nissan Leaf. The EV Project offered a free residential Blink charger and credit of up to $1,200 toward the cost of installing it in exchange for the vehicle purchaser allowing the EV Project to collect data and report on their charging patterns for the duration of the project.

The original project schedule, which was based on Nissan and Chevrolet PEV sales projections, anticipated that full residential participation (i.e., 8,300) and deployment would occur by the end of 2011.

Because PEV sales did not meet expectations, the EV Project added three more markets in 2012 in order to meet the deployment target as soon as possible. The markets were as follows:

1. Chicago, IL
2. Philadelphia, PA
3. Atlanta, GA.

The extended deployment period and new markets added costs to the EV Project. To manage costs within the original project budget, installation credit offered to participants was reduced to $400 in all markets as of August 2012.

Figure 1 shows that sales momentum and addition of three new markets overtook any negative impact from the reduced installation credit. In addition, Nissan introduced a very attractive lease program for the Leaf in the fourth quarter of 2012, which nearly doubled the pre-August participation rate (enrollment for qualified PEV drivers and residential chargers ended on January 31, 2013, resulting in the decrease in monthly installations).

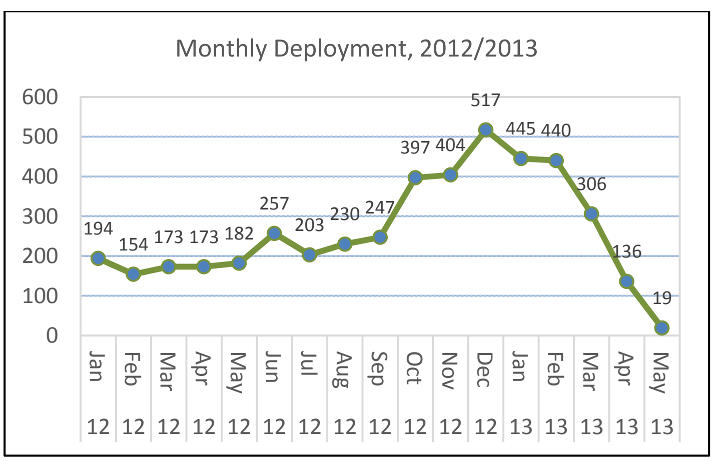

Figure 1. Monthly residential EVSE deployment for 2012 and 2013.

Data Analyzed

The data analyzed for this paper came from reports generated from the EV Project's residential participant database. This database was populated with data from participants, PEV suppliers, EV Project administrators, and CCN installing the home charging units. The paper also benefits from the direct experience of EV Project staff, which managed deployment of more than 8,300 residential chargers over 2 ½ years.

Installation Cost Breakdown

Because residential EVSE installations were only at single-family residences, variation in installation costs was driven by the following:

- Materials
  - Service panel upgrade needed
  - Breaker for dedicated 40-ampere circuit
  - Wiring length
  - Conduit length
- Labor
  - The American Recovery and Reinvestment Act funding for the EV Project required compliance with DBA. Prevailing electrician labor wages under DBA varied from over $55 per hour to under $12 per hour
  - Administrative effort to comply with DBA over the 2-plus years of the residential portion of the EV Project, including supplementary weekly payroll documentation
- Permit fees and administration
- Other market-specific conditions.

Analyses Performed

Total installation costs cited in this paper are based on fees paid to the CCN contractor performing installation. This amount included EV Project-funded credit plus whatever additional costs the residential participant paid. It does not include the cost of the Blink charger unit.

The average total cost for installation of residential charging units in each of the 13 markets analyzed was $1,354. The average for each of the markets is shown in Figure 2.

The average installation cost in Los Angeles was approximately 20% higher than the next highest market. The next nine markets were within 20% of each other. The three markets that have the lowest cost were the final markets added to the EV Project.

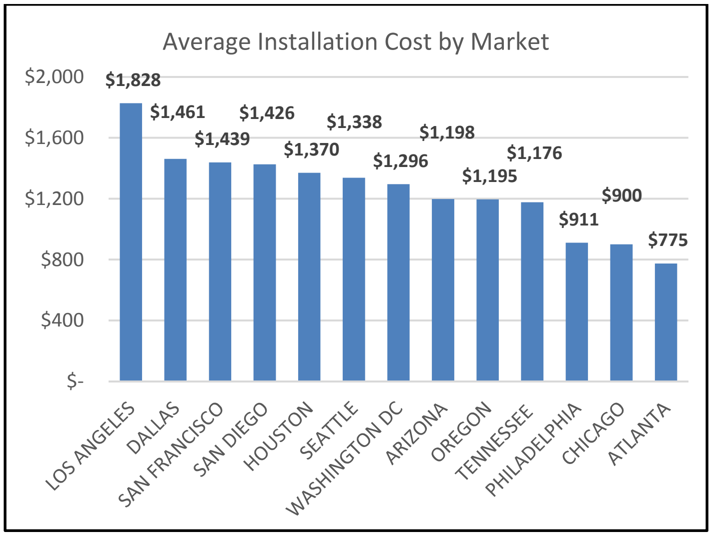

Figure 2. Average total installation cost by market.

Maximum Installation Cost in Each Market

As shown in Figure 3, the maximum cost for a residential installation occurred in Los Angeles and represented a significant upgrade to the electrical service for this home. The second highest was nearer to the maximum in other markets at $5,900. However, it is interesting to note that Los Angeles had 22 installations over $5,000 (and 30 of the 40 highest cost installations).

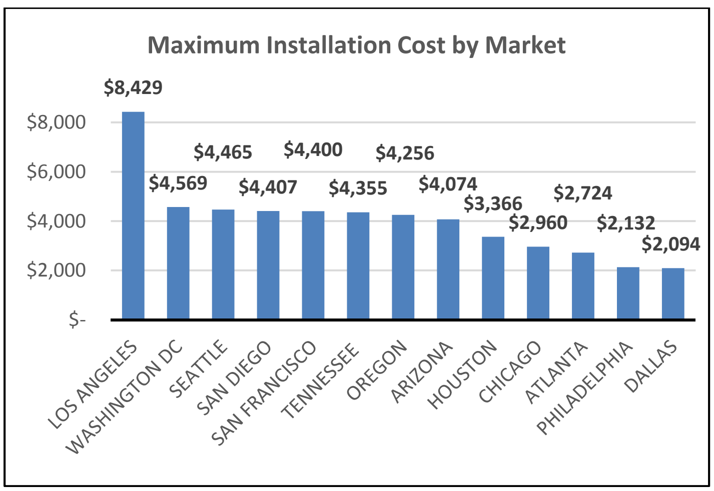

Figure 3. Maximum residential installation cost in each market.

These high installation costs in Los Angeles were likely the result of three market drivers. The first has to do with the coincident *Charge Up LA* rebate program being conducted by the Los Angeles Department of Water and Power (LADWP). This rebate provided EV Project participants with an additional $800 toward the reimbursement of installation costs. With the LADWP Program (i.e., *Charge Up LA),* a total of $2,000 ($1,200 EV Project and $800 LADWP) was potentially reimbursed. Because the EV Project provided the free charging unit, all $2,000 could go toward installation cost reimbursement. This likely attracted Leaf and Volt drivers with more expensive installations that otherwise may have not participated in the EV Project.

Another factor associated with LADWP's Program that significantly increased installation cost was the requirement for a second electric meter to separately meter energy supplied to the Blink charger.

The third likely contributor to higher costs in Los Angeles is the age of homes in affluent areas of greater Los Angeles. Addition of an EV charging unit to these older homes is much more likely to necessitate changes to the electric service or, at least, the service panel.

Installation Costs – Materials

Although the cost of materials did not vary significantly based on the market (i.e., wiring, conduit, and circuit breaker prices were unchanged across the various markets), there were geographic aspects regarding what materials were needed to install a dedicated 40-amp circuit that terminated at the Blink EVSE unit in the garage. Those geographic considerations were primarily associated with the age of the homes into which the EVSE unit was installed. Older homes were more likely to have lower-capacity electric service panels and need a new panel in order to add the dedicated 40-amp circuit. These panels also may have been located far from the garage (e.g., in the basement, kitchen, on an outside wall, etc.), further increasing material costs.

Installation Costs – Labor

Labor costs varied significantly by geographic location. This was due not only to the DBA prevailing wage for the electricians, but administration costs associated with installations (e.g., financial accounting, reporting, permit applications, filing, etc.).

Electrician prevailing wages were over $55/hour in counties around San Francisco and Seattle, while rates in some Texas counties were as low as $11/hour. The electrician's wages were only part of the labor costs, because company costs for administration, overhead, and profit margin magnified the differences in labor costs for the EV Project. The labor element of installation cost was also affected by permitting requirements of the local government agency having jurisdiction for permitting. Some jurisdictions had very labor-intensive permitting processes, including local filing of written applications and pre and post-installation inspections. These requirements result in significant hourly costs associated with driving, waiting in line for permits, and waiting onsite for inspections. Other jurisdictions (e.g., Portland) offered innovative self-inspection programs that allowed CCN contractors to sign-off on installations themselves, with inspectors conducting only random sample inspections to verify compliance with code requirements.

Installation Costs – Permit Fees

In addition to labor costs associated with obtaining a permit to install a charger, fees were associated with the permit. The average permit fee in the EV Project varied from less than $50 in Oregon and Tennessee to over $206 in San Diego. Figure 4 shows the average permit fee for the 13 EV Project markets analyzed.

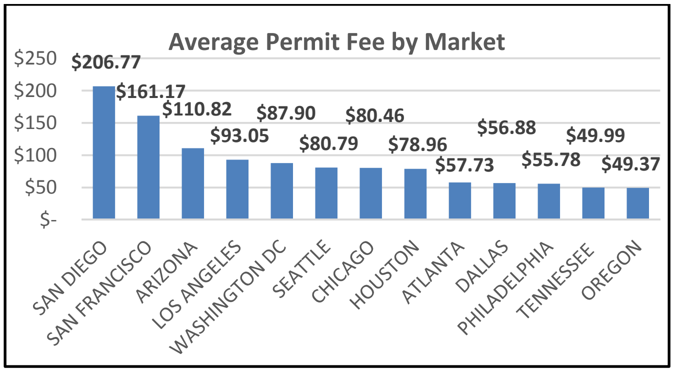

Figure 4. Average permit fee by market.

Figure 5 shows the percentage of total installation cost that is represented by the permit fees. On average, permit fees represented 8.6% of the installation cost. San Diego's higher fees also represent the highest percentage of the installation costs (14.5%).

Permits were not always required; however, the EV Project required CCN contractors to be conservative and obtain permits unless it was clearly not required. The best examples of circumstances that did not require a permit for EVSE installation were when a building permit was already open for other construction work being undertaken by the homeowner or when the Blink unit was replacing a previously permitted home charging unit. However, these were very infrequent occurrences.

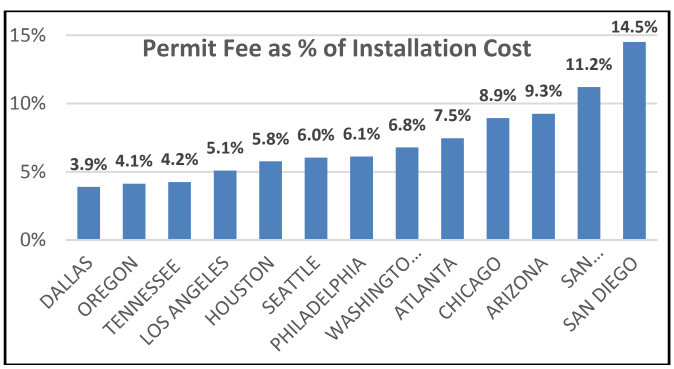

Figure 5. Permit fee as a percentage of installation cost by market.

The lowest permit fees (i.e., Oregon and Tennessee) resulted, in part, from local government action, which simplified a new permit item and a new process. Both of these states encouraged the use of simplified permitting. As a result, their fees were not only less expensive, but also more convenient than many of the others. "Best practices" observed for permitting in the EV Project is subject of a separate paper.

Other Market-Specific Conditions

A few other specific market conditions influenced installation costs in some markets.

The first and most obvious is those markets that were added in 2012 and only received a $400 credit toward installation. These markets (i.e., Atlanta, Chicago, and Philadelphia) had the lowest average cost for installations. Two factors contributed to their lower average costs: (1) these markets benefitted from experience gained by the company that managed these installations in the EV Project (i.e., SPX/Bosch) and (2) the more significant factor was the 18-plus months that the PEV community had matured since the start the EV Project at the end of 2010. This close-knit community was and is very active and very communicative. They knew there were installation and equipment options that were less expensive and did not include any of the "strings" associated with the federally funded EV Project (e.g., DBA compliance, smart charger using home wireless internet access to transmit data, no choice of installer, etc.). Consequently, this more informed group of EV Project candidates would elect to not participate if they considered the cost to be too high. Thus, the project attracted those whose installation costs would be lower. The effect of this is borne out in the data, because these three markets had maximum installation costs amongst the lowest in the EV Project (see Figure 3).

Older homes typically required an upgrade to their electric service panels in order to accommodate the alternating current Level 2 charging unit's dedicated 40-amp circuit. This was a significant cost driver, with the greatest impact on installation costs in Los Angeles.

This requirement for dedicated 40-amp service also affected participation in somewhat less affluent areas (e.g., coastal California), where homes often times did not have air-conditioning and the electrical service to the home was not sufficient to support a dedicated 40-amp charging circuit. The cost to add this additional capacity may also have affected participation in these areas.

Another factor that affected installation costs in San Diego was the concurrent time-of-use study being conducted by San Diego Gas and Electric. This program was for Leaf owners only and only those who chose to participate (although very few declined). The study required the installation of a second electrical meter, whose cost was included in EV Project installation costs when applicable. This time-of-use program increased the average installation cost in San Diego by about 10 to 12%.

Permit costs were not affected by this time-of-use program; therefore, subtracting the cost of the second meter, the actual impact from permitting costs in San Diego would be higher than the 14.5% shown in Figure 4.

Conclusions

Geographic variation in residential installation costs primarily resulted from three factors: (1) regional labor costs, (2) age of homes in the market, and (3) regional programs that were being conducted concurrently.

Although permit costs varied significantly across the geographic markets in the EV Project, it typically represented less than 10% of the total cost.

Labor cost variation reflected prevailing market wages.

Older homes typically required an upgrade to their electrical service panels in order to accommodate the alternating current Level 2 charging unit's dedicated 40-amp circuit. This was not only a significant cost driver, but likely affected the PEV driver's decision whether to participate in the EV Project.

About The EV Project

The EV Project was the largest PEV infrastructure deployment and 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, it supported the initial rollout of the Nissan Leaf and Chevrolet Volt PEVs and first deployment of PEVs in an all-PEV ride share application. The EV Project deployed over 12,000 alternating current Level 2 charging stations and over 100 dual-port direct current fast chargers in 17 geographic regions across the United States during the period January 1, 2011, through December 31, 2013. Drivers of approximately 8,300 Nissan Leafs, Chevrolet Volts, and Smart ForTwo Electric Drive vehicles participated in the Project.

Project participants allowed EV Project researchers to collect and analyze data from their vehicles and chargers. Data collected from project vehicles and charging infrastructure document nearly 125 million miles of driving and over 4 million charging events in significant detail, characterizing the earliest days of electric vehicle adoption through significant penetration of both vehicles and charging infrastructure. These data reside at Idaho National Laboratory, which is responsible for analyzing the data and publishing summary reports, technical papers, and lessons learned on vehicle and charger 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.

Appendix A, Tables of Average Residential Installation Costs by Market

Average Permit Cost

Market	Average Permit Cost
San Diego	$206.77
San Francisco	$161.17
Arizona	$110.82
Los Angeles	$93.05
Washington, DC	$87.90
Seattle	$80.79
Chicago	$80.46
Houston	$78.96
Atlanta	$57.73
Dallas	$56.88
Philadelphia	$55.78
Tennessee	$49.99
Oregon	$49.37
Average Permit	$115.30

Average Total Installation Cost

Market	Average Total Installation Cost
Los Angeles	$1,827.88
Dallas	$1,461.33
San Francisco	$1,438.95
San Diego	$1,425.51
Houston	$1,369.78
Seattle	$1,337.61
Washington, DC	$1,295.64
Arizona	$1,197.97
Oregon	$1,195.27
Tennessee	$1,176.32
Philadelphia	$910.54
Chicago	$900.29
Atlanta	$774.58
Average Installation	$1,354.60