What were the Cost Drivers for the Direct Current Fast Charging Installations?

March 2015

Key Conclusions

- By the end of 2013, the EV Project had installed 111 direct current (DC) fast chargers (DCFCs).
- Overall, installation costs varied widely from $8,500 to over $50,000.
- The median cost to install the Blink dual-port DCFC in the EV Project was $22,626.
- The addition of new electrical service at the site was the single largest differentiator of installation costs.
- The surface on or under which the wiring and conduit were installed was the second largest cost driver.
- Cooperation from the electric utility and/or the local permitting authority is key to minimizing installation costs (both money and time) for DCFCs.

Introduction

To evaluate the cost drivers for DCFC installations in the EV Project, some of the features of the installed hardware and site conditions must be understood.

Four significant characteristics of the Blink dual-port DCFC affected installation costs:

1) Separate ground power unit (GPU) and charge dispensing unit (CDU)
2) Availability in both 208-volt and 480-volt models
3) Dual port configuration
4) 60-kW power rating.

The EV Project DCFC was designed with all power electronics in a single industrial-style cabinet (i.e., GPU) and all user interface equipment in a separate stylized cabinet, including a large video display. Separating the GPU from the CDU (Figure 1) provided two advantages for installation of the Blink DCFC. One, it enabled the production of a common CDU and two different GPUs: one at 208 volts (which could more easily be installed in a commercial facility with more commonly found 208-volt service) and the other at 480 volts. Offering two GPUs enabled the most appropriate equipment to be directly installed without requiring a separate transformer.

Two, the separate units also enhanced safety, because the high-voltage GPU could be installed away from vehicle traffic, with a lesser likelihood of impact damage.

The dual-port configuration of the CDU (Figure 2) allows two electric vehicles to be parked at the DCFC and connected at the same time. The Blink DCFC sequencing technology initiates charging for the first connected vehicle and automatically shifts charging to the second vehicle upon completion of the first vehicle’s charge. The dual-port configuration had little effect on the electrical installation cost, because no additional field-installed conduit or wire was required to implement this feature.

However, the dual-port arrangement impacted siting because two adjacent parking spaces were required to provide user access to both charge ports.

Finally, the 60-kW charge power capability of the Blink unit affected installation costs because it often required a new electrical service to be provided by the local electric utility. The magnitude of this cost increase depended on the existing electrical services (both available power and space for additional circuit breakers) at the host site and costs from the electric utility to install a new metered electrical service. It is likely the cost impact of a new service for supporting a 60-kW charger would be the same as it would be for a 50, 40, or 20-kW unit. However, it is more likely
that the host electrical service will have 20 kW of additional power capability available than it will have 60 kW available.

All other installation cost drivers (e.g., distance from power source and installation site surface features such as concrete, asphalt, grass, etc.), local labor costs, and cost to add new service to the charging site were not affected by the hardware design and can be assumed as cost drivers for all DCFC installations.

**Data Analyzed**

This evaluation reviews not only the costs and site conditions associated with the 111 DCFC deployed during the EV Project, but also includes estimates obtained for another 50+ DCFC sites that were planned, but were not installed. These estimates were performed by experienced EV Project electrical contractors, validated by EV Project field services personnel, and accepted by the electrical contractor for a fixed cost installation. Therefore, they are assumed to be valid data points to be included in this assessment of installation cost drivers.

The total cost of installations cited in this report includes only the costs paid to the electrical contractors to install Blink DCFCs. This cost would typically include permit costs, engineering drawings (usually required), contractor’s installation and administration labor, subcontracted construction labor or equipment (e.g., concrete, asphalt, trenching, boring, etc.), and materials other than the DCFC itself, which was provided by the EV Project. Installation costs do not include the cost of any alternating current Level 2 EVSE units that may have been simultaneously installed at the same site.

**Analyses Performed**

The first analysis performed quantified and characterized the costs for installation of DCFCs in the EV Project.

Examination of the DCFC installation costs gathered in the EV Project found the following:

- **Average cost** $23,662
- **Median cost** $22,626
- **Minimum** $8,500
- **Maximum** $50,820

Further, statistical analysis of the costs (Figure 3) revealed that the average and median costs are not a good measure of what one could expect for the cost of DCFC installation. The standard deviation from the mean of $8,965 is nearly 40% of the average installation cost (i.e., $23,662), indicating there was a wide distribution of installation costs.

Figure 3. Number of EV Project DCFC sites by installation cost, shown in thousands of dollars.

Removing the effect of the Cracker Barrel installations, the distribution of typical costs followed a pattern similar to that for the Arizona market, which is shown in Figure 4.

Figure 4 shows the distribution of installation costs in Arizona and clearly shows two distinct installation cost groups. The average cost for installations in Arizona was $23,301, which is within 1.5% of the overall average cost. However, further examination finds that cost differences represent those that were able to use existing site electrical service and those that required a new metered service to accommodate the DCFC. Although the methods and materials varied when a new metered service was added, the aggregated cost to provide a new metered service had a significant impact on the overall installation cost.
Discussion of Results

Impact of Blink DCFC Hardware Features (Dual-Port, and Separate Power and Dispensing Units) on Installation Costs

There are some unique costs for installing the Blink DCFC unit, with its separate power and charge dispensing units, dual-port connector design, and include the following:

- Two parking places dedicated for electric vehicle charging
- Two pads on which units are set
- Marginal increase in wiring/conduit due to the possibility of two trenches (one for GPU and one for CDU), but overall length of trenches is the same as a more typical single-unit, single-dispenser DCFC
- 60-kW power required for the DCFC.

Separating the unit into two parts also increased costs associated with two ground surface-mounted structures. The GPU base measures 3 ft x 4½ ft, while the CDU occupies a 2-ft x 5-ft space. The large size of the CDU was an intentional design decision because it made the DCFC more prominent for use as an advertising medium and easier to see; therefore, making it safer and easier to find. Depending on the installation location, a concrete surface or pre-cast pad was used for mounting the DCFC.

Because the CDU required two parking spaces, restriping of these parking spaces was typically required, increasing installation costs. Existence of two voltage-rated models provided installation cost savings because it eliminated the need for a separate transformer for installation.

Primary Installation Cost Drivers

The following are the significant DCFC installation cost drivers observed in the EV Project that are not specific to the Blink dual-port DCFC. Their impact on installation costs would be applicable for any installation of a DCFC unit rated at 20 kW or more:

1) Materials
2) Administration
3) Ground surface conditions
4) Electrical service upgrade.

Materials:

The materials used in DCFC installations can be separated into the following three groups:

1) Standard installation materials, which would be in nearly every installation, but whose quantities may vary. Examples of standard installation materials include conduit, conductors, emergency shut-off switch, circuit breaker, fasteners, etc.

2) Installation surface replacement materials, which would depend entirely on where the DCFC was sited relative to the power source and work needed to restore the surface(s) impacted by installation of the unit and its associated electrical wiring (e.g. concrete, asphalt, gravel, etc.).

3) New electrical service materials, which include switch gear with meter section, conduit, and wire.

Administration:

Administrative costs that were specifically associated with total DCFC installation costs include permit application processing, permit fees, engineering drawings, and, where required by the permitting authority, load studies. Just as the materials were affected by the specific installation site, so too were administration costs.

Permit fees varied greatly depending on permitting jurisdiction, extent of construction, whether installation was stand alone or part of another construction project, and whether it was for a new service or just an addition to the existing host electrical system.

The costs for preparing engineered drawings were another significant administrative cost. These varied, but generally represented from $1,000 to $3,000 or 5 to 10% of the total installation cost.

Ground Surface Conditions:

It is self-evident that the DCFC site surface impacted by installation of conduit, concrete mounting pads, parking spaces, striping, etc. would vary depending on the surface the DCFC was installed on. Installation of underground electrical conduit was done either by trenching or boring (Figure 5). The basis for this decision depended on the site owners’ preference regarding the appearance of after work restoration. The decision was also impacted by underground (e.g. water, gas, or electrical services) or aboveground (e.g., planters) features that may have made trenching impractical and the length of the underground passage.

Electrical Service Upgrades:

Many of the DCFC installations required new electrical service to be added to the host’s site. The cost of these installations was significantly higher than those that did not require new service. The total cost increased due to the fees charged by the local electric utility to extend the service from the grid to the host site and the additional electrical switch gear and new meter required to manage this new electrical service.
Costs paid to the electric utility for service extension to the site varied due to circumstances associated with the surrounding grid and the electric utility’s willingness to absorb some of these costs. Some of the utilities in the EV Project acted as partners and absorbed some or all of the costs to get the power to the charging site host’s property.

Electrical service extension costs also varied depending on the electric utility’s policies for aboveground or underground service. Overhead service is typically less expensive and quicker than trenching for an underground service extension. Electrical service extension costs for the EV Project’s DCFCs varied from $3,500 to $9,500.

Addition of this service not only increased installation costs due to electric utility line extension costs and electrical switch gear needed, but also extended the time required to install the DCFC by many weeks.

Characteristics of Least Expensive Installations

Very simply put, the least expensive installations had sufficient electrical power at the site to accommodate the Blink dual-port DCFC. The very lowest cost installations had sufficient power and a simple installation with either short underground conduit runs (i.e., hand-shoveled) or surface-mounted conduit. Figure 6 shows one of three installations that costed less than $9,000. In addition to sufficient existing power at the site, this installation used surface-mounted electrical conduit.

Characteristics of Most Expensive Installations

As with the least expensive, the primary characteristic of the more expensive installations can be simply identified as those that had a new service installed to accommodate the DCFC. In some cases, the increased cost for new service was compounded by long underground conduits and surface conditions that were expensive to restore (e.g., concrete or asphalt).

Other Costs and Considerations

**Time:** Most of the “costs” discussed in this paper are monetary costs. However, another consideration for the DCFC site hosts is the amount of time this installation process takes, which can be divided into three installation conditions: (1) contractors installing equipment, (2) contractors waiting to start, and (3) contractors waiting to finish.

When things went smoothly and construction started and finished on consecutive days (no waiting for inspections or materials after installation started), the installation took from 30 to 60 days from the agreement to proceed. However, in many circumstances, there were delays in administration and materials. When a new service was required, the duration of the installation from start to finish often exceeded 90 days.

**Electrical Contractors:** Installation contractors were selected for participation in the EV Project based on their interest, qualifications, and ability to meet U.S. Department of Energy (DOE)-mandated Davis-Bacon Act requirements. When the EV Project began in late 2009, the economic conditions of the construction trade were significantly affected by the recession. During this time, contractors were very willing to accept the additional administrative requirements of working under Davis-Bacon and other administrative requirements of a federally funded project. Three years later, when the majority of the DCFC installations were underway, the economy had improved and the contracting requirements of this federally funded project became an impediment to securing contractors capable of providing timely installations and competitive estimates.

**Electric Utilities and Municipalities:** As previously discussed, the costs associated with permits, inspections, and new service increased costs, not only in monetary terms, but in time. Both the electric utility and municipal partners in deployment of EV infrastructure had a significant impact on the time cost of the installation project.
These time costs were often many weeks waiting for permit approval, plan approval, or service extension work to be scheduled. The EV Project cooperated with local municipalities and electric utilities by providing these two important partners in the project with advanced notification of installations in an effort to minimize the impact of time and, in some cases, cost.

In efforts to not leave out any of the very helpful municipalities or utilities, who provided valuable support for the process, this paper will not identify any of them by name, but the EV Project appreciates very much their help in making the EV Project a successful study of plug-in electric vehicle charging infrastructure deployment and use.

**Conclusions**

The primary cost driver for DCFCs installed or scheduled to be installed in the EV Project was the requirement for new electric service. This cost had the greatest impact on overall installation costs.

Other significant cost drivers were as follows:

a) Surface material under which electrical wiring/conduit was installed
b) Distance from the electrical power source to the DCFC GPU
c) Distance from the GPU to the CDU
d) Permit and engineering drawings.

In some instances, cost drivers b and d were either reduced or eliminated through support and cost share by electric utilities and local government.

Electric utilities have a significant impact on the cost of what is required to add new service. Meanwhile local governments can (and did) provide support by waiving permit fees or expediting the permit process.

**About The EV Project**

The EV Project was the largest PEV infrastructure demonstration project in the world, equally funded by 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 DCFCs 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**

INL 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. INL 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

### List of Blink DCFCs Deployed during the EV Project

Name of host and street address for dual-port DCFCs deployed in the EV Project:

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<th>Number</th>
<th>DCFC Name</th>
<th>Street Address</th>
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<tr>
<td>1.</td>
<td>Cracker Barrel 29 East Ridge</td>
<td>1460 North Mack Smith Road</td>
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<td>2.</td>
<td>Cracker Barrel 21 Cleveland</td>
<td>1650 Clingan Ridge Drive NW</td>
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<td>3.</td>
<td>Cracker Barrel 9 Athens (Sweetwater)</td>
<td>110 Burkett L. Witt Blvd Athenas, TN 37303</td>
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<td>4.</td>
<td>Cracker Barrel 15 Cookeville</td>
<td>1295 S Walnut Avenue Cookeville, TN 37851</td>
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<td>5.</td>
<td>Cracker Barrel 79 Crossville</td>
<td>23 Executive Drive Crossville, TN 38555</td>
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<td>6.</td>
<td>Cracker Barrel 75 Farragut (W. Knoxville)</td>
<td>716 N Campbell Station Road Exit 573 Farragut, TN 37934</td>
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<td>7.</td>
<td>Cracker Barrel 6 Harriman</td>
<td>1839 South Roane Street Harriman, TN 37748</td>
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<td>8.</td>
<td>Cracker Barrel 565 Kimball</td>
<td>550 Kimball Crossing Drive Kimball, TN 37347</td>
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<td>9.</td>
<td>Cracker Barrel 3 Manchester</td>
<td>103 Paradise Street Exit 110 Manchester, TN 37355</td>
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<td>10.</td>
<td>Cracker Barrel 90 Murfreesboro</td>
<td>138 Chaffin Place Murfreesboro, TN 37129</td>
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<td>11.</td>
<td>Cracker Barrel 23 Nashville</td>
<td>3454 Percy Priest Drive Nashville, TN 37214</td>
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<td>12.</td>
<td>Riverview Toyota</td>
<td>2020 W Riverview Auto Drive Mesa, AZ 85201</td>
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<td>13.</td>
<td>Bell Ford</td>
<td>2401 W. Bell Road Phoenix, AZ 85032</td>
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<td>Fred Meyer - #663 Sandy</td>
<td>16625 SE 362nd Ave Sandy, OR 97055</td>
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<td>Walmart #2927</td>
<td>23500 NE Sandy Blvd Wood Village, OR 97060</td>
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<td>Fred Meyer - #661 Sunset</td>
<td>22075 NW Imbrie Drive Hillsboro, OR 97124</td>
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<td>Nissan of Santa Rosa</td>
<td>1275 Santa Rosa Ave. Santa Rosa, CA 95404</td>
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<td>Linear City Development LLC - Mateo Street</td>
<td>662 Mateo Street Los Angeles, CA 90021</td>
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<td>Hillsboro Civic Center</td>
<td>150 E Main Street Hillsboro, OR 97123</td>
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<td>South Lake Union Discovery Center - DCFC</td>
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<td>Elmer's</td>
<td>255 N Arney Rd # 255 Woodburn, OR 97071</td>
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<td>Intuit - Menlo Park Campus</td>
<td>180 Jefferson Drive Menlo Park, CA 94025</td>
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<td>23.</td>
<td>Wash Wizard</td>
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<td>Trillium North</td>
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<td>25.</td>
<td>Silver Spring Networks</td>
<td>585 Broadway Street Redwood City, CA 94063</td>
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<td>MJ - Santa Ysabel</td>
<td>30250 Julian Rd Highway 78 and 79 Santa Ysabel, CA 92070</td>
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<td>Good Earth Market/Route Zero</td>
<td>720 Center Blvd. Fairfax, CA 94930</td>
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<td>Chateau Montelena Winery</td>
<td>1429 Tubbs Lane Calistoga, CA 94515</td>
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<td>29.</td>
<td>Intuit - Mountain View Campus, Building 4</td>
<td>2500 Garcia Ave. Mountain View, CA 94043</td>
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<td>Burgerville #41 92nd and Powell</td>
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<td>11900 SE 82nd Ave Happy Valley, OR 97086</td>
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<td>Facebook - Building 12</td>
<td>1601 Willow Rd. Menlo Park, CA 94025</td>
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<td>35.</td>
<td>Bellevue College</td>
<td>3000 Landerholm Circle SE Bellevue, WA 98007</td>
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<td>36.</td>
<td>Wilsonville Town Center</td>
<td>8255 SW Wilsonville Road Wilsonville, OR 97070</td>
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<td>37.</td>
<td>Camelback Toyota - South Side of Dealership</td>
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For more information, visit [avt.inl.gov](http://avt.inl.gov)
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| 79. | Edgewood Plaza  
2050 Channing Way  
Palo Alto, CA 94303 |
| 80. | Fry’s Store #64 Gilbert  
714 S. Val Vista  
Gilbert, AZ 85296 |
| 81. | 19 Duncan St  
19 Duncan St  
Clayton, GA 30525 |
| 82. | Walgreens Store #7677  
1502 Lake Tapps Pkwy SE  
Auburn, WA 98092 |
| 83. | Walgreens Store #7480  
1701 Auburn Way S  
Auburn, WA 98002 |
| 84. | Walgreens Store #7700  
34008 Hoyt Rd SW  
Federal Way, WA 98023 |
| 85. | Walgreens Store #7594  
1416 Harvey Rd  
Auburn, WA 98002 |
| 86. | DCFC - SDSU Lot G  
5500 Campanile Dr  
San Diego, CA 92182 |
| 87. | City of Hayward - 805 B St  
805 B Street  
Hayward, CA 94541 |
| 88. | Haselwood Family YMCA Silverdale  
Haselwood YMCA  
3909 NW Randall Way  
Silverdale, WA 98383 |
| 89. | Roth’s Silverton  
918 N 1st Street  
Silverton, OR 97381 |
| 90. | Alexandria Real Estate - Owens St Parking Garage  
1670 Owens Street  
San Francisco, CA 94158 |
| 91. | Simpson Strong Tie DCFC  
5956 West Las Positas Boulevard  
Pleasanton, CA 94588 |
| 92. | Santa Clara Convention Center  
5001 Great America Parkway  
Santa Clara, CA 95054 |
| 93. | Walgreens Store #12168  
3929 Kitsap Way  
Bremerton, WA 98312 |
| 94. | Dalton Utilities - College Drive  
890 College Drive  
Dalton, GA 30722 |
| 95. | Blink Network (2nd Avenue)  
430 S. 2nd Avenue  
Phoenix, AZ 85003 |
| 96. | City of Chula Vista - Towne Center Parking Structure  
340 F Street  
Chula Vista, CA 91910 |
| 97. | Mira Mesa – AT&T Building  
8248 Mira Mesa Blvd  
San Diego, CA 92126 |
| 98. | Plaza Escuela, West Parking Lot, 2nd Floor  
1500 Botelho Drive  
Walnut Creek, CA 94596 |
| 99. | Stanford Shopping Center  
600 Stanford Shopping Center  
Palo Alto, CA 94304 |
| 100. | IdleAir at Carneys Point, NJ - Flying J #688 - I-295 Exit 2C  
326 Slapes Corner  
Carneys Point, NJ 08069 |
| 101. | IBEW 48 - Union Hall  
15937 NE Airport Way  
Portland, OR 97230 |
| 102. | Serramonte Center  
3 Serramonte Center  
Daly City, CA 94015 |
| 103. | Equity Office - 101 Metro  
101 Metro Drive  
San Jose, CA 95110 |
| 104. | Walgreens Store #4372 San Jose  
780 East Santa Clara Street  
San Jose, CA 95112 |
| 105. | Walgreens Store #2612 Santa Clara  
200 N Winchester Blvd  
Santa Clara, CA 95050 |
| 106. | Shell Station #70 - 1509 E. Buckeye  
1509 E. Buckeye  
Phoenix, AZ 85034 |
| 107. | Thousand Oaks Transportation Center - DCFC  
265 S Rancho Rd  
Public Works Department  
Thousand Oaks, CA 91320 |