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.

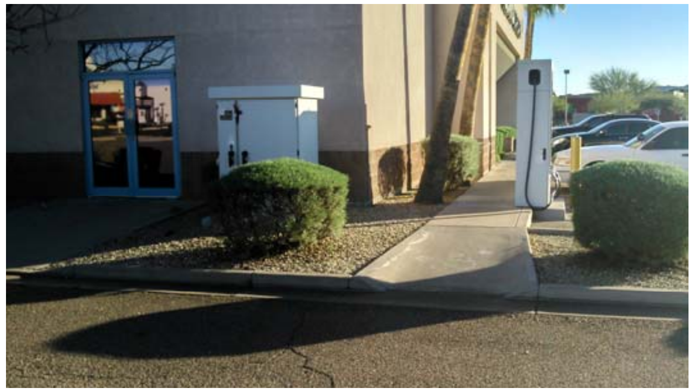

Figure 1. GPU (left) and CDU (right) for Blink DCFC.

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.

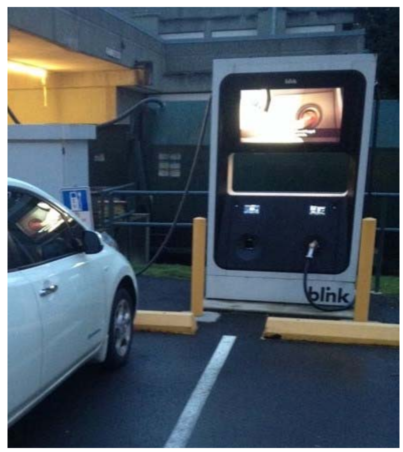

Figure 2. Dual-port Blink DCFC (photo courtesy of Plugshare.com).

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.

Further investigation of installation costs at or near the average finds that nearly 50% of them were Tennessee installations at Cracker Barrel restaurants. These 12 installations all followed the same pattern of a new service from a single electrical utility with the GPU installed near a pole-mounted utility transformer in the parking lot, resulting in costs that varied very little (within $720 [i.e., 3%] of the mean).

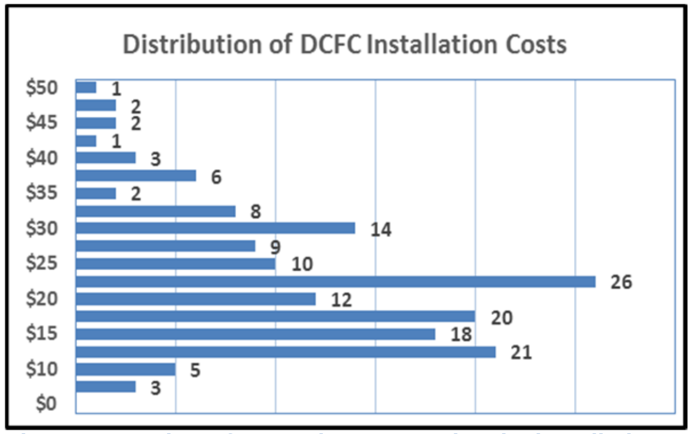

Figure 3. Number of EV Project DCFC sites by installation cost, shown in thousands of dollars.

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.

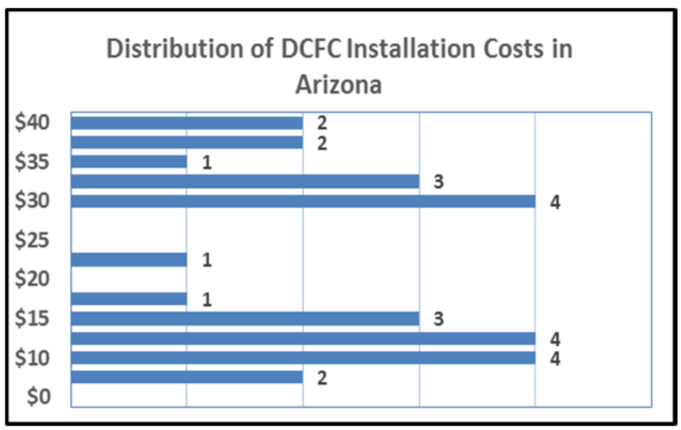

Figure 4. Figure 3. Number of EV Project DCFC sites by installation cost, shown in thousands of dollars.

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.

Figure 5. Trenching for DCFC electrical conduit and wiring.

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).

Figure 6. Example of one of the least expensive installations.

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:

1. Cracker Barrel 29 East Ridge
1460 North Mack Smith Road
East Ridge, TN 37412

2. Cracker Barrel 21 Cleveland
1650 Clingan Ridge Drive NW
Cleveland, TN 37312

3. Cracker Barrel 9 Athens (Sweetwater)
110 Burkett L. Witt Blvd
Athens, TN 37303

4. Cracker Barrel 15 Cookeville
1295 S Walnut Avenue
Cookeville, TN 38501

5. Cracker Barrel 79 Crossville
23 Executive Drive
Crossville, TN 38555

6. Cracker Barrel 75 Farragut (W. Knoxville)
716 N Campbell Station Road
Exit 373
Farragut, TN 37934

7. Cracker Barrel 6 Harriman
1839 South Roane Street
Harriman, TN 37748

8. Cracker Barrel 565 Kimball
550 Kimball Crossing Drive
Kimball, TN 37347

9. Cracker Barrel 3 Manchester
103 Paradise Street
Exit 110
Manchester, TN 37355

10. Cracker Barrel 90 Murfreesboro
138 Chaffin Place
Murfreesboro, TN 37129

11. Cracker Barrel 23 Nashville
3454 Percy Priest Drive
Nashville, TN 37214

12. Riverview Toyota
2020 W Riverview Auto Drive
Mesa, AZ 85201

13. Bell Ford
2401 W. Bell Road
Phoenix, AZ 85032

14. Fred Meyer - #663 Sandy
16625 SE 362nd Ave
Sandy, OR 97055

15. Walmart #2927
23500 NE Sandy Blvd
Wood Village, OR 97060

16. Fred Meyer - #661 Sunset
22075 NW Imbrie Drive
Hillsboro, OR 97124

17. Nissan of Santa Rosa
1275 Santa Rosa Ave.
Santa Rosa, CA 95404

18. Linear City Development LLC - Mateo Street
662 Mateo Street
Los Angeles, CA 90021

19. Hillsboro Civic Center
150 E Main Street
Hillsboro, OR 97123

20. South Lake Union Discovery Center - DCFC
101 Westlake Ave N
Seattle, WA 98109

21. Elmer's
255 N Arney Rd # 255
Woodburn, OR 97071

22. Intuit - Menlo Park Campus
180 Jefferson Drive
Menlo Park, CA 94025

23. Wash Wizard
1845 E. University Drive
Tempe, AZ 85281

24. Trillium North
20425 North 7th Street
Phoenix, AZ 85024

25. Silver Spring Networks
585 Broadway Street
Redwood City, CA 94063

26. MJ - Santa Ysabel
30250 Julian Rd
Highway 78 and 79
Santa Ysabel, CA 92070

27. Good Earth Market/Route Zero
720 Center Blvd.
Fairfax, CA 94930

28. Chateau Montelena Winery
1429 Tubbs Lane
Calistoga, CA 94515

29. Intuit - Mountain View Campus, Building 4
2500 Garcia Ave.
Mountain View, CA 94043

30. Burgerville #41 92nd and Powell
3504 SE 92nd
Portland, OR 97266

31. Spirent Communications
1325 Borregas Avenue
Sunnyvale, CA 94089

32. Shell Station 35408 - 24805 N Lake Pleasant Pkwy
24805 N Lake Pleasant Pkwy
Peoria, AZ 85383

33. Clackamas Town Center - Barnes and Noble Parking
11900 SE 82nd Ave
Happy Valley, OR 97086

34. Facebook - Building 12
1601 Willow Rd.
Menlo Park, CA 94025

35. Bellevue College
3000 Landerholm Circle SE
Bellevue, WA 98007

36. Wilsonville Town Center
8255 SW Wilsonville Road
Wilsonville, OR 97070

37. Camelback Toyota - South Side of Dealership
1550 E. Camelback Road
Phoenix, AZ 85014

38. BP #1101 Bell Road
1101 Bell Road
Antioch, TN 37013

39. Shari's Restaurant and Pies - Keizer
4998 River Rd. N
Keizer, OR 97303

40. North Bay Nissan
1250 Auto Center Drive
Petaluma, CA 94952

41. Sunset Development - Bishop Ranch
2430 Camino Ramon
San Ramon, CA 94583

42. SEARS - Store #1078
6515 E Southern Ave
MESA, AZ 85206

43. SEARS - Store #1798
7780 W Arrowhead Towne Ctr
GLENDALE, AZ 85308

44. SEARS - Store #1768
4604 E CACTUS RD
PHOENIX, AZ 85032

45. SEARS - Store #1115 (Hamilton Place Mall)
2100 Hamilton Place Blvd
Chattanooga, TN 37421

46. Concord Hilton
1970 Diamond Blvd.
Concord, CA 94520

47. Chevron Discovery Market
2128 E. Florence Blvd
Casa Grande, AZ 85122

48. Best Western Escondido
1700 Seven Oaks Road
Escondido, CA 92026

49. Applied Materials - Building 12
3225 Oakmead Village Drive
Santa Clara, CA 95051

50. Ohlone College - Fremont Campus - Hyman Hall
43600 Mission Blvd
Fremont, CA 94539

51. Shari's Restaurant and Pies - Sherwood
16280 SW Langer Dr
Sherwood, OR 97140

52. Toyota of El Cajon
965 Arnele Ave
El Cajon, CA 92020

53. City of Azusa - San Gabriel and W. 6th
San Gabriel and W. 6th
Azusa, CA 91702

54. SEARS - Store #1169
3111 W Chandler Blvd
Chandler, AZ 85226

55. Harvard Market
1401 Broadway
Seattle, WA 98122

56. Tahoma Market (I-5 Exit 137)
6006 Pacific Highway East
I-5 Exit 137
Fife, WA 98424

57. Fred Meyer - #683 Grand Central
2500 Columbia House Blvd
Vancouver, WA 98661

58. Fred Meyer - #460 Salmon Creek
800 NE Tenney Rd
Vancouver, WA 98685

59. Fred Meyer - #391 Totem Lake
12221 120th Ave NE
Kirkland, WA 98034

60. Fred Meyer - #090 East Salem
3740 Market NE
Salem, OR 97301

61. Fred Meyer - #375 Tigard
11565 SW Pacific Highway
Tigard, OR 97223

62. Fred Meyer - #179 Lake City Way
13000 Lake City Way NE
Seattle, WA 98125

63. Fred Meyer - #600 Hollywood
3030 NE Weidler St
Portland, OR 97232

64. CBRE - Britannia Point Grand
280 E Grand Ave
South San Francisco, CA 94080

65. Cracker Barrel 2 Lebanon
635 South Cumberland
Lebanon, TN 37088

66. CBRE-Britannia Oyster Point
1110 Veterans Parking Garage
South San Francisco, CA 94080

67. United Markets San Anselmo
100 Red Hill Rd.
San Anselmo, CA 94960

68. 1935 Waterman Ave -San Bernardino- LA/CA
1935 S. Waterman Ave, San Bernardino
San Bernardino, CA 92408

69. Fry's Store #612 Phoenix
4707 E. Shea Blvd.
Phoenix, AZ 85028

70. Nissan of the Eastside
11815 NE 8th Ave
Bellevue, WA 98005

71. Fred Meyer - #393 Tualatin
19200 SW Martinazzi
Tualatin, OR 97062

72. MAPCO - Hillsboro Road - Franklin TN
1100 Hillsboro Road
Franklin, TN 37064

73. United Markets San Rafael
515 Third St.
San Rafael, CA 94901

74. 450 South Street Parking Garage
450 South Street
San Francisco, CA 94158

75. EAI, Inc.
1337 E. Washington
Phoenix, AZ 85034

76. Santa Clara City Library DCFC
2635 Homestead Drive
Santa Clara, CA 95051

77. Fred Meyer - #023 Bellevue
2041 148TH NE
Bellevue, WA 98007

78. Ohlone College - Newark Campus
39399 Cherry Street
Newark, CA 94560

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