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DC Fast Charger Usage in the Pacific Northwest

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WEST COAST ELECTRIC HIGHWAY

Key Conclusions

- The West Coast Electric Highway Project established a network of direct current fast chargers (DCFC) in the states of Oregon and Washington. In addition, The EV Project installed a dozen DCFCs in metropolitan areas throughout the region. Data from these two networks were analyzed to determine how often the DCFCs were used between September 1, 2012, and December 31, 2013. The most highly used DCFCs were located in the Seattle, Washington, metropolitan area. Other highly used DCFCs were found in Portland and Salem, Oregon, and along Interstate 5 (I-5) north from Salem to Vancouver, British Columbia. Usage generally decreased as distance from I-5 increased.
- When Nissan Leafs in The EV Project based in Washington and Oregon used DCFCs located inside Seattle and Portland, they tended to use them during round-trip outings of less than 75 miles. This is less than the range of the Leaf on a single charge.
- Leaf drivers used DCFCs located outside city boundaries to support longer travel, often driving 150 miles or more before returning home. For these drivers, the West Coast Electric Highway successfully enabled significant range extension.

Introduction

The deployment of DCFCs is a major topic of discussion within the electric vehicle (EV) community. DCFCs are a type of electric vehicle supply equipment (EVSE) that charge EVs by providing DC power directly to the EV's battery pack. Generally, DCFCs can charge vehicles at 50 kW or higher (compared to charge rates of 1 to 7 kW when vehicles charge using alternating current Level 1 and Level 2 EVSE), allowing vehicles to be charged quickly. For example, under the right conditions, the Nissan Leaf can charge its battery pack from near full depletion to around 80% state of charge in 30 minutes or less using a DCFC [1]. For this reason, many believe that DCFCs should have a major role in public EV charging infrastructure.

Most EV models currently on the market typically require recharging after driving less than 100 miles. Most EVs offer a driving range sufficient to meet the needs of most drivers most of the time. However, if drivers of these EVs want to take long trips, even infrequently, they need a convenient way to charge during the trip. One concept to overcome EV range limitation is to install DCFCs along transportation corridors to provide EV drivers opportunities to recharge quickly along their journey. This paper describes the use of DCFCs that have been installed for this purpose along major highways in the Pacific Northwest of the United States to determine whether they enable long distance travel in EVs.

What was Studied?

The West Coast Electric Highway Project was launched in 2011 to provide a widespread charging network of AeroVironment brand DCFCs located along highways to enable EV drivers to travel along the western coast of the United States. Also in 2011, The EV Project was launched to install a network of Blink brand EVSE in metropolitan areas of the Pacific Northwest, among other regions. In the states of Washington and Oregon, a total of 56 AeroVironment and 12 Blink DCFCs were installed within 1 mile of Interstate 5 and other highways as a result of these two projects. The DCFC were spaced 25 to 50 miles apart [2].

Idaho National Laboratory received charging data from 45 AeroVironment brand DCFCs and 12 Blink brand DCFCs along highways in Oregon and Washington. These data were analyzed, along with data from 1,063 privately-owned Nissan Leafs enrolled in The EV Project in Oregon and Washington. Analysis determined how often each DCFC was used and how far vehicles were driven on journeys during which they were charged at the DCFCs.

The period of study for this paper was September 1, 2012, through December 31, 2013. During the study period period, the 57 corridor DCFCs reporting data were used 36,846 times by 2,515 distinct EVs. Of the 1,063 Nissan Leafs whose data were analyzed, 319 Leafs were charged at least once using any of the 57 DCFCs in this study. These 319 vehicles performed 3,325 total charging events at these DCFCs during the study period.

All of the DCFCs had CHAdeMO connectors during the study period. Any CHAdeMO-compatible EV could have used these DCFCs, regardless of whether they were participants in The EV Project.

Weekly Usage of DC Fast Chargers on the West Coast Electric Highway

The usage frequency of each DCFC was determined using the data logged by the DCFC themselves. Figure 1 shows a histogram of usage frequency, in terms of the average number of charging events performed at each DCFC per week.

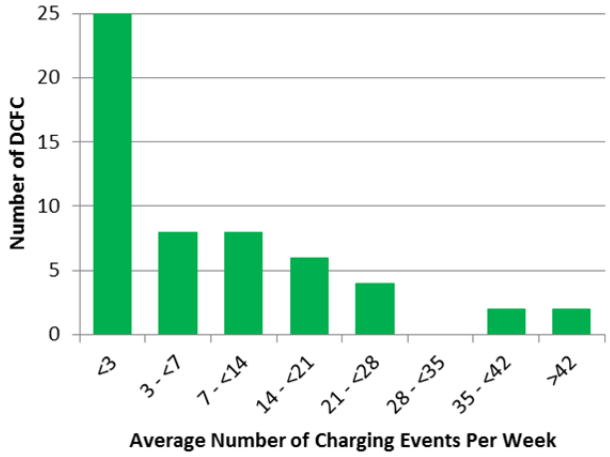

Figure 1. Distribution of usage frequency of DCFCs on the West Coast Electric Highway.

There was a wide range in the usage of DCFCs. The majority were used less than seven times per week, or once per day. However, four were used 35 or more times per week, or 5 or more times per day. A map was created to show how usage frequency varied geographically. This map is shown in Figure 2.

The figure shows a trend in DCFC usage related to its location. Generally, the DCFC that are closer to large cities were used more frequently than those in more sparsely populated areas. The DCFCs directly between the larger cities (i.e., Portland, Seattle, and Vancouver, British Columbia) also had high usage. DCFCs installed farther from large cities, especially to the east and west of I-5 and south of Eugene, were generally used less than 7 times per week. This low usage may not create high value for DCFC owners if they are counting on charger usage to produce revenue or bring in customers to their businesses. However, each individual charge may have been highly valued by the EV driver. It is important to note that the sites of the West Coast Electric Highway DCFC were not necessarily chosen based on projected usage; more important was to allow EV drivers to take longer trips and to raise awareness and visibility of EVs and charging infrastructure [3].

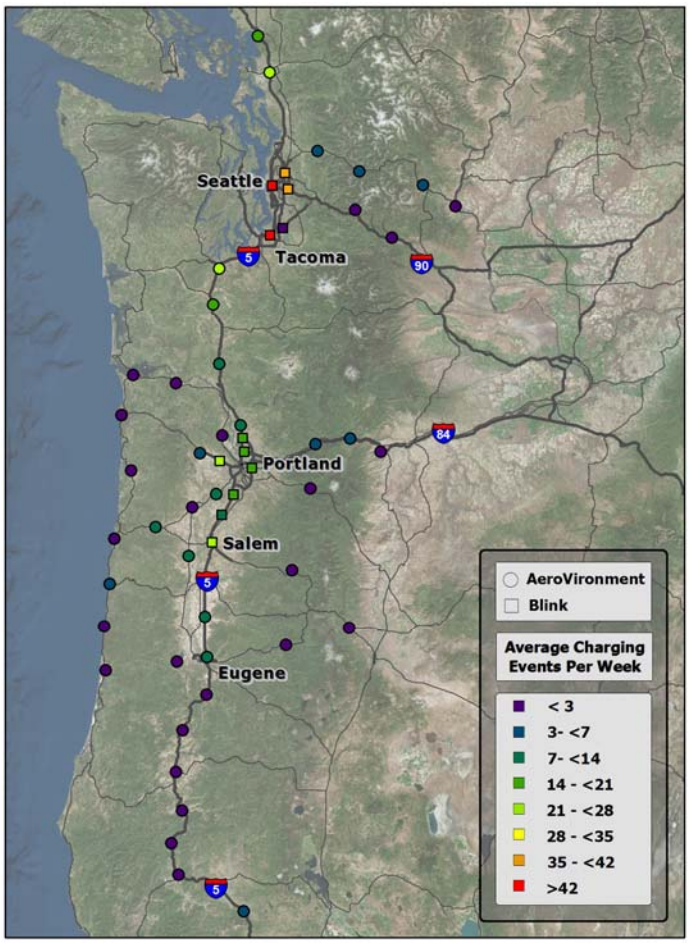

Figure 2. Usage frequency of DCFCs on the West Coast Electric Highway. The color of each symbol represents usage frequency. Symbol shape denotes the DCFC brand.

How have Electric Vehicle Drivers Used DC Fast Chargers?

To understand the usefulness to EV drivers of DCFCs located along highways, it is important to know how drivers incorporated the DCFCs into their travel. Were they using the DCFCs because they happened to be located where the drivers normally spent time or did they use them truly to enable long-distance travel along a highway corridor? To answer this question, data from Nissan Leafs in The EV Project that used the DCFC in this study were analyzed. Data from each vehicle were broken up into outings. An outing, which is sometimes also referred to as a journey or tour, represents all driving done from when a driver leaves home to when they return home. Outings can span multiple days and include numerous charges or they can be a single drive around the block.

A map was produced to show all of the places where EV Project Leafs parked when away from home during outings.

This map is shown in Figure 3. Light blue points denote where parking occurred during outings when, at some point during the outing, a DCFC was used. Parking locations were shown as black points if DCFCs were not used during the outing. For reference, the regions within which EV Project participants lived were shaded in light gray.

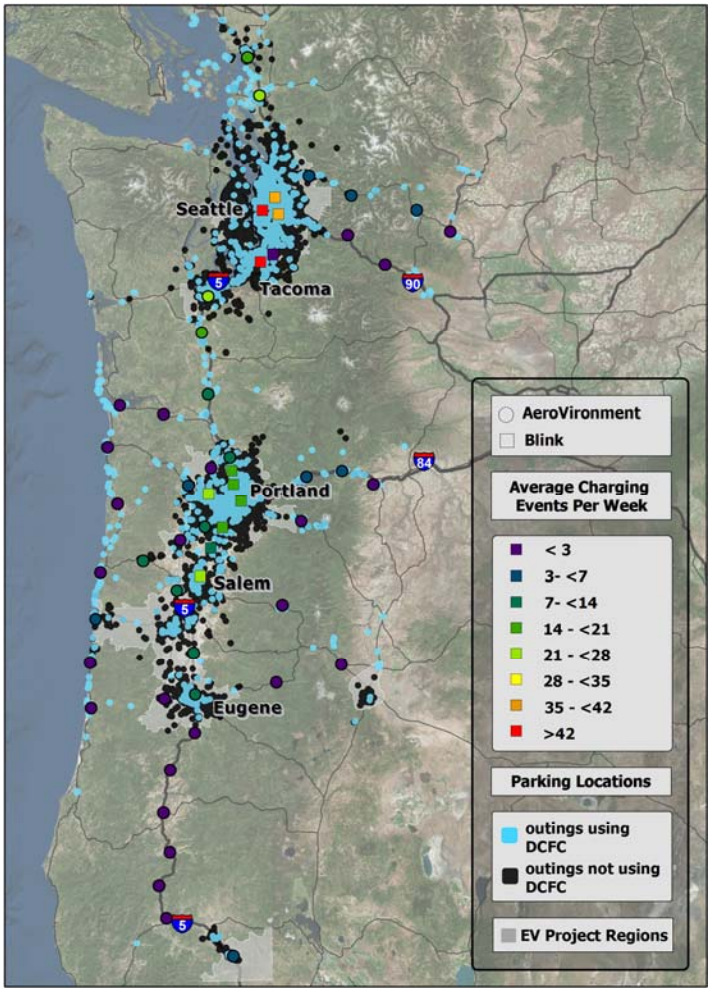

Figure 3. Away-from-home Nissan Leaf parking locations during outings were added to the map showing DCFC usage frequency. The color of the parking location points indicates whether a DCFC was used during the outing.

This map shows that when DCFCs were used, drivers covered a much larger geographic area than they did on outings without fast charging. During outings when DCFCs were not used, drivers rarely parked outside EV Project regions. From Figure 3, it is obvious that the West Coast Electric Highway DCFCs allowed drivers to cover more ground, but it is also important to quantify how far vehicles were driven before and after using these DCFCs.

For each outing during which a DCFC was used, the total distance driven in that outing was calculated. If a vehicle used a certain DCFC in multiple outings, those outing distances were averaged to remove any skewing effects that may arise from a single vehicle using a DCFC more than other vehicles. For each DCFC, this analysis produced a list of every vehicle that used it and each vehicle's average outing distance when they used the DCFC. The median of vehicle average outing distances for each DCFC was then used to represent the outings using that charger. The distribution of median outing distances for all DCFCs is shown as a histogram in Figure 4. To be included in this analysis, a DCFC had to be used in 30 or more outings. Many of the least frequently used DCFCs were not used enough by Leafs in The EV Project to be included in the outing analysis.

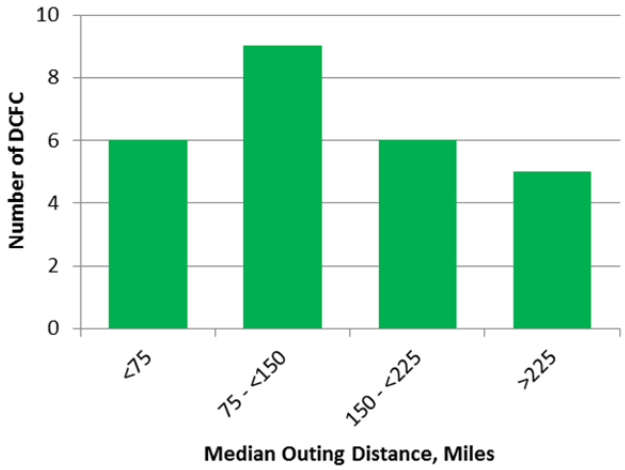

Figure 4. Histogram of median outing distance for DCFCs used during 30 or more outings by Leafs in The EV Project.

The median outing distances are fairly evenly distributed, with 75 to 150 miles being most common. The map from Figure 2 was updated to reflect the median outing distance values for each DCFC using stars of increasing size. This map can be seen in Figure 5. The symbols for the DCFCs not included in the outing analysis remain unchanged from Figure 2.

The DCFCs with the shortest median outing distances were almost all near the city centers of Seattle and Portland, which are the largest cities in Oregon and Washington. The median outing distances for these DCFCs were less than 75 miles, or less than the full charge range of the Leaf. This suggests that, in general, these DCFCs were not used to support corridor travel, but rather were used because they were in areas with high concentrations of EV Project Leafs.

Generally, the farther the DCFC was from larger cities, the higher the median outing distance was. Those that were used in the longest outings were between Portland and Seattle, on the Oregon Coast, and north of Seattle toward Vancouver, British Columbia. These DCFCs are similar in that they are not near large population centers; therefore, it

is unlikely that vehicle owners lived close to them and used them for convenience.

Looking at the DCFCs on I-5 between Portland and Seattle, as well as north of Seattle, they were all used one to four times per day. All of them had median outing distances of greater than 150 miles and some were greater than 225 miles, requiring at least three full charges of the Leaf battery. These results suggest that the West Coast Electric Highway in these areas is being used by EV drivers to support a considerable amount of long distance travel. In fact, further inspection of the data found that there were 19 outings longer than 500 miles. The longest of these outings was 770 miles. To accomplish this, the driver performed 16 fast charges at nine different DCFCs throughout the region.

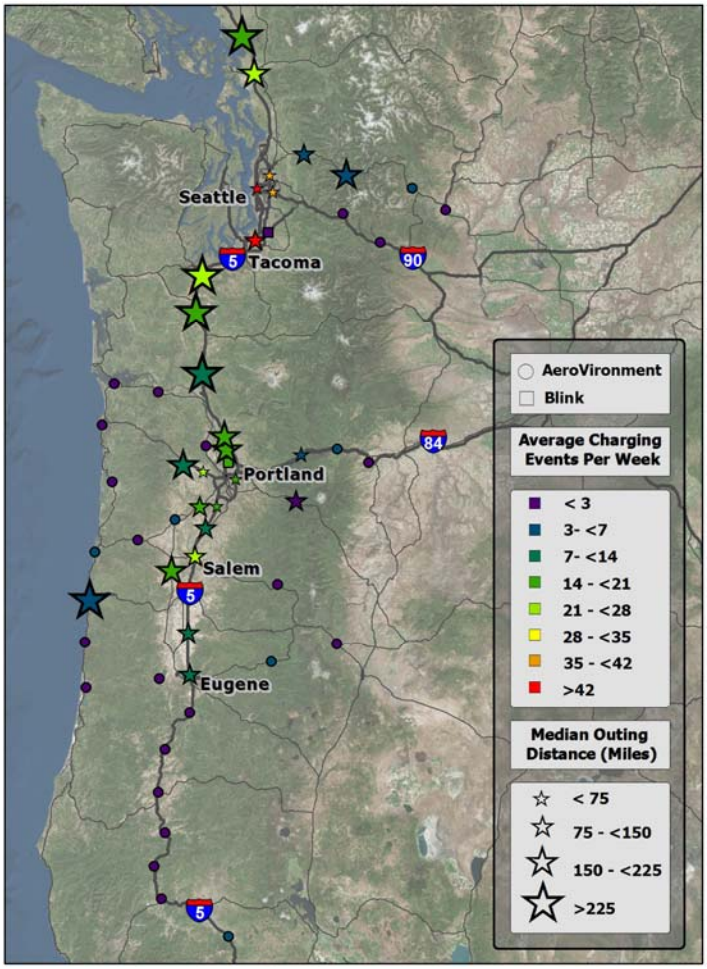

Figure 5. Stars of varying size were added to the map in Figure 2 to denote median outing distance of EV Project Leafs when using DCFCs on the West Coast Electric Highway.

About The EV Project

The EV Project was the largest plug-in electric vehicle infrastructure demonstration project in the world, equally funded by the United States Department of Energy (DOE) through the American Recovery and Reinvestment Act and private sector partners. The EV Project deployed over 12,000 alternating current Level 2 charging stations for residential and commercial use, as well as 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 The 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.

For more information about The EV Project, visit avt.inl.gov/evproject.shtml.

About the West Coast Electric Highway

The West Coast Electric Highway is a network of 56 alternating current (AC) Level 2 EVSE and DCFC located every 25 to 50 miles along Interstate 5 and other major roadways in the Pacific Northwest (i.e., Washington and Oregon).

For more information about the West Coast Electric Highway, visit www.westcoastgreenhighway.com/electrichighway.htm.

and www.oregonelectrichighway.com.

About the AeroVironment Data

Idaho National Laboratory expresses thanks to AeroVironment for providing EVSE usage data to Idaho National Laboratory, thereby making this study possible.

For more information about AeroVironment, visit evsolutions.avinc.com.

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 about Idaho National Laboratory, visit www.inl.gov.

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