AABC: Electric (EV) and Plug-in Hybrid Electric Vehicle (PHEV) Charging Habits

Jim Francfort
Advanced Transportation Group
Idaho National Laboratory

Advanced Automotive Battery Conference
Detroit, Michigan
June 2016

This presentation does not contain any proprietary, confidential, or otherwise restricted information

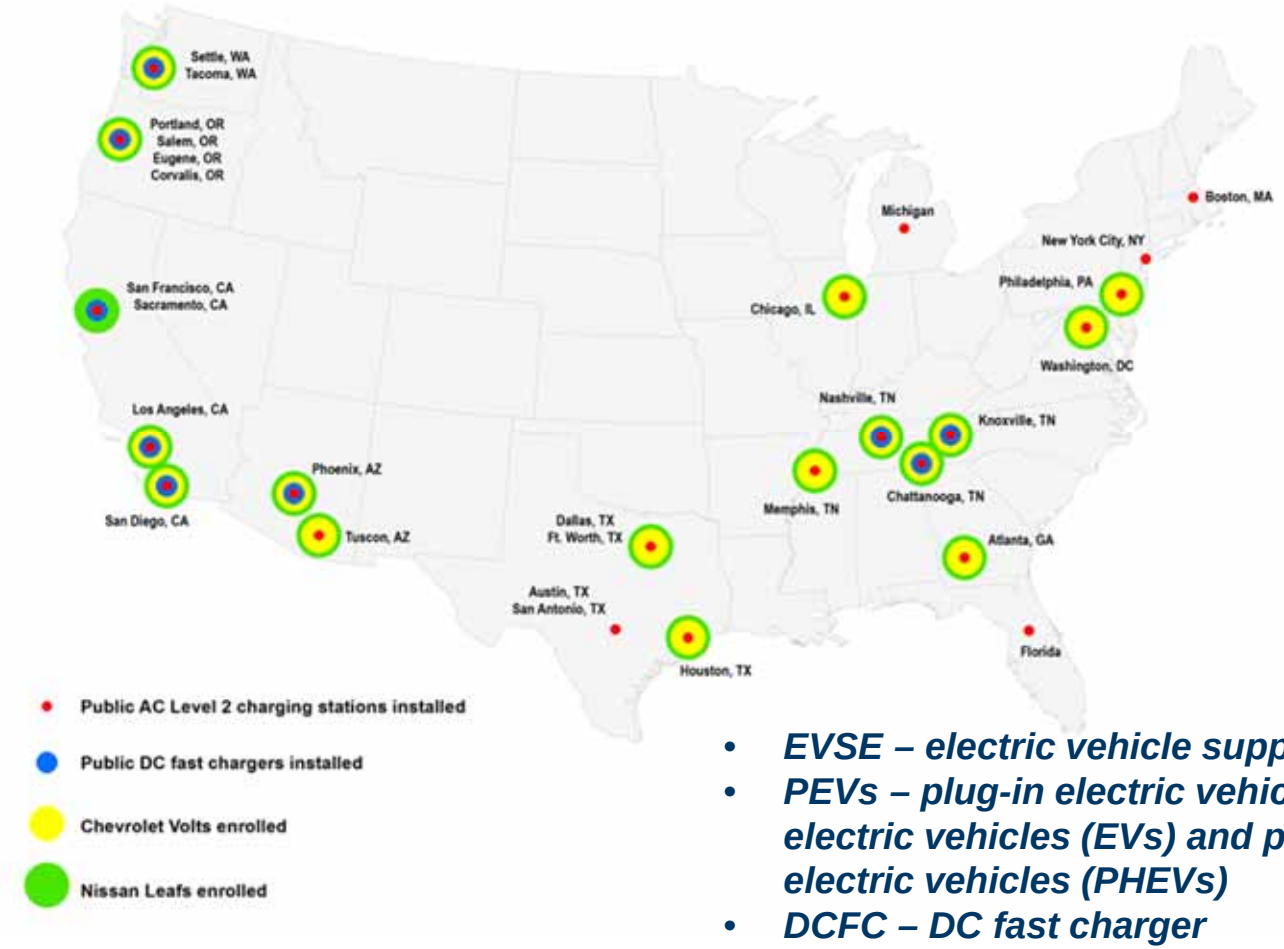
INL/CON-15-37556

www.inl.gov

Idaho National Laboratory

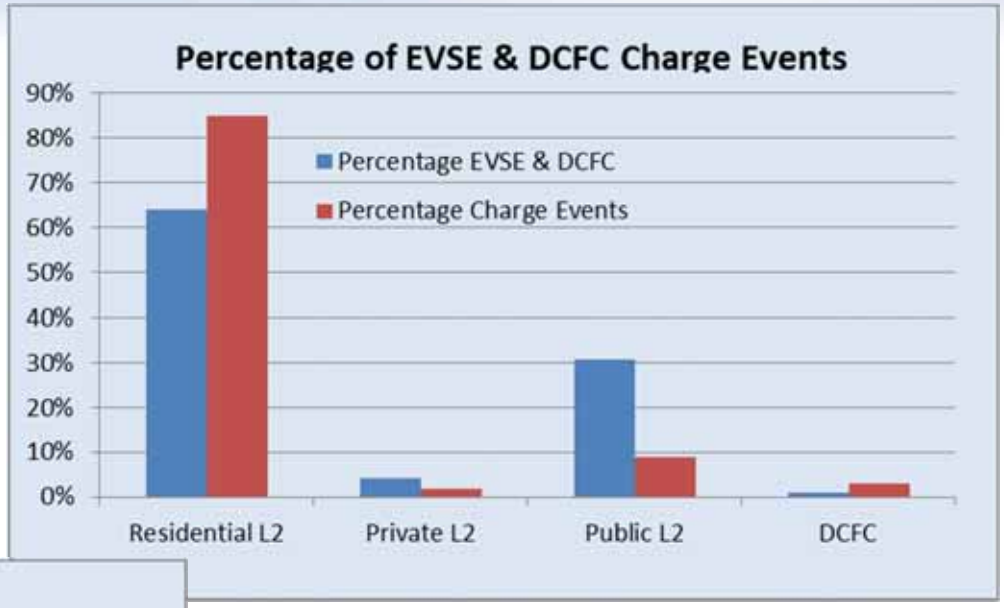
PEV and EVSE Locations – EV Project and ChargePoint America

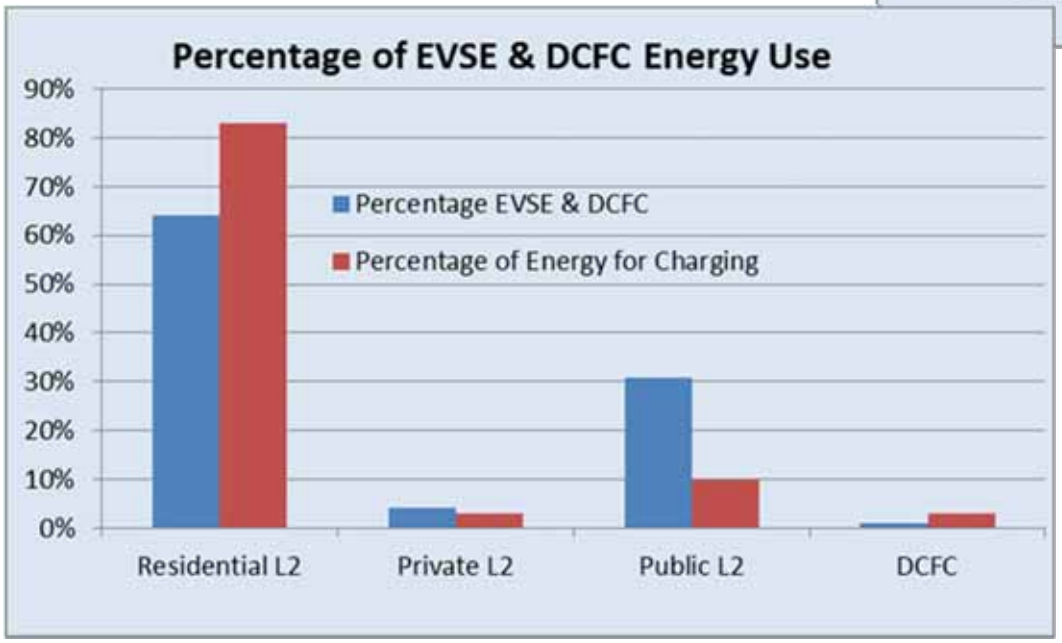
- **17,000 AC Level 2 EVSE and DCFC and 8,300 PEVs provided charging and vehicle operations data via telematics systems**



- ***EVSE – electric vehicle supply equipment***
- ***PEVs – plug-in electric vehicles. Includes electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs)***
- ***DCFC – DC fast charger***

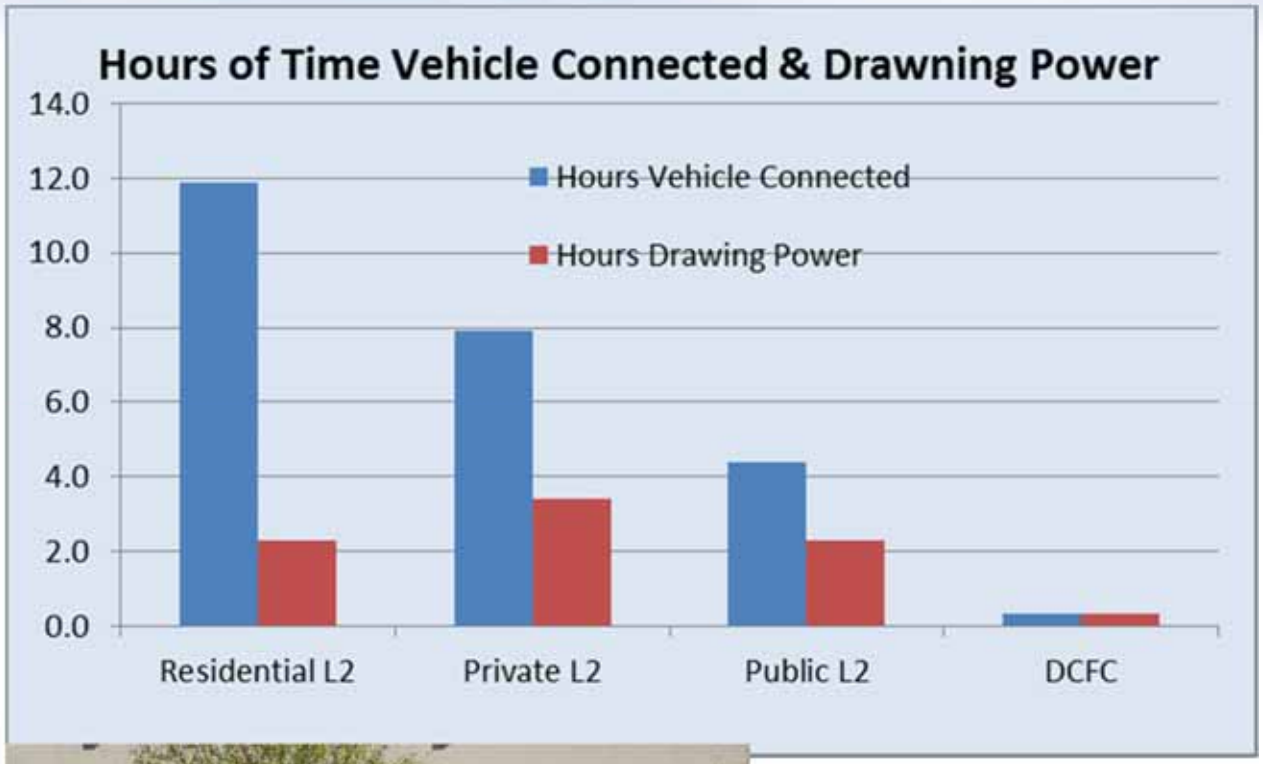
Plug-in Electric Vehicle (PEV) EVSE Use





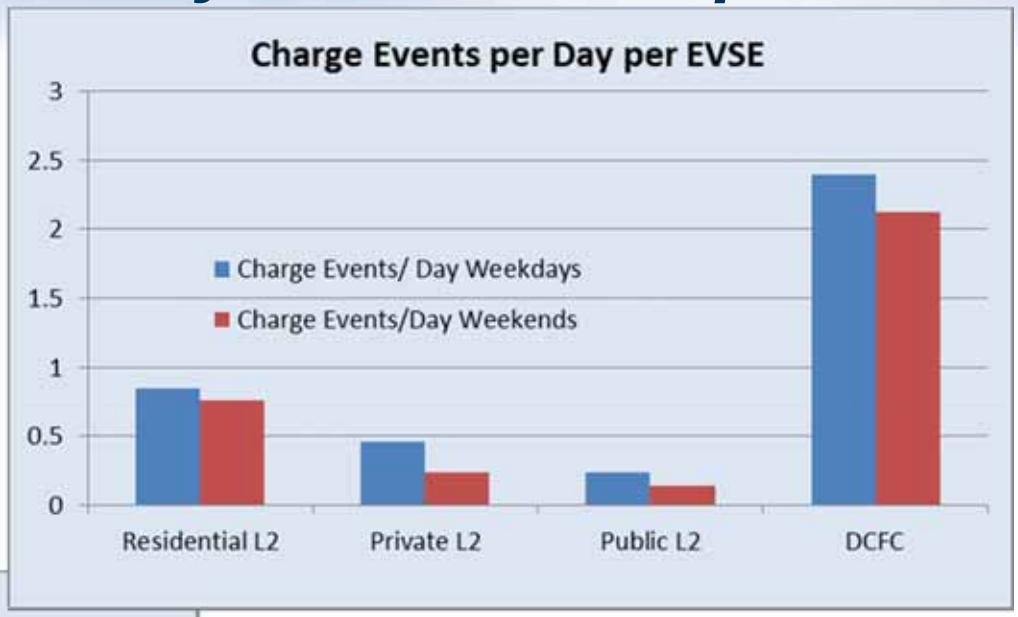
- ***EV Project data***
- ***Residential L2 – Residential AC Level 2 EVSE***
- ***Private L2 – Restricted access AC Level 2 EVSE***
- ***Public L2 – Open access AC Level 2 EVSE***

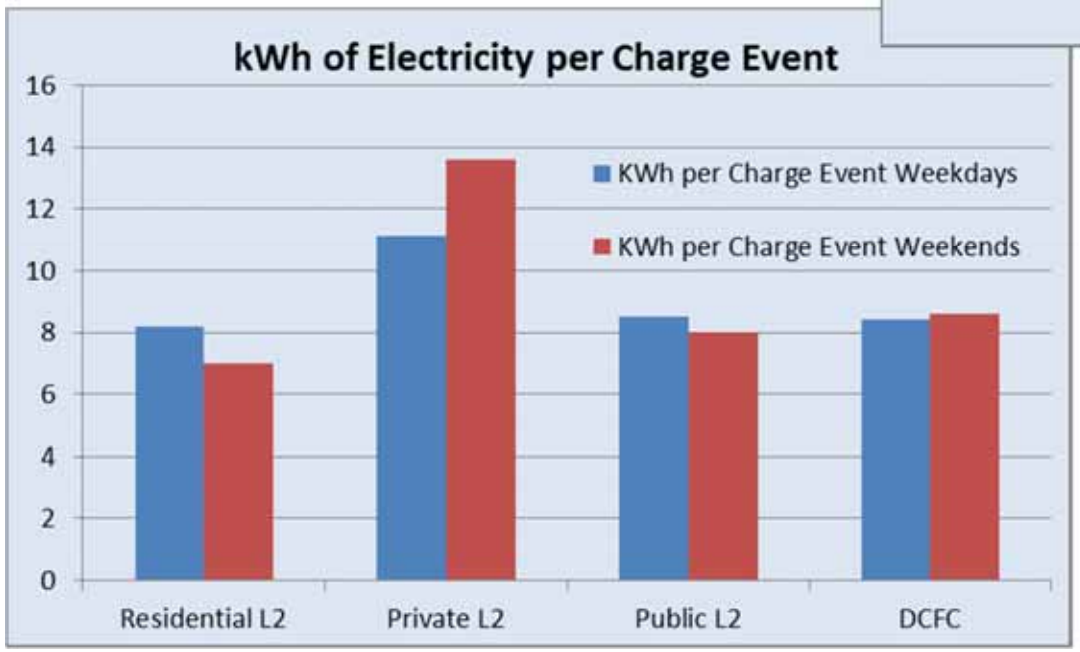
PEV Hours Connected and Drawing Power



- ***EV Project data***

EVSE Charge Events per Day & kWh Used per Charge Event

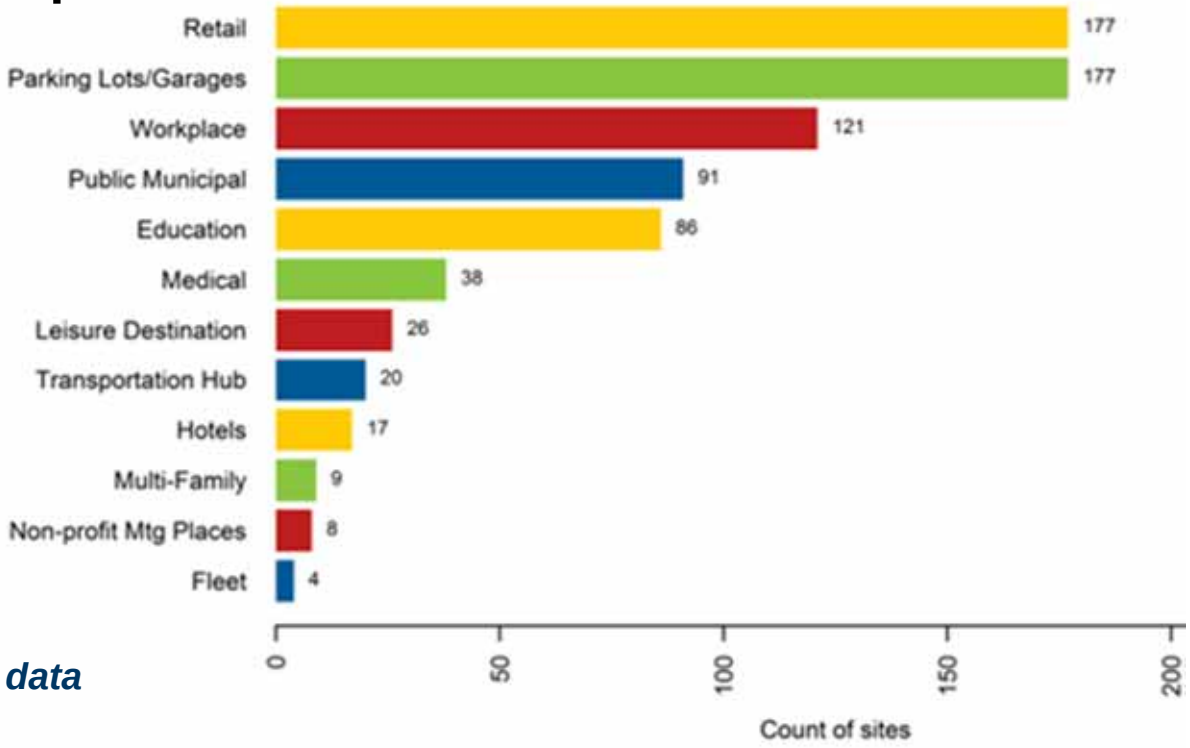




- ***EV Project data***

Public AC Level 2 EVSE Charging Venues

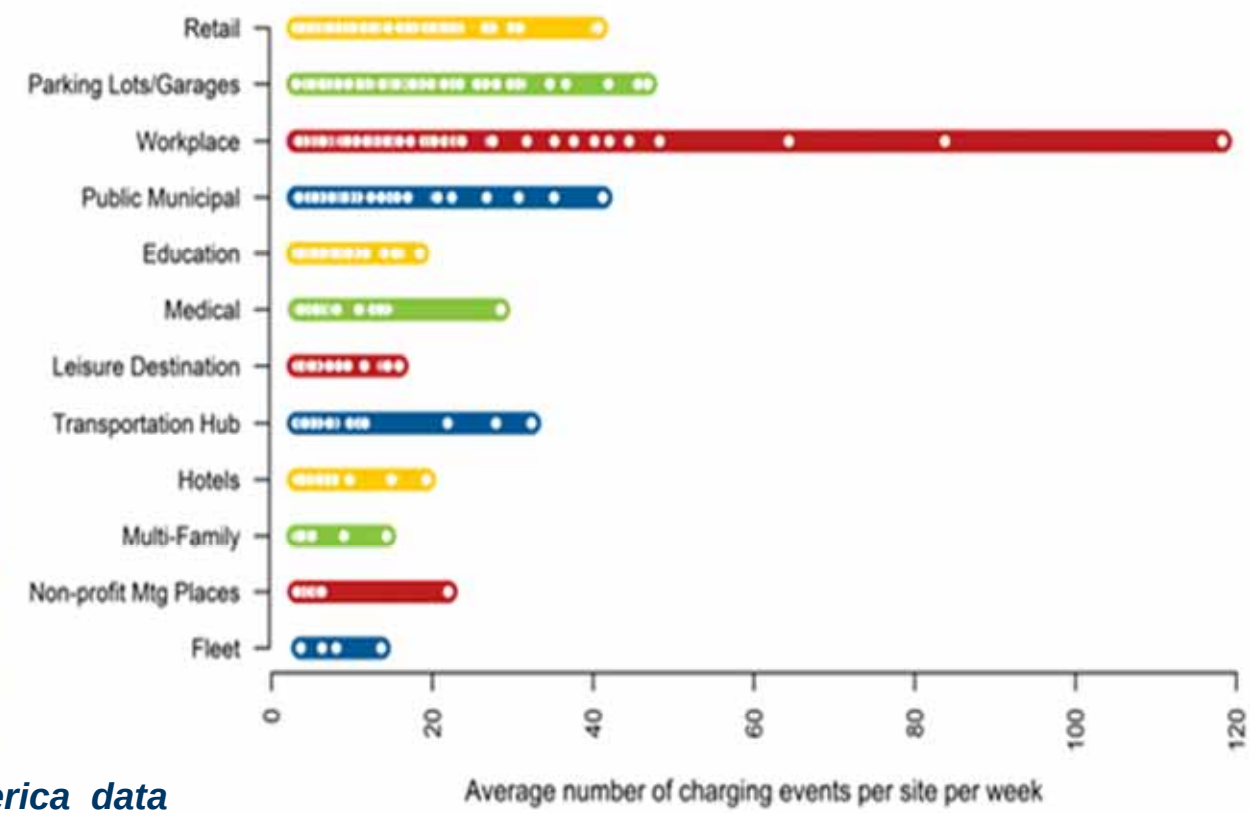
- **Public EVSE sites were comprised of as few as one AC Level 2 EVSE and as many as 18 per site**
- **774 public Level 2 (240V) sites in primary venues**
- **Retail and parking lot/garage venues contained over 45% of all public sites**
- **Workplace was 16% of all public sites**



- *EV Project & ChargePoint America data*

Frequency of Public AC Level 2 EVSE Charge Events by Venue

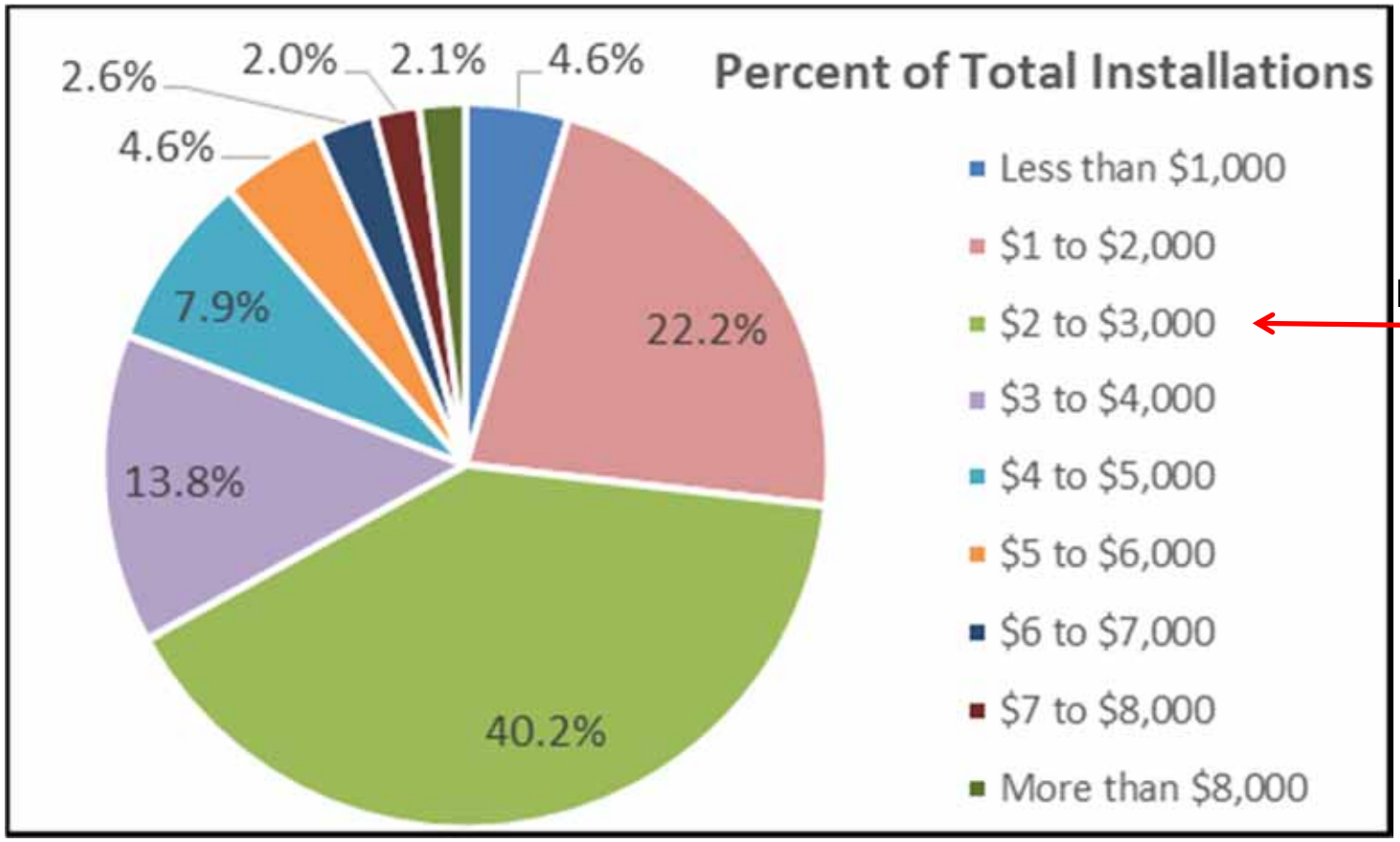
- **Average charge events per site per week**
- **One retail venue averaged 40 average events per week**
- **The top 7 workplace sites averaged over 40 charging events per week**



- *EV Project & ChargePoint America data*

Public AC Level 2 EVSE Installation Costs

- **Average cost for publicly accessible Level 2 EVSE was $3,108 per EVSE**
- **Average cost for workplace wall-mount AC Level 2 EVSE was $2,035**
- **Average cost for a workplace pedestal AC Level 2 was $3,209**

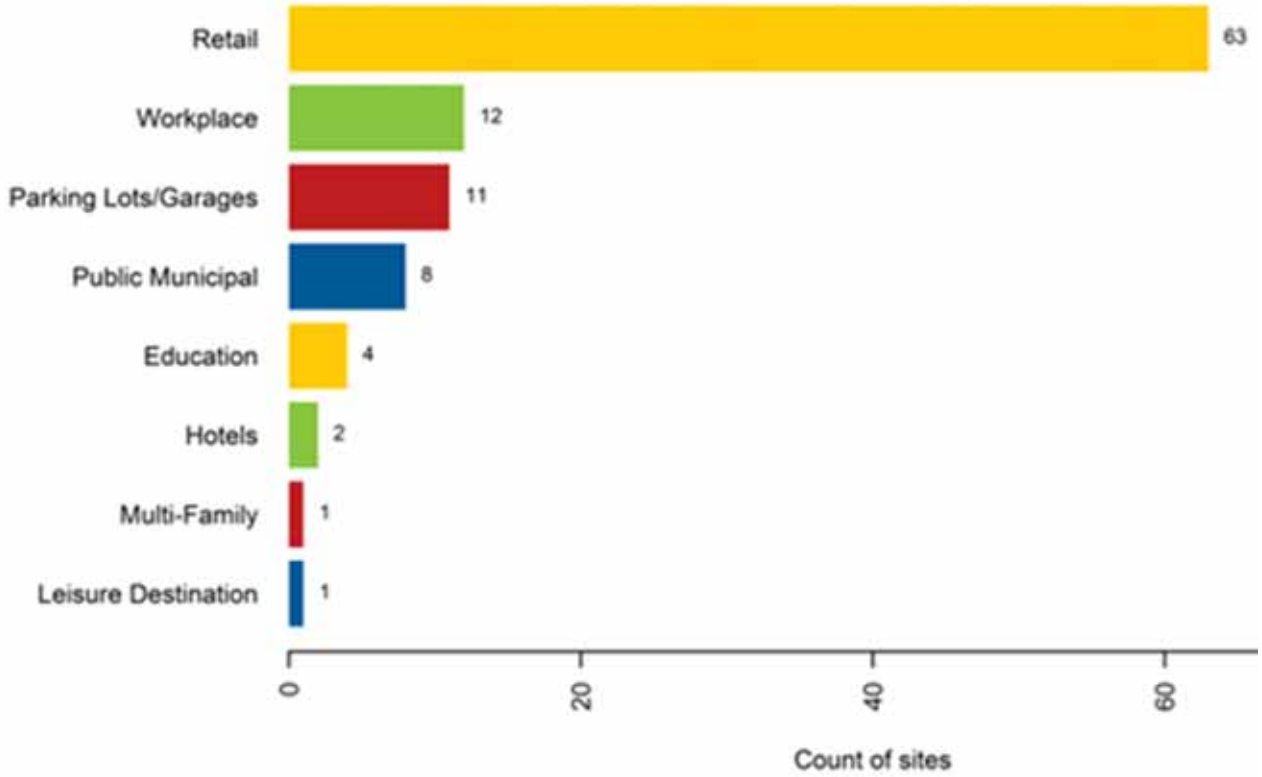


Public Level 2 Installation costs

- ***EV Project data***

Public DCFC Use

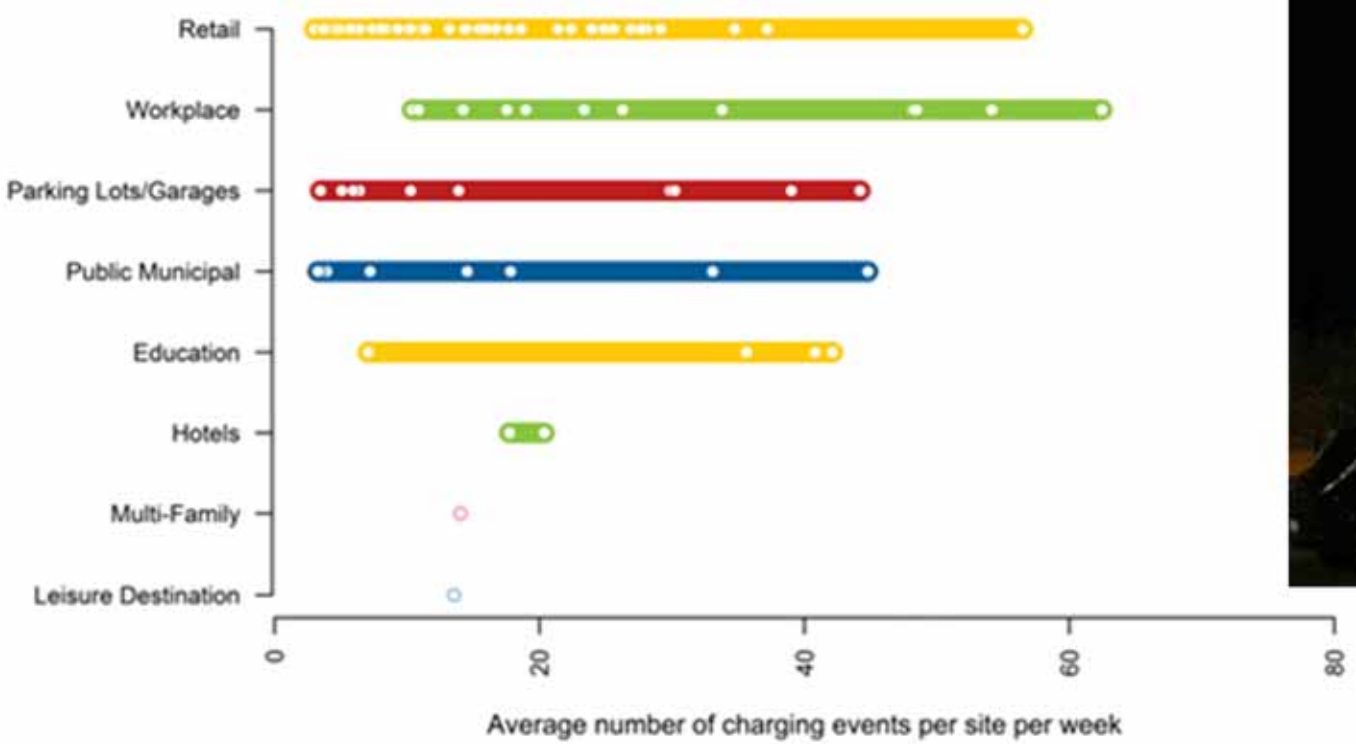
- **102 DCFC average number of charging events per week per site for DCFC sites by venue (note that workplace DCFC had to be publicly accessible)**
- **Retail venues constituted 62% of all DCFC installed in the EV Project**



- ***EV Project data***

Publicly Accessible DCFC Use

- **The site with the most usage is at a workplace venue**
- **DCFC utilization ranged from 3 to just over 60 charging events / week**
- **Workplace and education venues had the highest median charging frequency at 25 & 38 events per site per week**

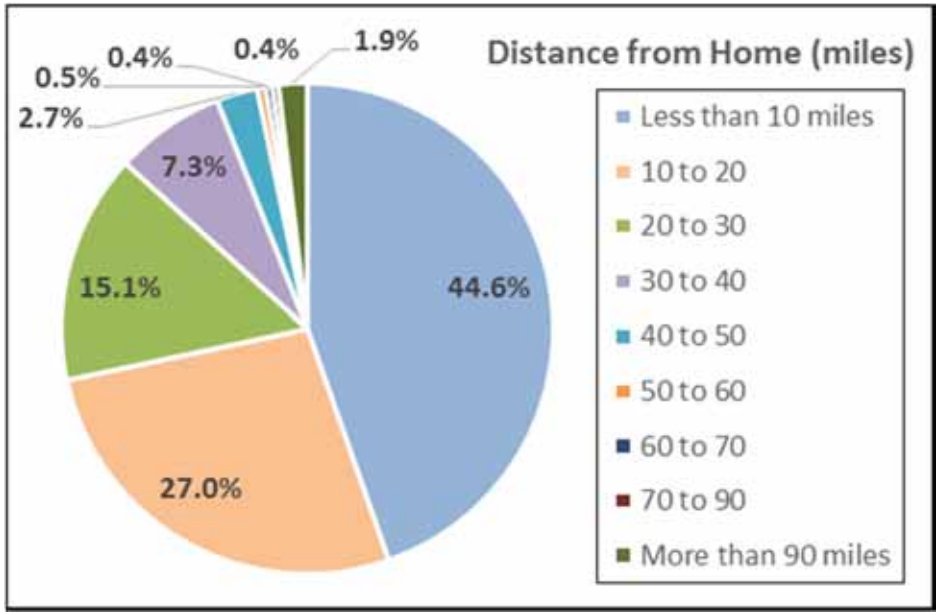


- ***EV Project data***

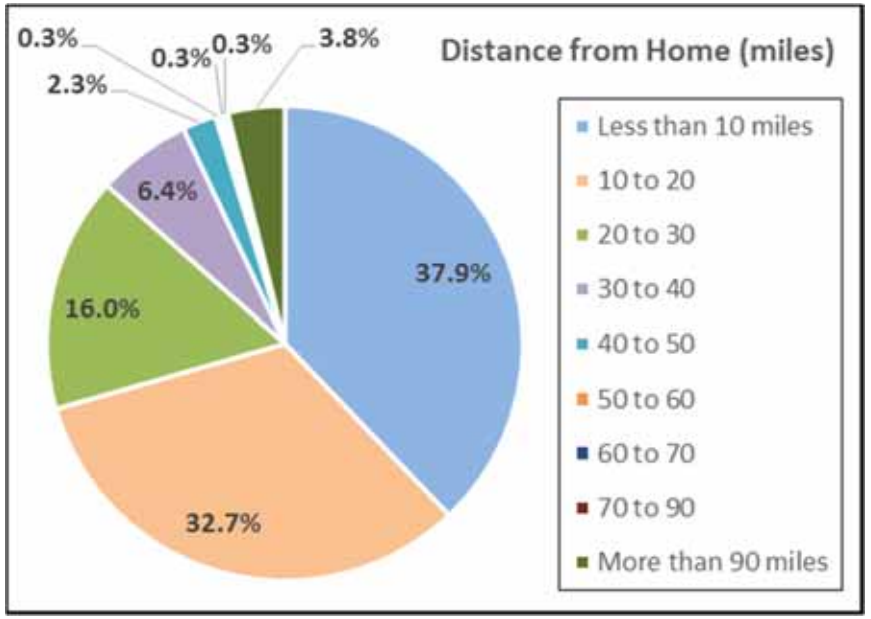
Use Patterns at Highly Utilized DCFC

- **20 highest utilized DCFC used an average of 21 to 66 times per week**
- **EV Project Leafs charged an average of 17 miles from home and the average state of charge was 35% at charge initiation**
- **Fees to charge during the last 6 months of the EV Project likely influenced greater distances from home when DCFC recharging**

Leafs distance from home when fast charging (life of the EV Project)



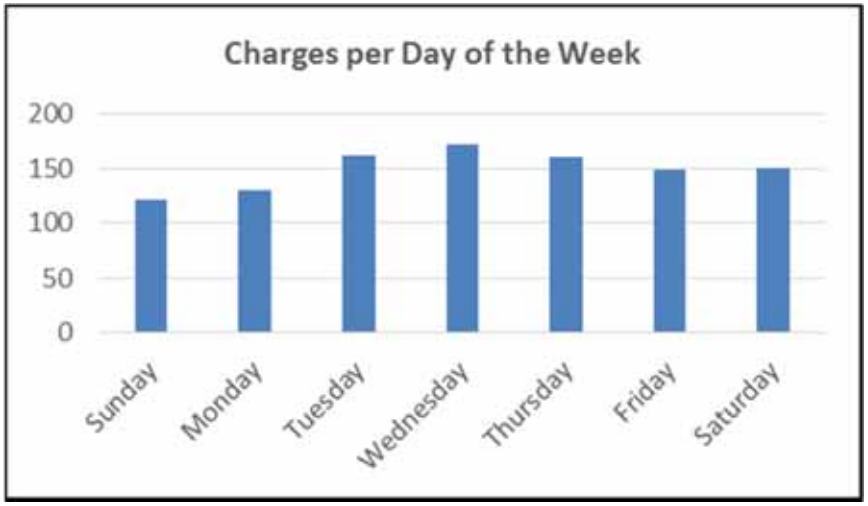
Leafs distance from home when fast charging (last 6 months of the EV Project)

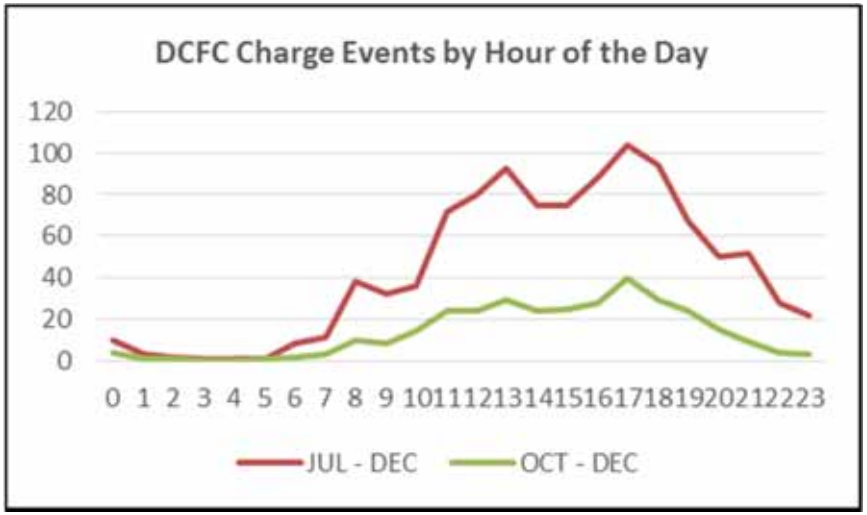


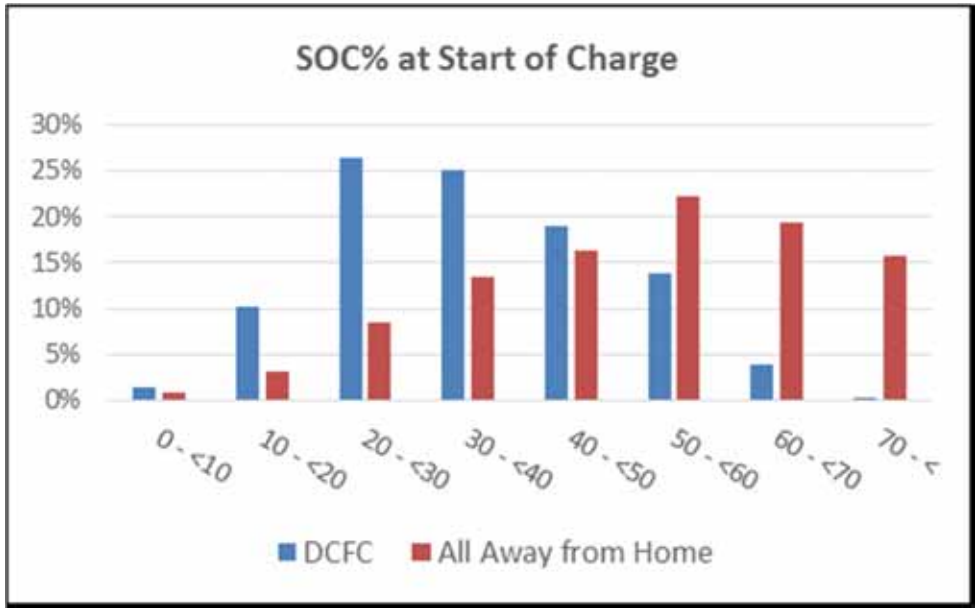
- ***EV Project data***

Use Patterns at Highly Utilized DCFC

Last 6 months of the EV Project



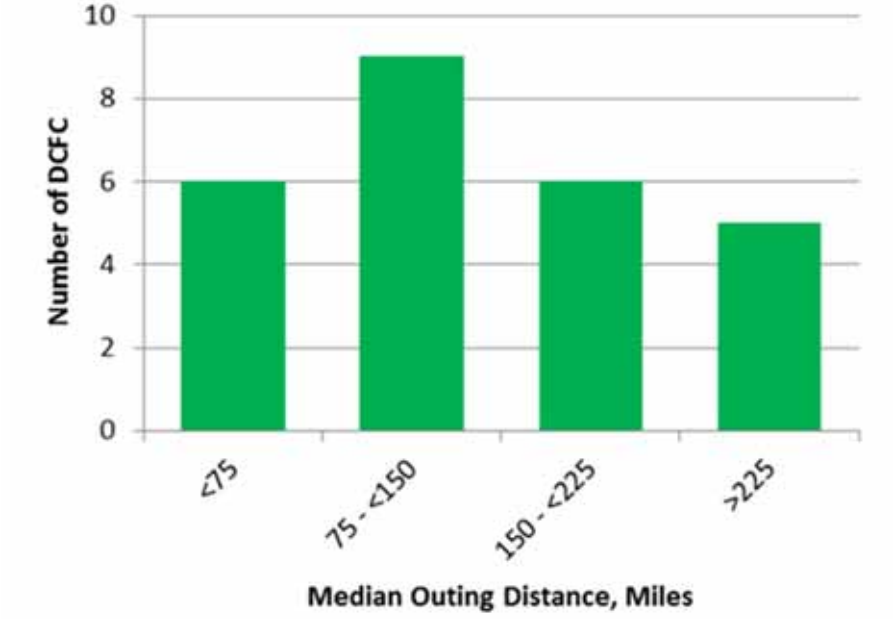




- ***EV Project data***

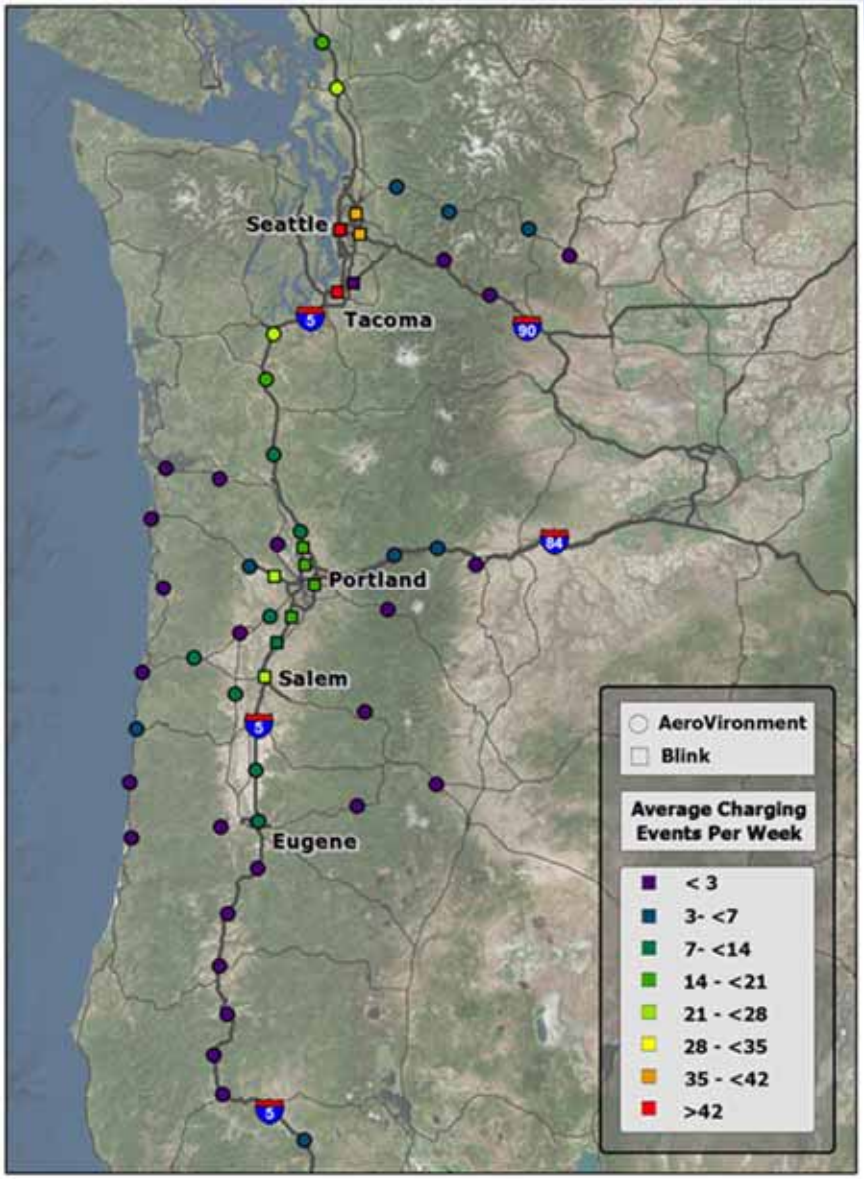
I-5 Corridor – 45 AeroVironment and 12 Blink DCFC

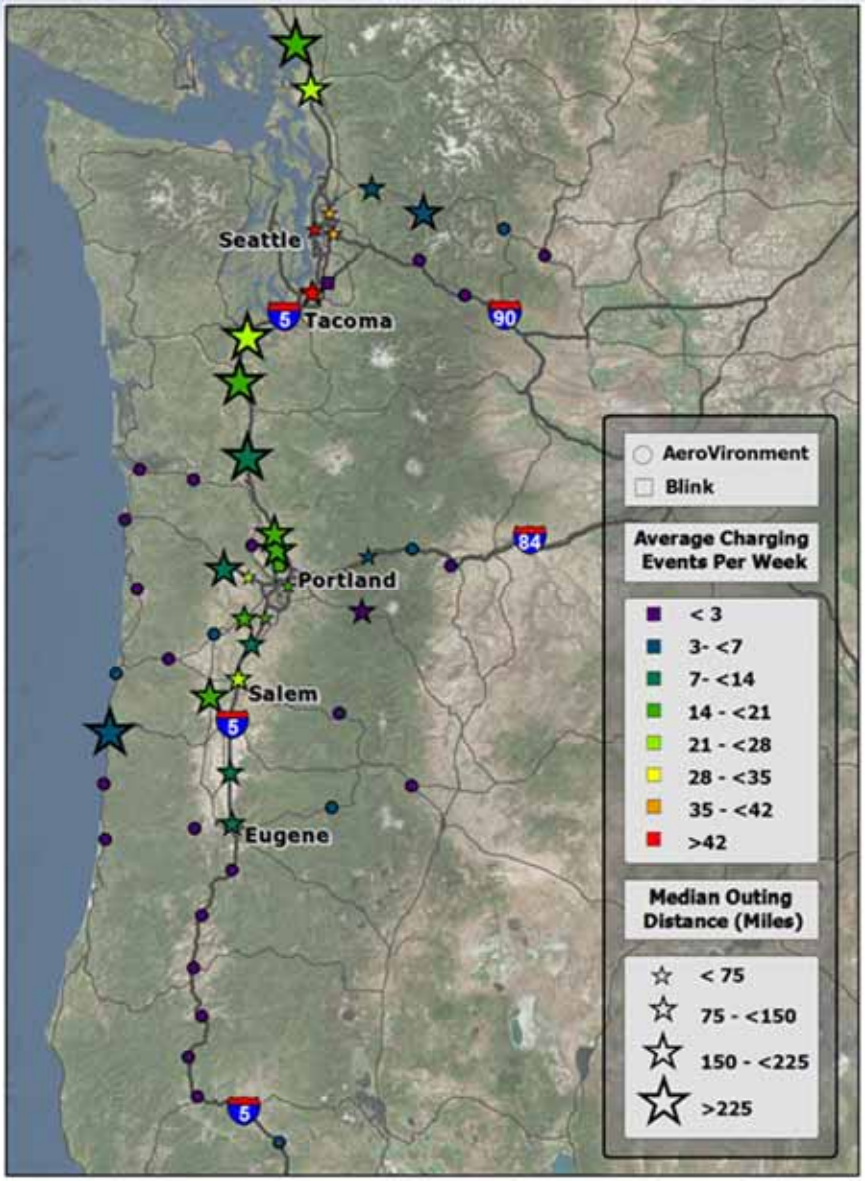
- 57 DCFC installed 1 mile of Interstate 5 & other highways OR/WA
- CHAdeMO DCFC spaced 25 to 50 miles apart
- INL received data for 45 AeroVironment and 12 Blink DCFC
- 36,846 charge events by 2,515 distinct EVs
- 1,589 EV Project Nissan Leafs in Washington and Oregon
- Of the 1,589 Leafs, 319 charged at least once at the 57 DCFC, with 3,325 charge events
- 19 outings greater than 500 miles
- One Leaf driver drove 770 miles during one outing, by fast charging 16 times at 9 different DCFC



- *EV Project & AeroVironment data*

I-5 Corridor – 45 AeroVironment and 12 Blink DCFC





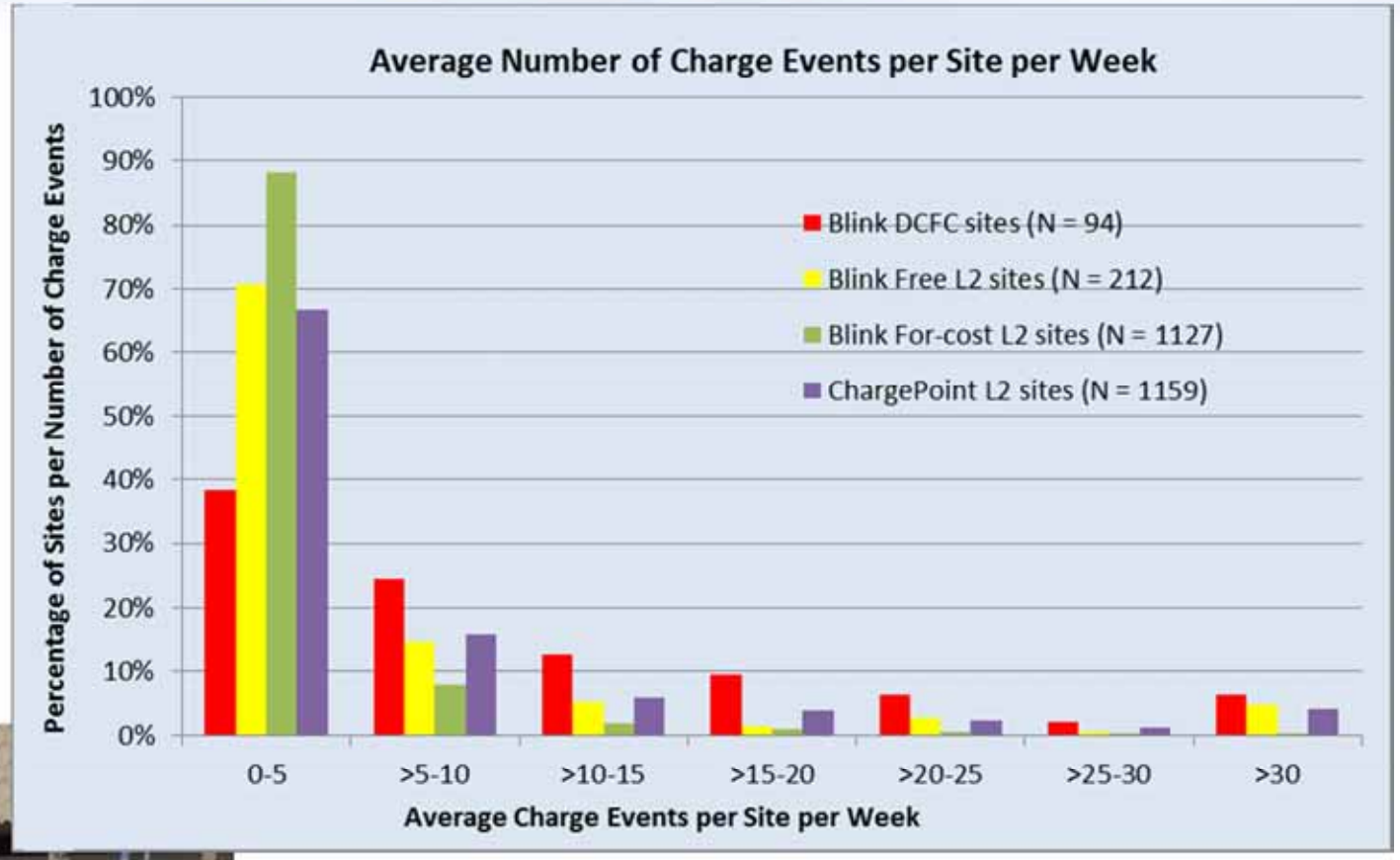
- *EV Project & AeroVironment data*

DC Fast Charger Installation Costs for 111 Units

- **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. This does NOT include DCFC unit cost**
- **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 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**

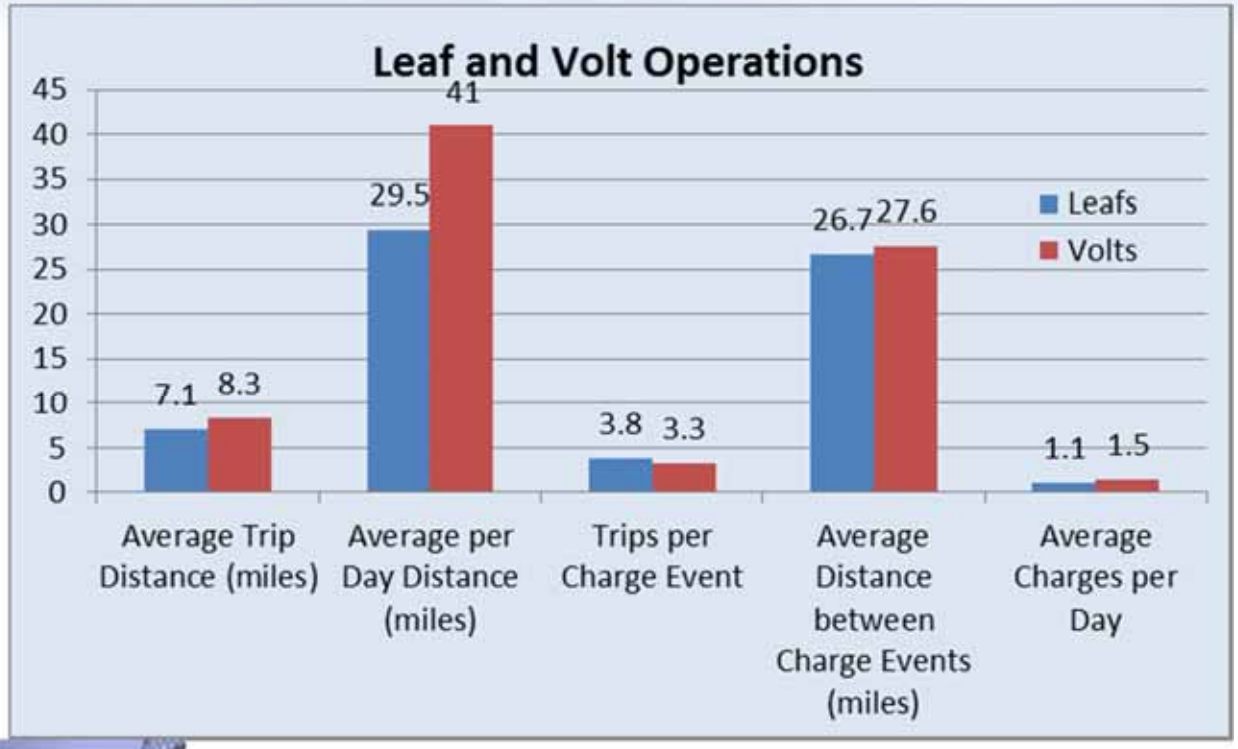
- ***EV Project data***

Public AC Level 2 and DCFC Use per Site per Week



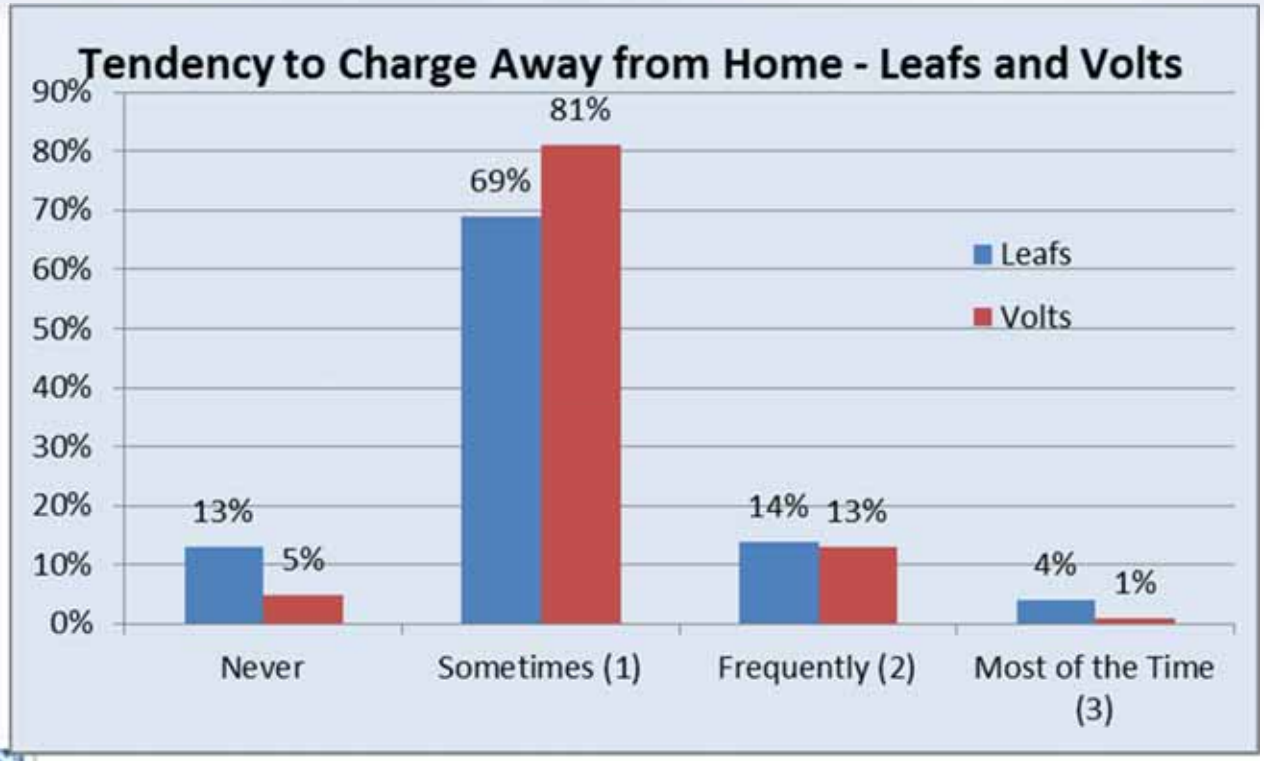
- ***EV Project data***

Leaf and Volt Operations Profile



- ***EV Project data***

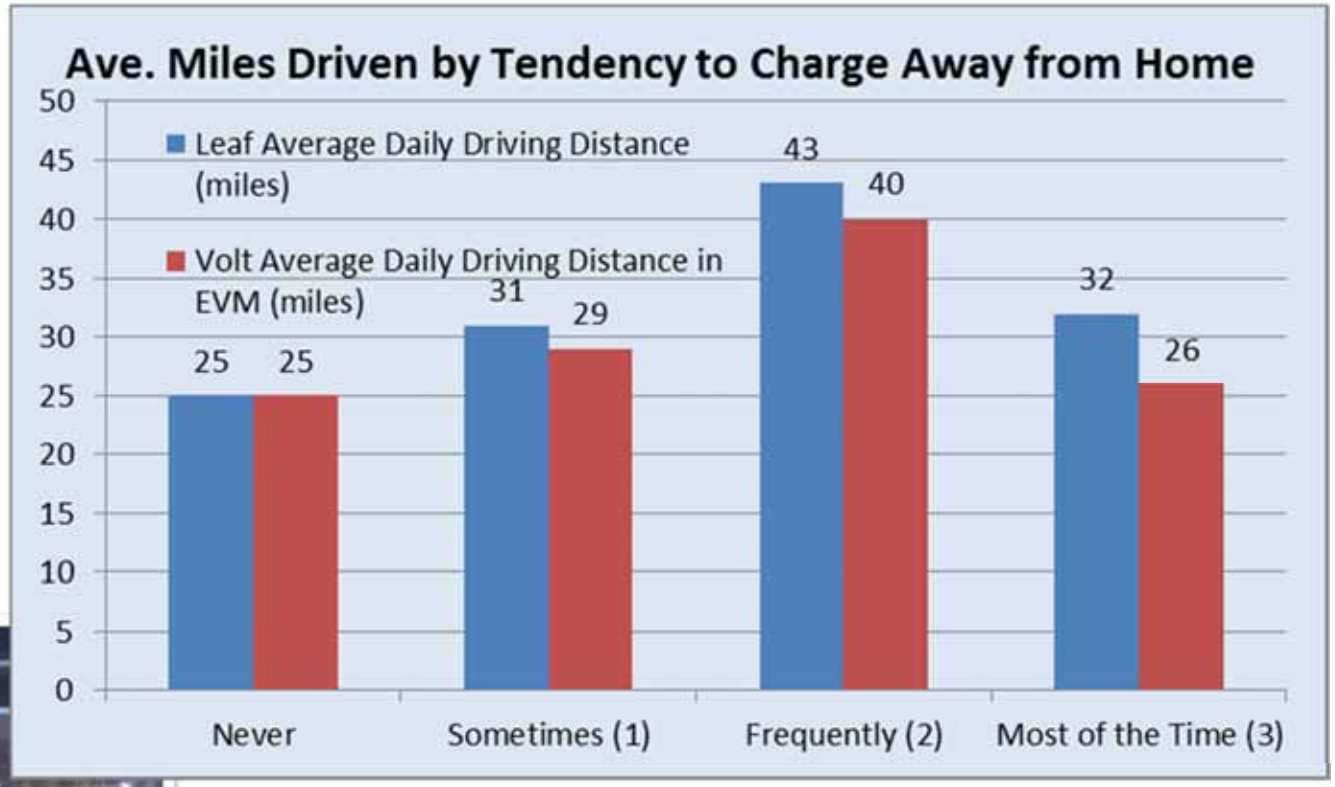
Leaf and Volt Drivers' Charging Preferences



(1) >0 to 30% of all charge events
(2) >30 to 60% of all charge events
(3) >60% of all charge events

- ***EV Project data***

Average Miles Driven Daily by Charging Away from Home Frequency

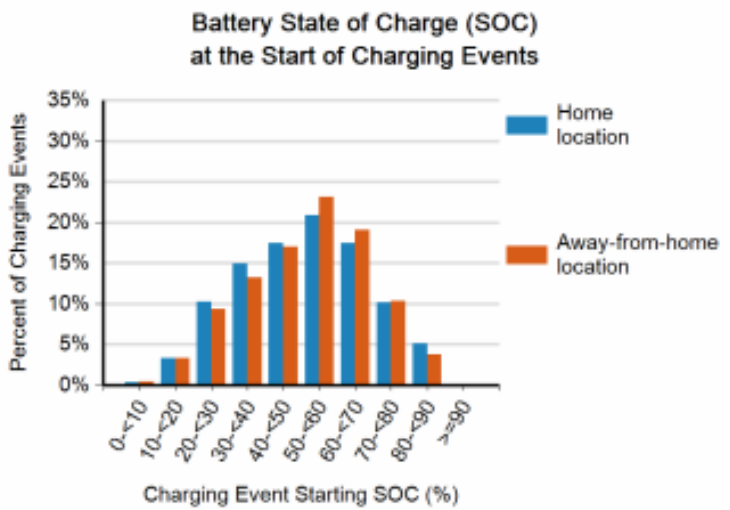


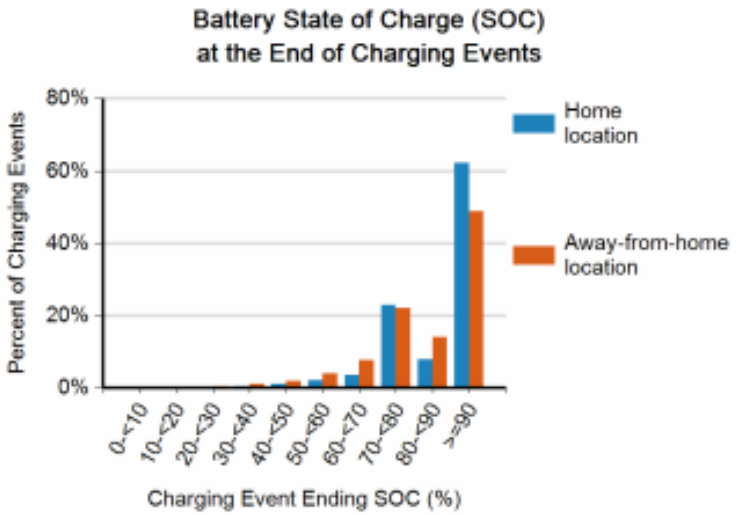
(1) >0 to 30% of all charge events
(2) >30 to 60% of all charge events
(3) >60% of all charge events
EVM – electric vehicle miles

- *EV Project data*

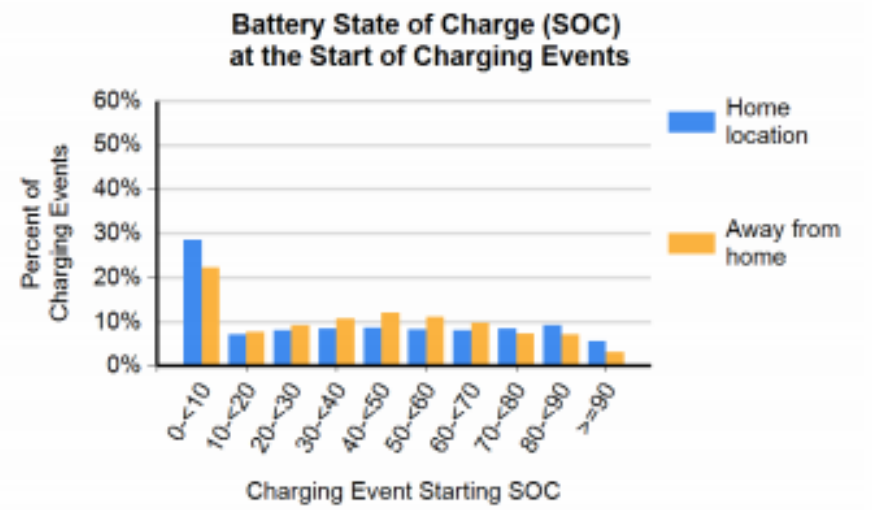
Leaf and Volt SOC at Start and End of Charge

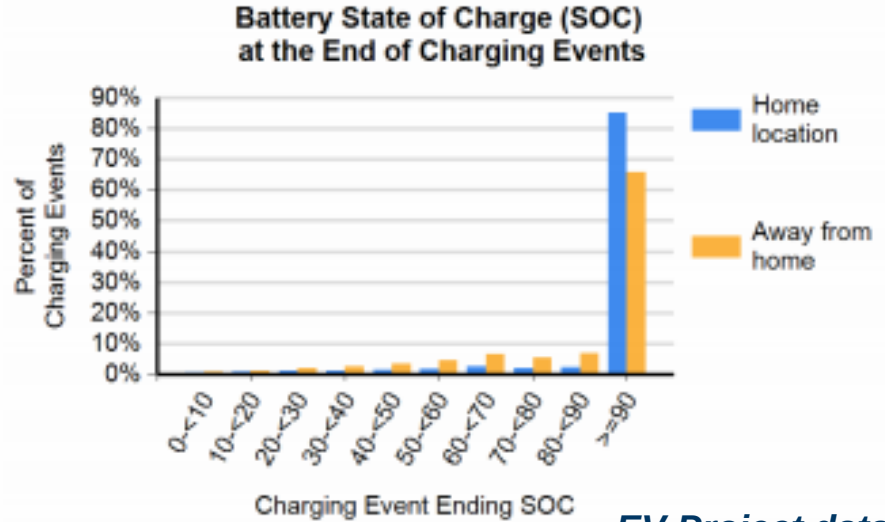
Leafs





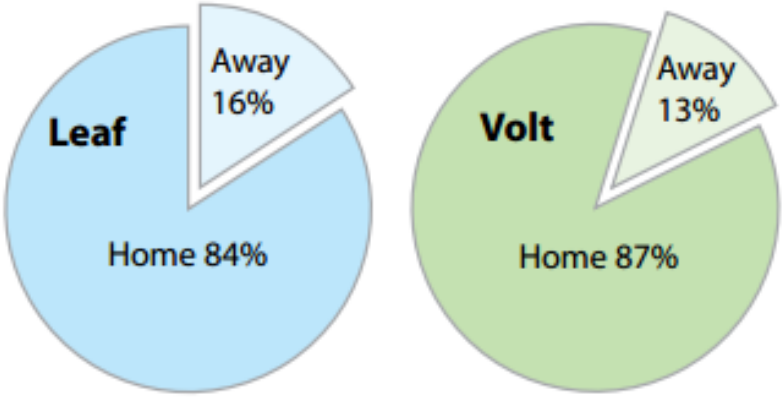
Volts



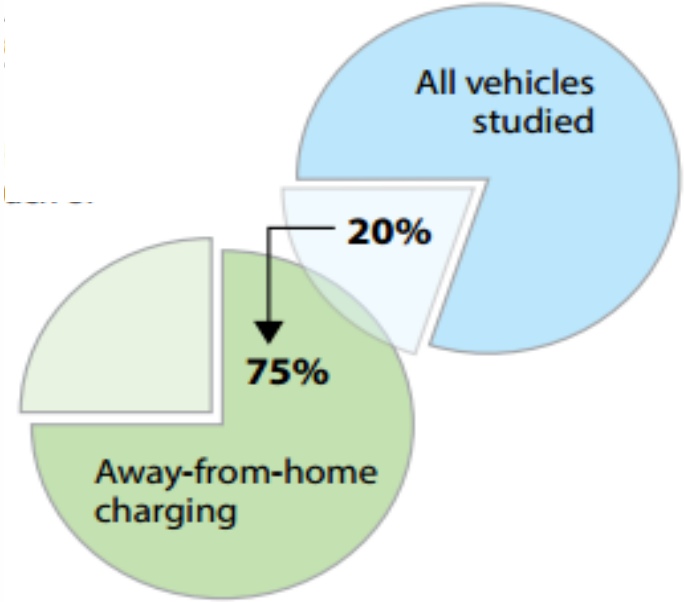


- ***EV Project data***

Leaf and Volt Drivers' Charging Preferences



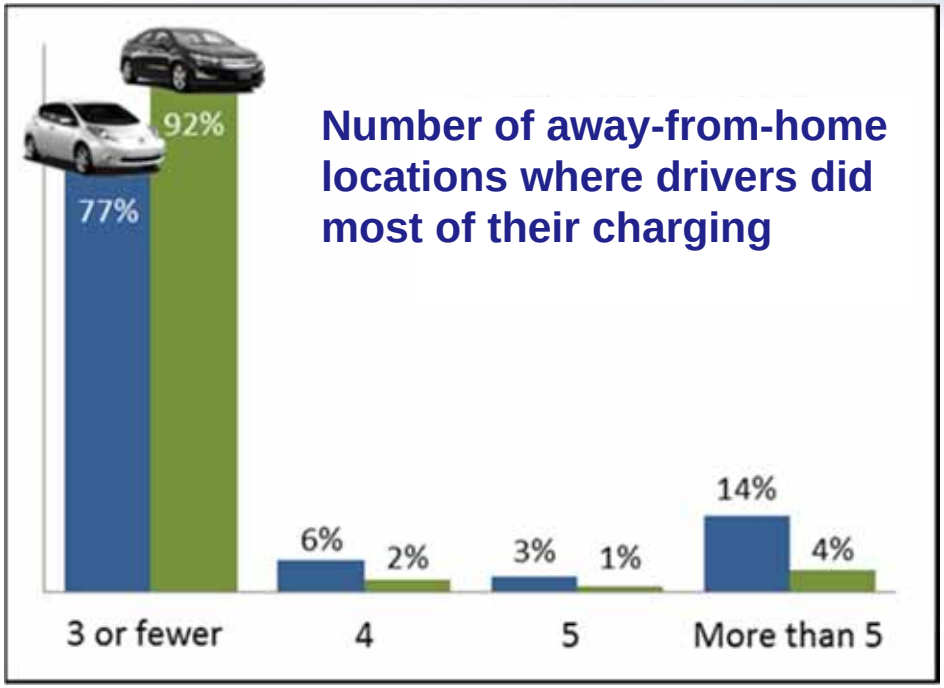
- **Most Leaf and Volt drivers performed their charging at home**



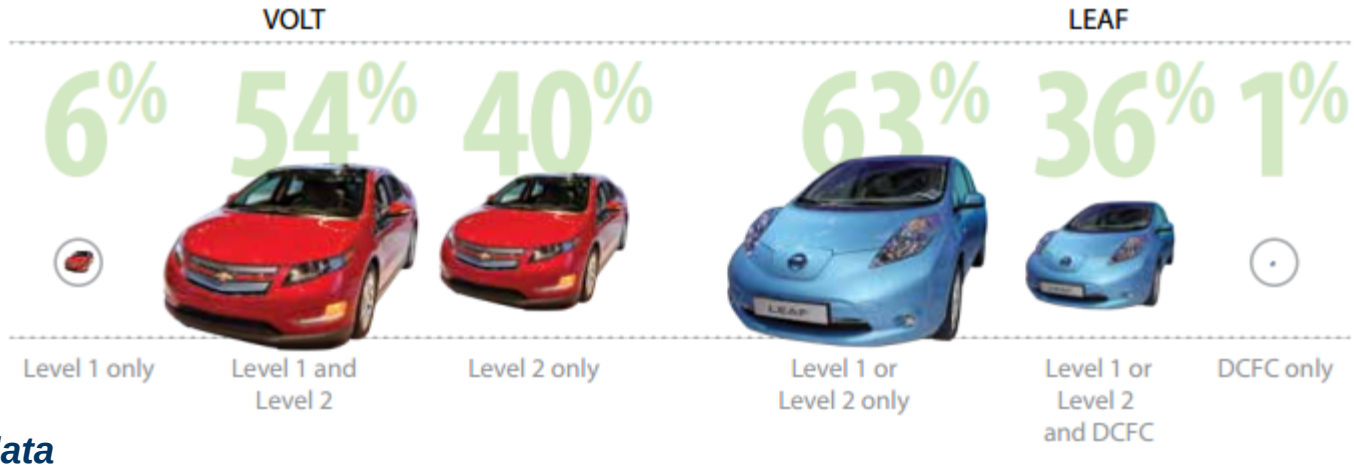
- **20% of the vehicles studied were responsible for 75% of the away-from-home charging. Much of this away-from-home charging can be attributed to workplace charging**

- ***EV Project data***

Number of Charging Locations & Power Levels



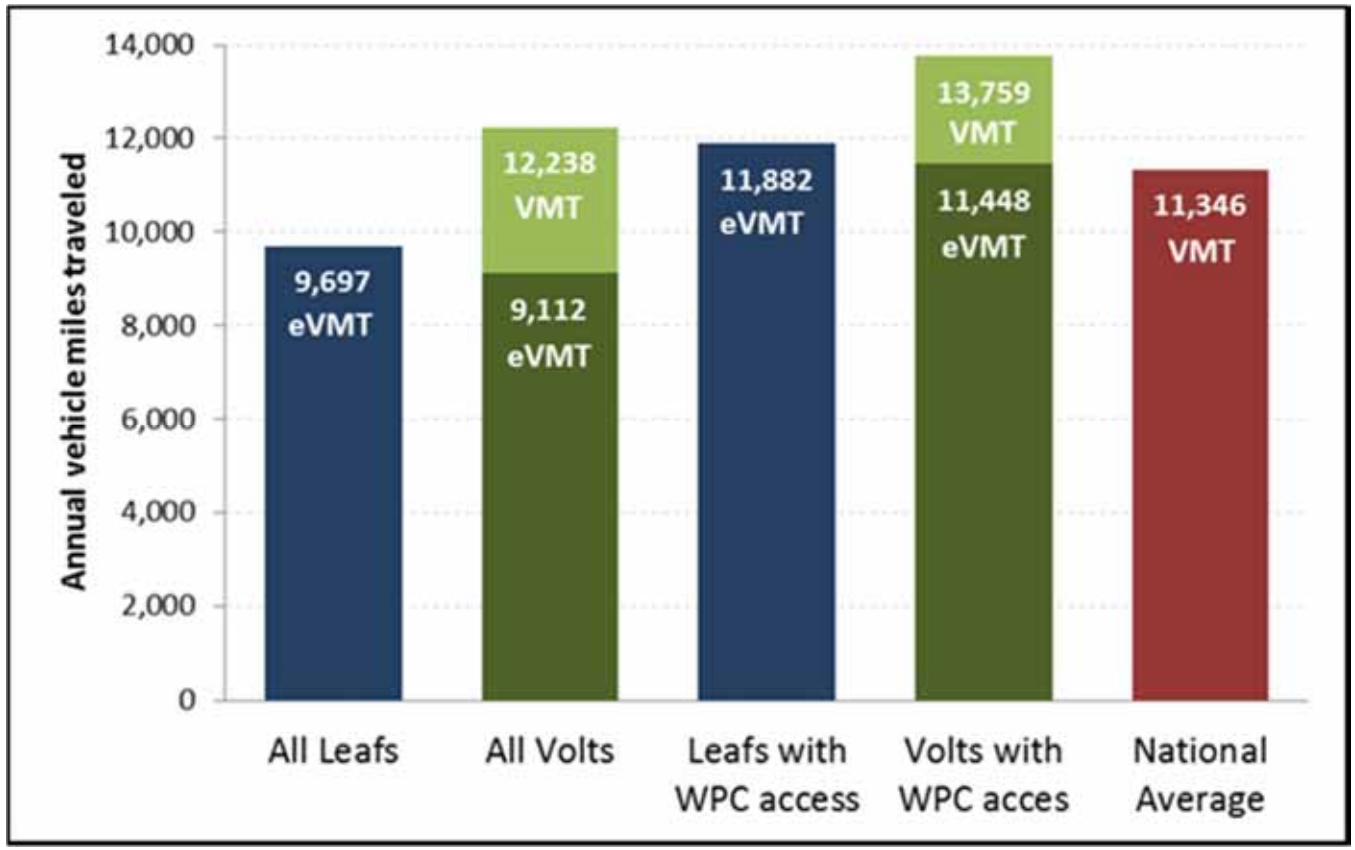
- **How Volt and Leaf drivers charging away from home chose charging equipment**



- ***EV Project data***

Work Place Charging and eVMT Impact

- **electric Vehicle Miles Traveled (eVMT) are extended for both Volts and Leafs when drivers have access to work place charging (WPC)**
  - **Leafs: 23% more annual eVMT**
  - **Volts: 26% more annual eVMT**

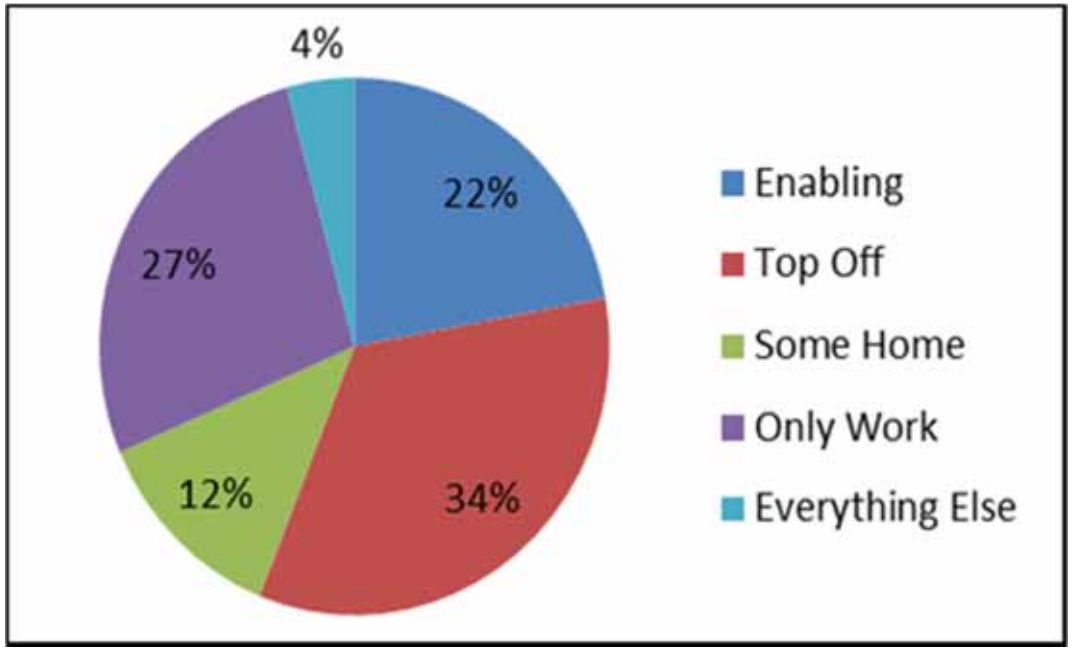


- ***EV Project data***

Leaf Workplace Charging Behavior

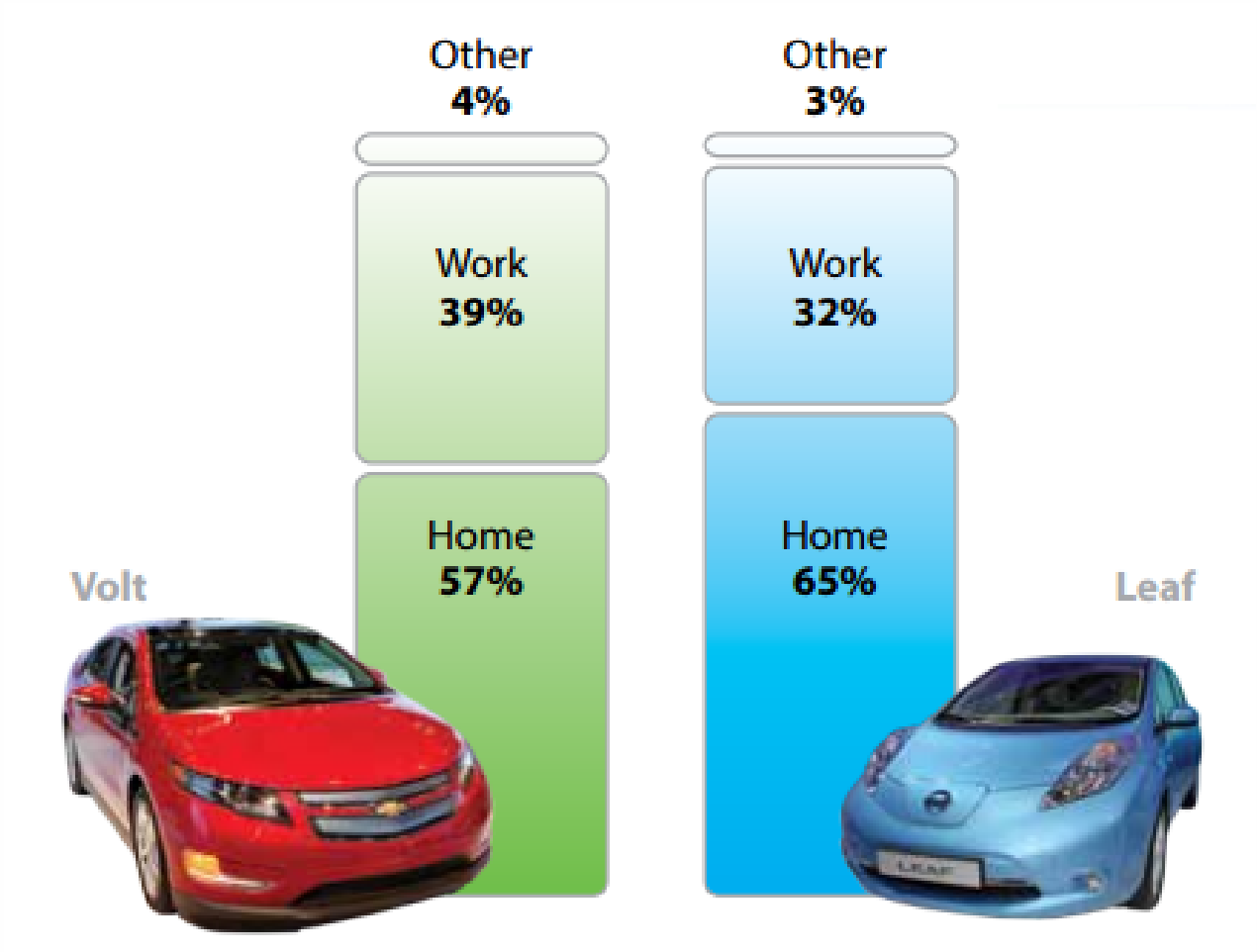
- **For drivers with residential and work place charging:**
  - **22% of daily driving required home and workplace charging in order to complete that day's driving (exceeded the battery range)**
  - **27% of the days at work, drivers only charged at work and not at their residences (free electricity)**

- **Conventional thinking says most Leafs would charge at home every night and workplace charge only when needed. However, this behavior only includes 56% of days (top off and enabling)**



- ***EV Project data***

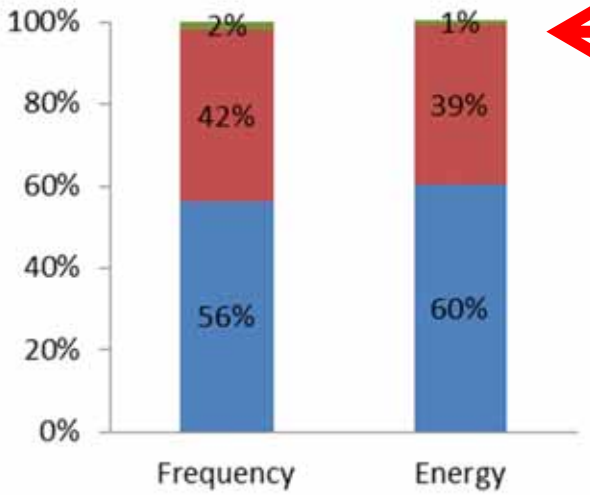
Leaf & Volt Drivers With Access to Home & Work Charging Preferences



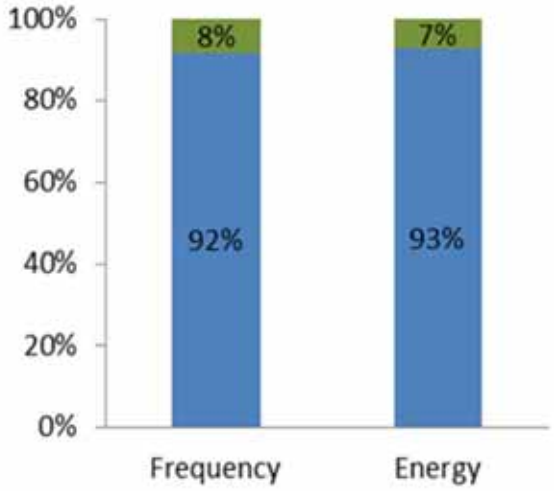
- ***EV Project data***

Workday and Non-Workday Charging Behavior

707 Leafs Charging on Workdays

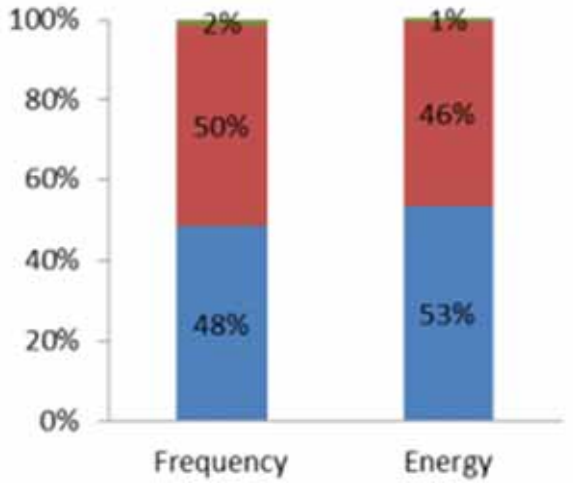


Same Leafs on non-work days

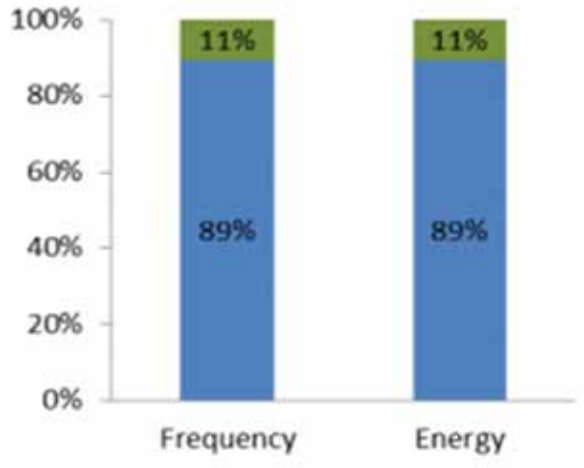


In aggregate, workplace vehicle drivers had little use for public infrastructure on days when they went to work

96 Volts Charging on Workdays



Same Volts on non-work days



- ***EV Project data***

PEV Infrastructure Charging Summary

- **Encourage AC Level 1 or 2 EVSE residential charging as it is popular and occurs off-peak**
- **Encourage AC Level 1 or 2 Workplace charging as it increases eVMT, often beyond the range of a single charge and it is popular**
- **DCFC should first be sited along major commuter routes within major metropolitan areas**
  - **The most highly utilized DCFCs in The EV Project were located in the metropolitan areas of Seattle and San Francisco, which represent two of the top five U.S. sales markets for the Nissan Leaf**
  - **Many of the highly utilized DCFCs were located near or associated with high-tech employers**

For plug-in electric vehicle and charging infrastructure information, visit

http://avt.inl.gov

Funding provided by DOE`s Vehicle Technologies Office