

# Plug-In Electric Vehicle Infrastructure Options and Use

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**ZEV Infrastructure Panel and Discussion -  
Pacific Coast Collaborative (PCC)  
Workshop on Zero Emission Vehicles in  
Fleets**

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## ***Vehicle / Infrastructure Testing Experience***

- **144 million test miles accumulated on 11,700 electric drive vehicles and 16,600 charging units**
- **EV Project: 8,228 Leafs, Volts and Smarts, 12,363 EVSE and DCFC, reporting 4.2 million charge events, 124 million test miles. At one point, 1 million test miles every 5 days**
- **Charge Point: 4,253 EVSE reporting 1.5 million charges**
- **PHEVs: 15 models, 434 PHEVs, 4 million test miles**
- **EREVs: 2 model, 156 EREVs, 2.3 million test miles**
- **HEVs: 24 models, 58 HEVs, 6.4 million test miles**
- **Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 608,000 test miles**
- **NEVs: 24 models, 372 NEVs, 200,000 test miles**
- **BEVs: 48 models, 2,000 BEVs, 5 million test miles**
- **UEVs: 3 models, 460 UEVs, 1 million test miles**
- **Other testing includes hydrogen ICE vehicle and infrastructure testing**

## ***Areas of Concern with Transportation Oil Dependency – Long Term***

- **Energy security**
  - Insufficient domestic supply of easily obtainable oil forces us to rely on imports
  - Global supply has reached “Peak Oil” (?)
- **Global climate change**
  - Tailpipe and smoke stack CO<sub>2</sub> emissions
- **Economic stability**
  - Unbalanced supply and demand affect all levels of the economy (global, national, personal)

# ***Advantages to PEVs as a Solution to Oil Dependency***

- **Displace petroleum consumption with electricity**
- **Diversify our transportation energy sources**
- **Enable *alternatives***
  - **Use domestically generated electricity from a variety of sources**
  - **Use existing infrastructure**
  - **Leverage nuclear and renewable energy sources (wind, solar, hydropower, geothermal)**

# ***Challenges of PEVs as a Solution to Oil Dependency***

- **Current technology limitations (batteries) and potentially a shortage of domestic rare earth materials**
- **Some infrastructure required**
  - **Charging stations (short term)**
  - **Communication between vehicles and electric grid (mid-term)**
  - **Additional electricity generation / transmission / distribution (long-term) or distributed storage is required**

## *Vehicle Technology Summary*

- **ICE:** only energy storage is hydrocarbon fuel – typically gasoline or diesel
- **HEV:** has 2 onboard energy sources – typically gasoline and electricity. All energy originates from gasoline and the battery is only used to recover braking energy. It can be charged by the ICE engine when it is efficient to do so
- **PHEV:** can be fueled with both gasoline from the pump and electricity from the grid. When the battery is charged, the gasoline engine may not even be used (All Electric Capable), or is used when the electric motor is not powerful enough by itself (Blended). When the battery is nearly empty, the vehicle operates like a typical HEV
- **BEV:** has one onboard energy source – electricity, obtained by plugging in (charging). When the battery is depleted, BEVs can't be driven until recharged - like running out of gas, but takes longer to 'refuel'
- A PEV includes both PHEVs and BEVs – both are “plugged in”

## ***Vehicle Electrification: Grid Impacts***

- **In the U.S., current grid capacity could supply electricity for 70% of our vehicles without adding capacity, but assumes:**
  - Vehicles would only charge off-peak
  - “Perfect” distribution of electricity
  - No local impacts such as overburdening neighborhood transformers
- **PEVs will not cause a grid “meltdown” but we clearly need to work to reduce vehicle rollout impacts**
- **Smart charging will be key to lowering costs and minimizing impacts**
- **Time of day pricing is important**



# ***Charging Definitions***

- **Defined in Society of Automotive Engineers (SAE) J1772**
  - **AC (On-board vehicle charger)**
    - **Level 1: 120V AC (up to 16 Amps, ~ 1.92kW Max)**
    - **Level 2: 240V AC (up to 80 Amps, ~ 20kW Max)**
    - **Level 3: > 20kW (proposed)**
  - **DC Charging (Off-board vehicle charger)**
    - **Level 1: Up to 20kW (proposed)**
    - **Level 2: Up to 80kW (proposed)**
    - **Level 3: >80kW (proposed)**
  - **There may be other levels proposed**
- **What is called “fast charging” today is DC Level 2**
- **Most vehicles have onboard chargers that operate at 3.3 or 6.6 kW. Tesla charges at 10 kW. Energy is supplied to the vehicle via electric vehicle supply equipment (EVSE) at AC Level 2**



## ***Selecting the EVSE or DCFC Type & Rate***

- **AC Level 1 (supplies electricity to on-board DC Charger)**
  - **110 VAC EVSE should be connected to commercial grade NEMA outlet and dedicated branch circuit**
  - **Convenience charge cord typically provided with PEV used for emergency purposes.**
  - **Charge times range from 6+ hours (PHEV) to 24+ hours (BEV) for a full recharge**
  - **Could be used to charge PHEV on a daily basis but dissatisfaction can occur if PHEV does not fully charge**
- **AC Level 2 (supplies electricity to on-board DC Charger)**
  - **240 VAC EVSE connected to dedicated branch circuit**
  - **Charge times range from 2 (PHEV) to 8 hours (BEV) for a full recharge**
  - **Good for malls, movie theatres, work place**

## ***Selecting the EVSE or DCFC Type & Rate***

- **DC (Off-board Charger, directly charges the vehicle battery pack. Does not use the onboard charger)**
  - **DC Level 2 (>20kW and up to 80kW)**
  - **50kW is the most commonly used power output today (Nissan Leaf)**
  - **Provides 2 to 4 miles range per minute of charge**
  - **Good for City corridors, convenience stores, fast food restaurants, and vehicles with large energy storage batteries**

# *Examples of Level 1 EVSE*



# Examples of Level 2 EVSE Hardware



# Examples of DC Fast Charging



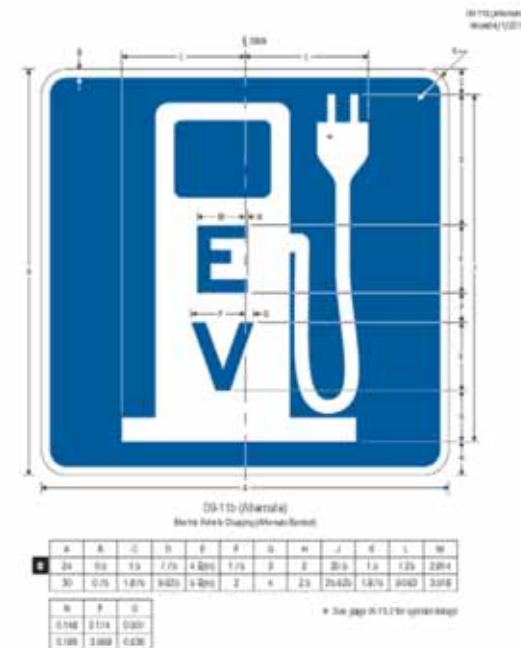


# ***Commercial Site Considerations***

- **Geographic Coverage / Planning**
- **Local attraction(s)**
- **Proper charger level for location**
- **ADA Requirements**
- **Lighting / Security**
- **Signage**
- **Access**
- **Local Permitting Authority**



# Signage Examples

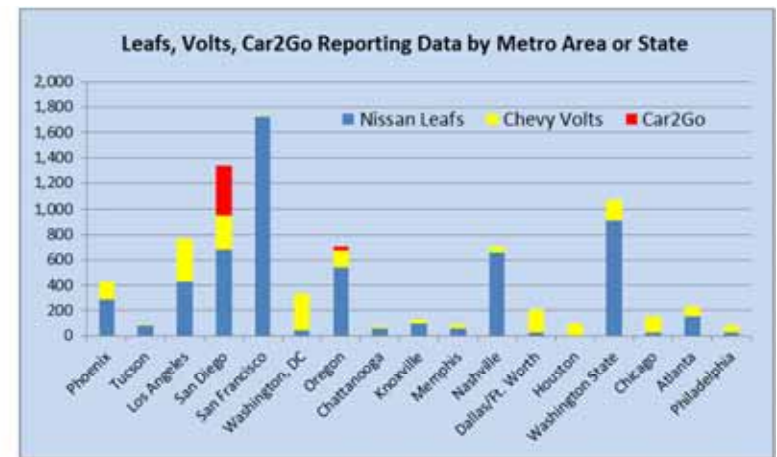
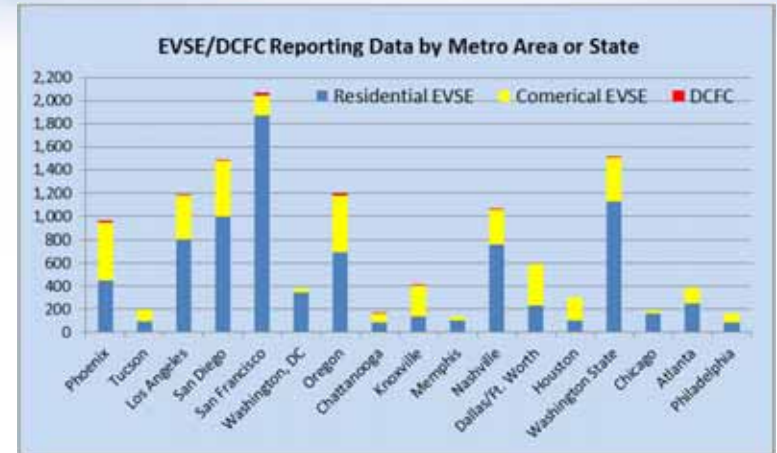


COLORS: LIGHTING BACKGROUND - BLUE (REFLECTIVE)  
SYMBOL, BORDERS - WHITE (REFLECTIVE)

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# EV Project Deployments

- **EVSE**
  - 8,251 Residential Level 2 EVSE
  - 4,005 Public Level 2 EVSE
  - 107 DCFC (DC Fast Chargers)
  - 12,363 Total EVSE & DCFC
- **Vehicles**
  - 5,788 Nissan Leafs
  - 2024 Chevy Volts
  - 416 Car2Go
  - 8,228 Total vehicles





# Vehicle Profiles (4<sup>th</sup> quarter 2013 data)

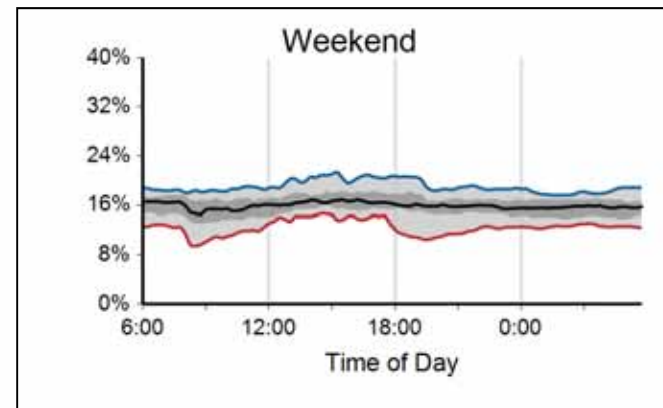
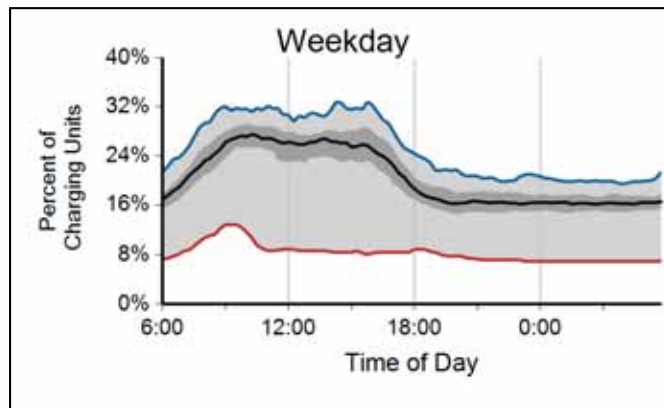
	<u>Leafs</u>	<u>Volts</u>
• Number of vehicles	<b>3,499</b>	<b>1,611</b>
• Number of Trips	<b>781,062</b>	<b>559,680</b>
• Distance (million miles)	<b>5.3</b>	<b>4.7</b>
• Average (Ave) trip distance	<b>6.7 mi</b>	<b>8.2 mi</b>
• Ave distance per day	<b>26.7 mi</b>	<b>39.8 mi</b>
• Ave number (#) trips between charging events	<b>3.6</b>	<b>3.3</b>
• Ave distance between charging events	<b>23.9 mi</b>	<b>27.2 mi</b>
• Ave # charging events per day	<b>1.1</b>	<b>1.5</b>



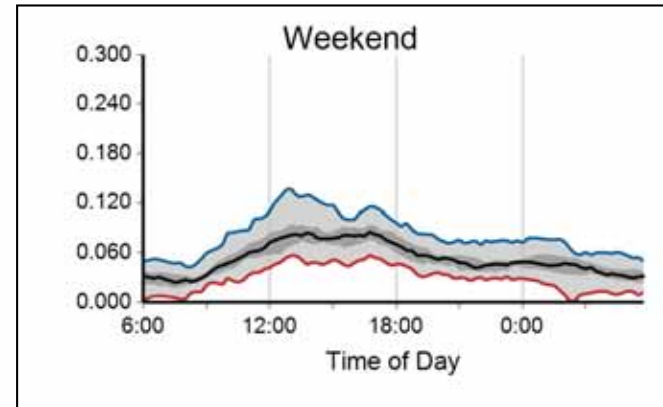
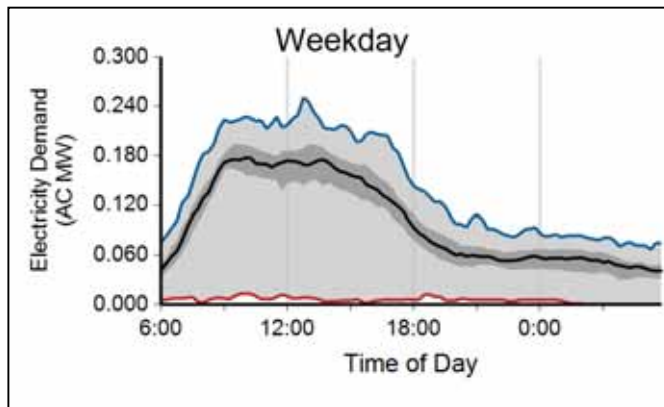
# Private Access Fleet EVSE – EV Project

- 4<sup>th</sup> Quarter 2013 data: 336 Level 2 EVSE, 16,000 charge events, 185 AC MWh

Percent of Charging Units with a Vehicle Connected versus Time of Day

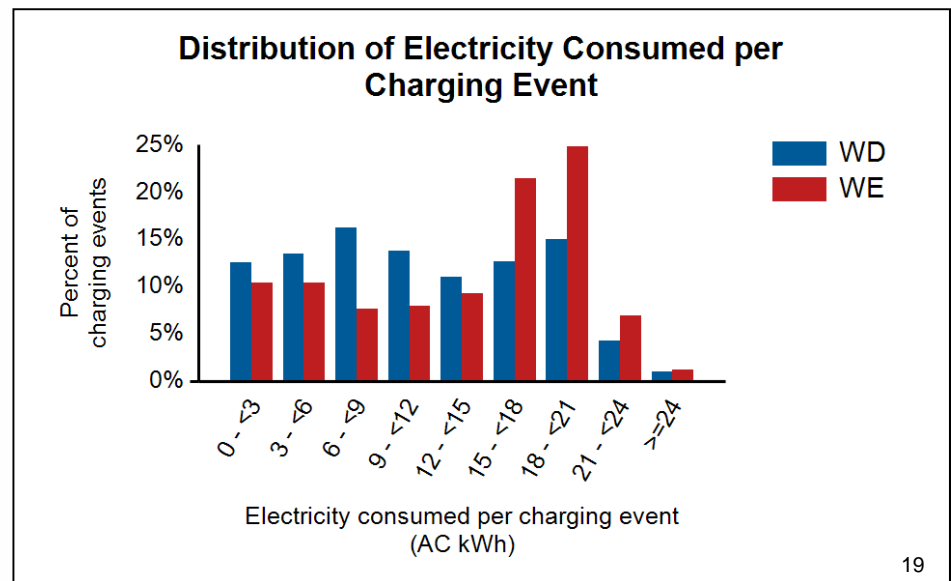
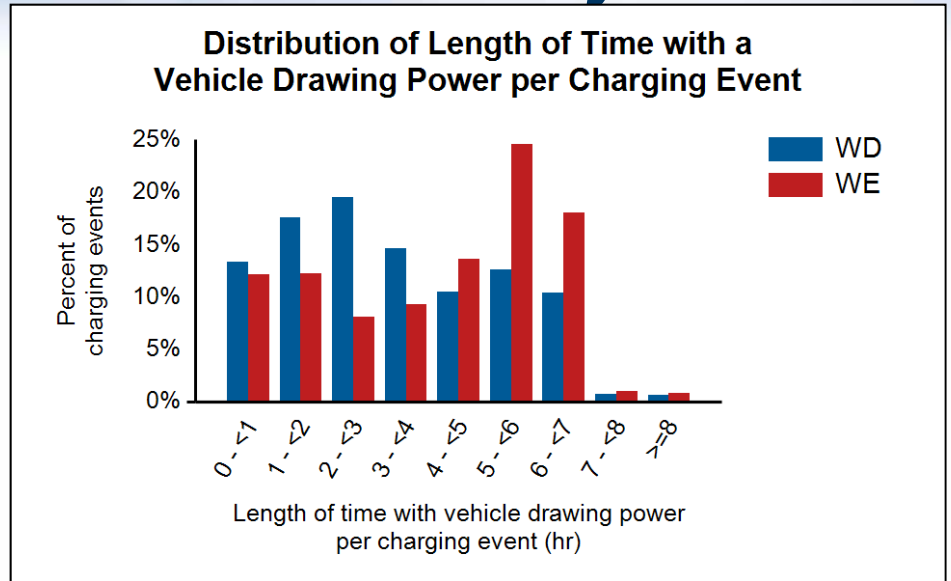
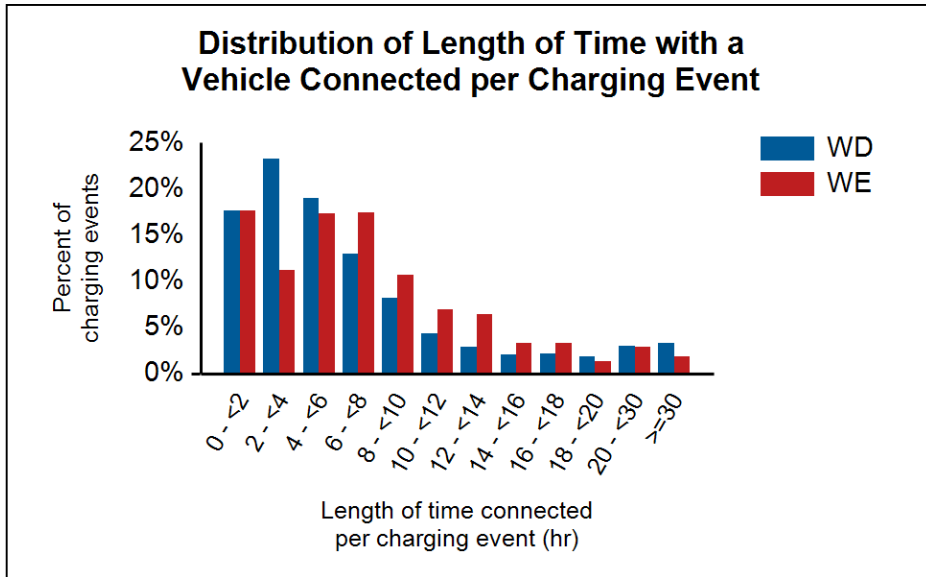


Aggregate Electricity Demand versus Time of Day



# Private Access Fleet EVSE – EV Project

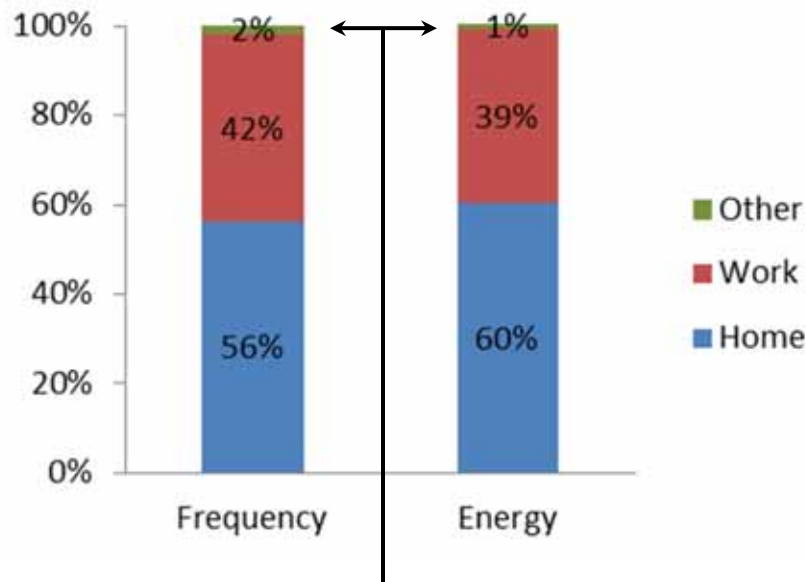
- 4<sup>th</sup> Quarter 2013 data



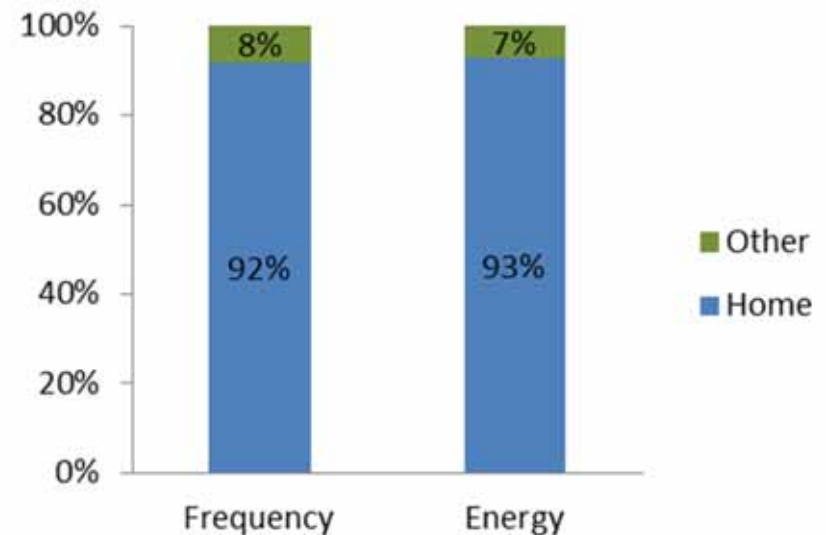
# Work Place Charging Location Preference for Nissan Leaf drivers

*Group of 707 Nissan Leafs with Access to Workplace Charging  
2012 – 2013*

**Days When Vehicles Were Parked at Work**



**Days When Vehicles Were Not Parked at Work**



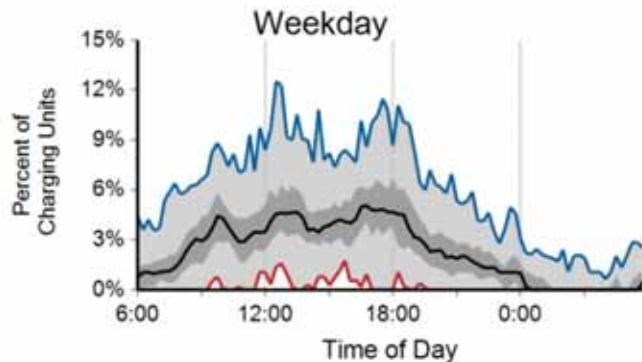
***In aggregate, workplace vehicle drivers had little use for public infrastructure on days when they went to work***

# Public DC Fast Charger (DCFC) Use

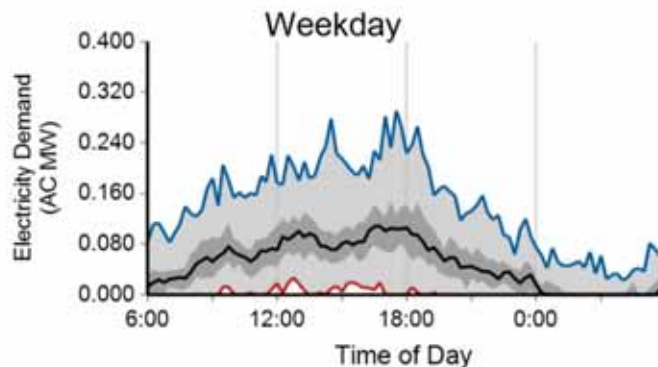
- 4<sup>th</sup> quarter 2013, DCFC weekday use profiles
- 95 DCFC, 11,704 charge events, & 109 AC MWh

- EV Project Leafs 18% charge events and 16% energy used
- 1.3 average charge events per day per DCFC
- 24.6 minutes average time connected
- 24.6 minutes average time drawing energy
- 9.3 kWh average energy consumed per charge

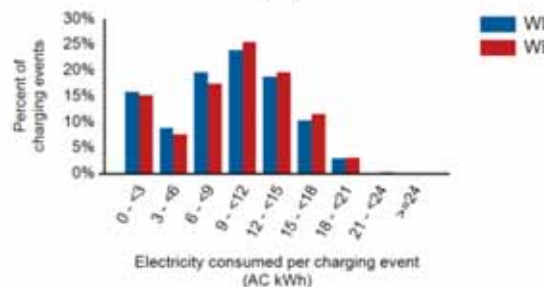
Weekday Connected Profile



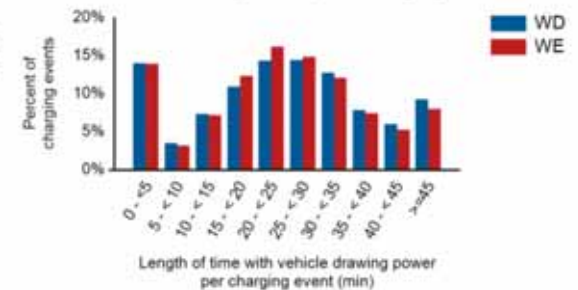
Weekday Demand Profile



Distribution of Electricity Consumed per Charging Event

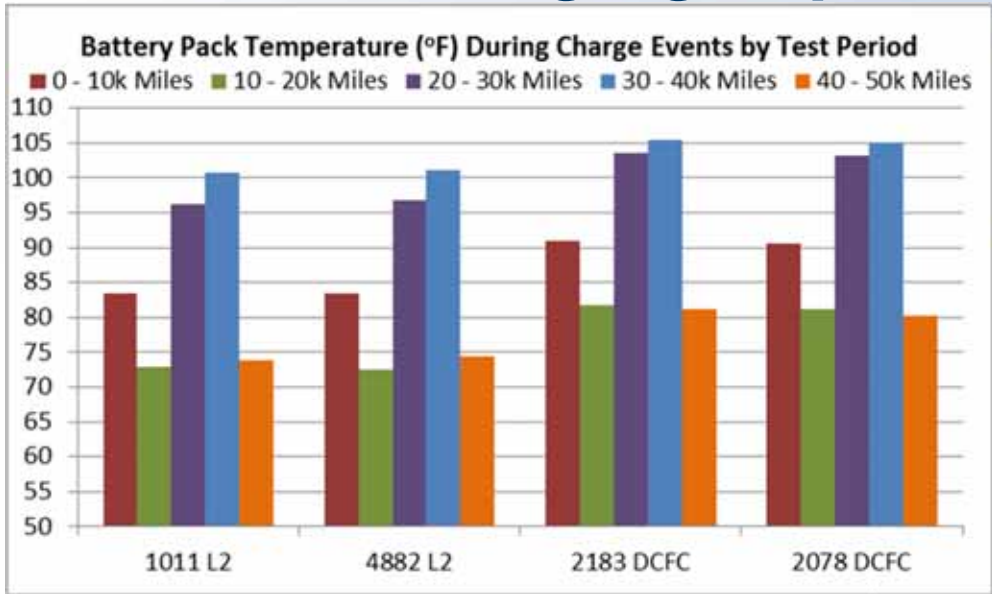


Distribution of Length of Time with a Vehicle Drawing Power per Charging Event

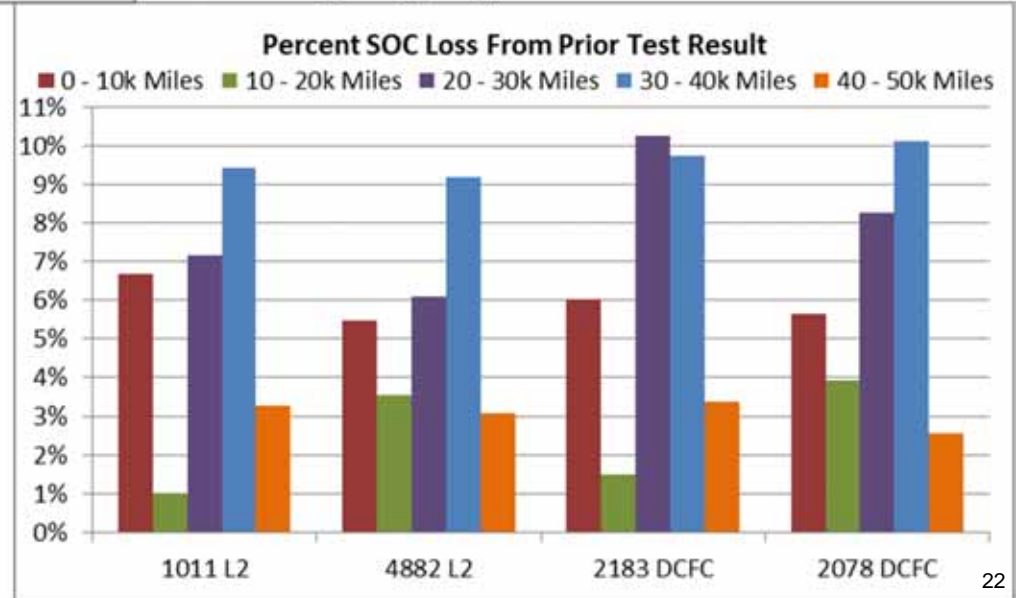




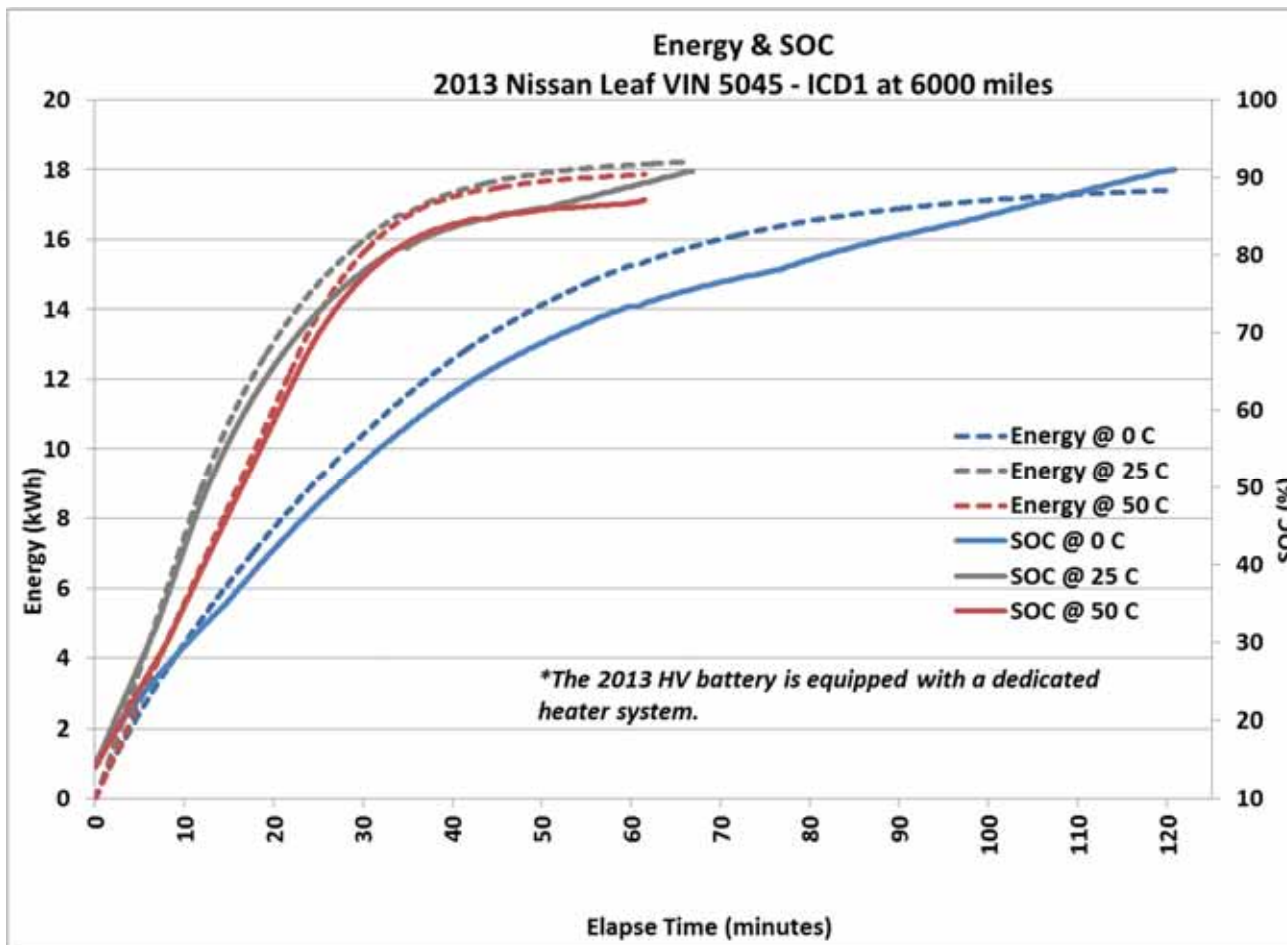
# DC Fast Charging Impact Study on 2012 Leafs



- Quantify in field & lab settings, impacts on battery performance and life
- DCFC 27% & L2 25% capacity losses at 50k miles/vehicle
- Phoenix heat likely accelerates results - largest decreases in capacity from test before occurred during high heat charging operation



# DC Fast Charging @ 0, 25 & 50 C Impacts – 2013 Nissan Leaf



## Preliminary Data Results

- **After 30 minutes:**
    - **50 C: 77% SOC**
    - **25 C: 77% SOC**
    - **0 C: 53% SOC**
  - **At charge end:**
    - **50 C: 87% SOC at 62 minutes**
    - **25 C: 91% SOC at 67 minutes**
    - **0 C: 91% SOC at 121 minutes**
  - **Total kWh:**
    - **50 C: 17.9 kwh**
    - **25 C: 18.2 kWh**
    - **0 C: 17.4 kWh**
- 0 C = 32 F**  
**25 C = 77 F**  
**50 C = 122 F**

# Commercial EVSE Level 2 Installation Costs

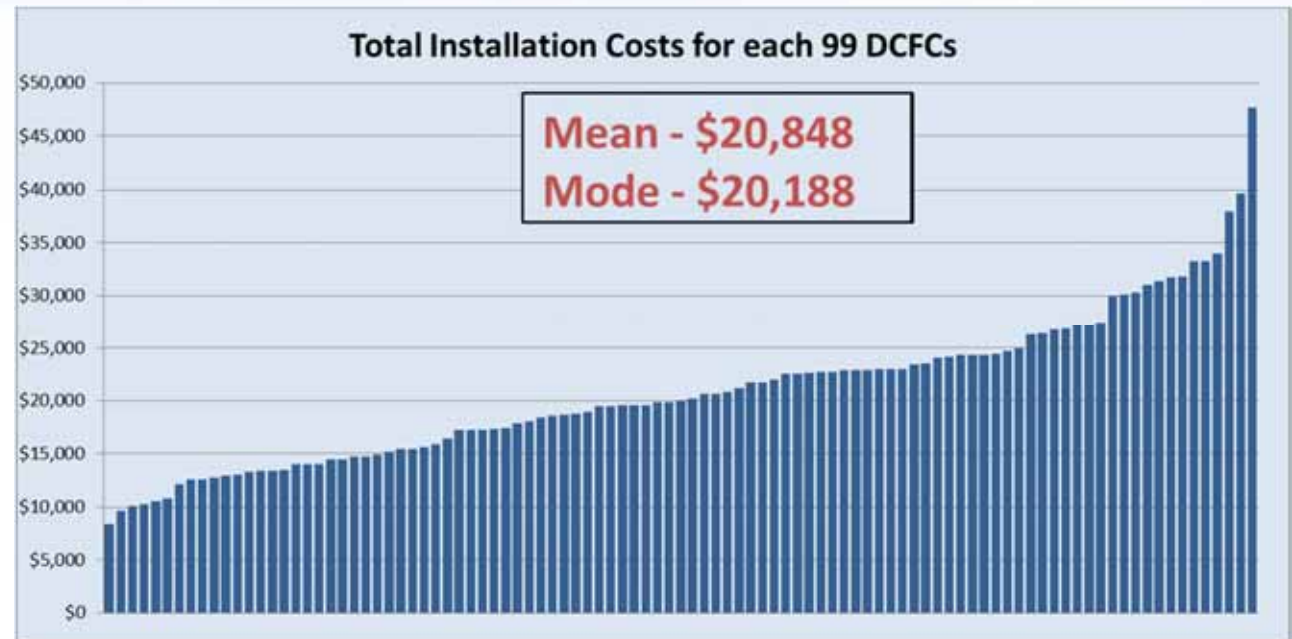
- Nationally, commercially sited Level 2 EVSE averaged \$4,000 for the installation costs. EVSE cost excluded
- There is much variability by region and by installation
- Multiple EVSE at one site drive down per EVSE install cost
- Tennessee and Arizona have average installation costs of \$2,000 to \$2,500
- Costs driven by poor siting requests
  - Example: mayor may want EVSE by front door of city hall, but electric service panel is located at the back of the building



Region	Count of Permits	Average Permit Fee	Minimum Permit Fee	Maximum Permit Fee
Arizona	72	\$228	\$35	\$542
Los Angeles	17	\$195	\$67	\$650
San Diego	17	\$361	\$44	\$821
Texas	47	\$150	\$37	\$775
Tennessee	159	\$71	\$19	\$216
Oregon	102	\$112	\$14	\$291
Washington	33	\$189	\$57	\$590



# DCFC Infrastructure Install & Demand Costs



Utility Demand Charges - Nissan Leaf		Cost/mo.
CA	Glendale Water and Power	\$ 16.00
	Hercules Municipal Utility:	\$ 377.00
	Los Angeles Department of Water and Power	\$ 700.00
	Burbank Water and Power	\$ 1,052.00
	San Diego Gas and Electric	\$ 1,061.00
	Southern California Edison	\$ 1,460.00
AZ	TRICO Electric Cooperative	\$ 180.00
	The Salt River Project	\$ 210.50
	Arizona Public Service	\$ 483.75
OR	Pacificorp	\$ 213.00
WA	Seattle City Light	\$ 61.00

- DCFC installation costs do not include DCFC hardware costs

## ***Additional Information***

**For publications and general plug-in electric vehicle  
performance, visit  
<http://avt.inl.gov>**