Charging Infrastructure Use Profiles and Installation Costs for 17,000 Units

John Smart, Jim Francfort

Idaho National Laboratory

TRB 2015 Annual Meeting

Session on Plug-in Electric Vehicle Infrastructure and Driver Behavior: Issues and Solutions for Continued Market Growth

Jan 12, 2015

Idaho National Laboratory

- U.S. Department of Energy (DOE) federal laboratory
- 890 square mile site with 4,000 staff
- Support DOE's strategic goal
  - Increase U.S. energy security and reduce the nation's dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Renewables and Hybrid Energy Systems
  - Advanced Vehicles, Batteries, Fuels, and Infrastructure
  - Unmanned Aerial Systems and Autonomous Vehicles
  - Cyber Security

INL was a primary partner in two national electric vehicle (EV) charging infrastructure demonstrations

The EV Project

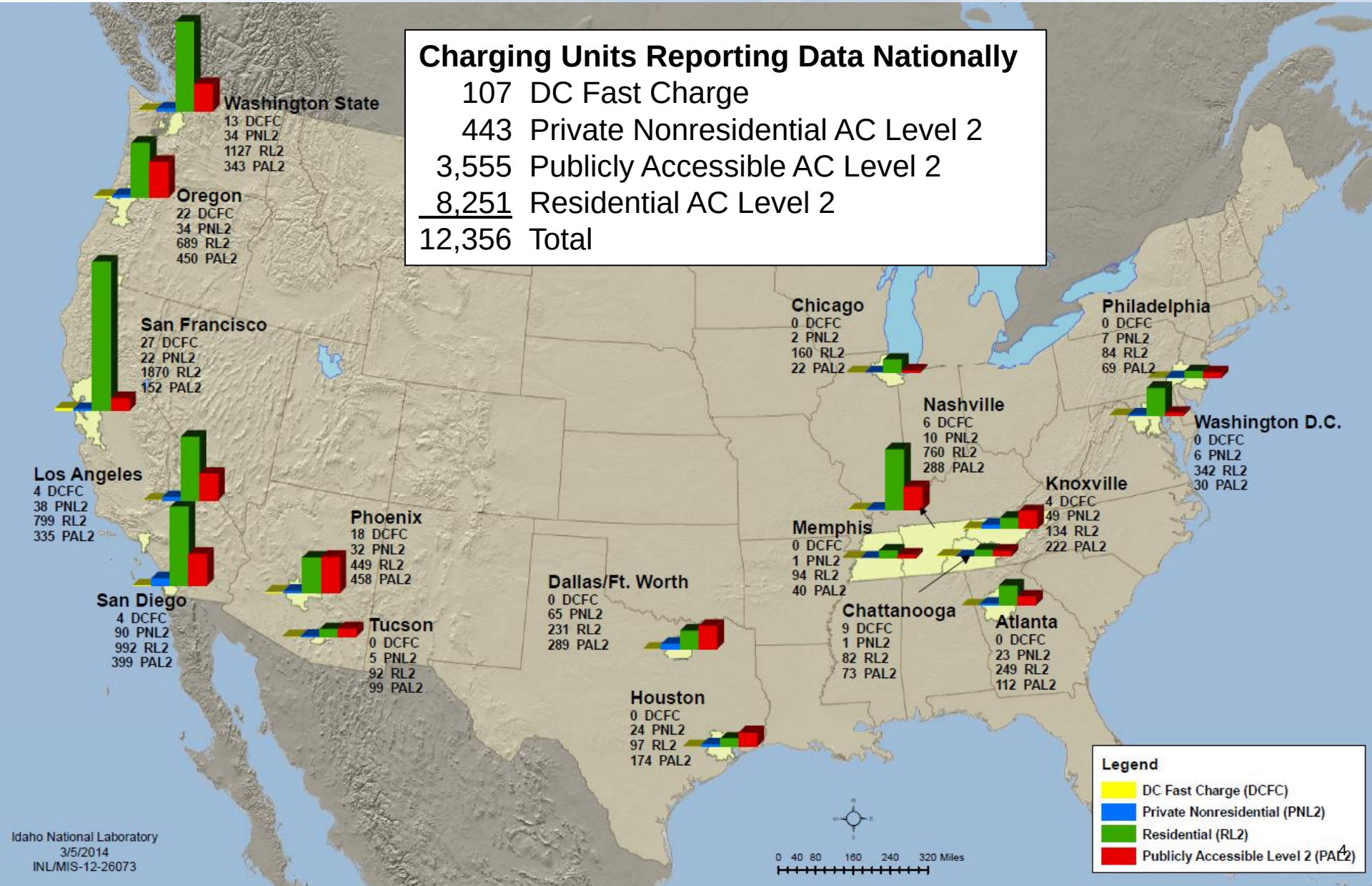
- Purpose is to build mature EV charging infrastructure in 17 US regions and study:
- Infrastructure deployment process
- Customer driving and charging behavior
- Impact on electric grid
- 12,000+ AC level 2 charging units, 100+ DC fast chargers
- 8,000+ Electric drive vehicles
- INL data collection Jan 2011 – Dec 2013
- Project partners:

ChargePoint America

- Deploy 4,700+ residential and public AC level 2 charging units in 11 US regions
- Study customer usage of residential and public infrastructure
- INL data collection May 2011 – Dec 2013

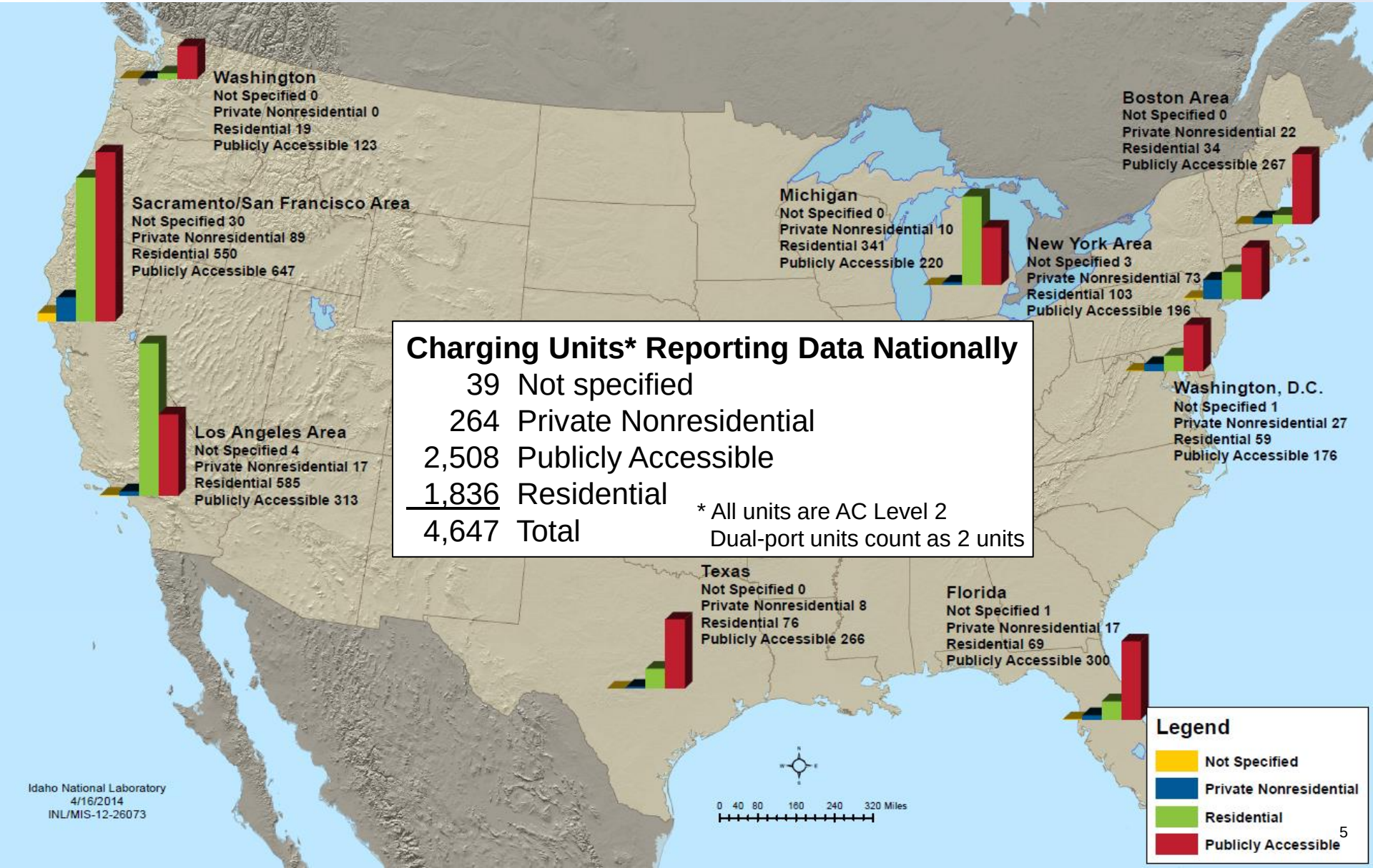
Infrastructure Deployment in The EV Project through December 2013

Idaho National Laboratory



Infrastructure Deployment in ChargePoint America through December 2013

Idaho National Laboratory



What have we learned from data collected from Nissan Leafs and Chevrolet Volts in The EV Project?

Nissan Leafs and Chevrolet Volts in The EV Project

Oct 2012 – Dec 2013

4,038 Leafs

1,867 Volts

	Leaf A	Leaf B	Leaf C	Volt A	Volt B	Volt C
Avg Daily eVMT (on days when driven)	25	31	43	25	29	40

Nissan Leafs and Chevrolet Volts in The EV Project

Oct 2012 – Dec 2013

4,038 Leafs

1,867 Volts

	A	B	C	A	B	C
Avg Daily eVMT (on days when driven)	25	31	43	25	29	40
Charges per day at home overnight	0.8	0.8	0.8	0.9	0.9	0.9

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at home during the day	0.1	0.2	0.1	0.3	0.4	0.3

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Percent of charges away from home	0%	>0 - 30%	>30 - 60%	0%	>0 - 30%	>30 - 60%
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Charges per day away from home	0	0.1	0.6	0	0.1	0.8

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Charges per day away from home	0	0.1	0.6	0	0.1	0.8
Overall charges per day	0.9	1.1	1.5	1.2	1.4	2.0

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Charges per day away from home	0	0.1	0.6	0	0.1	0.8
Overall charges per day	0.9	1.1	1.5	1.2	1.4	2.0
Number of vehicles	507	2,274	578	94	1,520	233
Percent of vehicles	13%	69%	14%	5%	81%	13%

Nissan Leafs and Chevrolet Volts in The EV Project

Oct 2012 – Dec 2013

4,038 Leafs

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Percent of charges away from home	0%	>0 - 30%	>30 - 60%	>60%	0%	>0 - 30%	>30 - 60%	>60%
Avg Daily eVMT (on days when driven)	25	31	43	32	25	29	40	26
Charges per day at home overnight	0.8	0.8	0.8		0.9	0.9	0.9	
at home during the day	0.1	0.2	0.1		0.3	0.4	0.3	
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Overall charges per day	0.9	1.1	1.5		1.2	1.4	2.0	
Number of vehicles	507	2,774	578	179	94	1,520	233	20
Percent of vehicles	13%	69%	14%	4%	5%	81%	13%	1%

Nissan Leafs and Chevrolet Volts in The EV Project

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Number of vehicles	507	2,274	578	179	94	1,520	233	20
Percent of vehicles	13%	69%	14%	4%	5%	81%	13%	1%

Conclusions:

- Away-from-home charging infrastructure was consistently effective as an EV range extender… for a small fraction of vehicles
- For both Leafs and Volts, 20% of the vehicles were responsible for 75% of the away-from-home charging

What about the remaining 80% of vehicles?

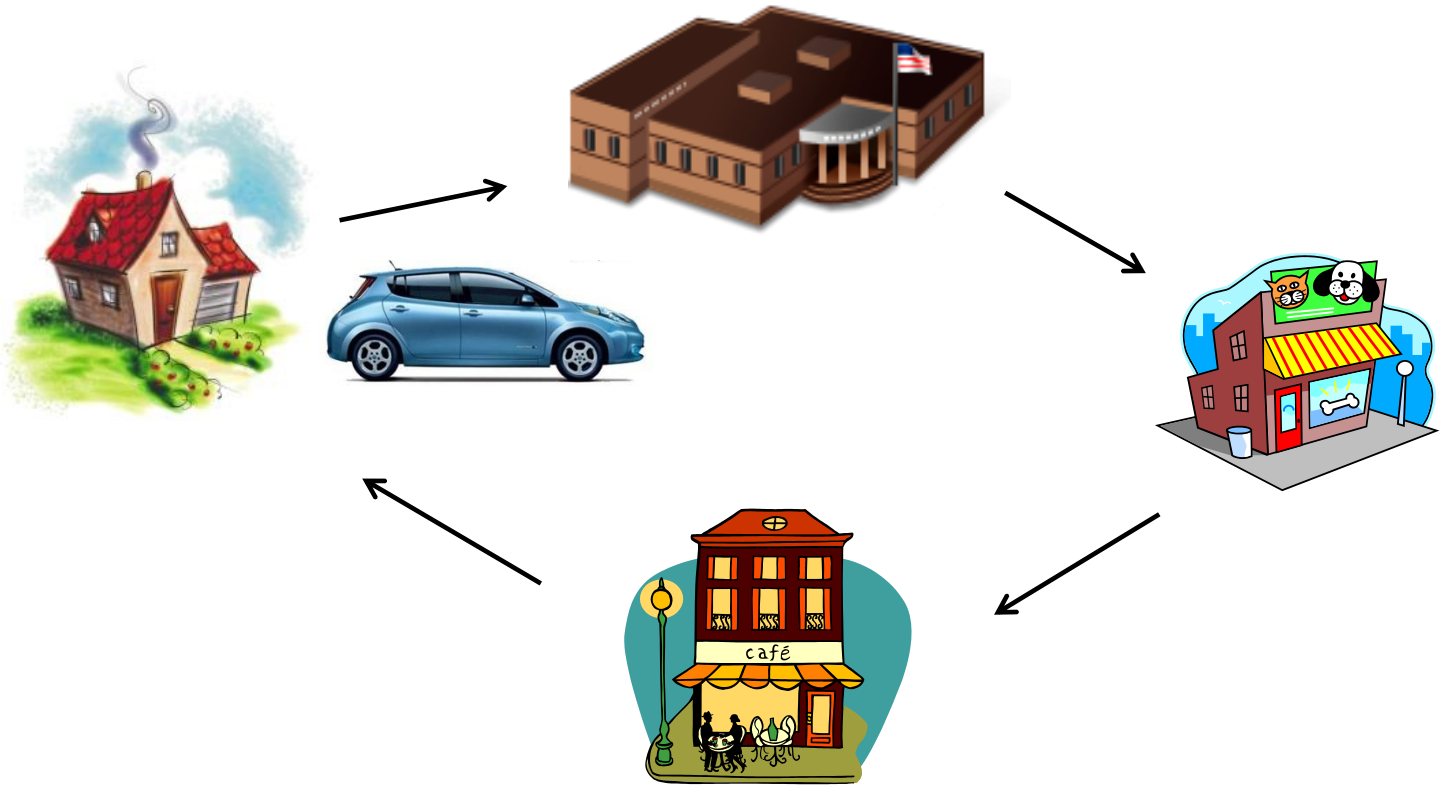
- It is not clear what role away-from-home charging infrastructure played for the majority of drivers who only used it occasionally or never used it
  - Psychological benefit as a safety net?
  - Occasional but important range extension?
  - Cool factor?
  - No role at all?

- Away-from-home charging can be public or workplace charging

What do we know about workplace charging?

Workplace Charging Analysis

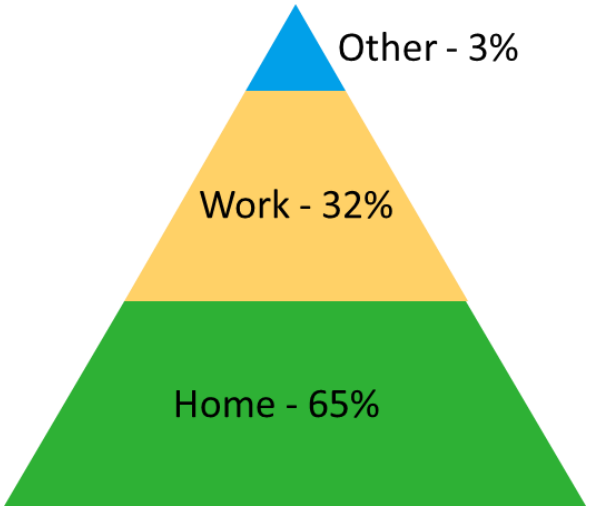
We observed driving and charging throughout the day of vehicles with access to charging at work



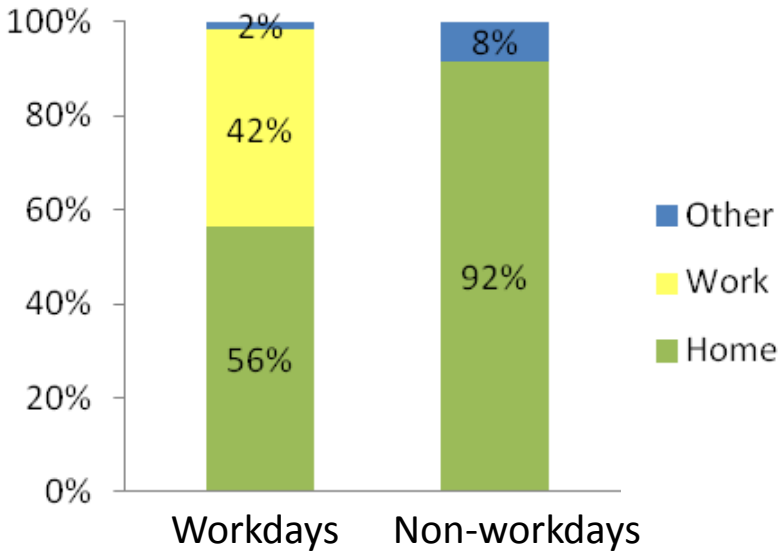
Where did PEV drivers with access to workplace charging choose to charge?

Nissan Leafs

Overall Charging Frequency by Location (to scale)



Percent of Charging Events by Location and Day

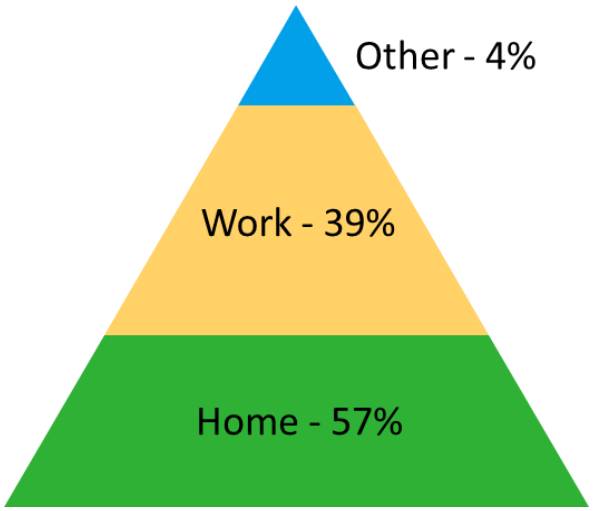


707 vehicles, Jan 2012 – Dec 2013

Where did PEV drivers with access to workplace charging choose to charge?

Chevrolet Volts

Overall Charging Frequency by Location (to scale)



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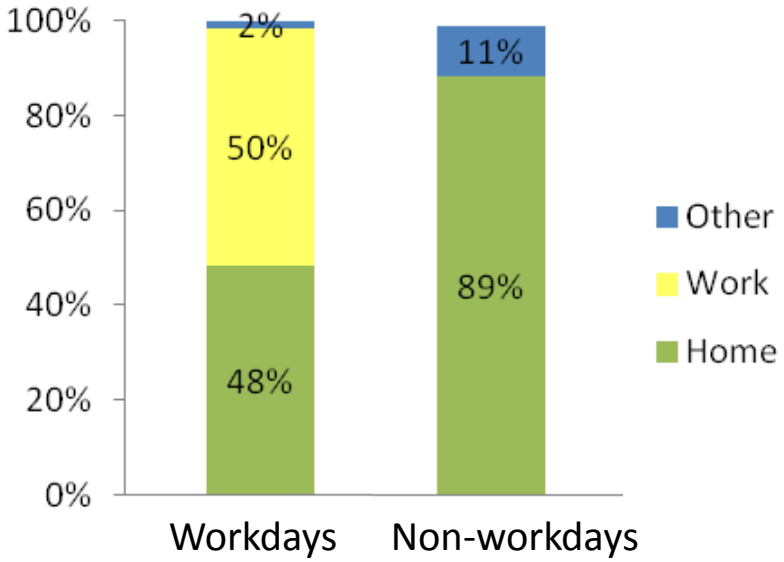
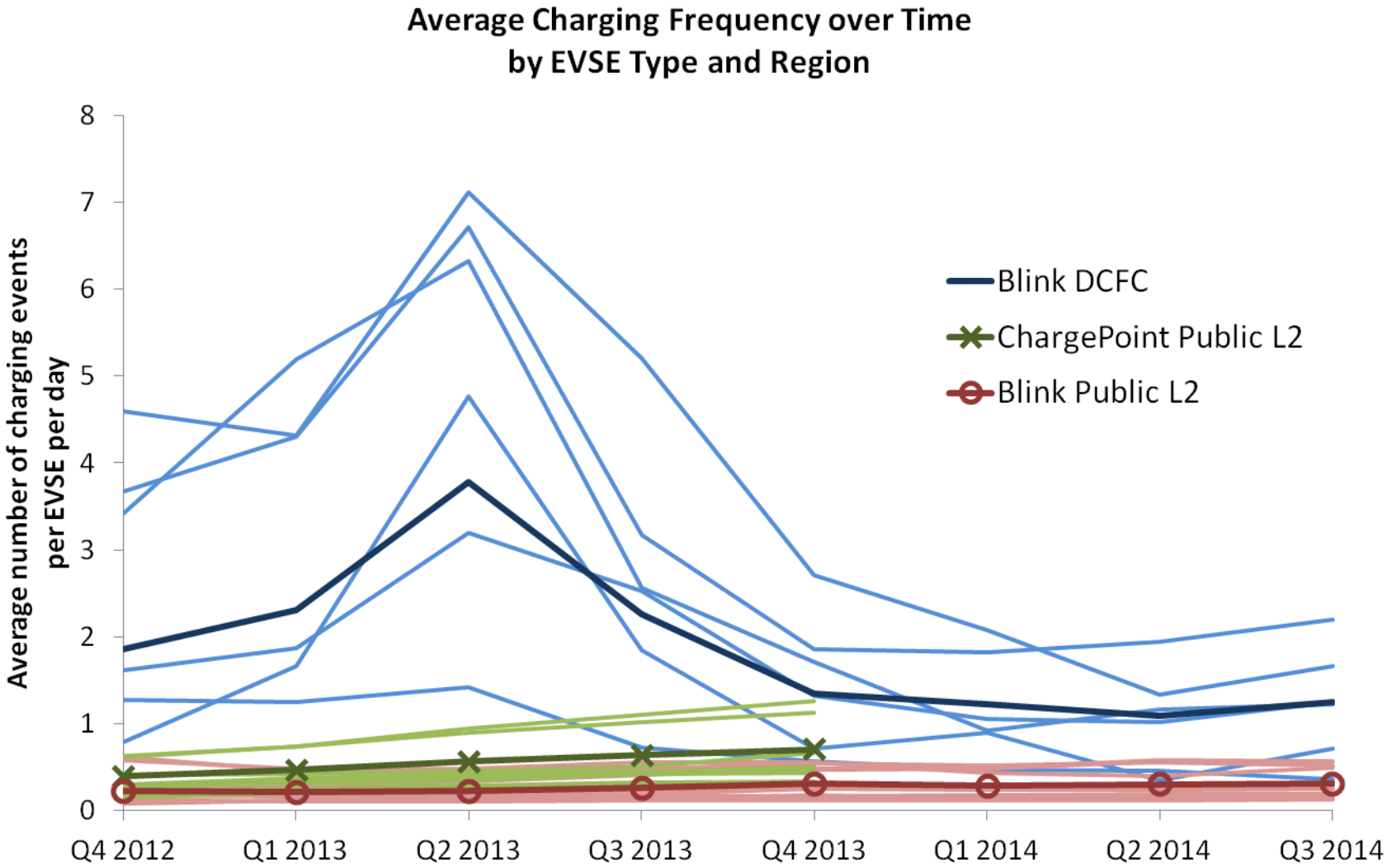


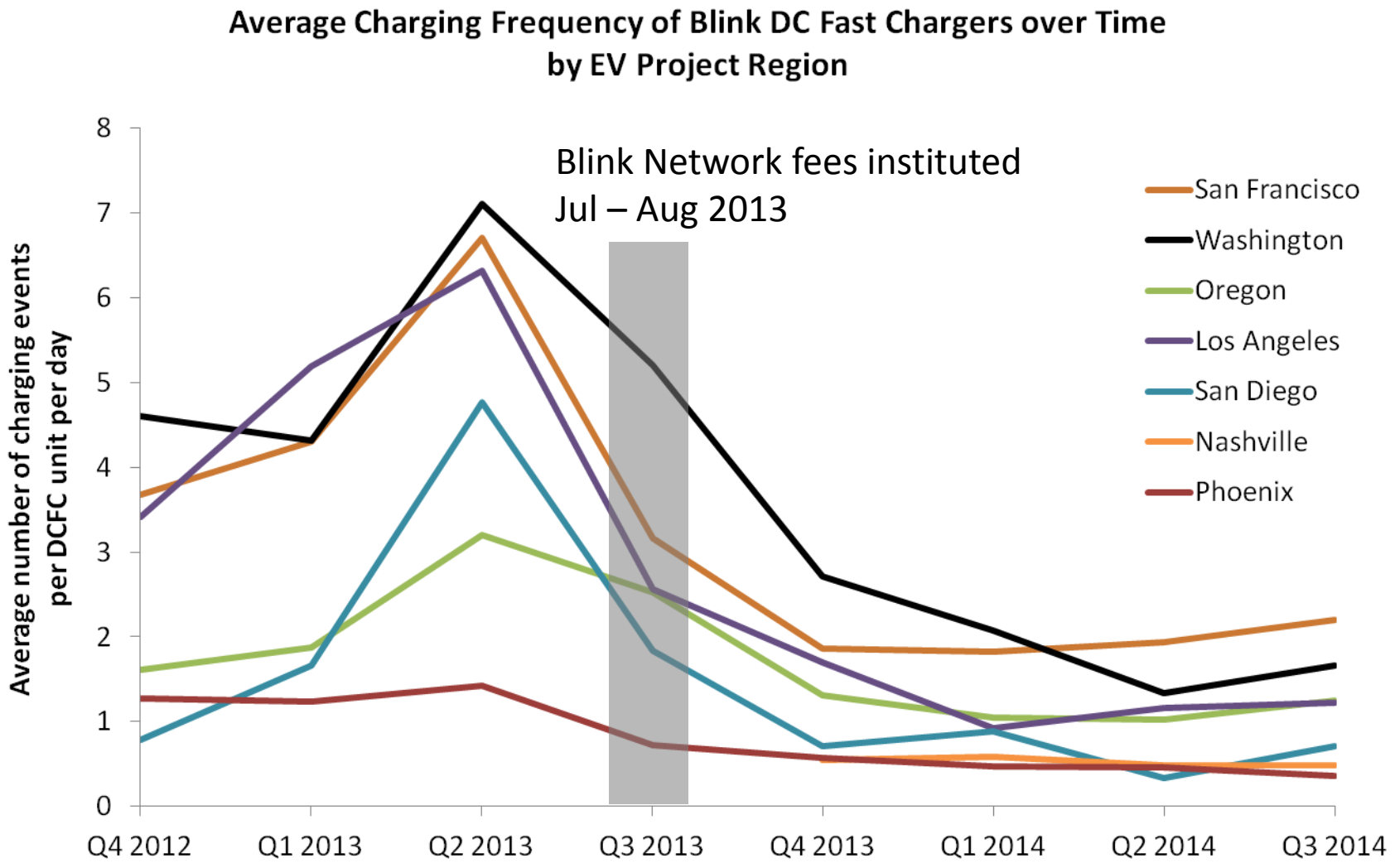
96 vehicles, Jan 2013 – Dec 2013

How has public AC level 2 EVSE and DC fast charger usage changed over time?

Usage Frequency of Public Level 2 EVSE and DC Fast Chargers by Region



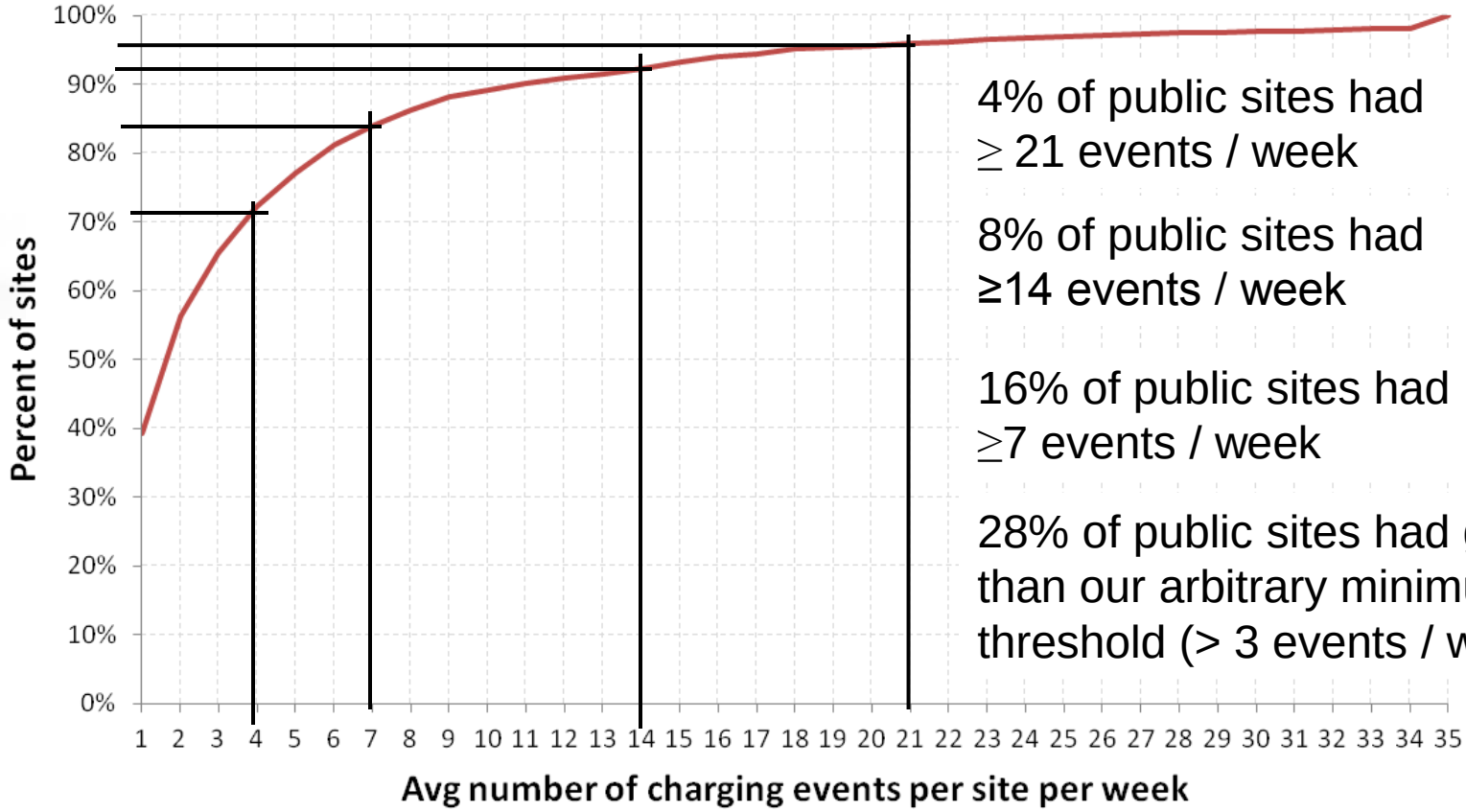
Usage Frequency of Blink DC Fast Chargers



Which public charging sites are used most frequently?

Usage of Publicly Accessible Level 2 Sites

Cumulative Distribution of Charging Frequency of Blink and ChargePoint Level 2 Publicly Accessible Sites



4% of public sites had ≥ 21 events / week

8% of public sites had ≥14 events / week

16% of public sites had ≥7 events / week

28% of public sites had greater than our arbitrary minimum threshold (> 3 events / week)

9/1/2012 to 1/1/2014 N = 2,498 sites

Usage of Publicly Accessible Level 2 Sites

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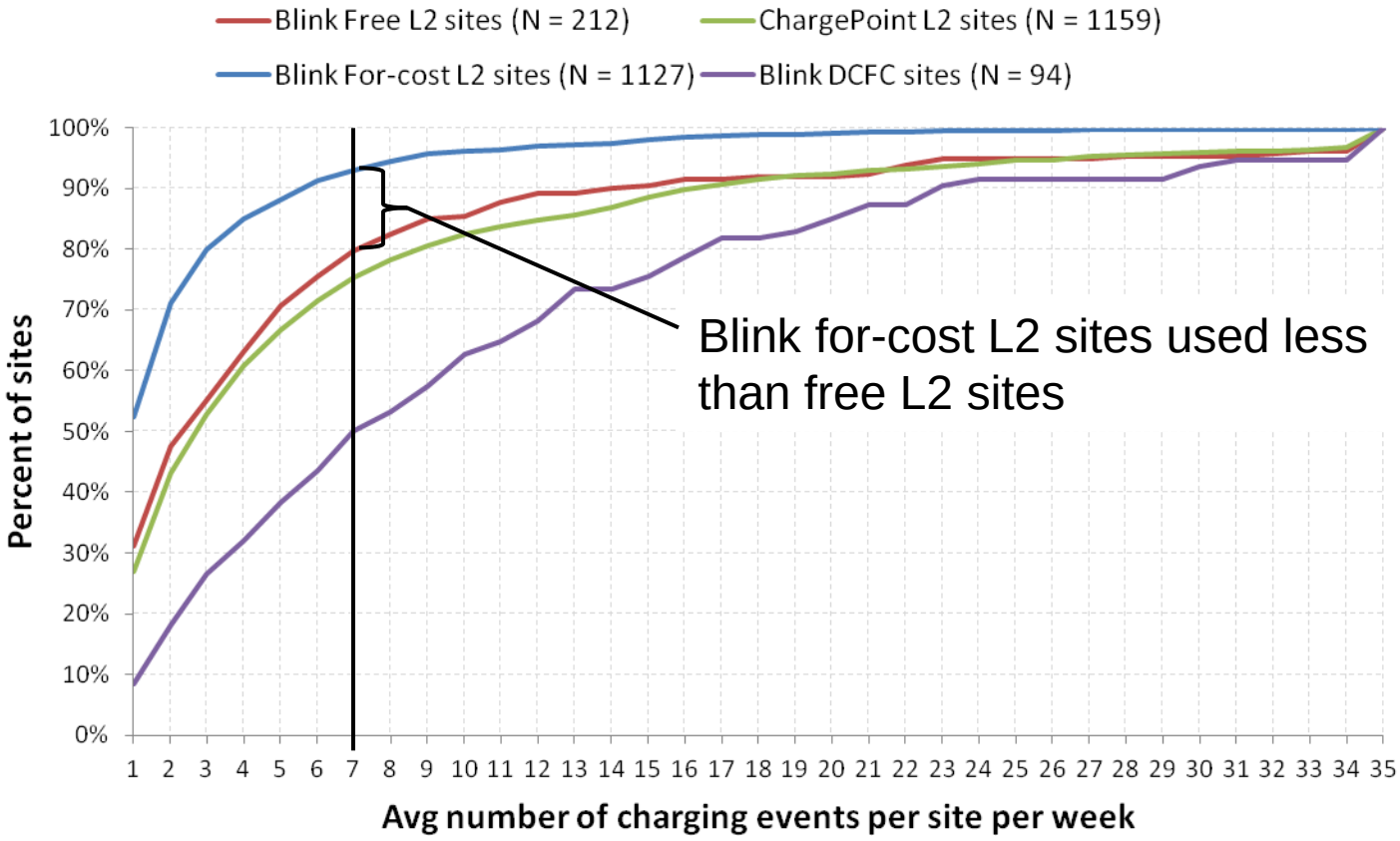
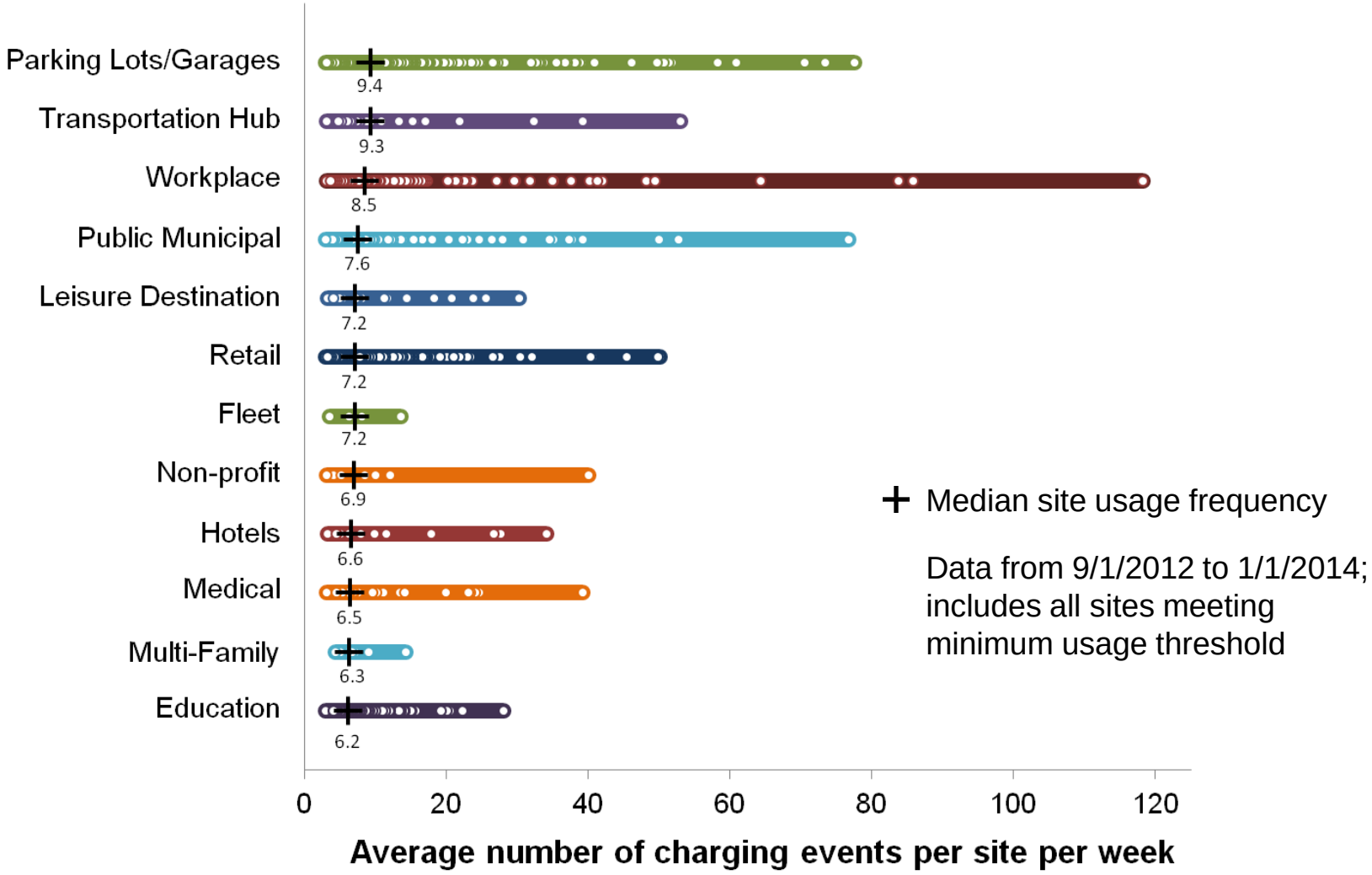


9/1/2012 to 1/1/2014

Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue



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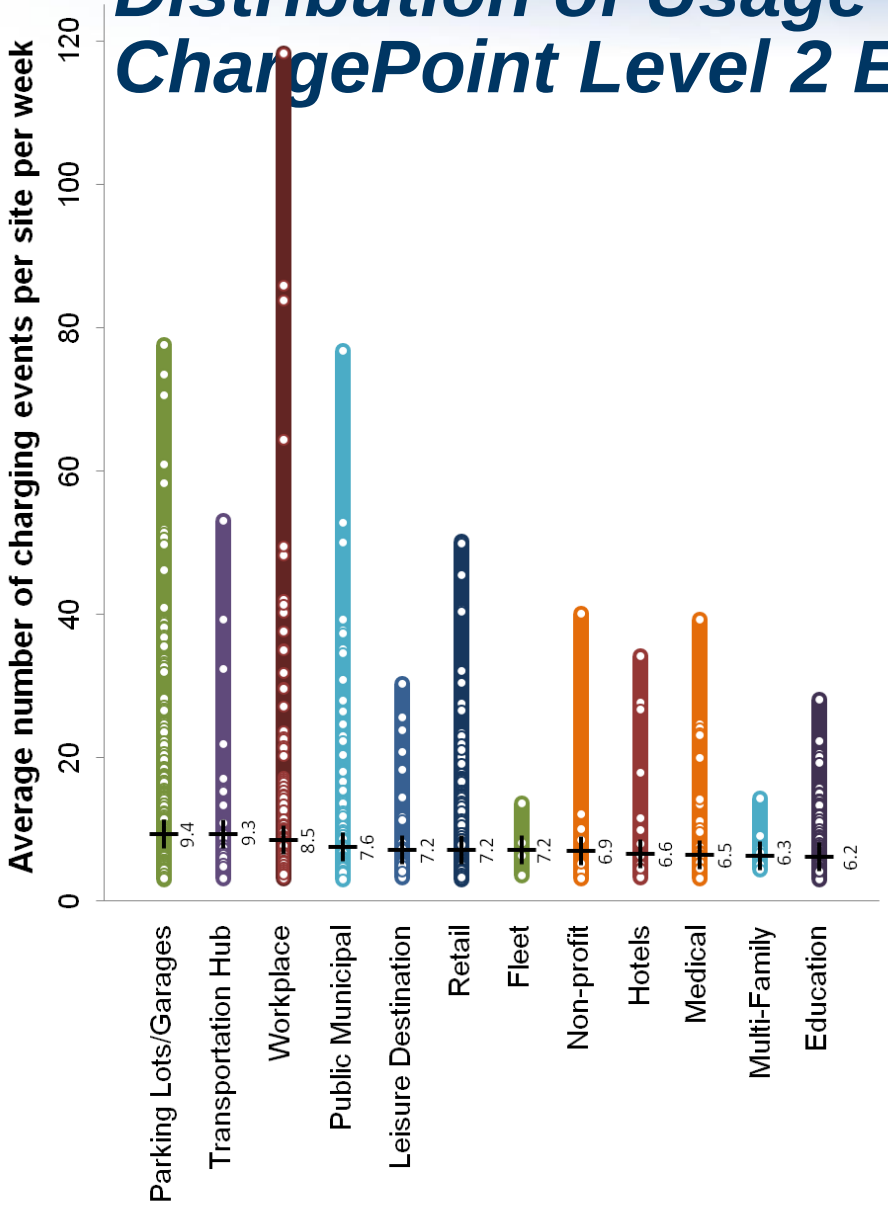

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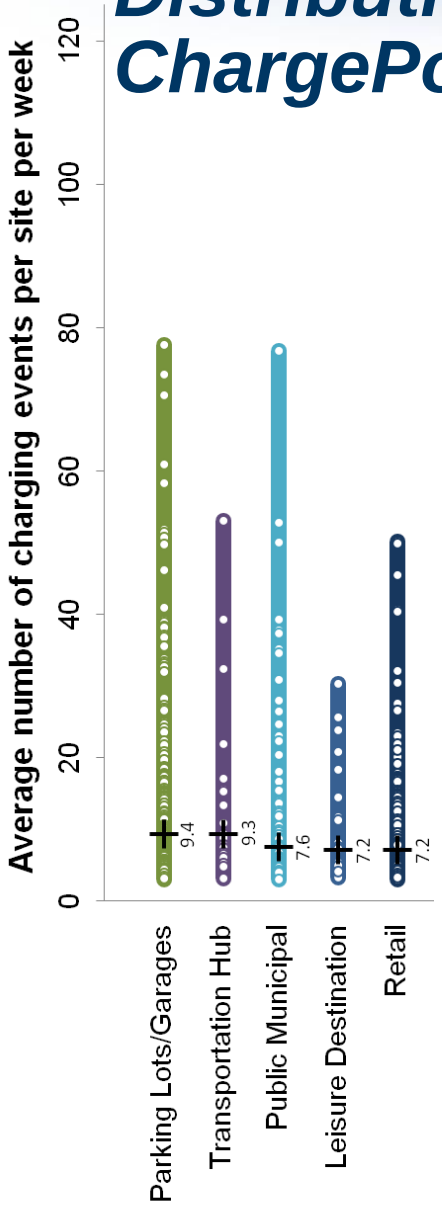
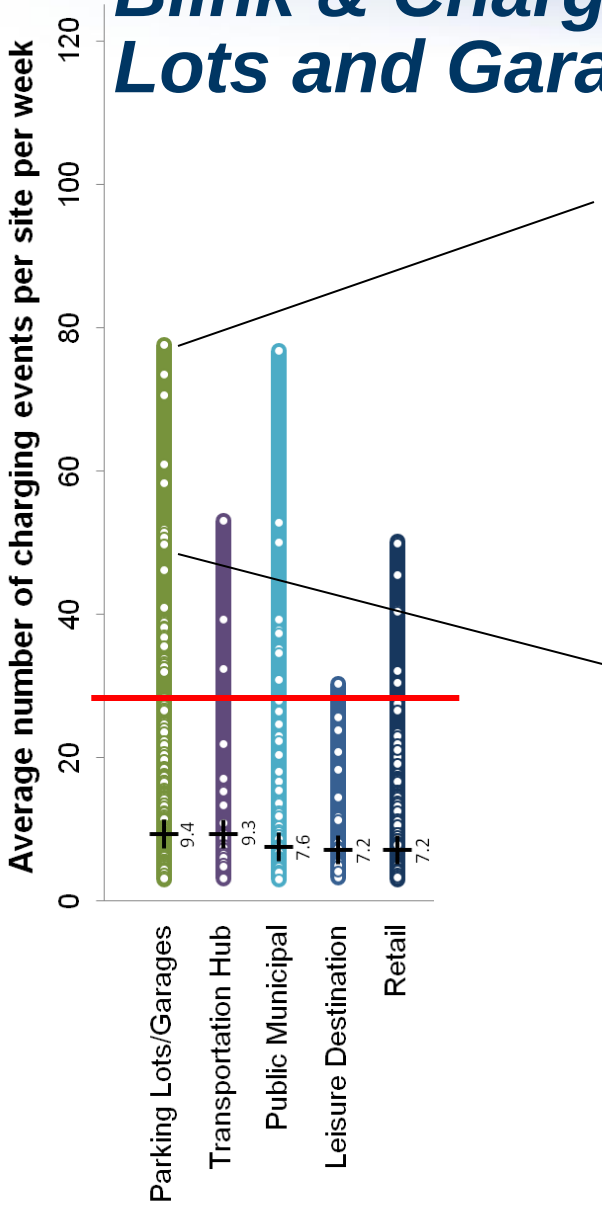
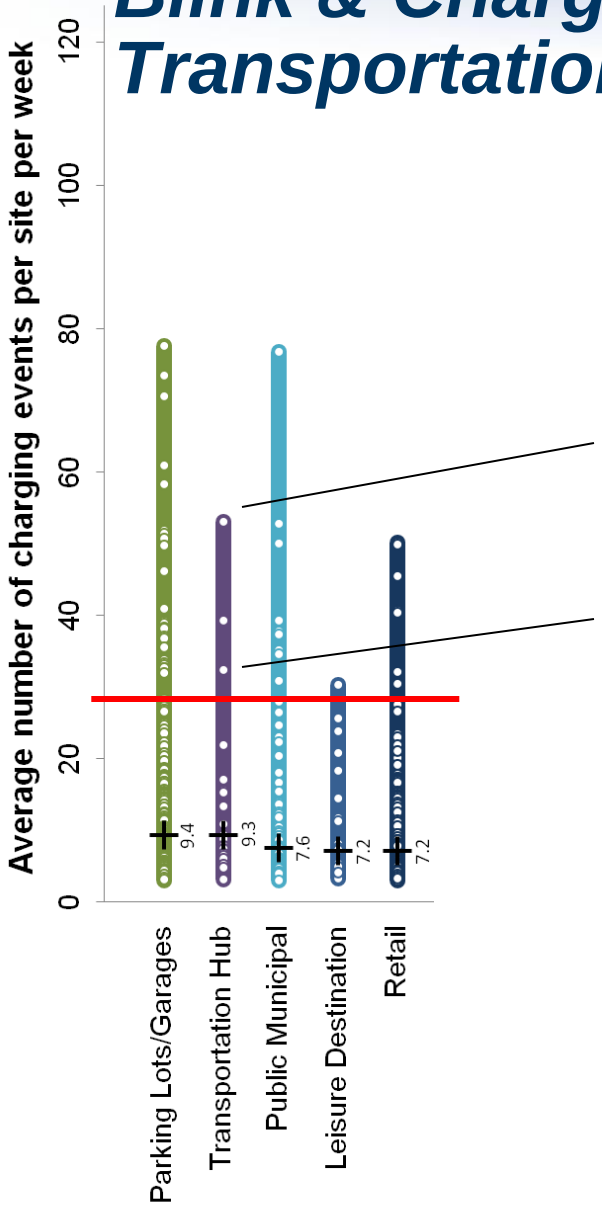


Blink & ChargePoint Level 2 Sites – Parking Lots and Garages



77.5 Downtown Palo Alto CA
73.4 Fifth & Mission Garage, San Francisco CA
70.6 Downtown Palo Alto CA
60.9 Downtown Redwood City CA
58.3 Parking Structure, Irvine CA
51.8 Parking Structure, Irvine CA
51.4 Parking garage, San Francisco CA
50.7 Sutter Stockton Garage, San Francisco CA

Blink & ChargePoint Level 2 Sites – Transportation Hubs

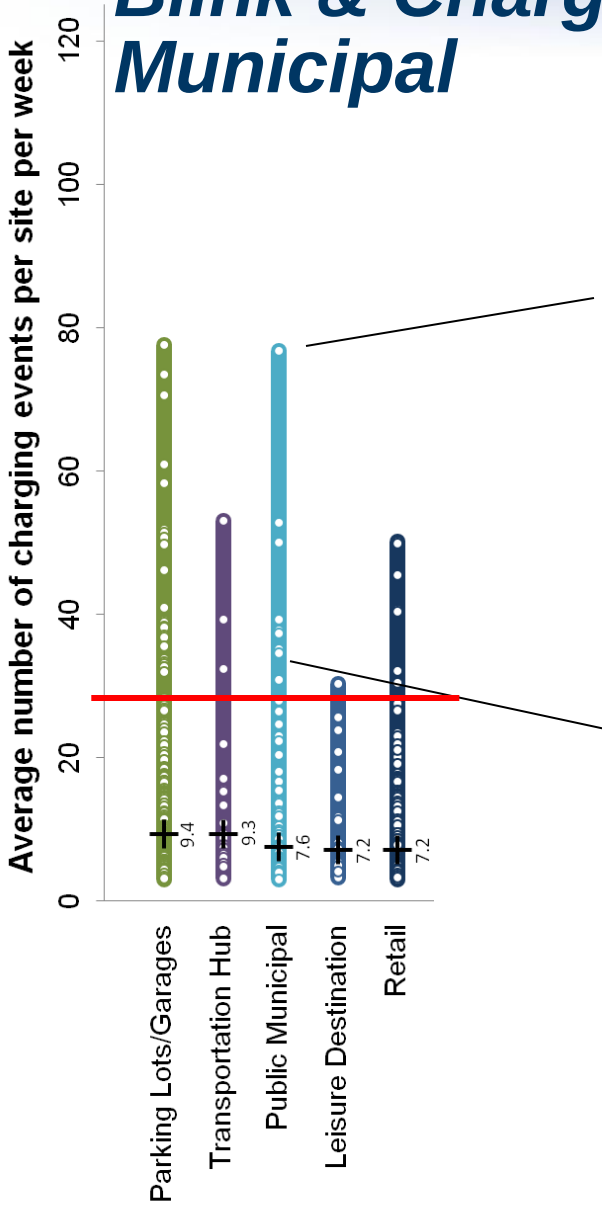


53.0 San Francisco International Airport

39.3 Metrolink park and ride, Anaheim CA

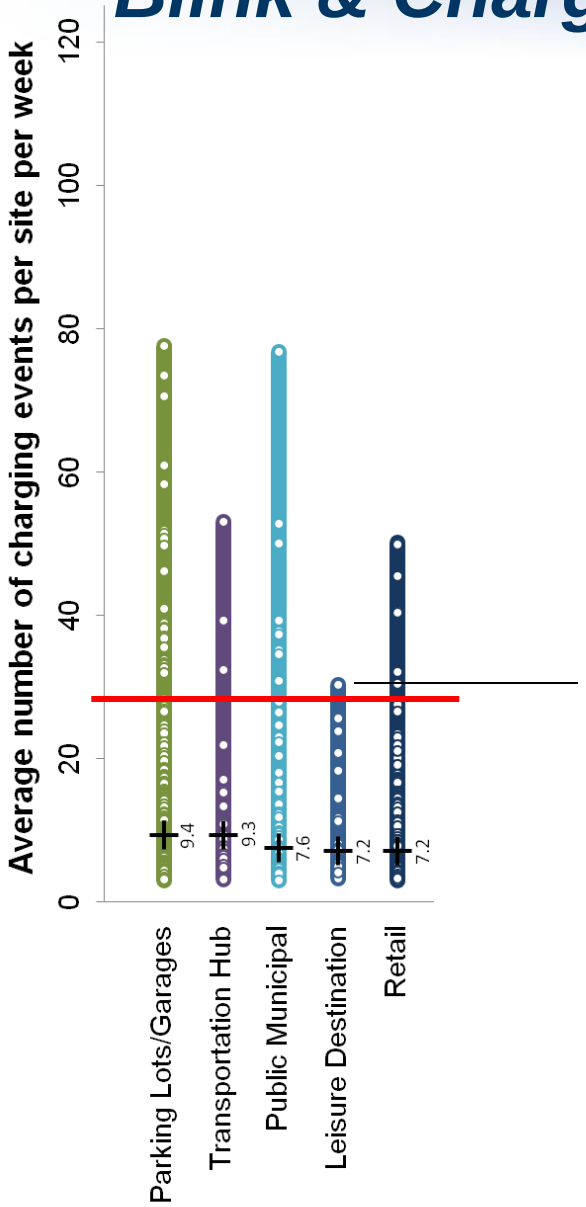
32.3 Metrolink park and ride, Oceanside CA

Blink & ChargePoint Level 2 Sites – Public / Municipal



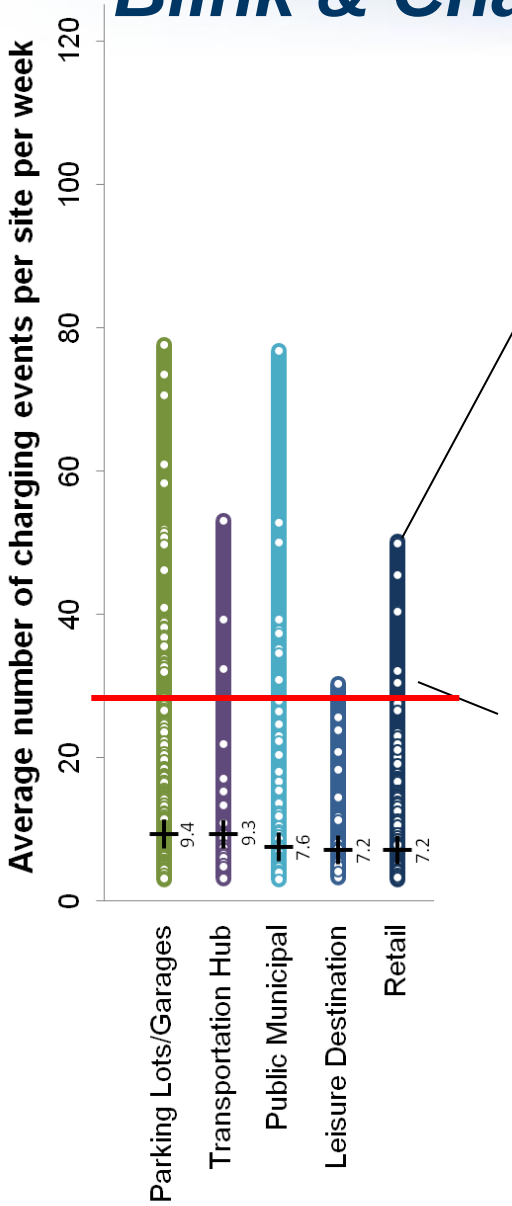
76.7	SCAQMD HQ building, Diamond Bar CA
52.8	City library, Dublin CA
50.0	City library, Redwood City CA
39.3	City hall, Hungtington Beach CA
37.7	Civic center, Campbell CA
37.3	City hall, Hermosa Beach CA
35.1	SCAQMD HQ building, Diamond Bar CA
34.6	City hall, Orange CA

Blink & ChargePoint Level 2 Sites – Leisure



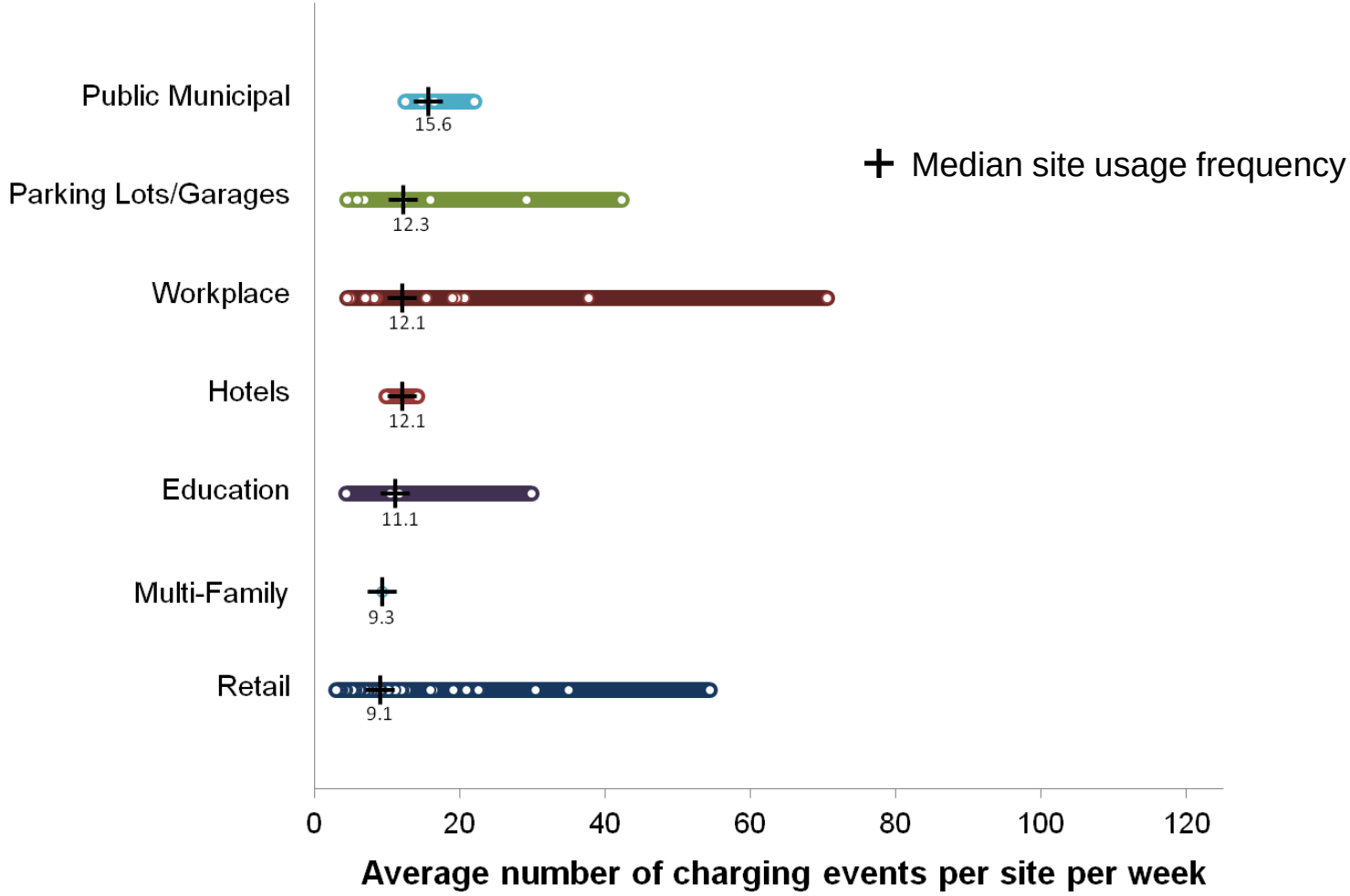
30.3 Rialto Sebastopol Cinemas, Sebastopol CA

Blink & ChargePoint Level 2 Sites – Retail



50.1	Retail-Small (Becker Surfboards), Hermosa Beach CA
49.9	Mall (Bella Terra Shopping Ctr), Huntington Beach CA
45.5	Mall (Westfield Galleria Mall), Roseville CA
40.7	Mall (The Grove), Los Angeles CA
40.3	Mall (The Americana at Brand), Glendale CA
32.1	Mall (Stanford Shopping Center), Palo Alto CA
30.4	Mall, Beverly Hills CA

Distribution of Usage Frequency of Blink DCFC Sites by Venue



8/1/2013 to 1/1/2014 (after Blink network fees were instituted)

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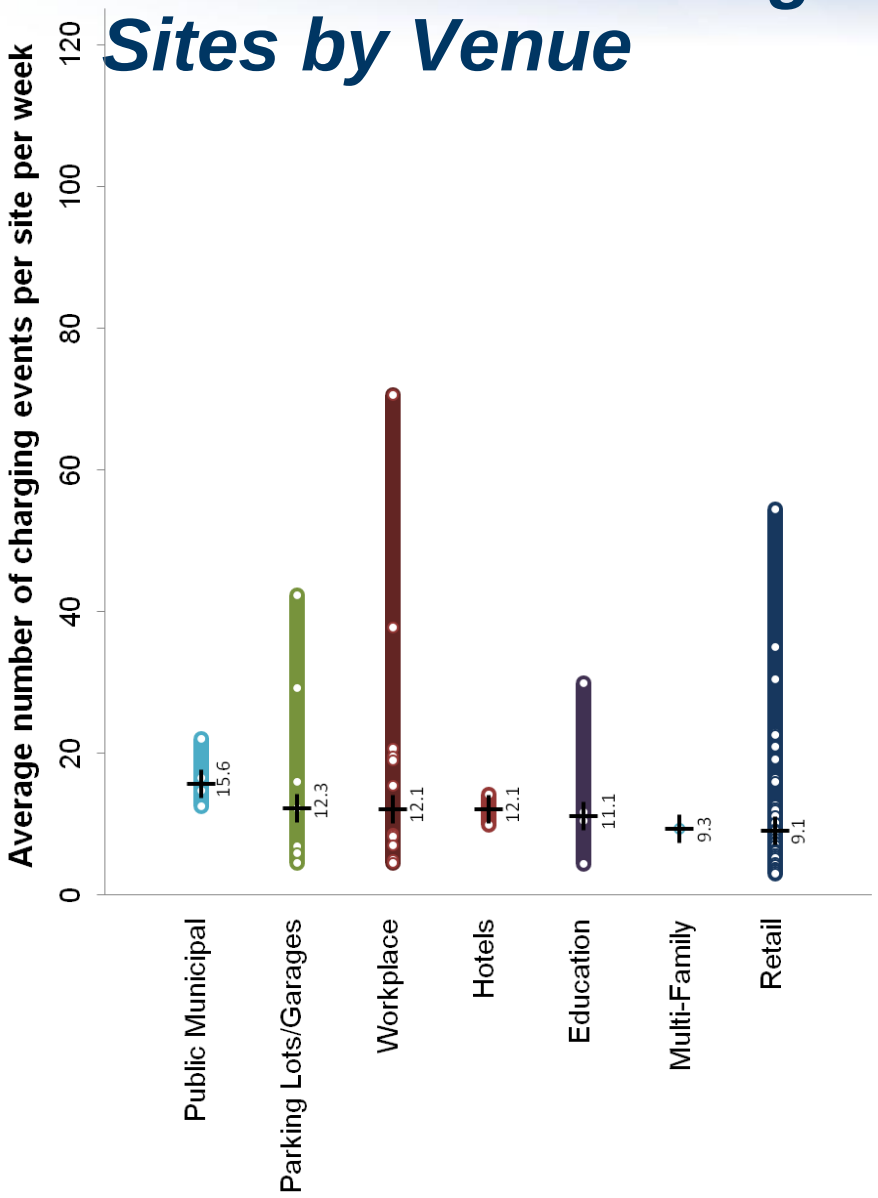

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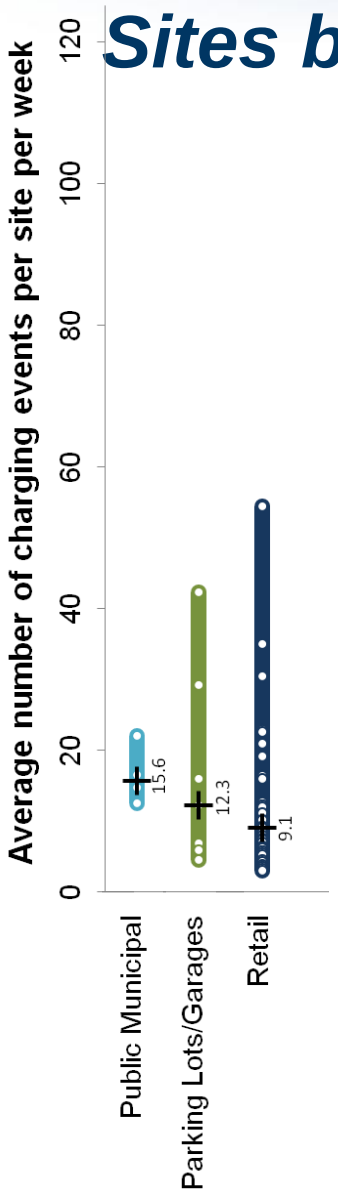

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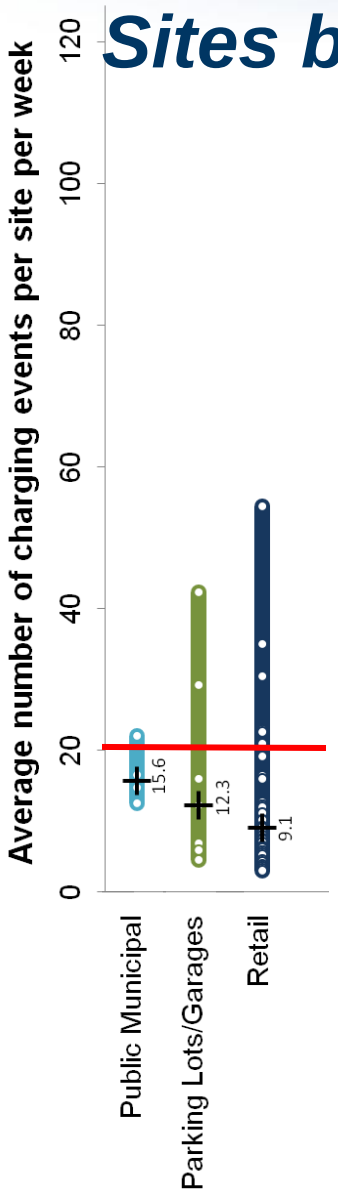


54.4	Tahoma Market on I5, Tacoma WA
42.3	Parking lot downtown Seattle WA
35.0	Fred Meyer, Kirkland WA
30.4	Nissan dealership, Bellevue WA
29.2	Parking garage downtown Seattle WA
23.1	Fred Meyer, Hillsboro OR
22.8	Fred Meyer, Seattle WA
22.6	Mall on I205, Happy Valley OR
22.0	City hall , Hayward CA
20.9	Fred Meyer, Salem OR

EVSE Installation Costs

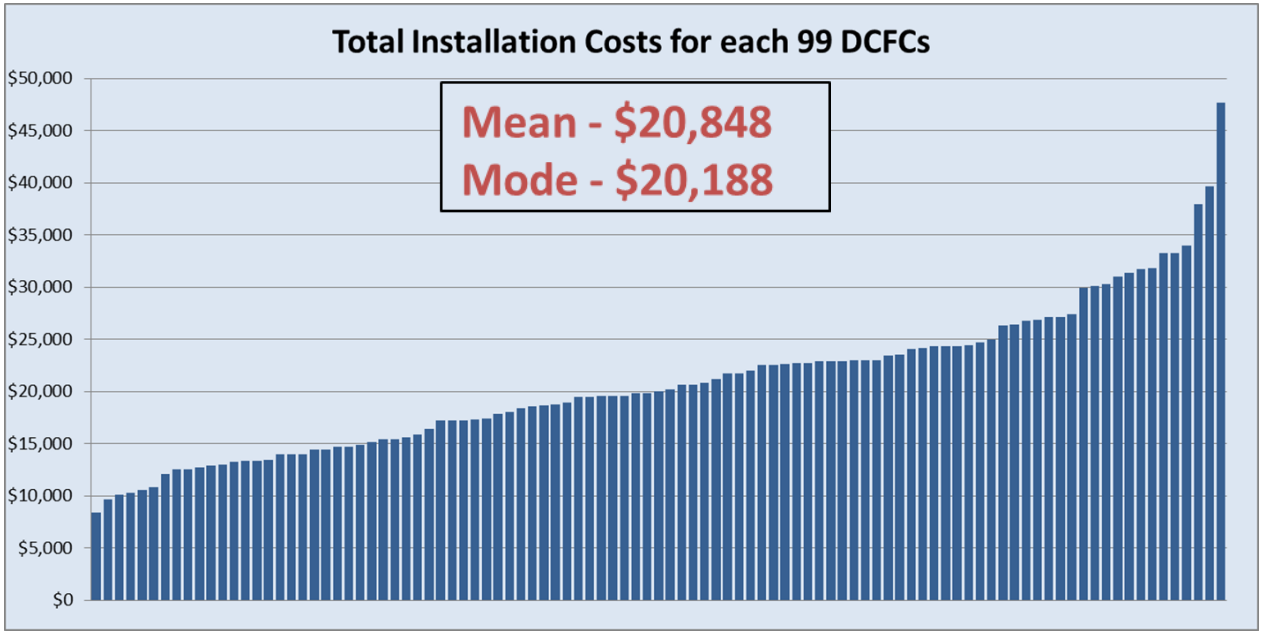
Commercial Level 2 EVSE Permitting Costs

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

Commercial Level 2 EVSE Installation Costs

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

DC Fast Charger (DCFC) Infrastructure Installation & 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**
- **DCFC Demand Charges can have significant negative financial impacts**

Recommendations to Support Market Growth

- Promote workplace charging
  - DOE is leading this through the EV Everywhere Workplace Charging Challenge
- Identify public charging hot spots
  - INL is using vehicle and infrastructure data to characterize known hot spots and build predictive tools
- Continue work to understand consumer mindset

For all EV Project and ChargePoint America publications, visit

avt.inl.gov/evproject.shtml

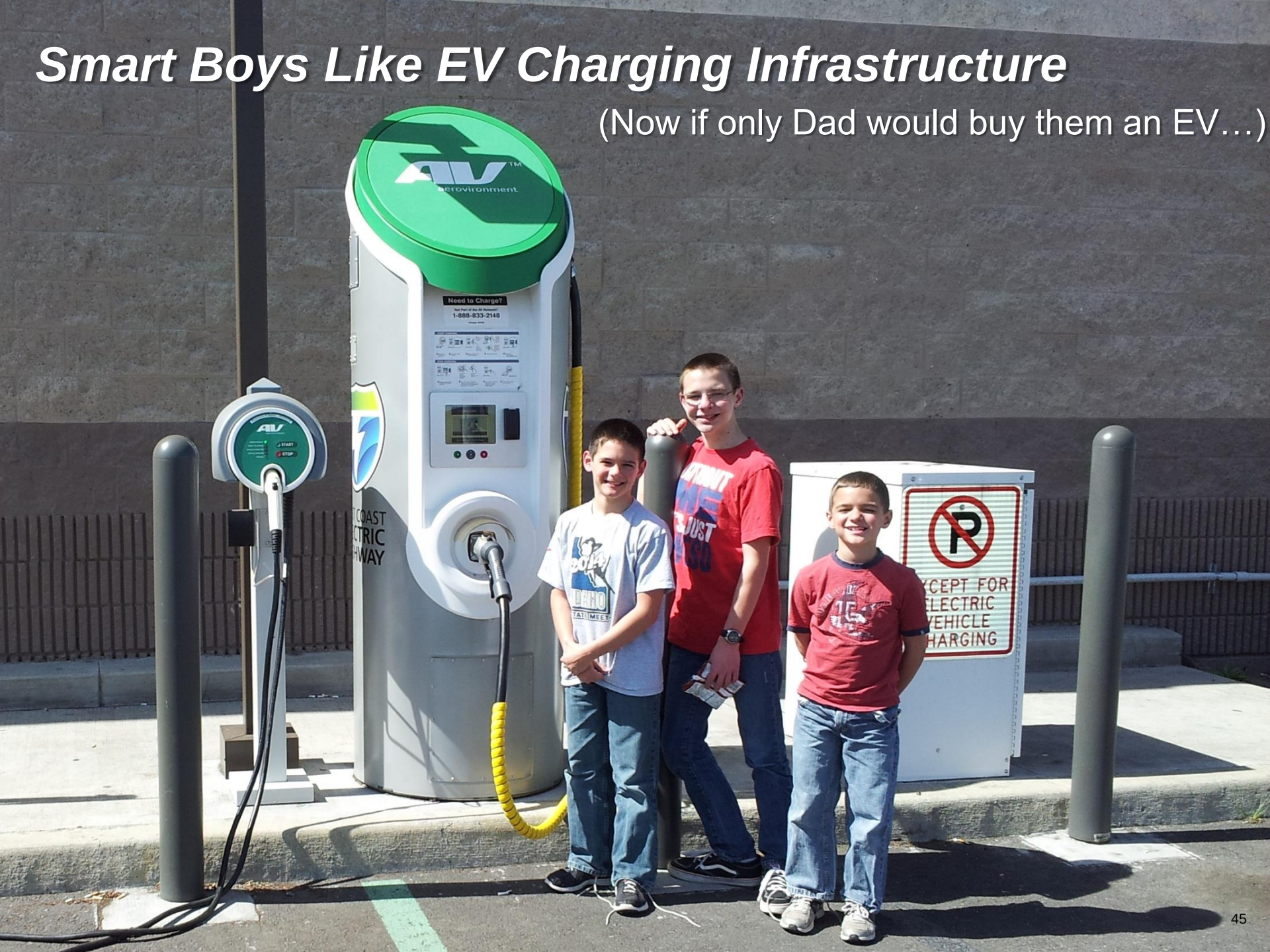
avt.inl.gov/chargepoint.shtml

INL's funding for this work comes from DOE's Vehicle Technologies Office

INL/MIS-15-34033

Smart Boys Like EV Charging Infrastructure

(Now if only Dad would buy them an EV…)



BACKUP SLIDES

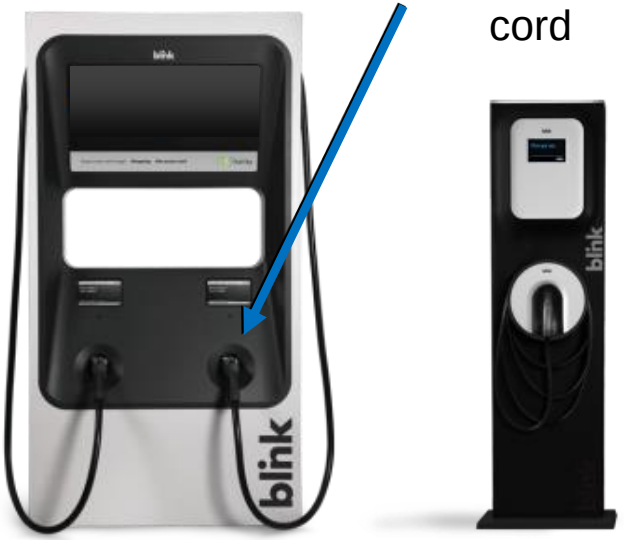
Measures of "Goodness"

There are numerous ways to assess how "good" public charging sites are:

- Charging frequency: **number of charge events per day or week**
- Charging time: hours connected
- Charging energy: **kWh consumed** / EV miles provided
- Parking time: time spent in parking space / in store
- Charging site host may want electric vehicle supply equipment (EVSE) for other reasons, such as image or cool factor
- etc.

Terminology

Charging site



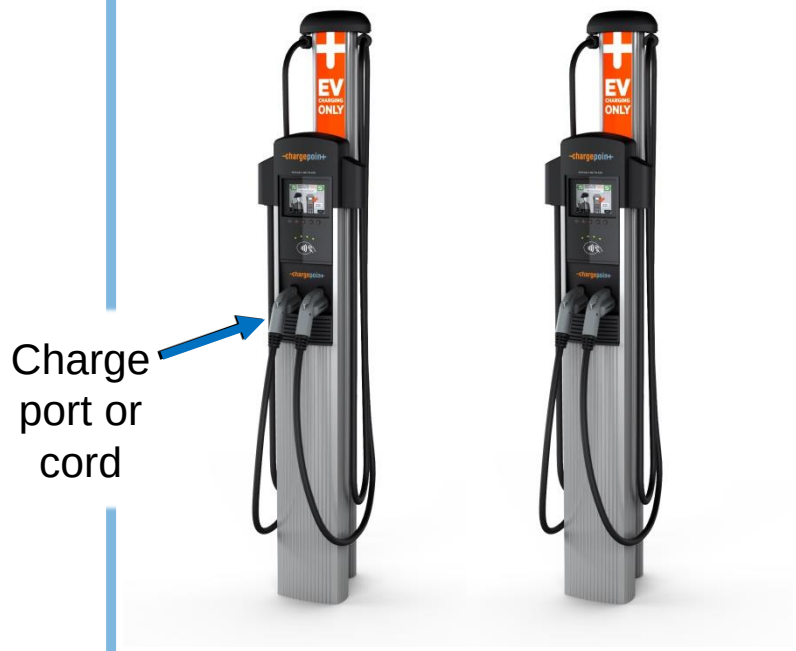
Dual-port DC fast charge EVSE unit or charging station

Single-port AC Level 2 EVSE unit or charging station

Charging site

Dual-port AC Level 2 EVSE unit or charging station

Dual-port AC Level 2 EVSE unit or charging station



Public EVSE Usage Fees

Blink

- Public AC Level 2 fees started Jul – Aug 2012
  - Varies from $1.00 to $2.00 **per hour connected**
  - 16% of sites were still free as of Dec 31, 2013 (per local site host discretion)
- DC Fast Charger fees started Jul 2013
  - $5 for Blink member / $8 for non-member **per session**

ChargePoint

- Vary by site (per local site host discretion)
- Many are free (rumored 70% free / 30% cost)

AeroVironment in WA/OR

- Free prior to Apr 1, 2014
- After Apr 1, 2014 – Monthly subscription fee of $19.99 for unlimited usage or “drive up” fee of $7.50 per session for DCFC and $4 per session for L2