Results and Impact of National Plug-in Electric Vehicle Charging Infrastructure Demonstrations

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Idaho National Laboratory

Presentation Outline

- Executive Summary
  - What did we do?
  - What have we learned?
  - Impact: Who has it benefitted?
  - Recommendations: What's next?
- Results
  - Leaf and Volt driving and charging
  - Workplace charging
  - Public charging
  - Corridor charging
- Impact
  - More on who we have helped
- Hot Topics Recap

EXECUTIVE SUMMARY

Building the "Laboratory"

- In a competitively-awarded, cost-shared effort with industry partners, the U.S. Department of Energy supported the largest-ever demonstration of plug-in electric vehicles (PEV) and electric charging infrastructure
- Data collection and analysis led by Idaho National Laboratory (INL) has provided valuable insights to inform future deployment

The EV Project

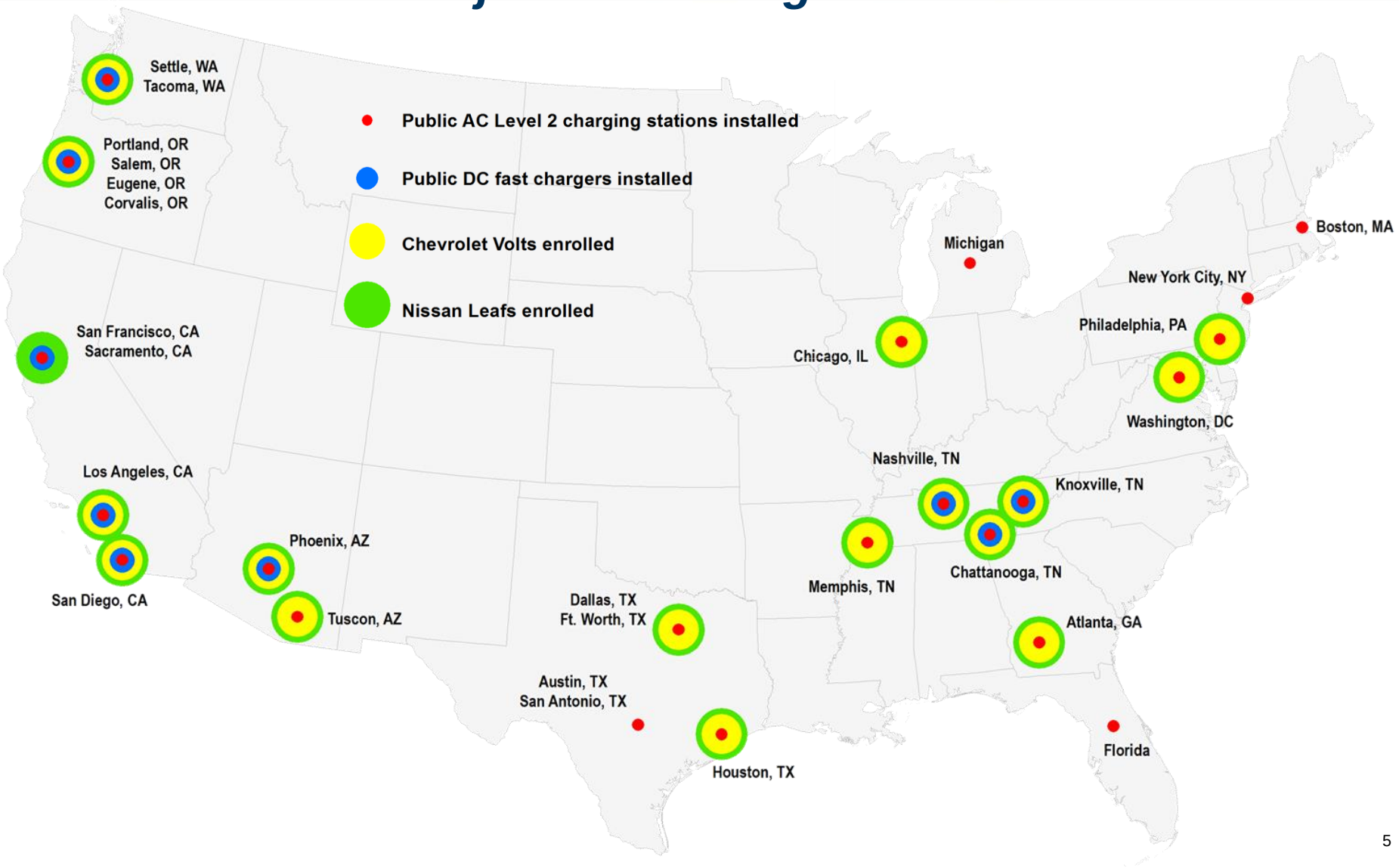
- 12,000+ residential and public AC level 2 charging units
- 100+ DC fast chargers
- 8,000+ Electric drive vehicles
- INL data collection Jan 2011 – Dec 2013

ChargePoint America

- 4,700+ residential and public AC level 2 charging units
- INL data collection May 2011 – Dec 2013

Project partners:

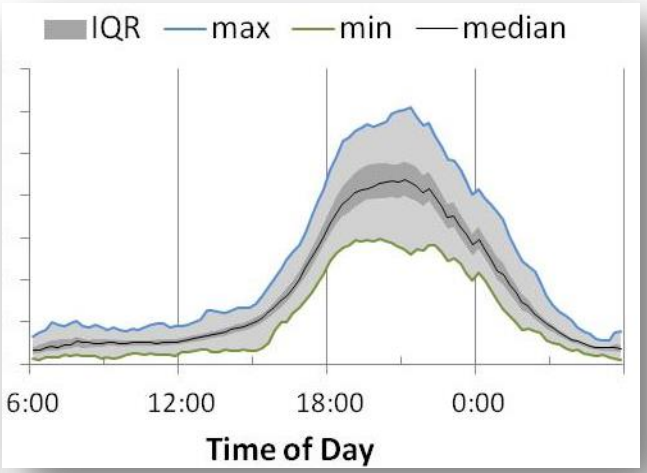
Infrastructure and Vehicle Deployment in The EV Project and ChargePoint America



Demonstration Objectives

Establish a “laboratory” to study:

- PEV driving and charging behavior
- Infrastructure deployment and usage
- Impact of PEV charging on the grid



Project Outcomes

- Provide defensible, independent findings for the numerous stakeholders needed to advance the PEV market
  - Automakers
  - Charging equipment manufacturers and service providers
  - Electric utilities
  - Regulators and policy makers
  - Fleet managers
  - Start-up companies, innovators
  - Private consumers
- Characterize real-world usage for DOE EV Everywhere and other RD&D activities

Using data describing124 million miles and 6 million charging events from over 8,000 PEVs and 17,000 charging stations, INL has provided the most comprehensive view of PEV and charging usage to date

What Have We Learned about Public Charging?

- Although many suggest there is a need for extensive public charging infrastructure, most charging was done at home and work
- Most drivers who charged away from home using AC Level 2 charging units favored three or fewer locations (including work)
- Most public AC Level 2 charging stations were rarely used, but a small minority were used extensively
- **Conclusion**: Instead of having charging stations everywhere, public charging infrastructure needs to be concentrated in the hot spots

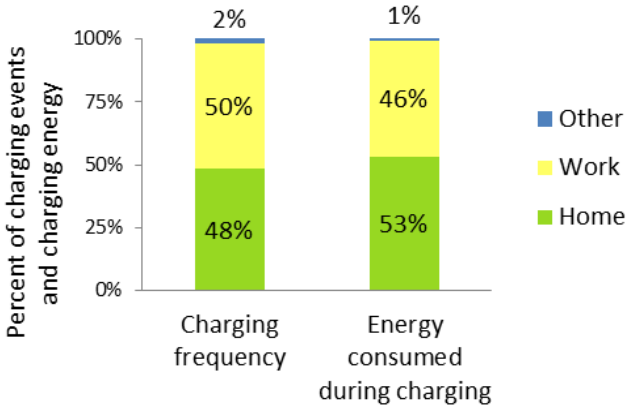
Data from The EV Project and ChargePoint America can be used to characterize existing hot spots and model charging choice behavior to understand where new infrastructure deployment should be focused

What Have We Learned: Away-from-home Charging for Range Extension

- Consistent use of away-from-home charging infrastructure increased EV miles traveled up to 72%
- Even if they didn't need to charge to make it home, PEV drivers tended to drive more EV miles if they plugged in away from home
- Battery electric vehicle (BEV) drivers often drove 2-3 times farther than their single-charge range using DC fast chargers along travel corridors
- **However**, most drivers did not charge away from home very often so the overall benefit to EV miles traveled was small

What Have We Learned: Workplace Charging

- Workplace charging is highly utilized, sometimes even more than home charging
- Drivers with access to home and work charging rarely charged elsewhere



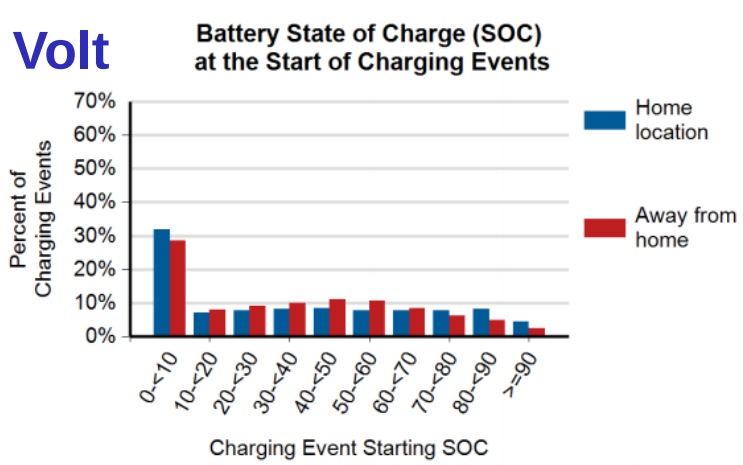
- Workplace charging is an effective range extender
  - 6% of drivers drove a Leaf to work even though they couldn't make it back home unless they charged at work
  - 40% of Leaf drivers at least sometimes relied on workplace charging to allow them to drive more miles than they could have driven with home charging alone
- PEV drivers will adjust their charging habits based on conditions, such as fees and rules for use. Employers offering workplace charging need to consider their goals and select policies accordingly

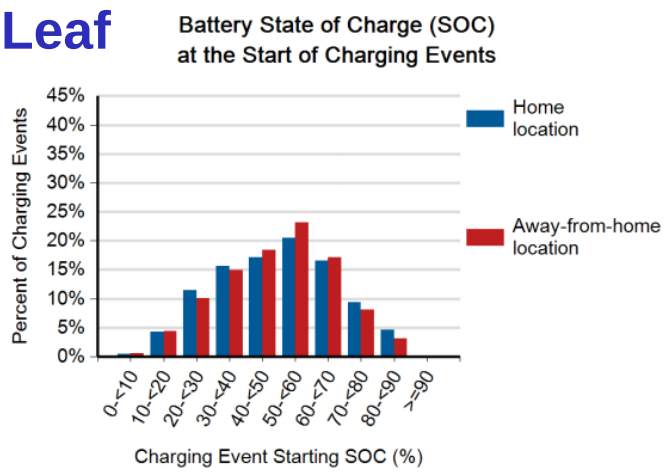
What Have We Learned: Grid Impact & Integration

- Clustering of PEV owners in residential neighborhoods is happening and will affect local distribution
- Uncontrolled PEV charging peak demand overlaps with periods of high system demand in some areas
- The opportunity is ripe for demand-side management using smart charging
  - Overnight home charging typically took less than 3 hours but vehicles were usually connected for more than 10 hours
  - Only about 100 PEVs are needed in a utility service area before the number of PEVs connected to the grid at any given time is consistent and predictable
- Money talks
  - Drivers responded to time-of-use rate price signals
  - Drivers charged less at public charging stations when fees were applied
  - This allows utilities and facility managers to manage charging demand through pricing (and it also helps drivers who truly need to charge to find an available charging station)

What Have We Learned: BEVs vs. EREVs

- Volt average annual vehicle miles traveled (12,238 mi) was above the national average of 11,346 mi
- Leaf average annual vehicle miles traveled was 9,697 mi
- Volt drivers averaged 9,112 miles per year in EV mode, only 6% fewer EV miles per year than Leaf drivers, despite having less than half as much battery capacity
- Volt drivers charged more often (1.5 avg charge/day vs. 1.1 for Leaf)
- Volt drivers tended to fully deplete their batteries prior to recharging, whereas Leaf drivers tended to recharge with significant charge left in their batteries





Upcoming FY-15 EV Project White Papers

- What we've learned from The EV Project and ChargePoint America – public affairs-friendly report
- How do residential charging infrastructure installation costs vary by geographic location
- How do publicly accessible infrastructure installation costs vary by geographic location
- What were the cost drivers for DCFC installations
- What were the cost drivers for publicly accessible charging installations
- Characterize clustering of residential EVSE with respect to grid impacts
- How does the location of public infrastructure actually deployed correlate with EV Project Micro-Climate planning locations
- What percent of total charging energy is dispensed at residential vs. workplace vs. commercial vs. public venues vs. DCFC locations
- What makes a DCFC site highly utilized - correlation between utilization and three location based factors
- What makes an L2 public site highly utilized - correlation between utilization and three location-, host-, and user-based factors
- What makes a DCFC site highly utilized - correlation between utilization and three location-, host-, and user-based factors
- What is the impact of utility demand charges on a Level 2 host
- What is the impact of utility demand charges on a DCFC host
- SDG&E Project description and lessons learned - TOU rates
- What was the impact of the car sharing on Publically Available charging infrastructure in San Diego
- What were 'best practices' for residential infrastructure permitting
- What were 'best practices' for public infrastructure permitting
- Final Report (includes all ARRA-funded PEV and charging infrastructure demo projects)

Impact: Who Has Benefitted?

- Results have been used by a host of organizations to guide decisions in a wide variety of areas related to PEV development and charging infrastructure deployment
- Special reports and presentations were requested by and produced for over 70 organizations:
  - Charging station hosts
  - Communications, outreach, and standards development organizations
  - Electric utilities
  - Government agencies and planning organizations
  - Manufacturers and service providers
  - National laboratories
  - Non-government research and planning organizations
  - Universities

Impact: National Policy Recommendations

- The National Research Council of the National Academy of Sciences released the report "Overcoming Barriers to Deployment of Plug-in Electric Vehicles."
- This 204-page report is the result of an intensive two year study conducted by the NRC for DOE and makes recommendations to the federal government and others on actions to take or to avoid to enable the adoption of plug-in electric vehicles by the mass market.
- INL provided a presentation and a series of follow-up reports from The EV Project. INL or The EV Project was cited 17 times in the report.

Thank you for your presentation to the National Academies Committee on Overcoming Barriers to Electric Vehicle Deployment…. Understanding the role of public charging and how consumers are using EVs is very important to the committee's work…. Thank you again for taking the time to prepare and present your work at INL to us.

- National Academy of Sciences staff member

Impact: State Infrastructure Planning Decisions

- California Air Resources Board (ARB), the California Energy Commission (CEC), and the California Public Utilities Commission (CPUC) solicited INL for information regarding the development of sustainable public charging infrastructure for the growing number of PEVs in California
- INL presented analysis results about away-from-home charging observed in PEV charging infrastructure demos
- The information provided assisted CEC in validating model assumptions used in their Statewide PEV Infrastructure Plan, and ultimately fed into the PEV Infrastructure Assessment to be presented to the Air Resources Board in October 2014

Impact: Regional Electric Utility Planning

- INL analyzed PEV charging and presented results to a group of seven Northeast-based electric utilities, called the Regional Electric Vehicle Initiative (www.revi.net)
- The work analyzed diversity patterns and coincidence of PEV charging with utility system loads
- The utilities requested this information to guide decisions regarding system planning, rate design, and development of rate/program strategies to mitigate system impacts
- The presentation is available to the general public, accessible on INL/AVTA website at avt.inl.gov/pdf/EVProj/DiversityPatterns&CoincidenceOfEVChargingWUtiltiySystemLoads.pdf

Impact: Vehicle Regulations and Sales

- INL performed analysis of PEV driving data from The EV Project and additional data sets as an independent third party and presented results to California Air Resources Board (ARB) to support deliberations between ARB and automakers about the redefinition of zero-emission vehicle credits
- A revision to regulations on cars sold in California, the largest market in the US, would potentially shift billions of R&D dollars at various auto companies
- The study was performed on a data set of 158,000,000 miles from 21,000 vehicles operated throughout the U.S. Eight models from four automakers (Ford, GM, Honda, Toyota) were included
- INL's analysis and presentation of results was highlighted in an article in a leading auto industry news publication, Auto News www.autonews.com/article/20150328/OEM05/303309999/calif-considers-a-plea-for-plug-in-hybrids

"We can't thank you enough for your presentation, yesterday. It was exactly what we needed. "

- Auto company executive

Impact: DOE Leadership

- Analysis of workplace charging in The EV Project and ChargePoint America led to the publication of numerous reports for the EV Everywhere Workplace Charging Challenge
- INL researchers were also able to mine data to identify 140 companies offering charging to employees. This list was provided to DOE to aid its efforts to recruit employers to join the Workplace Charging Challenge

- The President's U.S.-China Electric Vehicles Initiative, launched in 2009, included demonstration projects in paired cities to collect and share data on charging patterns and consumer preferences
- The EV Project and ChargePoint America provided the means to execute this vision
- INL hosted a delegation of Chinese PEV experts for two days of discussions centered around PEV data collection and analysis

Impact: Independent Technology Assessment

- On Jun 17, GM issued a press releases announcing that Chevrolet Volt owners have surpassed half a billion electric miles. The press release included the following reference to INL EV Project results:

  "In an independent study conducted between July and December 2013, Volt drivers who participated in the Department of Energy's EV Project managed by Idaho National Labs totaled 1,198,114 vehicle trips of which 974,692, or 81.4%, were completed without the gasoline-powered generator being used."

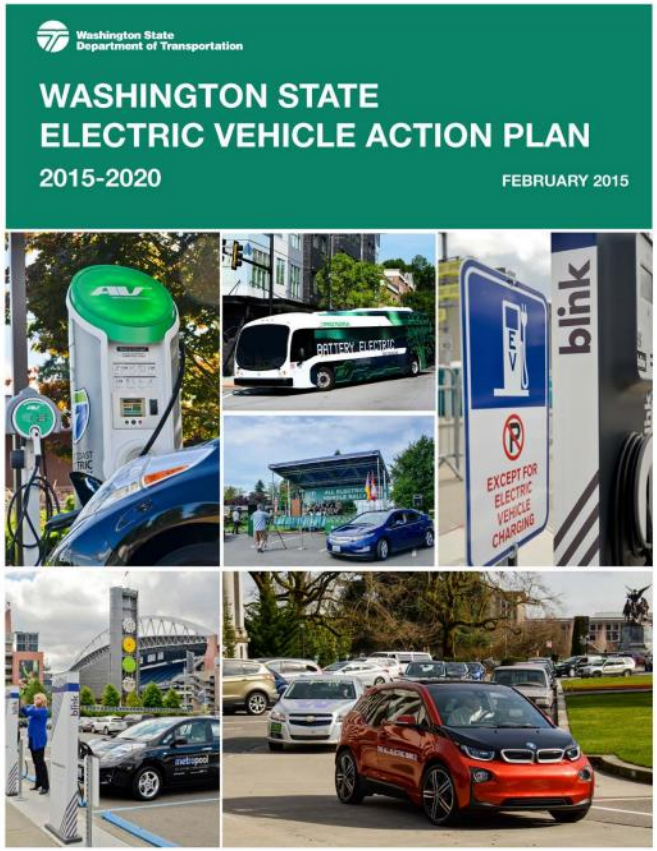
  media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2014/Jun/0617-volt.html

This is really great (and helpful) info. Many thanks!

- Auto company executive

Impact: State Policy and Planning

- INL provided Washington State Department of Transportation (WSDOT) with analysis results from data collected from PEVs and charging stations in Washington
- WSDOT incorporated these lessons learned into the Washington State Electric Vehicle Action Plan. The plan details WSDOT's expectations and plans to achieve Washington's governor's goal of 50,000 electric vehicles on the road in the state by 2020



Recommendations to Support Market Growth

- Continue to promote workplace charging
- Identify public AC Level 2 charging hot spots
- Continue to analyze DC fast chargers, especially along travel corridors, to determine the cost/benefit
- Continue work to understand consumer mindset, especially how households with multiple vehicles use all of their vehicles to meet their travel needs
- …

Top 10 Questions that Still Need Answers

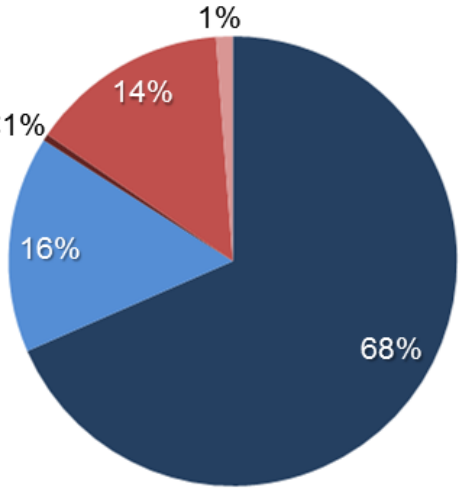
1. What is the true potential for PEVs to displace petroleum, considering how households manage the use of multiple vehicles?
2. What is the minimum amount of away-from-home charging infrastructure that meet drivers' need and/or desire for eVMT?
3. How can public charging infrastructure be optimized so it is cost-effective and sustainable?
4. How effective is public charging infrastructure in stimulating the PEV market, compared to other incentives?
5. As the number of PEVs and charge rates increase, how can PEV charging data be used to help utilities accurately forecast load?
6. As the number of PEVs and charge rates increase, what will be the real-world impact of PEV charging on local distribution and how should it be addressed?
7. What is the potential for PEVs as controllable distributed energy resources to integrate renewable and provide grid services?
8. How should workplace charging be implemented and managed to maximize long term benefits?
9. What is the range of PEV overall ownership cost?
10. What is DOE's role in promoting PEVs as appealing cars that work for ordinary Americans?

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

Percent of Charging Events by Location, Power Level, and Time of Day

Oct 2012 – Dec 2013

4,038 Leafs



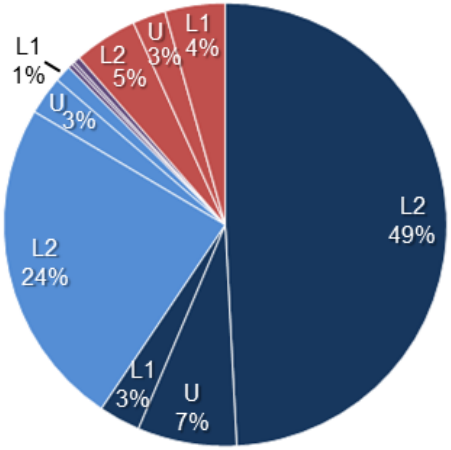
- Home Overnight L1 or L2
- Home Daytime L1 or L2
- Away Overnight L1 or L2
- Away Overnight DCFC*
- Away Daytime L1 or L2
- Away Daytime DCFC

84%

16%

* <<1% of all charge events

1,867 Volts



- Home Overnight
- Home Daytime
- Away Overnight*
- Away Daytime

87%

13%

*1% of all charge events

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

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
at home during the day	0.1	0.2	0.1	0.3	0.4	0.3

Nissan Leafs and Chevrolet Volts in The EV Project

Oct 2012 – Dec 2013

4,038 Leafs

1,867 Volts

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

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at home during the day	0.1	0.2	0.1	0.3	0.4	0.3
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

Nissan Leafs and Chevrolet Volts in The EV Project

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at home during the day	0.1	0.2	0.1	0.3	0.4	0.3
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

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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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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

- 250 work sites identified with workplace charging available
- 600+ Nissan Leafs and ~100 Chevrolet Volts in The EV Project who park at these sites
- 2012 – 2013

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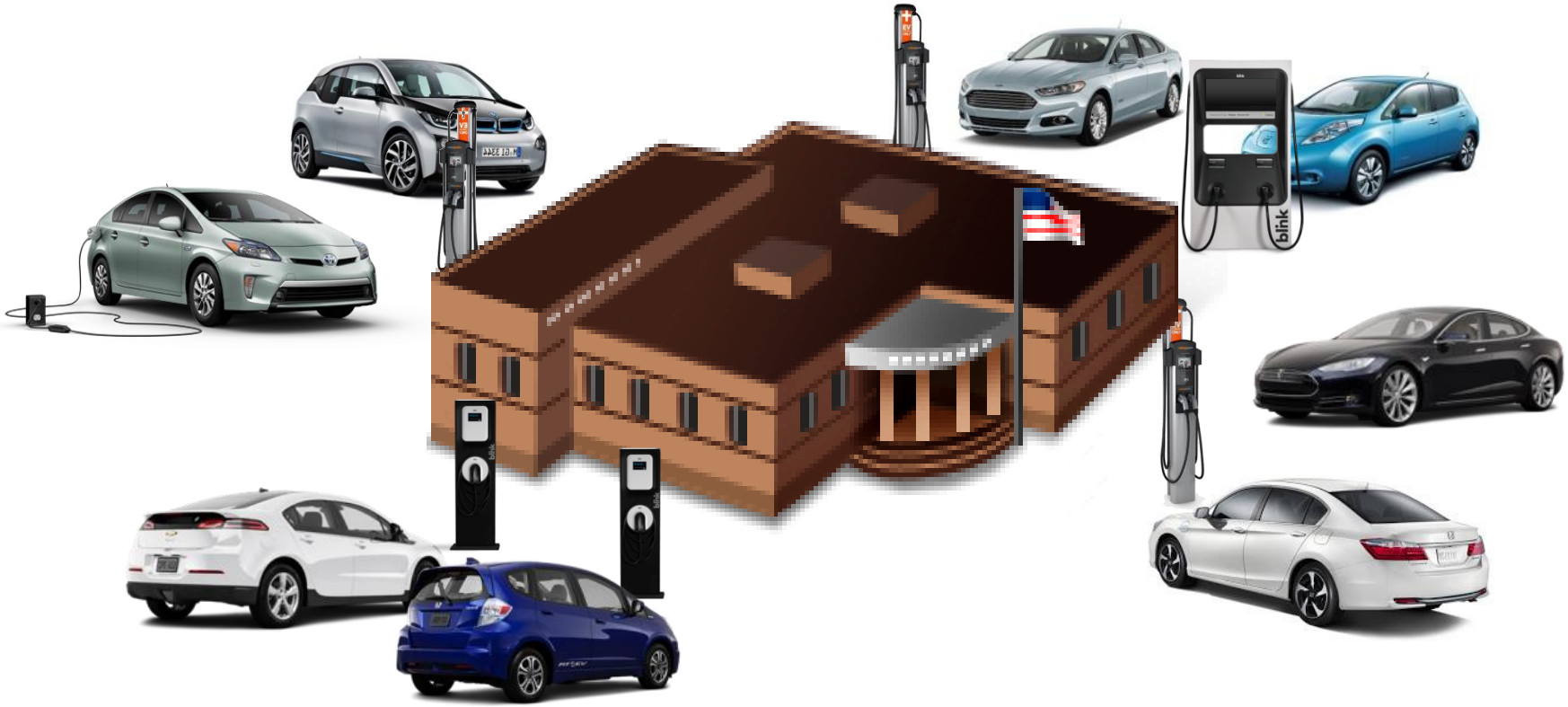
Workplace Charging Analysis

3 ways to look at data

1. Charging station usage at a work site



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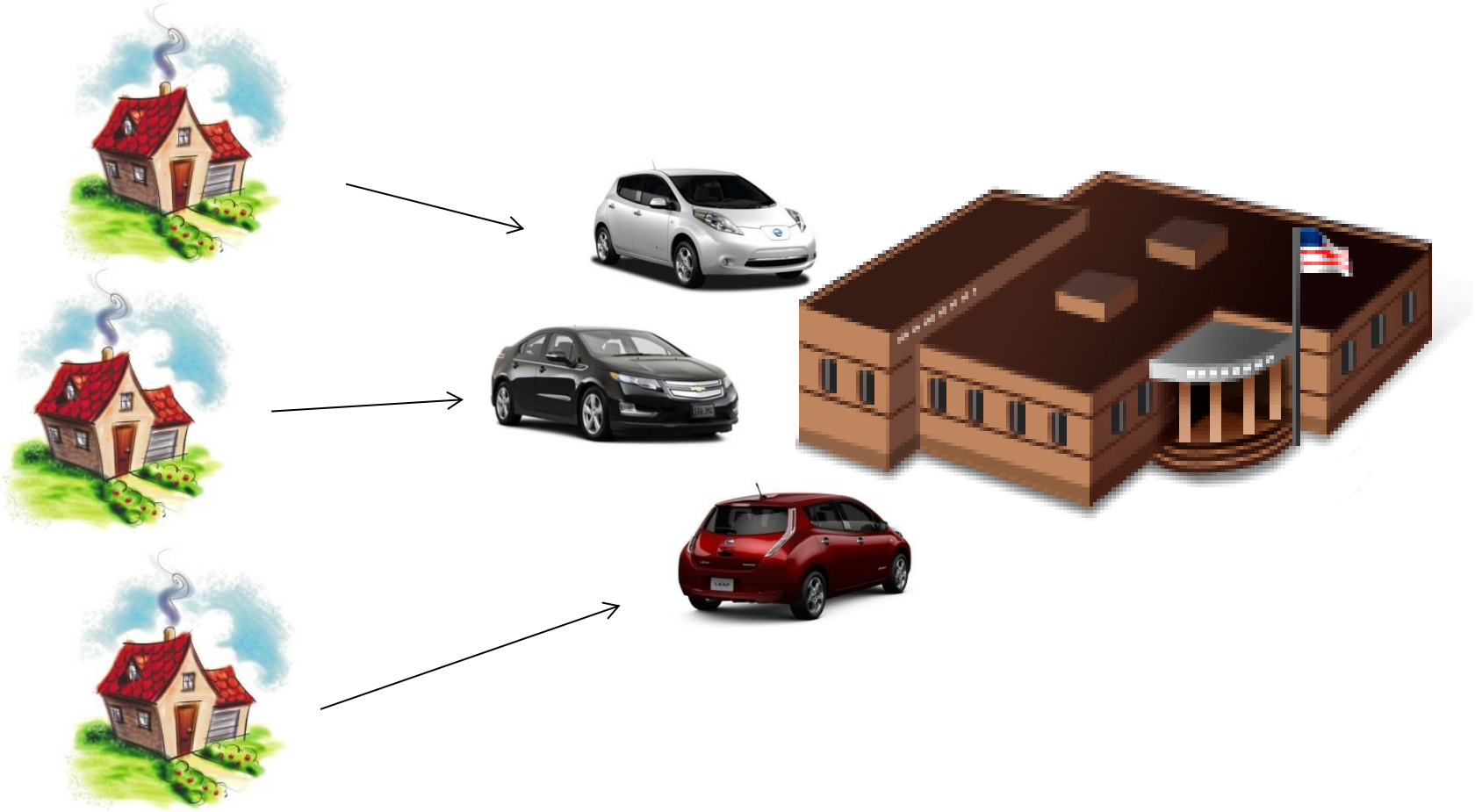
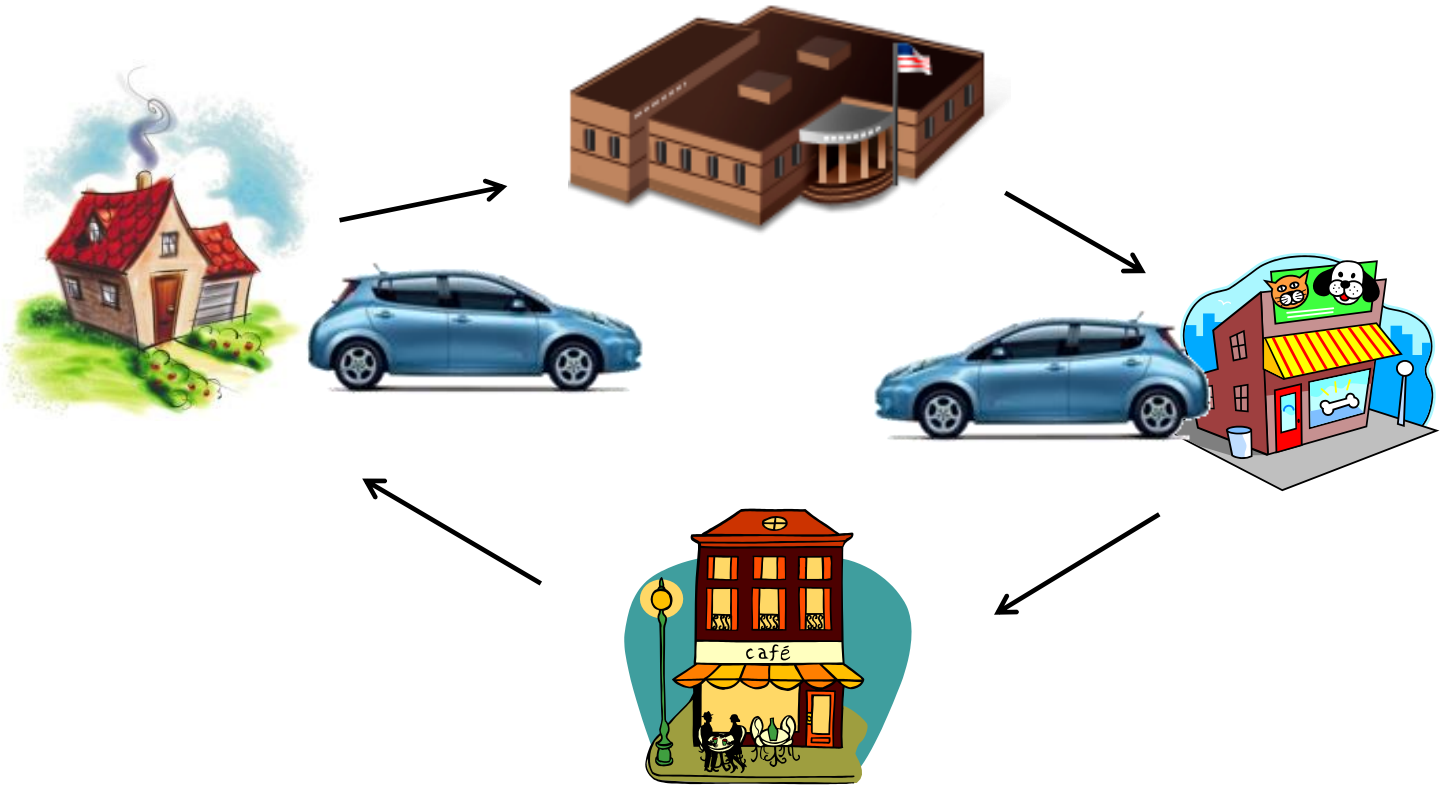
Workplace Charging Analysis

2. Parking and charging at a work site by vehicles reporting data



Workplace Charging Analysis

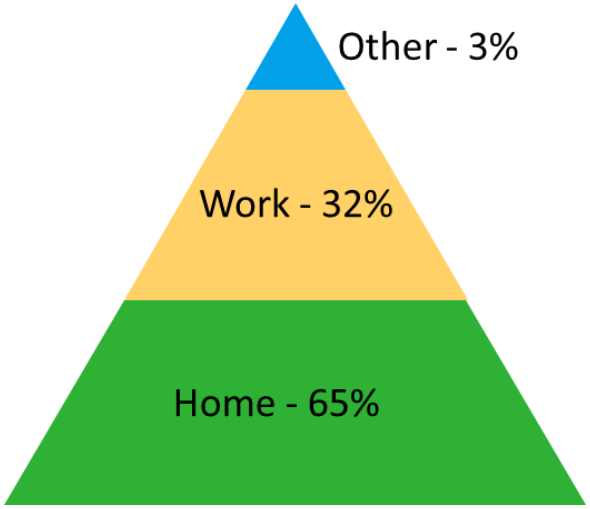
3. Vehicle driving and charging throughout the day



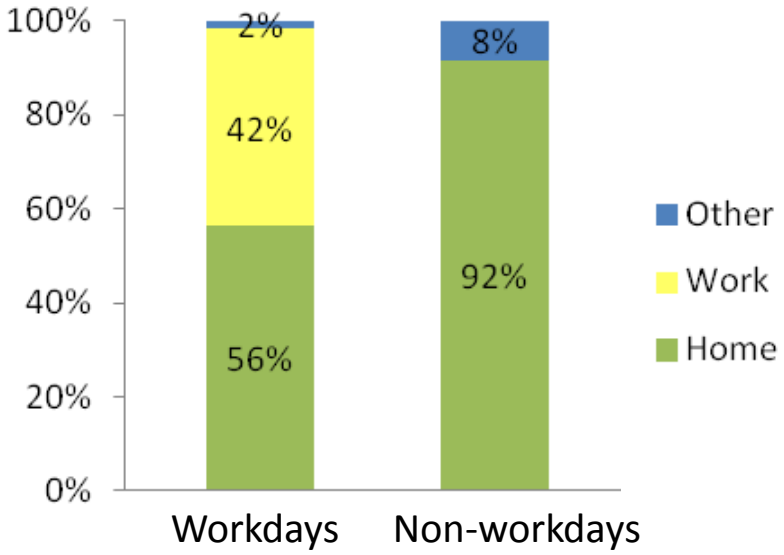
Where did PEV drivers with access to workplace charging choose to charge?

Nissan Leafs

Overall Charging Frequency by Location (to scale)



Percent of Charging Events by Location and Day

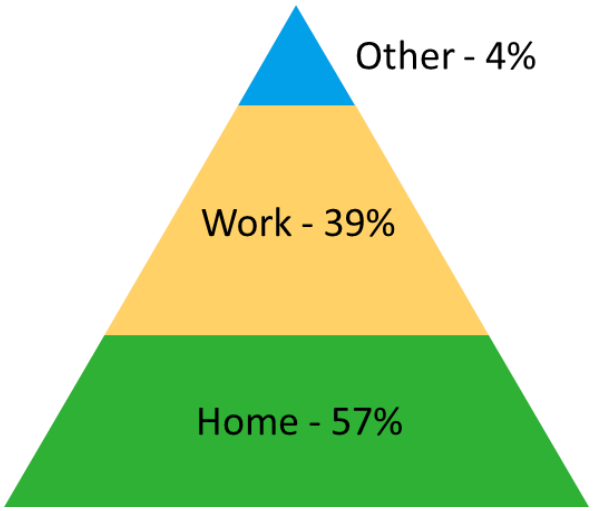


707 vehicles, Jan 2012 – Dec 2013

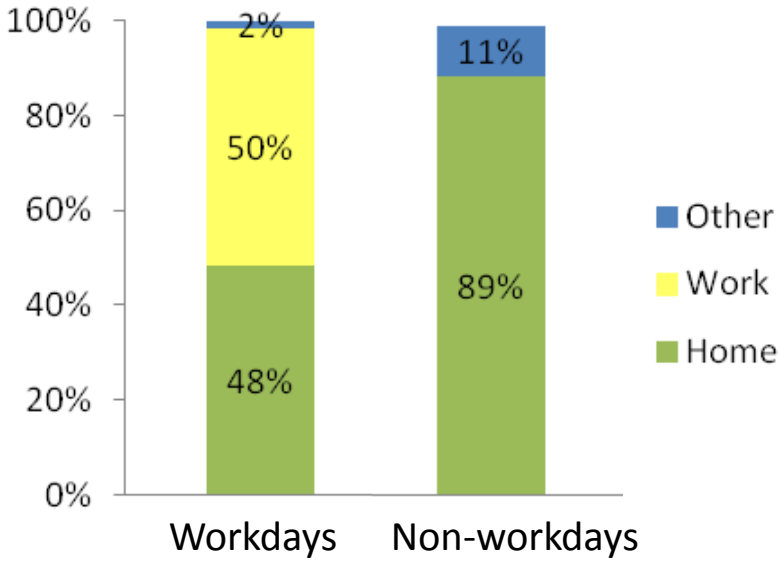
Where did PEV drivers with access to workplace charging choose to charge?

Chevrolet Volts

Overall Charging Frequency by Location (to scale)



Percent of Charging Events by Location and Day



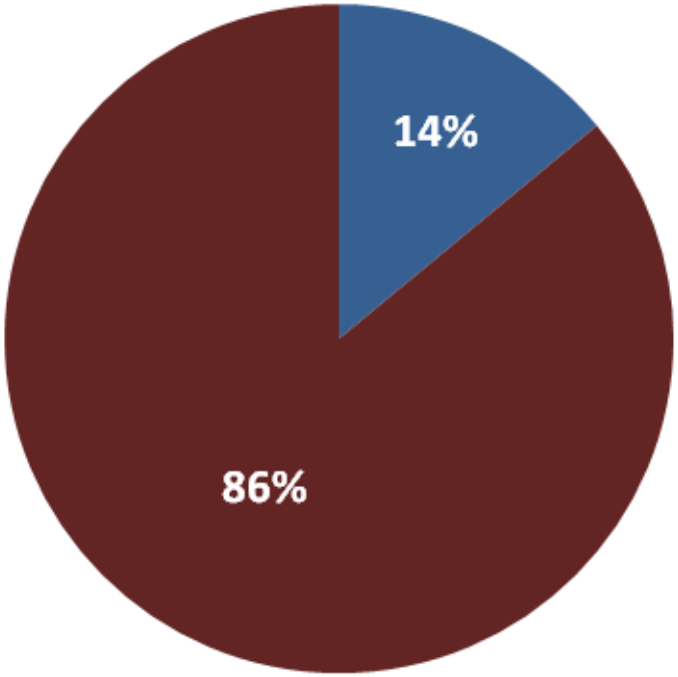
96 vehicles, Jan 2013 – Dec 2013

How much did PEV drivers charge at work vs. home?

- Common assumption: If drivers have access to home and work charging, they will charge at home and “top off” at work

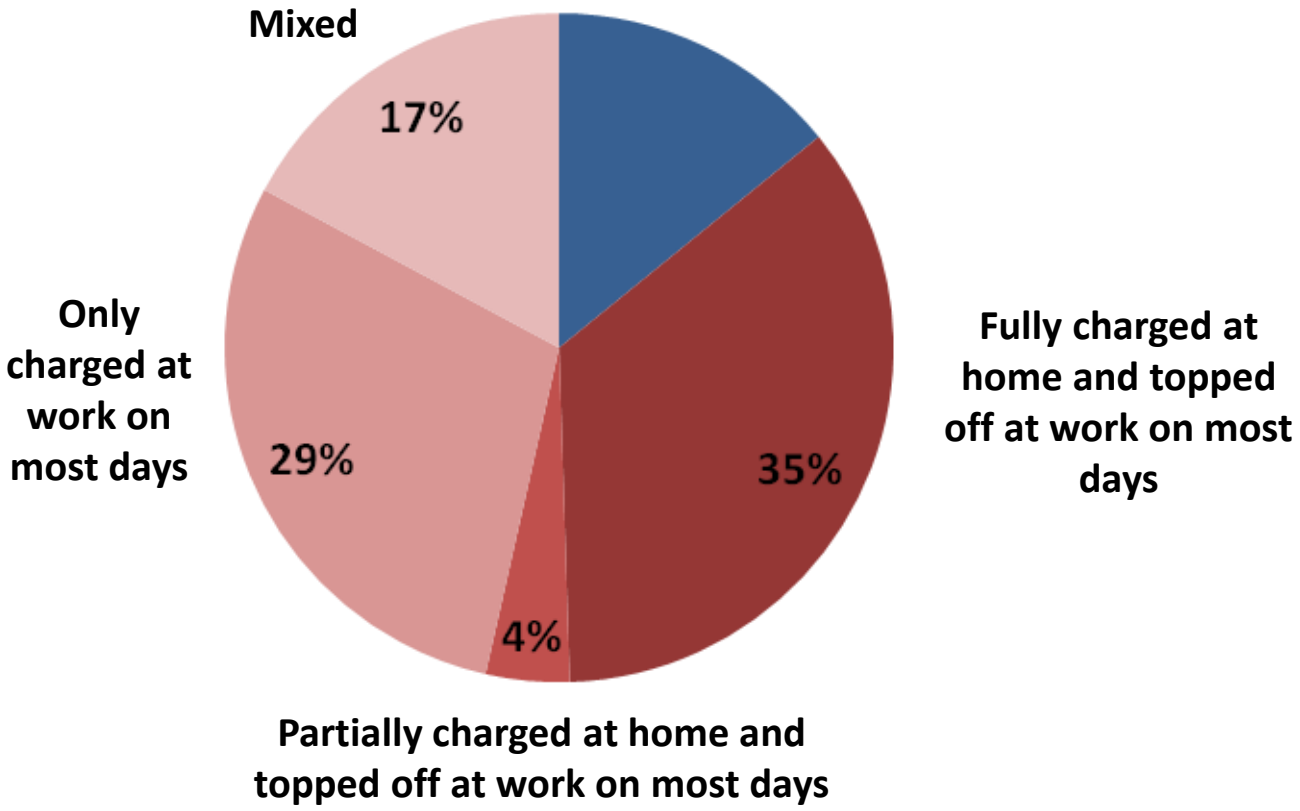
How much did PEV drivers charge at work vs. home?

- 14% of Leafs studied needed to charge at work in order to complete their daily commute on most days
- On these days, they charged at home and topped off at work as expected



How much did PEV drivers charge at work vs. home?

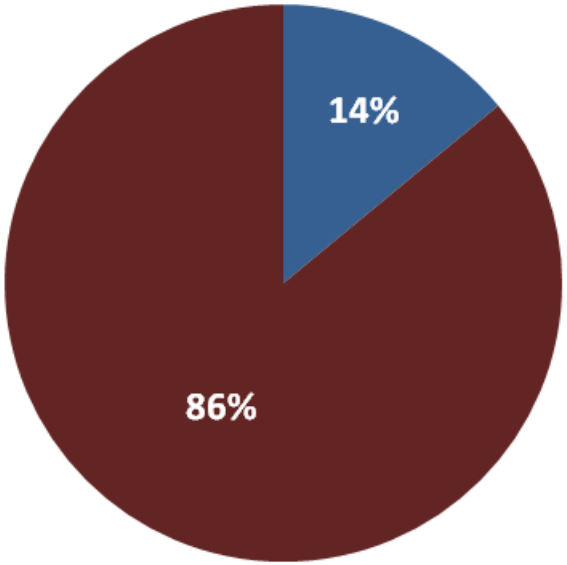
- Leaf drivers who did not need workplace charging on most days had varying behavior



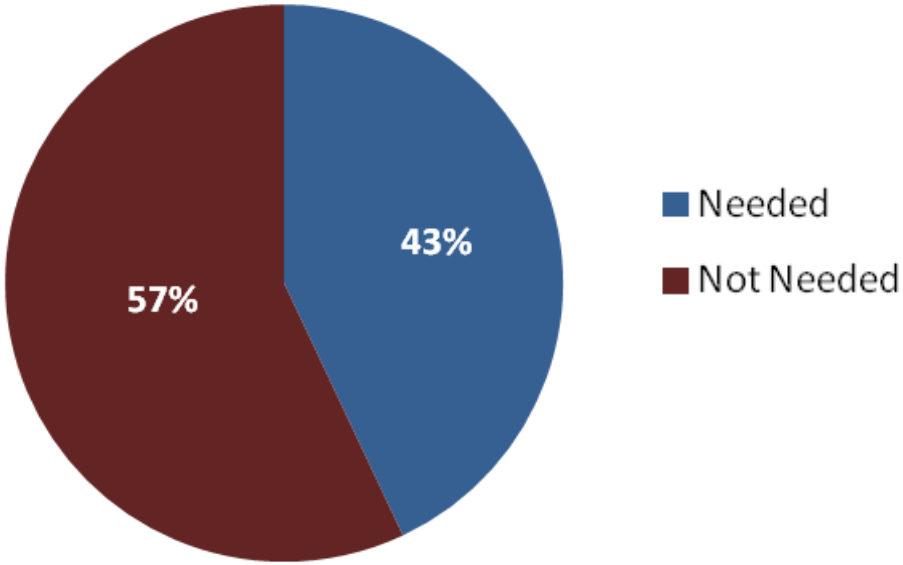
How many drivers needed to charge at work to complete their commutes?

- Assumption: if you need it, you need it; if you don't, you don't
- 14% of vehicles needed workplace charging to complete their daily driving on *most* days, but…
- 43% of vehicles needed workplace charging to complete their daily driving on *some* days

Percent of vehicles needing to charge at work on at least 50% of days



Percent of vehicles needing to charge at work on at least 5% of days



Does workplace charging increase electric vehicle miles traveled?

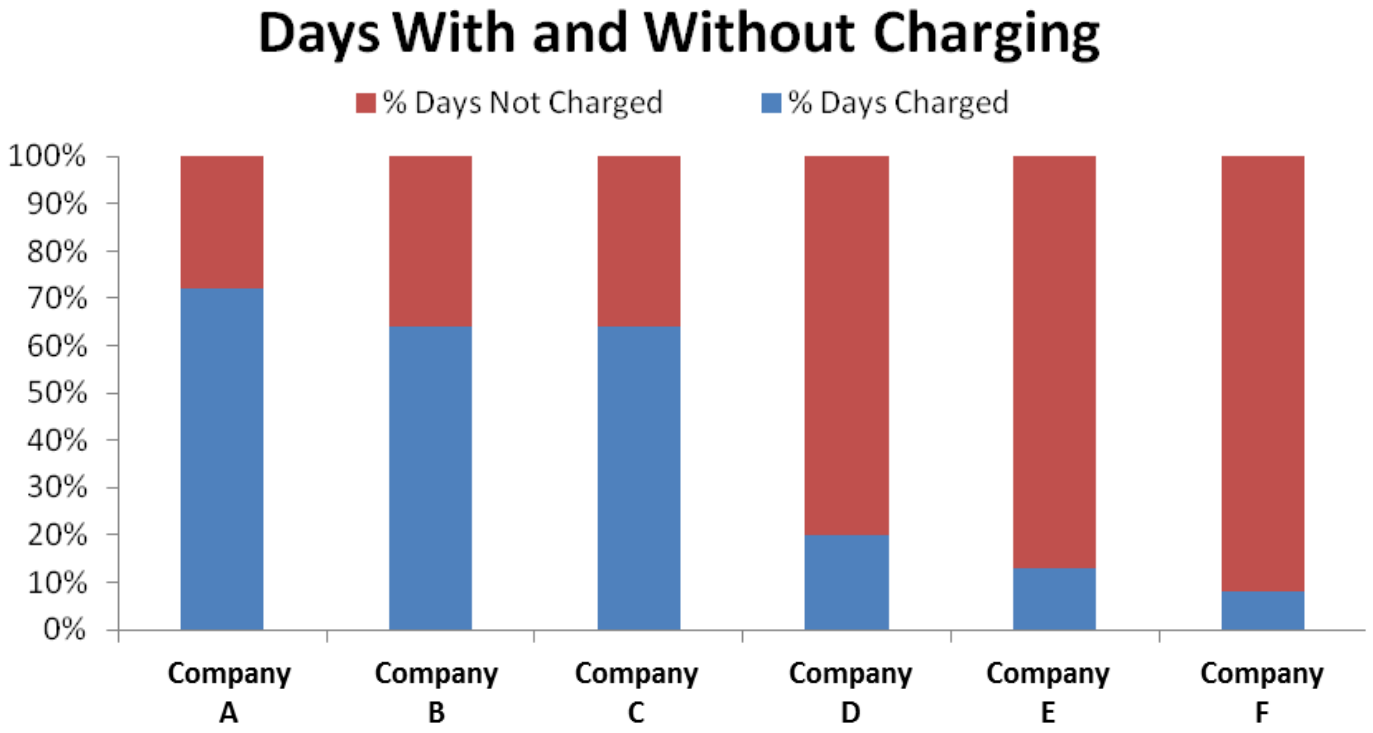
Yes!

- On days when Leaf drivers needed to charge at work, workplace charging extended their range by an average of 15 miles
- Round-trip commutes on these days averaged 73 miles

- On days when drivers did not need workplace charging but used it, they averaged 12% more miles than on days when they did not charge at work.

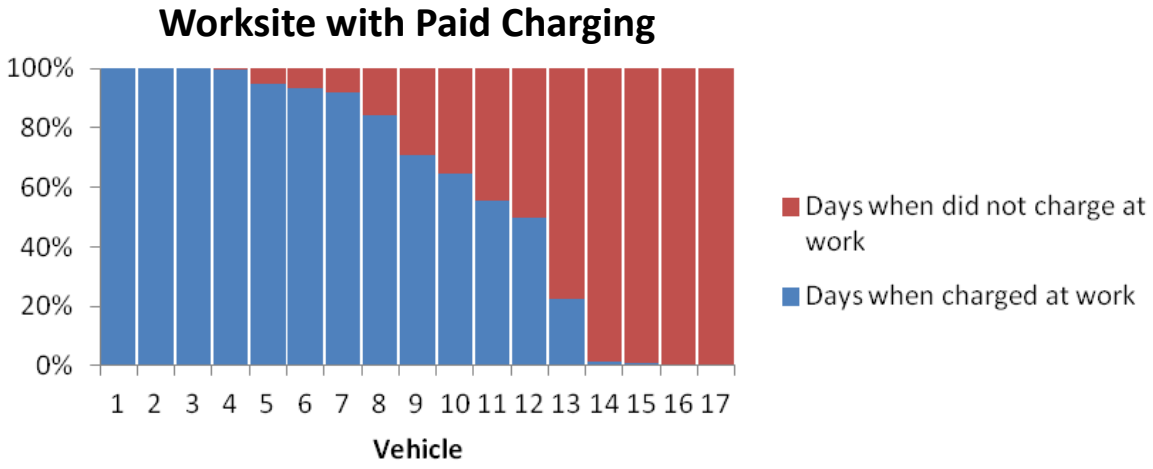
How often did drivers charge at work?

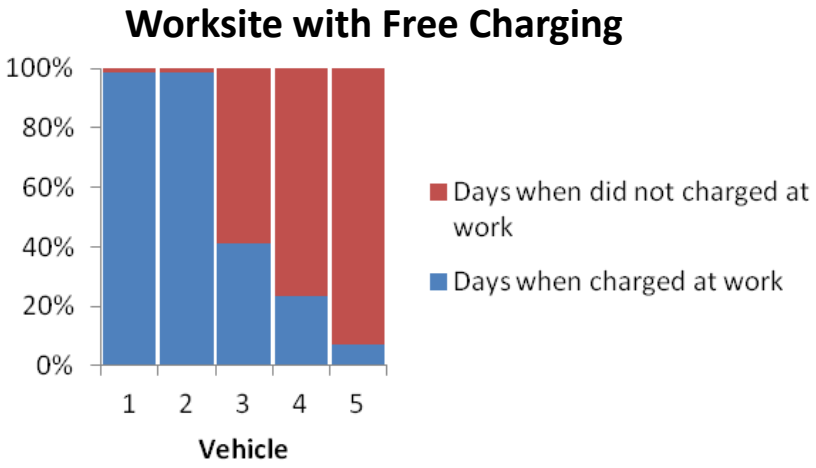
- Assumption: if they can charge at work, they will
- A study of Leaf and Volt parking and charging at 6 work sites showed dramatic differences from site to site…



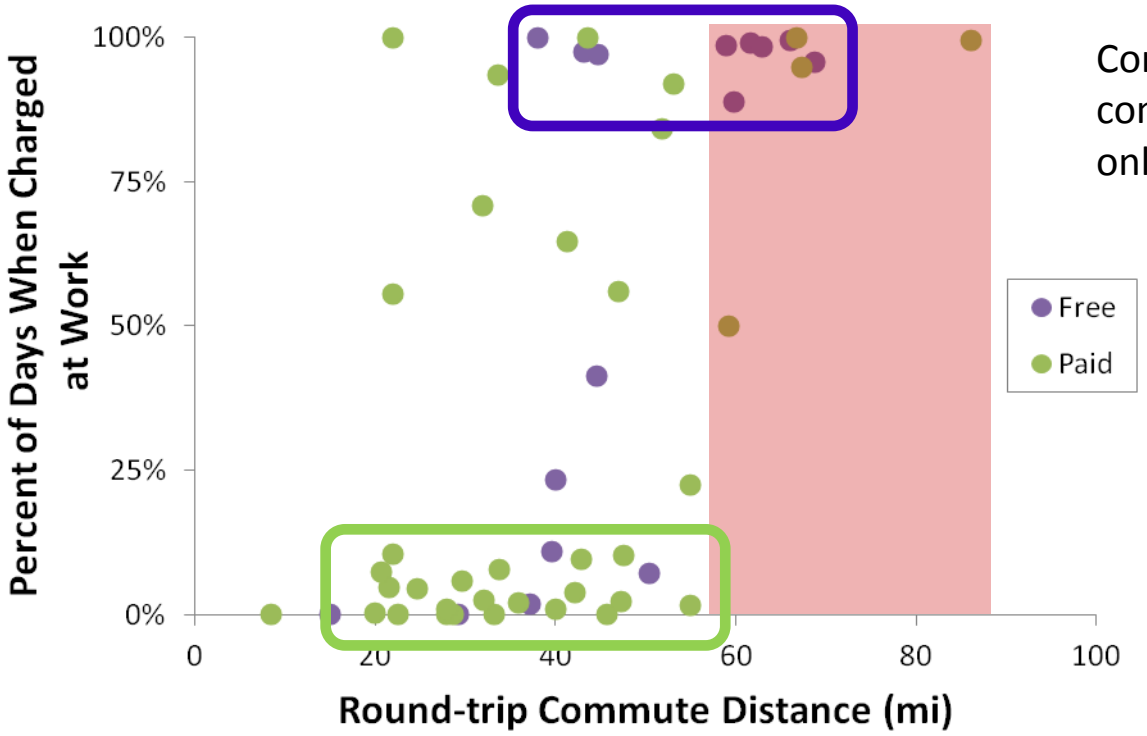
How often did drivers charge at work?

- … and from vehicle to vehicle at the same site





What determines whether drivers will charge at work?



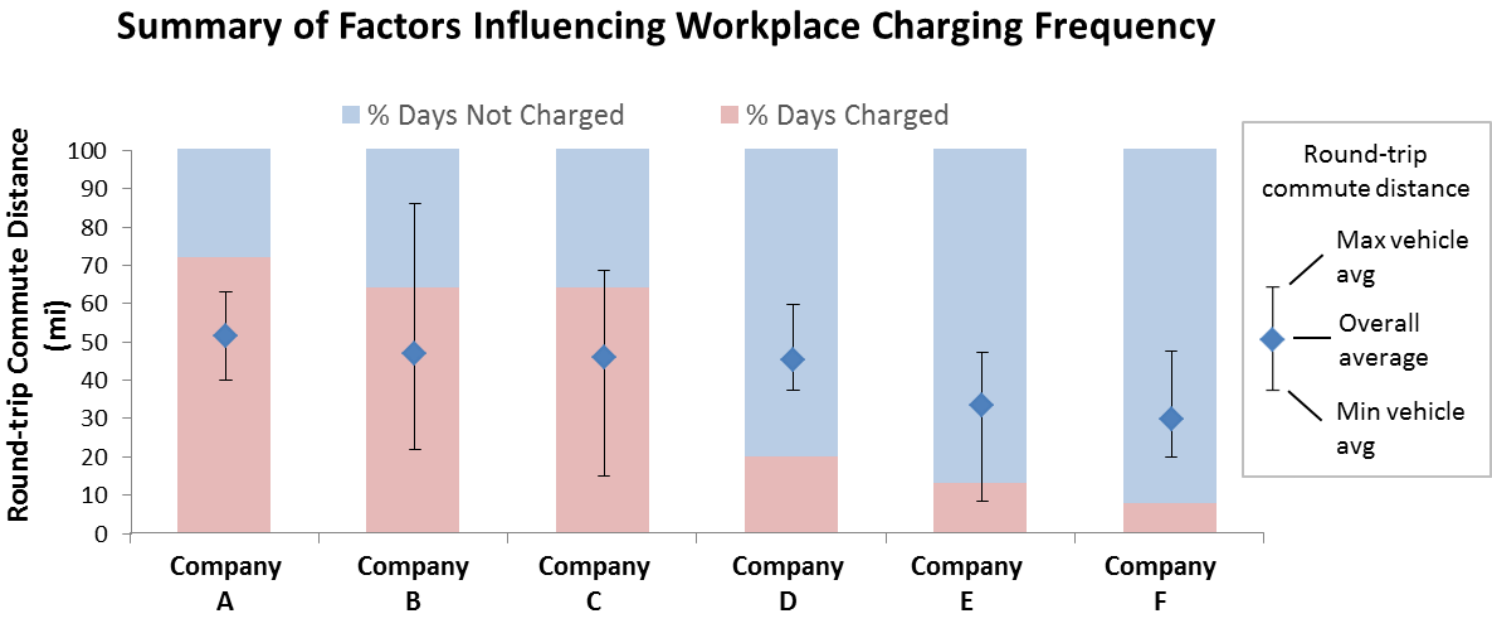
Correlation to commute distance only on high end

Some correlation to free/cost

Ratio of vehicles to charging units, policy for use, and other factors also matter also

From 47 Leafs, 5 Volts at 6 worksites

What determines whether drivers will charge at work?



Cost	Free	Cost per kWh	Free	Free	Cost per hour	Cost per kWh
Policy	Online reservation system	None	Move after charged (unenforced)	Move after charged (unenforced)	Move after charged (enforced)	None
PEV/EVSE Ratio	4.6	2.6	1.5	2.0	2.5	1.1

Which is better: AC Level 1, Level 2, or DC Fast Chargers

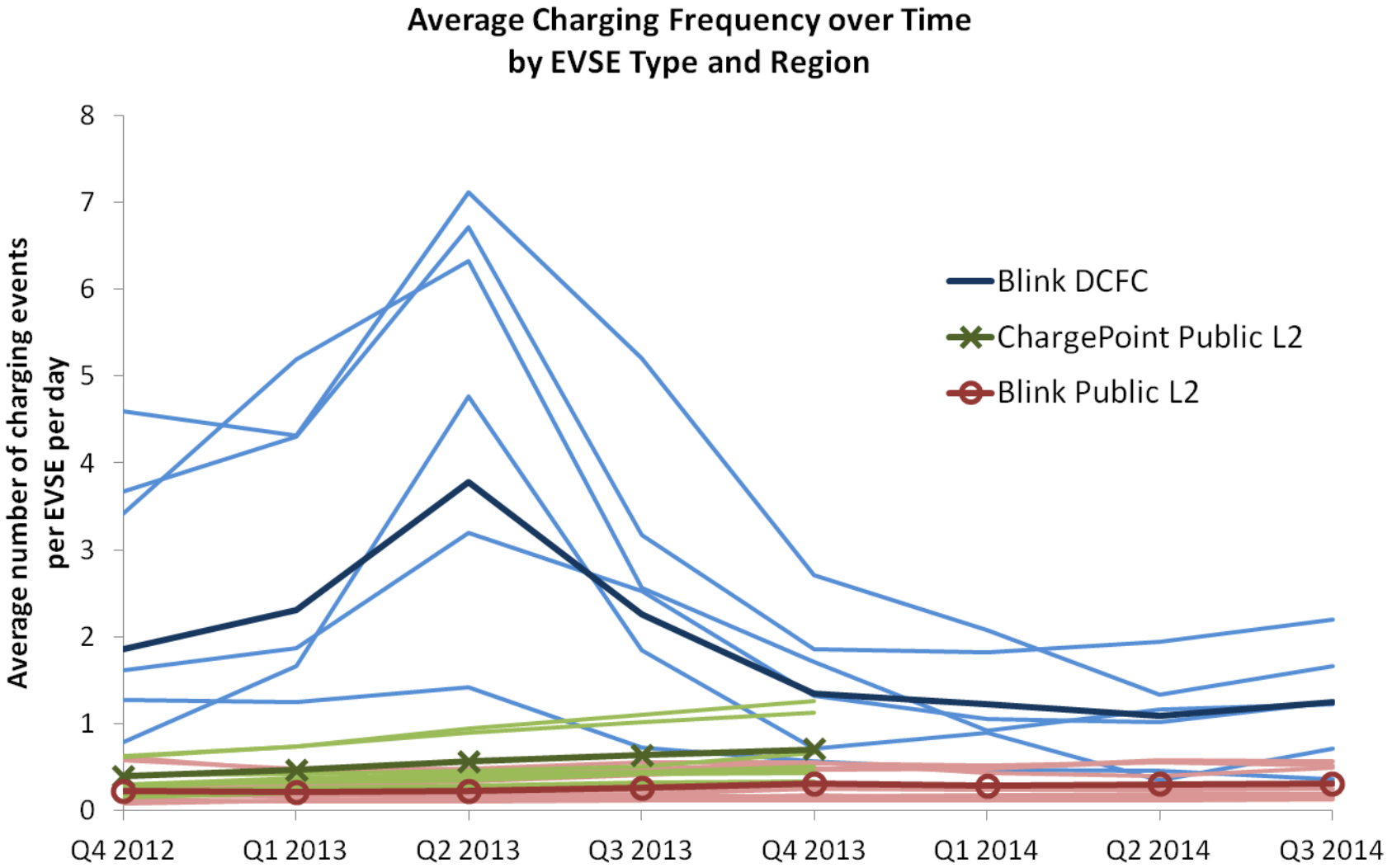
- Know your vehicles – charge power varies by vehicle
  - Toyota Prius Plug-in charges at only 2 kW
  - Thus far, only BEVs can use DCFC and connectors differ
- L2:
  - Can charge multiple vehicles per day
  - Provides option of managing load
- L1:
  - Employees can plug in and forget it
  - Cheaper equipment but probably same to install
  - Lower overall electricity demand
- DCFC:
  - Provides flexibility, good for “emergencies”
  - Expect visitors
  - Expensive (but do the math)

What policy should employers adopt to manage charging?

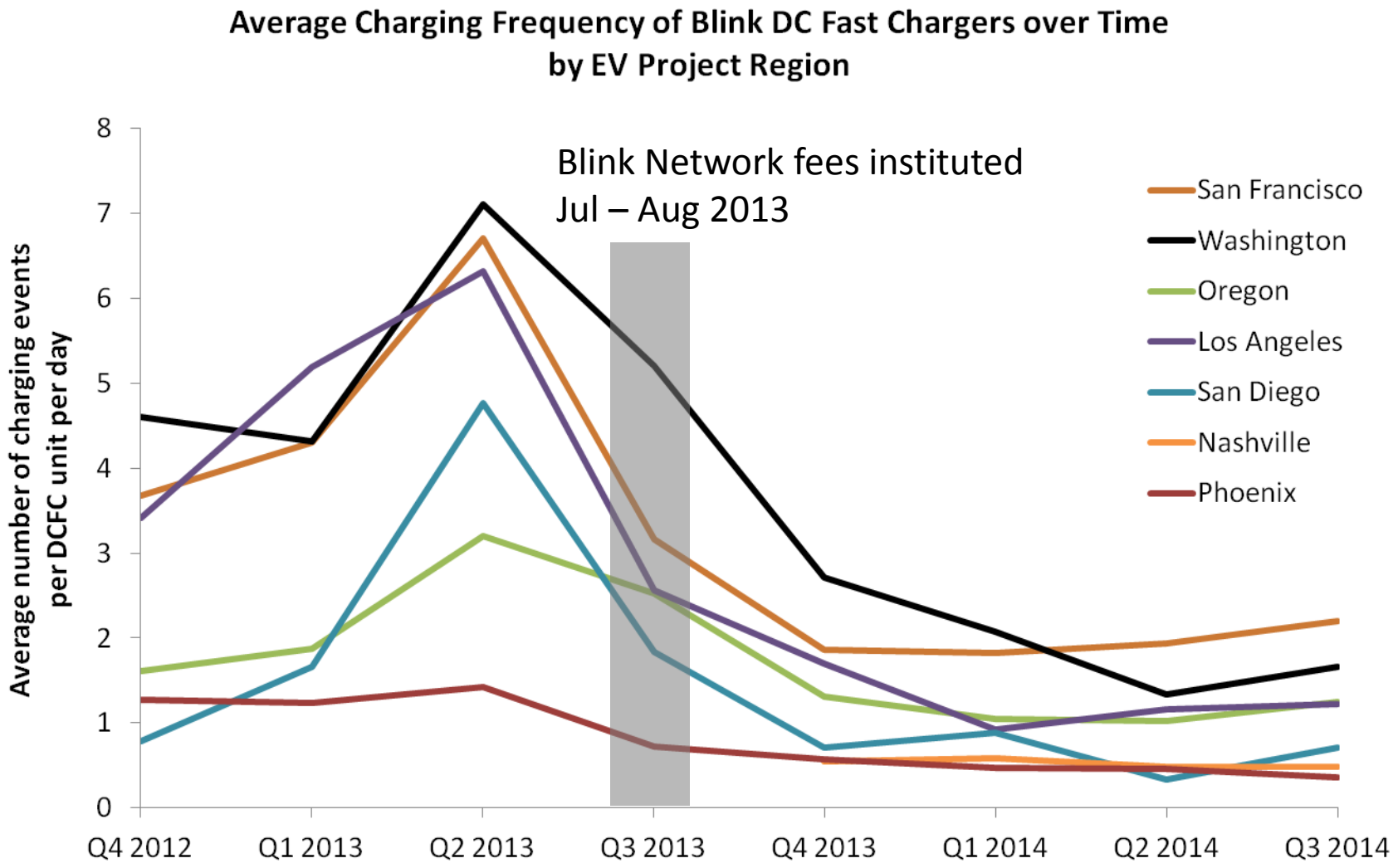
It depends on your goals!

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



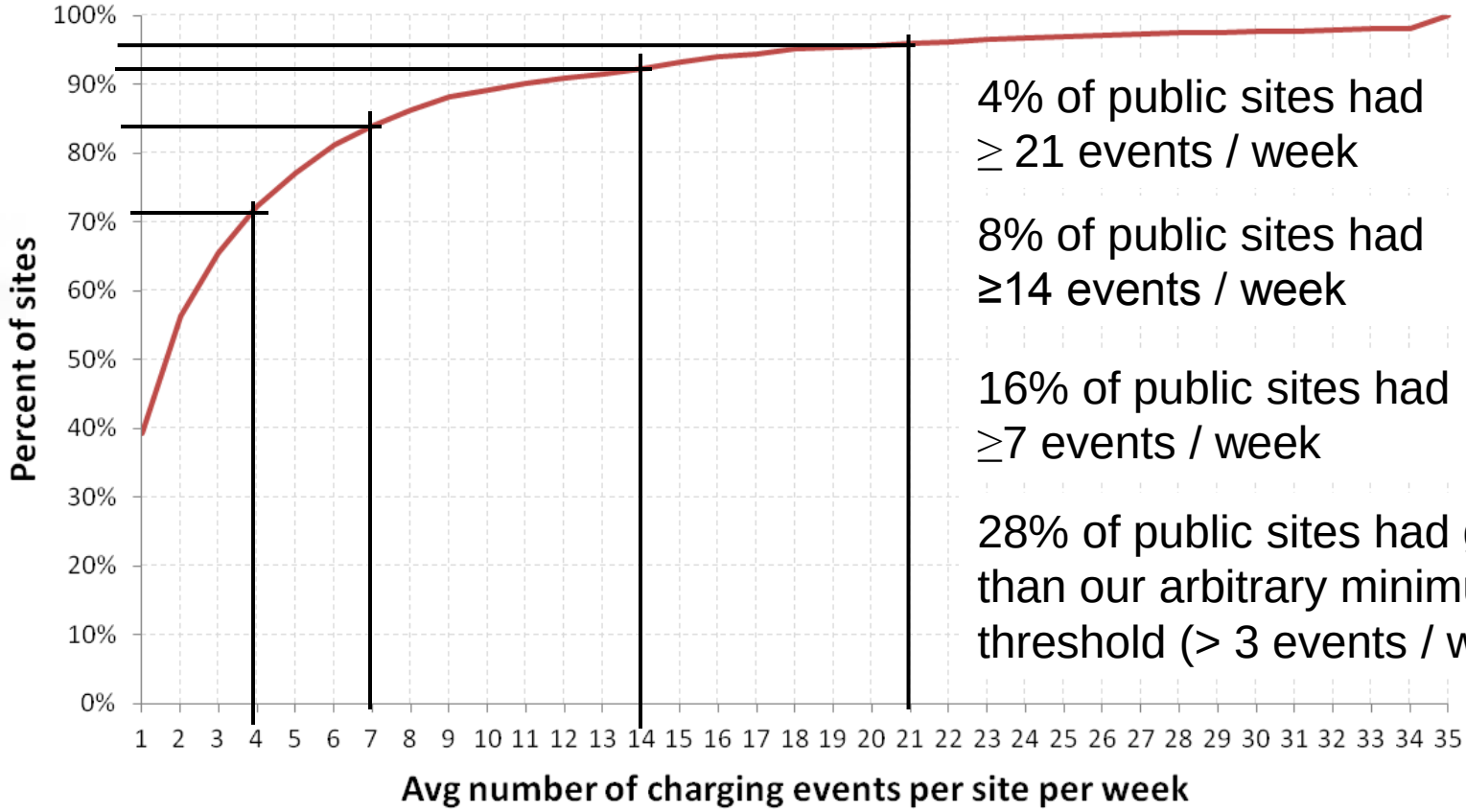
Usage Frequency of Blink DC Fast Chargers



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

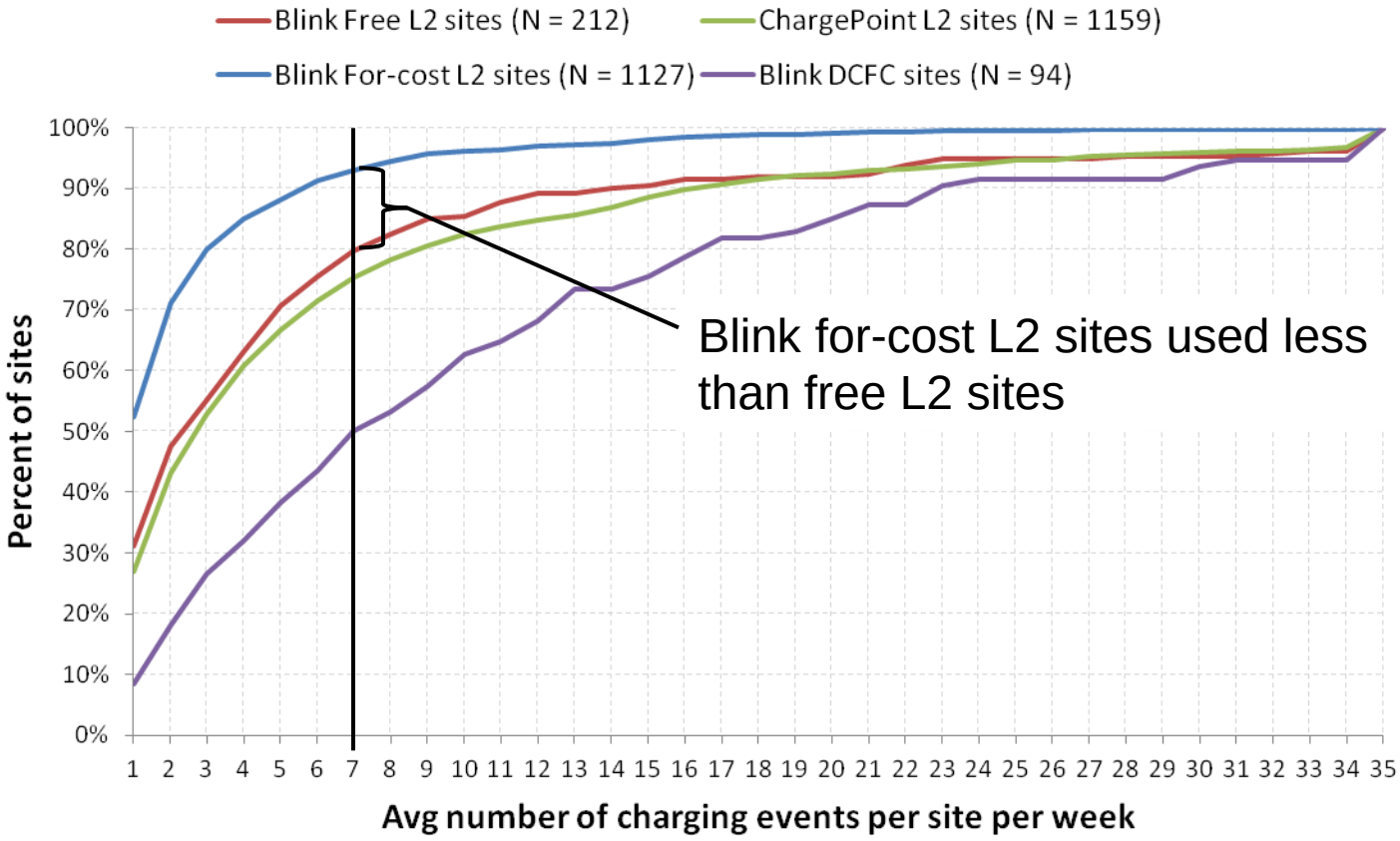
16% of public sites had ≥7 events / week

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

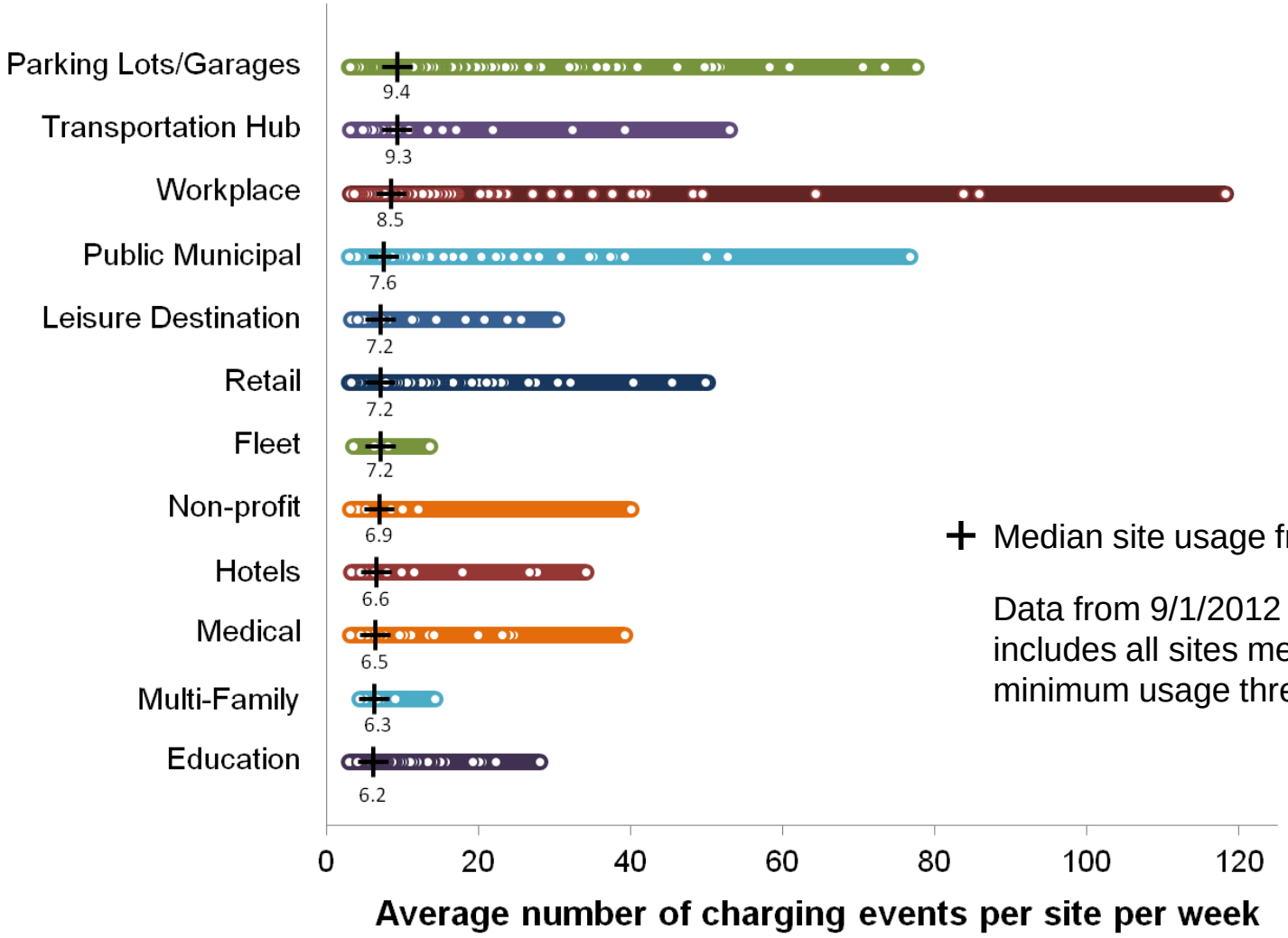
Usage of Publicly Accessible Level 2 Sites

Cumulative Distributions of Charging Frequency of Blink and ChargePoint Publicly Accessible Sites

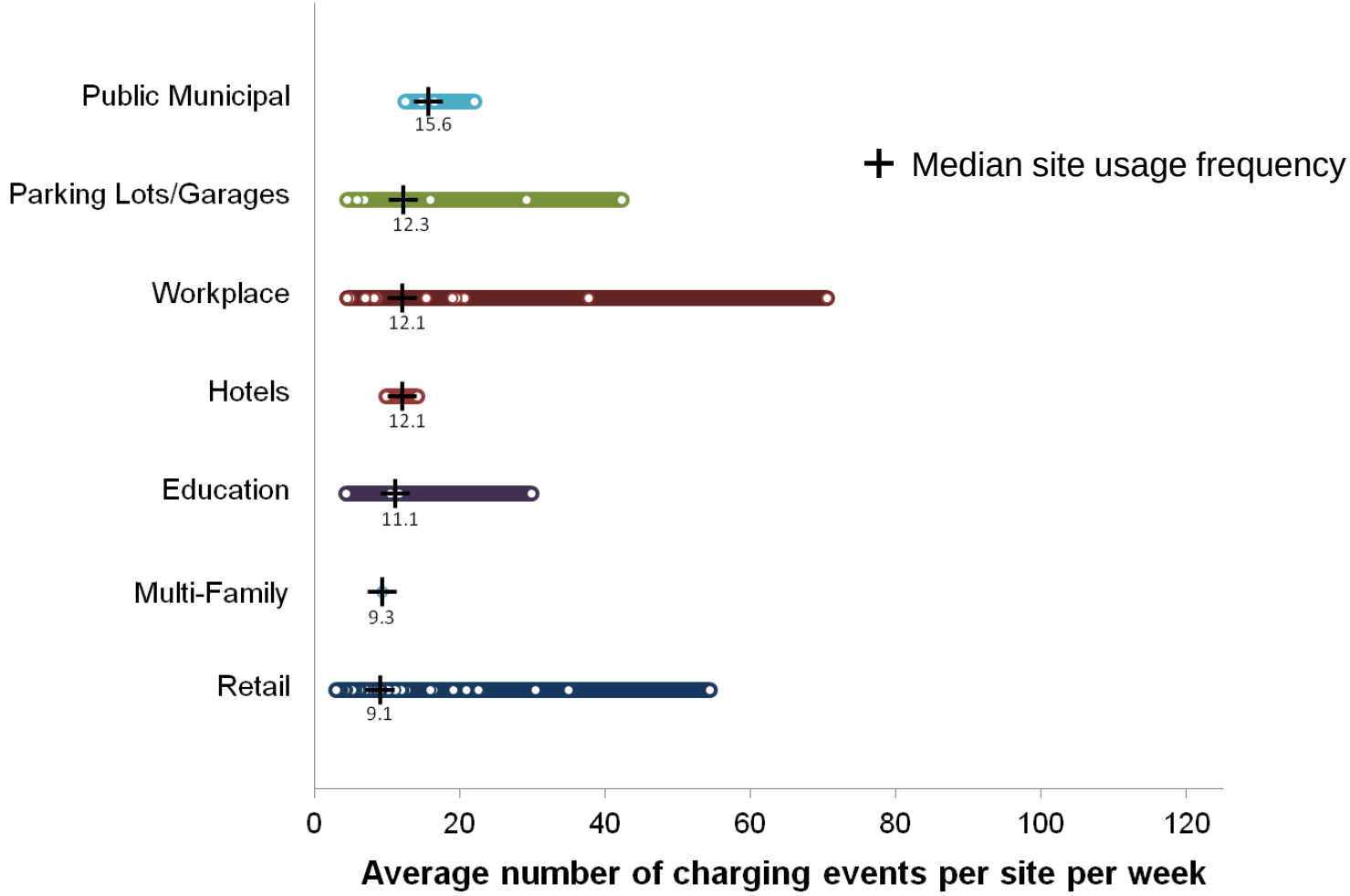


9/1/2012 to 1/1/2014

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



Distribution of Usage Frequency of Blink DCFC Sites by Venue

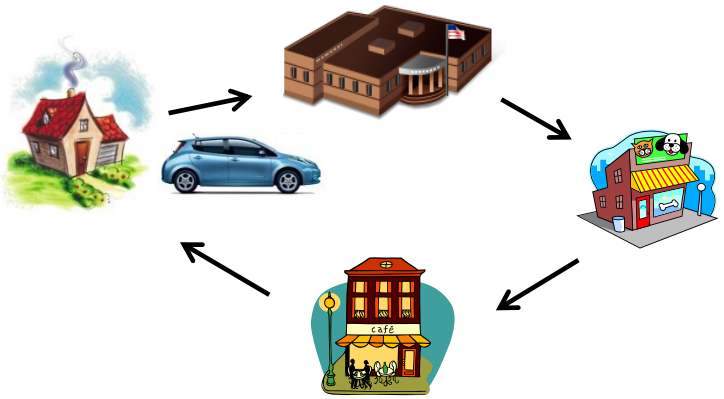


8/1/2013 to 1/1/2014 (after Blink network fees were instituted)

West Coast Electric Highway Corridor DC Fast Charger Usage

West Coast Electric Highway

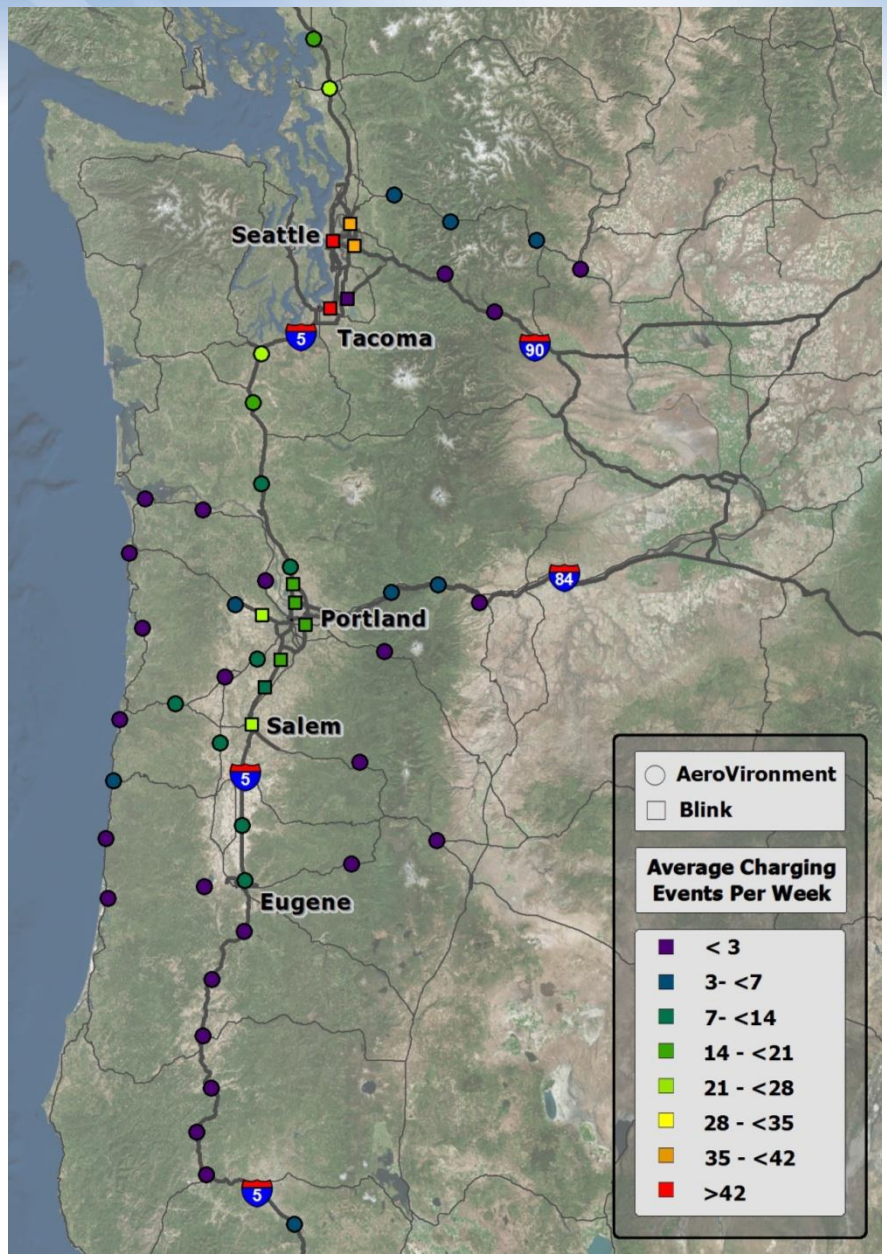
- WCEH was designed to support long distance EV travel in WA, OR, and CA
- Analysis included 45 AeroVironment and 12 Blink DCFC located in Oregon and Washington
- Using EV Project data, we can look at Leaf charging at these fast chargers
  - 1,589 EV Project Leafs in Oregon and Washington
  - 319 used at least one of the 57 DCFC in the study
- Driving was analyzed based on “outings” – all trips taken between leaving home and returning home



DCFC Usage Frequency

9/1/2012 to 1/1/2014

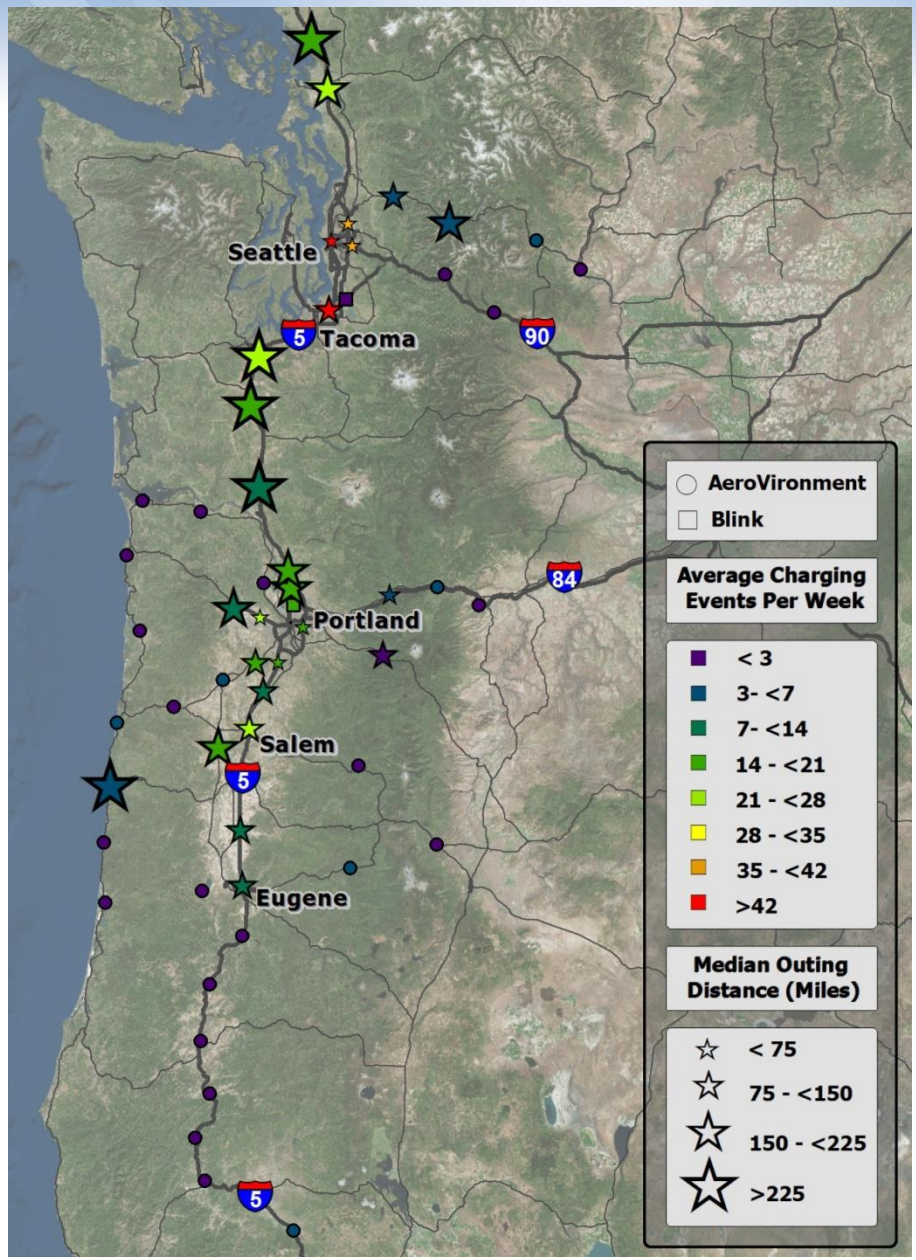
- Most highly used DCFC were in large cities and along interstate between them (Seattle, Portland)
  - Used 2 to 5 times per day, or more
- Usage tends to decrease as DCFC get farther from I-5
  - Also drops off south of Eugene
- DCFCs along the coast and east of I-5 were used a few times per week
  - This low frequency does not provide high value to DCFC owner
  - But each charge may be highly valued by the Leaf owner!



Median Outing Distance

9/1/2012 to 1/1/2014

- DCFC in cities were used in much shorter outings (usually less than full charge range of Leaf)
- As distance from DCFC to cities increases, outing distance increases
- Many DCFC along I-5 were used 2 to 4 times per day for outings over 150 miles
  - Some >225 miles
  - Regularly being used for outings that require 2,3, or more full charges to complete



Who Have We Helped?

Special reports and presentations were requested by and produced for the following organizations:

Charging Station Hosts

- Columbia Hospitality
- Seattle-Tacoma International Airport
-

Communications, Outreach, and Standards Development Organizations

- High Gear Media
- Clean Cities Coalitions (numerous)
- Drive Oregon
- Electric Drive Transportation Association
- Institute of Electrical and Electronics Engineers
- Society of Automotive Engineers
- Transportation Research Board
- Wall Street Journal

Electric Utilities

- Arizona Public Service
- City of Chattanooga, TN
- City of Knoxville, TN
- Commonwealth Edison Company
- Eugene Water & Electric Board
- Eversource Energy (formerly Northeast Utilities)
- Georgia Power
- London Hydro, Inc.
- Los Angeles Department of Water & Power
- Memphis Light Gas & Water
- Middle Tennessee Electric Membership Corporation

Who Have We Helped?

Electric Utilities (cont.)

- Nashville Electric Service
- National Grid
- New York Power Authority
- Oncor Electric Delivery
- Pacific Gas & Electric
- PacifiCorp
- PECO Energy Company
- Portland General Electric
- Public Utility District No. 1 of Snohomish County
- Puget Sound Energy
- Salem Electric
- Salt River Project
- San Diego Gas & Electric
- Seattle City Light
- Southern Company
- Tucson Electric Power
- Vermont Energy Investment Corporation

Government Agencies and Planning Organizations

- California Air Resources Board
- California Energy Commission
- Colorado State Energy Office
- Delaware Valley Regional Planning Commission
- DOE Clean Cities
- DOE Office of Electricity Delivery and Energy Reliability
- DOE Office of Energy Efficiency & Renewable Energy
- International Energy Agency
- Washington State Department of Transportation
- Washington State EV Working Group

Who Have We Helped?

Manufacturers and Service Providers

- American Honda Co.
- ChargePoint
- ECOtality
- Ford Motor Co.
- General Motors
- Nissan North America
- OnStar
- Toyota Motor Engineering & Manufacturing North America

National Laboratories

- Argonne National Laboratory
- Lawrence Berkley National Laboratory
- National Renewable Energy Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory

Non-government Research and Planning Organizations

- Center for Climate and Energy Solutions (formerly the Pew Center on Global Climate Change)
- Clinton Foundation - Clinton Climate Initiative
- Electric Power Research Institute Infrastructure Working Council
- Energy & Environmental Resources Group, LLC
- Idaho Association of Highway Districts
- International Council on Clean Transportation
- National Academy of Sciences Committee on Overcoming Barriers to EV Adoption
- National Governor's Association
- Union of Concerned Scientists

Who Have We Helped?

Universities

- Aalto University (Finland)
- Cardiff University (UK)
- Colorado State University
- Green Mountain College
- Harvard University
- Seattle University
- University of California - Davis Institute of Transportation Studies
- University of Georgia
- University of Texas Austin

Top 10 Questions that Still Need Answers

1. What is the true potential for PEVs to displace petroleum, considering how households manage the use of multiple vehicles?
2. What is the minimum amount of away-from-home charging infrastructure that meet drivers' need and/or desire for eVMT?
3. How can public charging infrastructure be optimized so it is cost-effective and sustainable?
4. How effective is public charging infrastructure in stimulating the PEV market, compared to other incentives?
5. As the number of PEVs and charge rates increase, how can PEV charging data be used to help utilities accurately forecast load?
6. As the number of PEVs and charge rates increase, what will be the real-world impact of PEV charging on local distribution and how should it be addressed?
7. What is the potential for PEVs as controllable distributed energy resources to integrate renewable and provide grid services?
8. How should workplace charging be implemented and managed to maximize long term benefits?
9. What is the range of PEV overall ownership cost?
10. What is DOE's role in promoting PEVs as appealing cars that work for ordinary Americans?

BACKUP SLIDES

Electric Vehicle Miles Traveled

eVMT Analysis

- Collaborative groups
  - Idaho National Laboratory
  - Honda North America
  - Ford Motor Company
  - Toyota Motor Engineering & Manufacturing NA
  - General Motors



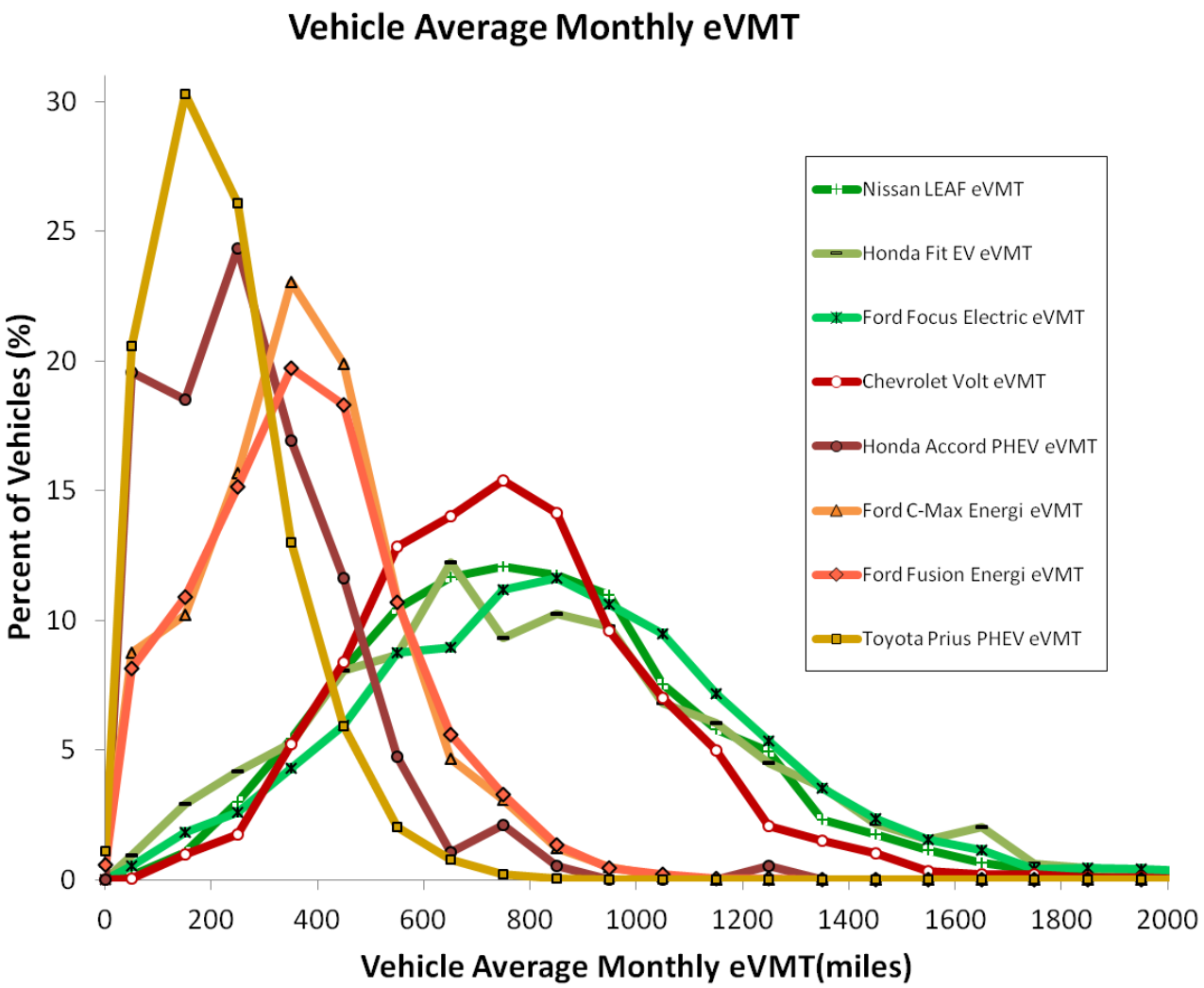
- Calculated electric vehicle miles traveled (eVMT) for:
  - Ford Fusion Energi
  - Ford C-Max Energi
  - Honda Accord PHEV
  - Toyota Prius PHEV
  - Chevrolet Volt
  - Ford Focus Electric
  - Honda Fit EV
  - Nissan Leaf





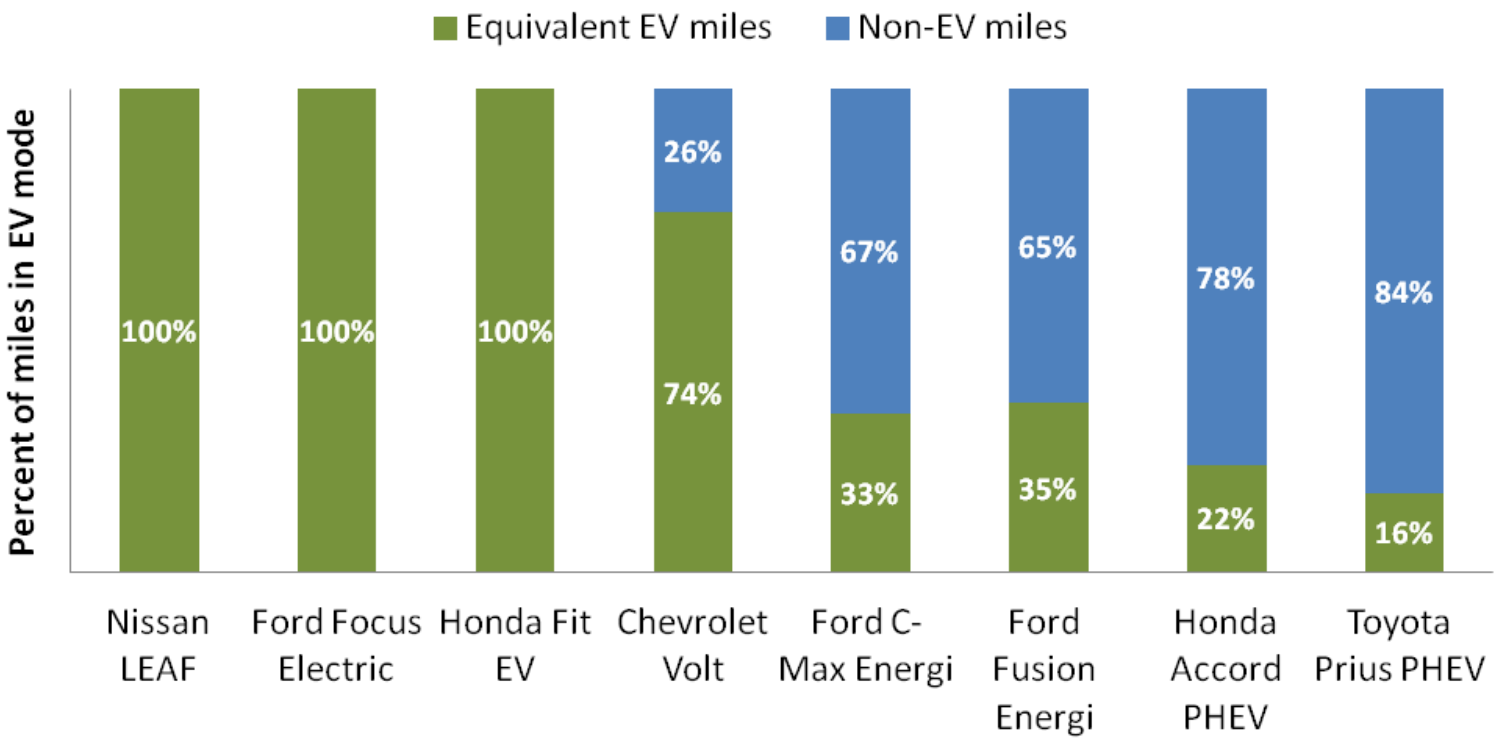
- Data is from actual customer, on-road vehicle operation
  - 158,468,000 miles from 21,600 vehicles
  - Across the U.S. (i.e. widely varying regions and climates)

eVMT (monthly electric vehicle miles traveled)



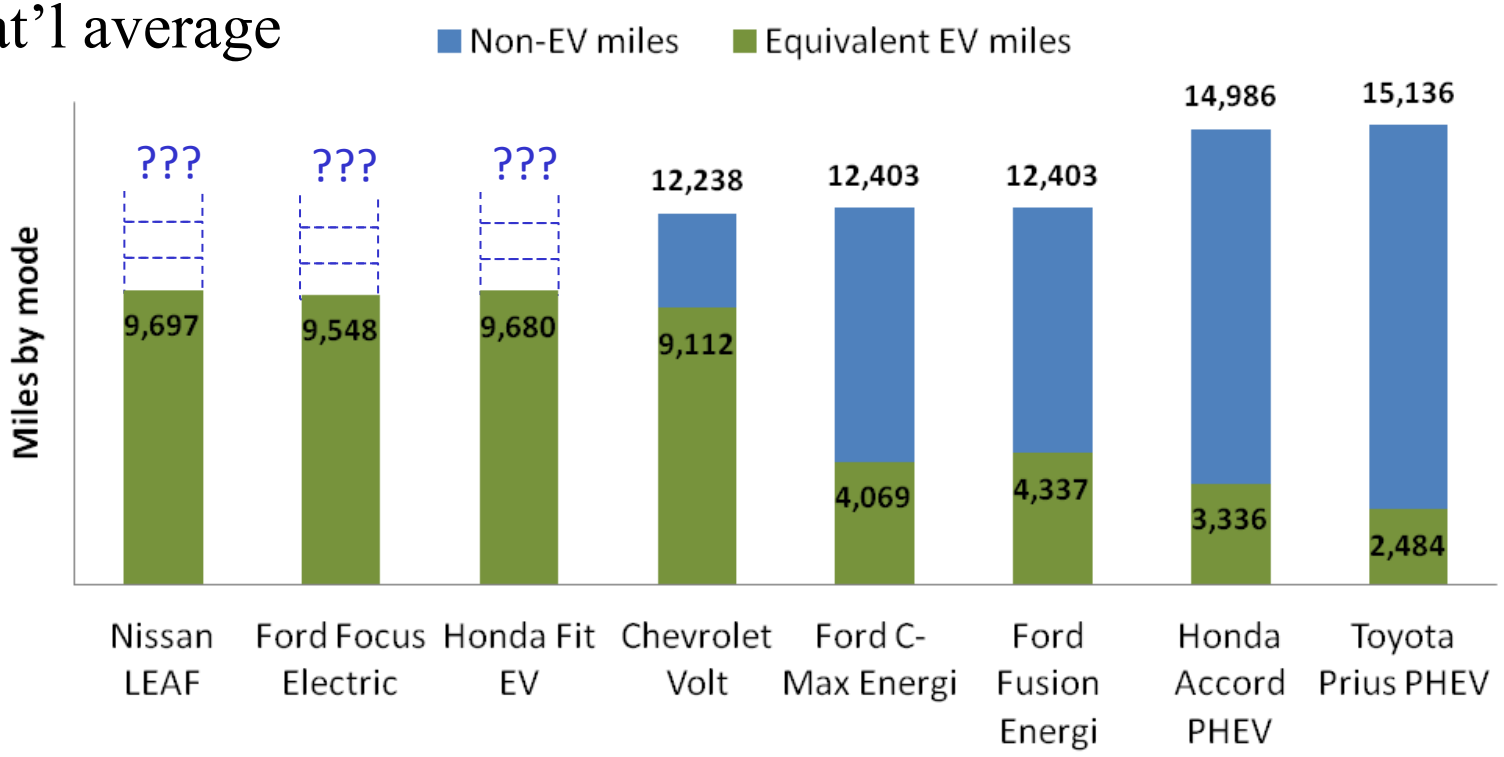
Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.

EV vs. Non-EV Miles



EV vs. Non-EV Miles

Nat'l average



Publications

Content of this presentation drawn from lessons learned white papers published to INL's EV Project web page (avt.inl.gov/evproject.shtml)

Workplace Charging

- Where do Nissan Leaf drivers in The EV Project charge when they have the opportunity to charge at work?
- Where do Chevrolet Volt Leaf drivers in The EV Project charge when they have the opportunity to charge at work?
- Workplace Charging Case Study: Charging Station Utilization at a Work Site with AC Level 1, AC Level 2, and DC Fast Charging Units
- Workplace Charging Frequency of Nissan Leafs and Chevrolet Volts in The EV Project at Six Work Sites
- Charging and Driving Behavior of Nissan Leaf Drivers in The EV Project with Access to Workplace Charging

Driving and Charging

- What Kind of Charging Infrastructure Do Chevrolet Volt Drivers in The EV Project Use and When Do They Use It?
- What Kind of Charging Infrastructure Did Nissan Leaf Drivers in The EV Project Use and When Did They Use It?
- How Many Electric Miles Do Nissan Leafs and Chevrolet Volts in The EV Project Travel?

Public Charging Venues

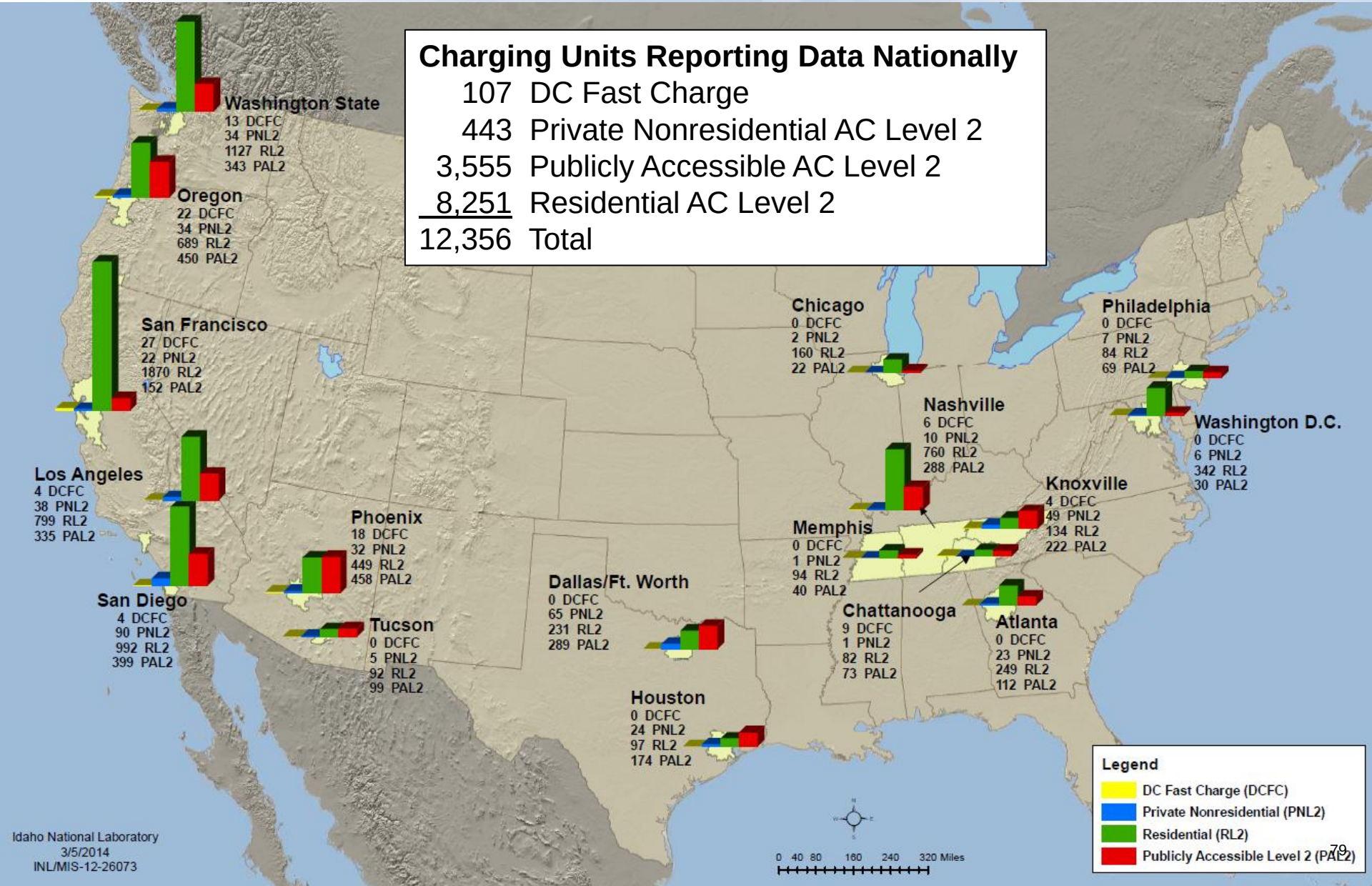
- Analyzing Public Charging Venues: Where are Publicly Accessible Charging Stations Located and How Have They Been Used?
- Categorizing EVSE Venues: Describing Publicly Accessible Charging Station Locations

Corridor Charging

- DC Fast Charger Usage in the Pacific Northwest (avt.inl.gov/ /evse.shtml)

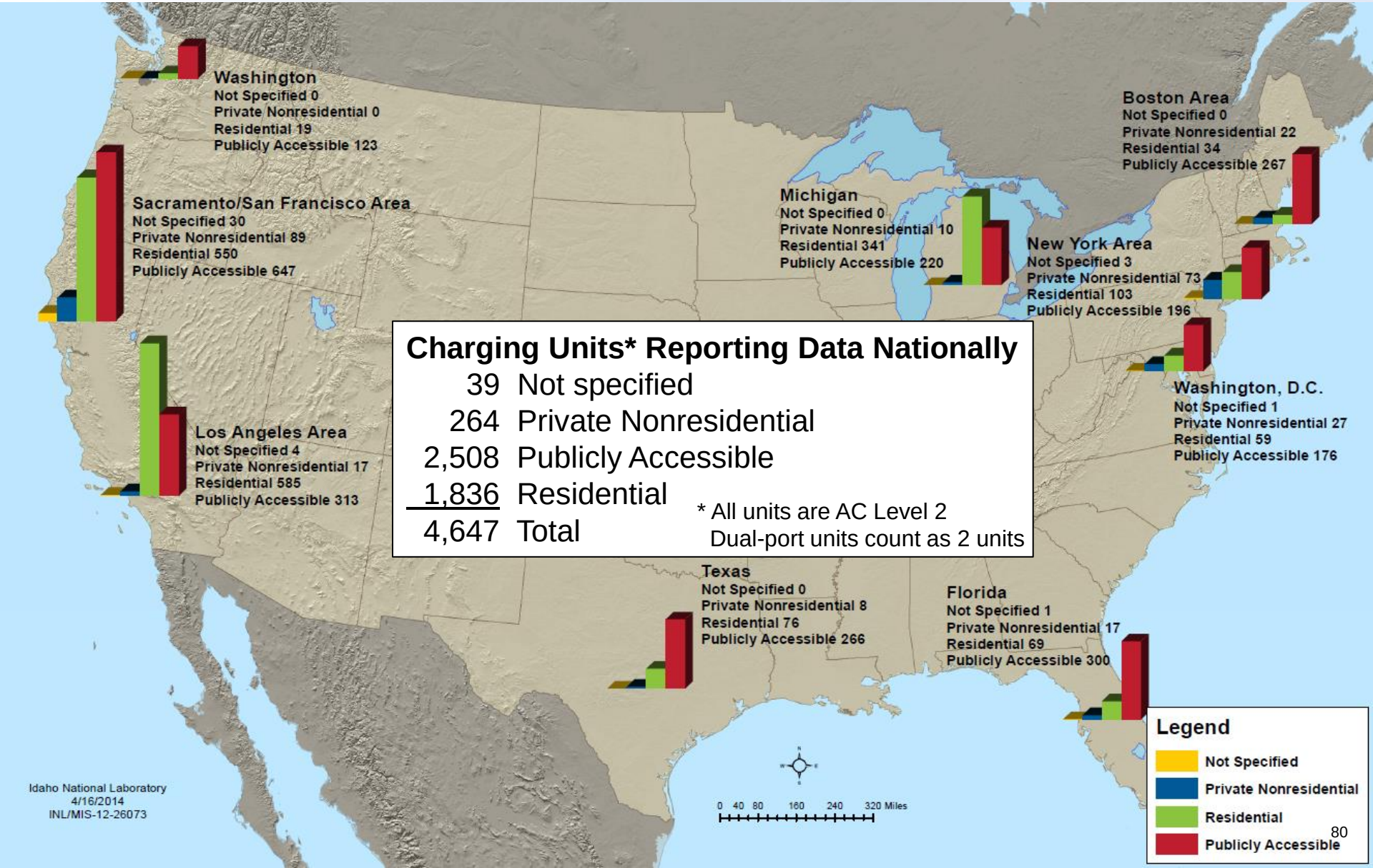
Infrastructure Deployment in The EV Project through December 2013

Idaho National Laboratory

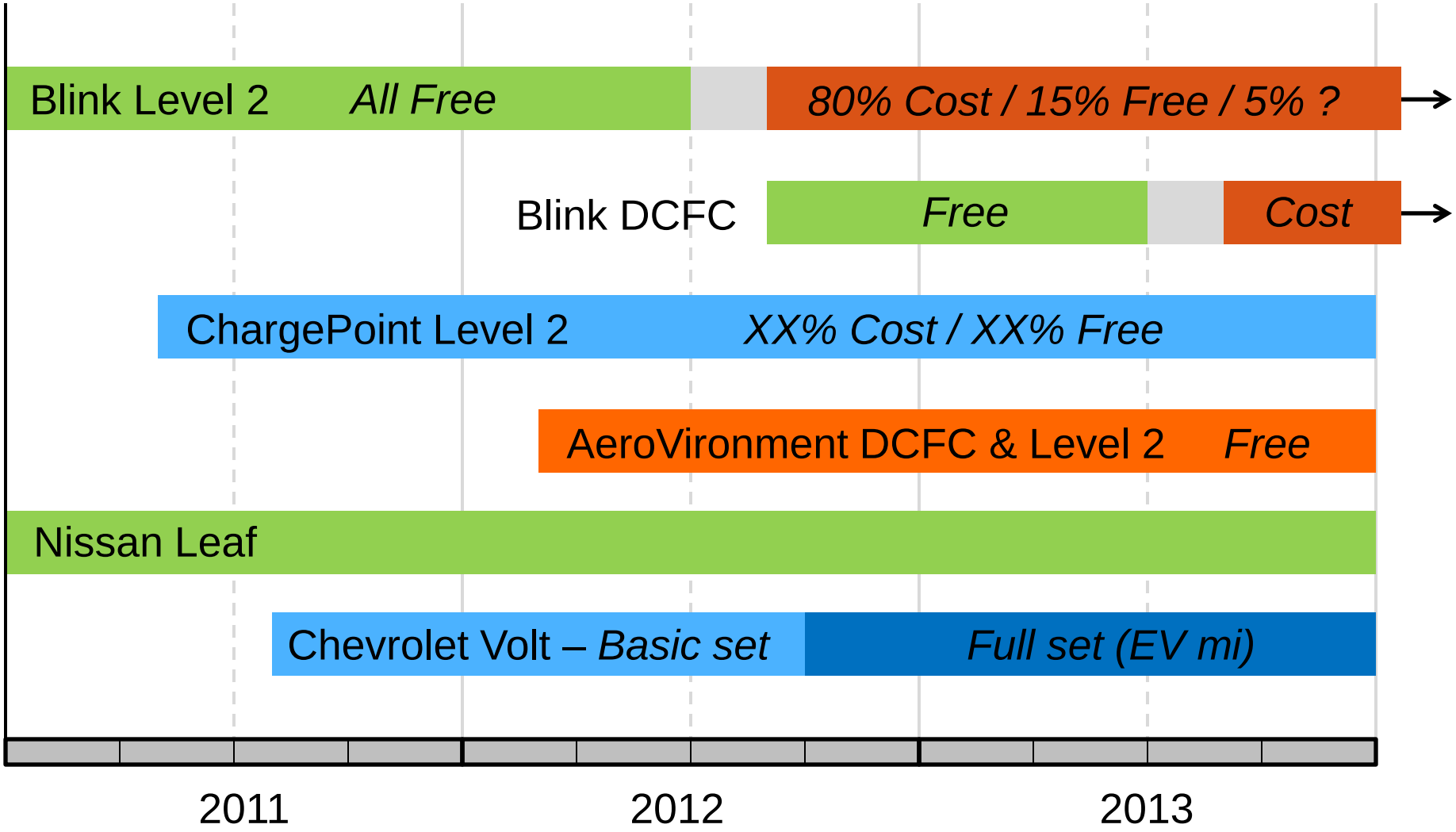


Infrastructure Deployment in ChargePoint America through December 2013

Idaho National Laboratory



Summary of INL Data Sets in This Presentation



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

Charge port or cord

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

Charge port or cord

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