

# ***Lessons Learned about Workplace Charging in The EV Project***

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Idaho National Laboratory**

**2015 Annual Merit Review  
Washington, DC  
June 9, 2015**

VSS170



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## Overview

### Timeline

- Start: Oct 1, 2013
- End: Jun 30, 2015
- 90% complete

### Budget

- FY14: \$50k
- FY15: \$10k

(project highly leverages DOE funding to INL for EV Project and ChargePoint America data analysis)

### Barriers Addressed

- Infrastructure
  - For consumers to accept, purchase, and use plug-in electric vehicles, the proper infrastructure must be in place to enable the full utilization of the technology with minimal impact to the usage habits of the consumer.

### Partners

- Nissan North America
- General Motors/OnStar
- Blink Network
- ChargePoint



## Relevance

- Proponents of plug-in electric vehicles are constantly challenged that public charging infrastructure is needed to support wide-spread PEV market adoption
- Workplace charging has been proposed as a promising option to meet this presumed need
- The purpose of this project is to demonstrate the usefulness and benefits of workplace charging to plug-in electric vehicles (PEV) owners by studying the charging and driving behavior of PEV drivers with access to workplace charging
- The study focused on the following questions:
  - Where do PEV drivers charge when they have the opportunity to charge at work?
  - How is workplace charging equipment used?
  - Does workplace charging affect electric vehicle miles traveled?
  - What guidelines for effective implementation can be crafted based on case studies of organizations with workplace charging?

# Milestones

- Phase I – Workplace Charging Case Studies

Task	Target completion date	Status
1. Identify worksites to study, based on vehicle and EVSE data availability	11/9/2013	Complete
2. Gather easily obtainable background information about worksites <ul style="list-style-type: none"> <li>a. Number of EVSE, usage fee (fee vs. free), charge power level, time period of EVSE installation, etc.</li> </ul>	11/29/2013	Suspended for entire data set; on-going for selected sites (see Phase II)
3. Choose time period that study will examine	11/29/2013	Complete
4. Publish white paper on how much Leaf and Volt drivers charge at work, home, and other locations	3/28/3014	Complete
5. Publish white paper on how workplace charging is being used <ul style="list-style-type: none"> <li>a. Utilization from EVSE data</li> <li>b. Driving and charging behavior of Leafs and Volts with access to workplace charging</li> </ul>	8/21/2014	Complete
6. Publish white paper on electricity demand at work site(s) with many EVSE, impact on demand charges, and potential ways to mitigate demand charges	8/29/2014	Delayed in order to complete phase II

# Milestones

- Phase II – Develop rules of thumb as inputs to tool to guide employers infrastructure deployment decisions

Task	Target completion date	Status
1. Characterize worksites studied above into scenario groups based on factors that heavily influence observed behavior: <ul style="list-style-type: none"> <li>a. Free vs. fee</li> <li>b. Other policy distinctions (public access vs. employee-only access, etc.)               <ul style="list-style-type: none"> <li>1. May require communication with employers (???)</li> </ul> </li> <li>c. Utilization</li> <li>d. Vehicle mix</li> <li>e. Those with/without drivers who charge at home</li> </ul>	3/28/2014	Complete
<b>Go/no go decision</b> – is there enough empirical data (EV Project) in a broad enough range of scenarios to compare to survey results?	3/28/2014	No go – insufficient data
2. Determine if/how we can fit survey responses to worksite data <ul style="list-style-type: none"> <li>a. Ex: if the survey response to question 1 is “a” and question 2 is “b”, then we can use behavior observed at worksites A and D as a guide to what they might expect.</li> <li>b. Update employee survey if necessary</li> <li>c. Create employer survey to understand employer objectives and desired outcomes</li> </ul>	6/30/2014	Canceled
3. Decide how to address scenarios that exist (per survey results) but are not represented in empirical data	7/31/2014	Canceled
4. Deliver report with rules of thumb and recommendations on methodology for interpreting survey results to inform infrastructure deployment decisions	8/29/2014	Canceled

# Milestones

- Phase II (revised) – Develop a lessons-learned document to guide employers’ infrastructure deployment decisions

Task	Target completion date	Status
Gather information to characterize selected worksites into groups based on factors that heavily influence behavior, including: <ul style="list-style-type: none"> <li>a. Free vs. fee</li> <li>b. Public access vs. employee-only access</li> <li>c. Vehicle mix</li> <li>d. Those with/without drivers who charge at home</li> </ul>	6/30/2014	Complete
Perform case studies on selected groups with reliable information about work site	7/31/2014	Complete
Deliver lessons-learned report on considerations guiding the management and use of workplace charging infrastructure	8/29/2014	Complete

## ***Milestones***

Phase III – produce easily digestible summary report of key take-aways

- Completion date: June 30, 2015
- Status: in progress

## Approach

- This study was performed by analyzing driving and charging data collected in DOE-funded national PEV infrastructure demonstrations
- 250 work sites identified with workplace charging available across the US
- Data collected from 600+ Nissan Leafs and ~100 Chevrolet Volts in The EV Project who parked at these sites in 2012 – 2013
- Case study of large work site with AC Level 1, AC Level 2, and DC Fast Charging Units (Facebook)
- Data collected from charging units at 6 worksites highlighted in case study by CA PEV Collaborative<sup>1</sup>



<sup>1</sup> Amping up California Workplaces: 20 Case Studies on Plug-in Electric Vehicle Charging at Work,” California Plug-in Electric Vehicle Collaborative, November 2013

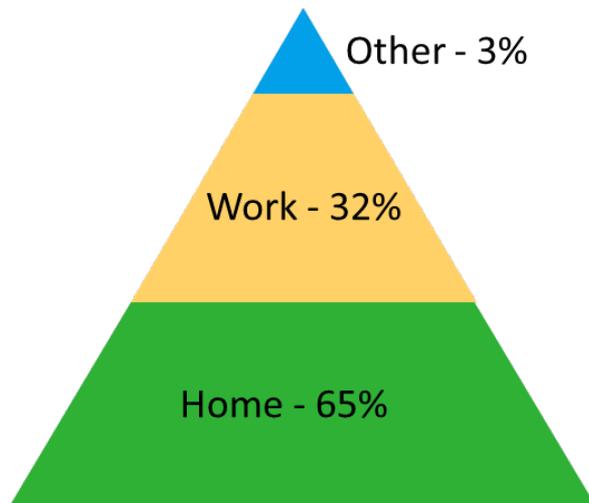
# Where did PEV drivers with access to workplace charging choose to charge?

Direct Testimony of David Packard  
Exhibit CP-DP-2  
Docket No. 4780  
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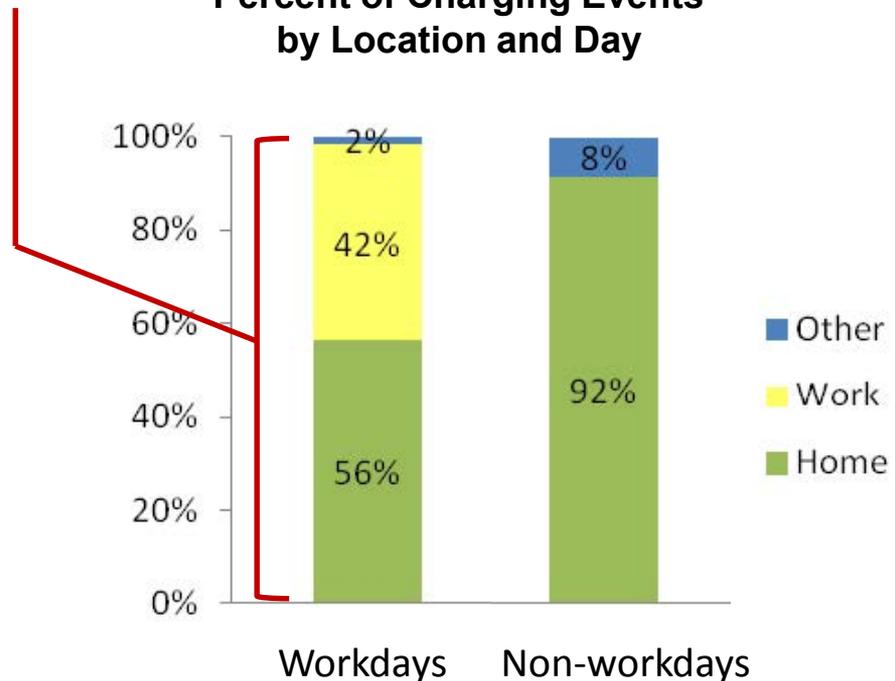
## Nissan Leafs

On work days, 98% of charging events was either at home or work and only 2% at other locations

Overall Charging Frequency by Location (to scale)



Percent of Charging Events by Location and Day



707 vehicles, Jan 2012 – Dec 2013

Charging at work was free for many of these drivers, which may have been one reason why they frequently charged there.

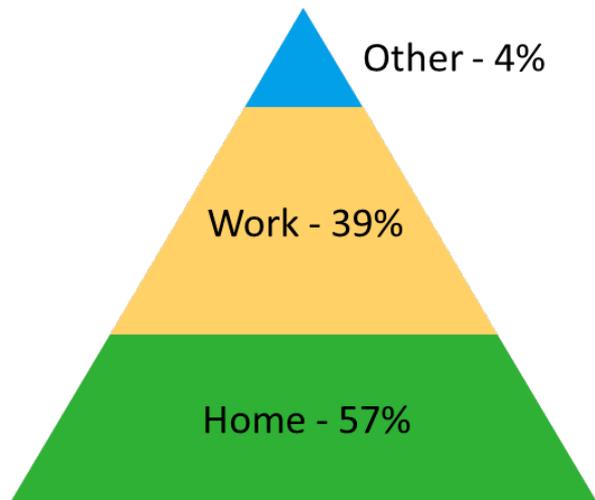
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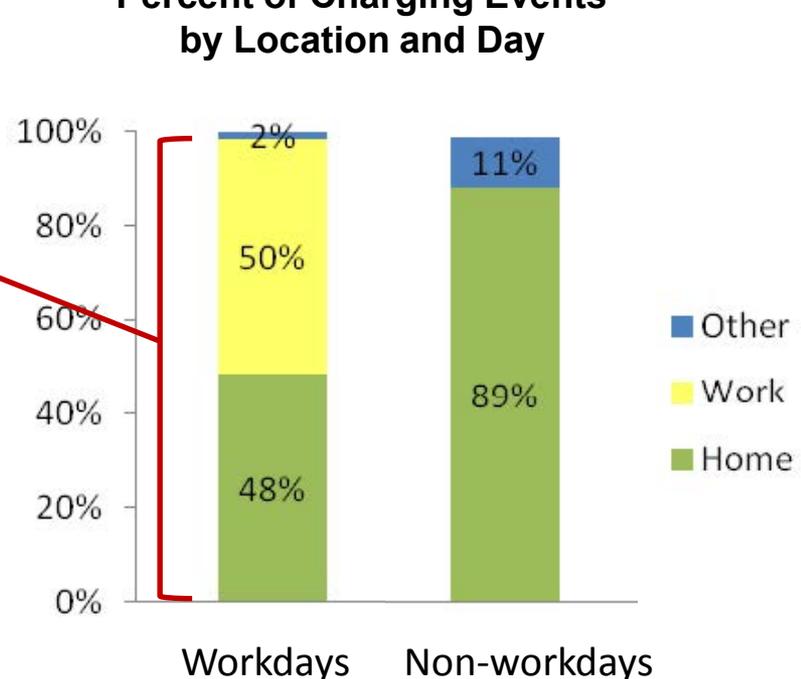
## Chevrolet Volts

On work days, 98% of charging events was either at home or work and only 2% at other locations

Overall Charging Frequency by Location (to scale)



Percent of Charging Events by Location and Day



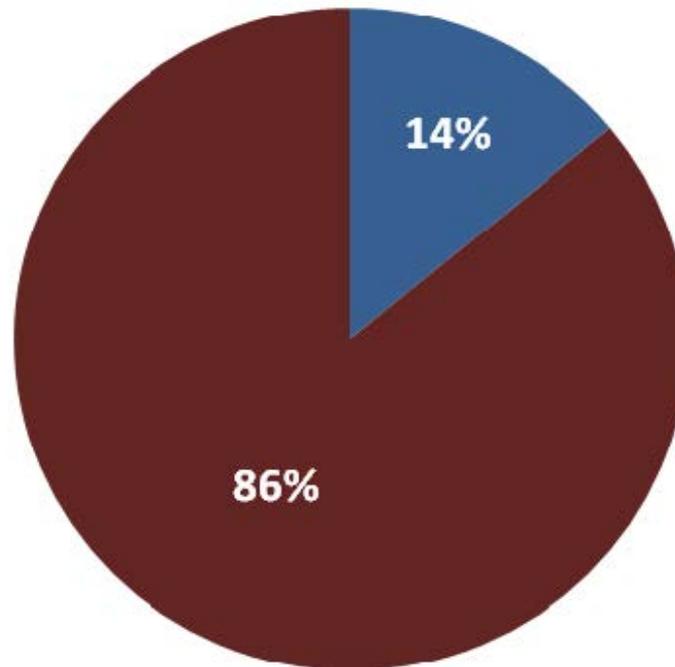
96 vehicles, Jan 2013 – Dec 2013

Charging at work was free for many of these drivers, which may have been one reason why they frequently charged there.

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

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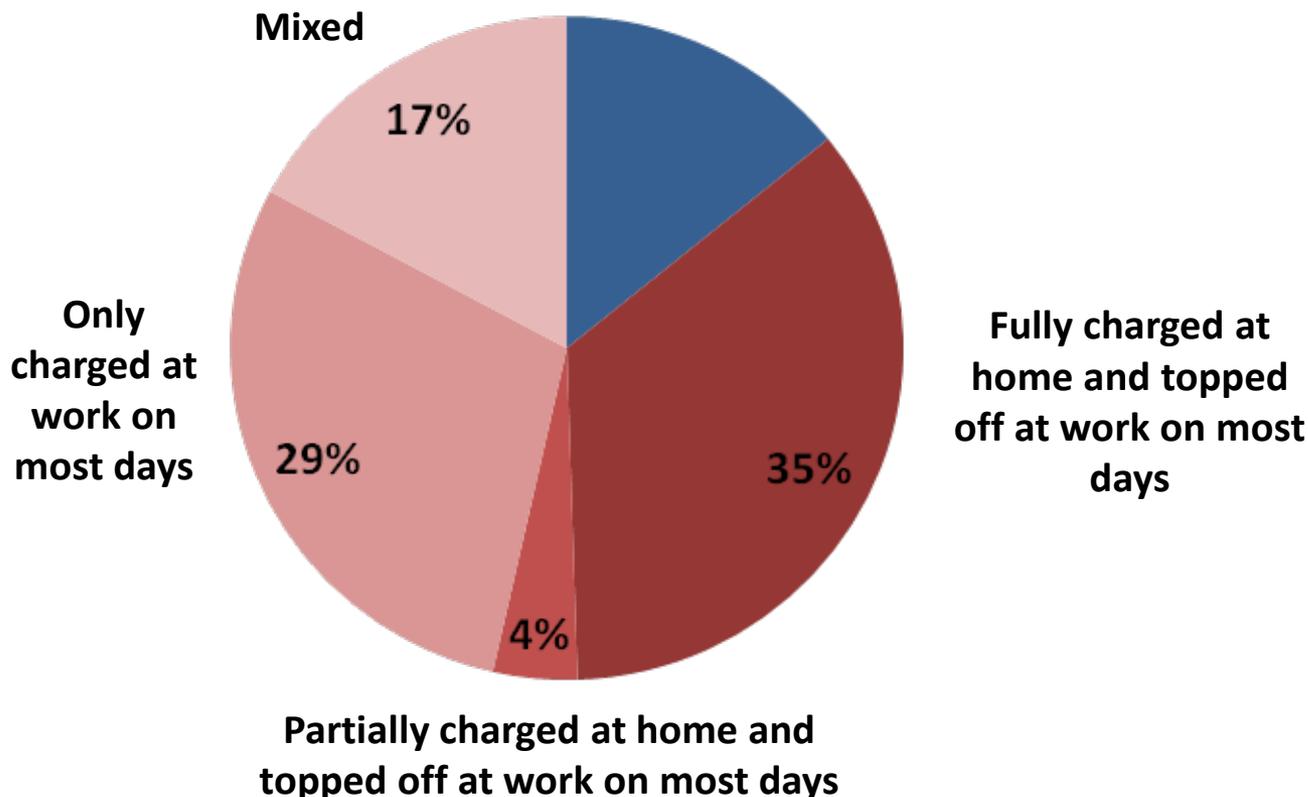
- 14% of Leafs studied needed to charge at work in order to complete their daily commute on most days
- On these days, they charged at home and topped off at work as expected



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

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

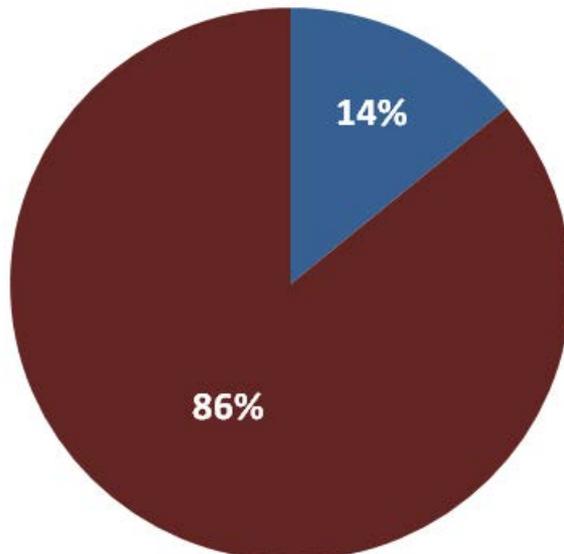


# How many drivers needed to charge at work to complete their commutes?

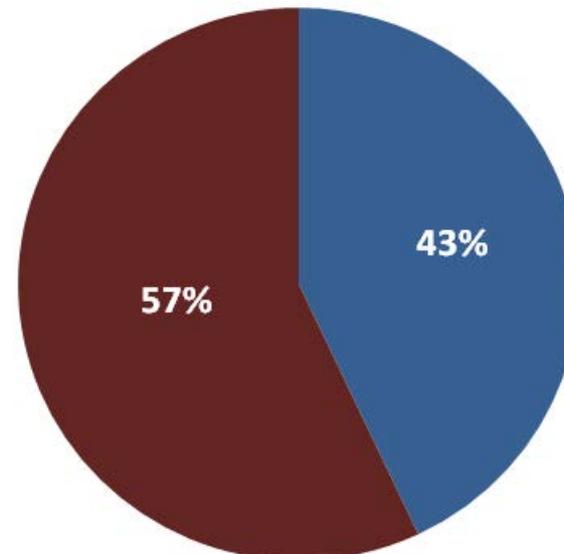
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- Assumption: if you need it, you need it; if you don't, you don't
- 14% of vehicles needed workplace charging to complete their daily driving on *most* days, but...
- 43% of vehicles needed workplace charging to complete their daily driving on *some*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



■ Needed  
■ Not Needed

# ***Does workplace charging increase electric vehicle miles traveled?***

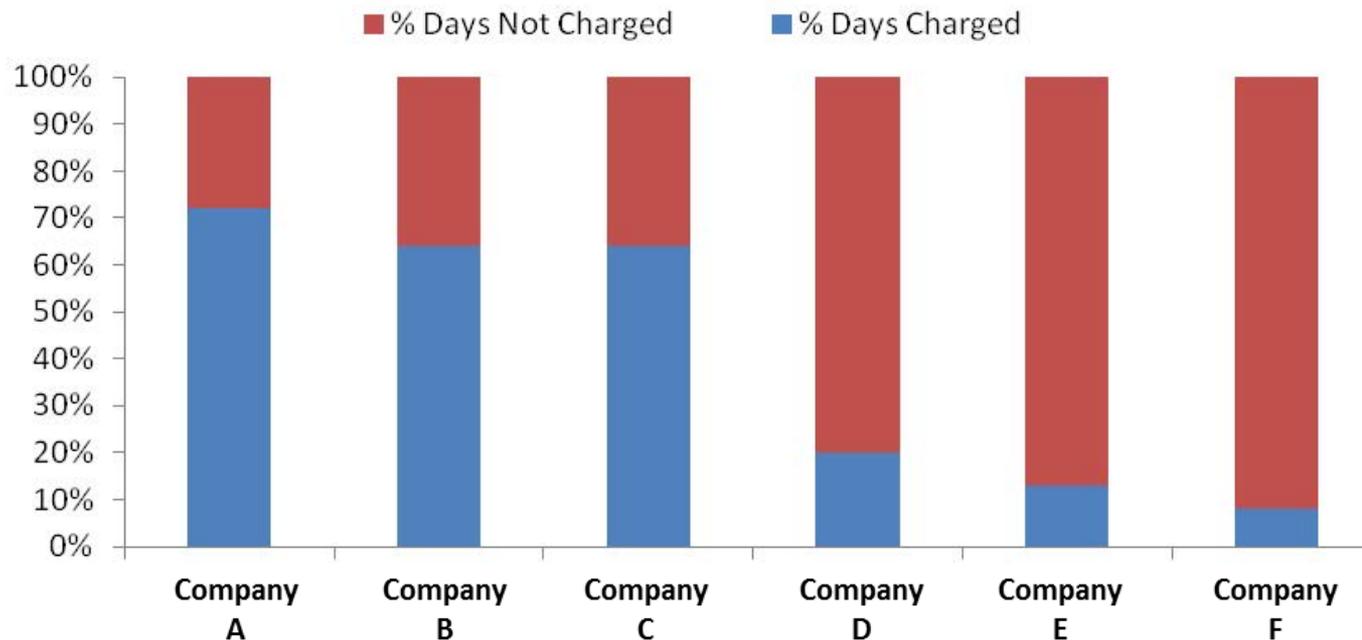
Yes!

- On days when Leaf drivers needed to charge at work, workplace charging extended their range by an average of 15 miles (21%)
- Round-trip commutes on these days averaged 73 miles
- On days when drivers did not need workplace charging but charged anyway, they averaged 12% more miles than on days when they did not charge at work.

# How often did drivers charge at work?

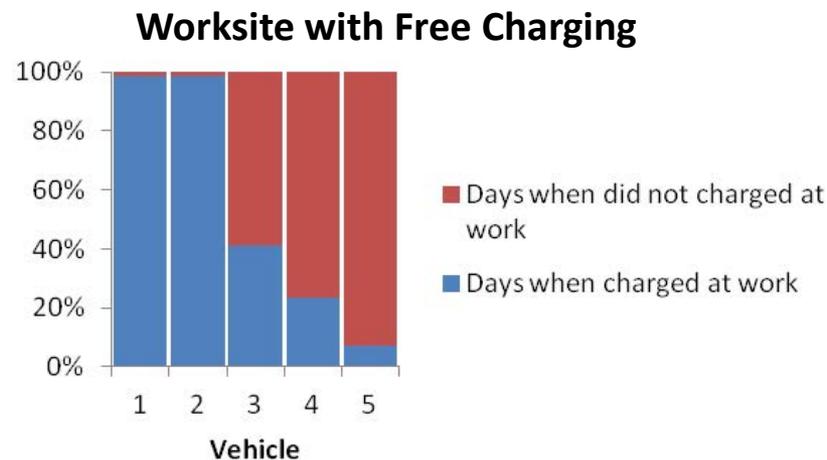
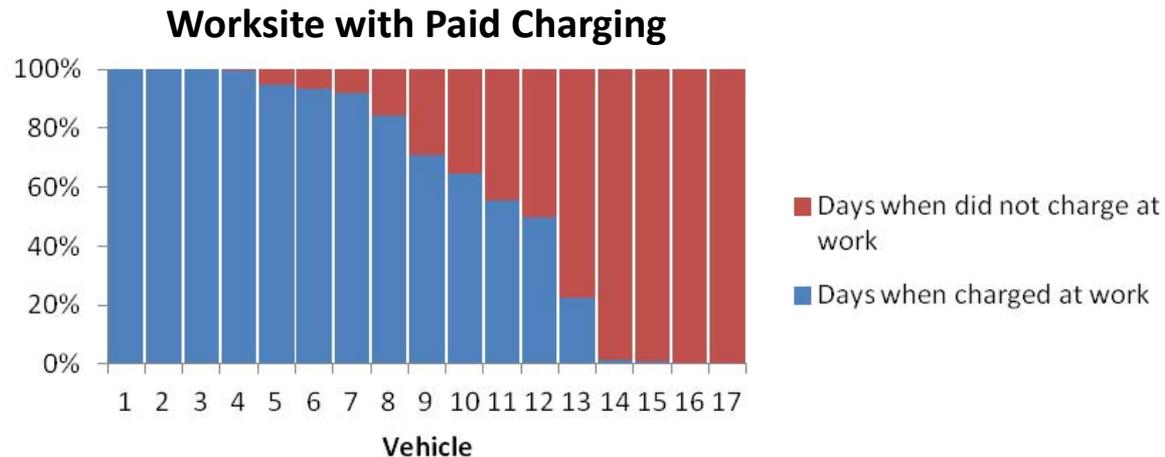
- Assumption: if they can charge at work, they will
- A study of Leaf and Volt parking and charging at 6 work sites showed dramatic differences from site to site...

## Days With and Without Charging

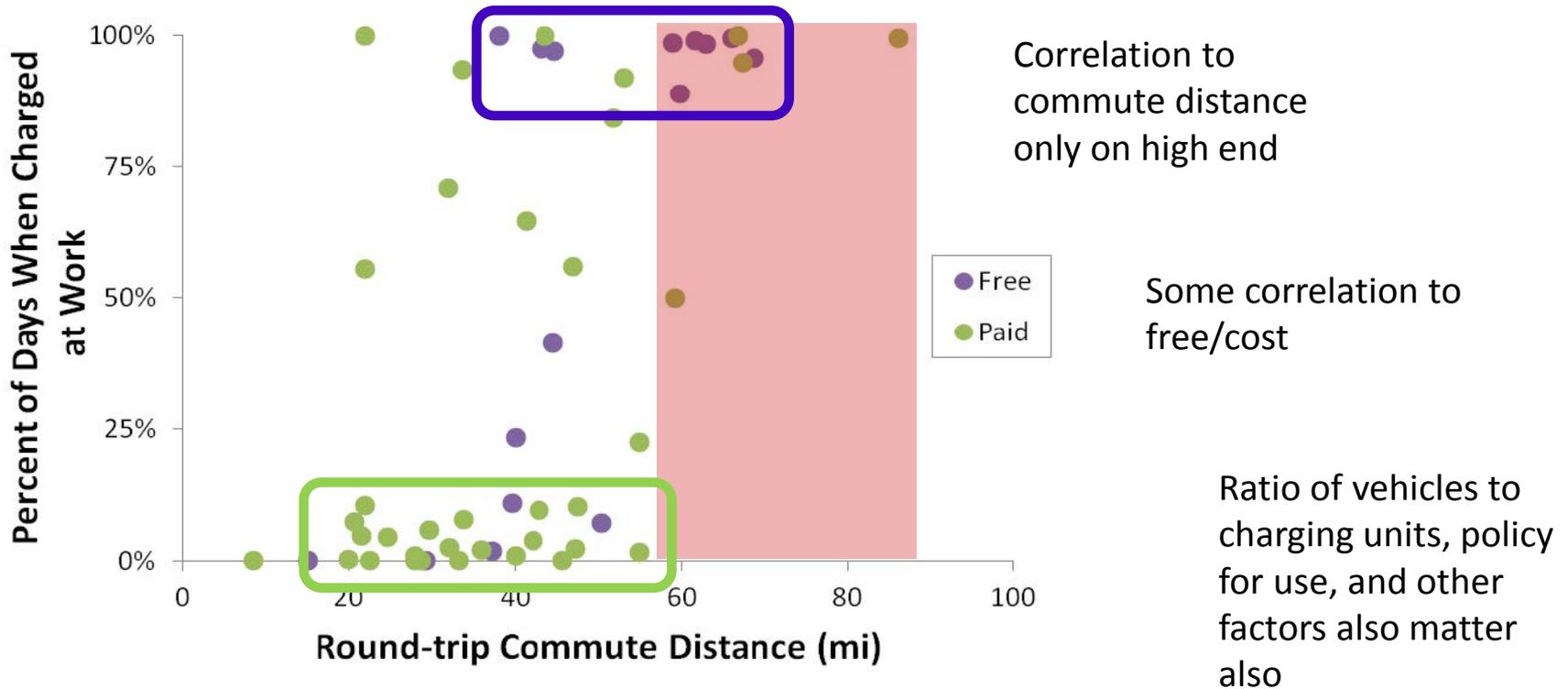


# How often did drivers charge at work?

- ... and from vehicle to vehicle at the same site



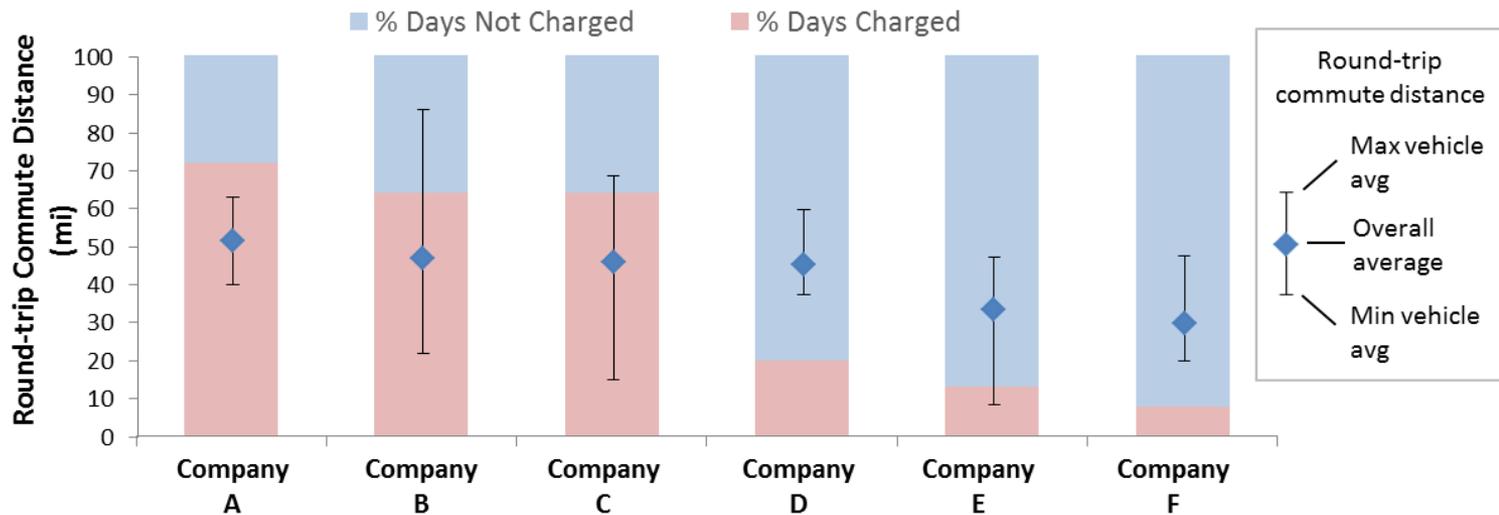
# What determines whether drivers will charge at work?



From 47 Leafs, 5 Volts at 6 worksites

# What determines whether drivers will charge at work?

Summary of Factors Influencing Workplace Charging Frequency



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

# ***Responses to Previous Year Reviewers' Comments***

- This project started in FY14

# Collaboration and Coordination with Other Institutions

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Data collection partner providing data from Blink residential and commercial AC Level 2 charging units and DC fast chargers



Data collection partner providing data from ChargePoint residential and commercial AC Level 2 charging units



Data collection partners providing data from Chevrolet Volts enrolled in The EV Project



Data collection partner providing data from Nissan Leafs enrolled in The EV Project



Participant in The EV Project and ChargePoint America; provided qualitative information about use of charging equipment at its offices

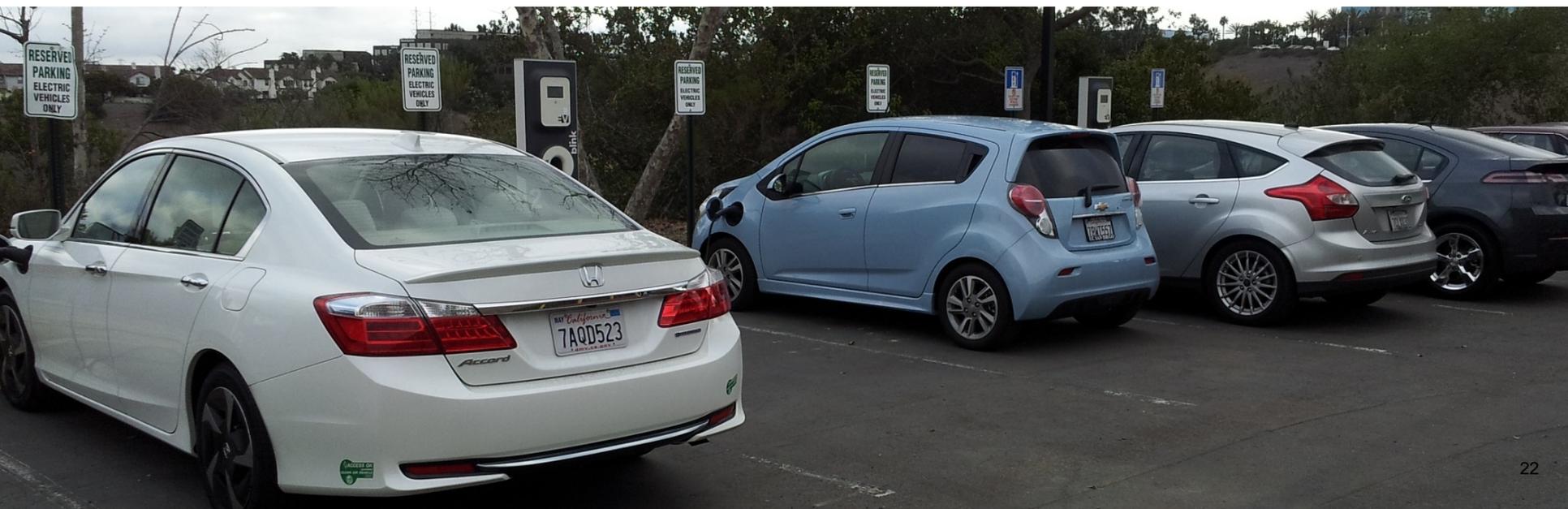
\* Vehicle and charging unit owners gave written permission for data to be collected and provided to researchers

## ***Remaining Challenges and Barriers***

- All data necessary to complete the remaining reports in this project have been collected and analyzed
- There are no anticipated barriers to completing these works by the end of the project
- One challenge is to distill the conclusions of this project's studies into easily digestible points that provide useful guidelines to organizations considering installing workplace charging. Care must be taken not to overstate the applicability of the results, in light of the limitations of the studies with respect to the following:
  - Samples were not representative of the overall PEV market
  - Only two PEV makes/models were studied included
  - Only early adopters studied

## ***Proposed Future Work***

- From Phase I, one additional paper on electricity demand from workplace charging will be completed
- The summary report of key take-aways for Phase III will be completed for use by DOE Workplace Charging Challenge staff
- The author recommends that DOE fund additional workplace charging studies to understand how the use and value of workplace charging changes as the PEV market evolves



# Summary

- Workplace charging has been proposed as an important part of the charging infrastructure necessary to support PEV adoption
- Using data collected from large PEV infrastructure demonstrations, the charging and driving behavior of >700 PEV drivers with access to workplace charging was analyzed to understand how they used workplace charging. Case studies on the use of charging stations at individual work sites were also performed.
- Workplace charging infrastructure was highly used
  - Leaf and Volt drivers performed nearly all charging at home and work on work days and only slightly less on non-workdays
- Workplace charging enabled range extension for Leaf drivers
  - 14% of Leaf drivers needed to charge at work to complete their daily commutes on *most* days. 43% of vehicles needed workplace charging to complete their daily driving on *some* days
  - On days when Leaf drivers needed to charge at work, workplace charging extended their range by an average of 15 miles (21%)
- Use of workplace charging varied based on many factors, including commuting distance, the cost to charge at work, the ratio of vehicles to charging units, and policies for use

# ***TECHNICAL BACK-UP SLIDES***

# 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

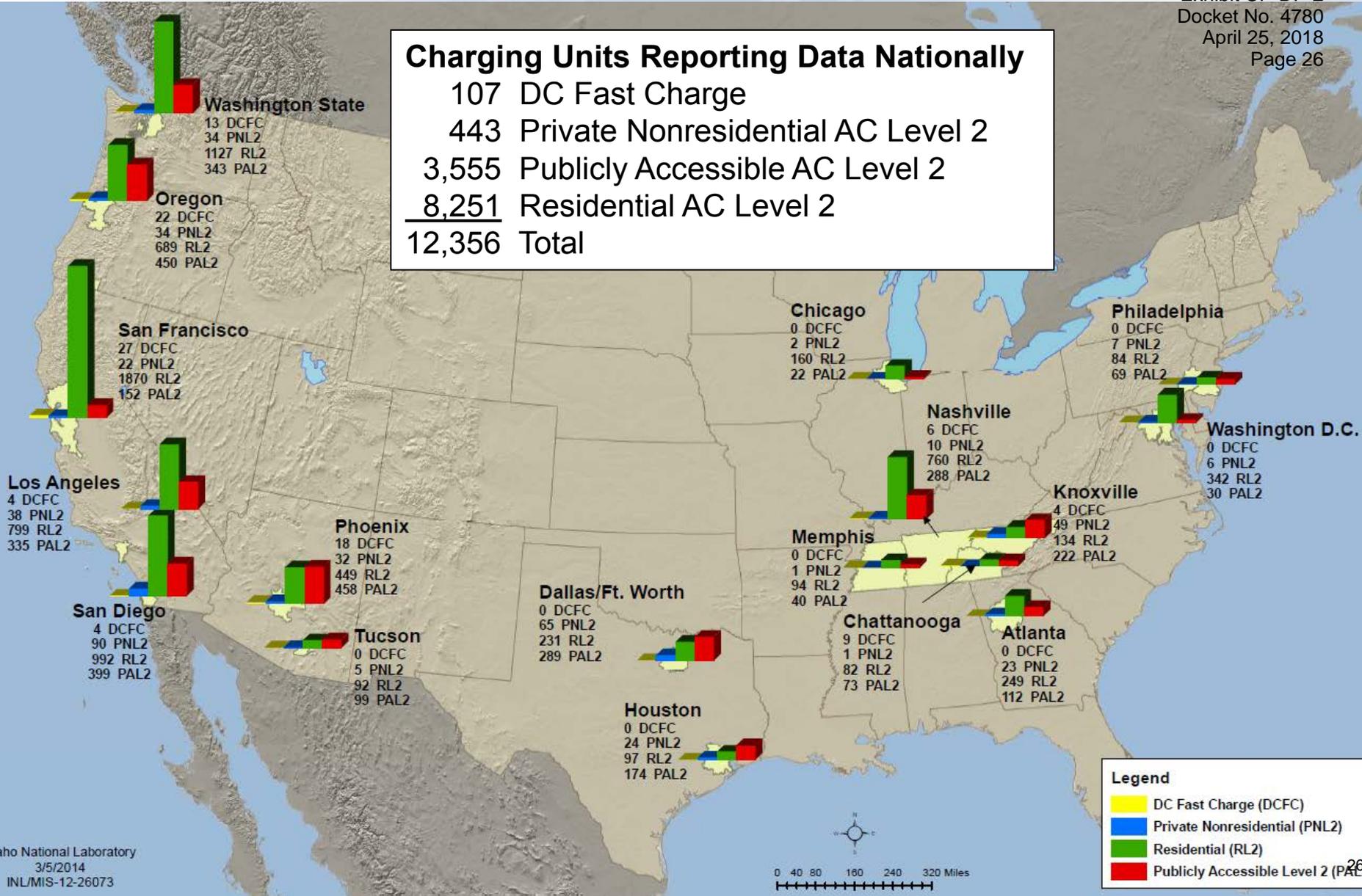
- Deploy 4,700+ residential and public AC level 2 charging units in 11 US regions
- Study customer usage of residential and public infrastructure
- INL data collection May 2011 – Dec 2013



# Infrastructure Deployment in The EV Project through December 2013

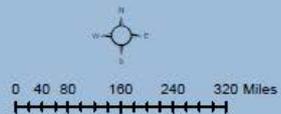
**Charging Units Reporting Data Nationally**

- 107 DC Fast Charge
- 443 Private Nonresidential AC Level 2
- 3,555 Publicly Accessible AC Level 2
- 8,251 Residential AC Level 2
- 12,356 Total**



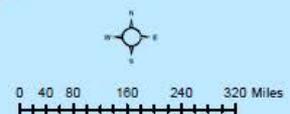
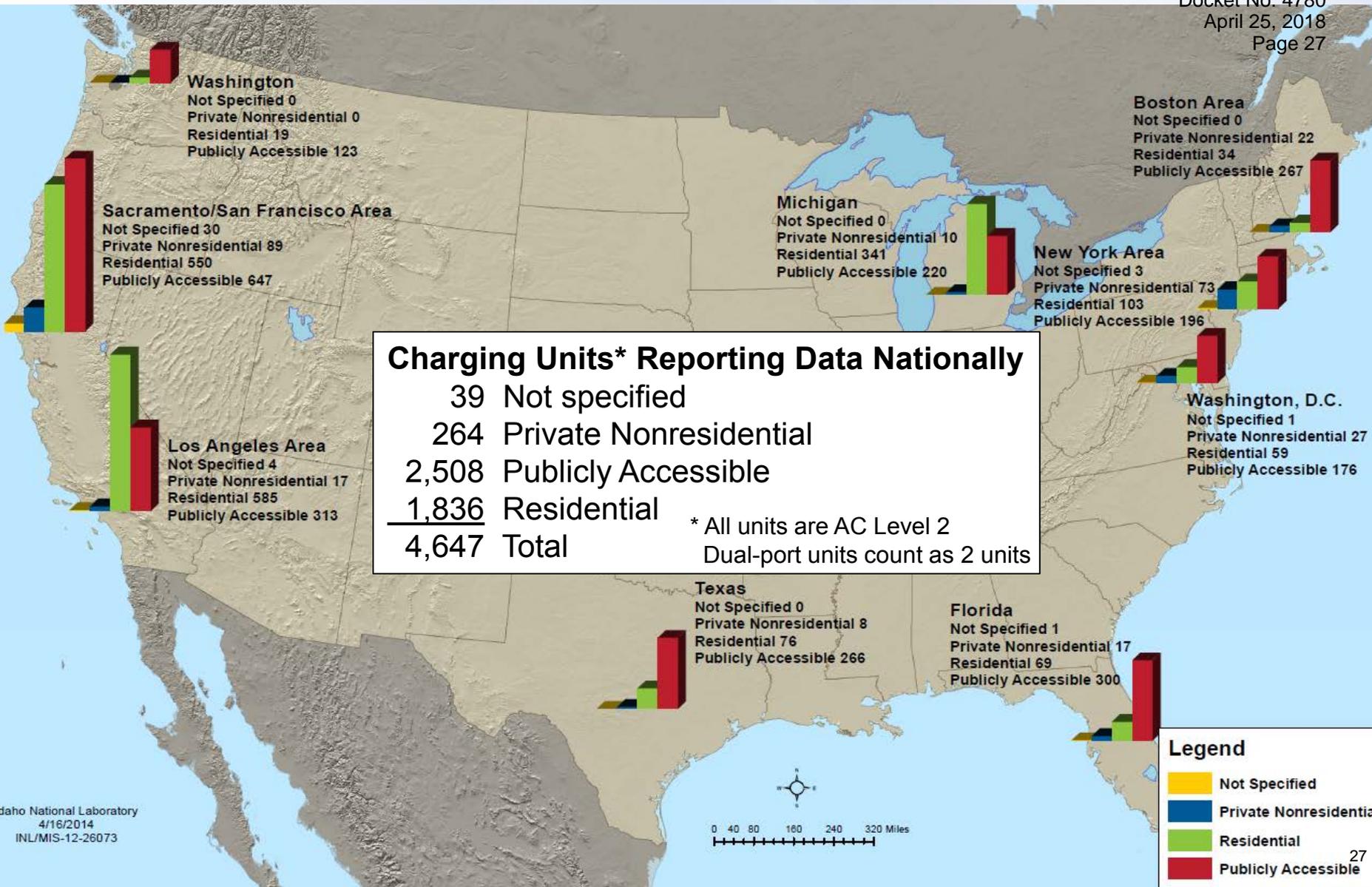
**Legend**

- DC Fast Charge (DCFC)
- Private Nonresidential (PNL2)
- Residential (RL2)
- Publicly Accessible Level 2 (PAL2)



# Infrastructure Deployment in ChargePoint America through December 2013

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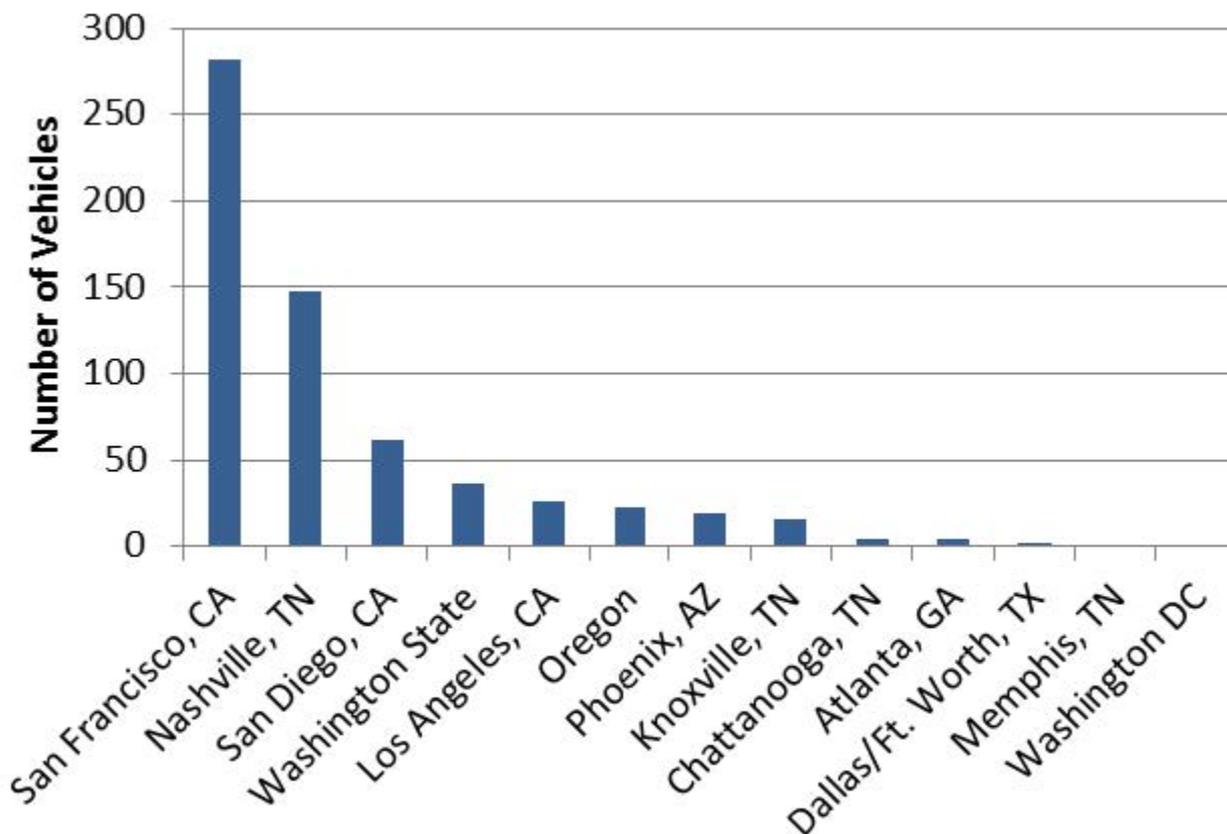


**Legend**

- Not Specified
- Private Nonresidential
- Residential
- Publicly Accessible

# Geographic Distribution of Vehicles

- Number of EV Project Nissan Leafs with access to workplace charging by area

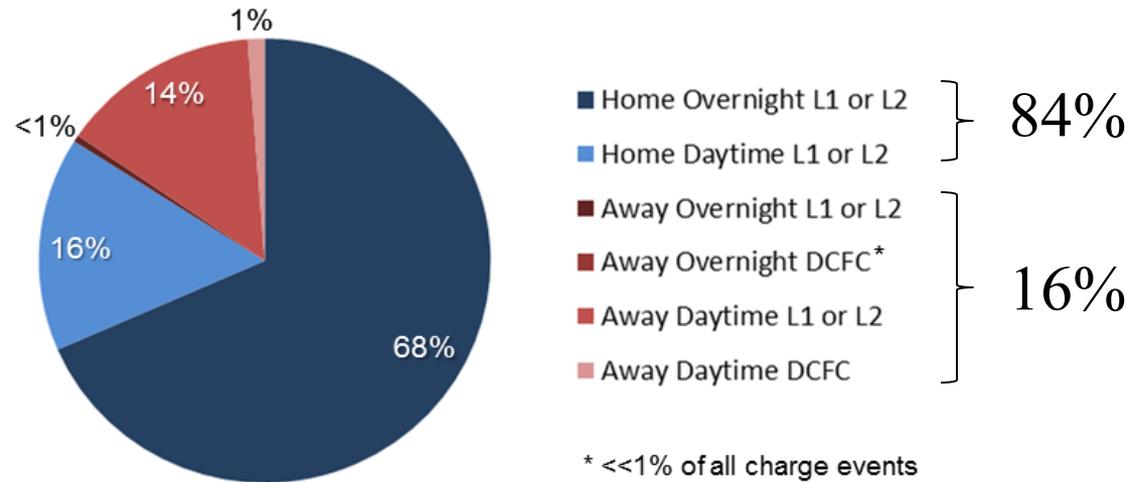


# Percent of Charging Events by Location, Power Level, and Time of Day

Oct 2012 – Dec 2013



4,038 Leafs



1,867 Volts

