# 2014 DOE Vehicle Technologies Office Review - EV Project

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**Idaho National Laboratory**
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## Project ID#: VSS137

INL/MIS-14-31743

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# Overview

## Timeline

- Project Start: Oct 1, 2009
- Data Collection End: Dec 31, 2013
- Data Collection: 100% Complete
- Data Analysis and Reporting Continues

## Barriers

- Slow deployment of vehicles
- Permitting requirements
- Utility demand charges
- Willingness to give up parking spaces
- Site selection: by electrical panel or the front door?

## Budget

- Total Project: $225,403,708
- DOE Share: $97,665,650
- Contractor: $110,503,708
- INL FWP: $7,803,440
- ORNL FWP: $6,800,000

## Partners

- Blink project lead
- Nissan North America
- General Motors / OnStar
- Car2Go
- DOE, INL & ORNL
- Thousands of PEV drivers & hosts
- 23 Electric Utilities
- 1 University
- California Energy Commission
- Bay Area AQMD

# Relevance - Objectives

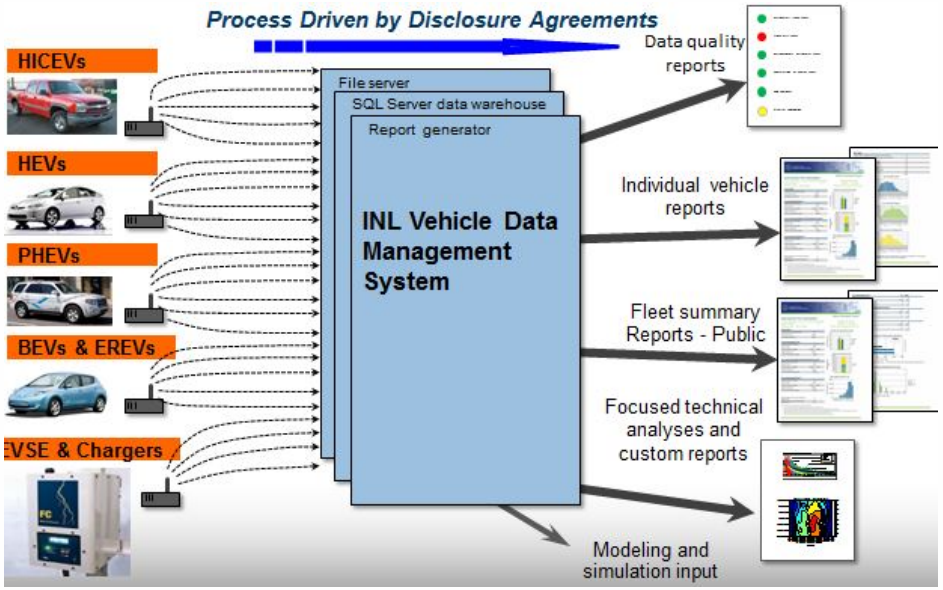
- **Build and study mature charging infrastructures and use the facts-driven lessons learned to support the future deployment of plug-in electric vehicles (PEVs) and charging infrastructure**
  - **Establish mature charge infrastructures in diverse geographies to examine regional use patterns**
  - **Deploy grid-connected vehicles to utilize infrastructure**
  - **Collect data characterizing infrastructure & vehicle utilization**
  - **Evaluate means to improve infrastructure effectiveness and increase vehicle utilization**
  - **Identify and resolve barriers to infrastructure deployment**
  - **Support EV Everywhere Grand Challenge & Work Place Charging Challenge with factual analysis of real-world use**
- **Create and retain jobs**

# Relevance - Milestones

| | |
|---|---|
| • Project initiation | 10/01/09 |
| • Complete EV Micro-Climate Plans | 08/30/10 |
| • Initial residential infrastructure installations | 12/01/10 |
| • Initial vehicle deliveries | 12/01/10 |
| • Initial commercial infrastructure installations | 06/06/11 |
| • Initial DC fast charger installations | 10/24/11 |
| • Residential infrastructure deployment completed | 06/30/13 |
| • Commercial & DCFC installations ended | 07/2013 |
| • Projects non-data collection stopped | 09/2013 |
| • Data collection completed | 12/31/13 |
| • Analysis and reporting continues | |

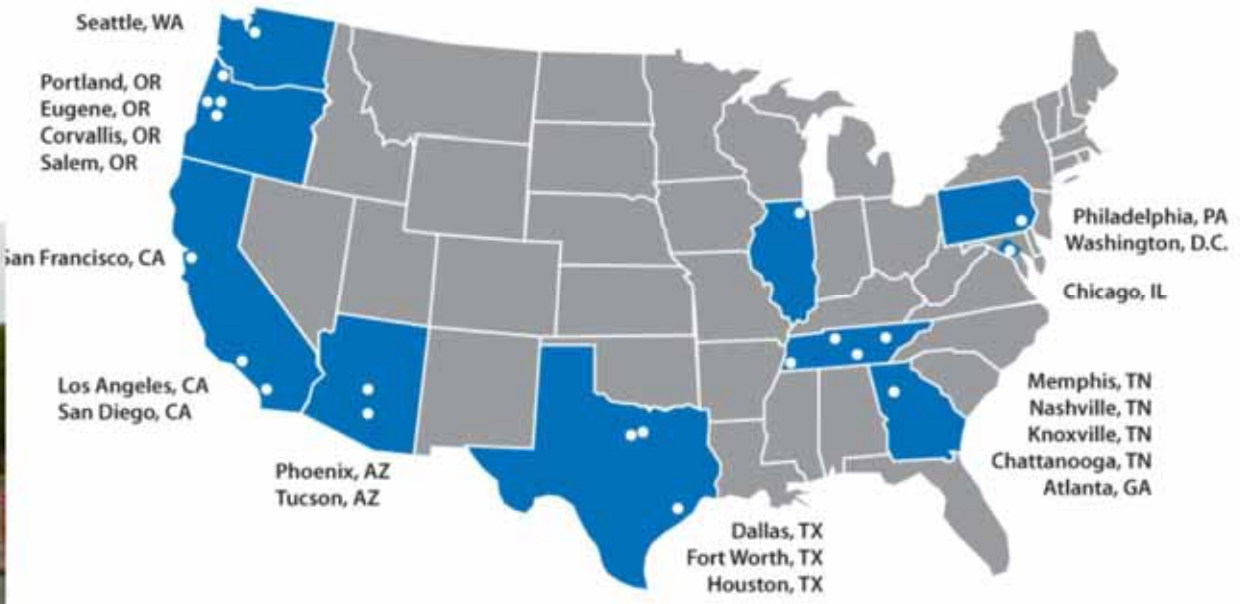
# Approach – Infrastructure Planning

- Organize regional stakeholders
  - Governments
  - Utilities
  - Employers
- Develop long-range Plan Deployment area
  - Vehicle penetration
  - Infrastructure requirements
- Develop EV Micro-Climate
  - Initial deployment

# Approach – Infrastructure Deployment

- EV Project develops mature infrastructures
  - Install residential Level 2EVSE for Leaf & Volt Vehicles
  - Install level 2 commercial EVSE
  - Install DC fast charge in cities and travel corridors
- EV Project utilizes Certified Contractor Network
  - Develop permitting and installation experience
  - Create and retain jobs



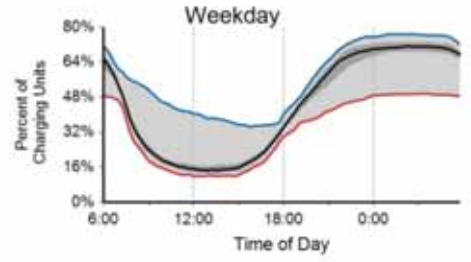
# Approach – Vehicle Data Collection

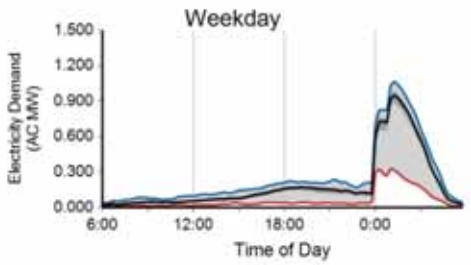
- General public purchases Leafs and Volts and agrees to provide data, in exchange for residential Level 2 EVSE
- Data is received via telematics providers from Chevrolet Volts and Nissan Leafs
- Parameters recorded for each key-on and key-off event
  - Odometer
  - Battery state of charge
  - Date/Time Stamp
  - Vehicle ID
  - Event type (key on / key off)
  - GPS (longitude and latitude)

- Additional data is received monthly from Car2go for the Smart EVs

# Approach – Infrastructure Data Collection

- **Collect Level 2 and DC fast charger (DFC) charge data using cellular and internet based network. Parameters**
  - **Connect and Disconnect Times**
  - **Start and End Charge Times**
  - **Maximum Instantaneous Peak Power**
  - **Average Power**
  - **Total energy (kWh) per charging event**
  - **Rolling 15 Minute Average Peak Power**
  - **Date/Time Stamp**
  - **Unique ID for Charging Event**
  - **Unique ID Identifying the EVSE**
  - **And other non-dynamic EVSE information (GPS, ID, type, contact info, etc.)**



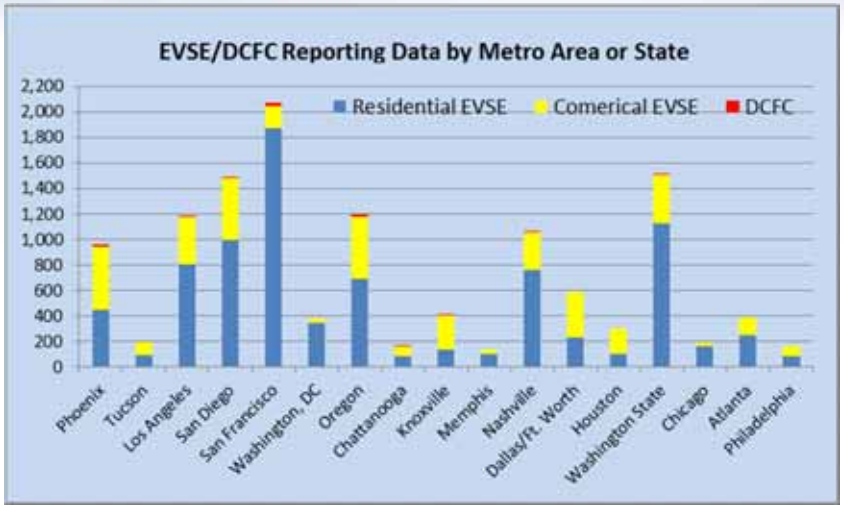

- **Multiple data streams are merged and stored at INL for analysis and reporting**

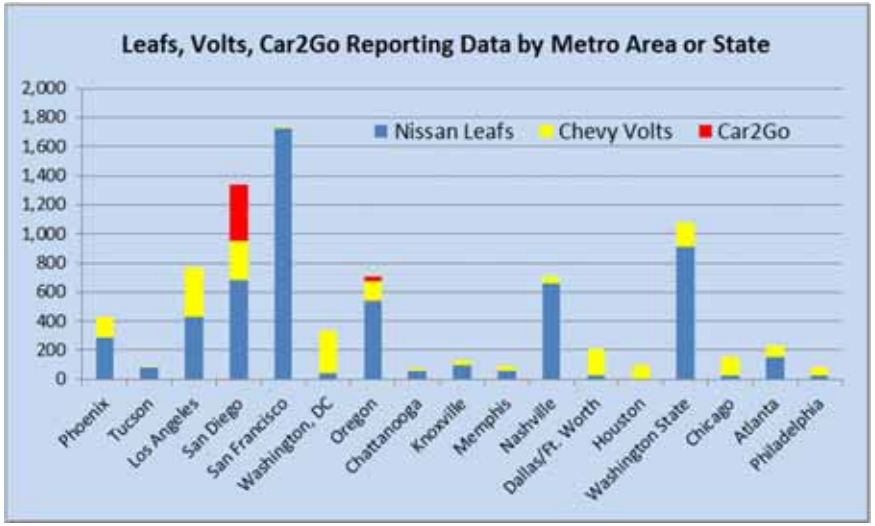
# Approach – Data Collection, Security & Protection

- All vehicle, EVSE, and PII raw data is legally protected by NDAs (Non Disclosure Agreements) and use agreements
  - Limitations on how proprietary and personally identifiable information can be stored and distributed
  - Raw data, in both electronic and printed formats, is not shared with DOE
  - Vehicle and EVSE data collection would not occur unless testing partners trust INL would strictly adhere to NDAs
  - Raw data cannot be legally distributed by INL
- NDAs between INL, Nissan, OnStar, Blink and Car2Go
- Over 10,000 Use Agreements with general public vehicle owners and site hosts

# Accomplishments – 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
- 20,591 discrete sources of data



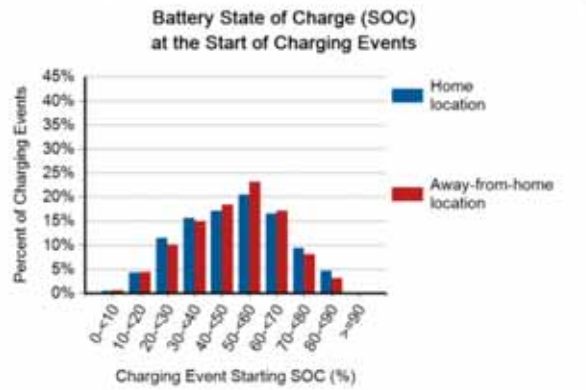



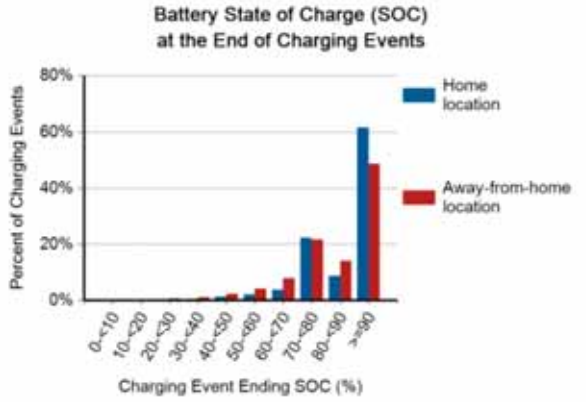

# Accomplishments – Vehicle Profiles *(4th quarter 2013 data)*

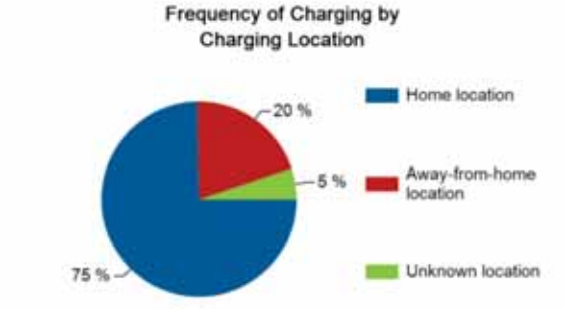
| | Leafs | Volts |
|---|---|---|
| • Number of vehicles | *3,499* | *1,611* |
| • Number of Trips | *781,062* | *559,680* |
| • Distance (million miles) | *5.3* | *4.7* |
| • Average (Ave) trip distance | *6.7 mi* | *8.2 mi* |
| • Ave distance per day | *26.7 mi* | *39.8 mi* |
| • Ave number (#) trips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

# Accomplishments – Vehicle Charging *(4th quarter 2013 data)*

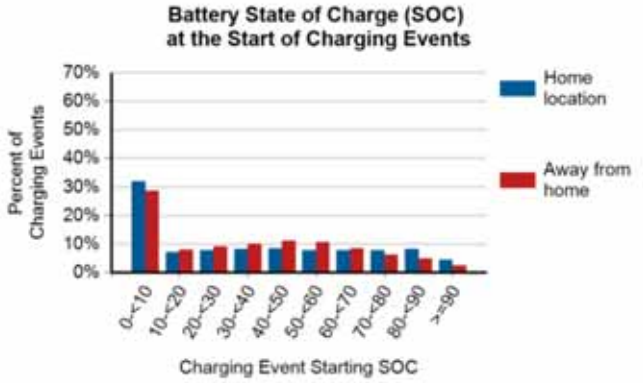
## Leafs

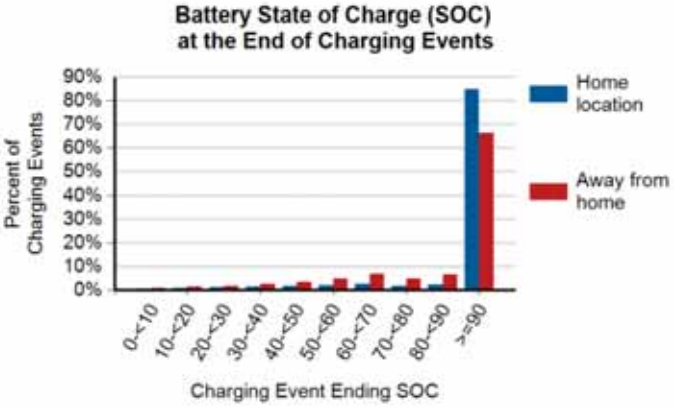


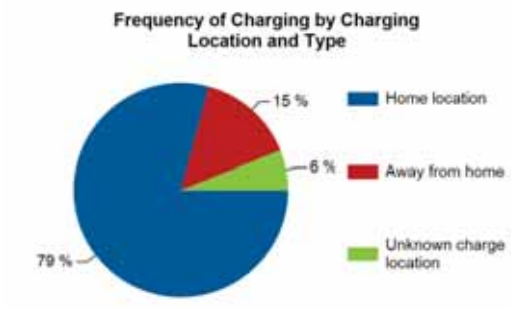




## Volts



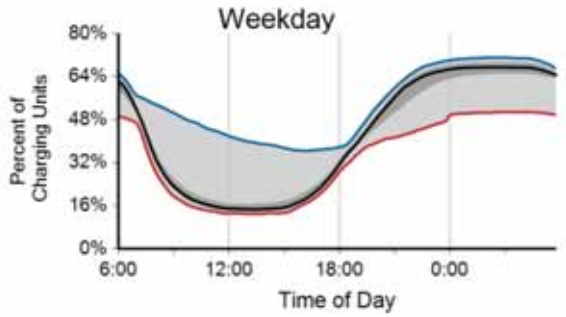



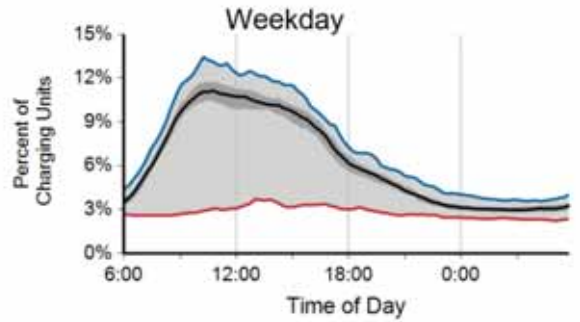
# Accomplishments – Level 2 EVSE Use

- **Weekday EVSE 4nd Quarter 2013. Residential and public connect time and energy use are fairly opposite profiles**

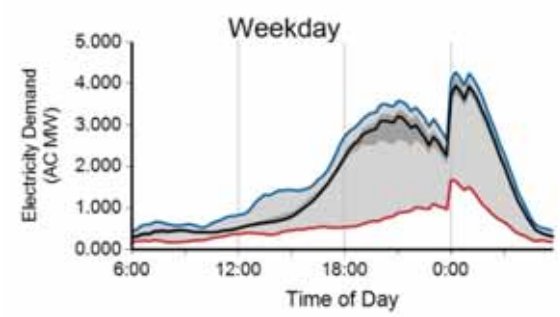
**National Residential Connect Time**



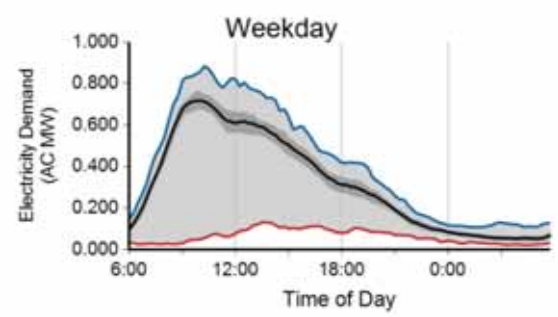

**National Public Connect Time**




**National Residential Demand**




**National Public Demand**

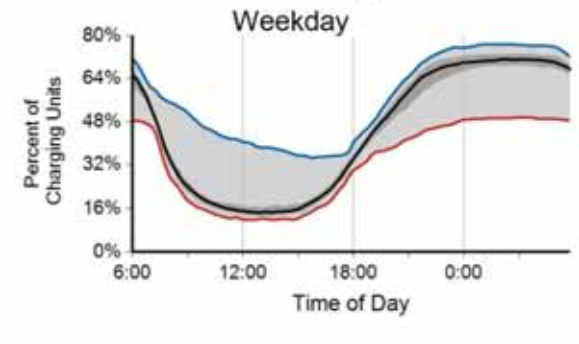



**Legend: 92 day reporting quarter. Data is max (blue line), mean (black line) and minimum (red line), for the reporting period. Dark gray shaded is plus and minus 25% quartile.**

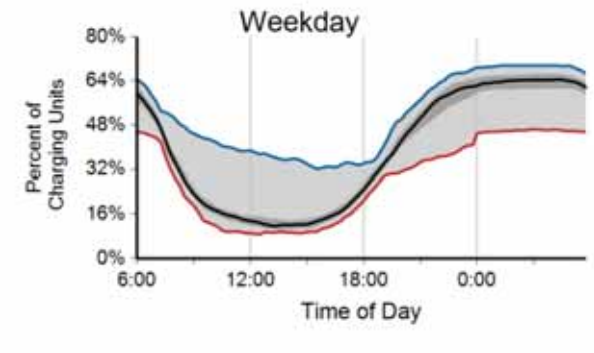
# Accomplishments – Residential L2 EVSE Connect

- **Weekday EVSE 4nd Quarter 2013**
- **San Diego and San Francisco, with Residential L2 Time-of-Use (TOUI) rates, are similar to other regional EVSE connect profiles**

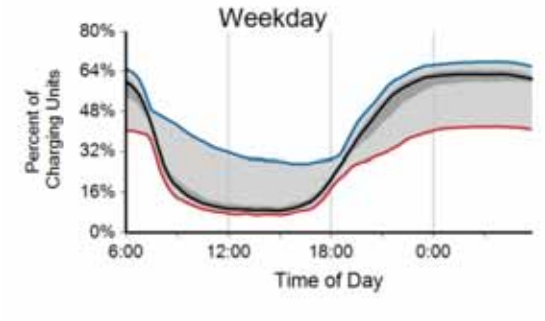
**San Diego**



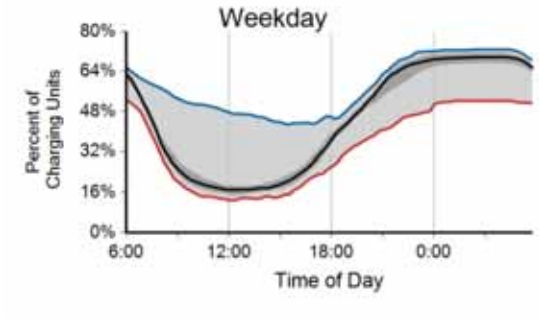

**Los Angeles**




**San Francisco**




**Washington State**

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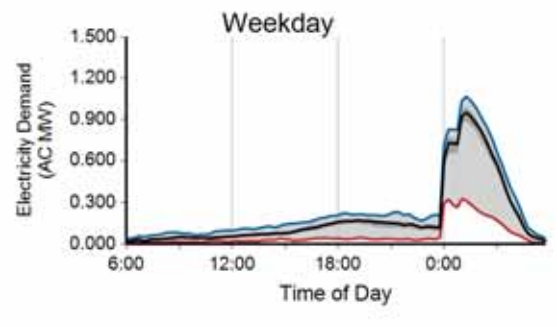
# Accomplishments – Residential L2 EVSE Connect

- **Weekday EVSE 4nd Quarter 2013**
- **Time of use rates in San Diego and San Francisco clearly impact when vehicle charging times are set**

**San Diego**

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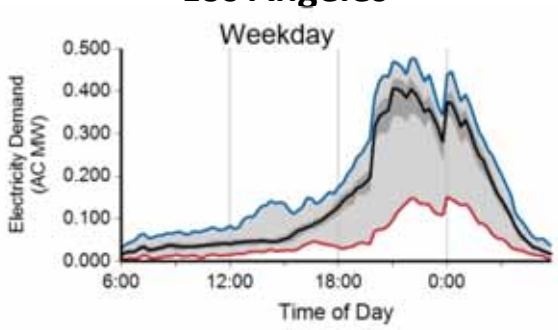
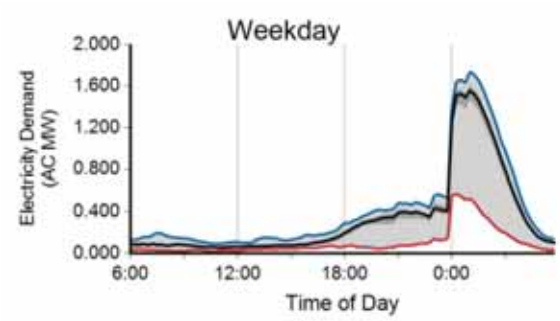
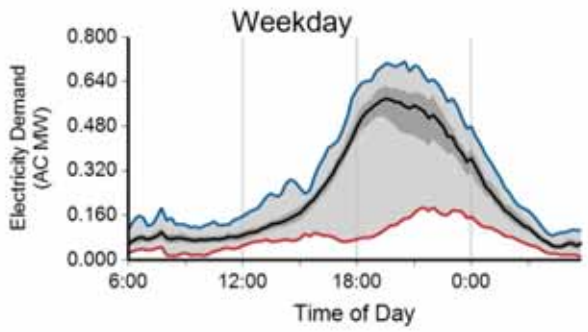



**San Francisco**




**Washington State**

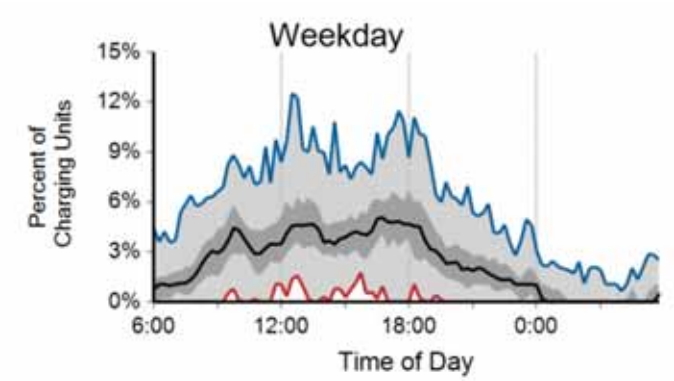



**Legend: 92 day reporting quarter. Data is max (blue line), mean (black line) and minimum (red line), for the reporting period. Dark gray shaded is plus and minus 25% quartile.**

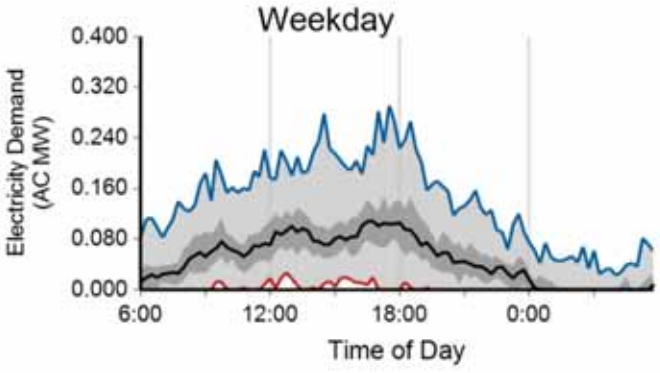
# Accomplishments – DC Fast Charger (DCFC) Use

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

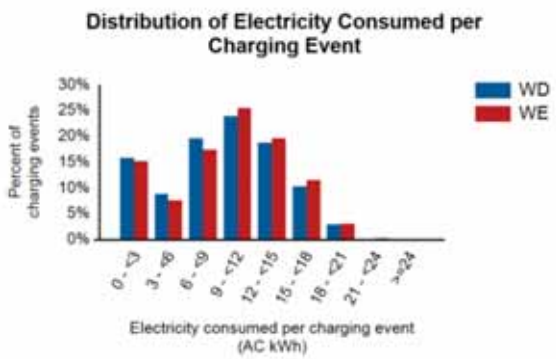
**Weekday Connected Profile**

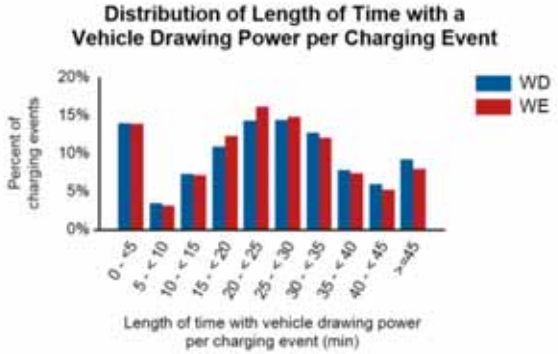



**Weekday Demand Profile**

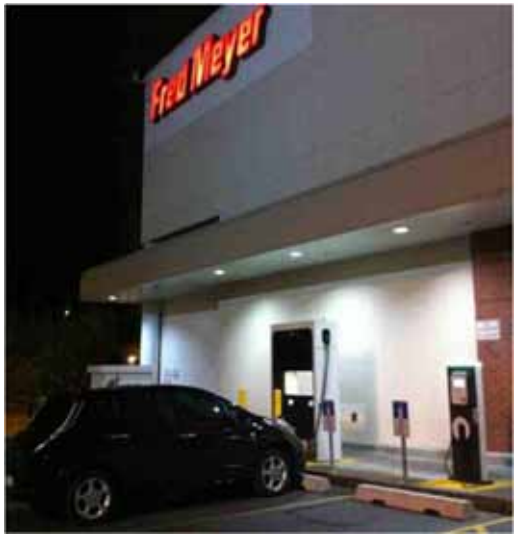


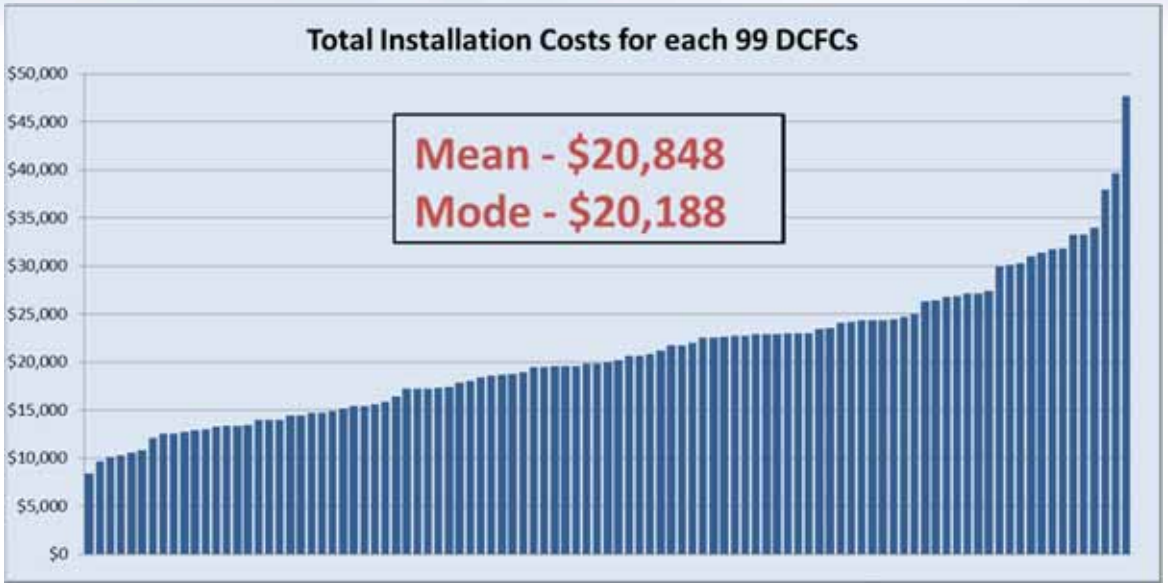

- EV Project Leafs 18% charge events and 16% energy used
- 1.3 average charge events per day per DCFC
- 24.6 minutes average time connected
- 24.6 minutes average time drawing energy
- 9.3 kWh average energy consumed per charge



# Accomplishments – 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**

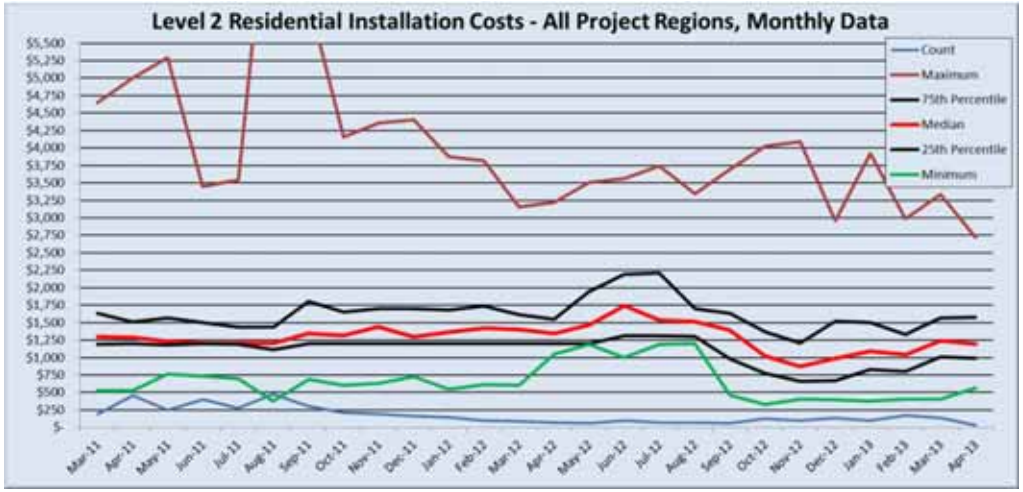
# Accomplishments – Commercial EVSE Level 2 Installation Costs

- Nationally, commercially sited Level 2 EVSE averaged $4,000 in installation costs. EVSE cost excluded, permit fees included
- 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 |

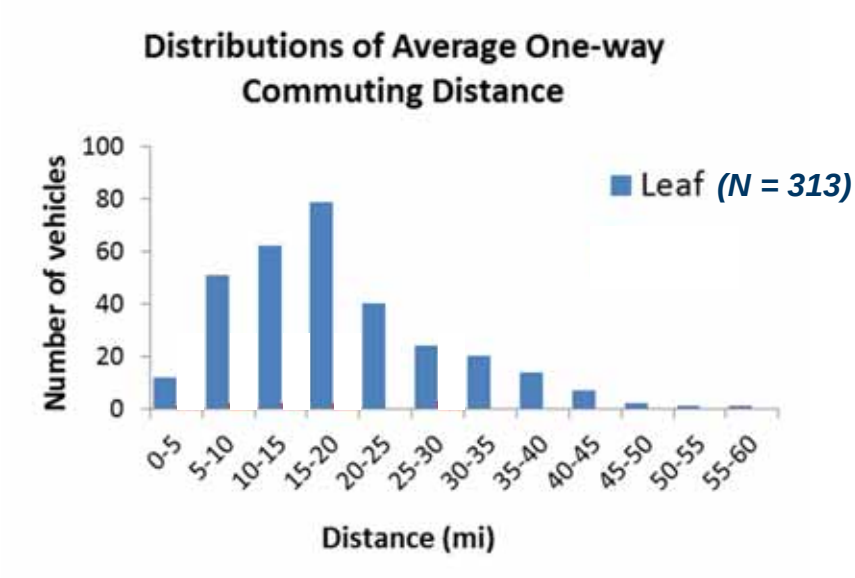
# Accomplishments – Residential EVSE Level 2 Installation Costs

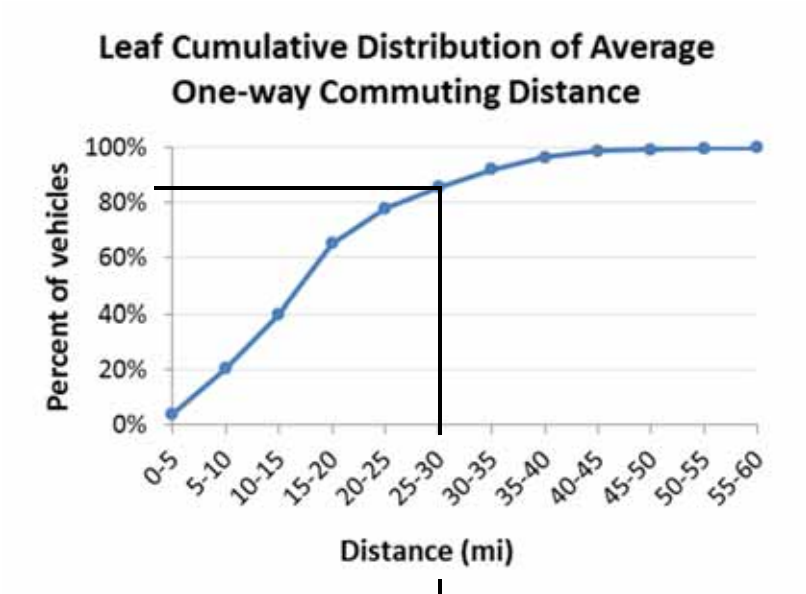
- Nationally, 4,466 residential sited Level 2 EVSE averaged $1,300 for the installation costs. EVSE cost excluded
- Max $8,429, min $250, mean $1,414, median $1,265
- High cost drivers
  - Replacing ($8,429) residential electrical service or not installing near the service panel
  - Desire to site away from the house
  - Cutting concrete or asphalt driveway, or other surfaces
- Low cost drivers
  - Existing 240 V outlet in the garage ($250)
  - Simple addition of a breaker and minimal conduit run
  - Space in the garage



# Accomplishments - Workplace Charging Case Studies – Commuting Distance

**Data from 313 EV Project Leafs which frequently parked at work sites with EV charging during Q2 2013**

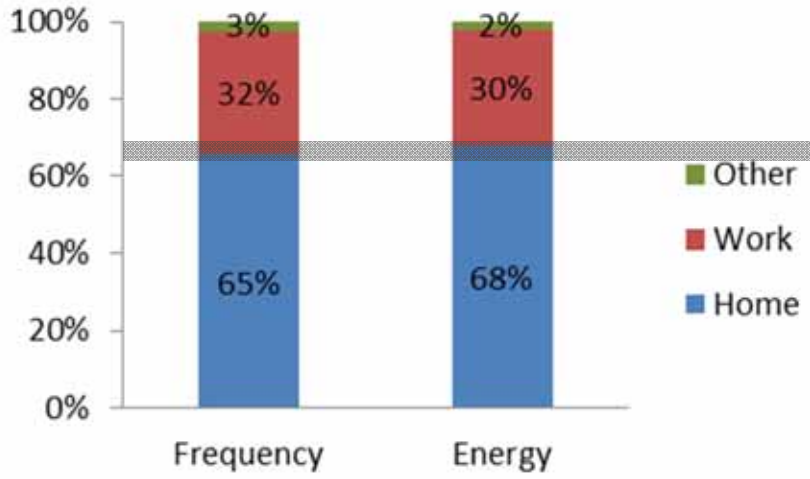


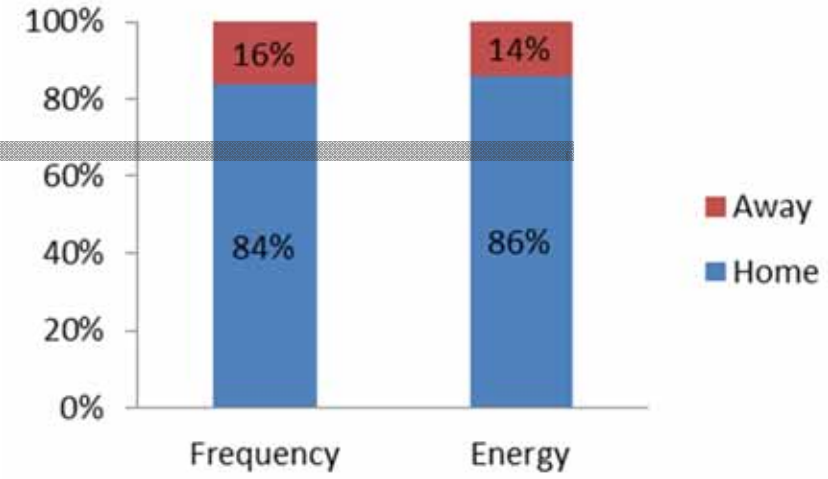

***86% of EV Project Leafs parking at worksites identified average 30 miles or less between home and work***

# Accomplishments - Charging Location Preference for Nissan Leaf drivers

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




***Overall Set of EV Project Nissan Leafs 2012 – 2013***



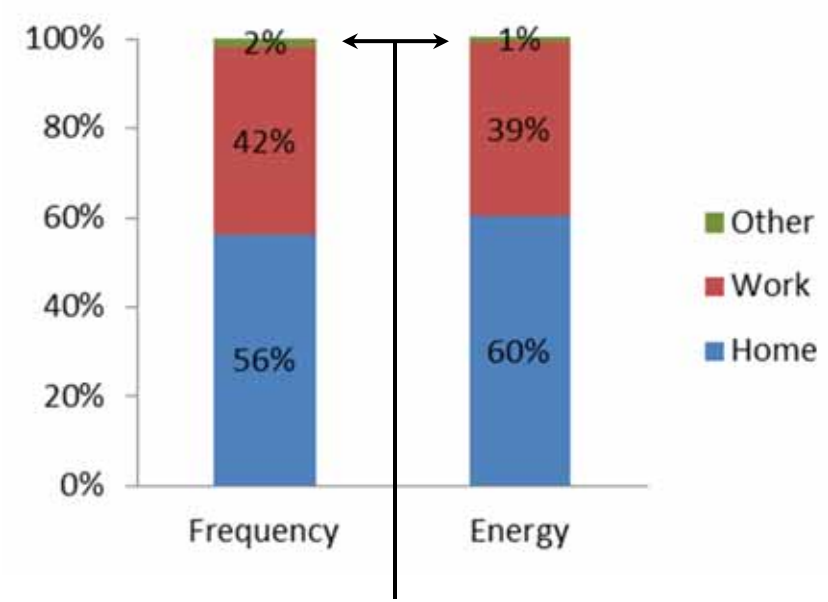

***"Workplace vehicles" charged away from home more than twice as much as the overall project group***

***Most of that away-from-home charging was at work***

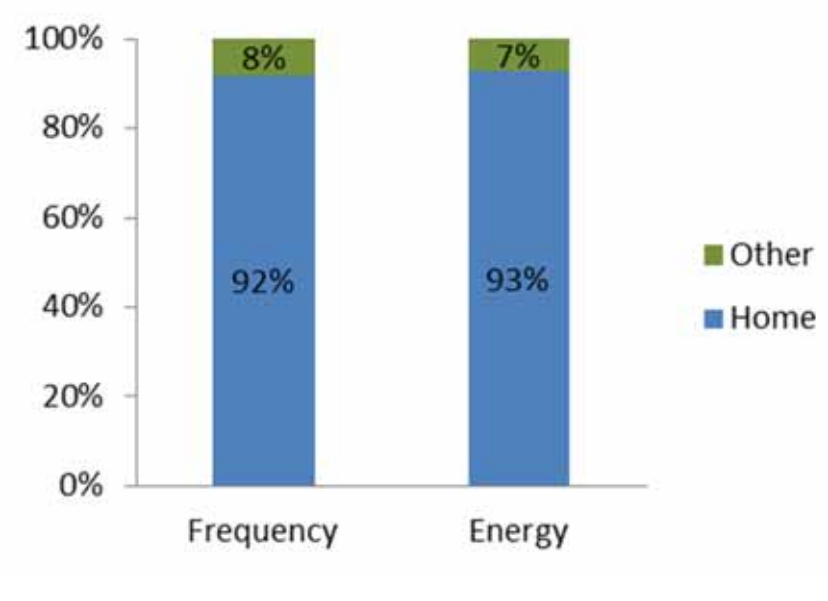
# Accomplishments - Charging Location Preference for Nissan Leaf drivers

***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***

# Response to Previous Year Review's Comments

| Comments from the 2013 Annual Merit Review[1] | Response |
|---|---|
| Question 3: four reviewers stated<br>• The reviewer observed that in addition to the research partners, who appear to interact seamlessly, the job of getting businesses, consumers, and municipal agencies all working together has been done extremely well.<br>• Partners appear to be well integrated into the project, according to the reviewer<br>• This reviewer cited an excellent set of stakeholders.<br>• The reviewer suggested that it is probably good to periodically probe the end user community to determine if the information being provided is as useful and convenient to use as possible. | Stakeholders were invited and attended several workshops designed to solicited input for the type of additional information that should be generated. This has been implemented |
| Question 2: Three reviewers stated<br>• The reviewer noted that the EV Project has deployed cars and chargers and has been collecting interesting data, which the reviewer commented is an effective use of Federal funds<br>• The reviewer observed that the project appears to be on track, and that the logistical and technical work on this project is very impressive<br>• This reviewer said that there was huge progress in implementing a demonstration program, with lots of data venues and excellent ideas. | The data collection and quarterly reporting has completed. |
| Question 4: three reviewers stated<br>• The reviewer noted that the project is nearly complete, but project management and future plans seem solid.<br>• The reviewer observed that the future plan seems to be to continue to collect data, which is good, because people might behave differently once the bloom is off the rose. The reviewer expressed some concern as to how ten-year projections are to be made.<br>• The reviewer claimed not to understand the future work here, other than put more vehicles on the road (in this demo). | There are not any ten-year projections. Trends where observed. Hopefully this presentation will explain out come of putting additional vehicles on the road. |

Note (1) Comments were provided to another organization last year. These are being used.

# Collaborations/Partnerships - Governmental

- **Several state and Federal organizations participated**
  - **U.S. DOE (OVT) provided 50% of the funding and project direction**
  - **Coordinate efforts with OR & WA State DOTs and FHWA to develop signage for EV parking**
  - **California regulatory, energy and air quality organizations provided project funding**
  - **Idaho National Lab (INL) collected data from multiple data streams and reported results, via lessons learned, technical papers, fact sheets, summaries, and presentations – ARRA direct funding**
  - **Oak Ridge National Lab installed solar-assisted charging stations and generated data and reported – ARRA direct funding**
  - **Approximately 12 city governments signed initial letters of support and worked to minimize "bureaucracy". Eventually dozens of local governments worked to support the deployments**

# Collaborations/Partnerships – Electric Utilities

- **The below electric utilities provided project support via several means (i.e., providing service territory data for reporting, installing transformers, implementing multi-tier time of use rates for experimentation, and reporting requirements)**
  - **Arizona Public Service Co**
  - **Chattanooga TN (City of)**
  - **Commonwealth Edison Co**
  - **Eugene Water & Electric Board**
  - **Memphis Light Gas & Water**
  - **Pacific Gas & Electric Co**
  - **Portland General Electric Co**
  - **Public Service Electric & Gas Co**
  - **PUD No 1 of Snohomish County**
  - **Puget Sound Energy Inc.**
  - **San Diego Gas & Electric Co**
  - **Los Angeles Dept of Water & Power**
  - **Georgia Power Co**
  - **Knoxville TN (City of)**
  - **PacifiCorp**
  - **PECO Energy Co**
  - **Middle Tennessee EMC**
  - **Nashville Electric Service**
  - **Oncor Electric Delivery**
  - **Salem Electric**
  - **Salt River Project**
  - **Seattle City Light**
  - **Tucson Electric Power Co**

# Collaborations/Partnerships - Others

- 7,901 members of the general public signed use agreements, allowing data sharing and paid for internet access for downloading EVSE data
- Nissan and General Motors made joining the EV Project part of their car buying experience. Also used telematics systems (Car Wings & OnStar) to provide raw data to INL
- Car2Go provided data sets to INL from 416 Smart Electric Drives in car sharing fleet in exchange to free EVSE access
- Blink (ECOtality and Car Charging) provided raw charging infrastructure data
- UC Davis conducted a survey as a subcontractor

# Learned Barriers



- Charge station signage
- Installation costs
- Utility demand charges
- Residential metering
- Power upgrades needed for sites
- Impact on local transformer
- Lack of DCFC SAE connector standard at project inception
- Ground surface material and cost to “put back” (e.g. concrete, asphalt, landscaping)
- Other underground services that may affect method of trenching power to DCFC
- Decision-maker for the property is not always apparent
- Time associated with permissions
  - Permits, load studies, and pre-, post-, and interim inspections
- ADA compliance costs (This does not suggest not being ADA compliant is acceptable. Just that it is expansive)

# Future Work

- INL is continuing to develop reports on lessons learned
- EV Project data is being combined with data from other projects for more complete analyses of travel corridors and regions, including DCFC trip enabling
- Greater emphasis is being placed on understanding behavior when work place charging is available
- Continuing to develop lessons learned and reports based on stakeholders' input at stakeholders meetings
- Additional case studies have been initiated, documenting use rates and cost drivers for EVSE and DCFC sites
- Generating reports supporting ongoing Blink activities
- Developing research projects that use EV Project data
- Providing information to DOE in support of
  - EV Everywhere Grand Challenge
  - Workplace Charging Challenge
  - Community and Fleet Readiness activities

# Summary

- 124 million test miles and 4.1 million charging events collected and combined to match drives and charges
- Time of Use and work place charging impacts documented
- Residential, work & public charging behaviors benchmarked
- EV Project overcame issues to accumulate the largest collection of charging infrastructure & PEV use patterns
- The results are being utilized by a broad array of organizations for planning, rule setting and research, including state and Federal organizations, regulatory agencies, vehicle manufacturers, electric utilities, universities, other national laboratories, National Academy, fleet owners
- Custom reports have been generated for project partners
- INL is striving to ensure the EV Project data is used to give the greatest value to other organizations, within the constraints of NDAs and user agreements
- EV Project publications - http://avt.inel.gov/evproject.shtml#

# *Reviewer-Only Slides*

# Critical Assumptions and Issues

- **Electric Utility Demand Charges Impacted Business Models**
  - **Demand charges that can be over $1,000.00/month/DC Fast Charger in some service areas. This was a deterrent to DCFC adoption by charger hosts. No know solution**
- **Plug-In Electric Vehicle Sales Rates**
  - **Vehicle sales were lower than expected by all. The EV Project expanded to additional markets in order to meet deployment targets. The original period of performance was extended from December 2012 to December 2013**
- **DC Fast Charging Connector Standard**
  - **EV Project deployed DCFC with the only charger connector available on production vehicles. SAE issued a different standard in 2012. These two standards in the EV marketplace (plus Tesla's own standard) represent an obvious hindrance to the adoption and sales of PEVs that are DCFC capable**

# Publications & Reports FY2103 & 2014

## Lessons Learned - http://avt.inel.gov/evproject.shtml#

- Where do Nissan Leaf drivers in The EV Project charge when they have the opportunity to charge at work? - March 2014
- What kind of charging infrastructure do Chevrolet Volts in The EV Project Use? - September 2013
- How much are Chevrolet Volts in The EV Project driven in EV Mode? - August 2013
- Demographics of The EV Project Participants = August 2013
- Clustering Effects that have been Seen by The EV Project - August 2013
- The Early Experiences in Using DC Fast Chargers - August 2013
- PEV Driver Responses to Time-of-Use (TOU) Rates while charging EV Project Vehicles - July 2013
- Venue Utilization First Look - May 2013
- The EV Micro-Climate Deployment Process in San Diego - May 2013
- EVSE Programming - April 2013
- Electric Vehicle Public Charging - Time vs. Energy - March 2013
- Regulatory Issues and Utility EV Rates - March 2013
- Greenhouse Gas (GHG) Avoidance and Fuel Cost Reduction - June 2012
- The EV Micro-Climate Planning Process - May 2012
- DC Fast Charge-Demand Charge Reduction - May 2012
- Signage - April 2012
- Accessibility at Public EV Charging Locations - October 2011

# Publications & Reports FY2103 & 2014

## Technical Reports - http://avt.inel.gov/evproject.shtml#

- A First Look at the Impact of Electric Vehicle Charging on the Electric Grid in The EV Project - May 2012
- Battery Electric Vehicle Driving and Charging Behavior Observed Early in The EV Project - April 2012
- Extended Range Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project - April 2013

## Quarterly Reports - http://avt.inel.gov/evproject.shtml#

- Observations from the EV Project: October - December 2013
- Overview Report: Project to date through December 2013
- Nissan Leaf Vehicle Summary Report: October - December 2013 (PDF)(DATA)
- Chevrolet Volt Vehicle Summary Report: October - December 2013 (PDF)(DATA)
- Electric Vehicle Charging Infrastructure Summary Report: October - December 2013 (PDF)(DATA)
- Blink Charging Units Map - Project to date through December 2013
- Nissan Leafs and Chevrolet Volts Map - Project to date through December 2013
- Observations from the EV Project: July - September 2013
- Overview Report: Project to date through September 2013
- Nissan Leaf Vehicle Summary Report: July - September 2013 (PDF)(DATA)

# Publications & Reports FY2103 & 2014

## Quarterly Reports cont'd - http://avt.inel.gov/evproject.shtml#

- Chevrolet Volt Vehicle Summary Report: July - September 2013 (PDF)(DATA)
- Electric Vehicle Charging Infrastructure Summary Report: July - September 2013 (PDF)(DATA)
- Blink Charging Units Map - Project to date through September 2013
- Nissan Leafs and Chevrolet Volts Map - Project to date through September 2013
- Overview Report: Project to date through June 2013
- Nissan Leaf Vehicle Summary Report: April - June 2013 (PDF)(DATA)
- Chevrolet Volt Vehicle Summary Report: April - June 2013 (PDF)(DATA)
- Electric Vehicle Charging Infrastructure Summary Report: April - June 2013 (PDF)(DATA)
- Residential Blink Charging Units Map - Project to date through June 2013
- Public Blink Charging Units Map - Project to date through June 2013
- Nissan Leafs and Chevrolet Volts Map - Project to date through June 2013
- Overview Report: Project to date through March 2013
- Nissan Leaf Vehicle Summary Report: January - March 2013 (PDF)(DATA)
- Chevrolet Volt Vehicle Summary Report: January - March 2013 (PDF)(DATA)
- Electric Vehicle Charging Infrastructure Summary Report: January - March 2013 (PDF)(DATA)

# Publications & Reports FY2103 & 2014

## Quarterly Reports cont'd - http://avt.inel.gov/evproject.shtml#

- Residential Blink Charging Units Map - Project to date through March 2013
- Public Blink Charging Units Map - Project to date through March 2013
- Nissan Leafs and Chevrolet Volts Map - Project to date through March 2013
- Overview Report: Project to date through December 2012
- Nissan Leaf Vehicle Summary Report: October - December 2012 (PDF)(DATA)
- Chevrolet Volt Vehicle Summary Report: October - December 2012 (PDF)(DATA)
- Electric Vehicle Charging Infrastructure Summary Report: October - December 2012 (PDF)(DATA)
- Residential Blink Charging Units Map - Project to date through December 2012
- Public Blink Charging Units Map - Project to date through December 2012
- Nissan Leafs and Chevrolet Volts Map - Project to date through December 2012

# Publications & Reports FY2103 & 2014

## Presentations - http://avt.inel.gov/evproject.shtml#

- Electric Vehicle Charging Infrastructure Usage Observed in Large-scale Charging Infrastructure Demonstrations - Irvine, CA - February 2014
- PEV Infrastructure Deployment Costs and Drivers' Charging Preferences in the EV Project - La Jolla, CA - February 2014
- Trends Observed in Plug-in Electric Vehicle Infrastructure Demonstrations - Washington, D.C. - January 2014
- EV Roadmap 6 Conference - Portland, OR - August 2013
- Information Dissemination Plan Presentation - June 2013
- Electrifying the Vehicle Market in the Southeast: In-Use Performance of Electric Drive Vehicles and Infrastructure: EV Project Results to Date Knoxville, TN - May 2013
- SAE International: Extended Range Electric Vehicle Driving and Charging Behavior Observed Early in the EV Project - April 2013
- Lessons Learned on the EV Project and DC Fast Charging - April 2013
- Information Dissemination Peer Review - March 2013
- EUEC 2013 Session E8: The EV Project Lessons Learned - Deployment Barriers - January 2013