

# **U.S. Department of Energy's Vehicle Technologies Program -**

## **Fully Charged 2012 International EV Summit – The EV Project Update**

**Jim Francfort – Idaho National Laboratory**

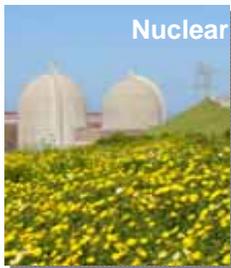
**Fully Charged 2012 International EV Summit  
Dublin, Ireland  
July 11, 2012**

# Outline

- **Participants, goals and testing experience**
- **Data processes and data security**
- **EV Project**
  - **Description and data parameters**
  - **Project status**
  - **Leaf, Volt, and EVSE benchmarking results**
  - **Bulk of presentation**
- **Potential grid impacts**
- **Other electric drive vehicle research activities**
- **Summary**
- **Future work**

# Idaho National Laboratory (INL)

- Eastern Idaho based U.S. Department of Energy (DOE) Federal research laboratory
- 890 square mile site with 4,000 staff
- Support DOE's strategic goal:
  - Increase U.S. energy security and reduce the nation's dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Energy Critical Infrastructure Protection
  - Homeland Security and Cyber Security
  - Advanced Vehicles and Battery Development
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy



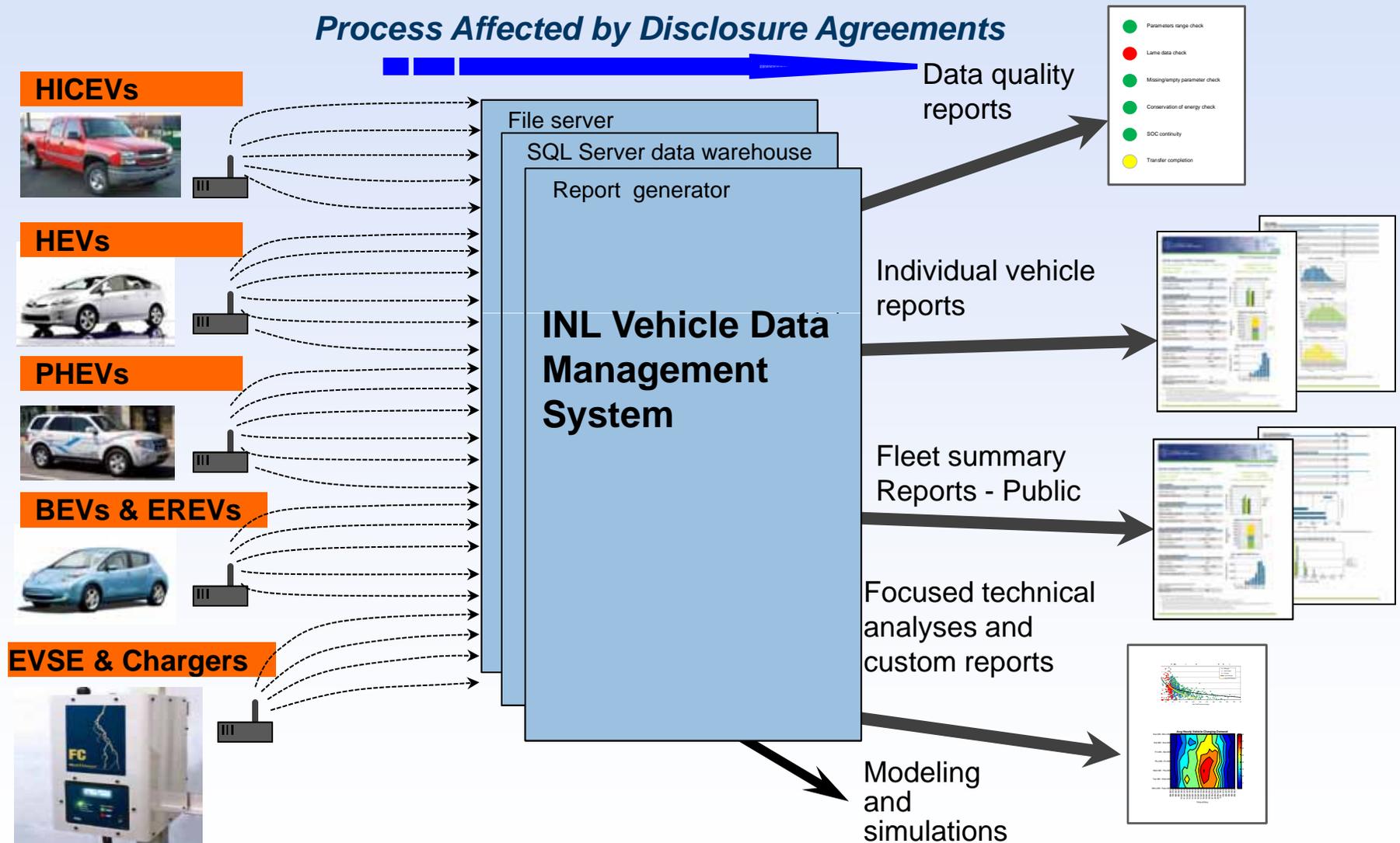
# AVTA Participants and Goals

- **INL manages the Advanced Vehicle Testing Activity's (AVTA) field testing of advanced technology light-duty vehicles for DOE**
  - AVTA is part of DOE's Vehicle Technologies Program
  - ECOTality provides testing support via DOE's National Energy Testing Laboratory
- **Test partners include electric utilities, Federal, state and local government agencies, private companies, and individual vehicle owners**
- **The AVTA goal: Petroleum reduction and energy security**
  - **Confusing people with facts via testing regimes**
  - Providing benchmark data to DOE, technology modelers, R&D programs, vehicle manufacturers (via VSATT), and target and goal setters
  - Assist fleet managers, via Clean Cities, FEMP and industry gatherings, in making informed vehicle and infrastructure deployment and operating decisions

# Vehicle / Infrastructure Testing Experience

- **48 million test miles accumulated on 8,200 electric drive vehicles representing 114 models**
- **EV Project: 4,700 Leafs and Volts, 6,200 EVSE (electric vehicle supply equipment)**
  - **30.3 million test miles**
  - **865,000 charge events, 7,300 MWh**
- **PHEVs: 14 models, 430 PHEVs, 4 million test miles**
- **EREVs: 1 model, 150 EREVs, 900,000 test miles**
- **HEVs: 21 models, 52 HEVs, 6.2 million test miles**
- **Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 485,000 test miles**
- **NEVs: 24 models, 372 NEVs, 200,000 test miles**
- **BEVs: 47 models, 2,000 BEVs, 5 million test miles**
- **UEVs: 3 models, 460 UEVs, 1 million test miles**
- **Other testing includes hydrogen ICE vehicle and infrastructure testing**

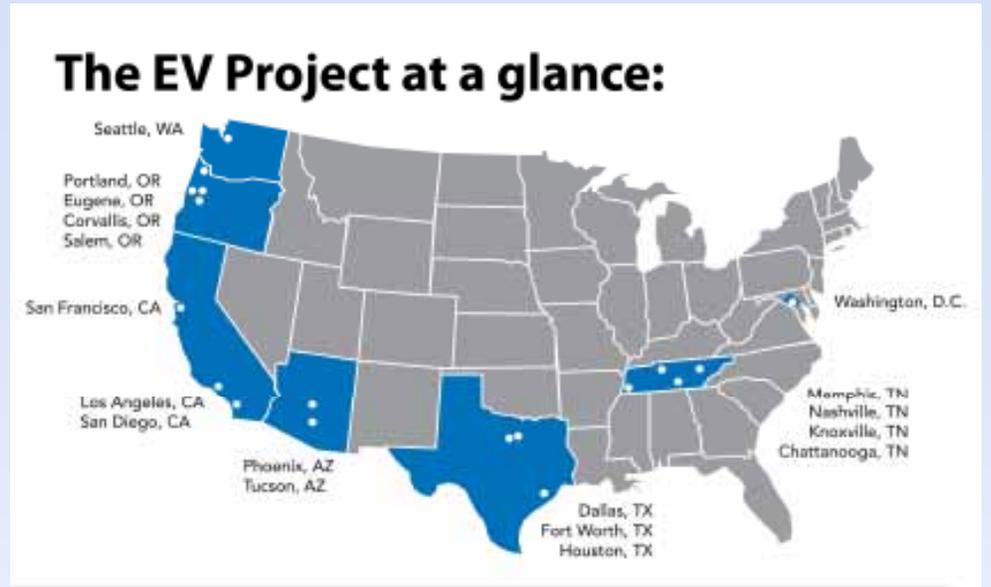
# INL Vehicle/EVSE Data Management Process



# Data Security, Protection and Use

- **All vehicle, EVSE, and personal information raw data protected by NDAs (Non Disclosure Agreements)**
  - Limitations on how proprietary data can be distributed, stored, and used
  - No raw data can or will be distributed by INL
  - Raw data, in both electronic and printed formats, is not shared with DOE in order to avoid exposure to FOIA
- Vehicle and EVSE data collection would not occur unless the above limitations are strictly adhered by INL
- **The AVTA has used data loggers on vehicles and EVSE (electric vehicle supply equipment) since 1993 to benchmark vehicle and charging equipment profiles**

# EV Project Locations and Goal



- 18 current locations with more being added
- **Goal: Build and study mature charging infrastructures and take the lessons learned to support the future streamlined deployment of grid-connected electric drive vehicles**
- **ECOtality is the EV Project lead, with INL, Nissan and GM/OnStar as significant partners**
- **EV Project reporting requires INL to blend three distinct data streams based on GPS and time/date stamps, and provide independent reports to DOE, ECOtality, project participants, industry, and the general public**

# EV Project – EVSE Data Parameters Collected per Charge Event

- Data from ECOtality's Blink EVSE network
- Unique ID for Charging Event
- Unique ID Identifying the EVSE
- **Date/Time Stamp**
- **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**
- **And other non-dynamic EVSE information (GPS, ID, type, contact info, etc.)**



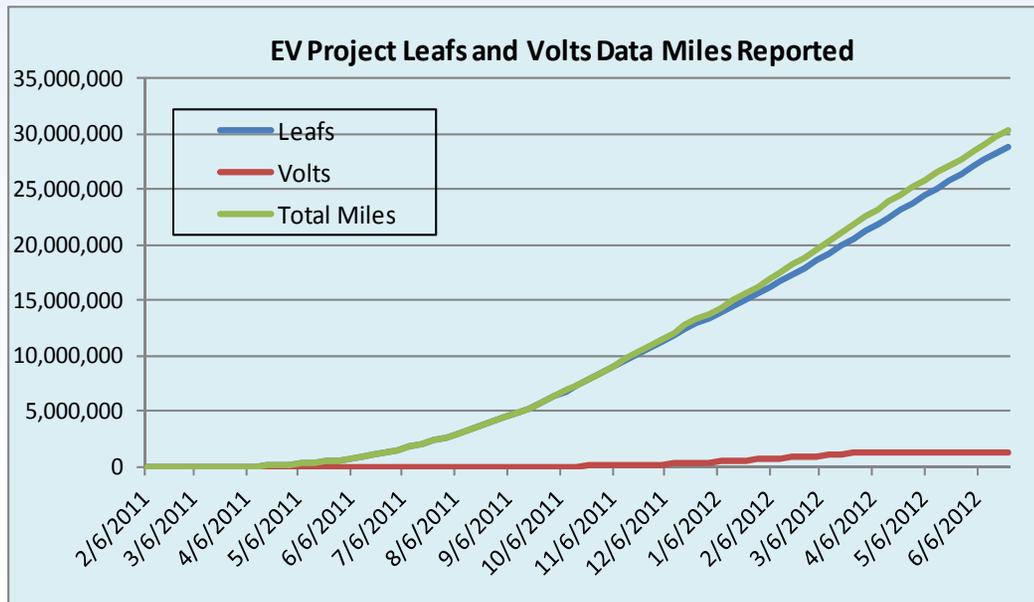
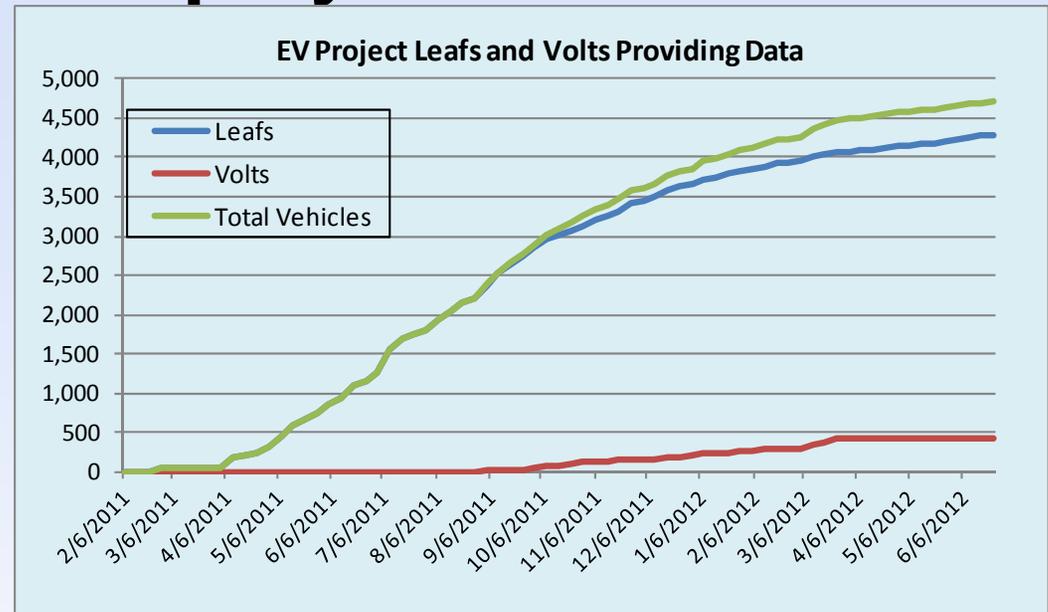
# EV Project – Vehicle Data Parameters Collected per Start/Stop Event

- Data is received via telematics providers from Chevrolet Volts and Nissan Leafs
- Vehicle ID
- Event type (key on / key off)
- Odometer
- Battery state of charge
- Date/Time Stamp
- GPS (longitude and latitude)
- Recorded for each key-on and key-off event

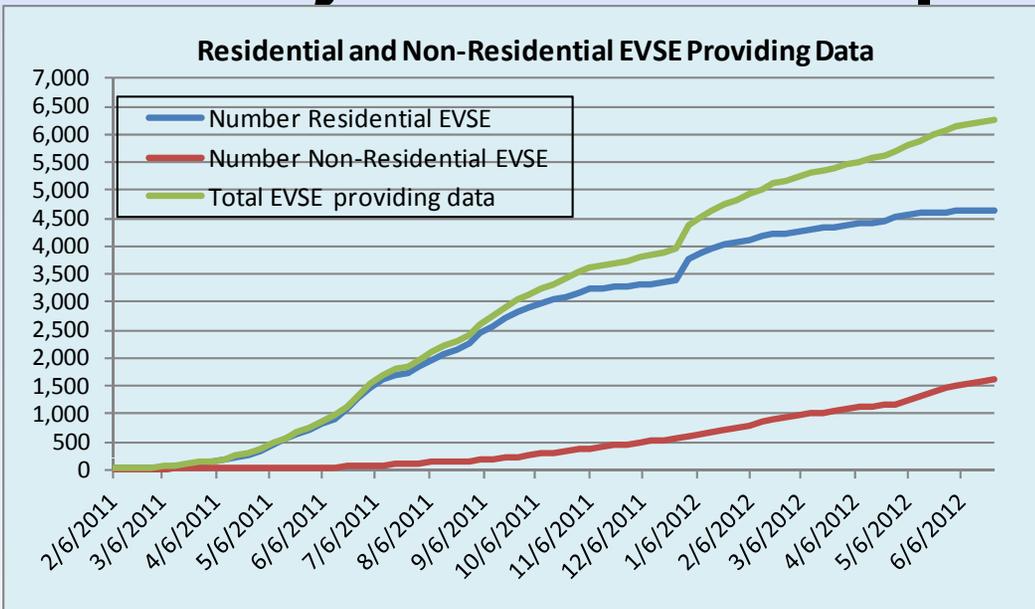


# EV Project – Vehicle Deployments / Miles

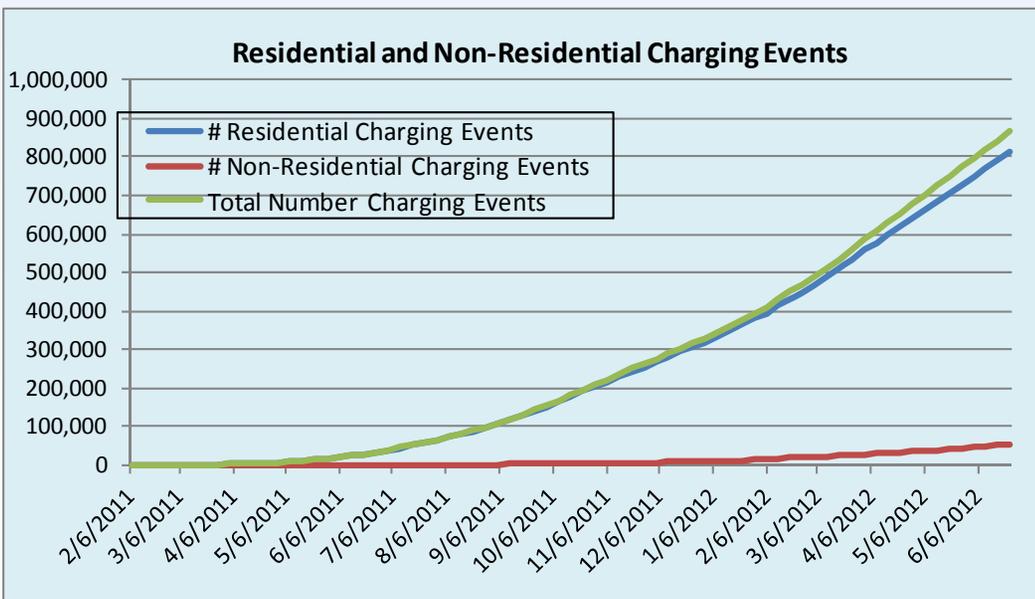
- 4,278 Leafs (6/24) and 428 Volts (4/01) reporting data
- 4,706 vehicles and growing
- 30.3 million total miles
- 105,000 test miles per day



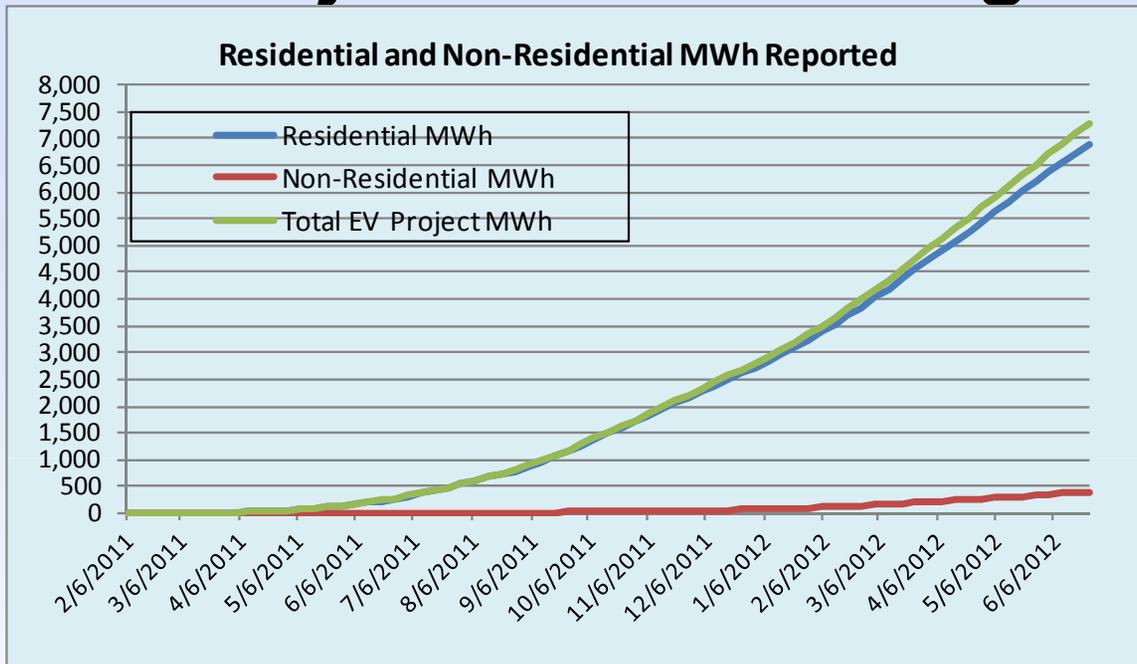
# EV Project – EVSE Deployment and Use



- 4,634 Res. EVSE
- 1,623 non-Res EVSE
- **6,257 total EVSE**
- **865,000 charge events**
- **3,500 charge events per day**
- **Non-Residential includes DCFC**
- **Above as of 6/24/12**
- **Data is continuously back-filled**



# EV Project – Total Charge Energy (MWh)



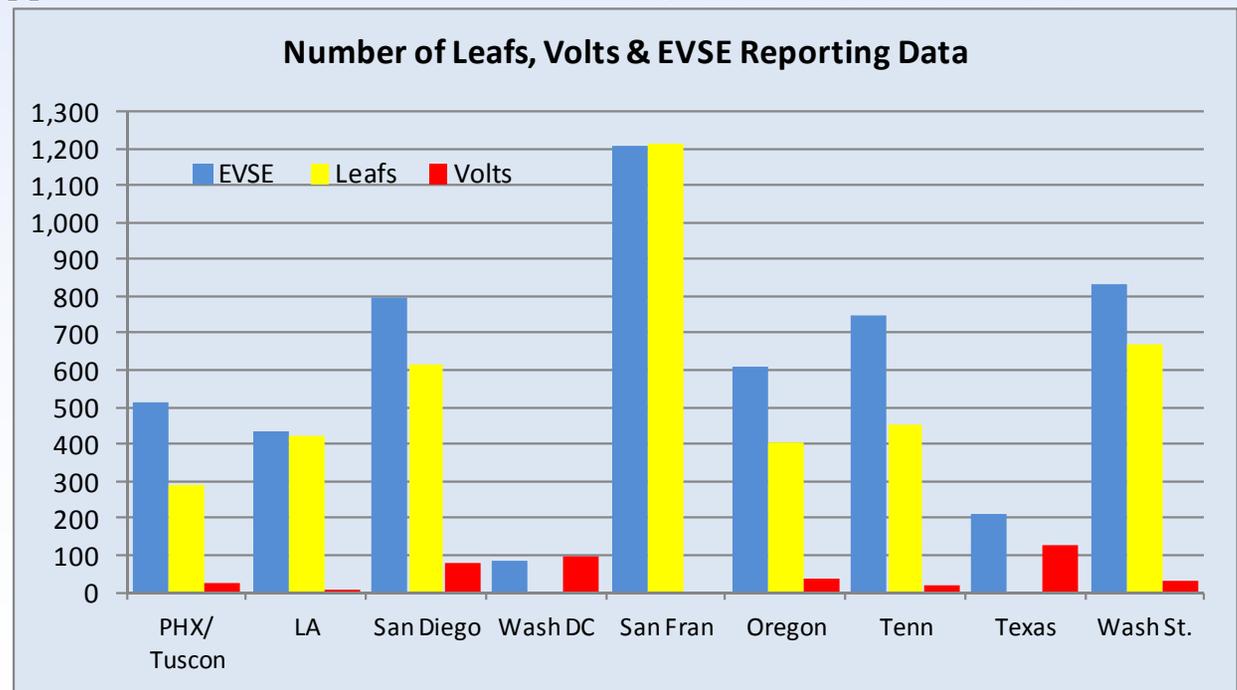
- 6,888 MWh residential
- 401 MWh non-residential
- 7,300 MWh total electricity charged
- 26 MWh used for charging per day

- Vehicle efficiency cannot be accurately calculated using total vehicle miles and total energy
- Non-EV Project vehicles sometimes charge at EV Project EVSE
- EV Project vehicles may charge at 110V or other 240V non-EV Project EVSE

# EV Project – Overview Report 1st Quarter

- Vehicles and charging infrastructure deployed to date 1<sup>st</sup> quarter 2012 and data received by INL
- Charging infrastructure
  - 5,432 units installed
  - 665,968 charging events
  - 5,069 AC MWh
- Vehicles
  - 4,066 Leafs
  - 427 Volts
  - 22.6 million miles

- **Regional analyses are conducted and reported each quarter as 4 summary reports (93 pages last quarter)**



# EV Project – Vehicle Usage Report

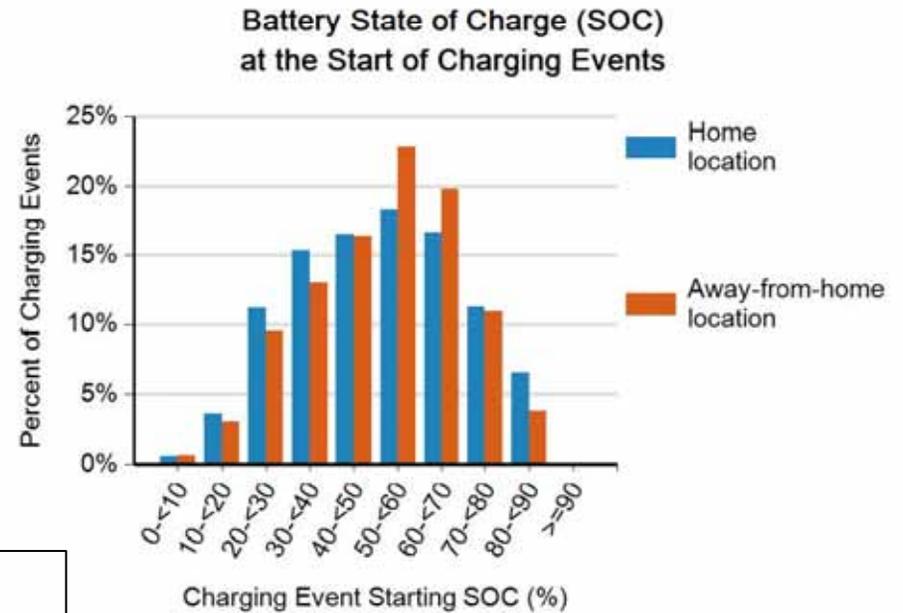
## Vehicle Usage – 1st quarter 2012

|   | <u>Leafs</u>   | <u>Volts</u>   |
|---|----------------|----------------|
| • Number of vehicles                                  | 2,987          | 317            |
| • Number of Trips                                     | 773,602        | 76,425         |
| • Distance (thousands)                                | 5,558 mi       | 610 mi         |
| • <b>Average (Ave) trip distance</b>                  | <b>7.2 mi</b>  | <b>8.0 mi</b>  |
| • <b>Ave distance per day</b>                         | <b>30.2 mi</b> | <b>36.4 mi</b> |
| • <b>Ave number (#) trips between charging events</b> | <b>3.8</b>     | <b>3.0</b>     |
| • <b>Ave distance between charging events</b>         | <b>27.4 mi</b> | <b>24.1 mi</b> |
| • <b>Ave # charging events per day</b>                | <b>1.1</b>     | <b>1.5</b>     |

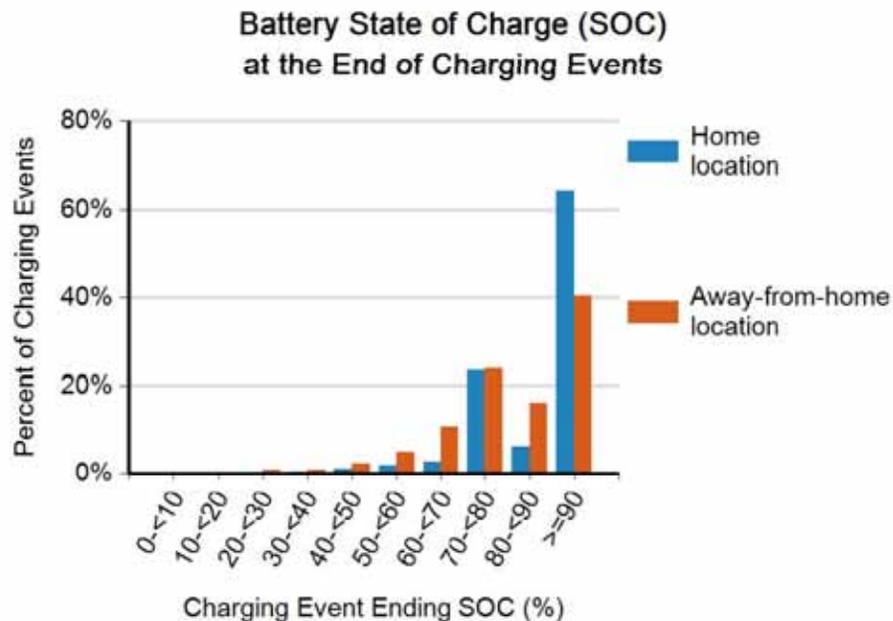
**Note that per day data is only for days a vehicle is driven**

# EV Project – Leaf Usage Report (1<sup>st</sup> ¼ 2012)

- **Battery state-of-charge quarterly trends may indicate greater driver confidence in vehicle range and EVSE availability**

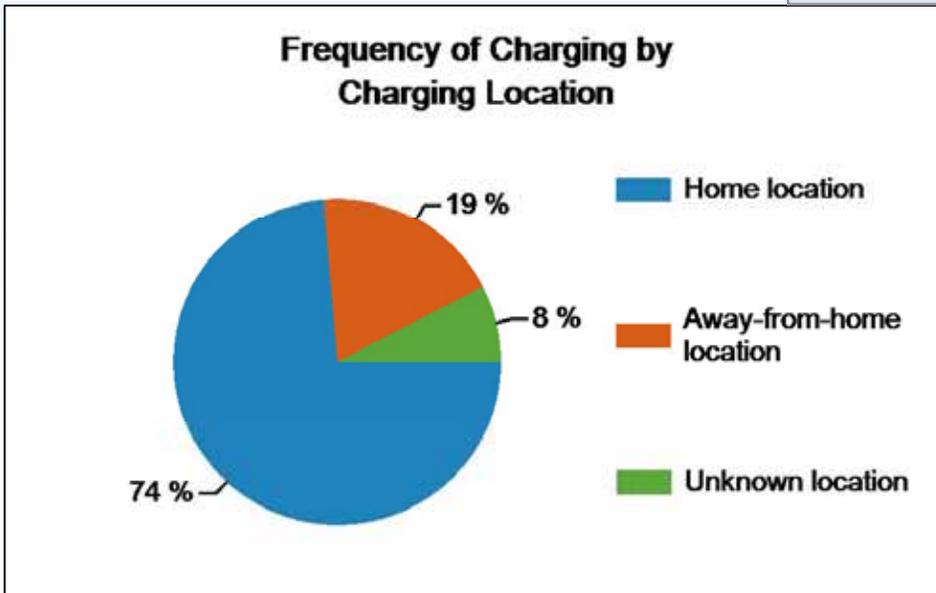
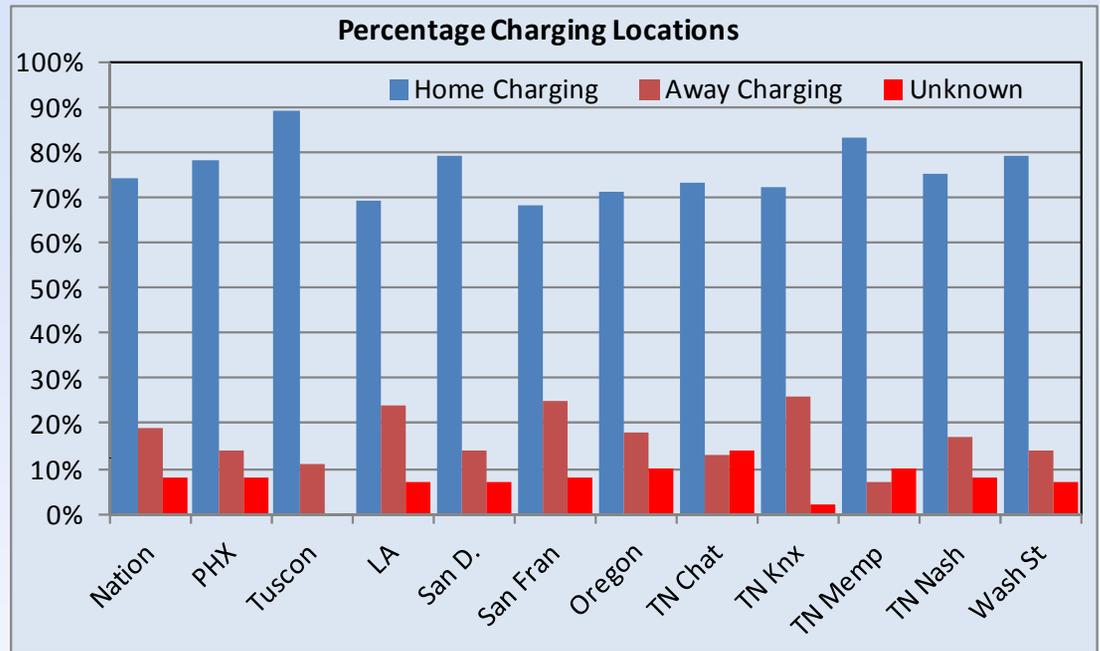


- **SOC is also available for Volts**



# EV Project – Leaf Usage Report (1<sup>st</sup> ¼ 2012)

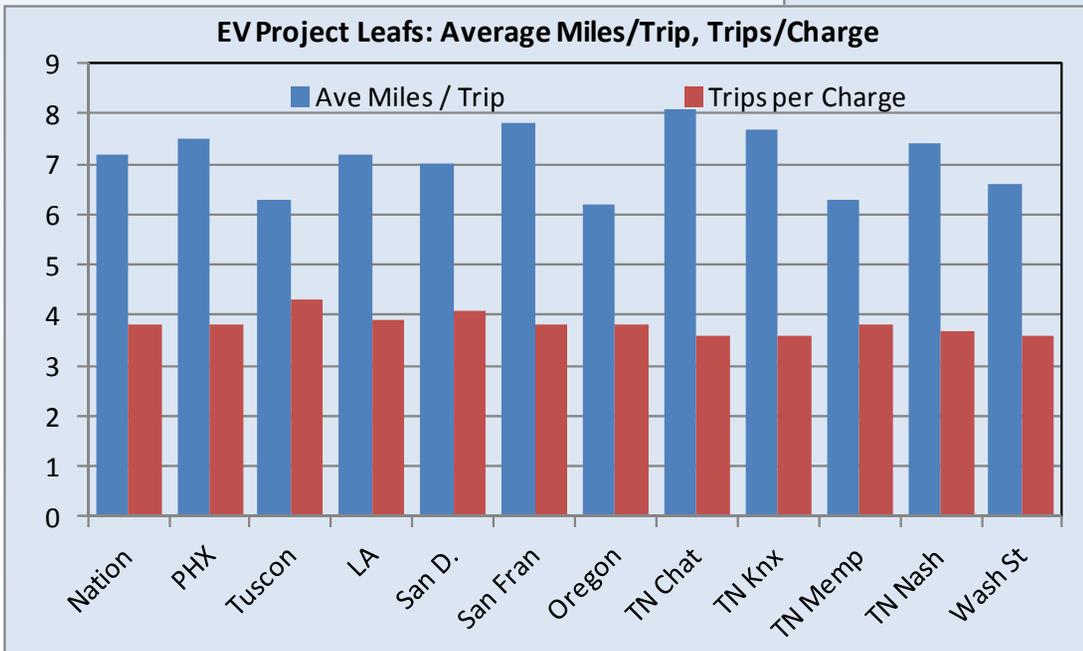
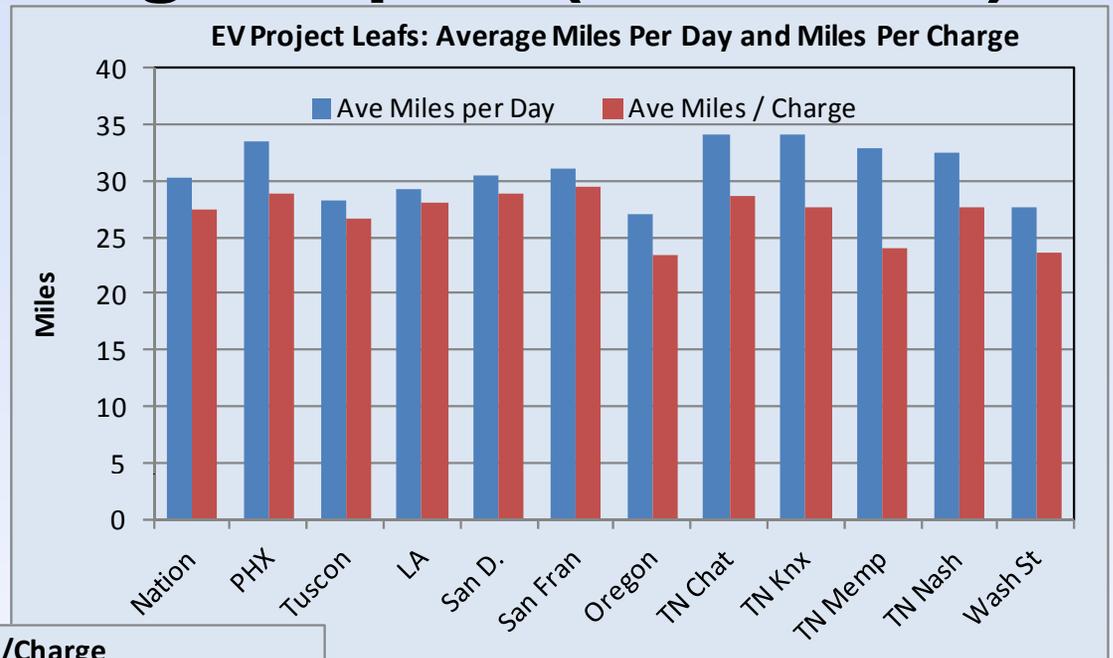
- Regional variations in charge behavior
- Possible rich versus non-rich public charge environment impacts



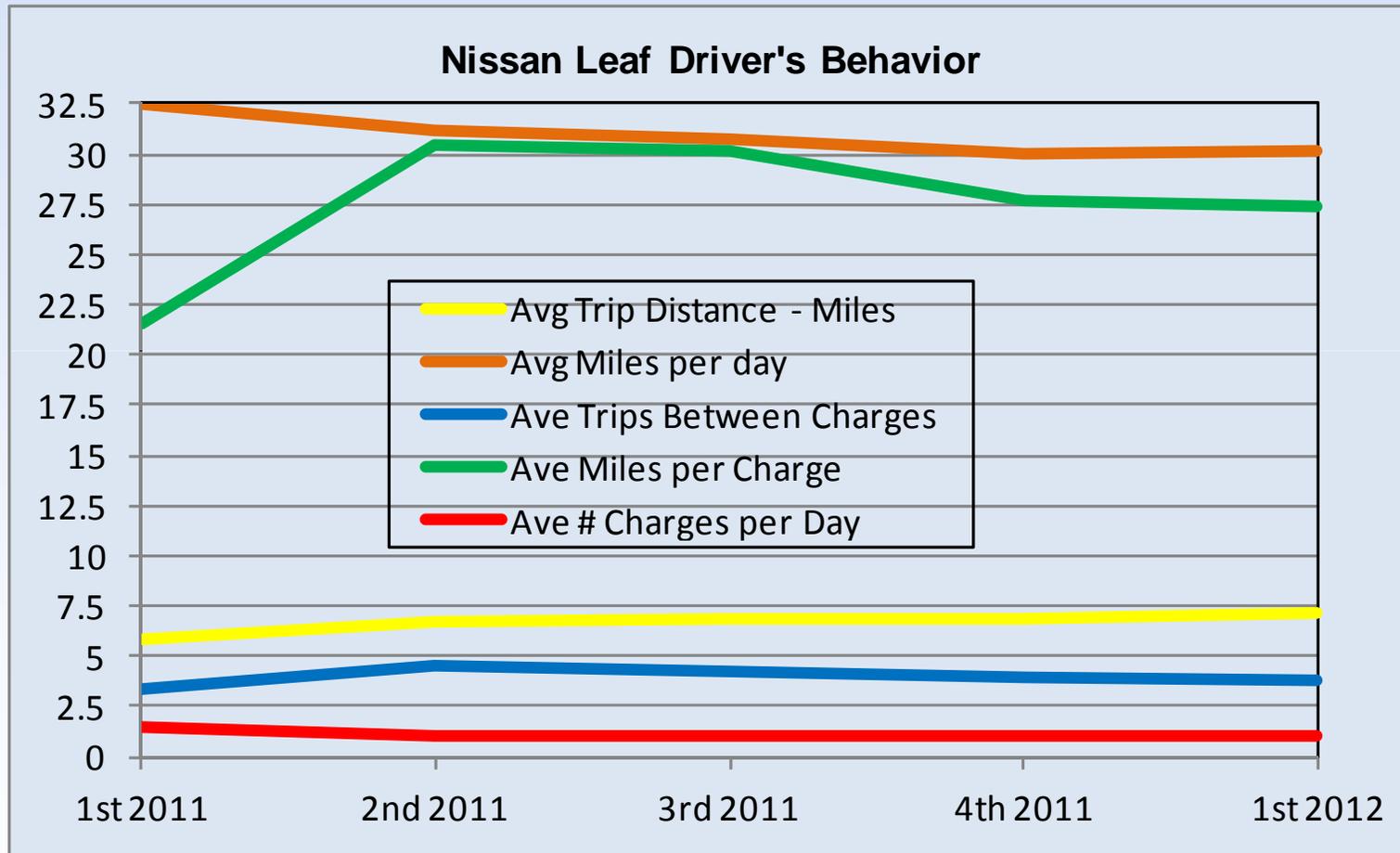
- Data is also available for Volts

# EV Project – Leaf Usage Report (1<sup>st</sup> ¼ 2012)

- Regional variations in drive profiles
- Need to be compared to ICE vehicle travel patterns (if data available)

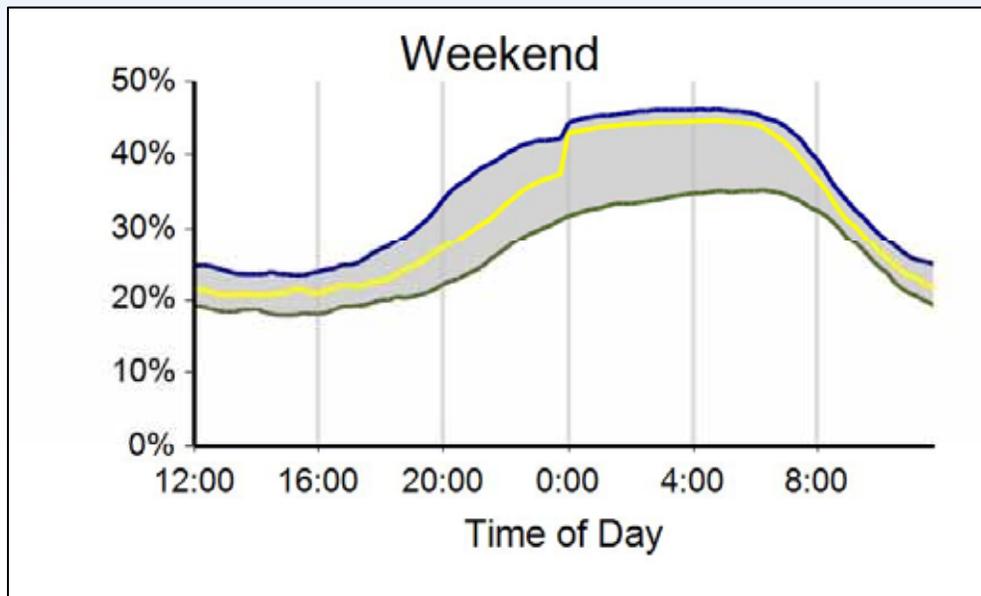
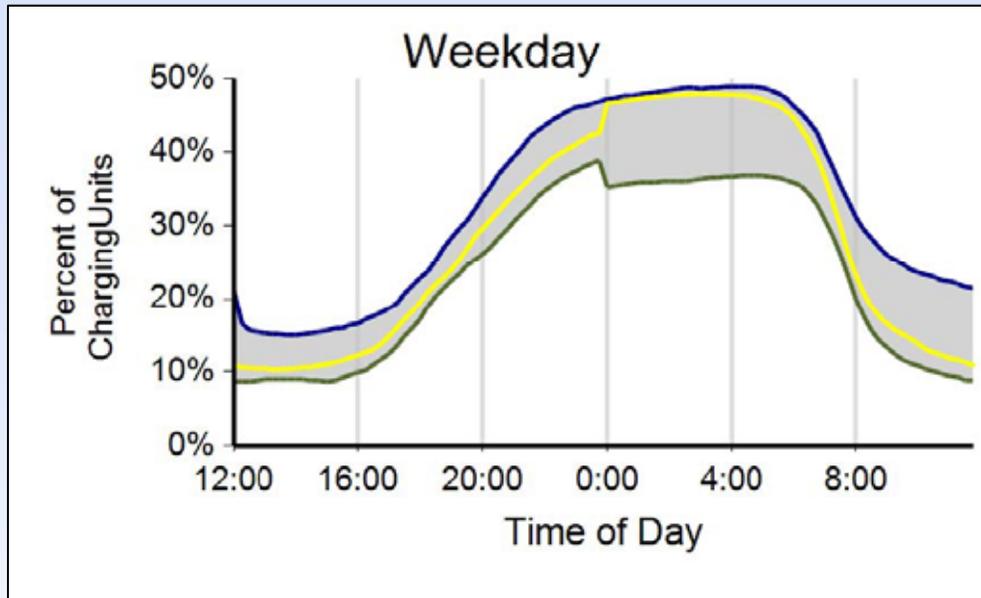


# EV Project – Leaf Usage Report 5 Quarters



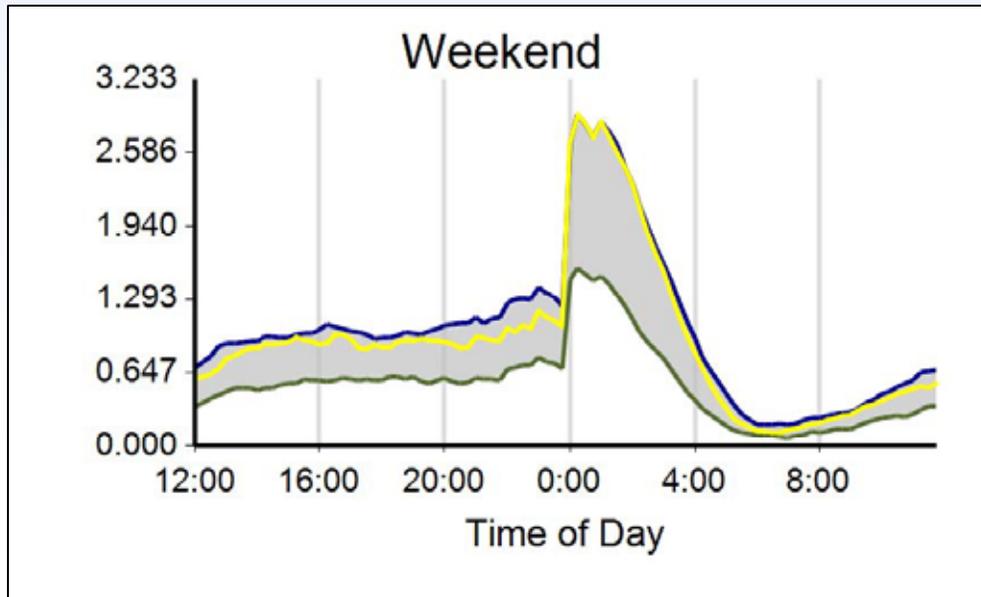
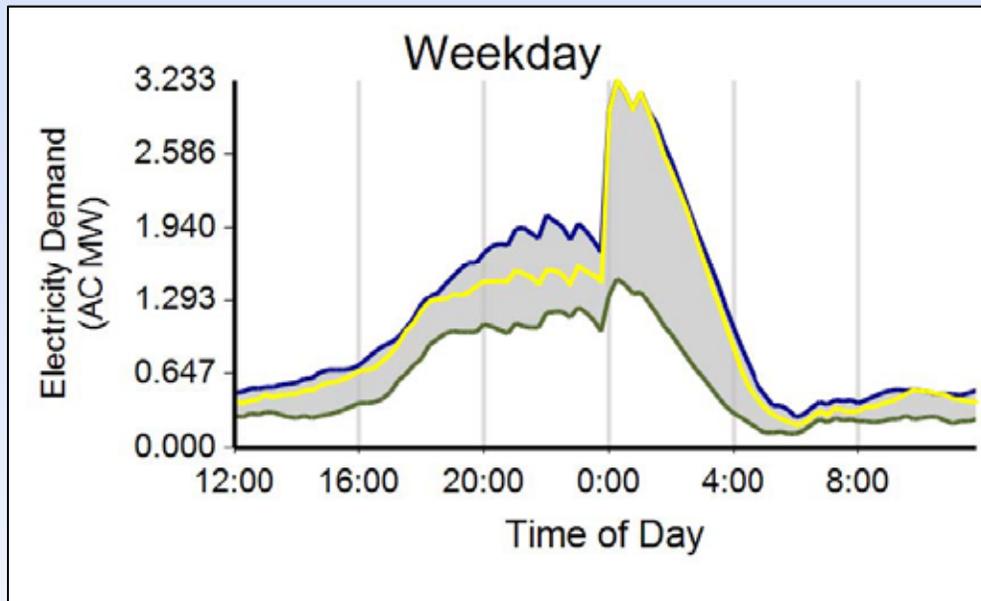
- **Seasonal variations may not be significant yet, given low number of vehicles and “early adapters” in early quarters**

# EV Project – EVSE Infra. Summary Report



- **Charging Availability**
- National Data
- Range of Percent of Charging Units with a Vehicle Connected vs. Time of Day
- 1<sup>st</sup> quarter 2012
- 3,324 residential and 955 publicly available Level 2 EVSE
- 10 DC fast chargers
- **51,476 values calculated just for 1<sup>st</sup> quarter 2012 infrastructure (Infra.) report**

# EV Project – EVSE Infra. Summary Report

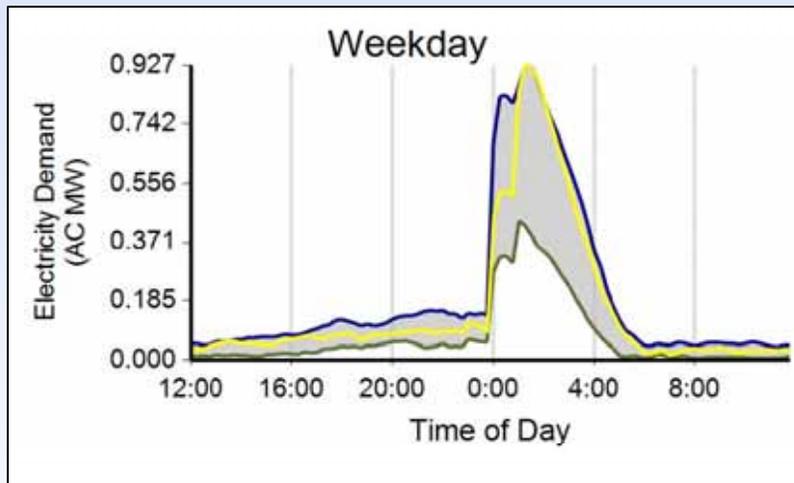


- **Charging Demand**
- National Data
- Range of Aggregate Electricity Demand vs. Time of Day (AC MW)
- 1<sup>st</sup> quarter 2012
- 3,324 residential and 955 publicly available Level 2 EVSE
- 10 DC fast chargers
- **Time of day kWh rates are influencing charging start times as measured by AC MW demand**

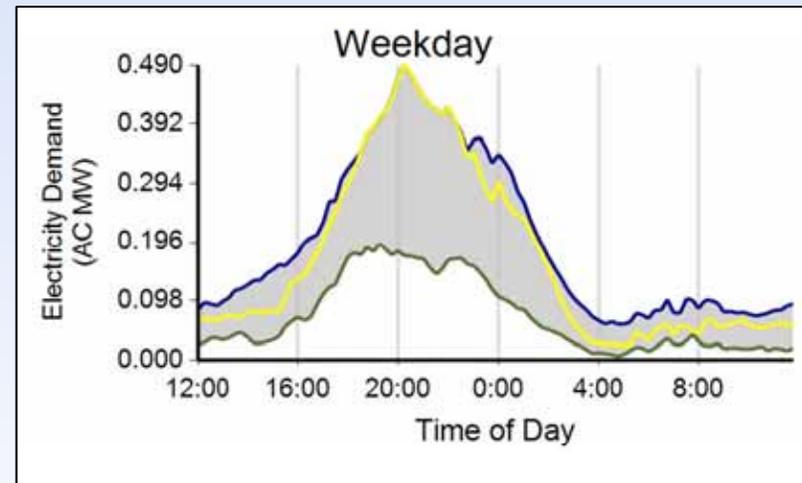
# EV Project – EVSE Infra. Summary Report

- Residential Level 2 Weekday EVSE 1<sup>st</sup> Quarter 2012
- **Time of day kWh rates clearly influence charge patterns**

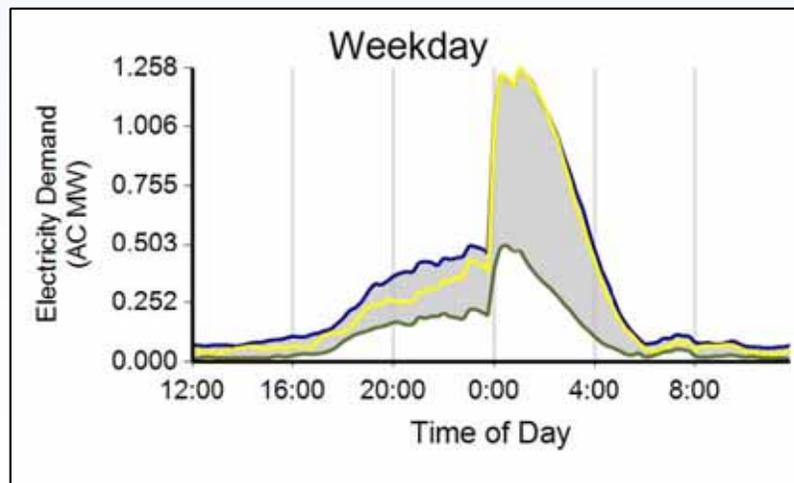
San Diego



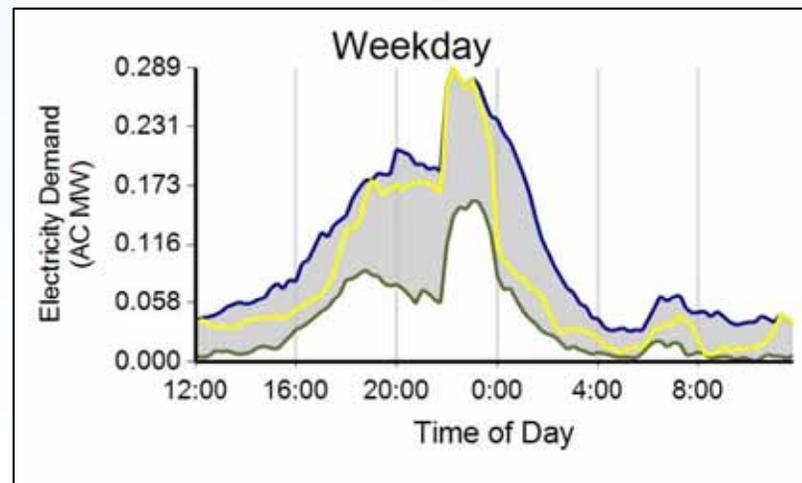
Washington State



San Francisco



Oregon



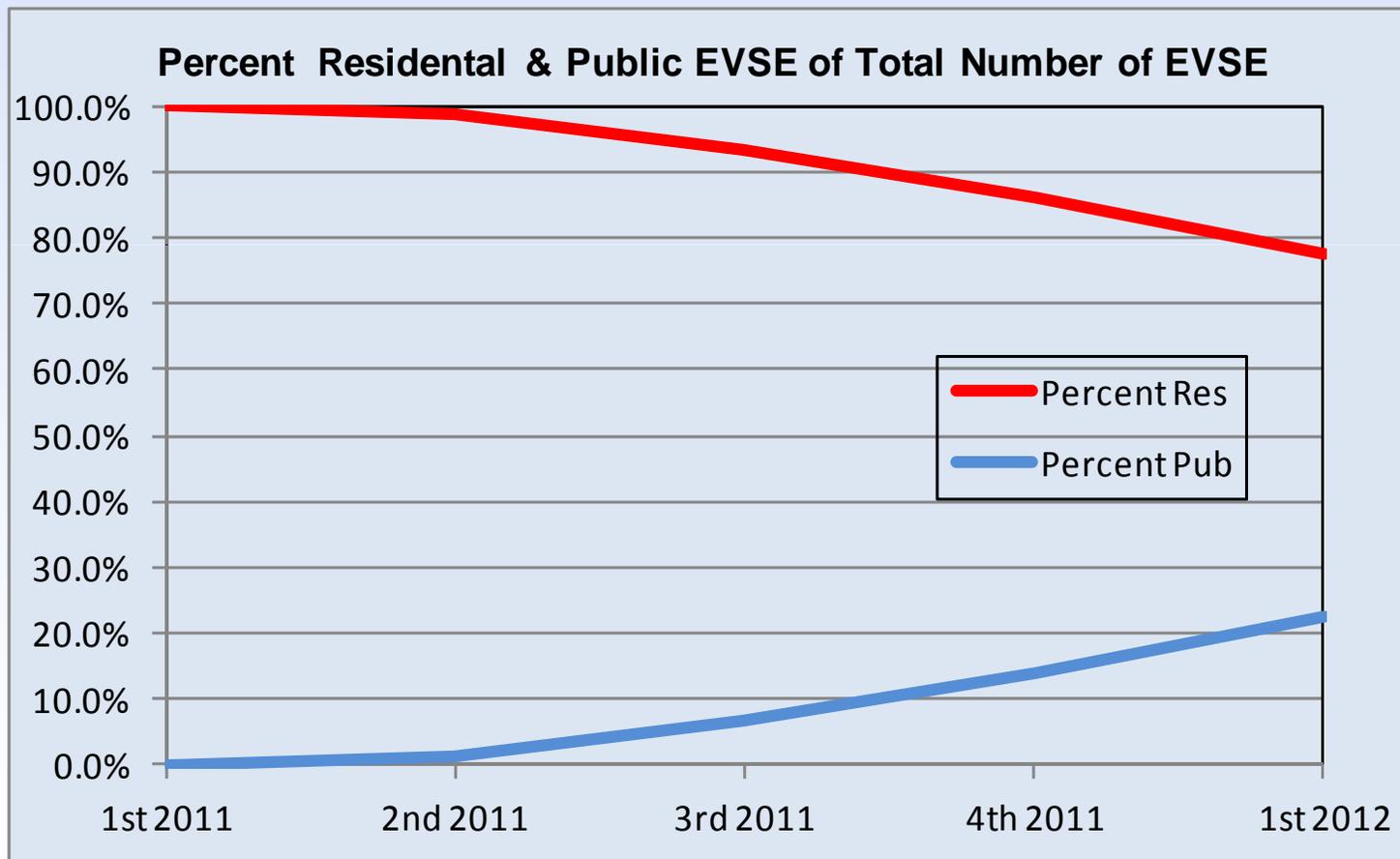
# EV Project – EVSE Infra. Summary Report

- National Data – 1<sup>st</sup> quarter 2012
  - Ave time vehicle connected R2 WD **11.4 hours**
  - Ave time vehicle connected R2 WE **11.8 hours**
  - Ave time vehicle drawing power R2 WD **2.4 hours**
  - Ave time vehicle drawing power R2 WE **2.0 hours**
  - Ave energy per charge event R2 WD **8.7 AC kWh**
  - Ave energy per charge event R2 WE **7.3 AC kWh**
  - Ave time vehicle connected P2 WD **6.3 hours**
  - Ave time vehicle connected P2 WE **4.1 hours**
  - Ave time vehicle drawing power P2 WD **2.1 hours**
  - Ave time vehicle drawing power P2 WE **1.9 hours**
  - Ave energy per charge event P2 WD **7.3 AC kWh**
  - Ave energy per charge event P2 WE **6.6 AC kWh**
- **Yes, this is an ugly slide**
- R: residential, P: public, WD: weekday, WE: weekend, 2: Level 2 EVSE



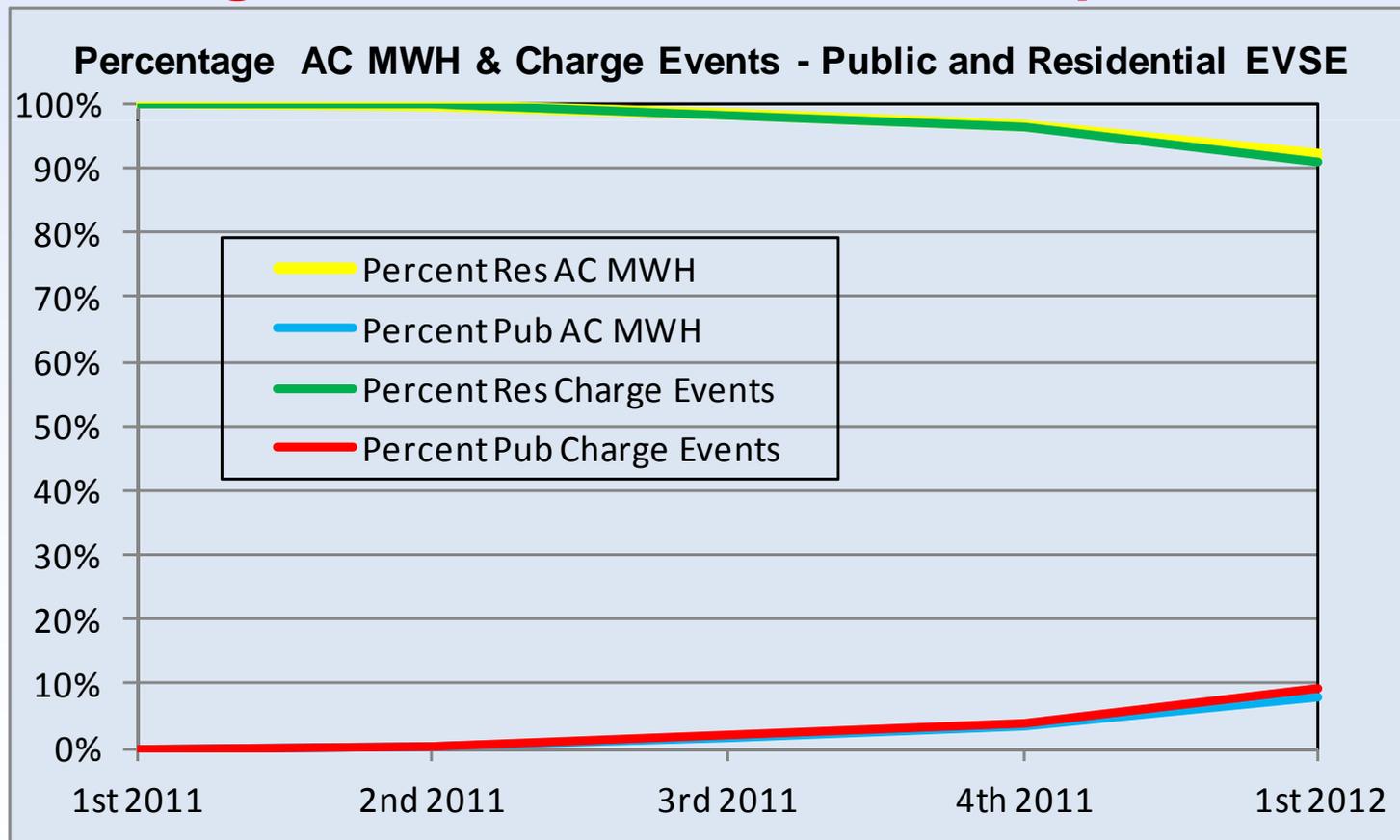
# EV Project – EVSE Infra. Summary Report

- **Percent of public EVSE deployed is increasing (22%)**
- **However, use is increasing at a slower rate (next slide)**



# EV Project – EVSE Infra. Summary Report

- Percent charge events and AC MWH use by residential and public EVSE each reporting quarter
- **Percent public EVSE use (red and blue lines) is clearing increasing as it is deployed in larger numbers**
- **9.1% charge events and 8.0% MWh 1<sup>st</sup> quarter 2012**



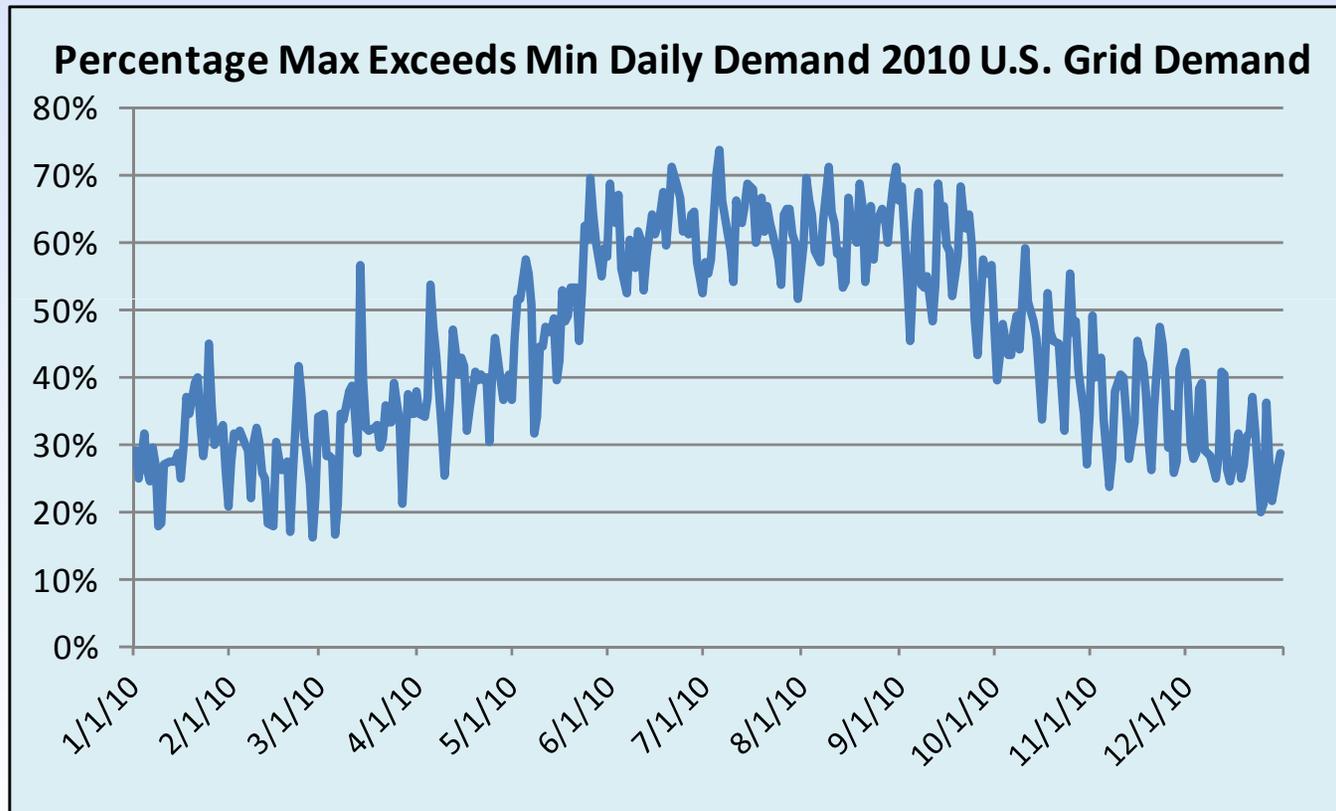
# U.S. Grid Impacts

- **Average daily delta between peak and off peak demand**

|                               |       |
|-------------------------------|-------|
| Arizona Public Service Co.    | 33.7% |
| Salt River Project            | 32.2% |
| Tucson Electric Power Co.     | 34.0% |
| LA Dept of Water & Power      | 37.0% |
| Pacific Gas & Electric Co.    | 35.2% |
| San Diego Gas & Electric Co.  | 39.8% |
| Portland General Electric Co. | 35.6% |
| Puget Sound Energy            | 35.7% |
| Seattle City Light            | 33.0% |
| Arizona Public Service Co.    | 33.7% |
| Average above utilities       | 35.1% |

# U.S. Grid Impacts

- Average daily delta between peak and off peak demand



# U.S. Grid Impacts

- **Average daily U.S. maximum demand is 45% higher than minimum demand = off-peak has much excess generation**
- **2010 total generation was 4,125,060 GWh**
- **At 2,920 kWh per year (assumes approximate Leaf use)**
  - **1% of generation charges 14.1 million Leafs**
  - **2% of generation charges 28.3 million Leafs**
  - **3% of generation charges 42.4 million Leafs**
  - **4% of generation charges 56.5 million Leafs**
  - **5% of generation charges 70.6 million Leafs**
- **Macro grid impacts are of no concern for the immediate future**
- **Micro grid impacts, if any, will hopefully be identified by the EV Project**

# Other AVTA Projects for DOE

- Other vehicle data collection activities
  - 150 Chevrolet Volt EREVs
  - 108 Chrysler Ram Pickup PHEVs
  - 21 Ford Escape Prototype PHEVs
  - 20 Quantum PHEV Escape conversions
  - 5 different US Postal Service electric delivery vehicle conversions
  - Field and laboratory fast charge study compares DC fast charging and Level 2 charging impacts on battery life in 6 vehicles
  - Above all equipped with lithium traction batteries



# More AVTA Projects for DOE

- Mass impacts on fuel efficiency of HEVs, ICEVs and BEVs
- Conducting testing of “dumb” and “smart” EVSE
- Initiated wireless charging test program
- Benchmarking ChargePoint America project with 2,453 EVSE deployed, 223,000 charge events & 1,500 AC MWH
- Other EVSE providers have started to provide charging data to INL
- Initiated first responders training program with the National Fire Prevention Association and NHTSA
- Battery mule test vehicle provides field testing of traction battery packs at any power and efficiency level



# EV Project Summary To Date

- EV Project vehicles connected much longer than needed to recharge - opportunities to shift charging times
- Significant residential Level 2 EV Project charging occurs off-peak with charge-starts occurring at the midnight starts of super off-peak kWh rates
- Significant opportunities to fully understand how the public uses public versus non-public infrastructure
- Revenue models for public charging being introduced – impacts?
- Only about 30% of EV Project data collected to date
- “Normal” research project process requires:
  - Design and execute the project, data collection completed, data analyzed, and finally, reports issued at completion of experiment
- INL/ECOtality needs to completely collect all data before definitively reporting seasonal trends and behaviors

# Future EV Project Data Analysis Subjects

- Pricing elasticity – TOU rate influences?
- Regional and seasonal demographics and charging behaviors?
- Density of residential and non-residential EVSE as input to local micro distribution studies – transformer failures?
- Charge control preferences – vehicle, Blink and web based, and scheduled versus random?
- Rich public versus non-rich EVSE charging behaviors?
- Level 2 EVSE versus DCFC behaviors?
- Travel corridor versus convenience charging at stores?
- Length of vehicle ownership and miles per day / week / charge?
- Non-residential subcategories (public and work parking)?
- Etc., etc., etc.?

# Acknowledgement

**This work is supported by the U.S. Department of Energy's EERE Vehicle Technologies Program**

**And this presenter is very grateful for their support**

## More Information

**<http://avt.inl.gov>**

**This presentation can be found in the publications section of the above website**

INL/CON-12-26525

