U.S. Department of Energy's Vehicle Technologies Program

NYC TLC - Plug-in Electric Vehicle Infrastructure and Usage Information

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New York, New York
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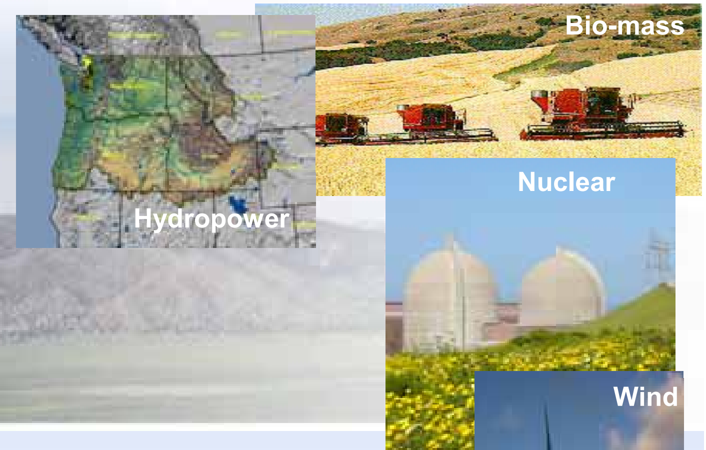
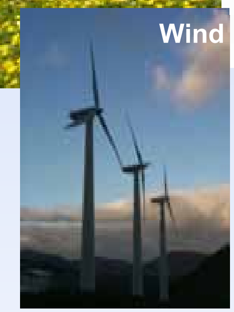
Idaho National Laboratory





- U.S. Department of Energy (DOE) 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
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Development
  - Homeland Security and Cyber Security

AVTA Participants

- The Advanced Vehicle Testing Activity (AVTA) is the U.S. Department of Energy, Vehicle Technologies Program's (VTP) singular field, tract, and laboratory based source of testing light-duty whole vehicle systems and subsystems
  - Idaho National Laboratory manages the AVTA for VTP
  - ECOtality provides testing support via a competitively bid NETL (National Energy Testing Laboratory) contract
- For the EV Project, ECOtality is the project lead and INL provides data collection, analysis and dissemination support
- Test partners include electric utilities, Federal, state and local government agencies, private companies, and individual vehicle owners

AVTA Goals

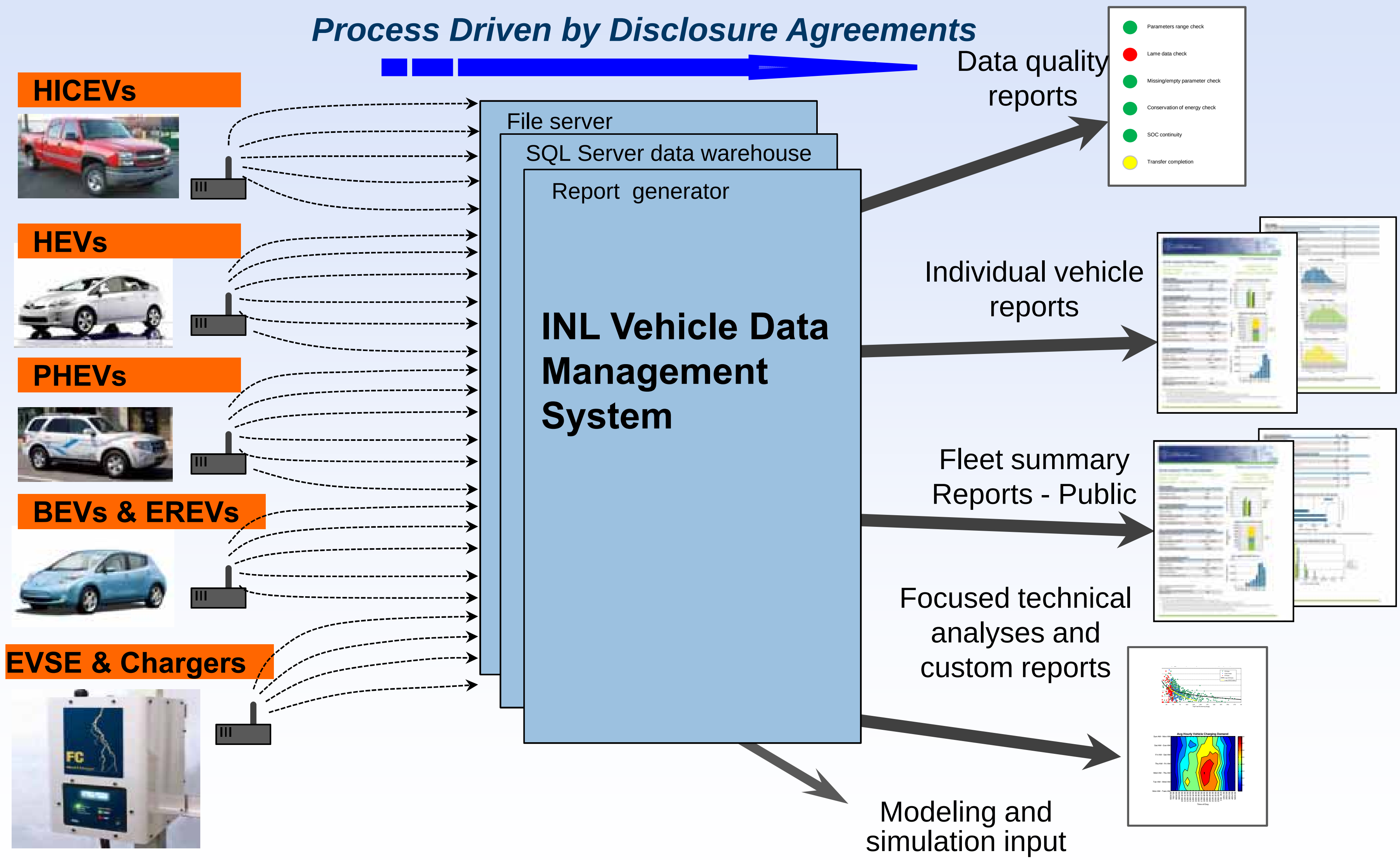
- The AVTA goals
  - Petroleum reduction and energy security
  - Benchmark technologies that are developed via DOE research investments
- Provide benchmark data to DOE, National Laboratories (ANL, NREL, ORNL, PNNL), Federal Agencies (DOD, DOI, DOT, EPA, USPS), technology modelers, R&D programs, vehicle manufacturers (via USCAR's VSATT, EESTT, GITT), 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

- 82 million test miles accumulated on 11,200 electric drive vehicles representing 115 models. 1 million miles / week
- EV Project: 7,700 Leafs, Volts and Smart EVs, 10,076 EVSE and DC Fast Chargers (DCFC), 64 million test miles
- ChargePoint: 3,908 EVSE reporting 761,000 charge events
- 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, 509,000 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

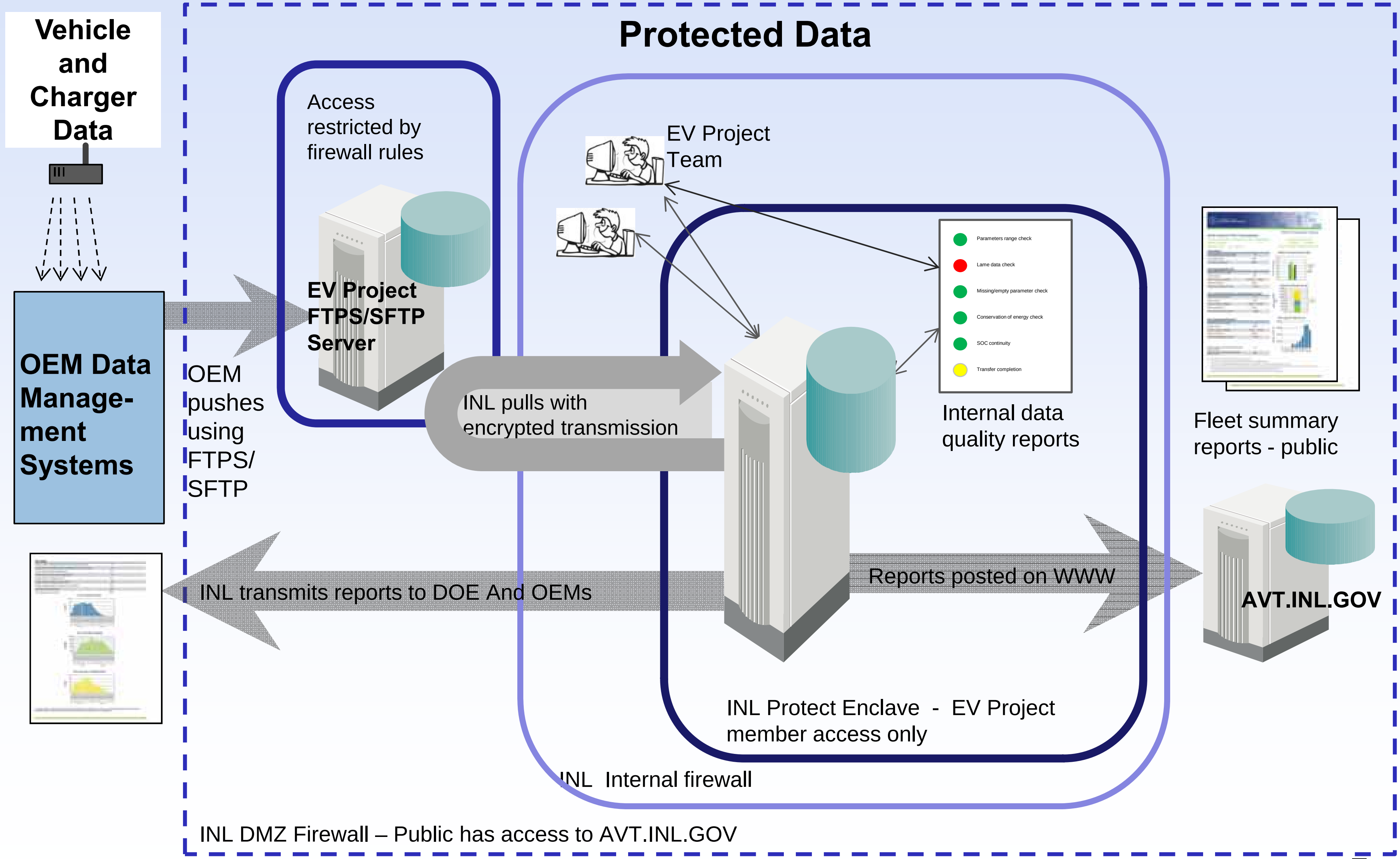
Note: all 4th quarter 2012 data is preliminary and subject to change

INL Vehicle/EVSE Data Management Process



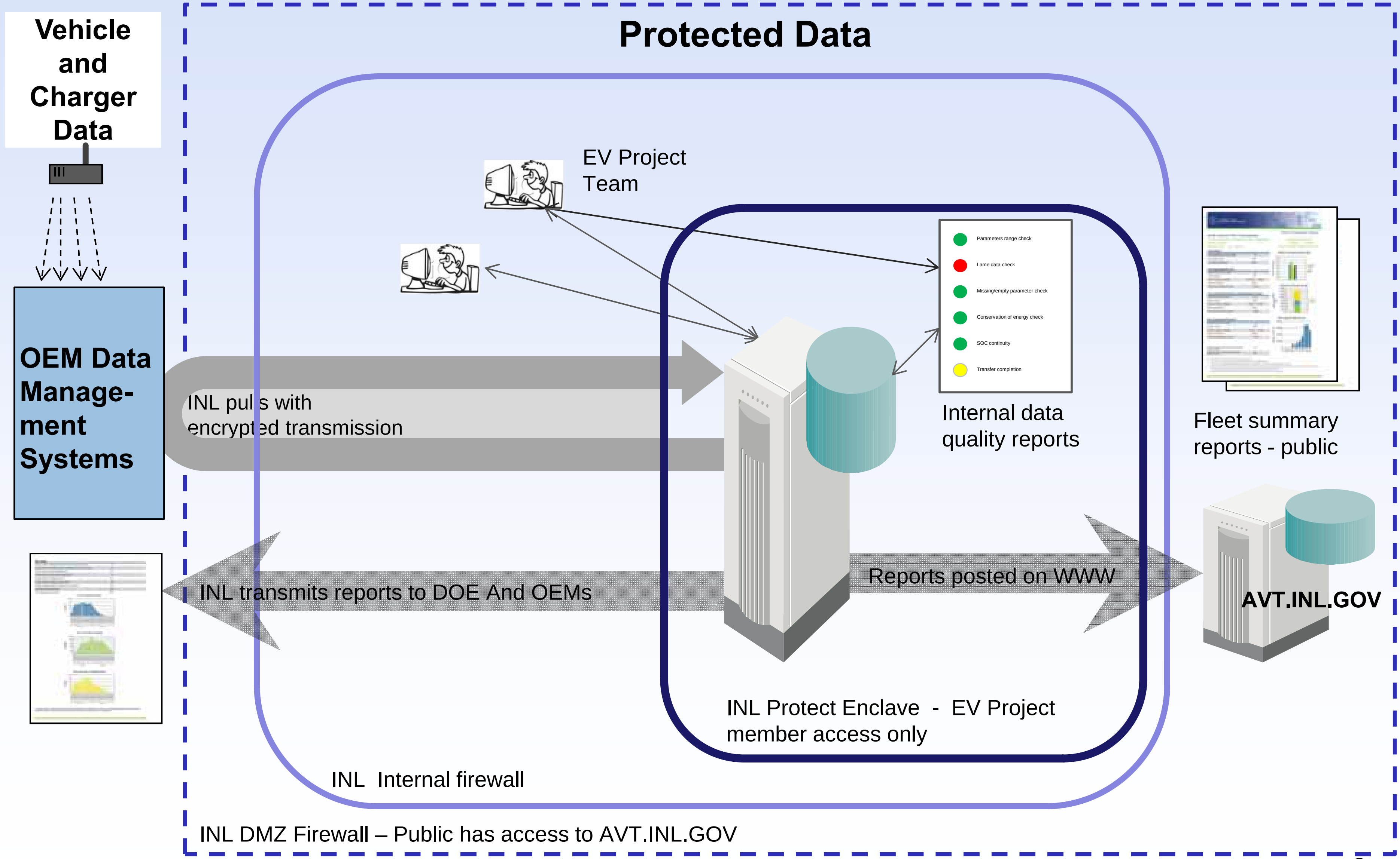
INL Data Management System - Push

(Nissan, GM, Chrysler, Coulomb, Aerovironment)



INL Data Management System - Pull

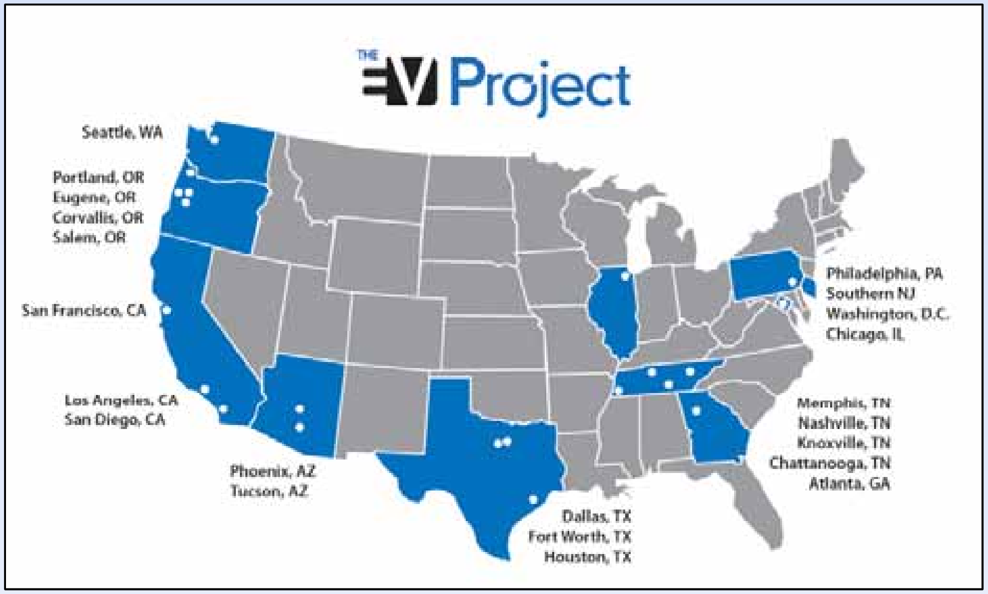
(ECOtality, Ford, conversion PHEVs, HEVs, HICEs)



Data Collection, Security and Protection

- **All vehicle, EVSE, and PII raw data is legally protected by NDAs (Non Disclosure Agreements) or CRADAs (Cooperative Research and Development 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 in order to avoid exposure to FOIA
  - Vehicle and EVSE data collection would not occur unless testing partners trust INL would strictly adhere to NDAs and CRADAs
  - **Raw data cannot be legally distributed by INL**

EV Project Goal, Locations, Participants, and Reporting



- 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 Onstar/GM as the prime partners, with more than 40 other partners such as electric utilities
- EV Project reporting requires INL to blend three distinct data streams from ECOtality, Nissan and Onstar/GM
- 40 different EV Project reports are generated quarterly for the general public, DOE, ECOtality, project participants, industry, regulatory organizations, as well as per special requests

EV Project – EVSE Data Parameters Collected per Charge Event

- Data from ECOtality's Blink EVSE network
- 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.)

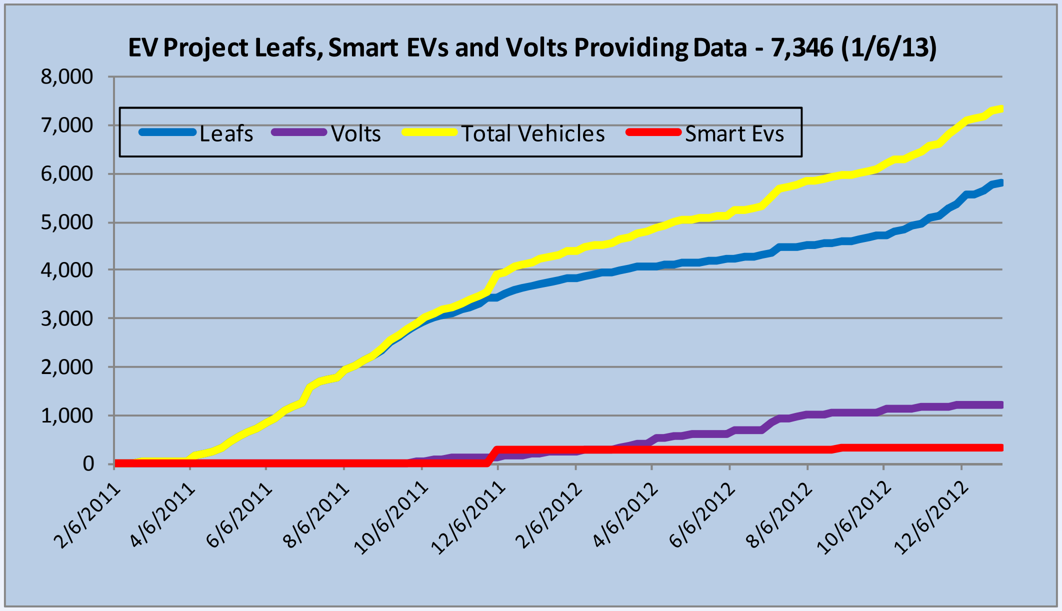
EV Project – Vehicle Data Parameters Collected per Start/Stop Event

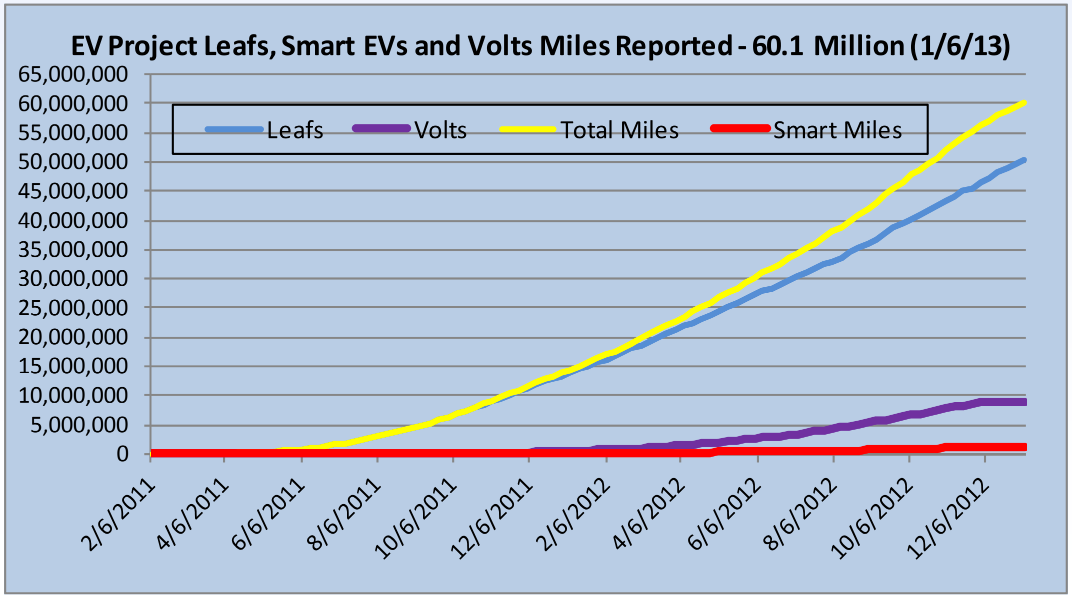
- Data is received via telematics providers from Chevrolet Volts and Nissan Leafs
- Odometer
- Battery state of charge
- Date/Time Stamp
- Vehicle ID
- Event type (key on / key off)
- GPS (longitude and latitude)
- Recorded for each key-on and key-off event

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

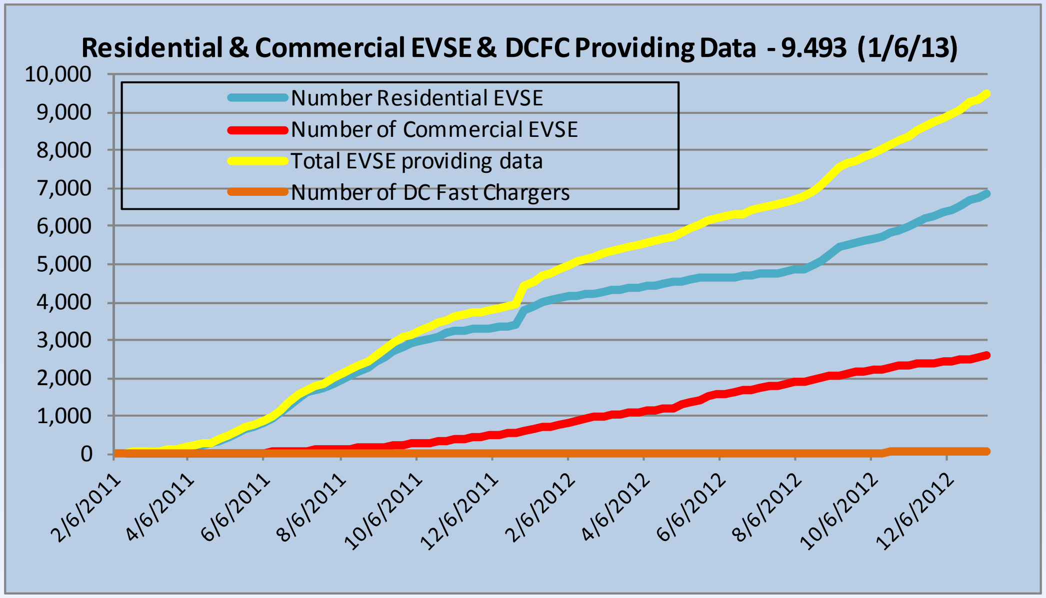
EV Project Vehicles / Miles, end of 2012

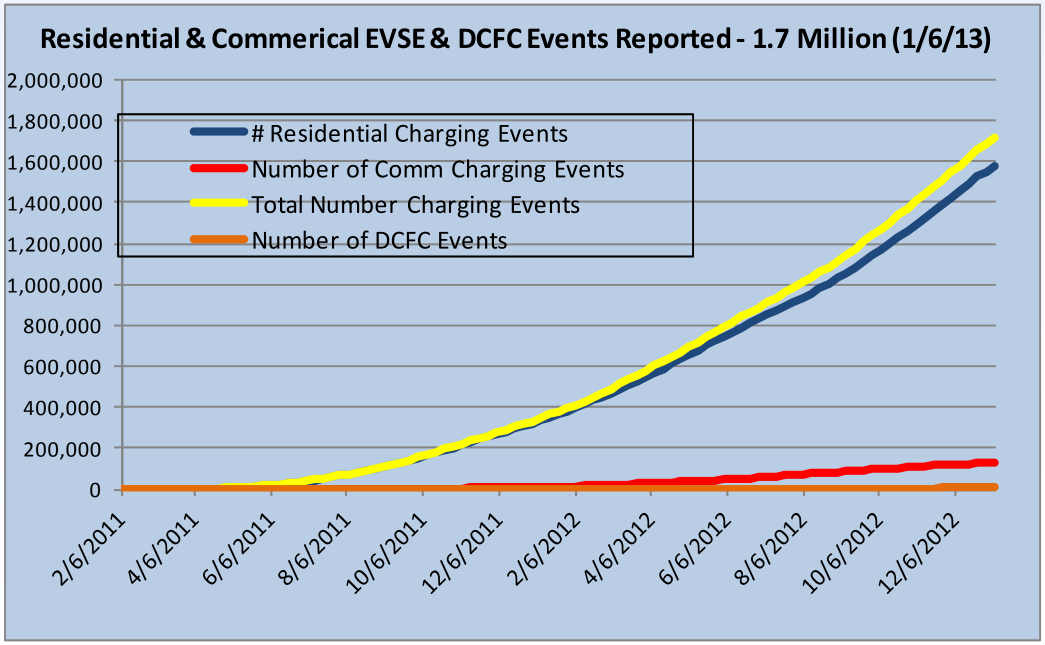
- 7,346 vehicles reporting data
  - 5,801 Leafs. 79%
  - 1,215 Volts. 17%
  - 330 Smart EVs. 4%
- 60.1 million total miles
- 150,000 test miles per day





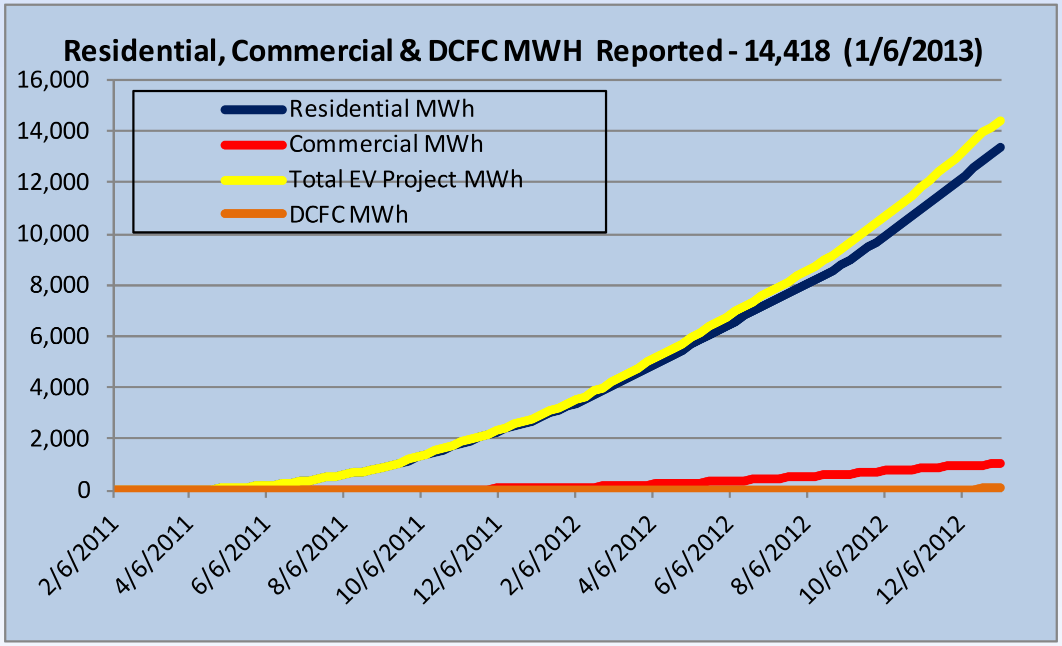
EV Project EVSE Deployed / Use end of 2012





- **9,493 total EVSE**
  - **6,864 (72%) Residential EVSE 2,575 (27%) non-residential EVSE**
  - **54 (1%) DCFC**
- **1.7 million charge events**
  - **1,579,894 (92%) Residential EVSE**
  - **131,298 (8%) non-residential EVSE**
  - **8,820 (1%) DCFC**

EV Project Charge Energy (MWh) end of 2012

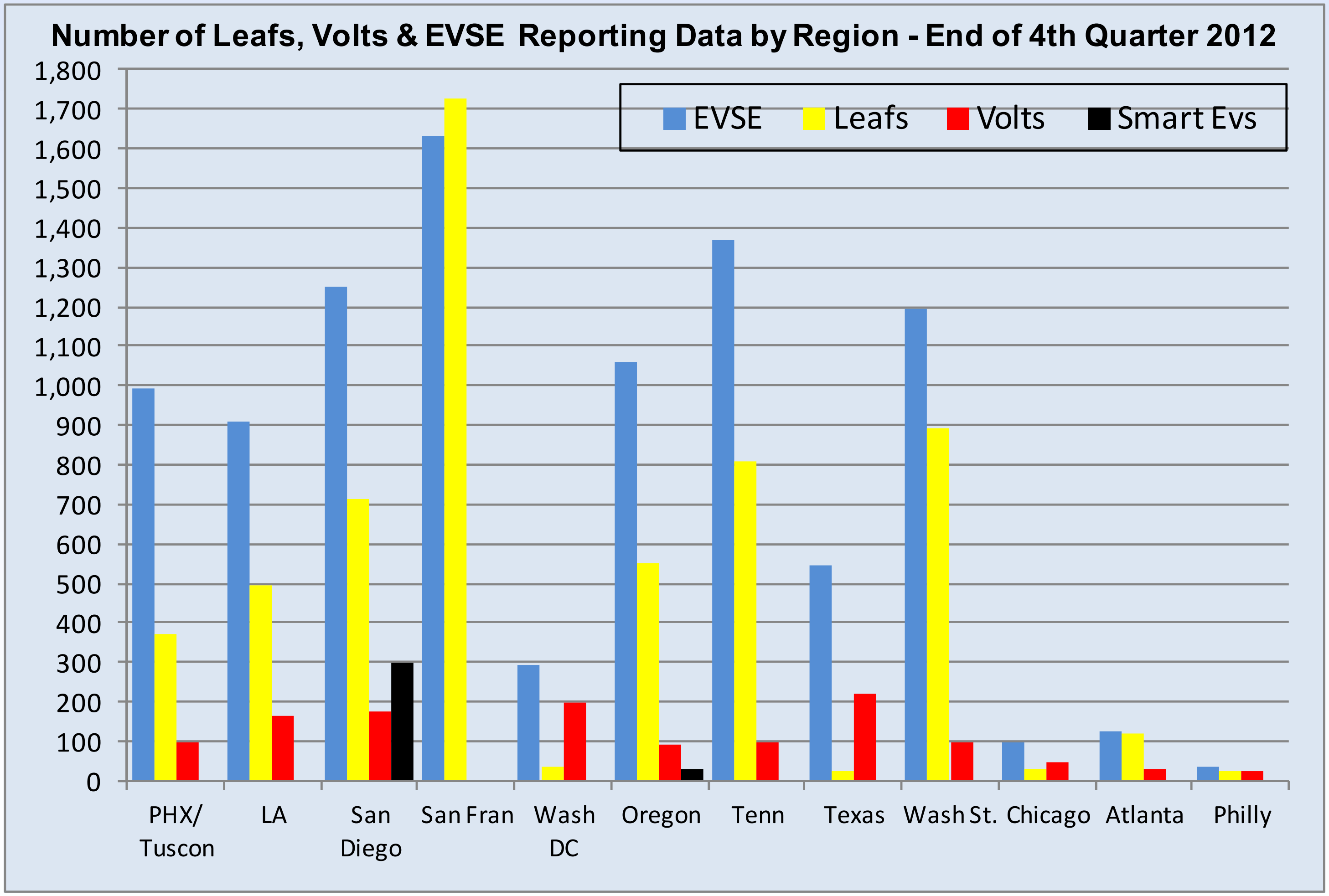


- **14,418 MWh total electricity charged**
  - **13,328 MWh (92%) residential**
  - **1,029 MWh (7%) non-residential**
  - **61 MWh (0.4%) DCFC 0**

- **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 4th Quarter 2012

- San Francisco has 17% of all EVSE 30% of all Leafs
- Washington DC has 16% and Texas has 18% of all Volts



EV Project – National Data

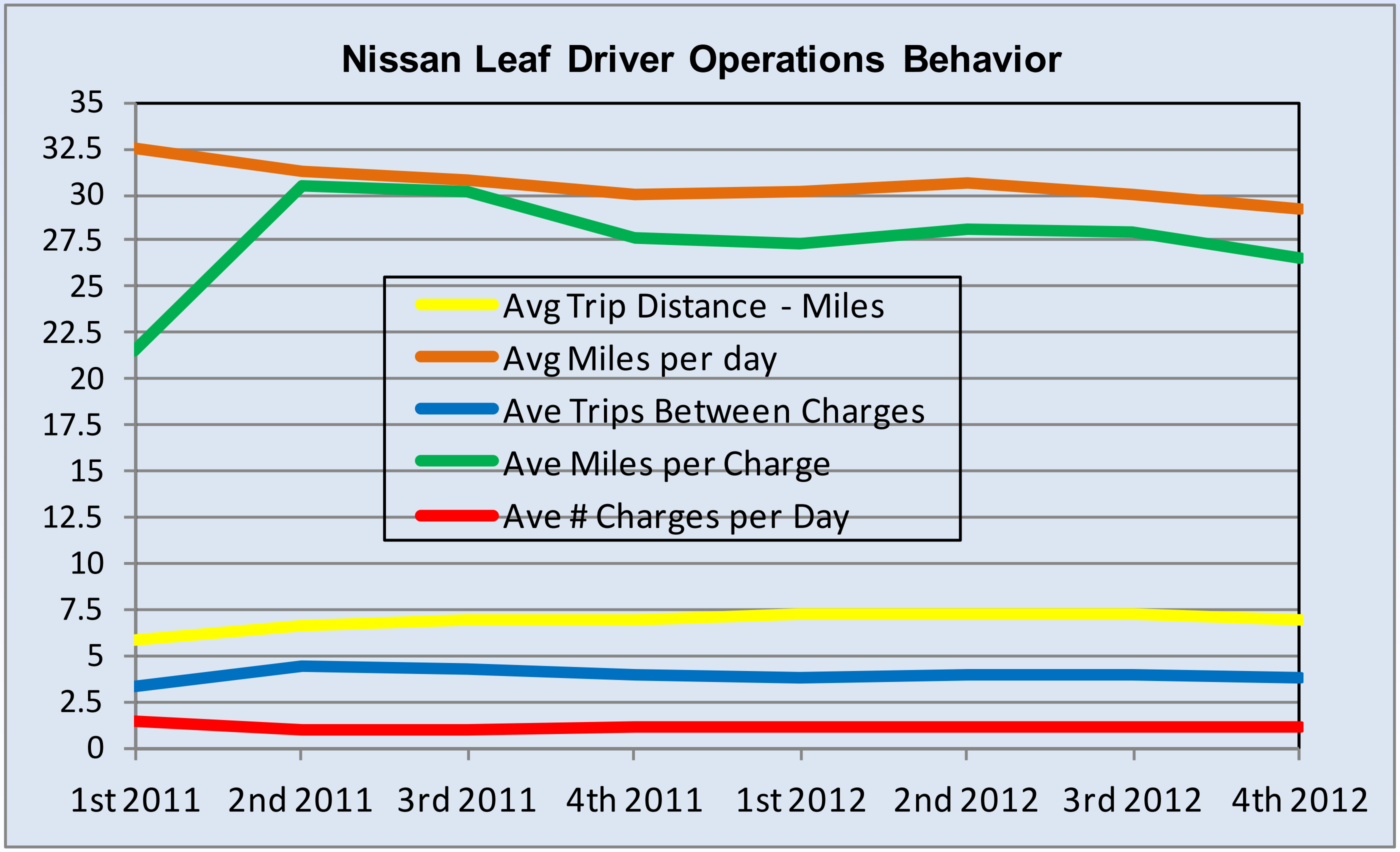
4th quarter 2012 Data Only

	Leafs	Volts
• Number of vehicles	3,762	1,021
• Number of Trips	969,853	369,118
• Distance (million miles)	6.7	3.0
• Average (Ave) trip distance	6.9 mi	8.1 mi
• Ave distance per day	29.2 mi	40.5 mi
• Ave number (#) trips between charging events	3.8	3.5
• Ave distance between charging events	26.3 mi	28.2 mi
• Ave # charging events per day	1.1	1.4

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

EV Project – Leaf Operations Trends

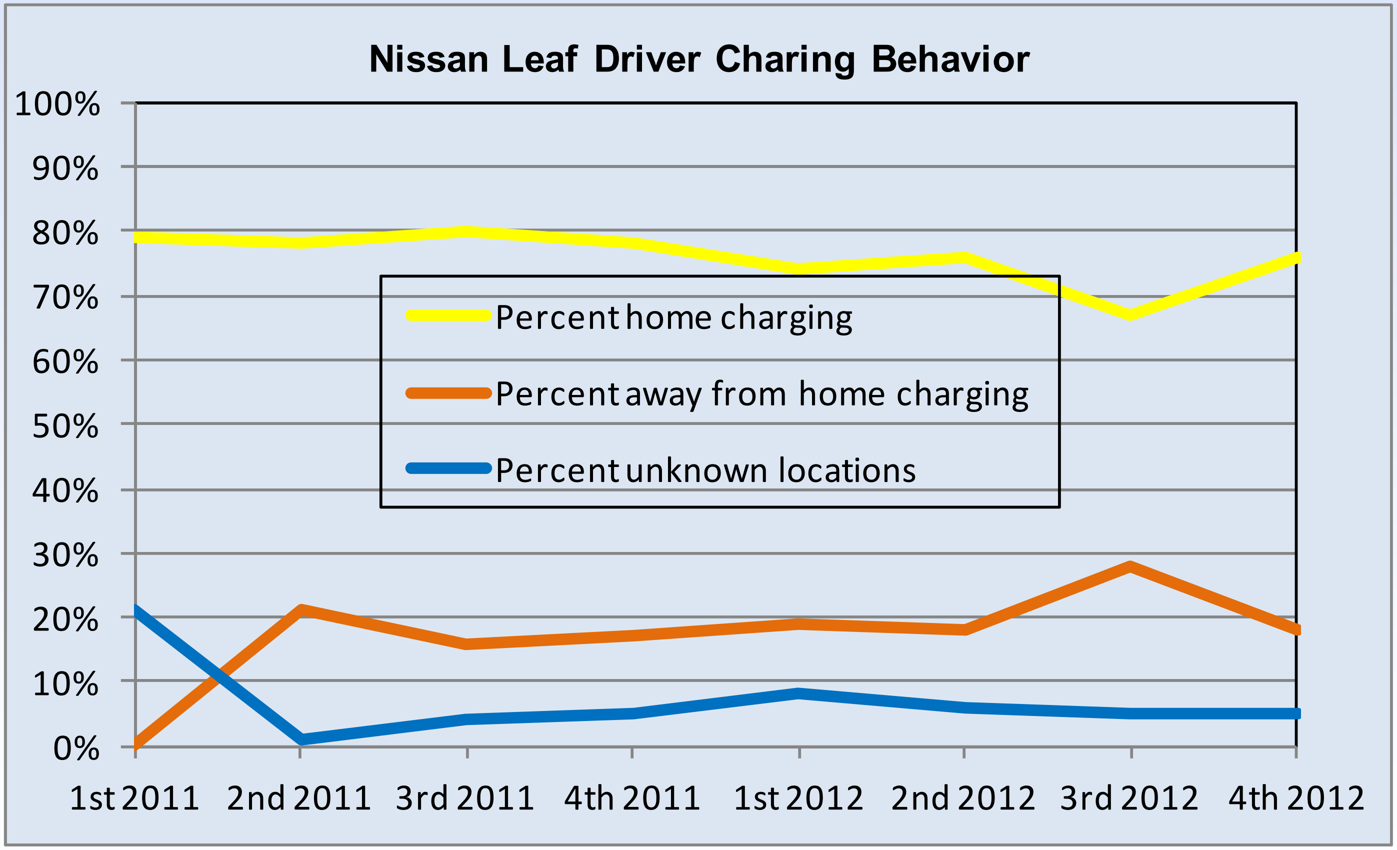
- **Some decreases in average miles per day and average miles per charge**



Number of Leafs reporting each quarter with matched EVSE data							
35	956	2,394	2645	2987	2911	3200	3762

EV Project – Leaf Charging Location Trends

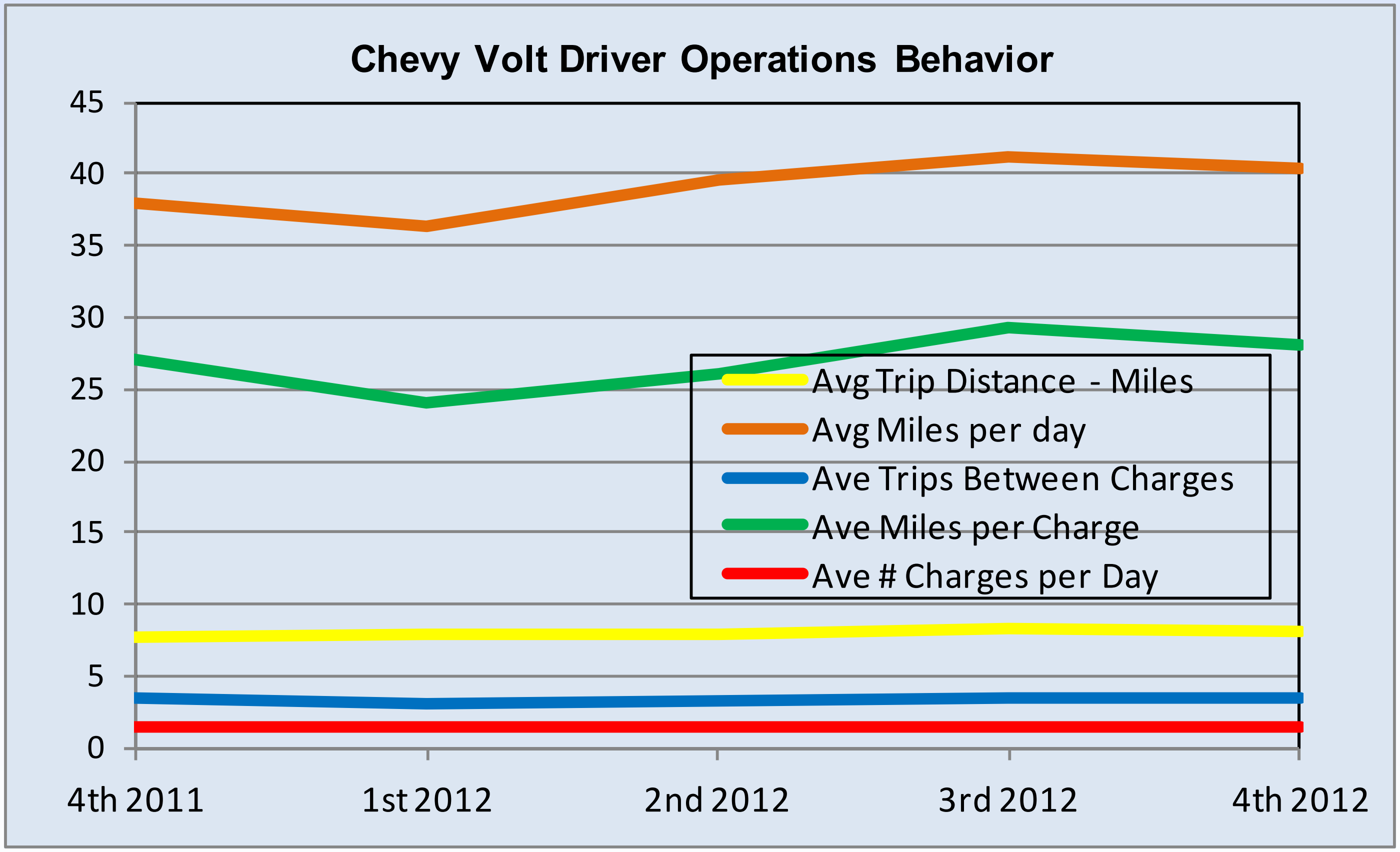
- **9% increase in home charging and 10% decrease in non-home charging as a revenue model is introduced**



Number of Leafs reporting each quarter with matched EVSE data							
35	956	2,394	2645	2987	2911	3200	3762

EV Project – Volt Operations Trends

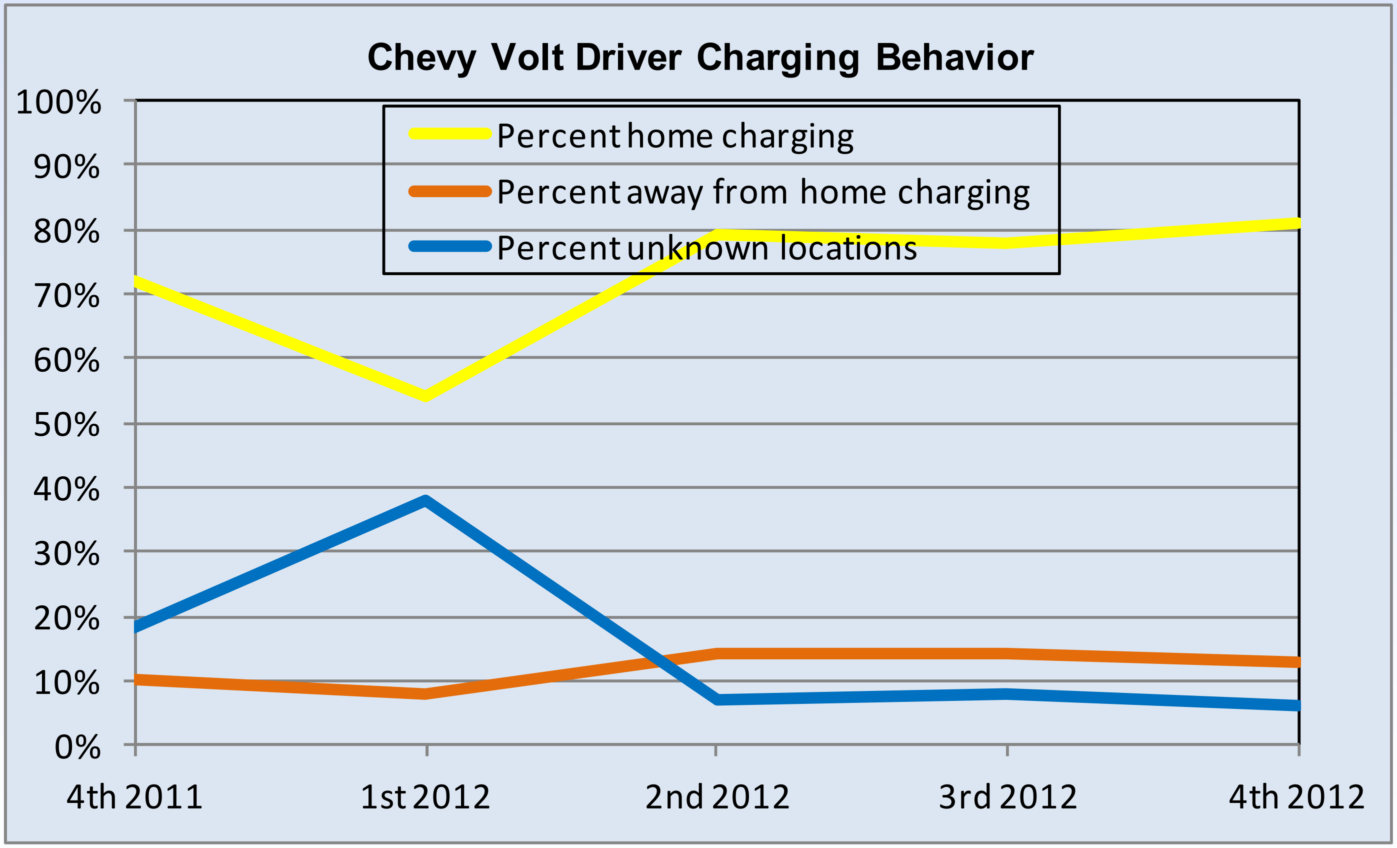
- **Average quarterly increases in miles per day and per charge have decreased most recently**



Number of Volts reporting each quarter with matched EVSE data				
45	317	408	809	1021

EV Project – Volt Charging Location Trends

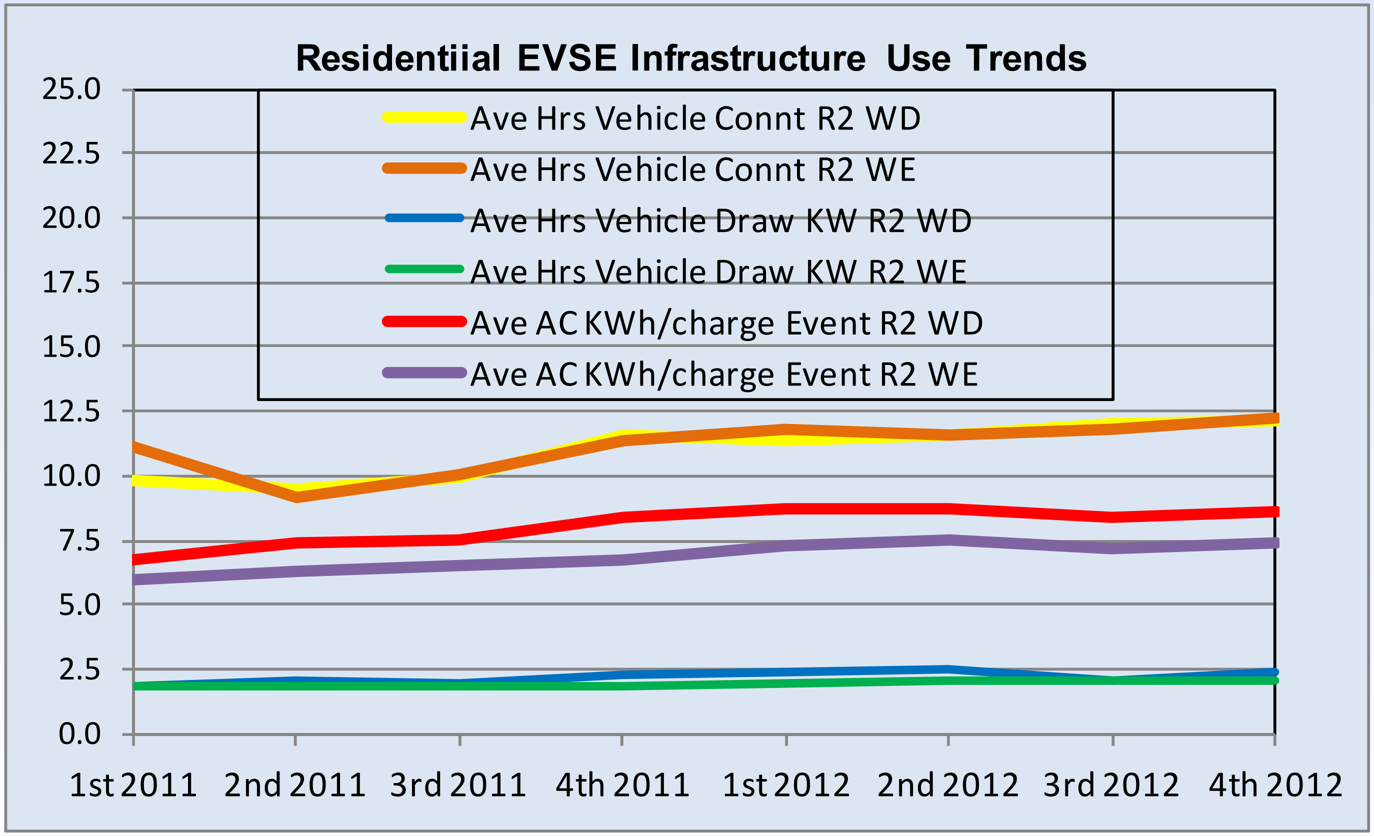
- **3% increase in home charging and 1% decrease in non-home charging as a revenue model is introduced**



Number of Volts reporting each quarter with matched EVSE data				
45	317	408	809	1021

EV Project – Residential EVSE L2 Use Trends

- **Continued gradual increases in time vehicles connected per charge and in AC KWh transferred per charge event**

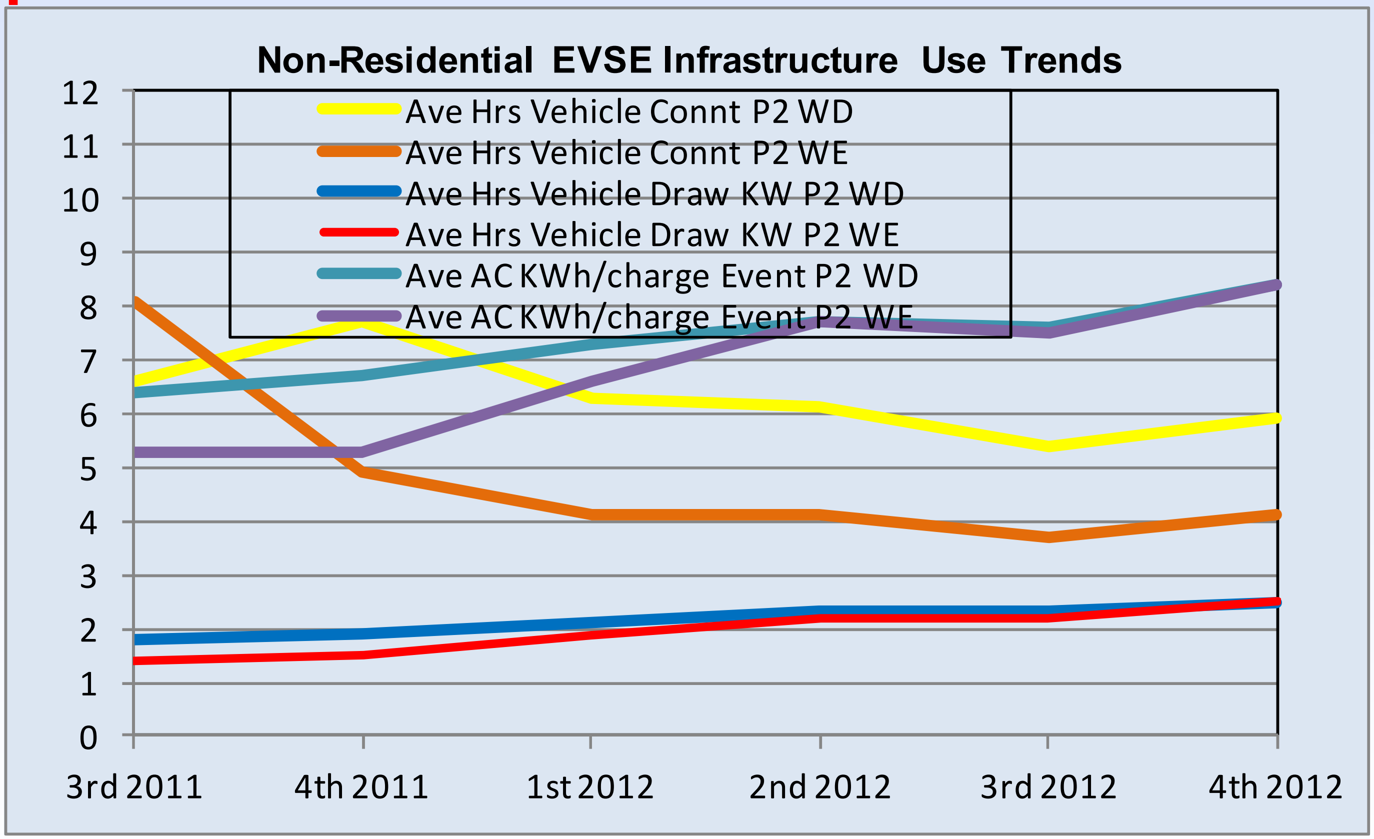


Number of Residential EVSE Level reporting each quarter							
35	955	2413	2704	3324	3338	4020	4819

Residential EVSE Level 2 = R2, Weekend = WE, Weekday = WD

EV Project – Public EVSE L2 Use Trends

- **Increases in kWh per charge and time energy is drawn**
- **Average time vehicle connected appears to be rising this last quarter**

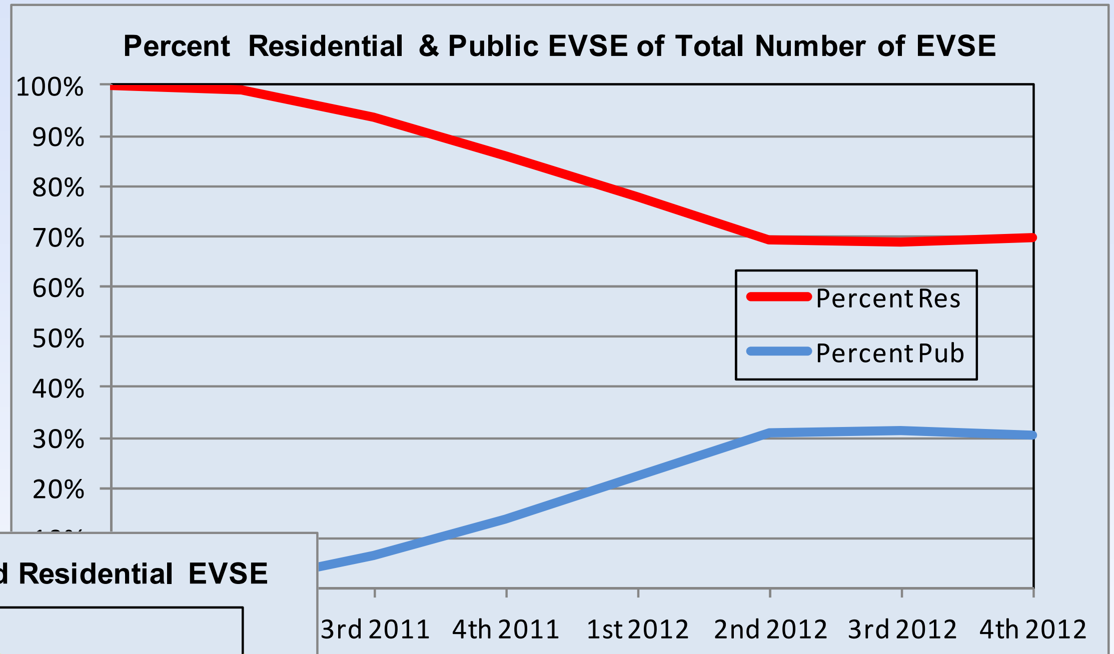


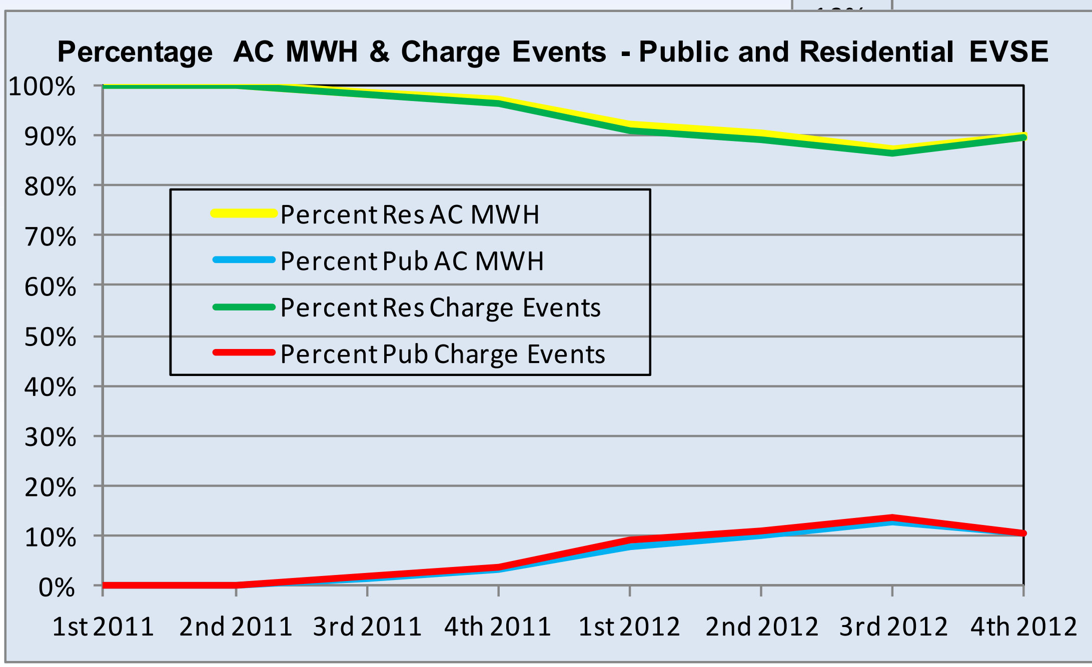
Number of Public EVSE Level reporting each quarter					
170	438	955	1483	1818	1988

Public EVSE Level 2 = P2, Weekend = WE, Weekday = WD

EV Project – EVSE Infra. Summary Report

- Percent of public L2 EVSE deployed is now 30% of all L2 EVSE





- As measured by kWh use and number of charge events, revenue model may be decreasing public L2 EVSE use

EV Project Public L2 EVSE Usage end of 2012

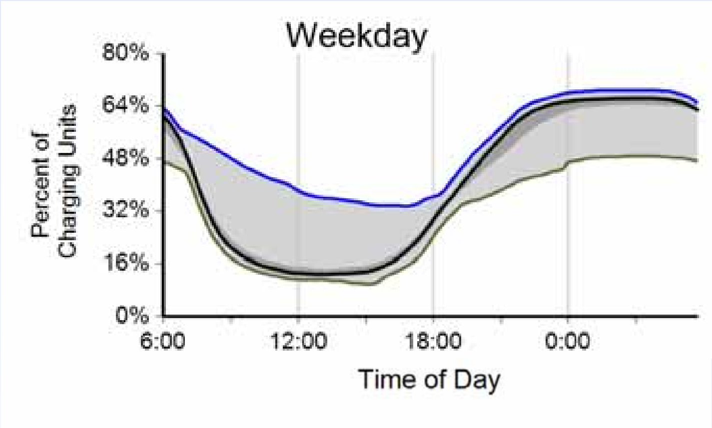
- **Contribution of Car Sharing Fleets is significant**

All territories				
Vehicles Charged	Car sharing fleet	Nissan Leaf	Chevrolet Volt	Unknown
Percent of charging events	25%	21%	5%	49%
Percent of kWh consumed	38%	17%	3%	41%
San Diego				
Vehicles Charged	**300 Car2Go fleet**	Nissan Leaf	Chevrolet Volt	Unknown
Percent of charging events	**59%**	16%	2%	23%
Percent of kWh consumed	**72%**	11%	1%	16%
Oregon (Car2Go in Portland)				
Vehicles Charged	30 Car2Go fleet	Nissan Leaf	Chevrolet Volt	Unknown
Percent of charging events	5%	29%	4%	61%
Percent of kWh consumed	11%	27%	4%	58%

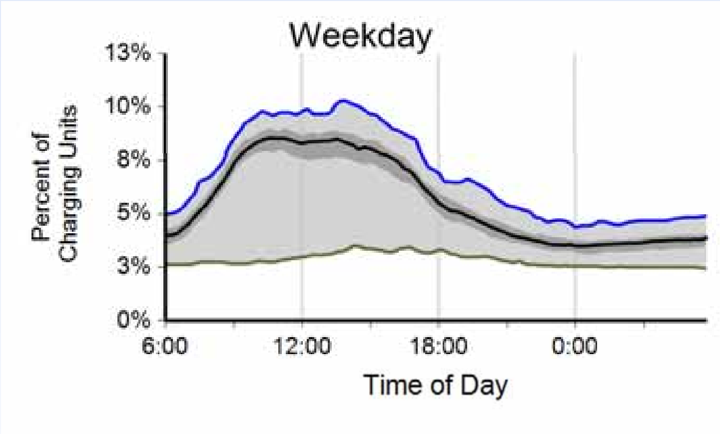
EV Project – EVSE Infra. Summary Report

- **National Residential and Public Level 2 Weekday EVSE 4th Quarter 2012**
- **Residential and public connect time and energy use are fairly opposite profiles. Note different scales**

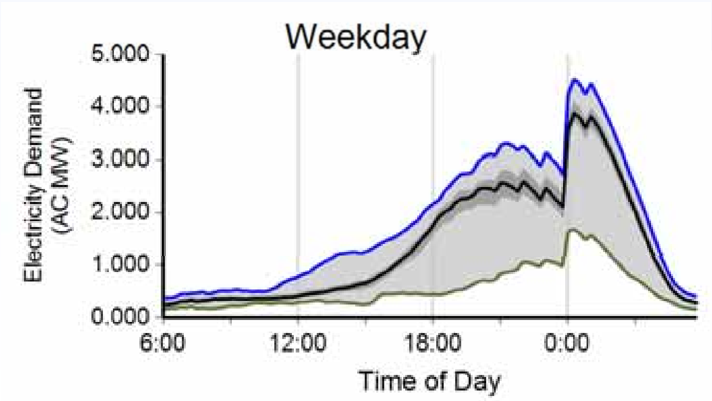
National Residential Connect Time



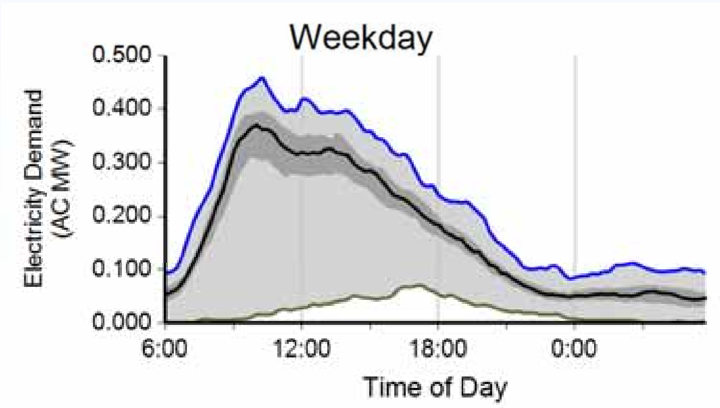
National Public Connect Time



National Residential Demand



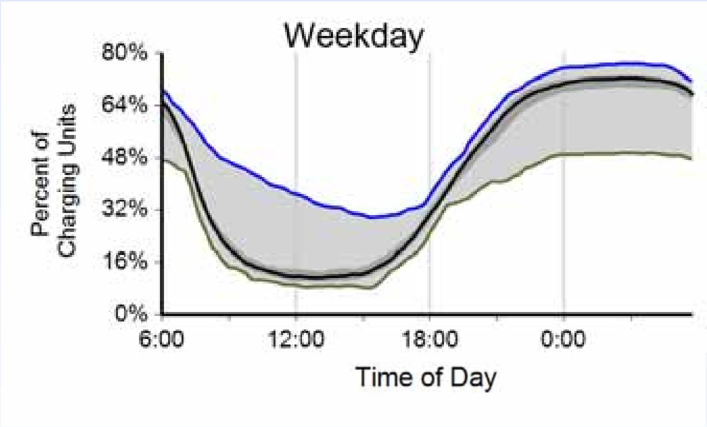
National Public Demand



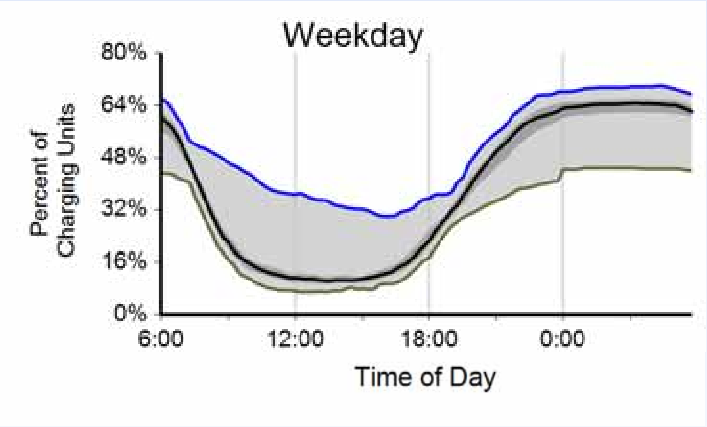
EV Project – EVSE Infra. Summary Report

- **Residential Level 2 Weekday EVSE 4th Quarter 2012**
- **San Diego and San Francisco, with residential L2 TOU rates, are similar to national and other regional EVSE connect profiles**

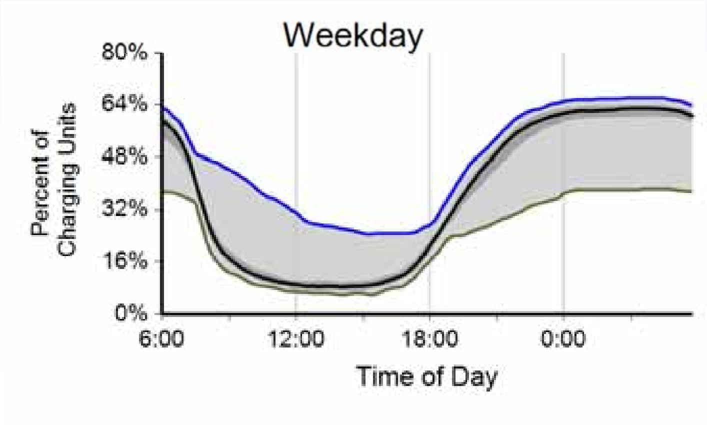
San Diego



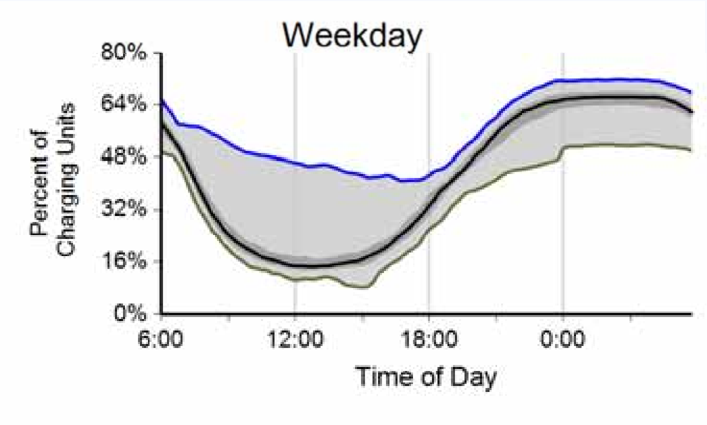
Los Angeles



San Francisco



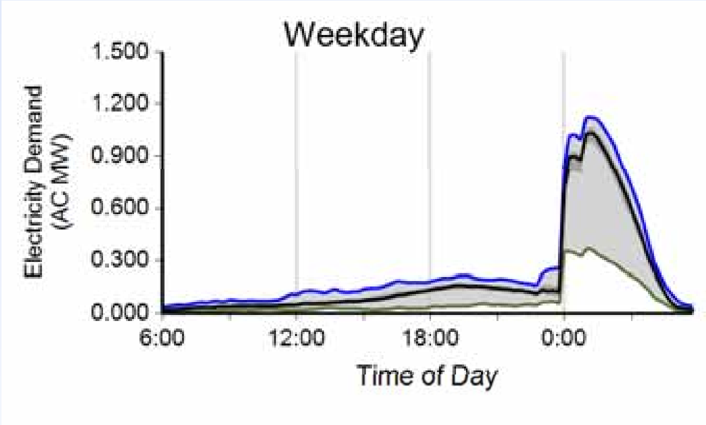
Washington State



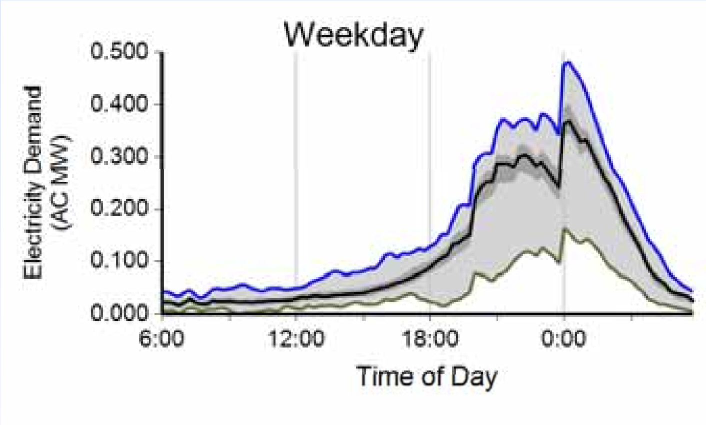
EV Project – EVSE Infra. Summary Report

- **Residential Level 2 Weekday EVSE 4rd Quarter 2012**
- **TOU kWh rates in San Diego and San Francisco clearly impact when vehicle charging start times are set**

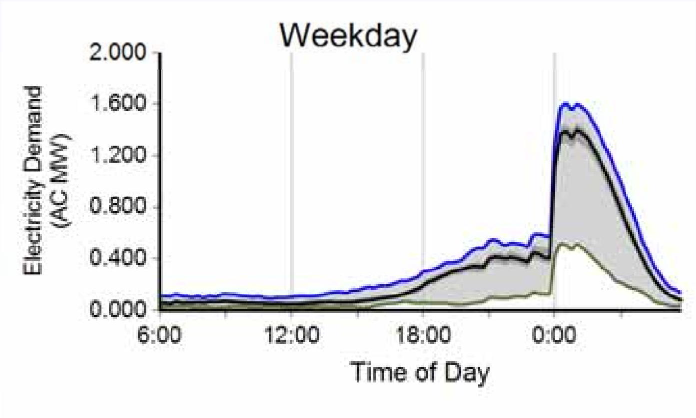
San Diego



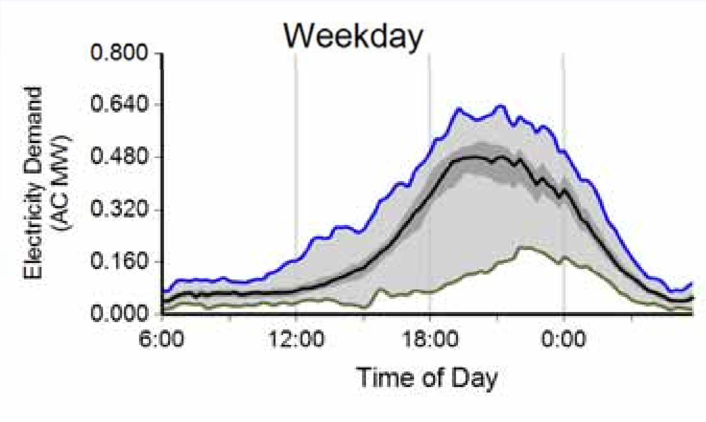
Los Angeles



San Francisco



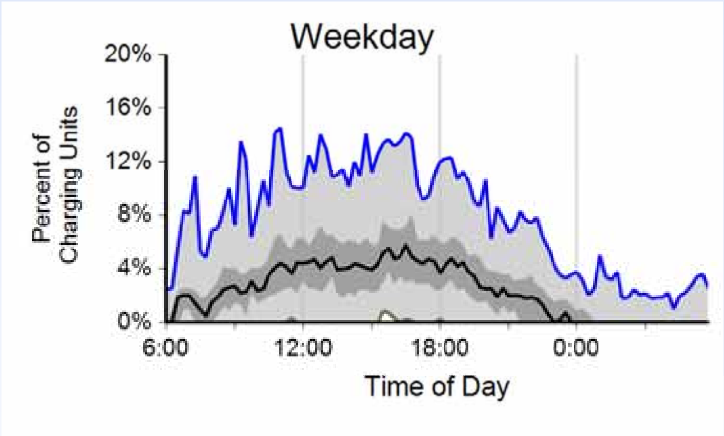
Washington State



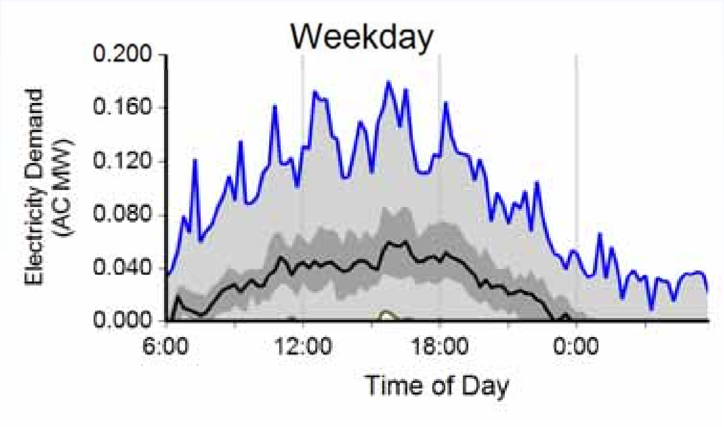
EV Project – EVSE Infra. Summary Report

- DC Fast Chargers Weekday 4th Quarter 2012
- 54 DCFCs connected and demand profiles

Weekday Connected Profile



Weekday Demand Profile



- 1.9 average charge events per day per DCFC
- Leafs 43% charge events and 45% energy
- Unknowns other charge events and energy
- 19.3 minutes average time connected
- 19.3 minutes average time drawing energy
- 7.2 kWh average energy consumed per charge

L2 Access Fees Structure

- 4th Quarter is first widespread implementation of simple and low cost access fees
- Blink member
  - Affiliate credit card with free Blink RFID "In Card"
  - Level 2 access fee of $1.00 per hour of connect time
- Guest - No Blink RFID "In Card" required
  - Guest Code using quick reservation code or website
  - Level 2 access feel of $2.00 per hour of connect time
- Future pricing
  - Pricing to reflect regional electricity rates
  - Cover electricity costs in all cases

DC Fast Charge (DCFC) Fees Structure

- Encourage DCFC use with initial free charging
- Implement DCFC access fees by region in 1st Quarter 2013 with beta testing currently underway
- Initial fee structure simple and low cost
  - Accommodate varying vehicle charge rates
  - Accommodate select limitation of charging output power
- Blink member
  - $25 per month unlimited use or $5.00 per session
- Guest
  - $8.00 per session

Residential Lessons Learned

- Permit timeliness has not been a problem
- Majority are over-the-counter
- Permit fees vary significantly- $7.50 to $500.00

Region	Count of Permits	Average Permit Fee	Minimum Permit Fee	Maximum Permit Fee
Arizona	66	$96.11	$26.25	$280.80
Los Angeles	109	$83.99	$45.70	$218.76
San Diego	496	$213.30	$12.00	$409.23
San Francisco	401	$147.57	$29.00	$500.00
Tennessee	322	$47.15	$7.50	$108.00
Oregon	316	$40.98	$12.84	$355.04
Washington	497	$78.27	$27.70	$317.25

Residential Lessons Learned

- Average residential installation cost ≈$1,375
- Individual installations vary widely
- Some user bias to lower costs

Marlets In Ascending Order Of Residential Installation Cost	Number of Installations	Average Installation Cost	Variation From Project Average
Tennessee (entire State)	542	$ 1,113.07	-19.0%
Arizona (Phoenix & Tucson)	357	$ 1,148.88	-16.4%
Washington DC	3	$ 1,197.44	-12.9%
Oregon (Portland, Eugene, Coralvls & Salem)	465	$ 1,229.06	-10.6%
Washington (Seattle & Olympia)	730	$ 1,289.56	-6.2%
Maryland	39	$ 1,311.75	-4.5%
Washington	80	$ 1,321.36	-3.8%
Virginia	38	$ 1,341.01	-2.4%
San Fransisco	1254	$ 1,386.13	0.9%
Texas (metro Houston & Dallas)	128	$ 1,422.77	3.5%
San Diego	726	$ 1,593.91	16.0%
Los Angeles	415	$ 1,794.64	30.6%

Commercial Lessons Learned

- **ADA significantly drives cost**
  - Accessible charger
  - Van accessible parking
  - Accessible electric and passage routes to facility
- **Permit fees and delays can are significant**
  - Load studies
  - Zoning reviews

Commercial Lessons Learned

- **Commercial permits range $14 to $821**

Region	Count of Permits	Average Permit Fee	Minimum Permit Fee	Maximum Permit Fee
Arizona	72	$228	$35	$542
Los Angeles	17	$195	$67	$650
San Diego	17	$361	$44	$821
Texas	47	$150	$37	$775
Tennessee	159	$71	$19	$216
Oregon	102	$112	$14	$291
Washington	33	$189	$57	$590

Commercial Lessons Learned

- Demand and energy costs are significant for some utilities
  - 25¢/kWh
  - $25/kW
- Some utilities offer commercial rates without demand charges
- Others incorporate 20 kW to 50 kW demand thresholds
- Nissan Leaf is demand charge free in some electric utility service territories

No Demand Charges - Nissan Leaf	
CA	Pacific Gas & Electric
	City of Palo Alto
	Alameda Municipal Power
	Silicon Valley Power
AZ	Tucson Electric Power
OR	Eugene Water & Electric Board
	Lane Electric Co-op
TN	Middle Tennessee Electric
	Duck River Electric
	Harriman Utility Board
	Athens Utility Board
	Cookeville Electric Department
	Cleveland Utilities
	Nashville Electric Service
	EPB Chattanooga
	Lenoir City Utility Board
	Volunteer Electric Cooperative
	Murfreesboro Electric
	Sequachee Valley Electric Cooperative
	Knoxville Utility Board
	Maryville
	Fort Loudoun Electric
	Memphis Light Gas and Water Division

Commercial Lessons Learned

- **Recurring Nissan Leaf DC fast charge demand charges are significant in many utility service territories**

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

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy — VEHICLE TECHNOLOGIES PROGRAM

ChargePoint ®America Vehicle Charging Infrastructure Summary Report

Project Status to Date through: June 2012

Charging Unit - By State	Residential	Private Commercial	Public	Not Specified	Charging Units Installed to Date¹	Number of Charging Events Performed²	Electricity Consumed (AC MWh)
California	791	39	518	3	1,351	213,758	1,487.7
Connecticut	11	-	-	-	11	2,569	15.1
District of Columbia	-	16	16	-	32	718	5.4
Florida	43	10	228	2	283	9,323	55.2
Maryland	18	7	46	-	71	5,956	37.9
Massachusetts	23	7	74	-	104	4,133	35.5
Michigan	252	14	172	-	438	60,436	407.1
New Jersey	51	2	17	-	70	15,397	95.7
New York	23	88	102	-	213	17,401	139.6
Texas	51	9	227	-	287	17,759	114.4
Virginia	23	17	43	-	83	10,061	65.0
Washington	12	7	123	-	142	8,153	50.0
Total	1,298	216	1,566	5	3,085	365,664	2,508.7

ChargePoint America Charging Unit Distribution

Project to Date

¹ Includes all charging units that were in use by the end of the repo

² A charging event is defined as the period when a vehicle is connected to a charging unit, during which period some power is transferred

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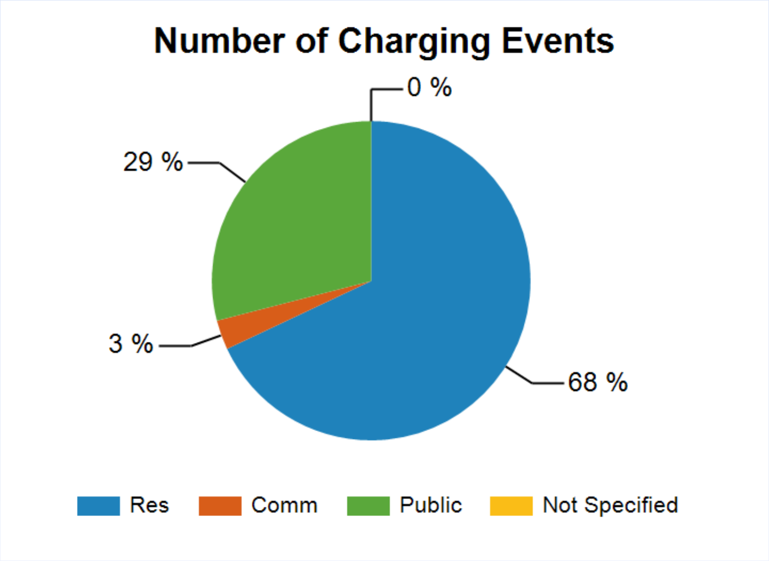
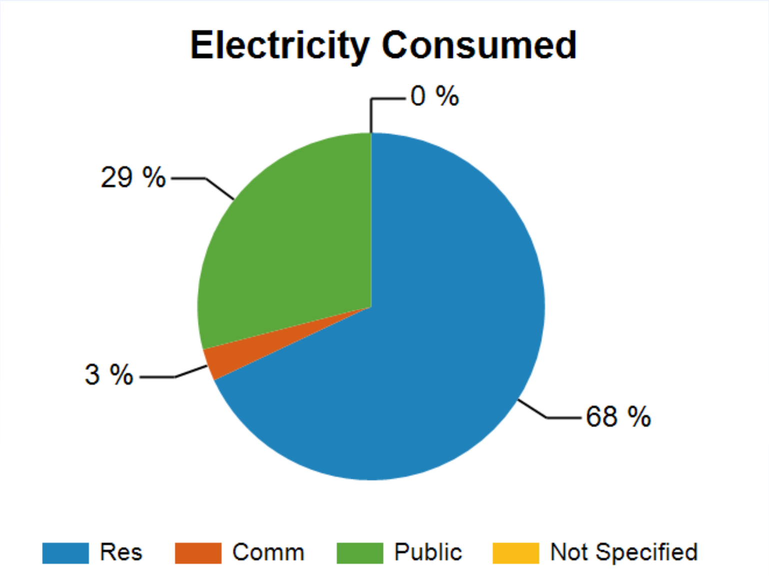
ChargePoint America ARRA Project

- **Conducted by Coulomb**
- **Project to Dec. 2012**
- **3,908 EVSE installed and reporting data**
  - **1,763 Residential**
  - **193 Private / commercial**
  - **1,940 Public**
  - **12 unknown**
- **760,995 charge events**
- **5,359 AC MWh**

ChargePoint America ARRA Project

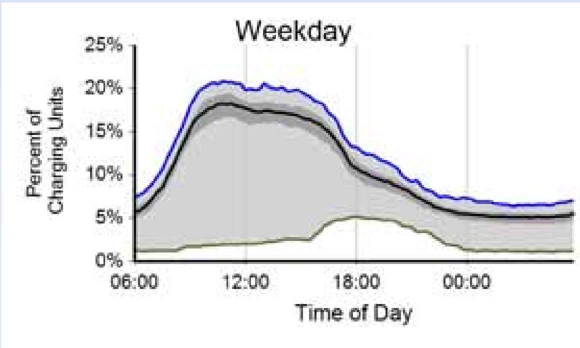
- Oct - Dec 2012 data
- 3,541 units
- Percent time vehicle connected
  - Residential 47%
  - Private/com 24%
  - Public 9%
- Percent time drawing power
  - Residential 9%
  - Private/com 5%
  - Public 4%
- EVSE data only



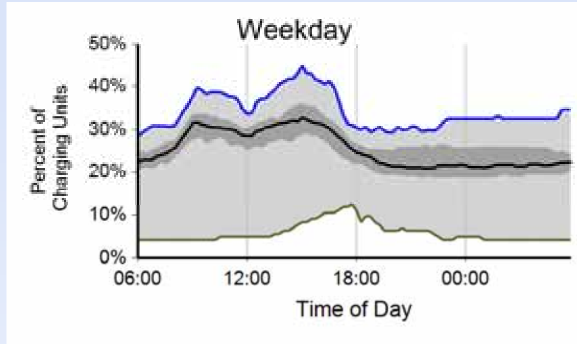


ChargePoint America: Oct – Dec. 2012

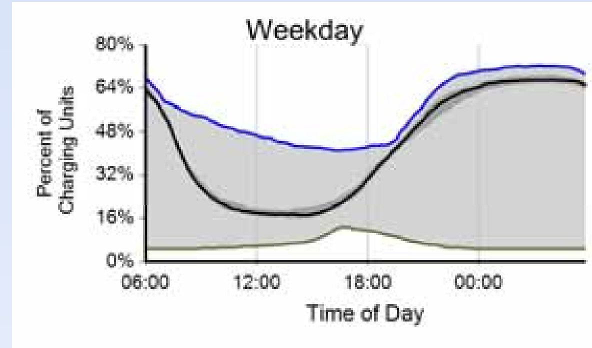
Public Connect Time



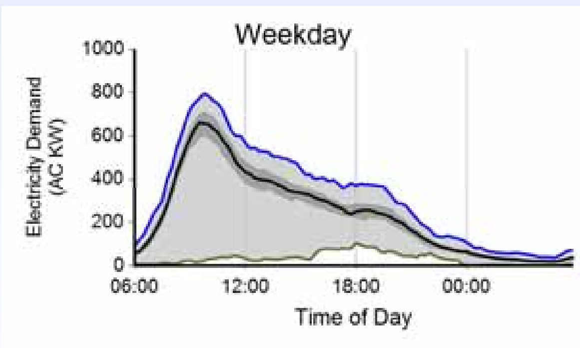
Commercial Connect Time



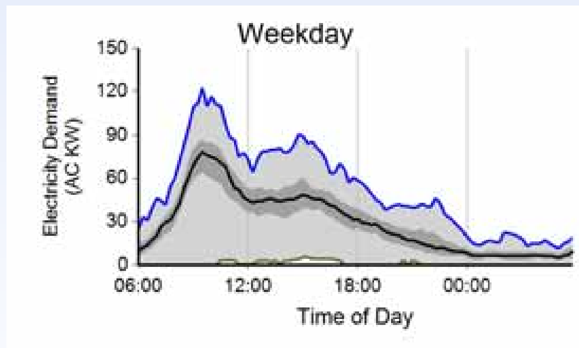
Residential Connect Time



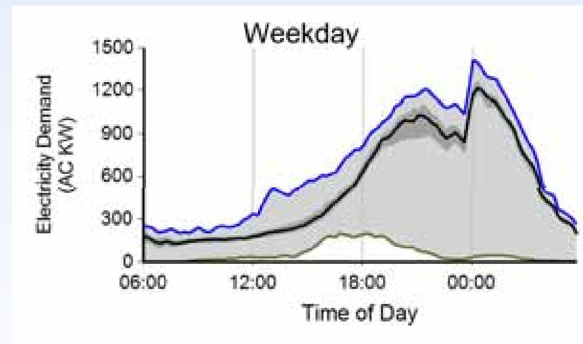
Public Demand



Commercial Demand



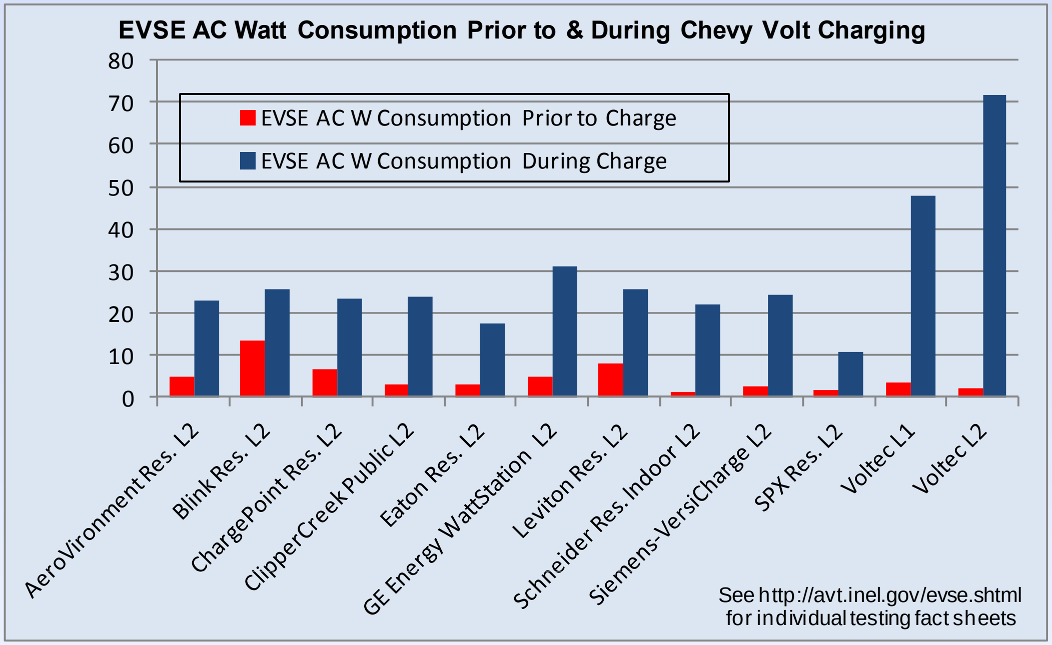
Residential Demand

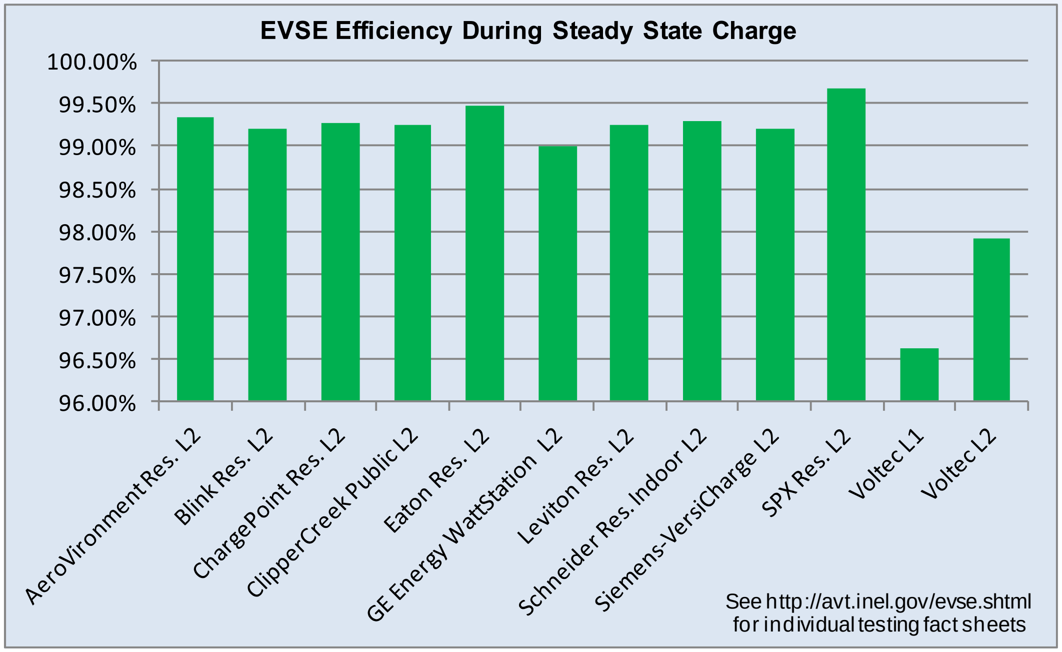


- Public is open access. Commercial are limited access
- Public and commercial reflect at work charging
- Residential reflects end of day return-to-home charging
- Note difference in scales

EVSE Testing

- AC energy consumption at rest and during Volt Charging benchmarked
- Steady state charge efficiency benchmarked

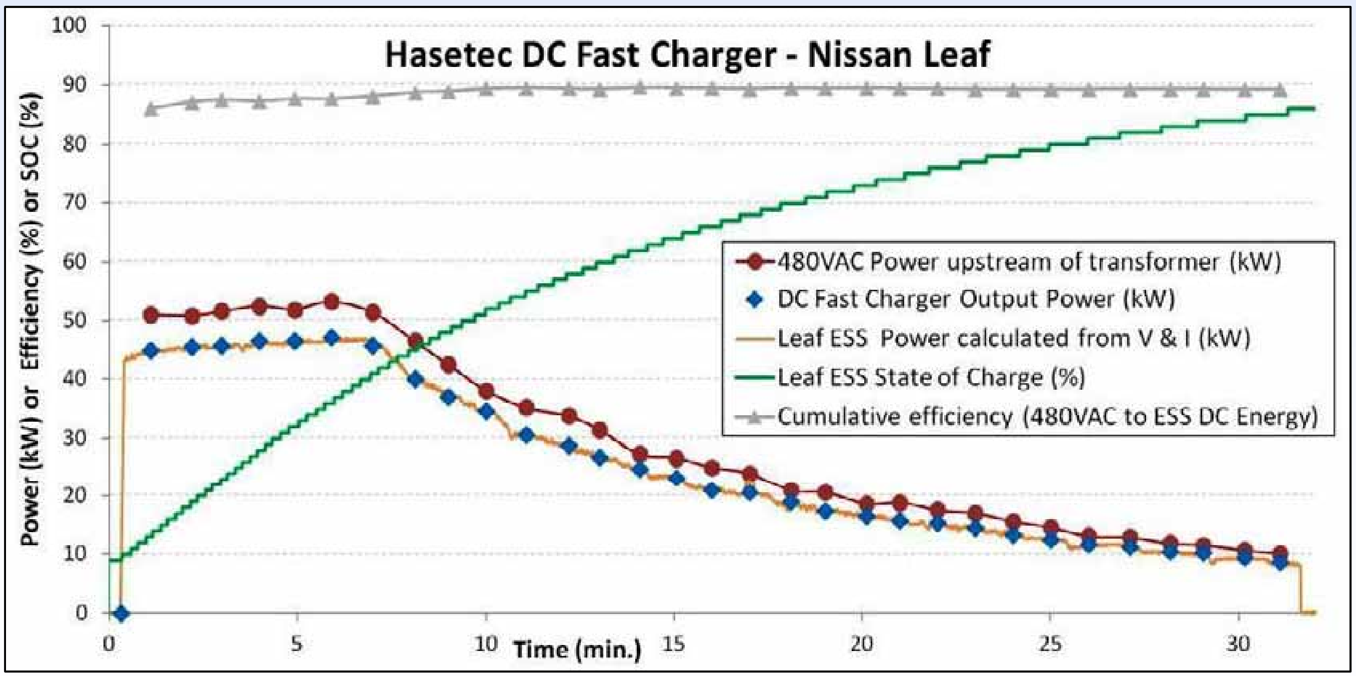




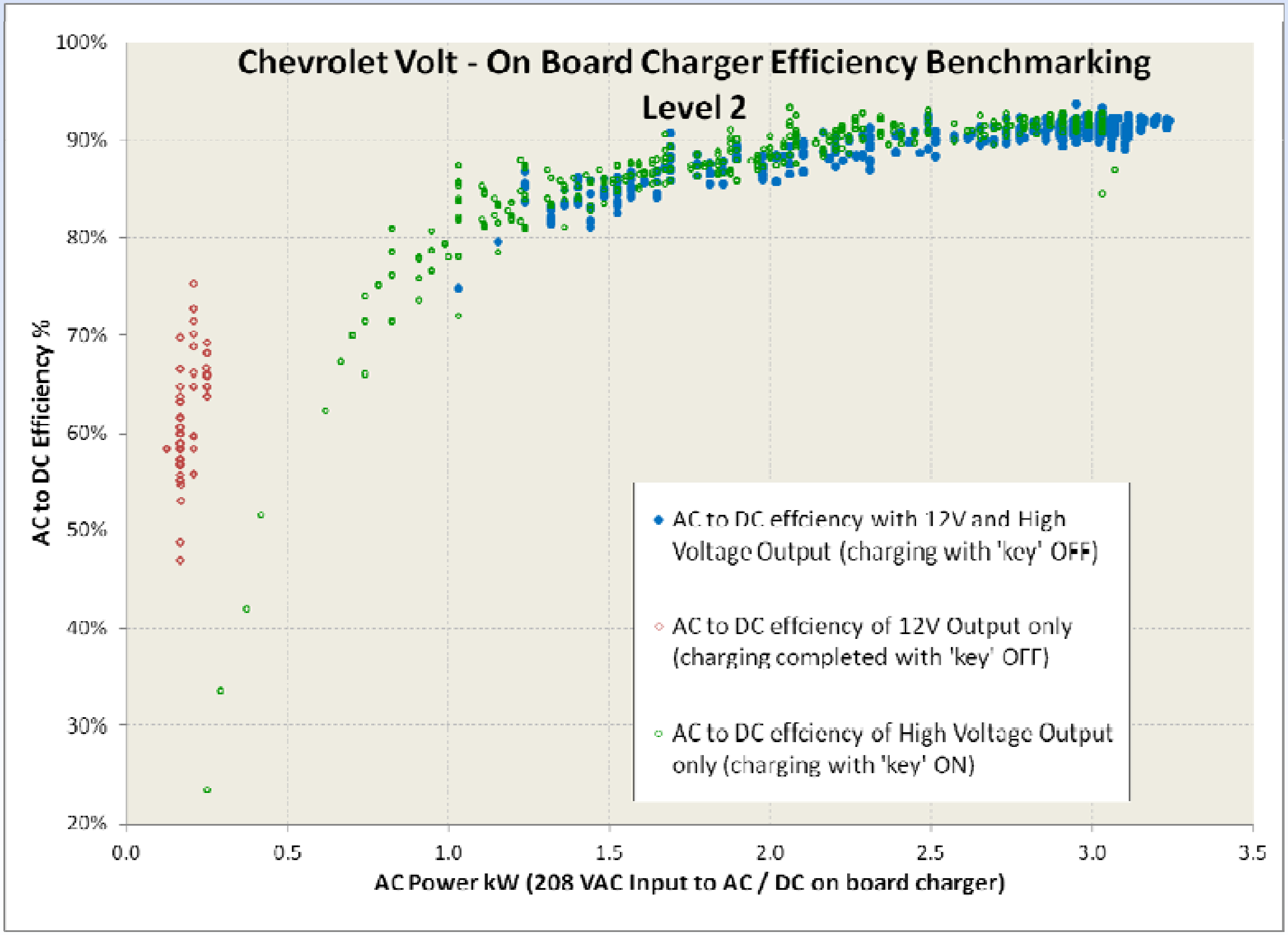
- Most EVSE consume 13 W or less at rest. Higher watt use tied to more EVSE features
- Most EVSE under 30 W during charge
- Most EVSE 99+% efficient during steady state charge of a Volt

Hasetec DC Fast Charging Nissan Leaf

- **53.1 AC kW peak grid power**
- **47.1 DC kW peak charge power to Leaf energy storage system (ESS)**
- **15.0 Grid AC kWh and 13.3 DC kWh delivered to Leaf ESS**
- **88.7% Overall charge efficiency (480VAC to ESS DC)**



Conductive System Benchmarking



Entire report can be found at: http://avt.inel.gov/pdf/phev/EfficiencyResultsChevroletVoltOnBoardCharger.pdf

Additional Testing

- Initiated field and lab DC Fast Charge and Level 2 charging study of impacts on battery life in 6 Nissan Leafs
  - Two vehicles driven on road and L2 charged
  - Two driven identical routes DCFC charged
  - One L2 and 1 DCFC in battery lab
  - At 10k miles each vehicle similar minimal capacity fade
- INL conducting with the NFPA and US DOT, PEV traction battery fire demonstrations and suppression project
- INL initiated ~400 New York EVSE data collection with NYSERDA, NYPA, Port Authority of NY/NJ, and Energetics
- INL initiated DOE's wireless charging test program

Summary

- 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 at midnight per TOU rates indicates consumers are price sensitive
- Revenue models for public charging are currently being introduced – long term impacts?
- Only about 60% of EV Project data collected to date
- DCFC charge events have significant demand impacts but this is an electric utility policy decision
- How, where, when we measure EVSE and vehicle system charging efficiencies results in significantly different results

Acknowledgement

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More Information

http://avt.inl.gov

This presentation will be posted in the publications section of the above website

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