Idaho National Laboratory

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

INL Update: The EV Project and Other Light-Duty Electric Drive Vehicle and Infrastructure Activities @ VSATT 2012

Jim Francfort / Barney Carlson

VSATT – ORNL, Knoxville, TN
November 7, 2012

This presentation does not contain any proprietary or sensitive information

Outline

- Participants
- Goals
- Testing experience
- Data processes and data security
- EV Project
  - Description and data parameters and project status
  - Leaf, Volt, and EVSE benchmarking results including demand and DCFC peak issues
  - Lessons learned, summary and future
- Other ARRA and TADA data collection activities
- DC Fast Charge battery impacts
- EVSE, DC FC and wireless activities
- Vehicle Mass impacts on fuel use
- Battery mule status
- Other

AVTA Participants

- INL is responsible to DOE for the light-duty vehicle portion of the Advanced Vehicle Testing Activity (AVTA)
- ECOtality provides testing support to the AVTA via a competitively bid contract through NETL (National Energy Testing Laboratory)
- Test partners include electric utilities, Federal, state and local government agencies, private companies, infrastructure and vehicle manufacturers
- Leverage DOE funding within DOE, other Federal Fleets, and with all external partners

AVTA Goals

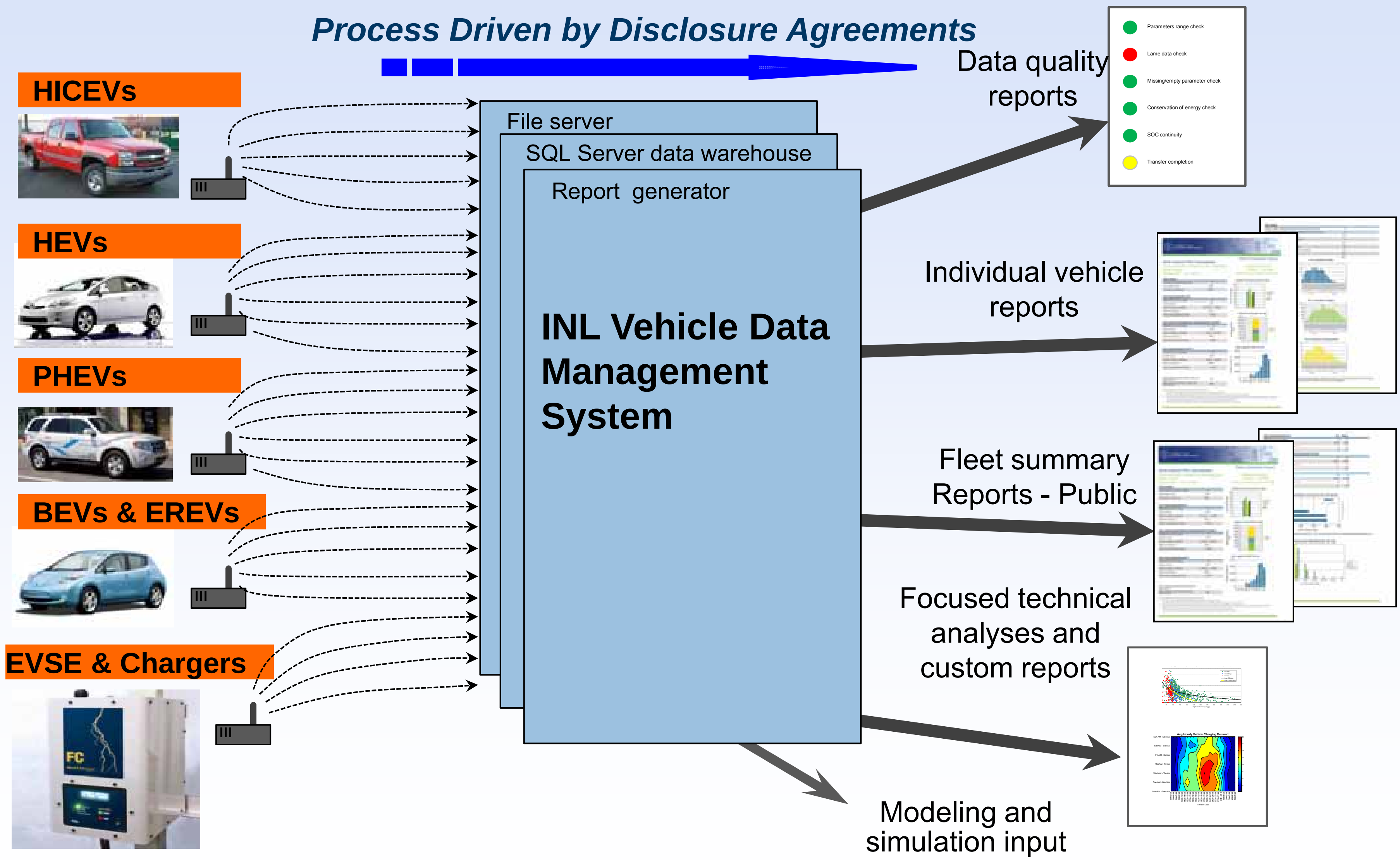
- The AVTA goals
  - Petroleum reduction and energy security
  - Benchmark technologies that are developed via DOE research investments
- The AVTA focuses on:
  - Real world field, test track, and laboratory testing of grid connected, electric drive vehicles and subsystems
  - Advanced energy storage systems
  - Charging infrastructure performance and use
- Confuse people with facts via structured benchmark testing
- Provide benchmark data to National Laboratories, Federal Agencies (DOD, DOI, DOT, EPA, USPS), technology modelers, fleet managers, and vehicle manufacturers to support informed vehicle and infrastructure deployment and operating decisions

Vehicle / Infrastructure Testing Experience

- **66 million test miles accumulated on 9,600 electric drive vehicles representing 110+ models, and 11,000+ EVSE**
- **Currently, 17,500 vehicles and EVSE provide 125,000 miles and 5,200 charging events of data to INL daily**
- **EV Project: 6,150 Leafs, Volts and Smart EVs, 7,971 EVSE (electric vehicle supply equipment), 48 million test miles**

- **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**

INL Vehicle/EVSE Data Management Process



Data Collection, Security and Protection

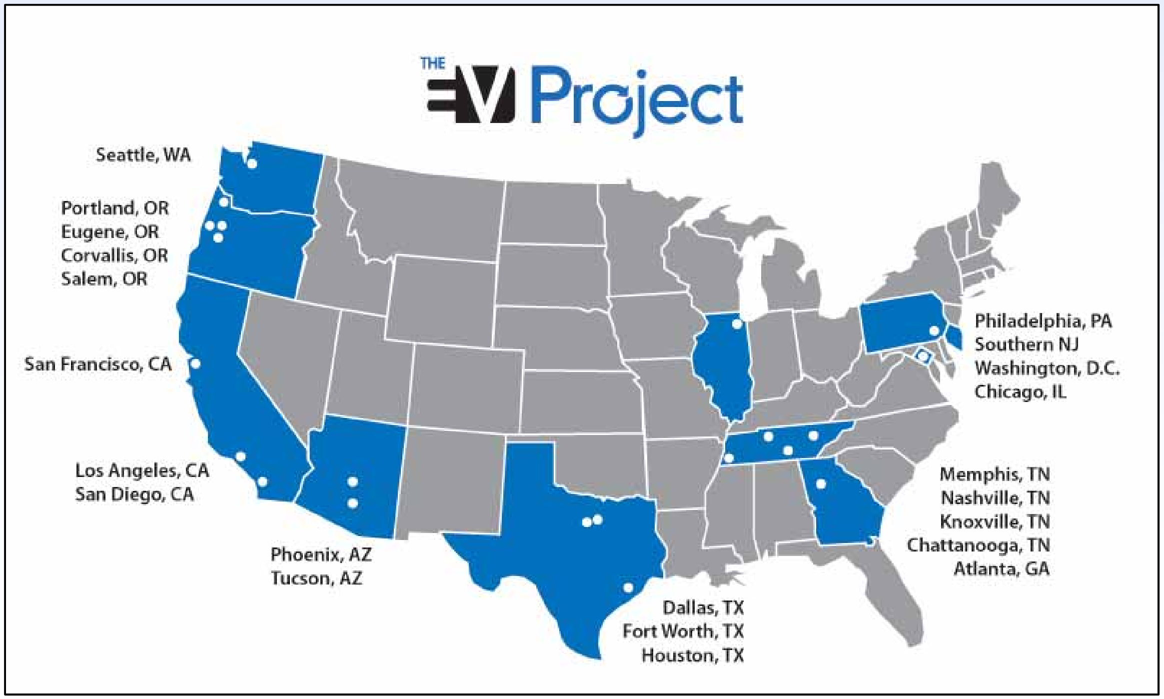
- **Includes EV Project and non-EV Project Activities**
- **All vehicle, EVSE, and personal raw data is legally protected by NDAs (Non Disclosure Agreements) or CRADAs (Cooperative Research and Development Agreements)**
  - **Limitations on how proprietary and personally identifiable information can be stored and distributed**
  - **Raw data, in both electronic and printed formats, is not shared with DOE to avoid exposure to FOIA requests**
  - **Vehicle and EVSE data collection would not occur unless testing partners trusted INL would strictly adhere to legally binding NDAs and CRADAs**
  - **Raw data cannot be legally distributed by INL**
- **Current AVTA staff have used data loggers on vehicles and EVSE since 1993 to benchmark vehicle and charging equipment profiles**

EV Project - Introduction

- ECOtality North America is the EV Project lead, with INL collecting data from the other participants
- Nissan and OnStar/GM are the prime partners, with more than 30 other partners such as electric utilities and air resource boards and state agencies
- For the EV Project, 7,500+ vehicle owners / infrastructure hosts have signed up to be testing partners
- Project objectives
  - Develop mature charge infrastructure "laboratories"
  - Collect and analyze data characterizing vehicle and infrastructure utilization
  - Demonstrate measures to minimize impacts of charging on the grid
  - Conduct trials of payment systems
  - Develop a sustainable business model for non-residential charging infrastructure
  - Document and disseminate the results of the EV Project

EV Project Deployment Objectives

- **8,000 Residential EVSE for 8,000 plug-in electric vehicles (Nissan Leaf, Chevrolet Volt & Smart EV)**
- **5,000 Non-residential EVSE (workplace, commercial, public, and street side)**
- **200 DC Fast Chargers (publicly accessible)**
- **Deploying in ten states plus the District of Columbia**



EV Project – EVSE Data Parameters, Collected per Charge Event

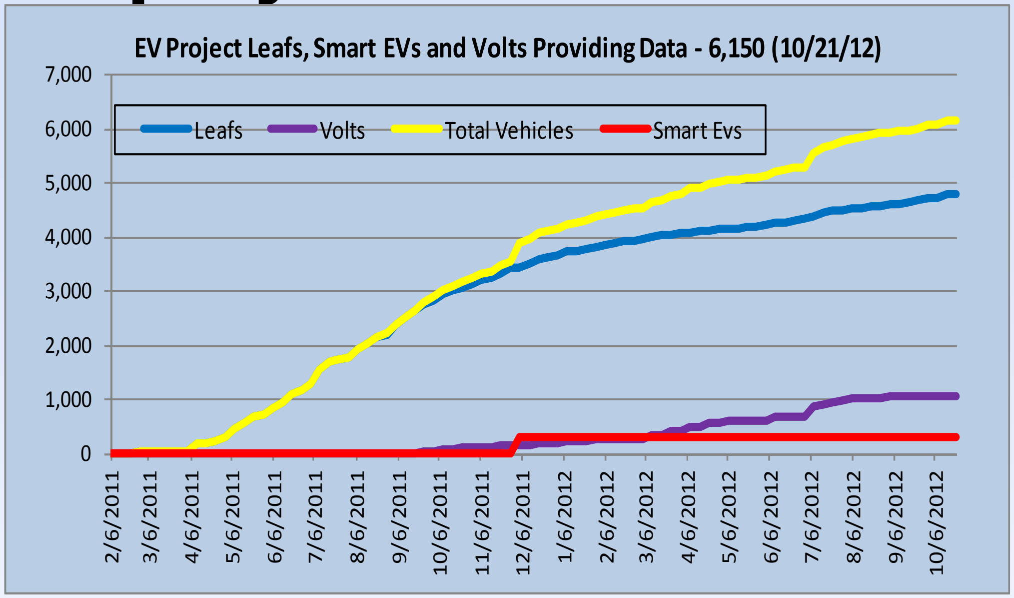
- Data from ECOtality's Blink EVSE network
- Connect and Disconnect Times
- Start and End Charge Times
- Maximum Instantaneous Peak Power
- Average Power
- Total energy (kWh) per charging event
- Rolling 15 Minute Average Peak Power
- Date/Time Stamp
- Unique ID for Charging Event
- Unique ID Identifying the EVSE
- And other non-dynamic EVSE information (GPS, ID, type, contact info, etc.)

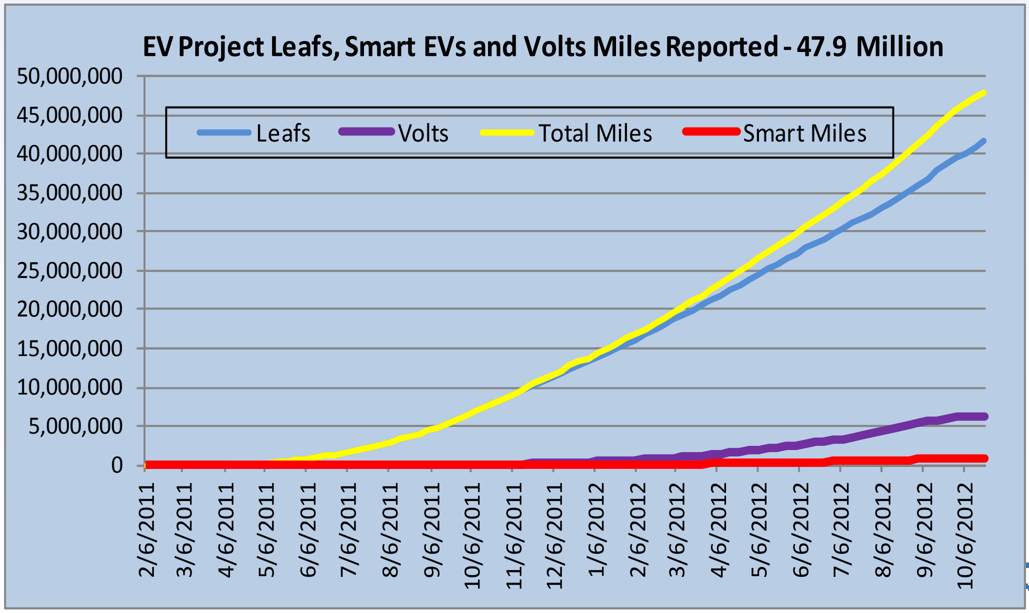
EV Project – Vehicle Data Parameters Collected per Key-On and Key-Off Event

- 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

EV Project – Vehicle Deployments / Miles

- **6,150 vehicles reporting data and growing**
- **4,798 Leafs, 300 Smart EVs, and 1,052 Volts reporting**





- **48 million total miles**
- **125,000 test miles per day**
- **Data is continuously back-filled**

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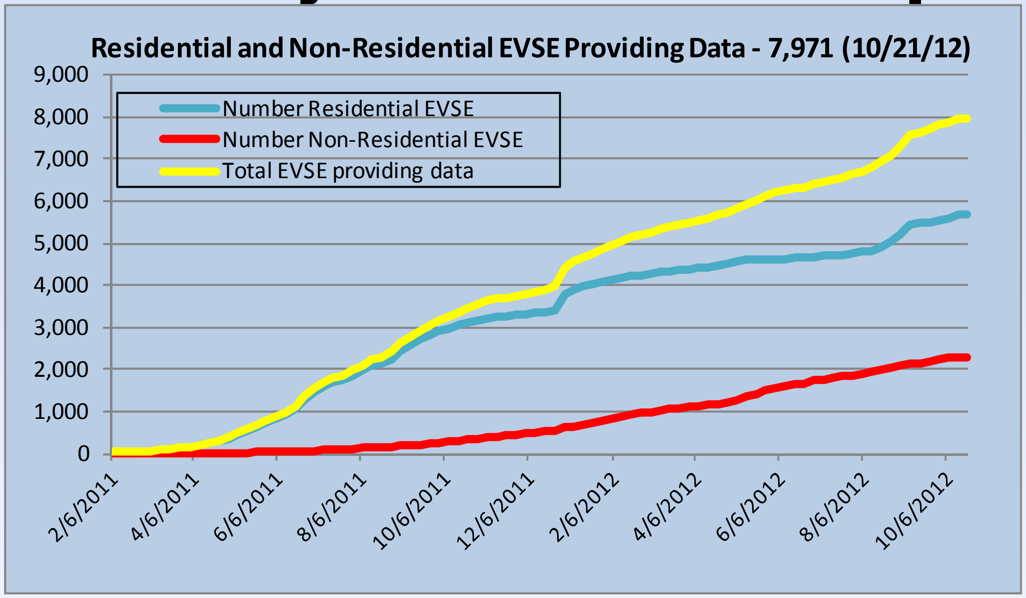
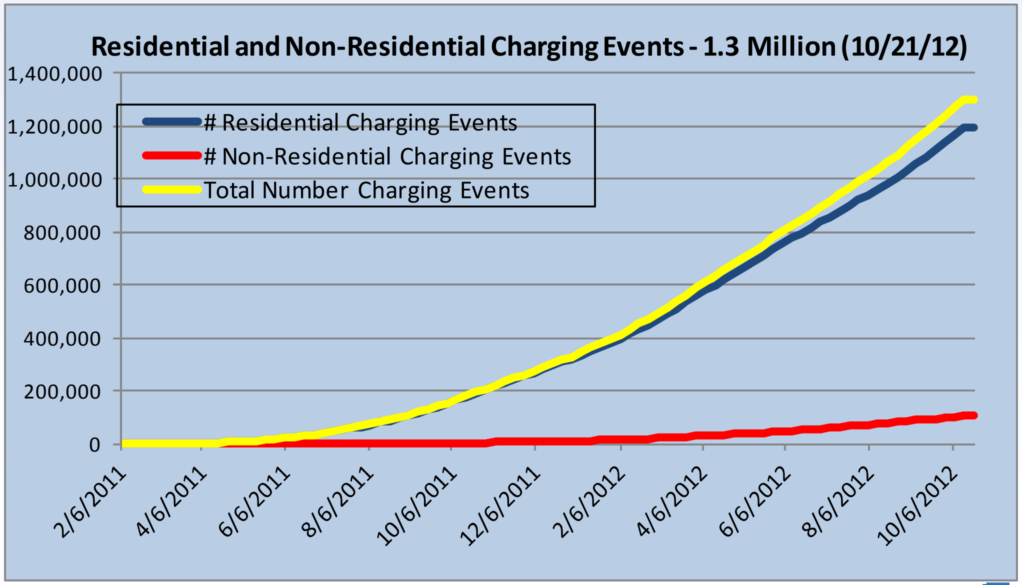
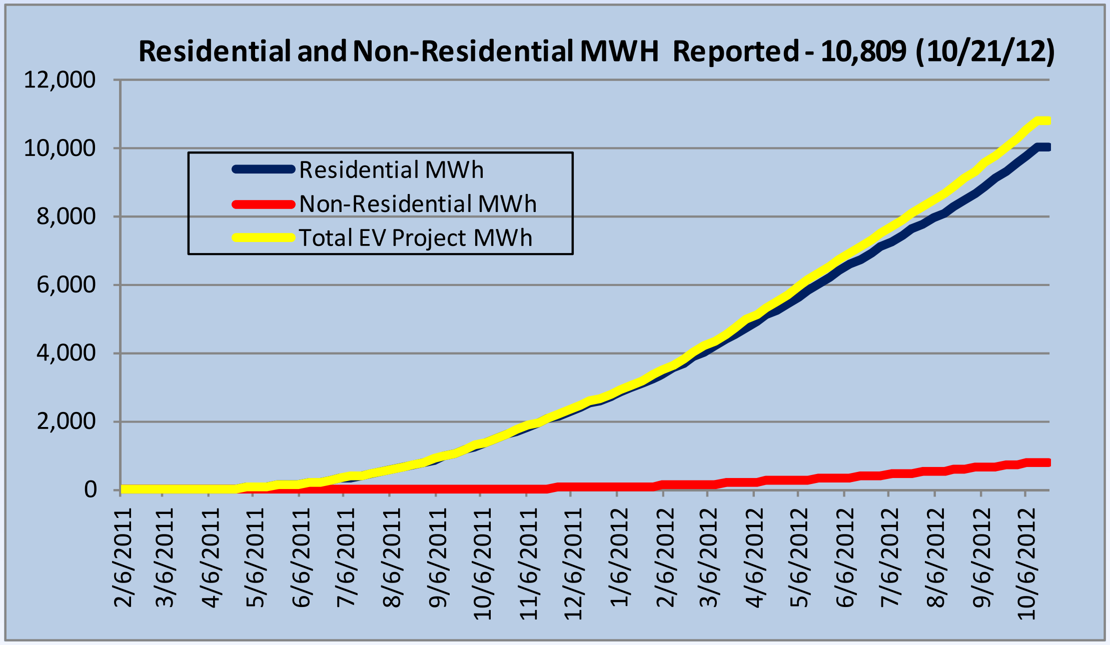
EV Project – EVSE Deployment and Use





- **7,971 total EVSE reporting**
  - **5,676 Residential EVSE**
  - **2,295 non-Residential EVSE, includes DCFC**
- **1.3 million charge events**
- **3,600 charge events per day**
- **Data is continuously back-filled**

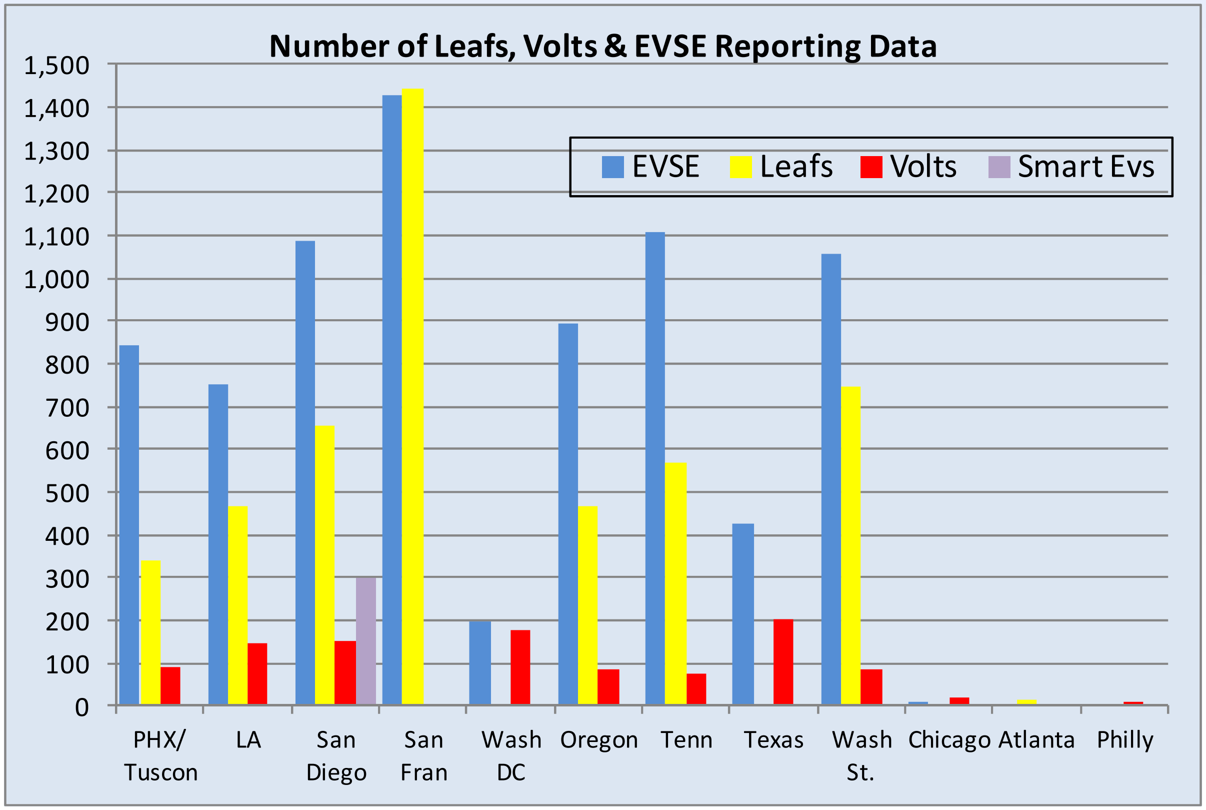
EV Project – Total Charge Energy (MWh)



- 11,000 MWh total electricity charged
  - 10,000 MWh residential
  - 800 MWh non-residential
- 32 MWh used for charging per day
- Data is continuously back-filled
- 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 3rd Quarter 2012

- **Vehicles and charging infrastructure deployed data @ INL**
- **Vehicles**
  - **46.7 million miles total**
  - **6,071 total vehicles**
  - **4,719 Leafs**
  - **1,052 Volts**
  - **300 Smart EVs**
- **Charging infrastructure**
  - **7,799 units installed**
  - **1,237,703 charging events**
  - **10,316 AC MWh**
- **Regional analyses reported each quarter**



EV Project Vehicle Usage Reports

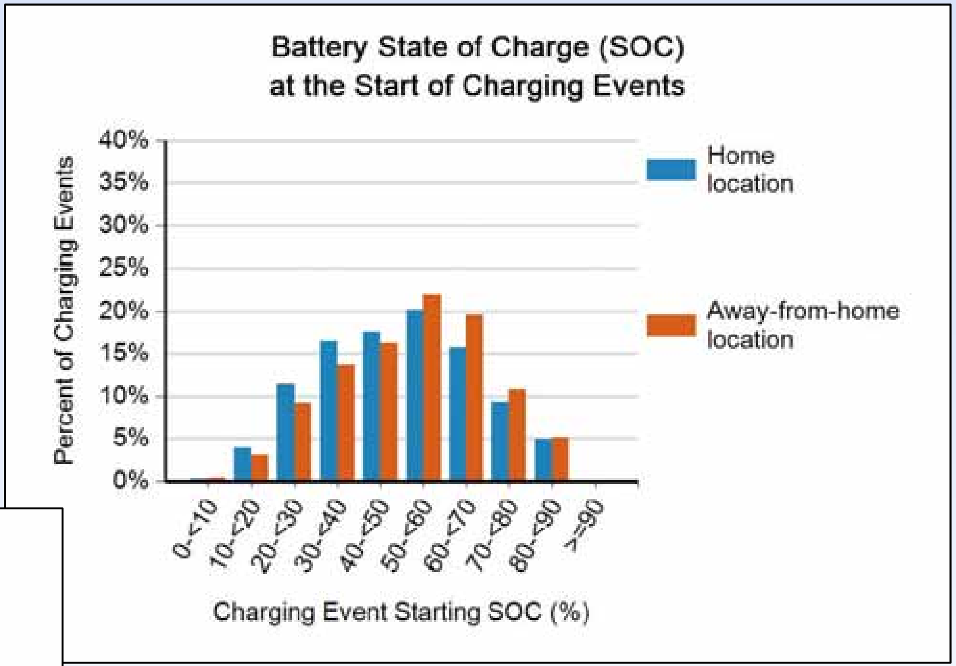
3rd quarter 2012 Data Only

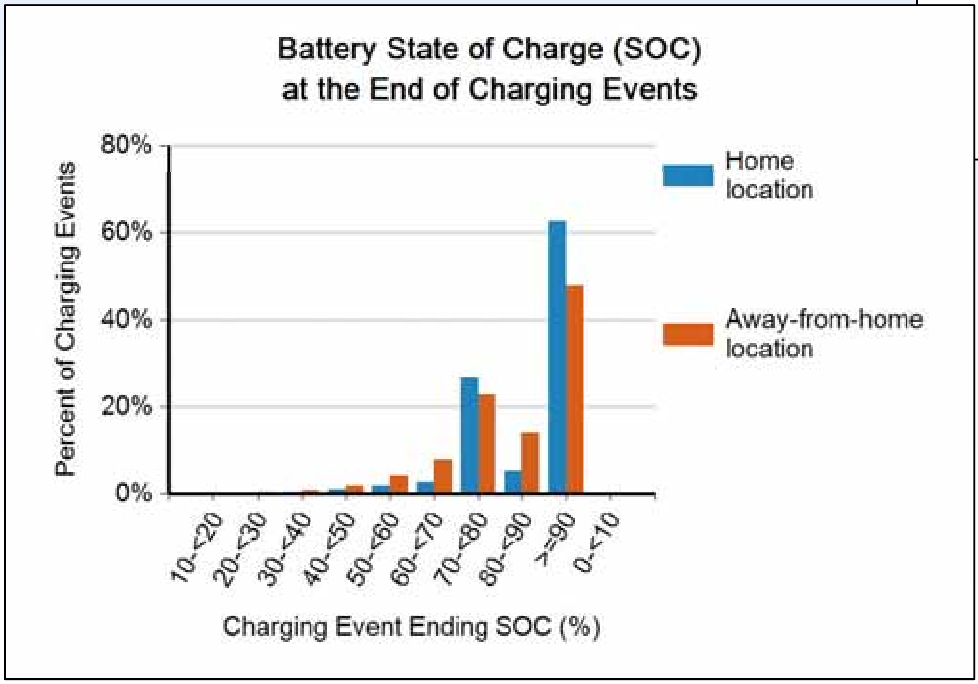
	Leafs	Volts
• Number of vehicles	3,200	809
• Number of Trips	813,430	286,682
• Distance (million miles)	5.84	2.39
• Average (Ave) trip distance	7.2 mi	8.3 mi
• Ave distance per day	30.0 mi	41.2 mi
• Ave number (#) trips between charging events	3.9	3.5
• Ave distance between charging events	27.9 mi	29.3 mi
• Ave # charging events per day	1.1	1.4
• Overall mpg		136 mpg
• Overall AC Wh/mi		222

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

EV Project – Leaf Usage Report (3rd 2012)

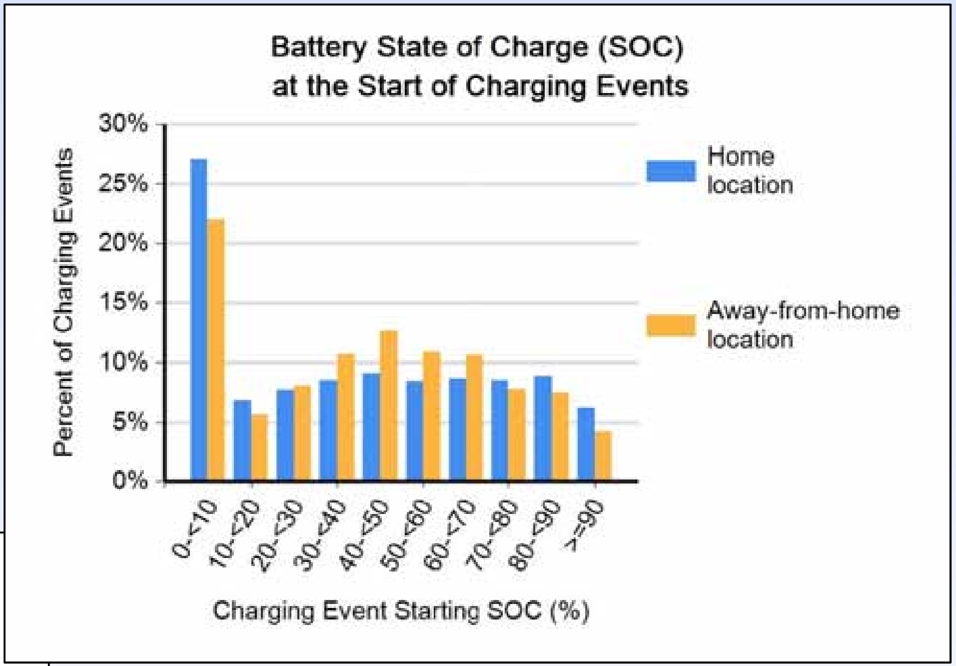
- **Leaf battery SOC before and after charge events by home and non-home locations – national data**

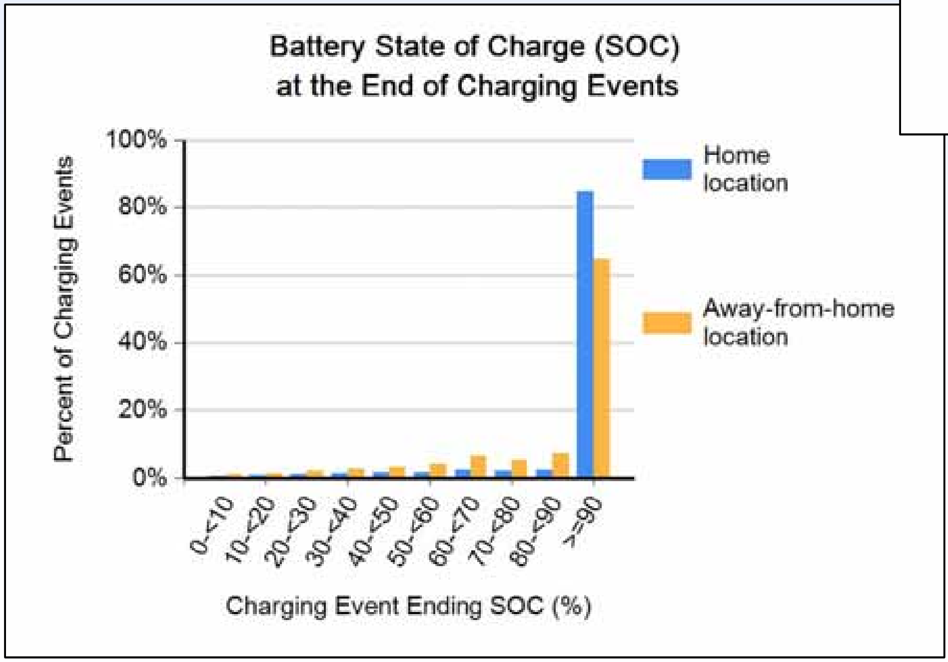




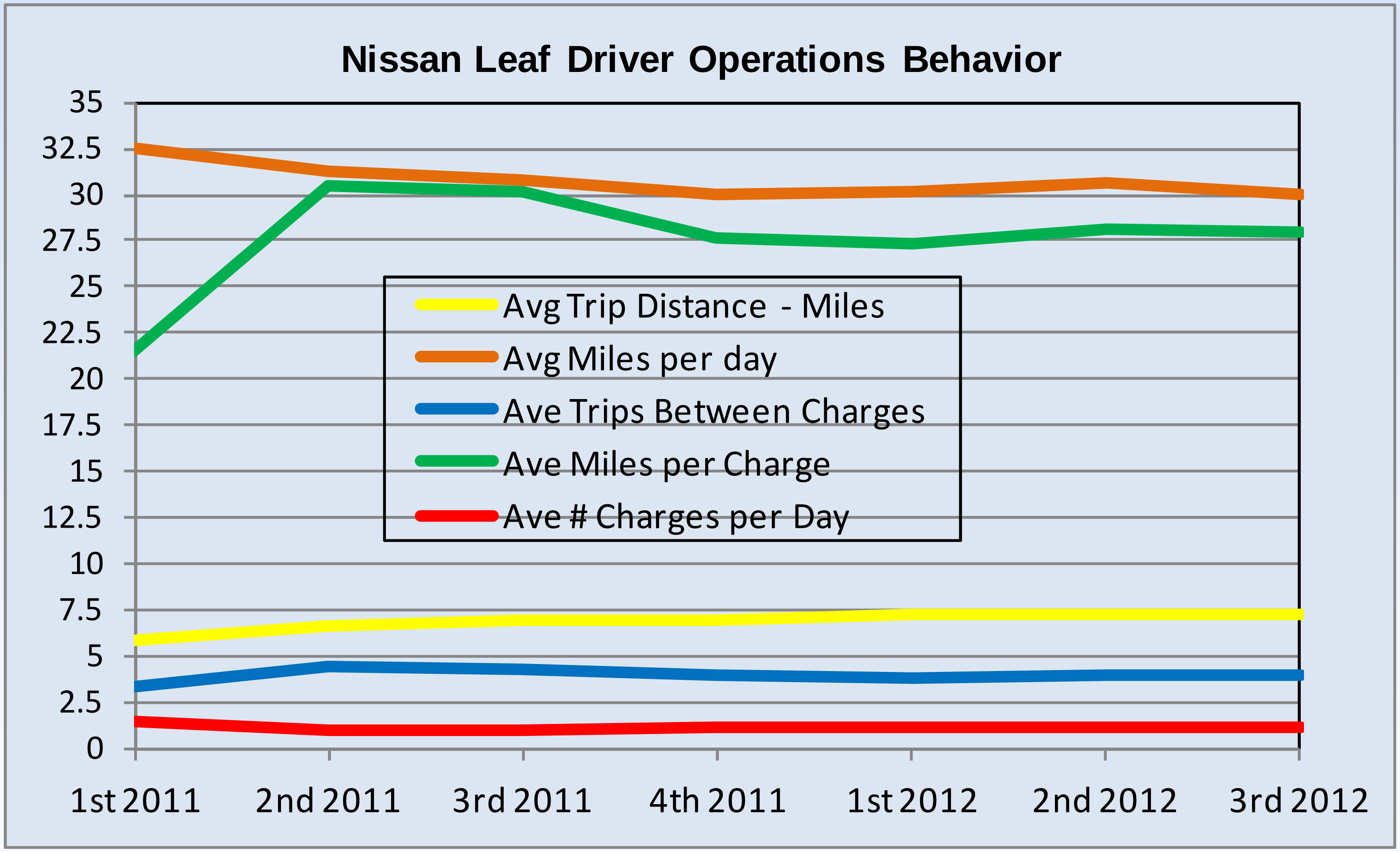
EV Project – Volt Usage Report (3rd 2012)

- **Volt battery SOC before and after charge events by home and non-home locations – national data**



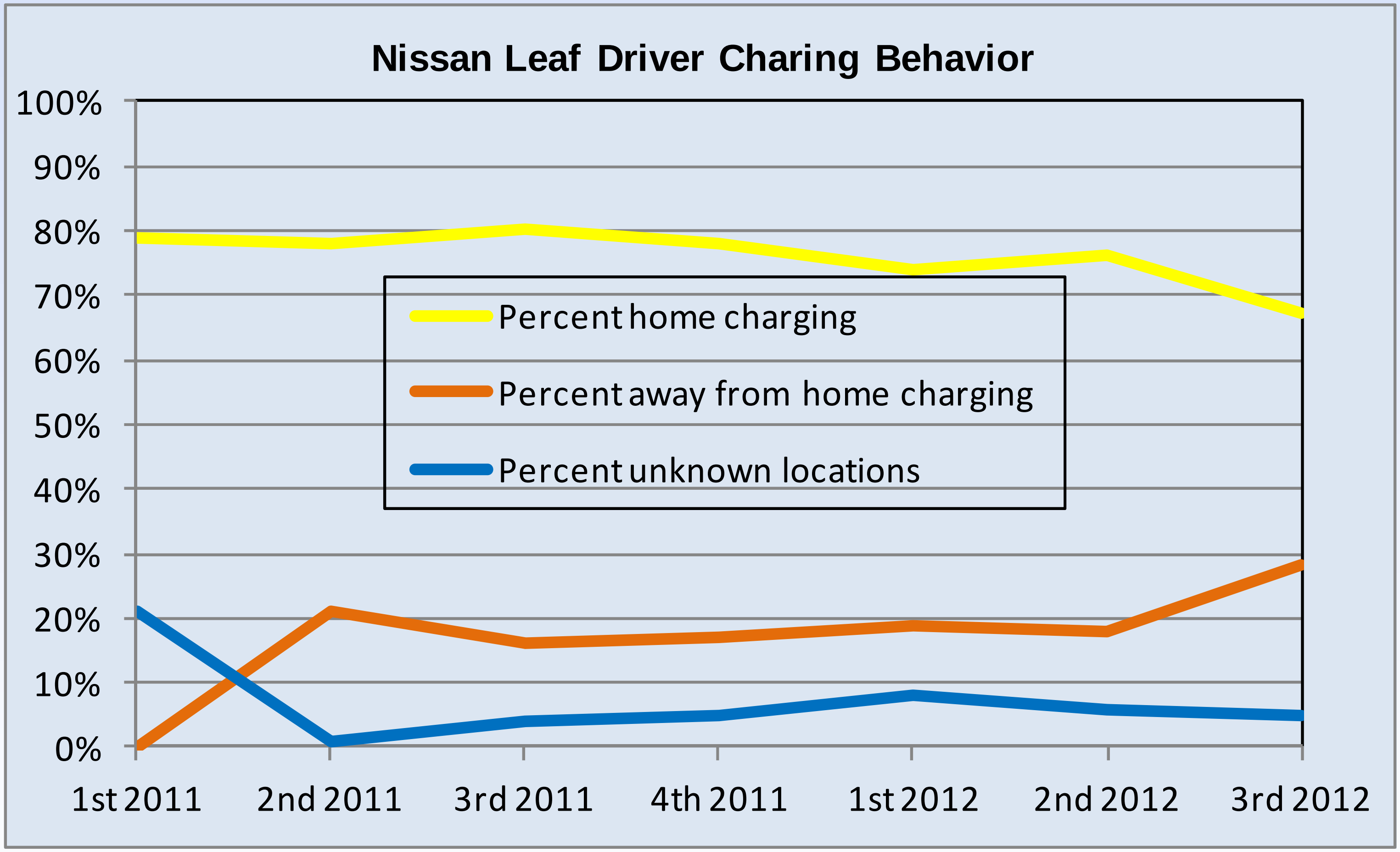


EV Project – Leaf Operations Trends



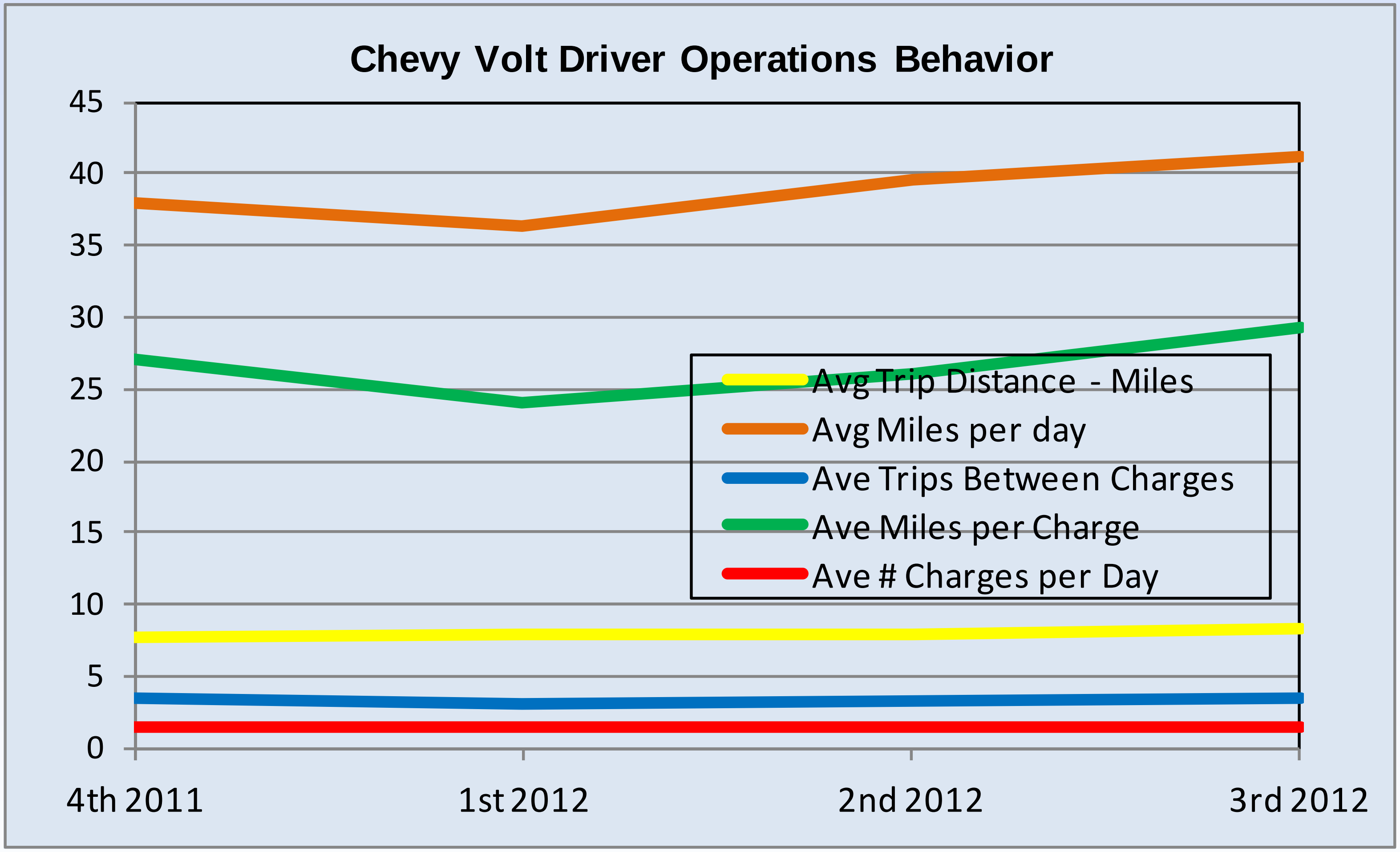
Number of Leafs reporting each quarter						
35	956	2,394	2645	2987	2911	3200

EV Project – Leaf Charging Location Trends



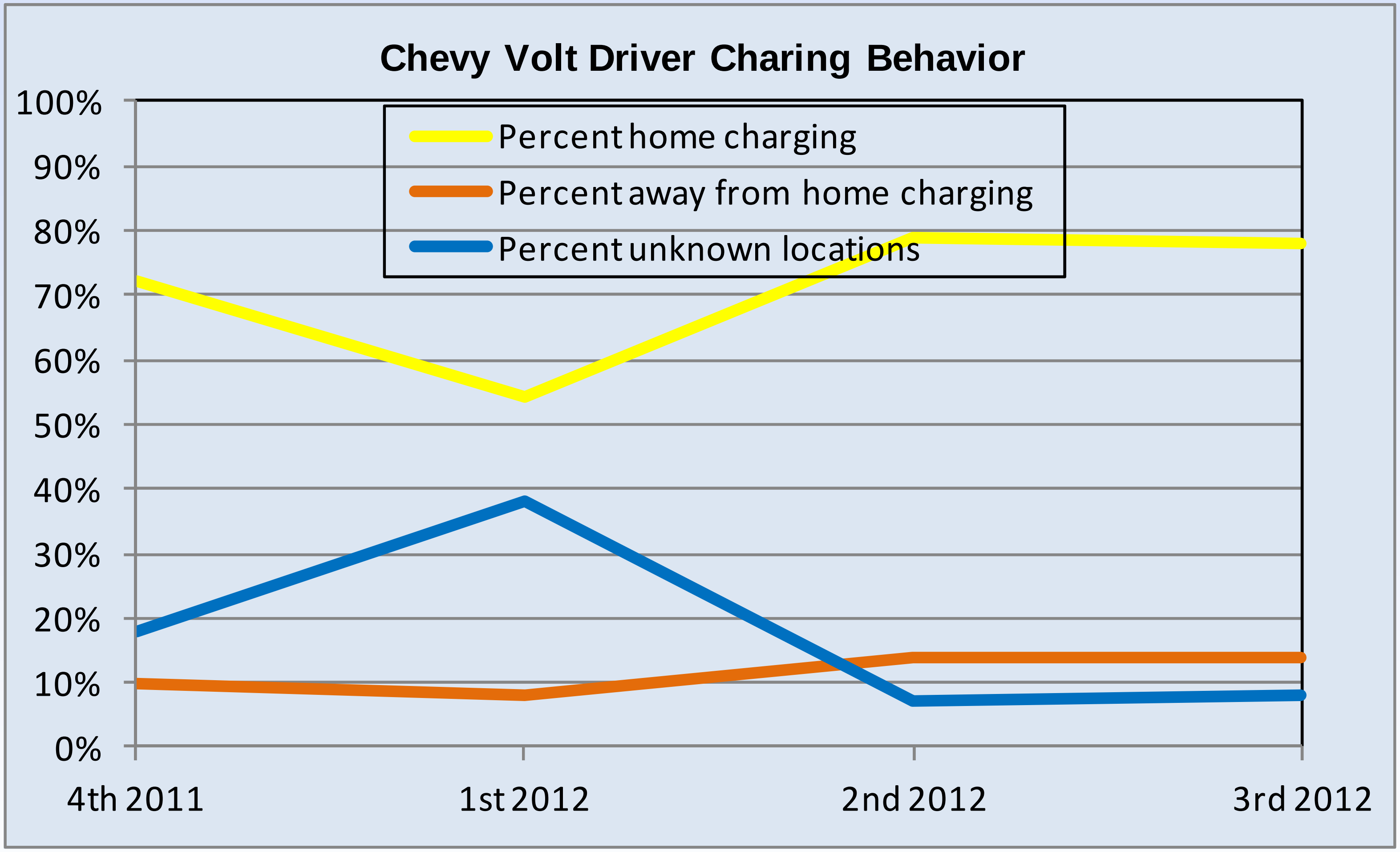
Number of Leafs reporting each quarter						
35	**956**	**2,394**	**2645**	**2987**	**2911**	**3200**

EV Project – Volt Operations Trends



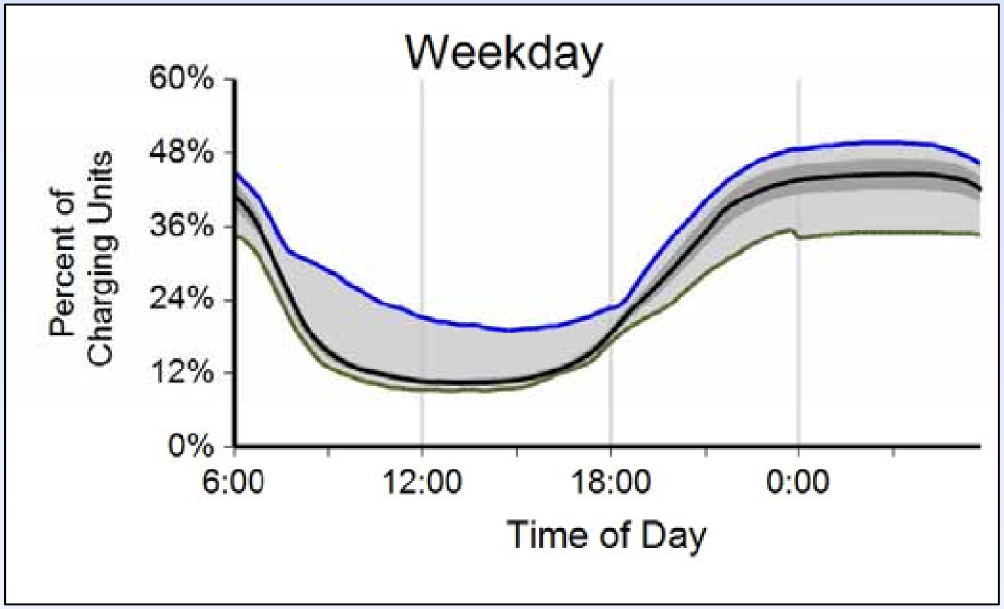
Number of Volts reporting each quarter			
45	317	408	809

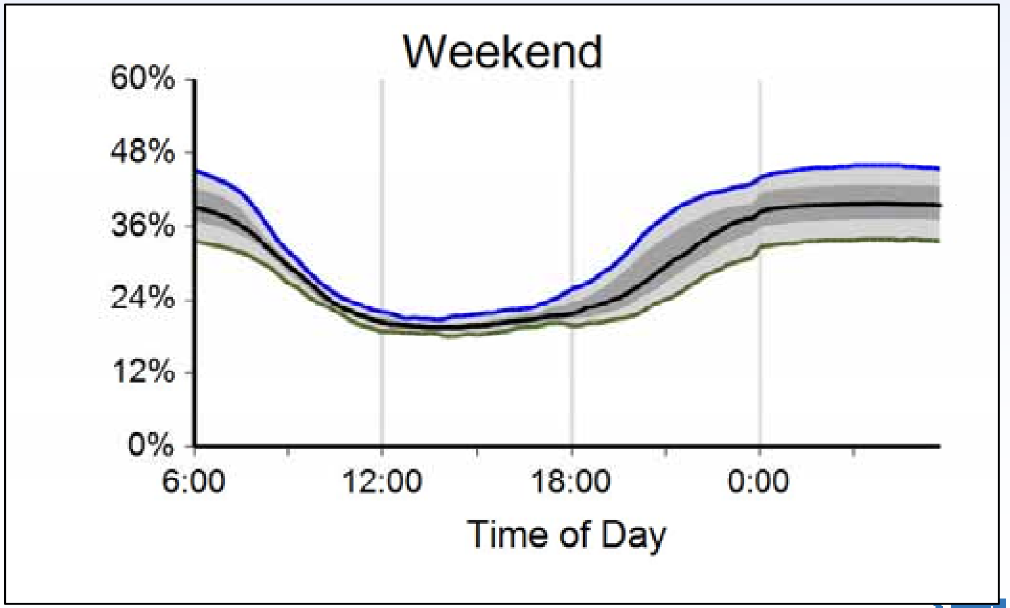
EV Project – Volt Charging Location Trends



Number of Volts reporting each quarter			
45	317	408	809

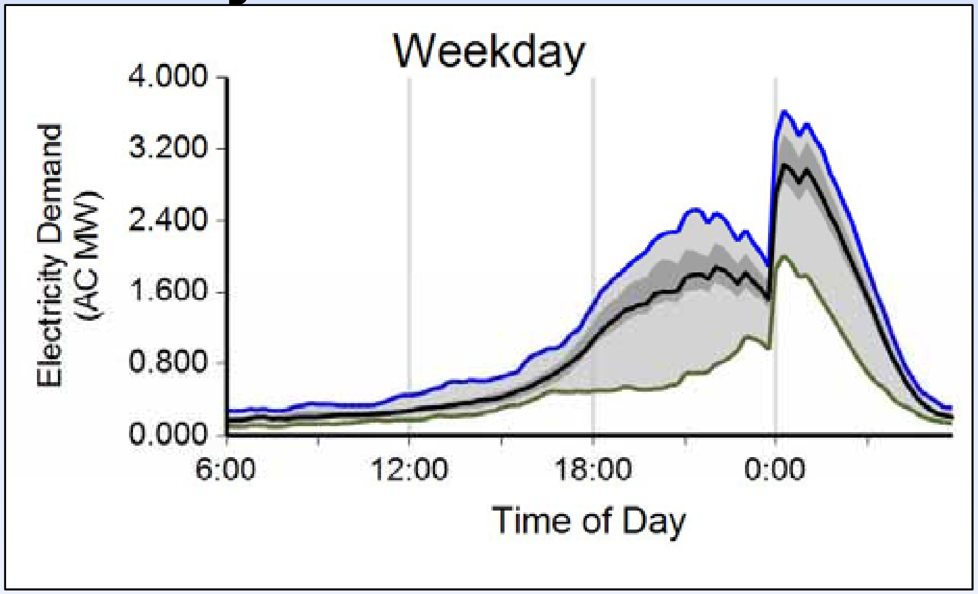
EV Project – EVSE Infra. Summary Report

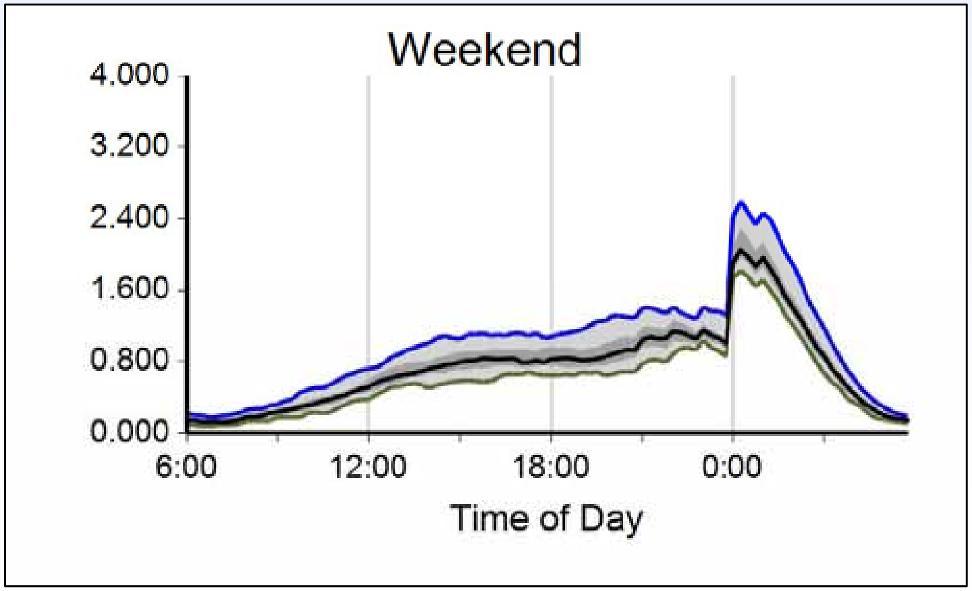




- **Graphs document when EVSE have a vehicle connected during the 3rd quarter 2012**
- **National Data, all EVSE**
- **Range of Percent of EVSE and DC Fast Chargers with a Vehicle Connected vs. Time of Day**

EV Project – EVSE Infra. Summary Report



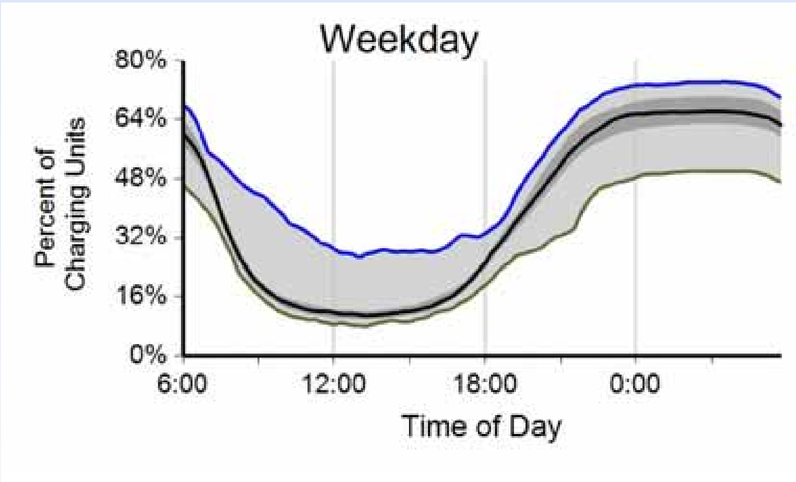


- **Charging demand in AC MW during the 3rd[nd] quarter 2012**
- **National data, all EVSE**
- **Time of day kWh rates are influencing charging start times as measured by AC MW demand**
- **Range of Aggregate Electricity Demand vs. Time of Day (AC MW)**

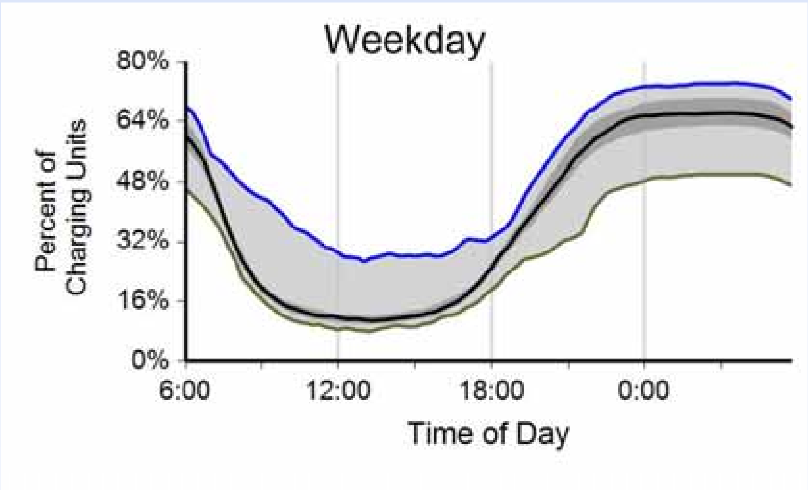
EV Project – EVSE Infra. Summary Report

- **Residential Level 2 Weekday EVSE 3rd Quarter 2012**
- **Regional time of day EVSE has a vehicle connected**

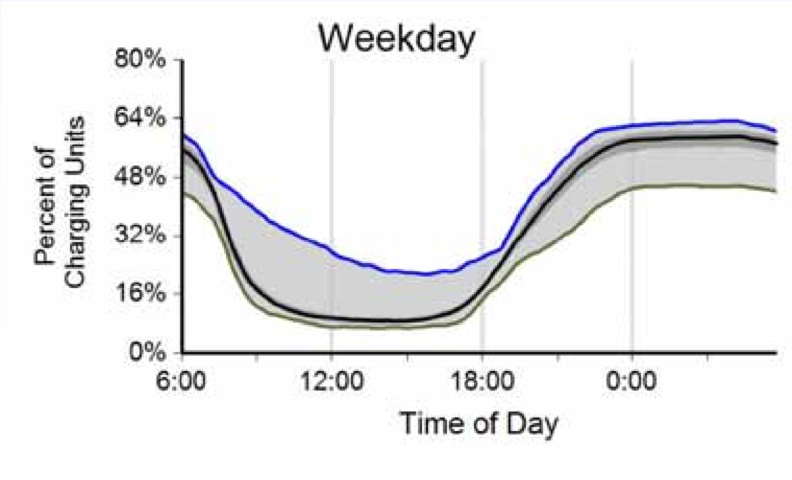
San Diego



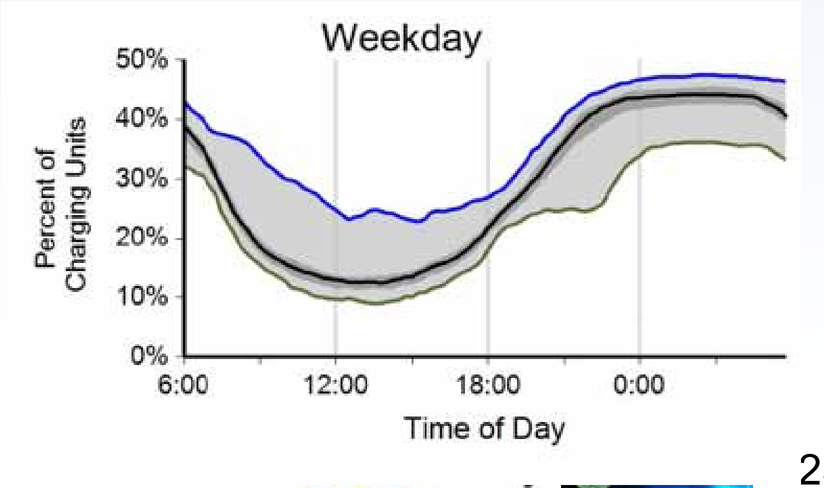
Oregon



San Francisco



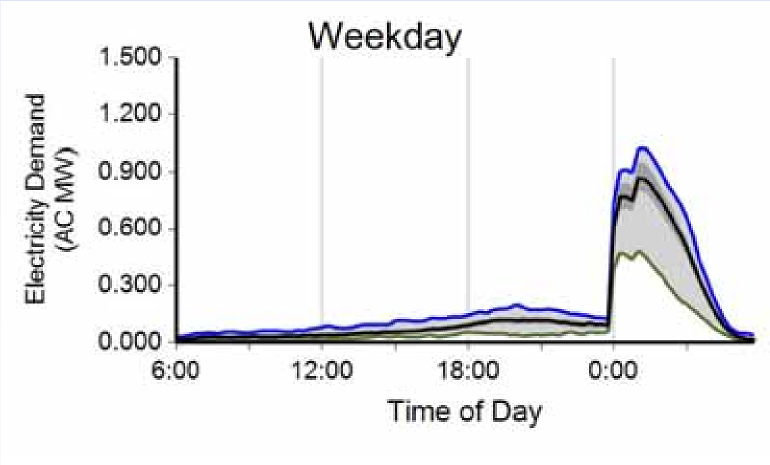
Washington State



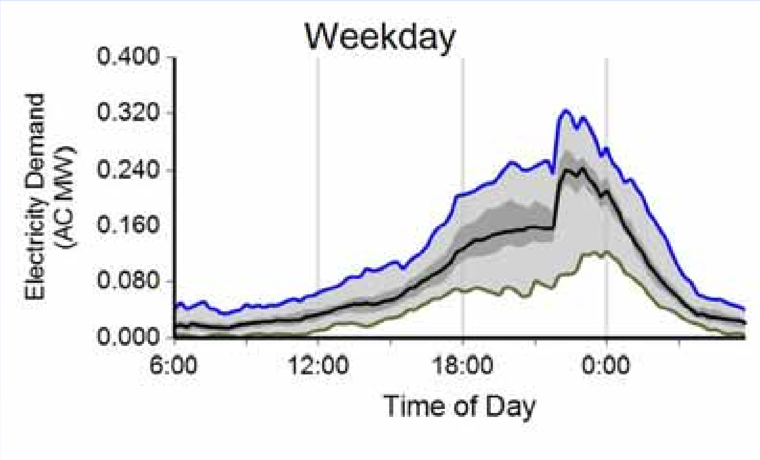
EV Project – EVSE Infra. Summary Report

- **Residential Level 2 Weekday EVSE 3rd Quarter 2012**
- **Time of day kWh rates clearly influence charge patterns**

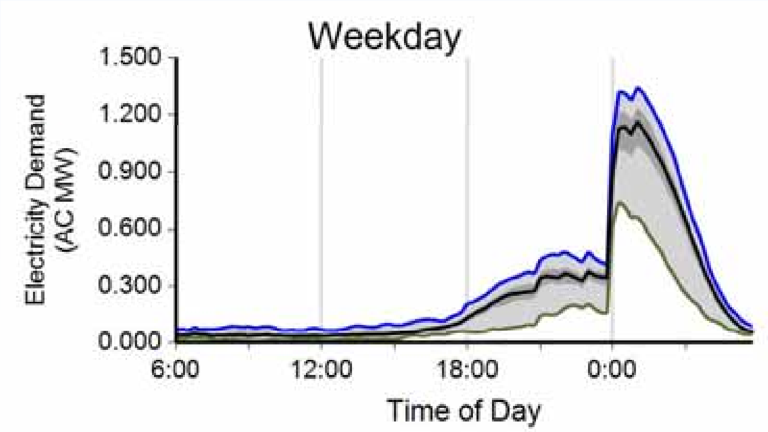
San Diego



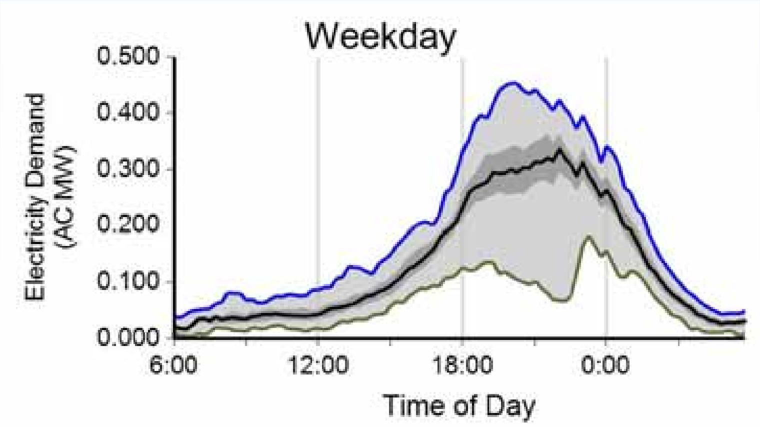
Oregon



San Francisco



Washington State



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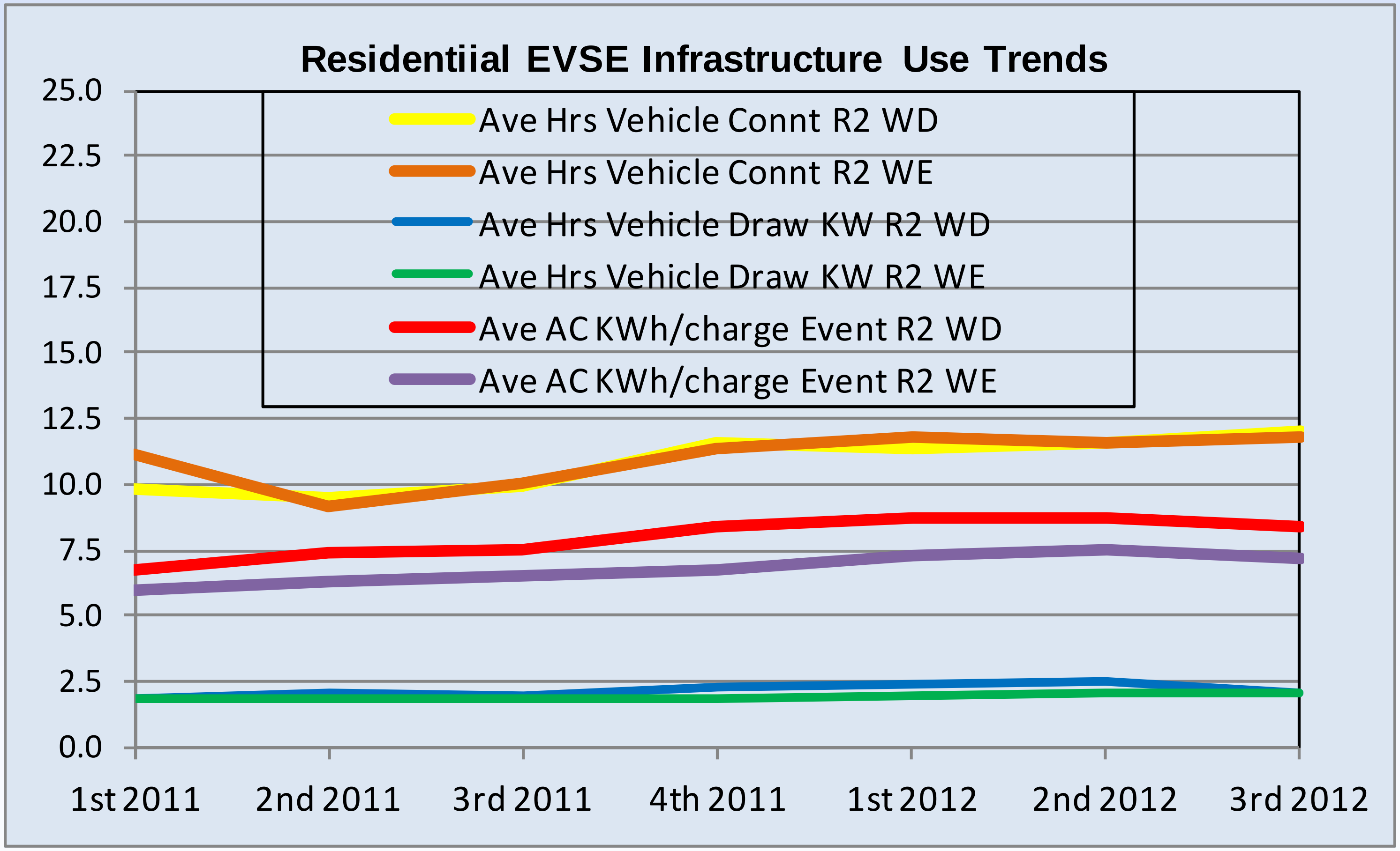
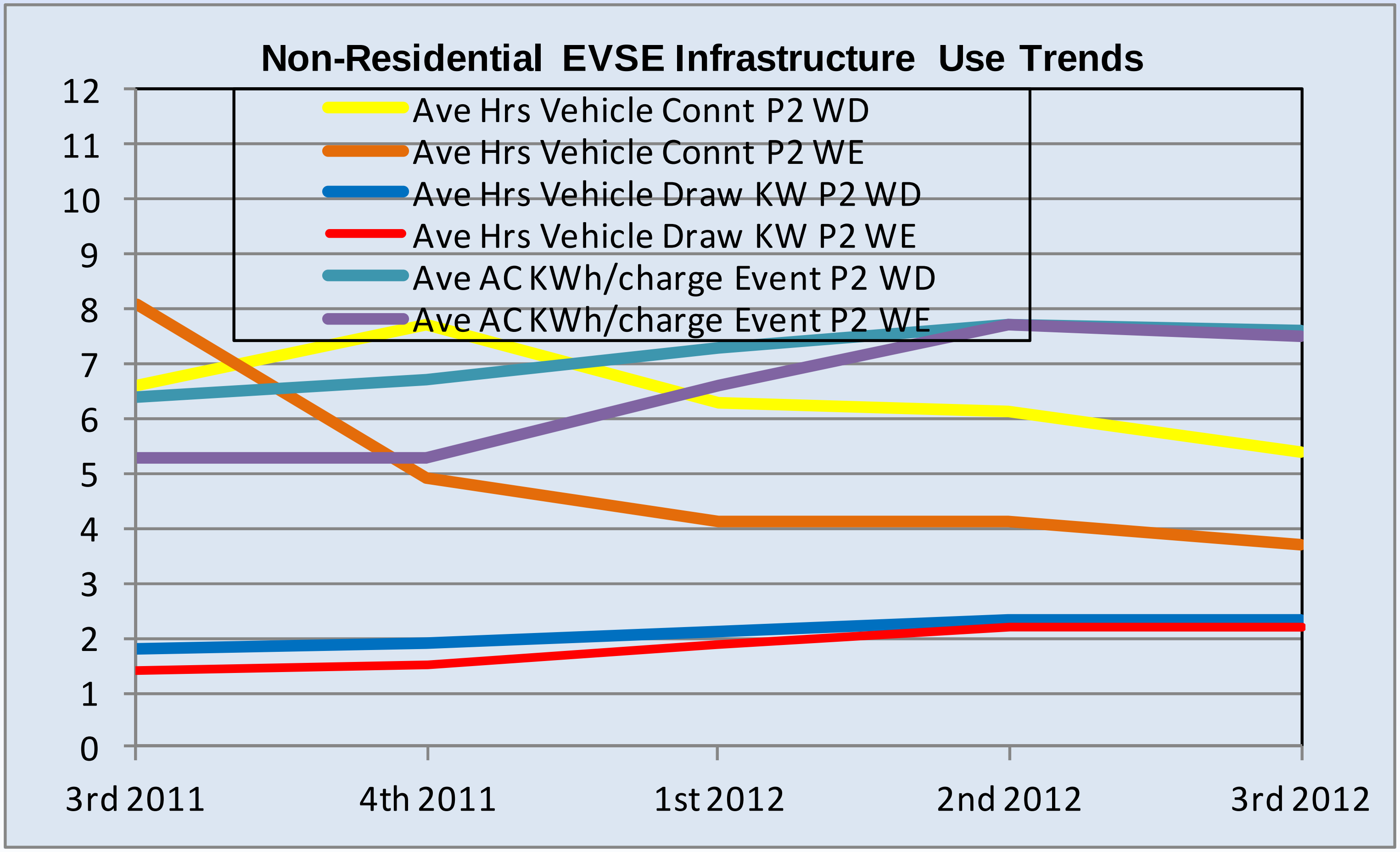
EV Project – Residential EVSE L2 Use Trends



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

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

EV Project – Public EVSE L2 Use Trends

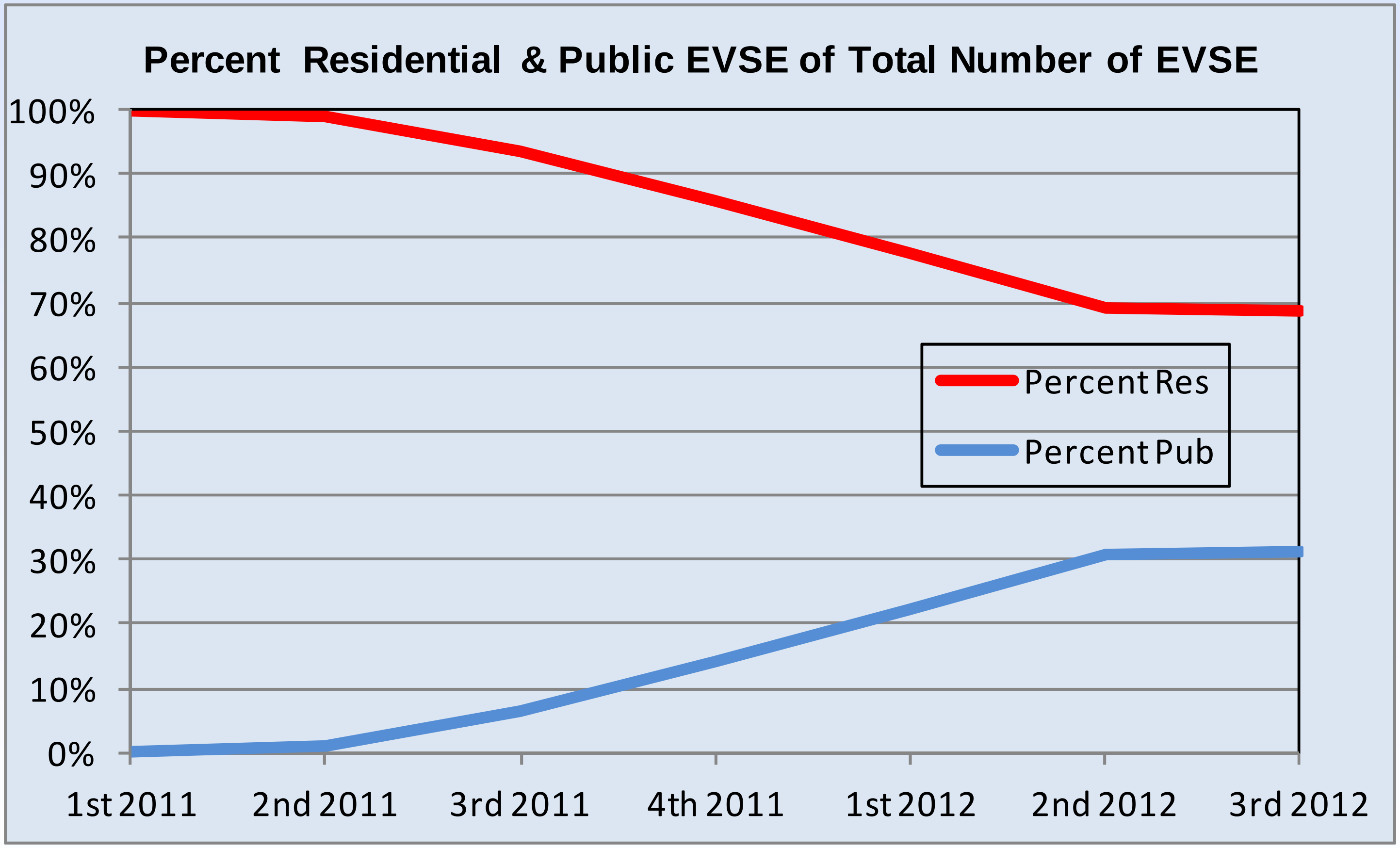


Number of Public EVSE Level reporting each quarter				
170	438	955	1483	1818

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

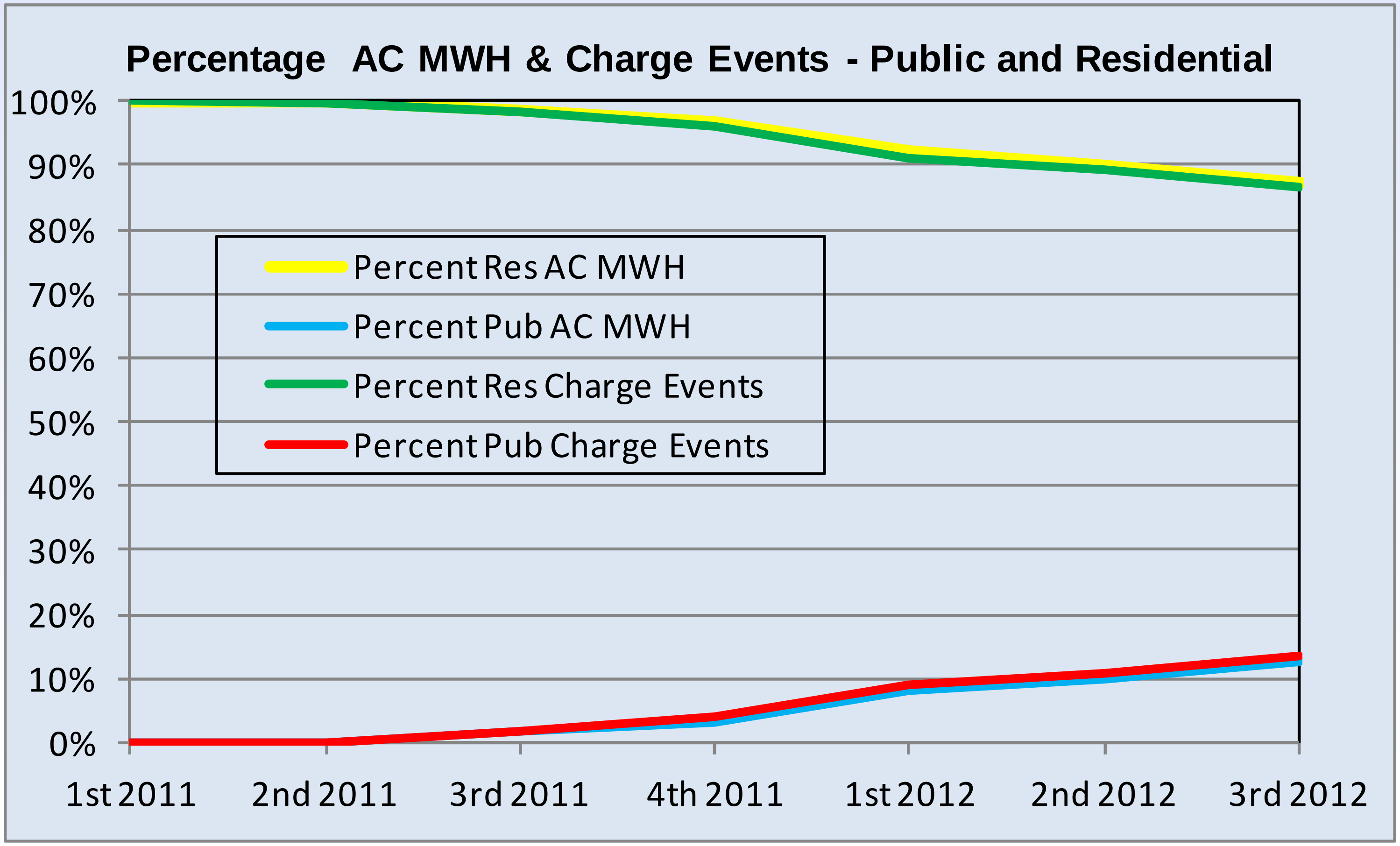
EV Project – EVSE Infra. Summary Report

- Percent of public EVSE deployed is increasing, now representing 31% of all EVSE



EV Project – EVSE Infra. Summary Report

- **Percent charge events and AC MWH use by residential and public EVSE**
- **Public EVSE use (red & blue lines) is increasing with 13.5% charge events and 12.80% MWh 3rd quarter 2012**



DC Fast Charging impacts on Demand

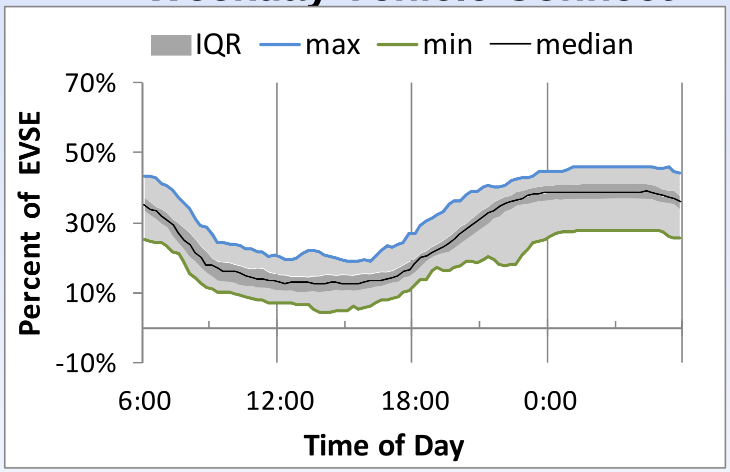
- **Northwest Electric Utility Service Area**

	Residential Level 2	Non Residential Level 2	DC Fast Charger
Number units	135	66	3
Number charge events	7996	1214	157
% time vehicle connected	35%	5%	2%
% time vehicle drawing power	6%	2%	2%
% of charging events	85%	13%	2%
% KWh consumed	86%	12%	2%

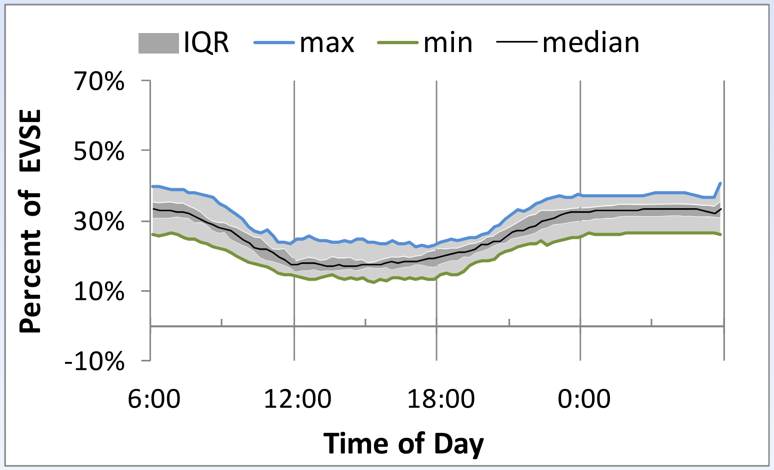
DC Fast Charging impacts on Demand (MW)

- **Northwest electric utility service area, 204 units**

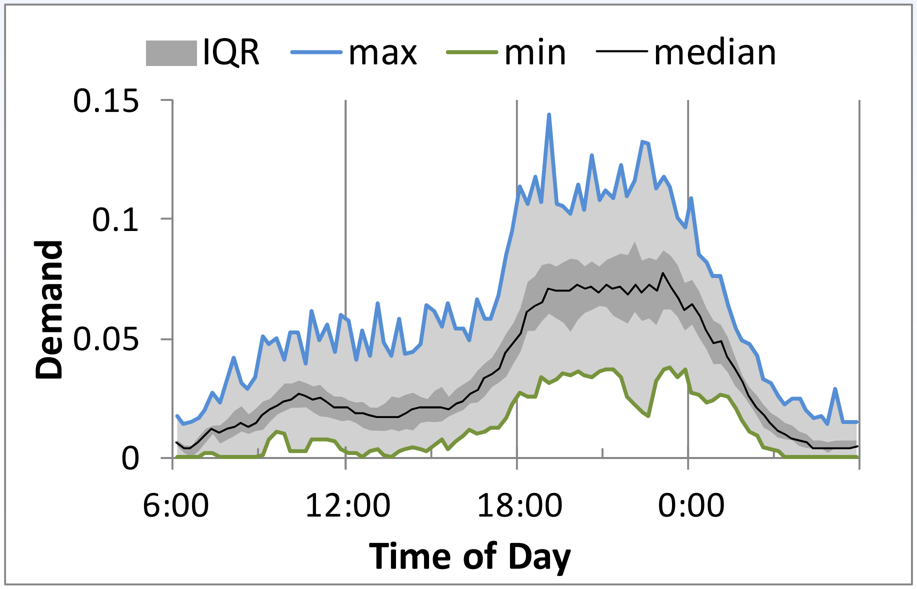
Weekday Vehicle Connect



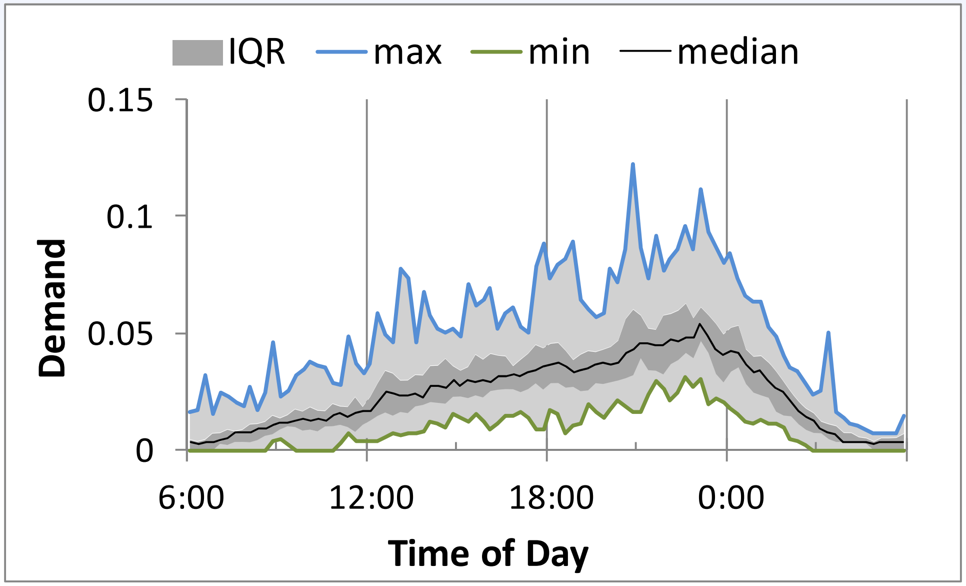
Weekend Vehicle Connect



Weekday Demand



Weekend Demand

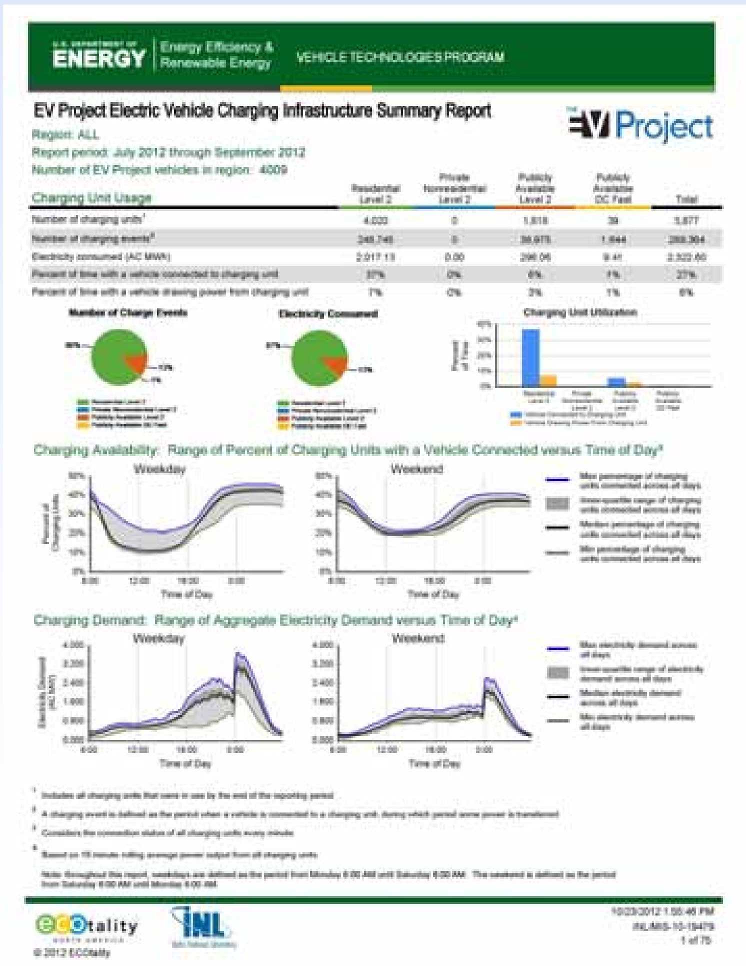


EV Project Data and Reporting

- EV Project reporting requires INL to blend three distinct data streams from ECOtality, Nissan and OnStar/GM
- Additional data streams from Daimler and a couple of EVSE manufacturers
- INL and ECOtality, with DOE concurrence, identified the type of reports that would be publicly released and all of the EV Project partners agreed (or relented)
- More than 80 EV Project reports are generated every reporting quarter
- More than 130 one time and special request reports have been generated
- 22 additional technical papers, lessons learned, and infrastructure planning reports published
- 56 presentations given by INL staff

EV Project Reporting

- **http://avt.inel.gov/evproject.shtml**
- **Public quarterly reports: 100 pages and 56,000 data values calculated for 4 public reports**



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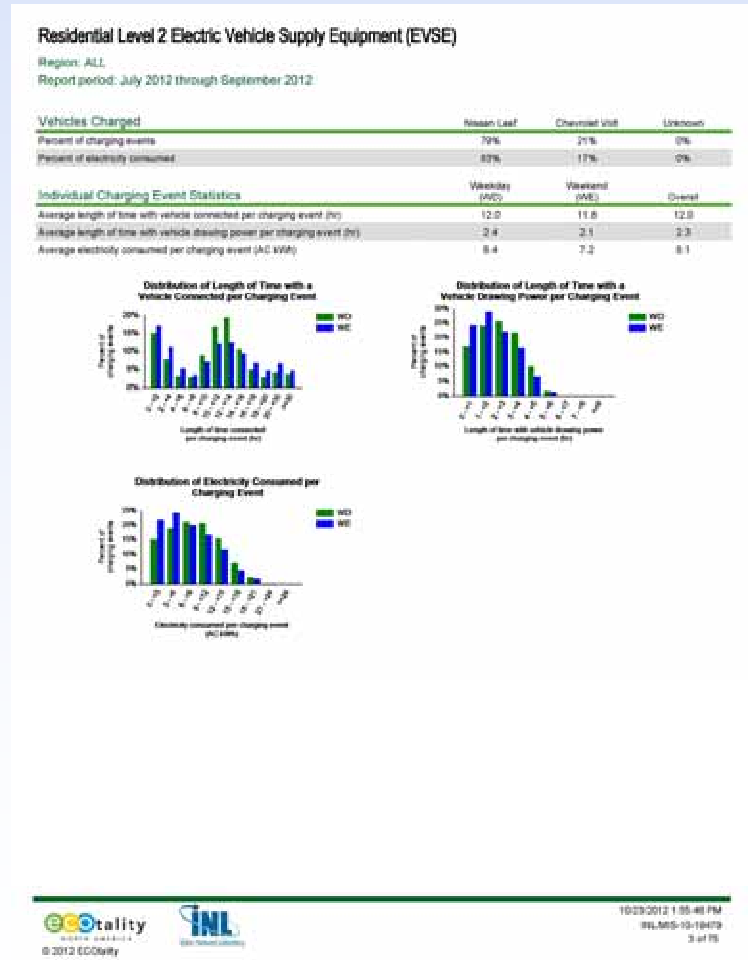
EV Project Electric Vehicle Charging Infrastructure Summary Report

Region: ALL

Report period: July 2012 through September 2012

Number of EV Project vehicles in region: 4009

Charging Unit Usage	Residential Level 2	Private Nonresidential Level 2	Publicly Available Level 2	Publicly Available DC Fast	Total
Number of charging units[1]	4,020	0	1,818	39	5,877
Number of charging events[2]	248,745	0	38,975	1,644	289,364
Electricity consumed (AC MWh)	2,017.13	0.00	296.06	9.41	2,322.60
Percent of time with a vehicle connected to charging unit	37%	0%	6%	1%	27%
Percent of time with a vehicle drawing power from charging unit	7%	0%	3%	1%	6%



Residential Level 2 Electric Vehicle Supply Equipment (EVSE)

Region: ALL

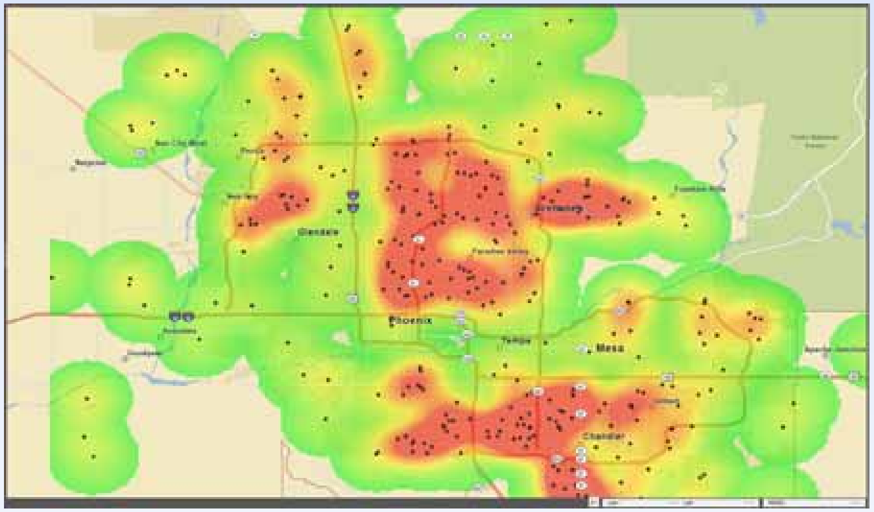
Report period: July 2012 through September 2012

Vehicles Charged	Nissan Leaf	Chevrolet Volt	Unknown
Percent of charging events	79%	21%	0%
Percent of electricity consumed	83%	17%	0%

Individual Charging Event Statistics	Weekday (WD)	Weekend (WE)	Overall
Average length of time with vehicle connected per charging event (hr)	12.0	11.8	12.0
Average length of time with vehicle drawing power per charging event (hr)	2.4	2.1	2.3
Average electricity consumed per charging event (AC kWh)	8.4	7.2	8.1

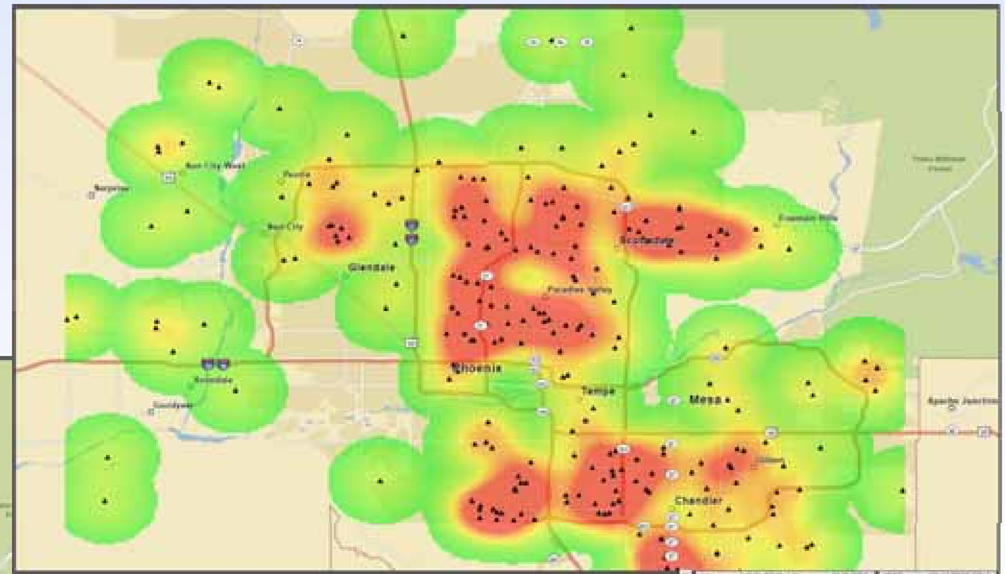
EV Project Reporting

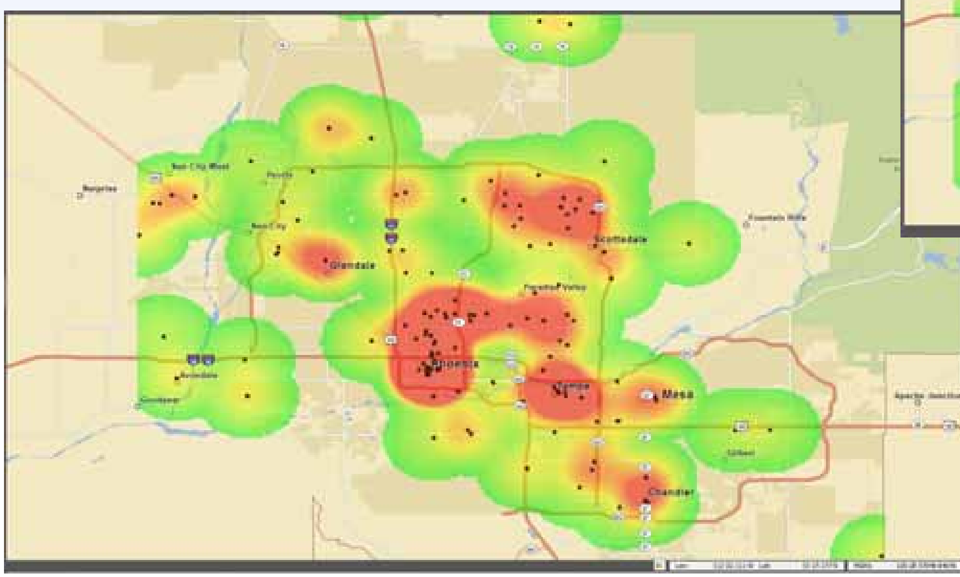
- Exploring visualization reporting methods via GIS



← EVSE Residential EVSE Phoenix

↓ Leaf "home" locations





← EVSE Public EVSE Phoenix

EV Project Lessons Learned – Currently Available

- http://www.theevproject.com/documents.php
- Reports available include
  - DC Fast Charge-Demand Charge Reduction (May 2012)
  - The EV Micro-Climate Planning Process (May 2012)
  - Signage (April 2012)
  - Greenhouse Gas (GHG) Avoidance and Fuel Cost Reduction (June 2012)
  - First Responder Training (March 2011)
  - Accessibility at Public EV Charging Locations (October 2011)
  - Battery Electric Vehicle Driving and Charging Behavior Observed Early in The EV Project (April 2012)
  - A First Look at the Impact of Electric Vehicle Charging on the Electric Grid in The EV Project (May 2012)

EV Project Lessons Learned - Coming

- http://www.theevproject.com/documents.php
  - Need for Commercial Charging
  - Pricing of Commercial Charging
  - Residential Installation Process
  - Commercial Installation Process
  - EV Energy Metering
  - Permitting Cost (Residential & Commercial)

Residential Lessons Learned

- **Permit timeliness has not been a problem**
- **Majority are over-the-counter**
- **Permit fees vary significantly- $7.50 to $500.00, mean $112.14**

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 are significant for ADA
  - 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 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

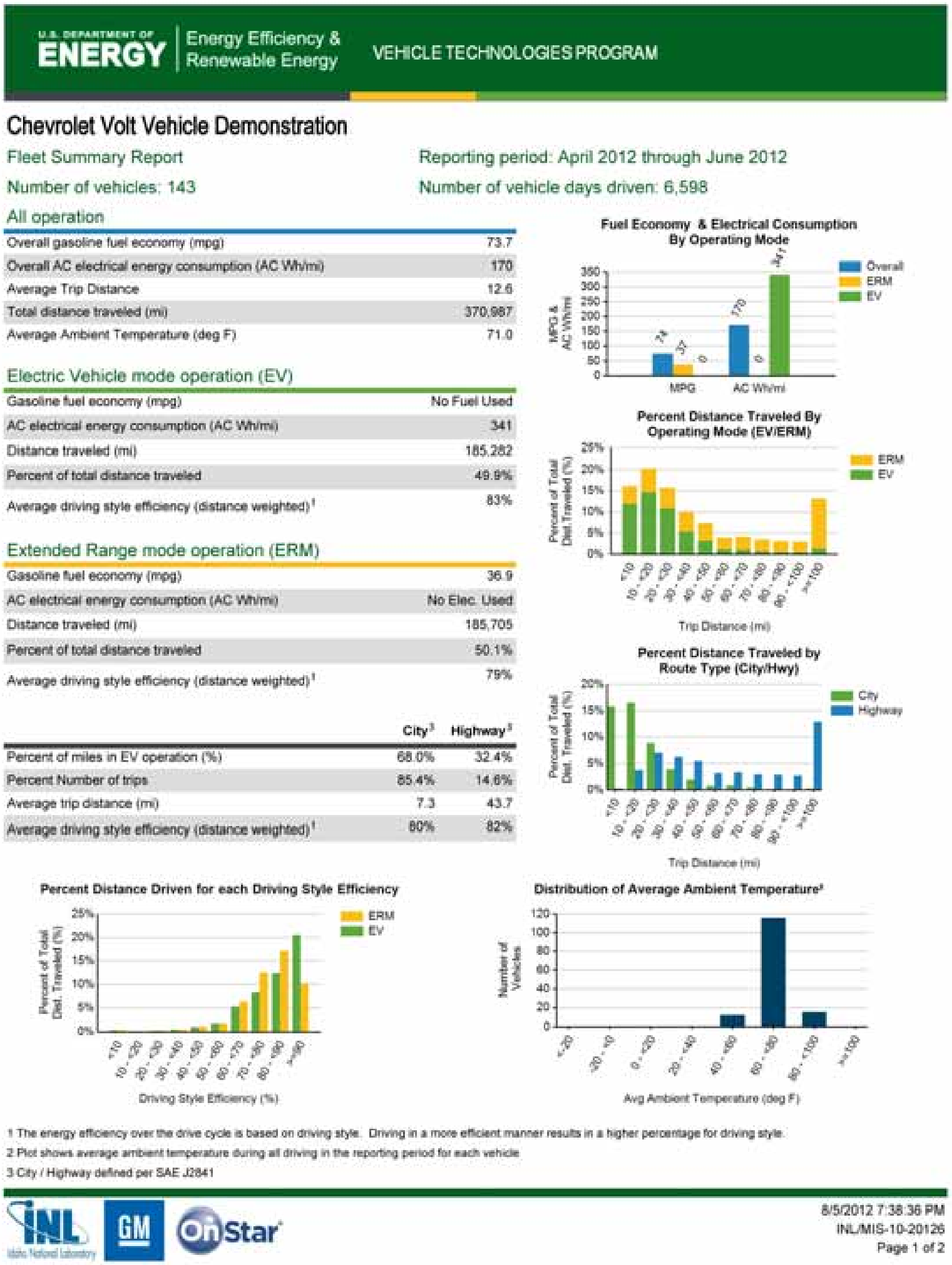
Commercial Lessons Learned

- **Recurring Nissan Leaf DC fast charge demand charges are significant in many (California) 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

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 public 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.?**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VEHICLE TECHNOLOGIES PROGRAM

Chevrolet Volt Vehicle Demonstration

Fleet Summary Report

Reporting period: April 2012 through June 2012

Number of vehicles: 143

Number of vehicle days driven: 6,598

All operation

Overall gasoline fuel economy (mpg)	73.7
Overall AC electrical energy consumption (AC Wh/mi)	170
Average Trip Distance	12.6
Total distance traveled (mi)	370,987
Average Ambient Temperature (deg F)	71.0

Electric Vehicle mode operation (EV)

Gasoline fuel economy (mpg)	No Fuel Used
AC electrical energy consumption (AC Wh/mi)	341
Distance traveled (mi)	185,282
Percent of total distance traveled	49.9%
Average driving style efficiency (distance weighted)[1]	83%

Extended Range mode operation (ERM)

Gasoline fuel economy (mpg)	36.9
AC electrical energy consumption (AC Wh/mi)	No Elec. Used
Distance traveled (mi)	185,705
Percent of total distance traveled	50.1%
Average driving style efficiency (distance weighted)[1]	79%

	City[3]	Highway[3]
Percent of miles in EV operation (%)	68.0%	32.4%
Percent Number of trips	85.4%	14.6%
Average trip distance (mi)	7.3	43.7
Average driving style efficiency (distance weighted)[1]	80%	82%

1 The energy efficiency over the drive cycle is based on driving style. Driving in a more efficient manner results in a higher percentage for driving style.
2 Plot shows average ambient temperature during all driving in the reporting period for each vehicle
3 City / Highway defined per SAE J2841

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Page 1 of 2

Chevrolet Volt DOE ARRA Project

- Non-public fleet drivers operating 150 Volts
- May '11 to June '12
  - 1.2 million total miles
  - All trips, 70.0 mpg, 174 AC Wh/mi
  - EV mode, 352 AC Wh/mi. 49.5% miles
  - Extended range mode, 35.4 mpg
- April to June 2012
  - 371,000 miles
  - EV mode, 341 AC Wh/mi. 49.9% miles

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Chevrolet Volt DOE ARRA Project

- Non-public fleet drivers
- 150 Volts (May '11 – June '12)
  - Average charging events per month 17
  - Average # charging events per vehicle day 1.3
  - Average miles per charging event 43 miles
  - Average trips between charging events 3.4
  - Average time connected per event 3.2 hours
  - Average energy per charge event 7.2 AC kWh
  - Average charging energy per vehicle month 125 AC kWh
  - Average trip distance city driving 7.3 miles
  - Average trip distance highway driving 44.0 miles
  - Percent of miles in EREV (electric) mode 49.5%

Ford Escape Adv. Research Vehicle

- **21 Ford Escape PHEVs**
- **Fleet drivers**
- **Nov 09 to Sept '12**
- **567,000 test miles**
- **All trips, 38 mpg, 101 AC & 69 DC Wh/mi**
- **Charge Depleting (CD), 52 mpg & 163 DC Wh/mi. 29% of all miles**
- **Charge Sustaining (CS), 32 mpg. 28% of all miles**
- **Charging = 63% overall increase in mpg when comparing CD to CS trips**

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Ford Escape Advanced Research Fleet

Number of vehicles:	21	Date range of data received:	11/01/2009 to 09/30/2012
Reporting period:	November 09 - September 12	Number of vehicle days driven:	9,925

All Trips Combined

Overall gasoline fuel economy (mpg)	38
Overall AC electrical energy consumption (AC Wh/mi)[1]	101
Overall DC electrical energy consumption (DC Wh/mi)[2]	69
Total number of trips	47,525
Total distance traveled (mi)	566,651

Trips in Charge Depleting (CD) mode[3]

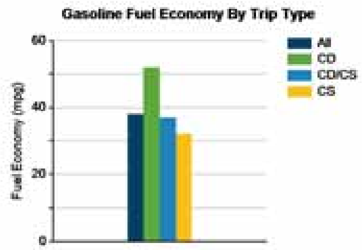
Gasoline fuel economy (mpg)	52
DC electrical energy consumption (DC Wh/mi)[4]	163
Number of trips	27,835
Percent of trips city | highway	83% | 17%
Distance traveled (mi)	164,934
Percent of total distance traveled	29%

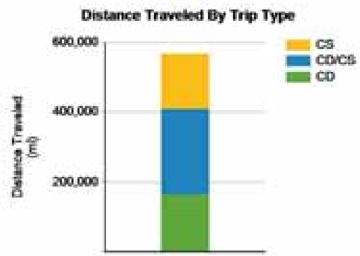
Trips in both Charge Depleting & Charge Sustaining (CD/CS) modes[5]

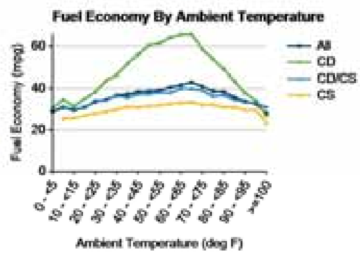
Gasoline fuel economy (mpg)	37
DC electrical energy consumption (DC Wh/mi)[6]	54
Number of trips	8,902
Percent of trips city | highway	38% | 62%
Distance traveled (mi)	242,847
Percent of total distance traveled	43%

Trips in Charge Sustaining (CS) mode[7]

Gasoline fuel economy (mpg)	32
Number of trips	10,778
Percent of trips city | highway	66% | 34%
Distance traveled (mi)	158,870
Percent of total distance traveled	28%







Notes: 1 - 7. Please see http://avt.inl.gov/pdf/phev/fordreportnotes.pdf for an explanation of all PHEV Fleet Testing Report notes.

Since these vehicles are flex-fuel capable, some driving events are conducted with E-85, which may decrease fuel economy results

"The Ford Escape Advanced Research Fleet was designed as a demonstration of customer duty cycles related to plug-in electric vehicles. The vehicles used in this demonstration have not been optimized to provide the maximum potential fuel economy."

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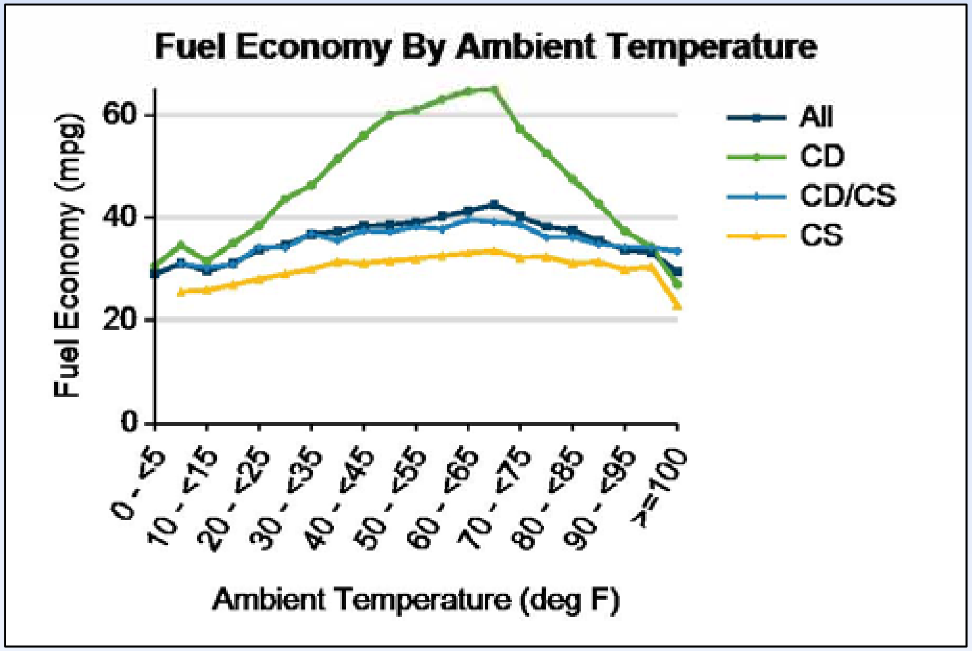
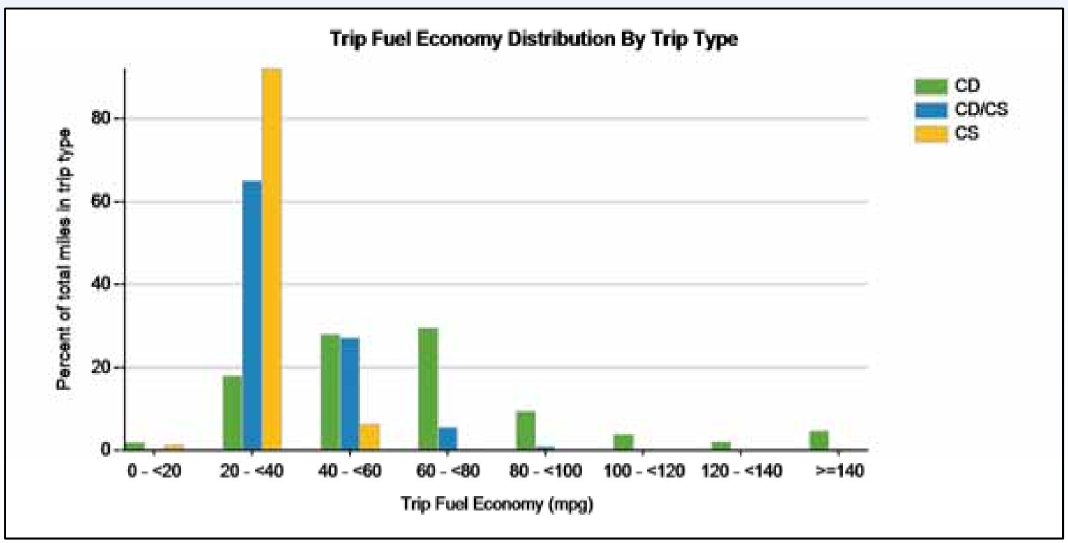
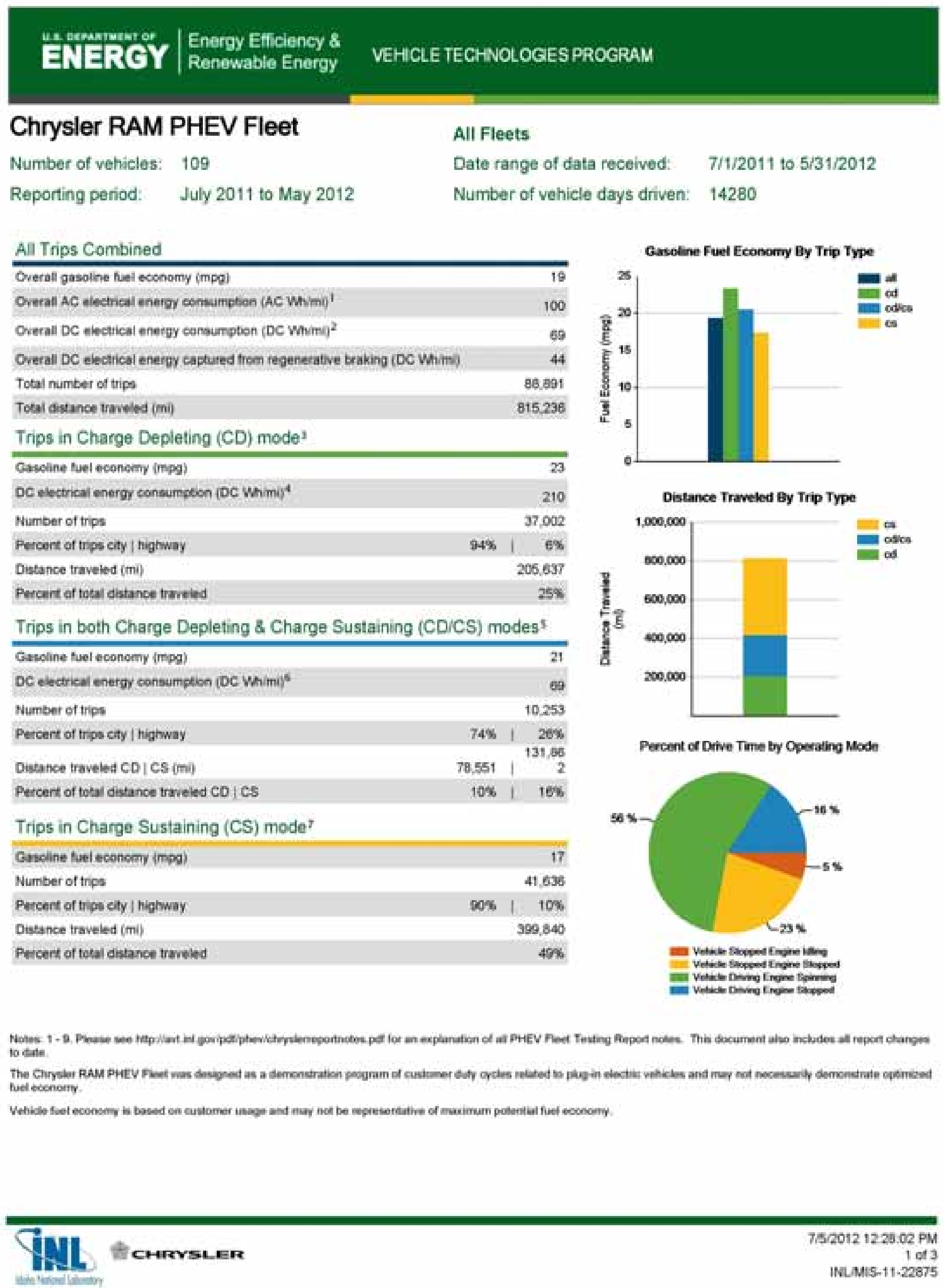
Ford Escape Adv. Research Vehicle





- **Ambient temperature and increased engine off-times impact mpg**
- **Charging = 60% increase in city mpg and 81% increase in highway mpg (compare CD to CS)**
- **City - 36% CD and 23% CS miles engine off**
- **Highway - 11% CD and 4% CS miles engine off**



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Chrysler RAM PHEV Fleet

Number of vehicles: 109

Reporting period: July 2011 to May 2012

All Fleets

Date range of data received: 7/1/2011 to 5/31/2012

Number of vehicle days driven: 14280

All Trips Combined

Overall gasoline fuel economy (mpg)		19
Overall AC electrical energy consumption (AC Wh/mi)[1]		100
Overall DC electrical energy consumption (DC Wh/mi)[2]		69
Overall DC electrical energy captured from regenerative braking (DC Wh/mi)		44
Total number of trips		88,891
Total distance traveled (mi)		815,236

Trips in Charge Depleting (CD) mode[3]

Gasoline fuel economy (mpg)		23
DC electrical energy consumption (DC Wh/mi)[4]		210
Number of trips		37,002
Percent of trips city | highway	94%	6%
Distance traveled (mi)		205,637
Percent of total distance traveled		25%

Trips in both Charge Depleting & Charge Sustaining (CD/CS) modes[5]

Gasoline fuel economy (mpg)		21
DC electrical energy consumption (DC Wh/mi)[6]		69
Number of trips		10,253
Percent of trips city | highway	74%	26%
Distance traveled CD | CS (mi)	78,551	131,86 2
Percent of total distance traveled CD | CS	10%	16%

Trips in Charge Sustaining (CS) mode[7]

Gasoline fuel economy (mpg)		17
Number of trips		41,636
Percent of trips city | highway	90%	10%
Distance traveled (mi)		399,840
Percent of total distance traveled		49%

Notes: 1 - 9. Please see http://avt.inl.gov/pdf/phev/chryslerreportnotes.pdf for an explanation of all PHEV Fleet Testing Report notes. This document also includes all report changes to date.

The Chrysler RAM PHEV Fleet was designed as a demonstration program of customer duty cycles related to plug-in electric vehicles and may not necessarily demonstrate optimized fuel economy.

Vehicle fuel economy is based on customer usage and may not be representative of maximum potential fuel economy.

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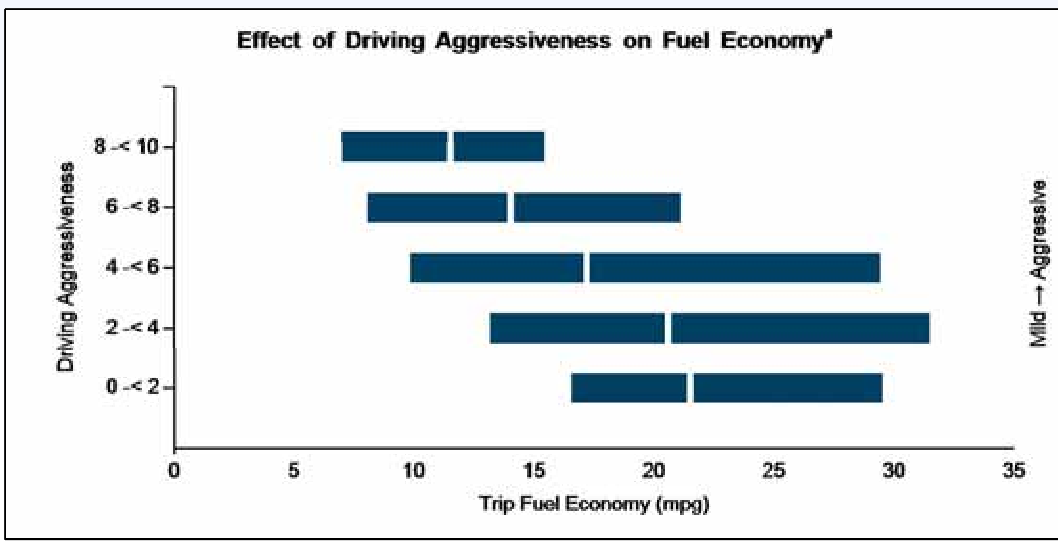
Chrysler Ram PHEV Project

- 109 Ram PHEVs
- Fleet drivers
- July 2011 to May 2012
- 815,000 test miles
- All trips, 19 mpg, 100 AC & 69 DC Wh/mi. 44 DC Wh/mi captured by regenerative braking
- CD, 23 mpg & 210 DC Wh/mi
- CS, 17 mpg
- Charging = 35% overall increase in mpg when comparing CD to CS trips

Chrysler Ram PHEV Pickups

- Rams in fleet applications
- Vehicle driving 16% time engine stopped
- Vehicle stopped 23% time engine stopped
- 64.1 miles per charge event
- 7.0 trips per charge event
- 0.89 charge events per vehicle day
- 2.4 average hours per charge event
- 6.4 AC kWh average energy / charge



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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 Date*	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

ChargePoint Network — INL Idaho National Laboratory

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Page 1 of 8

ChargePoint America ARRA Project

- Conducted by Coulomb
- Project to June 2012
- 3,085 EVSE installed and reporting data
- 1,298 Residential
- 216 Private/commercial
- 1,566 Public
- 5 unknown
- 367,000 charge events
- 2,500 AC MWh

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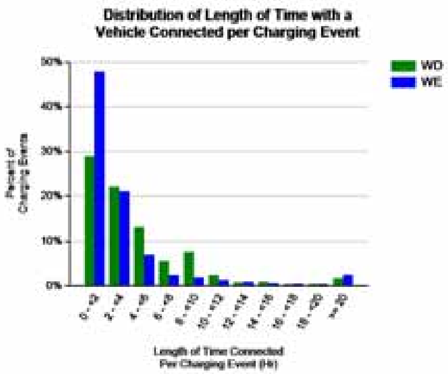
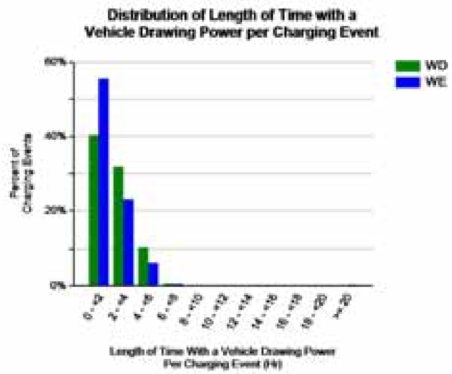
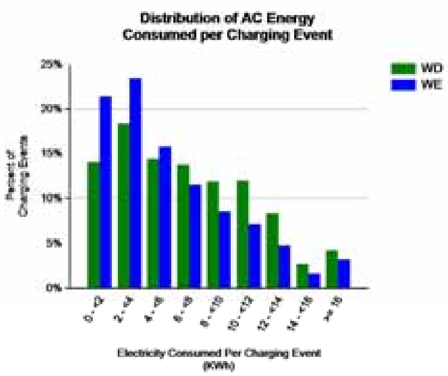
Public Electric Vehicle Supply Equipment (EVSE)

Report period: April 2012 through June 2012

Individual Charging Event Statistics	Weekday	Weekend	Overall
Average length of time with a vehicle connected per charging event (hr)	2.9	2.2	2.7
Average length of time with a vehicle drawing power per charging event (hr)	1.3	1.0	1.2
Average energy consumed per charging event (AC KWh)	7.06	6.16	6.89







[1] Includes all charging units that were in use during the reporting period and have reported data to the INL

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

Note: Weekends start at 6:00am on Saturday and end 6:00am Monday local time

ChargePoint Network

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Page 6 of 6

ChargePoint America ARRA Project

- **April – June 2012 data**
- **2,715 units**
- **Percent time vehicle connected**
  - **Residential 45%**
  - **Private/com 22%**
  - **Public 7%**
- **Percent time drawing power**
  - **Residential 9%**
  - **Private/com 4%**
  - **Public 3%**
- **EVSE data only**

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DC Fast Charge Impacts on Battery Life

- Quantify DC Fast Charge impacts via independent testing that compares AC Level 2 and DC fast charging
- Operate onroad two Nissan Leafs exclusively Level 2 charged and two Leafs exclusively DC Fast Charged on identical routes with same drivers and identical vehicles
- Laboratory cycle one Leaf at Level 2 and one at DC Fast Charge. Very controlled testing
- Compare battery capacity, resistance and other battery health indicator tests
- Periodic battery tests over 30,000 miles each, for one year, ending ~4th quarter FY2013. Publish results

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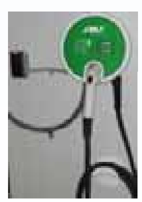
EVSE, DCFC and Wireless Charging Activities

- Benchmarked ten Level 2 EVSE for efficiency and standby power – 99.3 to 99.8% efficient
- Per NDAs, cyber security, EMF and efficiency test five low cost, smart Level 2 EVSE in support of DOE OE's FOA
- Developing with SAE Level 2 EVSE-to-PEV inter-operative capabilities demonstration with multiple units
- Completed first DCFC (Fast Charge) performance testing
- Developing with SAE a DCFC-to-PEV inter-operative capabilities demonstration with multiple units
- Per NDAs, cyber security, EMF and efficiency testing on manufacturer-developed wireless changing systems
- Based on lessons learned, conduct same testing on two wireless charging systems developed via an EERE FOA









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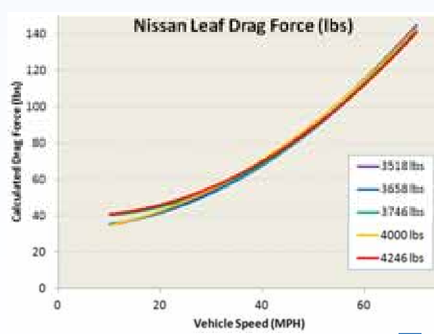
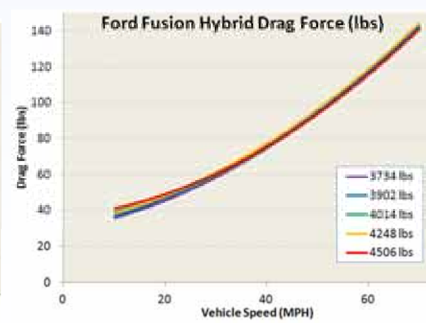
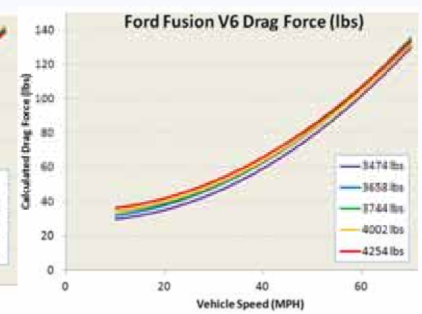
Vehicle Mass and Fuel Efficiency Impacts

- **With ANL / ECOtality, multiple test weights tested for each of three vehicles (Leaf, Fusion ICE and HEV) – 250 lb incremental increases and decreases from stock weight**
- **Coastdown testing determines the impact of mass change on vehicle road load and drag forces**
- **Vehicle road load is calculated from change in speed (while coasting) and the mass of the vehicle**
- **Road load coefficients determined from coastdown testing are used to configure the chassis dynamometer**
- **Chassis dynamometer testing uses standardized drive cycles to determine the impact of mass change on vehicle fuel economy and energy consumption (MPG and Wh/mi)**

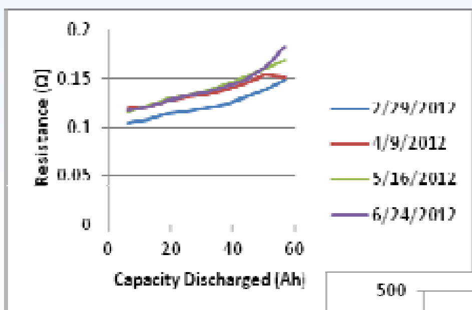


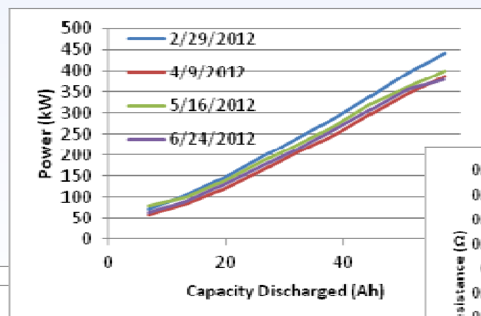


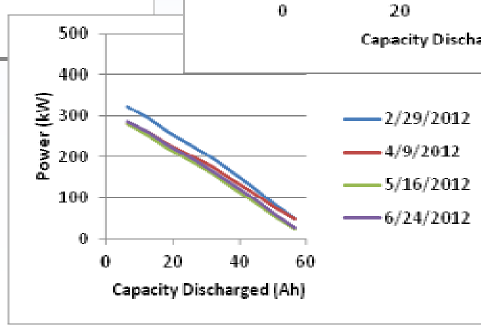


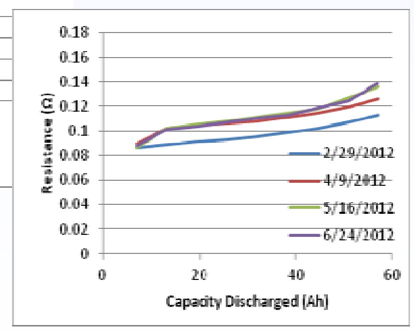
Energy Storage Testing – Battery Mule

- Test DOE funded advanced energy storage systems (ESSs) in on-road operations. Quantify capabilities, limitations, and performance fade over the life of the ESS
- **Only DOE project to perform onroad vehicle-system level testing of ESSs**
- Enerdel battery mimics the Leaf battery demands to benchmark changes in calculated discharge, capacity fade, resistance, discharge power capability, charge resistance and charge power capability
- Toshiba is the next test battery









Additional Activities

- **Conducting first responders training program with the National Fire Prevention Association and DOT / NHTSA**
  - **NFPA, OEMs and INL identify full size vehicle battery packs, procure and define demonstration “events”**
  - **OEMs are donating batteries and batteries will be ignited in NFPA fire suppression test mule**
- **DOD and Federal Fleets support with FEMP cost share**
  - **DOD studies electric infrastructure and PEV deployment Lewis McCord, Jacksonville / Mayport, and Pendleton**
  - **800 vehicles with data loggers, DOD, NPS, Veterans, etc.**

Above source: Jalopnik, October 30, 2012
http://updates.jalopnik.com/post/34669789863/more-than-a-dozen-fisker-karma-hybrids-caught-fire-and

Acknowledgement

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

More Information

http://avt.inl.gov

This presentation will be posted in the publications section of the above website under "VSATT – November 2012 Update INL Activities"

INL/MIS-12-27607