Idaho National Laboratory

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

EV ROADMAP 4 – DOE Light-Duty Electric Drive Vehicle and Infrastructure Demonstrations

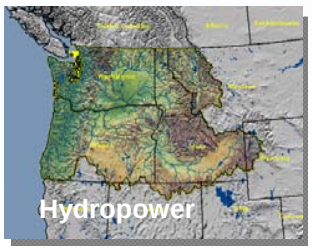
Jim Francfort – Idaho National Laboratory

EV ROADMAP 4
World Trade Center, Portland, Oregon
November 2 & 3, 2011

This presentation does not contain any proprietary or sensitive information

Idaho National Laboratory

- Eastern Idaho based U.S. Department of Energy (DOE) Federal 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
  - Energy Critical Infrastructure Protection
  - Homeland Security and Cyber Security



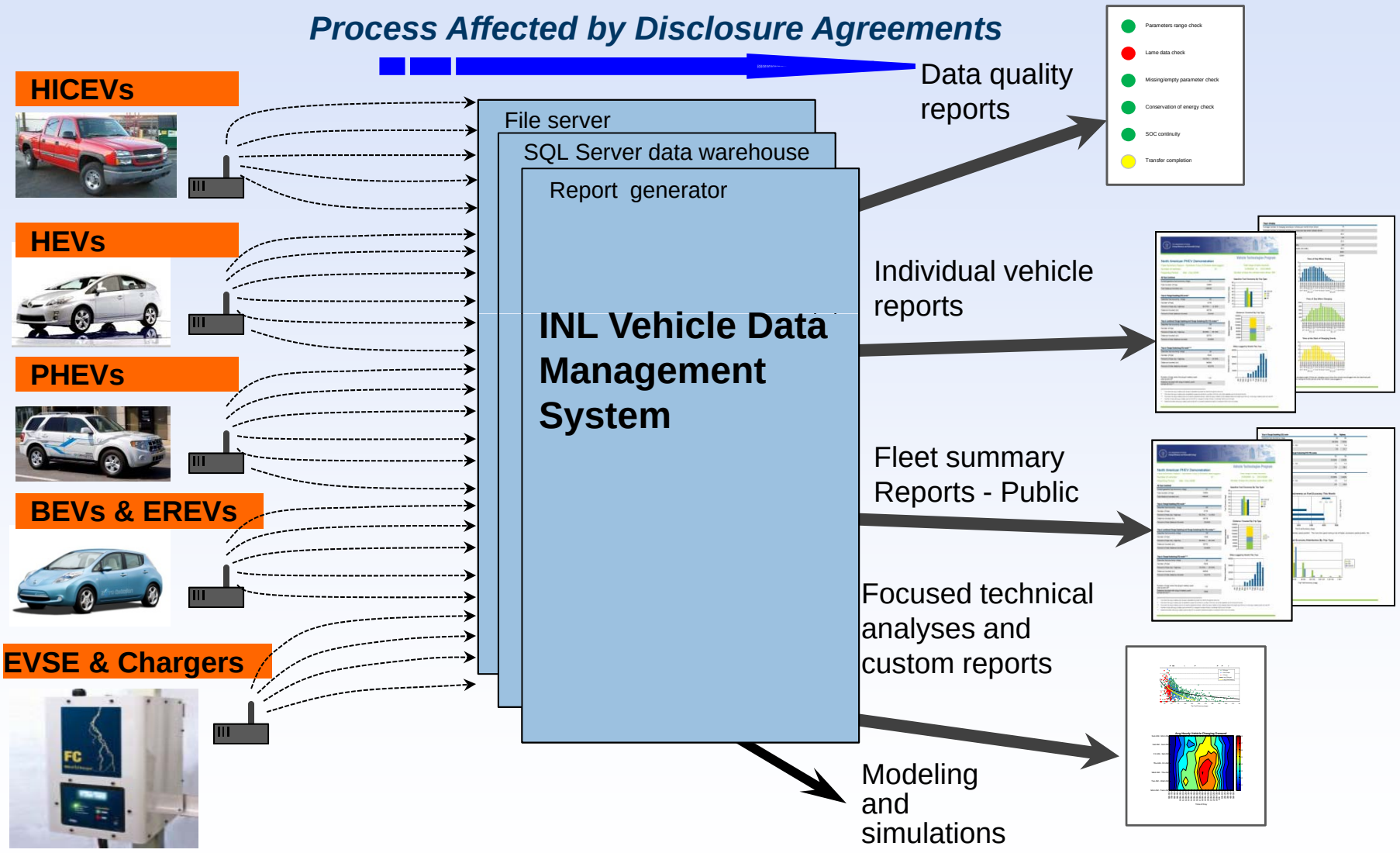
AVTA Participants and Goals

- **Participants**
  - **The Advanced Vehicle Testing Activity (AVTA) is part of DOE's Vehicle Technologies Program (EERE)**
  - **The Idaho National Laboratory (INL) conducts the light-duty vehicle portion of the AVTA per DOE guidance**
  - **Many of these testing activities are conducted with ECOtality North American**
  - **100+ fleet and organization test partners allows for leveraged demonstration activities**
  - **Support also provided to DOE Clean Cities and FEMP**
- **The AVTA goal - Petroleum reduction and energy security**
  - **Provide benchmark data to technology modelers, research and development programs, vehicle manufacturers (via VSATT), and target and goal setters**
  - **Assist fleet managers in making informed vehicle and infrastructure purchase, deployment and operating decisions**

Vehicle / Infrastructure Testing Experience

- **Plug-in hybrid electric vehicles: 14 models, 430 PHEVs, 5 million test miles**
- **Extended Range Electric Vehicles: 1 model, 150 EREVs, 400,000 test miles**
- **Hybrid electric vehicles: 19 models, 50 HEVs, 6 million test miles**
- **Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 200,000 test miles**
- **Neighborhood electric vehicles: 24 models, 372 NEVs, 200,000 test miles**
- **Battery electric vehicles: 47 models, 4,000 BEVs, 10 million test miles**
- **Urban electric vehicles: 3 models, 460 UEVs, 1 million test miles**
- **4,000 EVSE and first hydrogen generation/dispensing station in United States**
- **23 million test miles accumulated on 5,500 electric drive vehicles representing 111 models**

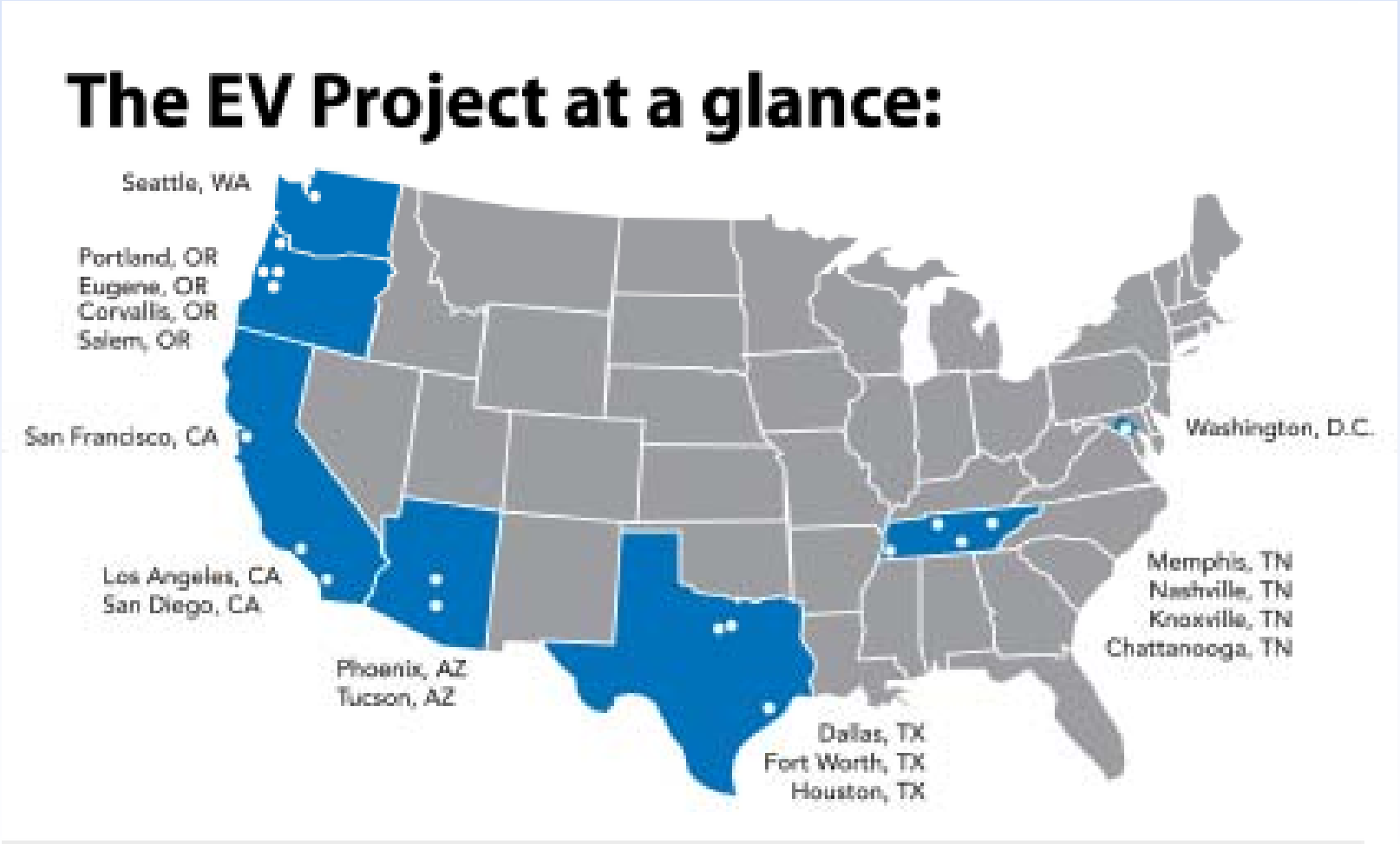
INL Vehicle Data Management Process



Data Security and Protection

- **All raw vehicle and EVSE data, and personal information protected by NDAs (Non Disclosure Agreements) or a CRADAs (Cooperative Research And Development Agreements), resulting in:**
  - **Limitations on how the proprietary raw 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, cannot be 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**
- **INL can bin data results into usable information formats for analysis in research partnerships**
- **No raw data can be shared by INL**

EV Project Locations (Largest World-Wide PEV and EVSE Data Collection Activity)

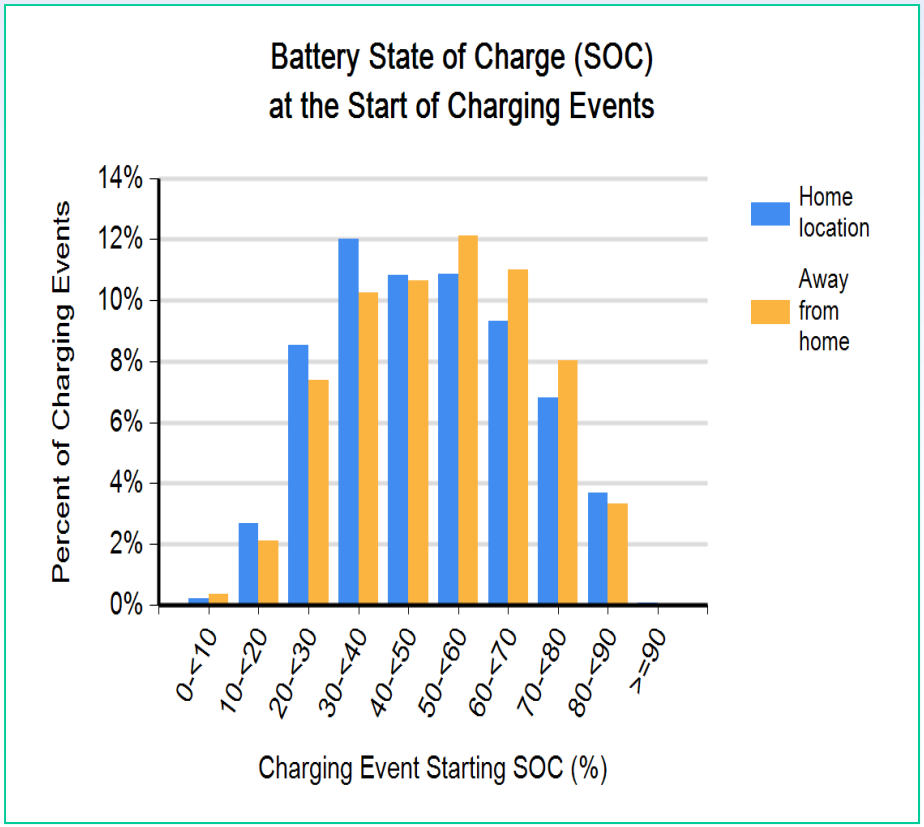


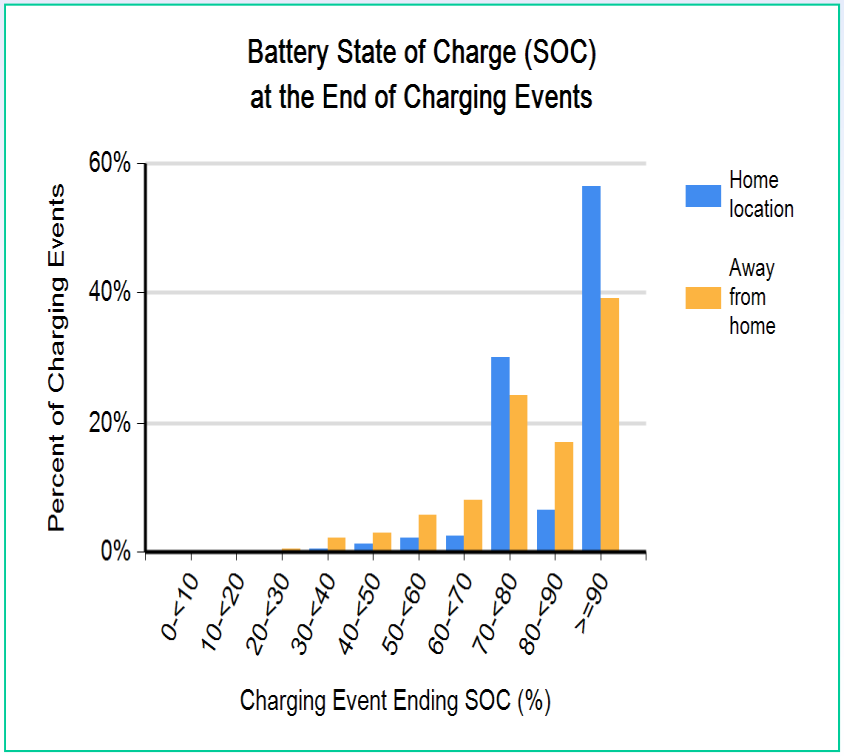
EV Project Vehicle and Charging Infrastructure

- Deploy **8,300 plug electric vehicles with data loggers**
  - 5,700 Nissan Leaf battery EVs
  - 2,600 Chevrolet Volt extended range EVs
- Install ~**14,000 level 2 EVSE and dual port DC fast chargers with data loggers**

EV Project – Nissan Leaf Usage

- **Infrastructure demonstration, not a vehicle test program**
- **Will SOC and recharging practices change over time?**
- **Will there be seasonal influences?**
- **Will vehicle operator familiarity with public infrastructure influence private vs. public EVSE use?**





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

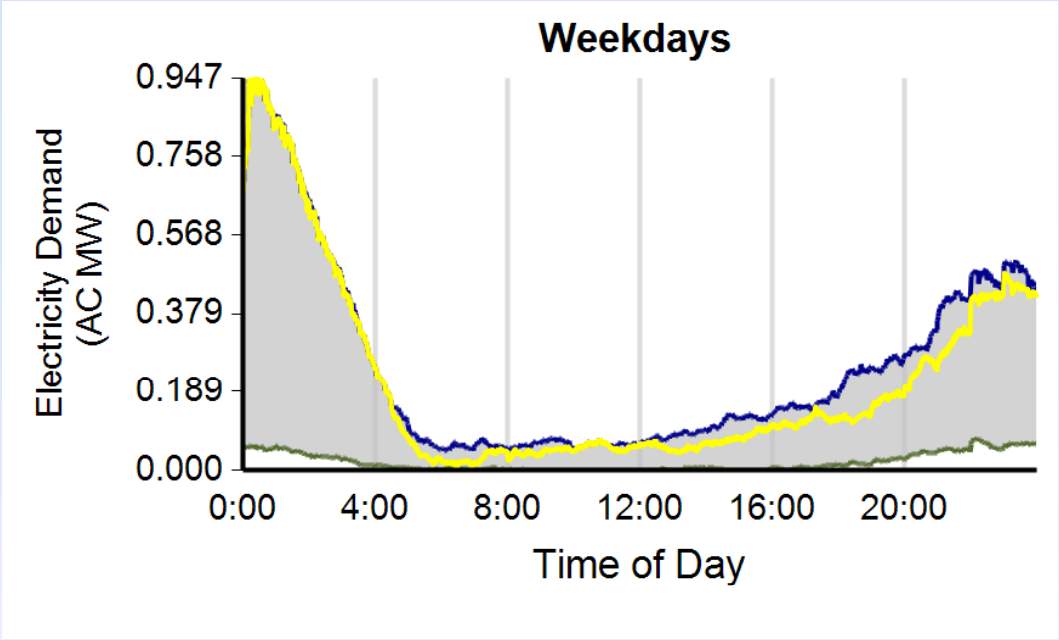
- Date/Time Stamp
- Vehicle ID
- Event type (key on / key off)
- Odometer
- Battery state of charge
- GPS (longitude and latitude)
- Recorded for each key-on and key-off event

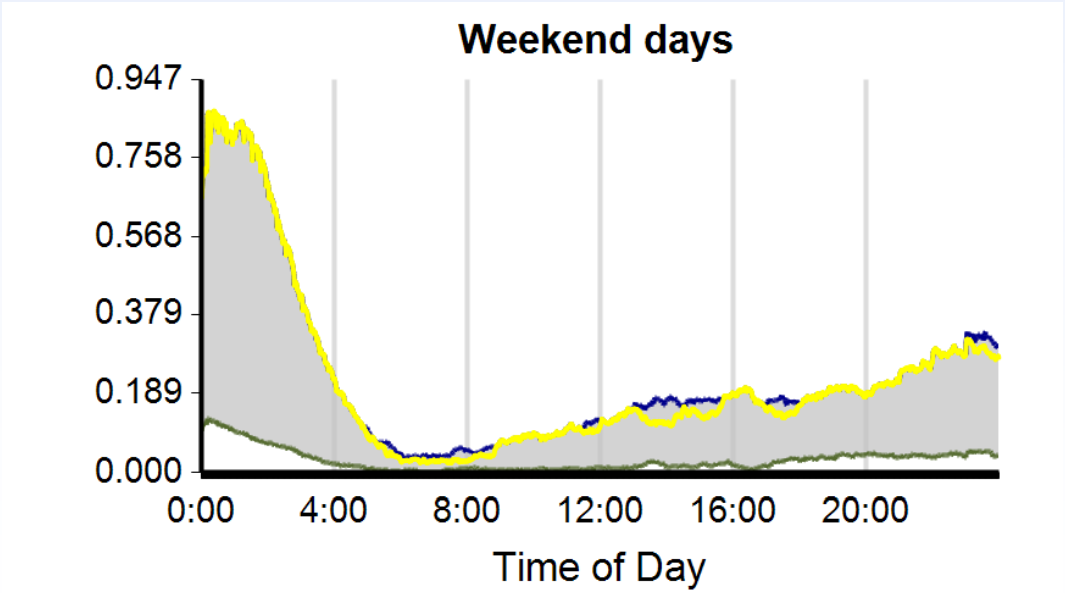
EV Project – Charge Infrastructure Data Parameters Collected per Charge Event

- Date/Time Stamp
- Unique ID for Charging Event
- Unique ID Identifying the EVSE – may not change
- 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 – Nissan Leaf & EV Charging Infrastructure Summary Report Results

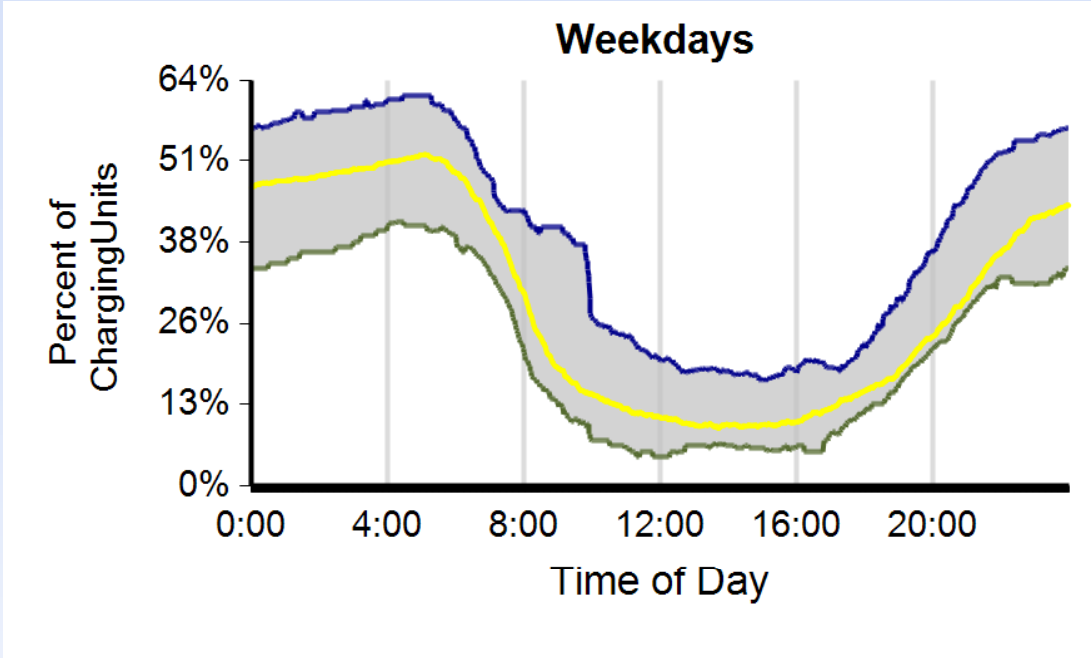
Infrastructure Usage – 2st quarter 2011	National	Oregon
– Ave time vehicle connected - hours	9.4	8.7
– Ave time vehicle drawing power - hours	2.0	2.0
– Ave energy per charge event – kWh	7.1	6.9
– Ave charging events per day	0.78	0.84
– Ave trip distance (miles)	6.7	6.3
– Ave miles per day when driven	31.2	30.6
– Ave # trips between charging events	4.5	4.6
– Ave miles between charging events	30.4	29.2
– Ave # charge events / day when driven	1	1

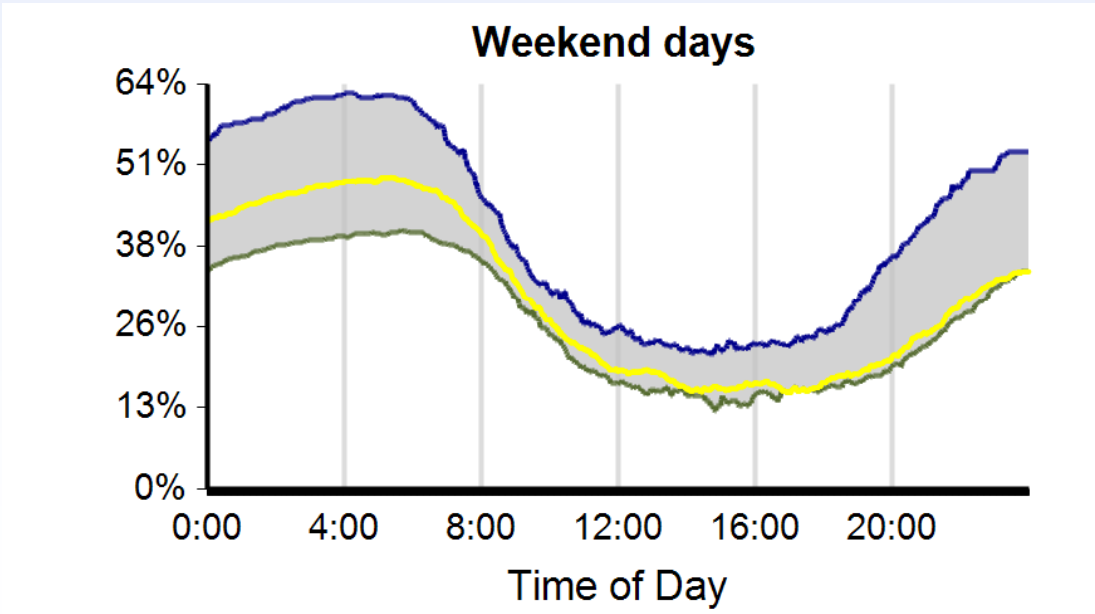




EV Project – EV Charging Infrastructure Summary Report

- Power demand range for any time during reporting quarter
- Yellow line is daily profile for the day with quarterly peak demand
- Both graphs in AC MW
- Min/Max based on 15 minute rolling MW demand from any 15-minute period any day

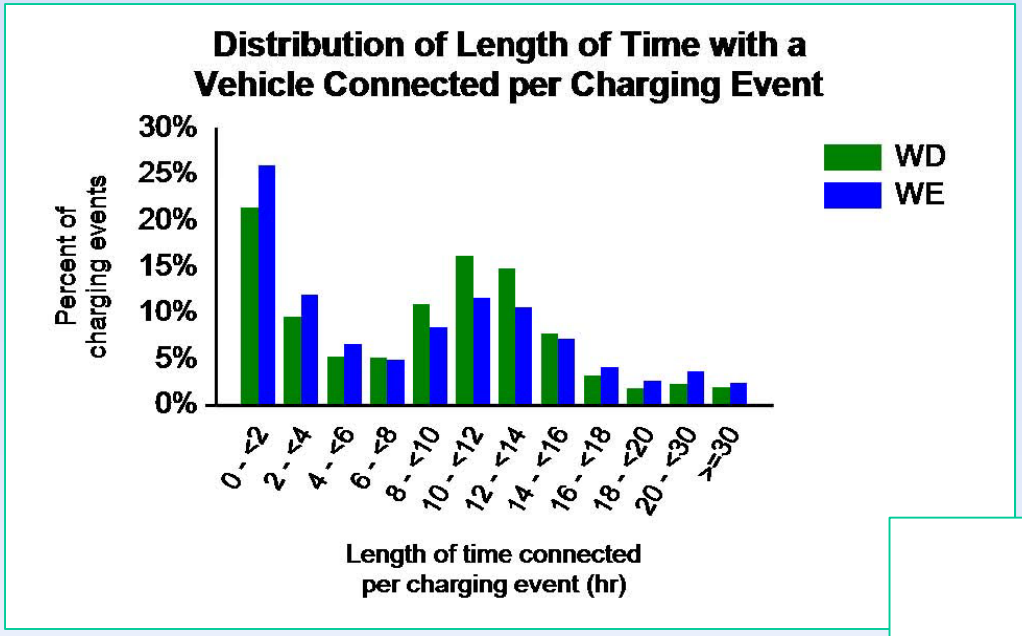


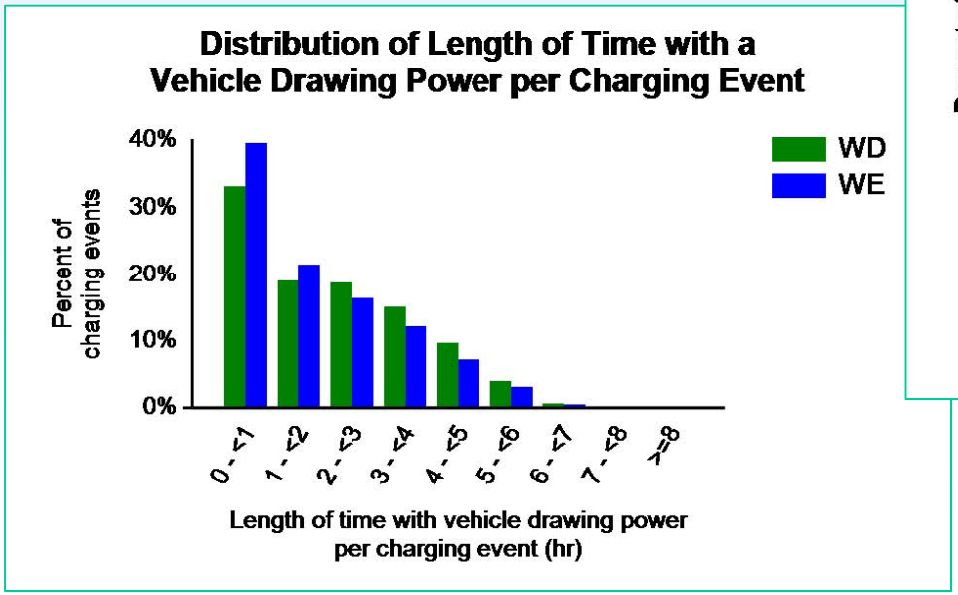


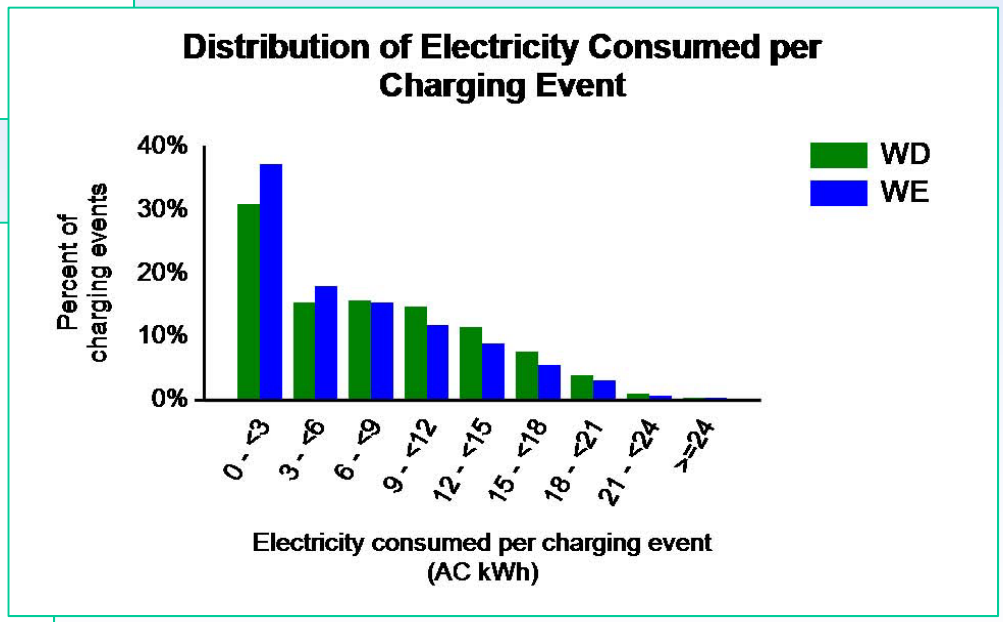
EV Project – EV Charging Infrastructure Summary Report

- **Range of charging units with a vehicle connected**
- **Yellow line is for day with peak power demand**
- **Both graphs percent of charging units**

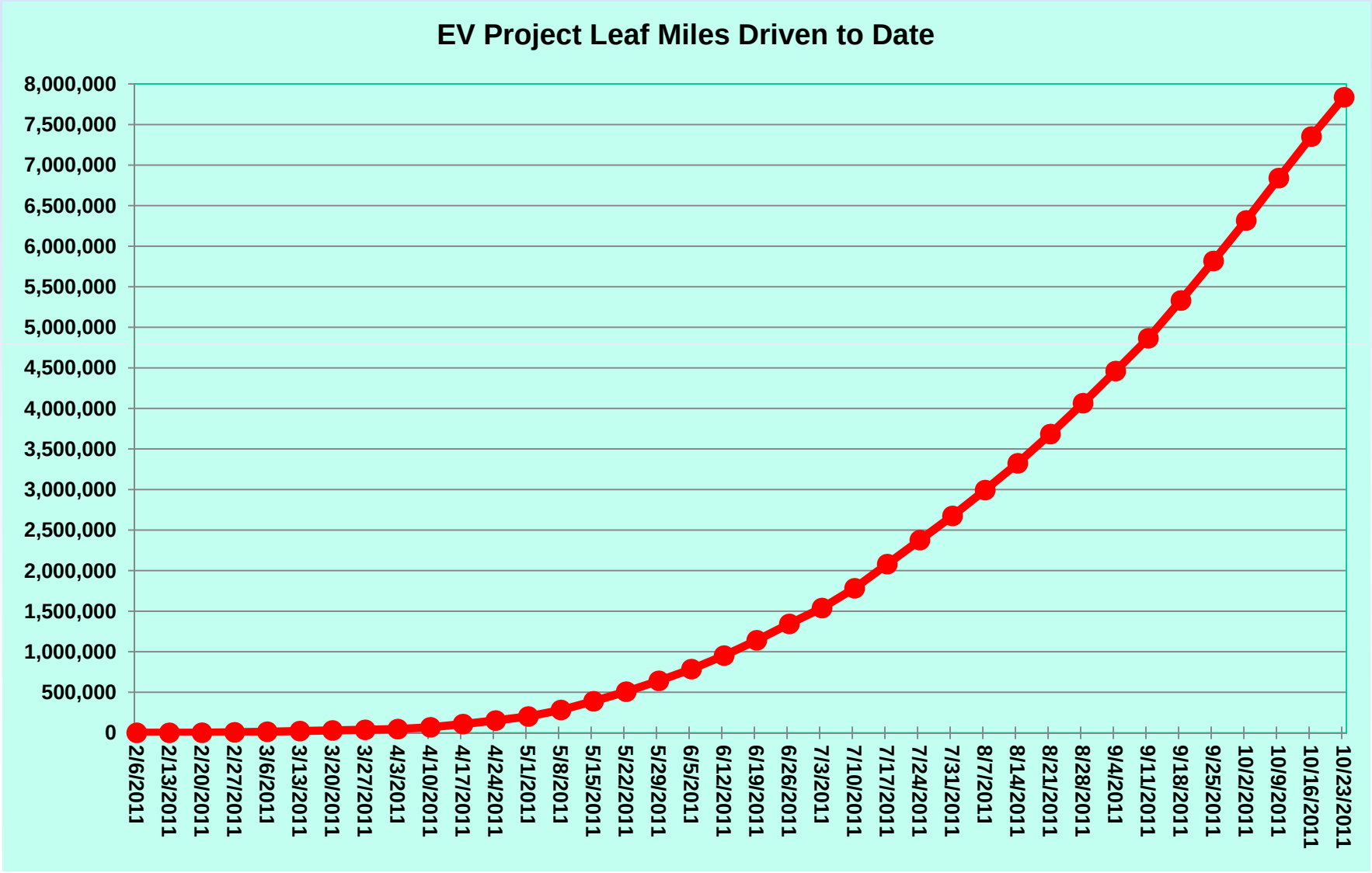
EV Project – EV Charging Infrastructure Summary Report



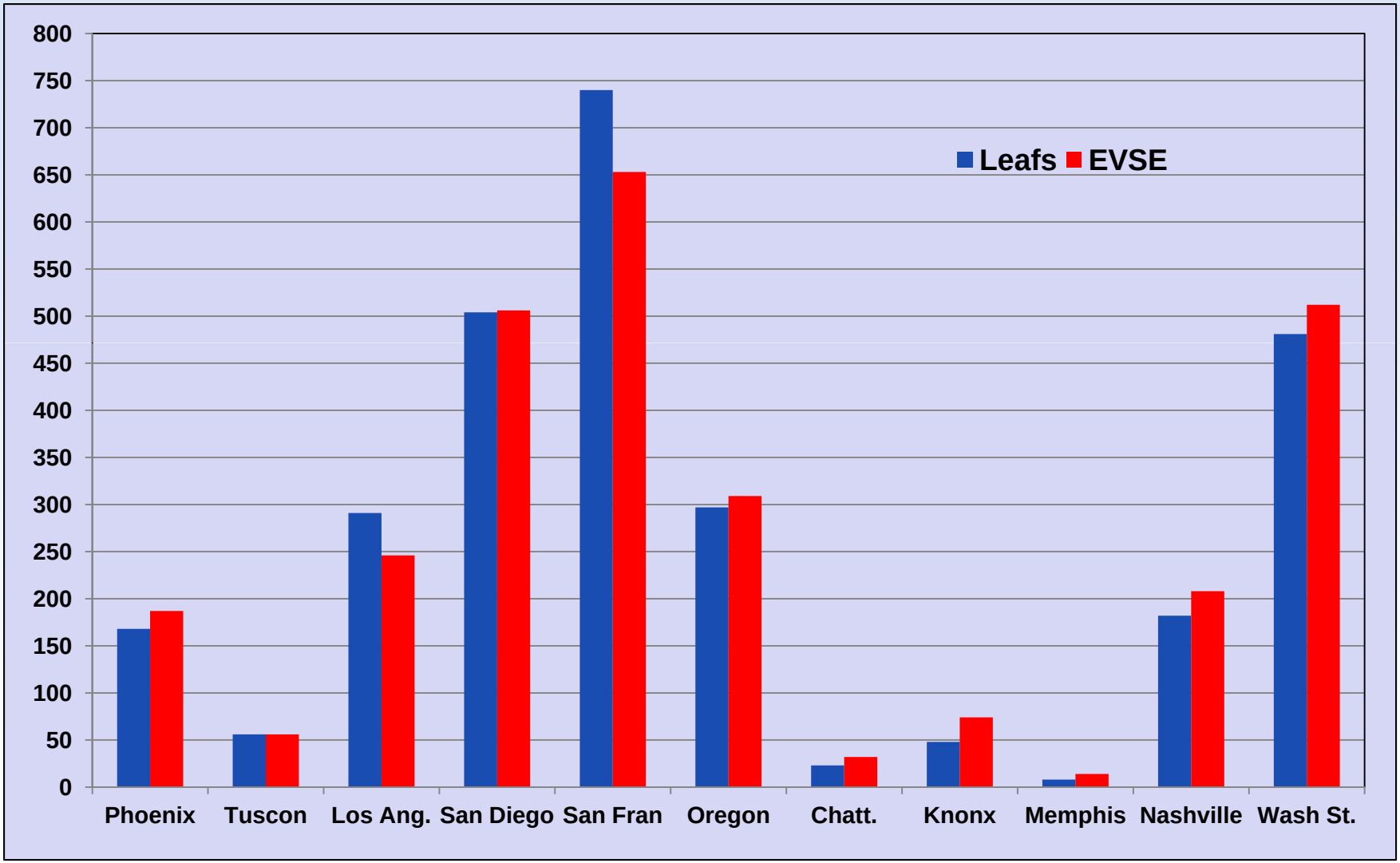




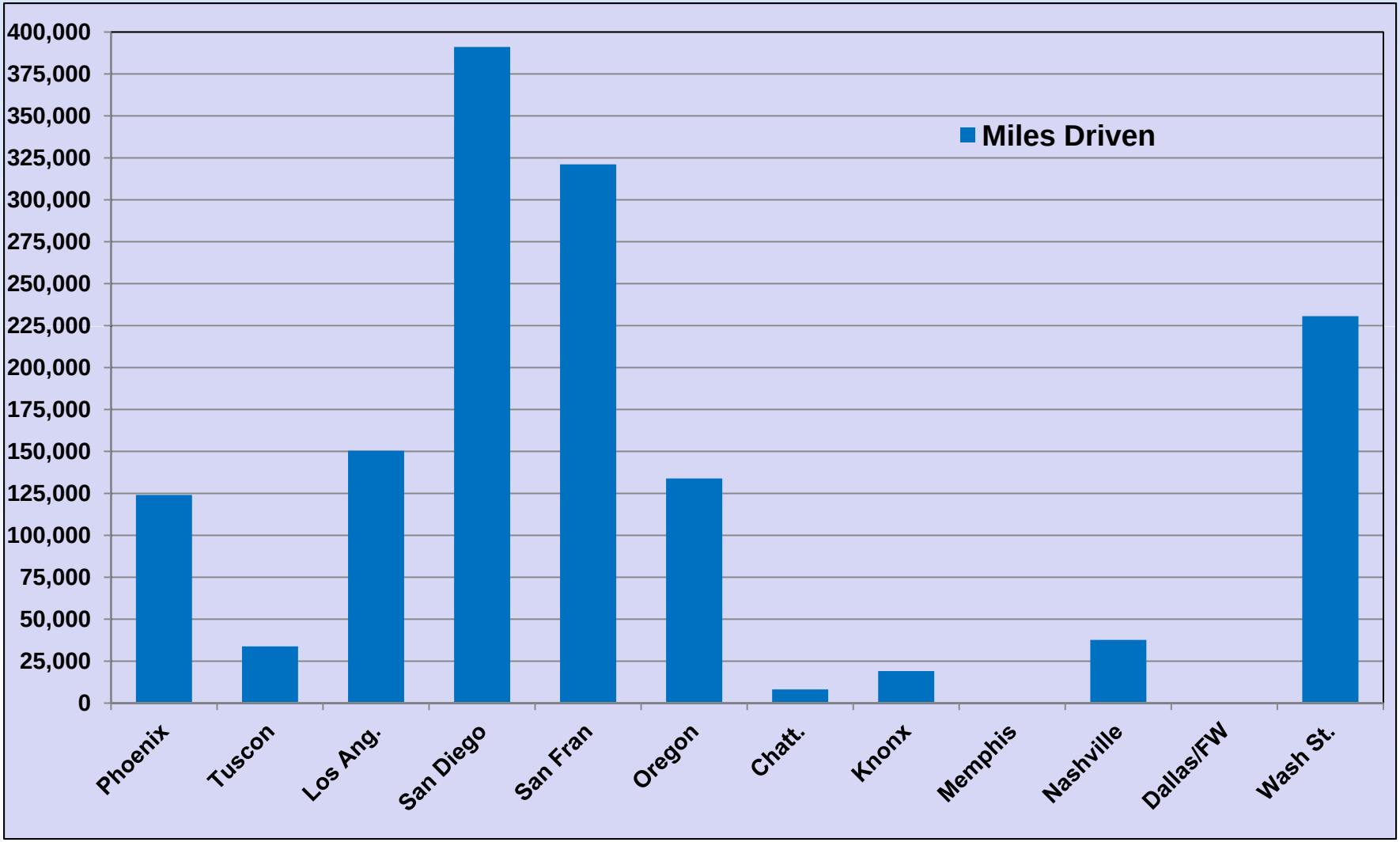
EV Project – Leaf Miles Driven to date



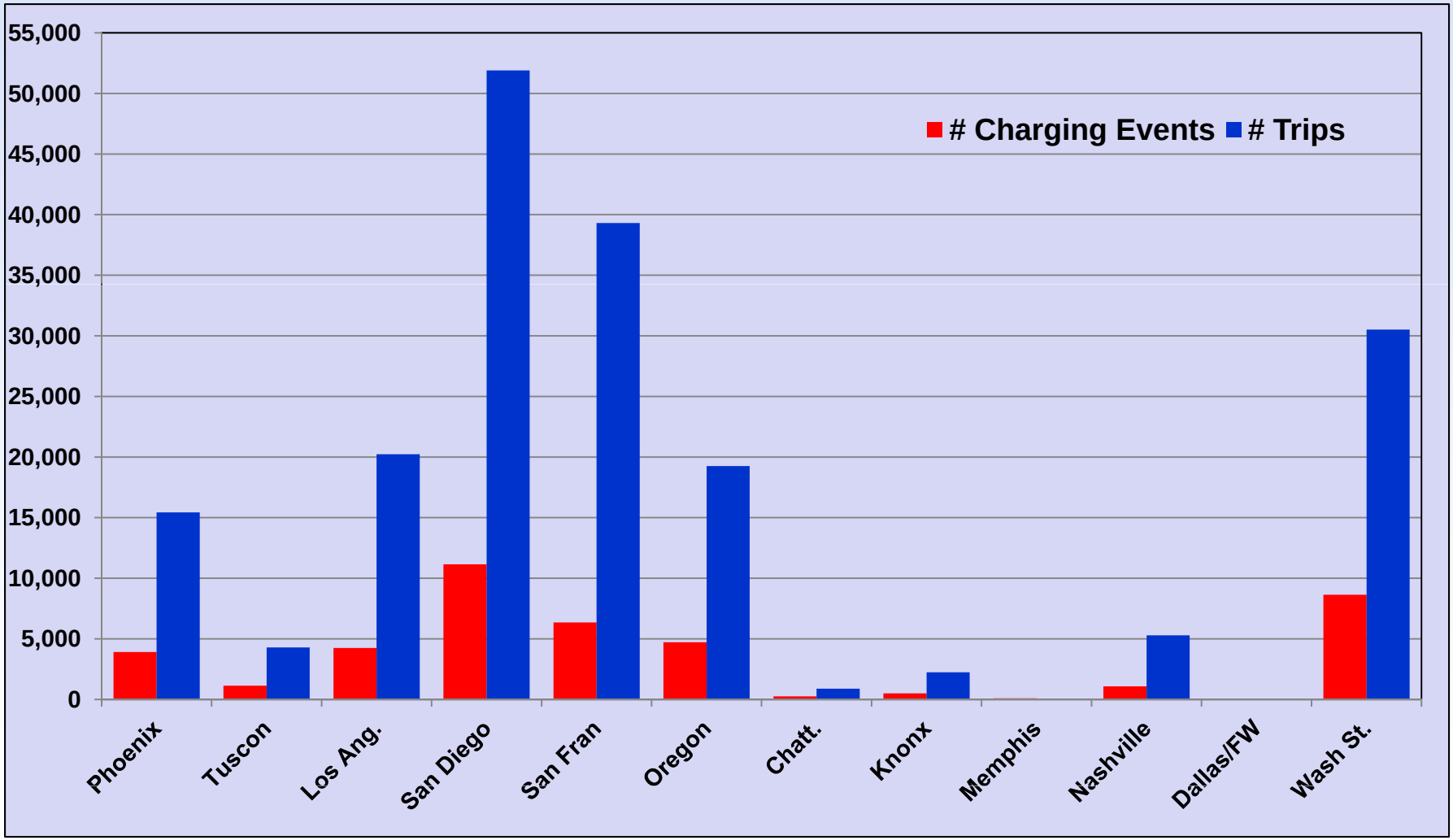
EV Project – Leafs & EVSE With Data (9/30/11)



EV Project – Miles Driven (2nd Quarter)



EV Project – Leaf # Charging Events & Trips (2nd Quarter)



The number of Leafs that can be charged at 5.538 kWh per day using a percentage of existing electricity generation

	Total 2009 Generation kWh	Number of Nissan Leafs that can be charged at 5.538 kWh per day (2021.37 kWh per year)
2009 kWh generation	3,950,331,000,000	
1% 2009 kWh generation	39,503,310,000	19,542,840
2% 2009 kWh generation	79,006,620,000	39,085,680
3% 2009 kWh generation	118,509,930,000	58,628,519
4% 2009 kWh generation	158,013,240,000	78,171,359
5% 2009 kWh generation	197,516,550,000	97,714,199

Generation Source: Electric Power Annual with data for 2009. November 23, 2010. http://205.254.135.24/cneaf/electricity/epa/epates.html

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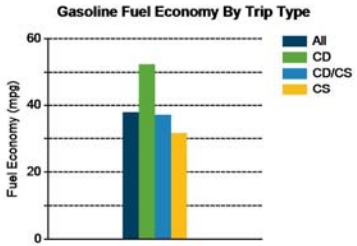
Ford Escape Advanced Research Fleet

Number of vehicles: 21
Reporting period: Nov 09 - Apr 11
Date range of data received: 11/01/2009 to 04/30/2011
Number of vehicle days driven: 5,425

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]	66
Total number of trips	23,548
Total distance traveled (mi)	299,960

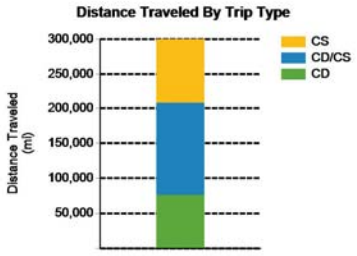


Trips in Charge Depleting (CD) mode[3]

Gasoline fuel economy (mpg)	52
DC electrical energy consumption (DC Wh/mi)[4]	170
Number of trips	13,205
Percent of trips city | highway	84% | 16%
Distance traveled (mi)	75,997
Percent of total distance traveled	25%

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

Gasoline fuel economy (mpg)	37
DC electrical energy consumption (DC Wh/mi)[6]	55
Number of trips	4,506
Percent of trips city | highway	38% | 62%
Distance traveled (mi)	131,484
Percent of total distance traveled	44%



Trips in Charge Sustaining (CS) mode[7]

Gasoline fuel economy (mpg)	32
Number of trips	5,831
Percent of trips city | highway	65% | 35%
Distance traveled (mi)	92,478
Percent of total distance traveled	31%

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."

Ford Escape PHEV

- 21 Ford Escape PHEVs
- 300,000 test miles and 24,000 trips
- All trips, 38 mpg, 101 AC Wh/mi & 66 DC Wh/mi
- Charge Depleting (CD), 52 mpg & 170 DC Wh/mi
- Charge Sustaining (CS), 32 mpg
- Plugging in = 63% increase in overall MPG when comparing CD to CS trips
- During CD trips, 50% of miles with engine off
- During CS trips, 27% of miles with engine off

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Chrysler RAM PHEV Fleet

Number of vehicles: 37
Reporting period: July 11 - Aug 11
Date range of data received: 7/1/2011 to 8/31/2011
Number of vehicle days driven: 615

All Trips Combined

Overall gasoline fuel economy (mpg)	16
Overall AC electrical energy consumption (AC Wh/mi)[1]	162
Overall DC electrical energy consumption (DC Wh/mi)[2]	94
Overall DC electrical energy captured from regenerative braking (DC Wh/mi)	53
Total number of trips	3,443
Total distance traveled (mi)	13,911

Trips in Charge Depleting (CD) mode[3]

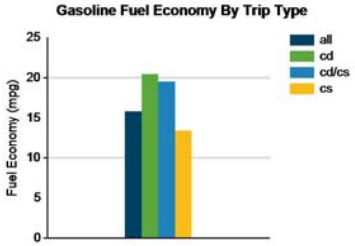
Gasoline fuel economy (mpg)	20
DC electrical energy consumption (DC Wh/mi)[4]	282
Number of trips	1,310
Percent of trips city | highway	98% | 2%
Distance traveled (mi)	3,779
Percent of total distance traveled	27%

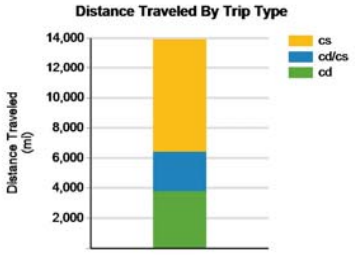
Trips in both Charge Depleting & Charge Sustaining (CD/CS) modes[5]

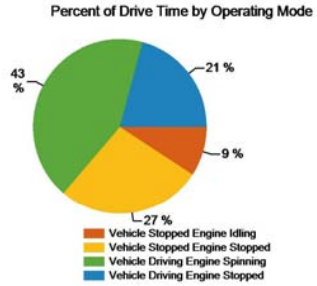
Gasoline fuel economy (mpg)	20
DC electrical energy consumption (DC Wh/mi)[6]	121
Number of trips	175
Percent of trips city | highway	86% | 14%
Distance traveled CD | CS (mi)	1,232 | 1,433
Percent of total distance traveled CD | CS	9% | 10%

Trips in Charge Sustaining (CS) mode[7]

Gasoline fuel economy (mpg)	13
Number of trips	1,958
Percent of trips city | highway	98% | 2%
Distance traveled (mi)	7,505
Percent of total distance traveled	53%







Notes: 1 - 9. Please see http://avt.inl.gov/pdf/phev/chryslerreportnotes.pdf for an explanation of all PHEV Fleet Testing Report notes.

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 Pickups

- 66 Chrysler Ram PHEV pickups
- 32,000 test miles and 6,400 trips
- All trips, 18 mpg, 151 AC Wh/mi & 87 DC Wh/mi
- Charge Depleting (CD), 22 mpg & 269 DC Wh/mi
- Charge Sustaining (CS), 15 mpg
- Plugging in = 47% increase in overall MPG when comparing CD to CS trips
- 45% driving and stopped time, the gas engine is stopped

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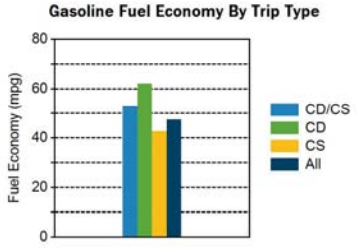
North American PHEV Demonstration

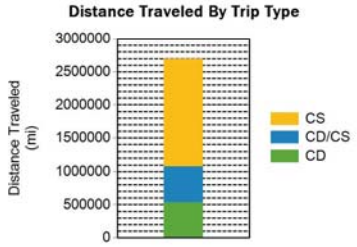
Vehicle Technologies Program

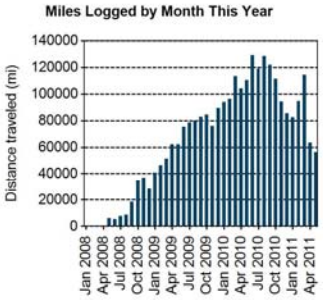
Fleet Summary Report: Hymotion Prius (V2Green data logger)
Number of vehicles: 184
Reporting Period: Apr 08 - May 11

Date range of data received:
4/18/2008 to 5/31/2011
Number of days the vehicles were driven: 1132

All Trips Combined	
Overall gasoline fuel economy (mpg)	47
Overall AC electrical energy consumption (AC Wh/mi) [1]	53
Overall DC electrical energy consumption (DC Wh/mi) [2]	38
Total number of trips	287,310
Total distance traveled (mi)	2,691,319
Trips in Charge Depleting (CD) mode [3]	
Gasoline fuel economy (mpg)	62
DC electrical energy consumption (DC Wh/mi) [4]	142
Number of trips	116,236
Percent of trips city / highway	87% / 13%
Distance traveled (mi)	534,289
Percent of total distance traveled	20%
Trips in both Charge Depleting and Charge Sustaining (CD/CS) modes [5]	
Gasoline fuel economy (mpg)	53
DC electrical energy consumption (DC Wh/mi) [6]	49
Number of trips	20,745
Percent of trips city / highway	47% / 53%
Distance traveled (mi)	541,395
Percent of total distance traveled	20%
Trips in Charge Sustaining (CS) mode [7]	
Gasoline fuel economy (mpg)	43
Number of trips	150,320
Percent of trips city / highway	77% / 23%
Distance traveled (mi)	1,619,064
Percent of total distance traveled	60%
Number of trips when the plug-in battery pack was turned off by the vehicle operator [8]	12479
Distance traveled with plug-in battery pack turned off by the vehicle operator (mi) [9]	274,084







Notes: 1 - 9. Please see http://avt.inl.gov/pdf/phev/ReportNotes.pdf for an explanation of all PHEV Fleet Testing Report notes.

Hymotion Prius PHEV Conversion

- CD 62 mpg and 142 DC Wh/mi
- CS 43 mpg
- Plugging in = 44% increase in overall MPG when comparing CD to CS trips
- Only 20% miles in CD trips
- 60% miles in CS trips
- Total to date – 3.3 million miles

Summary – Based on Very Early Data

- 30 miles per day, ~30 miles per charge, 1 charge per day, ~4.5 trips per charge, and ~7 kWh per charge
- Most EV Project charging occurs during off-peak periods
- EV Project vehicles connected ~4X's longer than needed to recharge = opportunities to shift charging times
- San Diego: significant charge-starts occur at the midnight start of super off-peak kWh rates. Other EV Project locations have more random start times
- 1% of 2009 generation would charge 20 million PEVs (U.S. Min/Max average daily demand delta is 44%)
- With today's vehicle technologies, electric drive operations result in 33% to 100% reductions in petroleum use by grid-connected light duty vehicles
- EV Project plan did not include an earthquake, tsunami or reductions in economic activity and vehicle sales
- Need to collect the EV Project data before reporting it

Acknowledgement

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

More Information

http://avt.inl.gov

INL/CON-11-23783