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 quality reports

Process Affected by Disclosure Agreements

File server

SQL Server data warehouse

Report generator

INL Vehicle Data Management System

Individual vehicle reports

Fleet summary

Reports - Public

Focused technical analyses and custom reports

Modeling and simulations

Parameters range check

Lame data check

Missing/empty parameter check

Conservation of energy check

SOC continuity

Data quality reports

HICEVs

HEVs

PHEVs

BEVs & EREV

EVSE & Chargers
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

<table>
<thead>
<tr>
<th></th>
<th>National</th>
<th>Oregon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave time vehicle connected</td>
<td>9.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Ave time vehicle drawing power</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Ave energy per charge event</td>
<td>7.1</td>
<td>6.9</td>
</tr>
<tr>
<td>Ave charging events per day</td>
<td>0.78</td>
<td>0.84</td>
</tr>
<tr>
<td>Ave trip distance (miles)</td>
<td>6.7</td>
<td>6.3</td>
</tr>
<tr>
<td>Ave miles per day when driven</td>
<td>31.2</td>
<td>30.6</td>
</tr>
<tr>
<td>Ave # trips between charging events</td>
<td>4.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Ave miles between charging events</td>
<td>30.4</td>
<td>29.2</td>
</tr>
<tr>
<td>Ave # charge events / day when driven</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
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

Distribution of Length of Time with a Vehicle Connected per Charging Event

Distribution of Electricity Consumed per Charging Event

Distribution of Length of Time with a Vehicle Drawing Power per Charging Event
EV Project – Leafs & EVSE With Data (9/30/11)
EV Project – Miles Driven (2nd Quarter)

- San Diego: 375,000 miles
- San Francisco: 350,000 miles
- Oregon: 325,000 miles
- Arizona: 275,000 miles
- Washington: 225,000 miles
- Dallas/FW: 200,000 miles
- Nevada: 175,000 miles
- Chicago: 150,000 miles
- Memphis: 125,000 miles
- Nashville: 75,000 miles
- Tucson: 25,000 miles
- Los Angeles: 25,000 miles

Miles Driven: The bar chart shows the miles driven by different cities in the EV Project during the 2nd quarter. San Diego leads with 375,000 miles, followed by San Francisco with 350,000 miles, and Oregon with 325,000 miles. The miles driven by other cities range from 225,000 miles for Washington to 25,000 miles for Tucson.
EV Project – Leaf # Charging Events & Trips (2nd Quarter)

# Charging Events
# Trips

- Phoenix: 5,000
- Tuscon: 1,000
- Los Ang.: 1,000
- San Diego: 30,000
- San Fran: 40,000
- Oregon: 20,000
- Chatt.: 10,000
- Kronx: 5,000
- Memphis: 5,000
- Nashville: 5,000
- Dallas/FW: 5,000
- Wash St.: 5,000

# Charging Events vs. # Trips
<table>
<thead>
<tr>
<th>Percentage of Generation</th>
<th>Total 2009 Generation kWh</th>
<th>Number of Nissan Leafs that can be charged at 5.538 kWh per day (2021.37 kWh per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 kWh generation</td>
<td>3,950,331,000,000</td>
<td></td>
</tr>
<tr>
<td>1% 2009 kWh generation</td>
<td>39,503,310,000</td>
<td>19,542,840</td>
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<tr>
<td>2% 2009 kWh generation</td>
<td>79,006,620,000</td>
<td>39,085,680</td>
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<td>3% 2009 kWh generation</td>
<td>118,509,930,000</td>
<td>58,628,519</td>
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<td>4% 2009 kWh generation</td>
<td>158,013,240,000</td>
<td>78,171,359</td>
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<tr>
<td>5% 2009 kWh generation</td>
<td>197,516,550,000</td>
<td>97,714,199</td>
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</tbody>
</table>

http://205.254.135.24/cneaf/electricity/epa/epates.html
All Trips Combined
- Overall gasoline fuel economy (mpg): 38
- Overall AC electrical energy consumption (AC Wh/mi): 101
- Overall DC electrical energy consumption (DC Wh/mi): 66
- Total number of trips: 23,546
- Total distance traveled (mi): 309,980

Trips in Charge Depleting (CD) mode¹
- Gasoline fuel economy (mpg): 52
- DC electrical energy consumption (DC Wh/mi): 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) modes²
- Gasoline fuel economy (mpg): 37
- DC electrical energy consumption (DC Wh/mi): 55
- Number of trips: 4,000
- Percent of trips city / highway: 39% / 61%
- Distance traveled (mi): 131,484
- Percent of total distance traveled: 44%

Trips in Charge Sustaining (CS) mode²
- Gasoline fuel economy (mpg): 32
- Number of trips: 5,831
- Percent of trips city / highway: 60% / 40%
- Distance traveled (mi): 92,479
- Percent of total distance traveled: 31%

Notes: ¹-² Please see http://erv.lbl.gov/pdfs/ev/evreportnotes.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."
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
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