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

INL’s ARRA / TADA Light-Duty Electric Drive Vehicle and Charging Infrastructure Data Collection Activities

Jim Francfort

DOE Review Meeting @ NREL
Golden, Colorado
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This presentation does not contain any proprietary or sensitive information
Presentation Outline

- INL and AVTA (DOE) Participants and Goals
- Vehicle Testing Experience
- INL data handling experiences and methods
- ARRA and TADA data collection projects
- EV Project what is it about
- EV Project data collection parameters
- EV Project results to date
- Ford PHEV data collection results to date
- Other data collection activities
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 AVTA per DOE guidance
  – 100+ fleets and organizations as testing partners
  – Some of these testing activities are also conducted with ECOtality North American

• 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 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 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, 1,300 BEVs, 5 million test miles (includes 500+ USPS BEVs)
- Urban electric vehicles: 3 models, 460 UEVs, 1 million test miles
- 18 million test miles accumulated on 2,300 electric drive vehicles representing 110 models
INL Vehicle Data Management Process

Process Affected by Disclosure Agreements

HICEVs

HEVs

PHEVs

BEVs & EREVs

EVSE & Chargers

File server

SQL Server data warehouse

Report generator

INL Vehicle Data Management System

Data quality reports

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
### Vehicle and Infrastructure Data Sources

<table>
<thead>
<tr>
<th>Vehicle time-history data (second-by-second)</th>
<th>HEV: 12 vehicle models, 1 data logger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HICE: 1 vehicle model, 1 data logger</td>
</tr>
<tr>
<td></td>
<td>Conversion PHEVs: 8 vehicle models, 3 data loggers</td>
</tr>
<tr>
<td></td>
<td><strong>Ford</strong> Escape PHEV, Ford wireless logger</td>
</tr>
<tr>
<td></td>
<td><strong>Chrysler</strong> Ram PHEV, Chrysler wireless logger</td>
</tr>
<tr>
<td>Vehicle event data (key-on, key-off)</td>
<td><strong>Nissan</strong> Leaf, Nissan telematics</td>
</tr>
<tr>
<td></td>
<td><strong>Chevrolet</strong> Volt, OnStar telematics</td>
</tr>
<tr>
<td>Charger event and 15 min time-history data</td>
<td><strong>ECOtality</strong> Blink networked level 2 EVSE, DC/fast chargers</td>
</tr>
<tr>
<td></td>
<td><strong>Coulomb</strong> ChargePoint networked level 2 EVSE</td>
</tr>
</tbody>
</table>

**Managing 26 different data models**
INL Data Management System - Push
(Nissan, GM, Chrysler, Coulomb)

Protected Data
- Access restricted by firewall rules
- EV Project Team
- Conservation of energy check
- SOC continuity
- Transfer completion
- Internal data quality reports
- INL Protect Enclave - EV Project member access only
- INL Internal firewall

Vehicle and Charger Data
- OEM Data Management Systems
- INL pulls with encrypted transmission
- INL DMZ Firewall – Public has access to AVT.INL.GOV

OEM Data Management Systems
- OEM pushes using FTPS/SFTP
- INL transmits reports to DOE and OEMs
- INL Protect Enclave
- INL transmits reports to DOE and OEMs
- Reports posted on WWW

INL Data Management System - Push (Nissan, GM, Chrysler, Coulomb)
INL Data Management System - Pull
(ECOtality, Ford, conversion PHEVs, HEVs, HICEs)

Protected Data

Vehicle and Charger Data

OEM Data Management Systems

INL Data Pulls with encrypted transmission

INL Protect Enclave - EV Project member access only

INL Internal firewall

INL DMZ Firewall – Public has access to AVT.INL.GOV

Fleet summary reports - public

AVT.INL.GOV

INL Pulls with encrypted transmission

Parameters range check
Lame data check
Missing parameter check
Conservation energy check
SOC continuity
Transfer completion

Internal data quality reports

INL transmits reports to DOE And OEMs

Reports posted on WWW

INL Protect Enclave - EV Project member access only

Reports posted on WWW

AVT.INL.GOV
Data Collection: Harder Than You’d Think.....

• Field data collection and processing is deceivingly complex due to remoteness and the many technical, environmental and human variables
  – 60 mpg PHEV in charge depleting mode and 130 mpg in charge sustaining mode - 6,000 foot mountain
  – 84 hour trips - So quiet, does it shut itself off?
  – <-10 to >140 degrees F
  – Internet companies don’t trust the internet for data transfers
  – Firmware, software and component upgrades
  – GPS and the advanced metal bucket technology
  – Work rules and the girlfriend factor (110 mph)
  – Is a Key-On event for rolling up a window or moving a vehicle ten feet considered a trip event?
    • 53-foot rule, 40% reduction result and 0.1% impact
Data Collection: Harder Than You’d Think…..

• All companies have data collection launch issues, regardless of company size. Examples:
  – Data from a conversion company in 2007: time stamps go backwards occasionally
  – Data from partner in 2011: time stamps go backwards occasionally
  – Start-up conversation company in 2008: “I wish we had more QA resources”
  – Partner in 2011: “We allocated resources for sending the data, but not for looking at the data
Quality Control Accomplishments

• INL has identified and/or assisted with root cause analysis of numerous vehicle data issues, including:
  – Control software version differences cause unexpected differences in vehicle operation
  – Logger resets during driving or charging, resulting in missing data or split events
  – Split or missing driving and charging events due to bugs in logger trigger programming or post-processing algorithms
  – Missing records to indicate Key On, Key Off, Start of Charge, or End of Charge
  – Odometer and cumulative fuel consumed rolls backward or resets to zero
  – Number of parameters logged and other data formatting changes from month to month as vehicle software updates are made
INL Data Security Accomplishments

• Internal servers “Franc” and “Fort” in protected enclave are fully operational
• External server “AVT-EXT” is fully operational, loaded with software for multiple secure file transfer and encryption protocols
• Instituted security and export control policies per lab-wide procedures
  – Project data and information considered Official Use Only / Proprietary or CRADA-Protected
  – Guidelines documented specific to each project
Data Security and Protection

- All raw vehicle and EVSE data, and personal information protected by NDAs (Non Disclosure Agreements) or a CRADA (Cooperative Research And Development Agreement), resulting in:
  - Limitations on how the proprietary data can be distributed, stored, and used
  - No raw data can or will be distributed by INL
  - Raw data, in both electronic and printed formats, 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 (electric utilities and DOE labs?)
- No raw data will be shared by INL
INL ARRA / TADA Data Collection Support

- INL tasked with data collection, analysis and reporting for charging infrastructure and light-duty vehicle ARRA and other DOE funded demonstrations:
  - EV Project: 8,300 Leaf EVs and Volt EREV, and 14,000 ECotality / Blink Level 2 EVSE and fast chargers. Data logging (DL) on all 23,000 pieces of equipment
  - 140 Chrysler Ram Pickup and minivan PHEVs with DL
  - 150 General Motors EREV Volts with DL
  - 21 Ford Escape PHEV SUVs with DL
  - 4,000 Level 2 EVSE deployed by Coulomb with DL
- INL, and OEM and EVSE partners collecting real-time data
The EV Project

• $230 million project
  – $115 million ARRA grant from DOE
  – $115 million match

• Purpose: To plan, build, study, and evaluate mature electric vehicle charging infrastructure in six states plus the District of Columbia

• Product: Lessons learned

• Largest data collection effort
The EV Project Locations

The EV Project at a glance:

- Seattle, WA
- Portland, OR
- Eugene, OR
- Corvallis, OR
- Salem, OR
- San Francisco, CA
- Los Angeles, CA
- San Diego, CA
- Phoenix, AZ
- Tucson, AZ
- Dallas, TX
- Fort Worth, TX
- Houston, TX
- Washington, D.C.
- Memphis, TN
- Nashville, TN
- Knoxville, TN
- Chattanooga, TN
EV Project Micro-Climate Plan

Structured program to make regions “plug-in ready”

1) Community Planning
   • Deployment Guidelines & Stakeholder Organization
   • Long Range Plan (10 years)
   • Micro-Climate Plan (1-3 years)

2) Road Mapping
   • 1-3 year action plan
   • Systematic GIS mapping

3) Infrastructure Implementation
   • Deployment of EV charge stations
   • Targets scalable national accounts
   • Implement sustainable business models
EV Project Residential Infrastructure

- Deploy 8,300 battery electric vehicles
  - 5,700 Nissan Leaf battery EVs
  - 2,600 Chevrolet Volt extended range EVs
- Install 8,300 level 2 residential EVSE
EV Project Commercial Infrastructure

• Install ~5,300 level 2 EVSE
  – Retail locations
  – Municipal locations
  – Employer locations
• Deploy 200 Dual Port DC Fast Chargers
EV Project Data Collection & Reporting

Vehicle Data
- EV & EREV
- Nissan GDC
- GM OnStar

EVSE Data
- EVSE
- ECOtality Data Center

MATCH
- EV Project Participant
- Non EV Project Participant

INL
- EV Project Participant
- Non EV Project Participant

INL
- Non EV Project EVSE
- EV Project EVSE
EV Project & Overall Data Collection Rational

- Document electric drive vehicle technology’s ability to reduce petroleum use by collecting data on:
  - Vehicle performance
  - Operational profiles and ambient conditions
  - Charging profiles
- Document fueling infrastructure technology, including:
  - Sitting
  - Use
  - Time-of-day pricing
  - Charging level (I, II, fast charging) utilization
  - Public vs. private charging
  - At-home vs public charging
  - Micro versus macro grid issues / impacts
EV Project & Overall Data Rational – cont’d

• Quantified testing results that avoid subjective reporting results
  – No “best” or “worst” results
  – Only “highest” or “lowest”, or “longest” or “shortest” achieved by reporting testing numbers
  – Minimize subjective and maximize quantitative measurements
EV Project – Eleven 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 – Seven 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)
- Fuel consumption (some vehicles)
- Recorded for each key-on and key-off event
EV Project – Nissan Leaf Usage Report

• 1 of 3 report types produced to date
• See next slides for details
• Initially, all reports produced quarterly
EV Project – Nissan Leaf Usage Report

• Vehicle Usage – 1st quarter 2011
  – Number of Trips  3,364
  – Total distance traveled (miles)  21,706 mi
  – Ave trip distance  5.8 mi
  – Ave distance per day when driven  32.5 mi
  – Ave # trips between charging events  3.3
  – Ave distance traveled between charging events  21.5 mi
  – Ave # charging events per day when a vehicle was driven  1.5

• This report requires matching Leaf and charging data
EV Project – Nissan Leaf Usage cont’d

• Charging Location and Type: Level 2 Home Location
  – Total number of charging events: 800
  – Total time plugged in: 8,126 hr
  – Percent of all time plugged in at EV Project units: 100%
  – Total electricity consumed: 5.25 AC MWh

• Charging Completeness
  – Number of complete charging events (SOC reported): 199
  – Number of partial charging events (SOC reported): 268

• This report will also include Away-from-home charging locations: EV Project Level 2 and DC fast charging as well as non-EV Project charging
EV Project – Nissan Leaf Usage – cont’d

Battery State of Charge (SOC) at the Start of Charging Events

- Percent of Charging Events
- Charging Event Starting SOC (%)

- Home location
- Away from home

Battery State of Charge (SOC) at the End of Charging Events

- Percent of Charging Events
- Charging Event Ending SOC (%)

- Home location
- Away from home
EV Project – Overview Report

- 2 of 3 report types produced to date
- Charging infrastructure
  - # units installed
  - # charging events
  - AC MWh consumed
- Vehicles
  - # enrolled
  - # trips
  - Distance driven
- Results provided by EV Project region

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**Charging Infrastructure**

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of EV Project Charging Units Installed To Date</th>
<th>Number of Charging Events Performed</th>
<th>Electricity Consumed (AC MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix, AZ Metropolitan Area</td>
<td>12</td>
<td>143</td>
<td>0.74</td>
</tr>
<tr>
<td>Tucson, AZ Metropolitan Area</td>
<td>2</td>
<td>40</td>
<td>0.20</td>
</tr>
<tr>
<td>Los Angeles, CA Metropolitan Area</td>
<td>15</td>
<td>249</td>
<td>1.81</td>
</tr>
<tr>
<td>San Diego, CA Metropolitan Area</td>
<td>32</td>
<td>483</td>
<td>3.23</td>
</tr>
<tr>
<td>San Francisco, CA Metropolitan Area</td>
<td>12</td>
<td>85</td>
<td>0.55</td>
</tr>
<tr>
<td>Washington, D.C. Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Oregon</td>
<td>11</td>
<td>210</td>
<td>1.28</td>
</tr>
<tr>
<td>Chattanooga, TN Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
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<tr>
<td>Knoxville, TN Metropolitan Area</td>
<td>1</td>
<td>0</td>
<td>0.00</td>
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<tr>
<td>Memphis, TN Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Nashville, TN Metropolitan Area</td>
<td>4</td>
<td>44</td>
<td>0.36</td>
</tr>
<tr>
<td>Dallas-Ft. Worth, TX Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Houston, TX Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Washington State</td>
<td>18</td>
<td>322</td>
<td>2.02</td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td>1,562</td>
<td>10.13</td>
</tr>
</tbody>
</table>

**Vehicles**

<table>
<thead>
<tr>
<th>Region</th>
<th>EV Project Vehicles Enrolled to Date</th>
<th>EV Project Vehicles Enrolled to Date</th>
<th>Number of Trips</th>
<th>Distance Driven (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix, AZ Metropolitan Area</td>
<td>8</td>
<td>0</td>
<td>629</td>
<td>4,888</td>
</tr>
<tr>
<td>Tucson, AZ Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Los Angeles, CA Metropolitan Area</td>
<td>8</td>
<td>0</td>
<td>656</td>
<td>6,018</td>
</tr>
<tr>
<td>San Diego, CA Metropolitan Area</td>
<td>15</td>
<td>0</td>
<td>2,285</td>
<td>15,349</td>
</tr>
<tr>
<td>San Francisco, CA Metropolitan Area</td>
<td>5</td>
<td>0</td>
<td>248</td>
<td>2,702</td>
</tr>
<tr>
<td>Washington, D.C. Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oregon</td>
<td>4</td>
<td>0</td>
<td>692</td>
<td>3,356</td>
</tr>
<tr>
<td>Chattanooga, TN Metropolitan Area</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Knoxville, TN Metropolitan Area</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Memphis, TN Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nashville, TN Metropolitan Area</td>
<td>3</td>
<td>0</td>
<td>234</td>
<td>1,813</td>
</tr>
<tr>
<td>Dallas-Ft. Worth, TX Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Houston, TX Metropolitan Area</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Washington State</td>
<td>11</td>
<td>0</td>
<td>1,517</td>
<td>9,528</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>0</td>
<td>6,343</td>
<td>44,497</td>
</tr>
</tbody>
</table>

Note: EV Project charging units may be used by vehicles that are not part of the EV Project. Likewise, EV Project vehicles may connect to non-EV Project charging units. Therefore, vehicle and charging infrastructure usage shown on this report are not directly comparable.

1 Region: Includes the larger Los Angeles, Orange, Riverside, and San Bernardino metropolitan areas.
2 Region: Includes the Greater Seattle and Olympia Metropolitan Areas.
3 Region: Includes the Greater Portland and Salem metropolitan areas.
4 Region: Includes the Greater Philadelphia and Harrisburg metropolitan areas.

Enrollment of EV Project Chevrolel Volt is expected to begin in the second quarter of 2011.
EV Project – EV Charging Infrastructure Summary Report

- 3 of 3 report types produced to date
- Charging unit usage
- Percent charging units with a vehicle connected by time of day
- Range of aggregate electricity demand versus time of day
- See next 2 slides
EV Project – EV Charging Infrastructure Summary Report – cont’d

- 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
- Based on 15 minute rolling average MW demand
EV Project – EV Charging Infrastructure Summary Report – cont’d

- Range of charging units with a vehicle connected
- Yellow line is for day with peak power demand
- Both graphs percent of charging units
Residential Level 2 Electric Vehicle Supply Equipment (EVSE)

<table>
<thead>
<tr>
<th>EVSE Usage</th>
<th>Weekday</th>
<th>Weekend</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of charging events</td>
<td>593</td>
<td>207</td>
<td>800</td>
</tr>
<tr>
<td>Electricity consumed (AC kWh)</td>
<td>4.01</td>
<td>1.24</td>
<td>5.25</td>
</tr>
<tr>
<td>Percent of time with a vehicle connected to EVSE</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Percent of time with a vehicle drawing power from EVSE</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Average number of charging events started per EVSE per day</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Average number of distinct vehicles charged per EVSE per day (EV Project vehicles only)</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vehicles Charged</th>
<th>Nissan Leaf</th>
<th>Chevrolet Volt</th>
<th>Non-EV Project vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of charging events</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Percent of electricity consumed</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual Charging Event Statistics</th>
<th>Weekday (WD)</th>
<th>Weekend (WE)</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average length of time with vehicle connected per charging event (hr)</td>
<td>9.8</td>
<td>11.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Average length of time with vehicle drawing power per charging event (hr)</td>
<td>1.9</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Average electricity consumed per charging event (AC kWh)</td>
<td>6.8</td>
<td>6.0</td>
<td>6.6</td>
</tr>
</tbody>
</table>

EV Project – EV Charging Infrastructure Summary Report – cont’d

- Page 2 of 1 of 3 report types produced to date
- To be produced for each “charger” type
- Detailed charging event breakdowns
- Graphs on next page
- Data shown for residential Level 2 EVSE
EV Project – EV Charging Infrastructure Summary Report – cont’d
## EV Project – Number of Units

<table>
<thead>
<tr>
<th>1st Quarter 2011 Report Leaf and EVSE Units</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Leafs</td>
<td>50</td>
</tr>
<tr>
<td>Number of Blink EVSE</td>
<td>107</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>June 7, 2011 Leaf and EVSE Units with Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Leafs</td>
<td>761</td>
</tr>
<tr>
<td>Number of Blink EVSE</td>
<td>784</td>
</tr>
</tbody>
</table>
Future EV Project Activities - Infrastructure Usage Report

• 117 metrics and plots, including:
  – Charging unit utilization
  – Aggregate charging demand vs. time of day and day of the week
  – Individual charging event metrics
    • How often, how long, how empty, how full
  – Reporting by various subgroups
EV Project Data Collection Summary

• Utilize a systematic process for planning and installing charging infrastructure
  – Document travel patterns
  – Document charging patterns

• Provide feedback on infrastructure deployment decisions

• Successful grid-connected electric drive vehicle deployment is dependent on successful infrastructure deployment

• Future charging infrastructure deployments must be based on real-world travel and charging patterns
Ford Escape PHEV 3-Page Report

- Reports 300,000 test miles and 24,000 trips
- Report by charge mode:
  - Charge depleting (CD)
  - Charge sustaining (CS)
  - Mixed (CD/CS)
- All trips, 38 mpg, 101 AC Wh/mi & 66 DC Wh/mi
- CD, 52 mpg & 170 DC Wh/mi
- CD/CS, 37 mpg & 55 DC Wh/mi
- CS, 32 mpg
- Plugging-in = 63% improvement in MPG
Ford Escape PHEV 3-Page Report

- Report fuel use by highway/city cycles and driver style
- CD city, 48 mpg, 171 DC Wh/mi
- CD highway, 57 mpg, 169 DC Wh/mi
- CS city, 30 mpg
- CS highway, 32 mpg
- Plugging-in = 60% improvement in city MPG and 78% improvement in highway MPG
### Ford Escape PHEV 3-Page Report

- Report charging stats, time of day driving, and charging profiles
- 30,276 AC kWh used
- 17,110 charging events
- Ave 3.2 charging events per day when driven
- 17.5 miles between charge events
- 1.4 trips between charge events
- 1.3 hours per charge
- 6.2 hours time plugged in per charge
- 1.8 AC kWh per charge

### Plug-in charging

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of charging events per vehicle per month when driven</td>
<td>47</td>
</tr>
<tr>
<td>Average number of charging events per vehicle per day when driven</td>
<td>3.2</td>
</tr>
<tr>
<td>Average distance driven between charging events (mi)</td>
<td>17.5</td>
</tr>
<tr>
<td>Average number of trips between charging events</td>
<td>1.4</td>
</tr>
<tr>
<td>Average time plugged in per charging event (hr)</td>
<td>0.2</td>
</tr>
<tr>
<td>Average time charging per charging event (hr)</td>
<td>1.3</td>
</tr>
<tr>
<td>Average energy per charging event (AC kWh)</td>
<td>1.8</td>
</tr>
<tr>
<td>Average charging energy per vehicle per month (AC kWh)</td>
<td>82.9</td>
</tr>
<tr>
<td>Total number of charging events</td>
<td>17,110</td>
</tr>
<tr>
<td>Total charging energy (AC kWh)</td>
<td>30,276</td>
</tr>
</tbody>
</table>
Other INL Data Collection Projects

- Five USPS electric long life vehicle (ELLV) conversions
  - ELLVs required five customized onboard data loggers
  - Testing to USPS and AVTA test procedures and cycles
  - All five subjected to baseline performance (track and dynamometer testing)
  - All five in Washington DC area delivery routes with data loggers
Other INL Data Collection Projects – cont’d

• 140 Ram PHEV pickups – same report format as Ford Escape PHEVs
• Federal fleet vehicle use profiles
• Mass change impacts on ICEV, HEV, and BEV fuel use
• Development of vehicle-based battery test-bed mule
  – Street legal, includes real world impacts of power electronics, and motor energy and power demands, ambient and mission impacts
  – First lithium battery pack being installed
Other INL Data Collection Projects – cont’d

- Coulomb EVSE data collection will be same parameters as the EV Project, but no vehicle data will be collected
- Coulomb reports 525 EVSE installed to date
- Nissan Leaf fast charge study
  - Comparison of fast versus Level 2 charging impacts on battery life
- 20 Lithium PHEV Escape Quantum conversions (SCAQMD) – same report format as Ford Escape PHEVs
Vehicles INL Declined Testing Opportunities
Acknowledgement

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More Information
http://avt.inl.gov