Presentation Outline

• INL’s Vehicle Technology Experience and General Data Collection Methods
• Comparing Electric Drive Vehicle Technologies
• Grid Connected Vehicle Charging Infrastructure Overview
• EV Project & National Results
• EV Project EVSE and DCFC – Usage, Deployment, Costs, and Some Lessons Learned
• Other Testing Activities
• Acknowledgements and Sources
• A little comic relief
Idaho National Laboratory

- U.S. Department of Energy (DOE) laboratory
- 890 square mile site with 4,000 staff
- Support DOE’s strategic goal:
  - Increase U.S. energy security and reduce the nation’s dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Development
  - Homeland Security and Cyber Security
Vehicle / Infrastructure Testing Experience

- 120 million test miles accumulated on 11,600 electric drive vehicles and 16,800+ EVSE and DCFC
- EV Project: 8,110 Leafs, Volts and Smart EVs, 12,604 EVSE and DC Fast Chargers (DCFC), 100 million test miles. 1 million miles of data every 6 days
- Charge Point: 4,217 EVSE reporting 997,000 charge events
- PHEVs: 15 models, 434 PHEVs, 4 million test miles
- EREVs: 2 model, 156 EREVs, 2.3 million test miles
- HEVs: 24 models, 58 HEVs, 6.4 million test miles
- Micro hybrid (stop/start) vehicles: 3 models, 7 MHVs, 608,000 test miles
- NEVs: 24 models, 372 NEVs, 200,000 test miles
- BEVs: 48 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

Process Driven 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 simulation input

Data quality reports

HICEVs
HEVs
PHEVs
BEVs & EREVs
EVSE & Chargers

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

Trip Fuel Economy (mpg)
CD/CS trips
Log. (CD trips)
Log. (CD/CS trips)

Avg Hourly Vehicle Charging Demand

Time of Day
600-659
700-759
800-859
900-959
1000-1059
1100-1159
1200-1259
1300-1359
1400-1459
1500-1559
1600-1659
1700-1759
1800-1859
1900-1959
2000-2059
2100-2159
2200-2259
2300-2359
000 - 059
100-159
200-259
300-359
400-459
500-559

Mon AM - Tues AM
Tue AM - Wed AM
Wed AM - Thu AM
Thu AM - Fri AM
Fri AM - Sat AM
Sat AM - Sun AM
Sun AM - Mon AM

0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Comparing Electric Drive Vehicle Technologies
Comparison of Vehicle Technology

Conventional vehicle with internal combustion engine (ICE) only
Comparison of Vehicle Technology

- Hybrid Electric Vehicle (HEV) with ICE and electric drive
- Does not plug in to electric grid
Comparison of Vehicle Technology

• Plug-in Hybrid Electric Vehicle (PHEV) with ICE and electric drive
Comparison of Vehicle Technology

- Battery Electric Vehicle (BEV) with electric drive only
Conceptual Comparison of Vehicle Operation

Hypothetical 15 mile drive cycle
Conceptual Comparison of Vehicle Operation

Conventional vehicle

HEV

PHEV10 (all-electric capable)

BEV (100 mi range)
Energy Efficiency

Drivetrain Efficiency – How much of the fuel energy gets to the road

Chemical or Electrical Energy (Gallons of gasoline, kWh of electricity, i.e. what you pay for)

Vehicle Engine & Drivetrain Efficiency (i.e. Engine, Transmission, Accessories)

Energy to the Wheels:
EV: 59-62%
Gasoline: 17-21%
PHEV: Somewhere in between...

Determines how much gasoline or electrical energy is used to drive some distance: i.e. MPG ratings.

Chassis Efficiency – How far does the wheel power move the car?

Energy to the wheels

Mass, Aerodynamic drag, Rolling Resistance, etc

Distance Travelled

Think Hummer vs. Civic
At the End of the Day, How Much $$$$?

<table>
<thead>
<tr>
<th>PEV Model</th>
<th>kWh / 100 Miles¹</th>
<th>Cost to Travel 100 Miles²</th>
<th>ICE Model</th>
<th>MPG¹</th>
<th>Gal / 100 Miles</th>
<th>Cost to Travel 100 Miles²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevrolet Volt</td>
<td>35</td>
<td>$3.85</td>
<td>Chevrolet Cruze</td>
<td>30</td>
<td>3.33</td>
<td>$12.17</td>
</tr>
<tr>
<td>Ford Focus EV</td>
<td>32</td>
<td>$3.52</td>
<td>Ford Focus</td>
<td>31</td>
<td>3.23</td>
<td>$11.77</td>
</tr>
<tr>
<td>Honda Fit EV</td>
<td>29</td>
<td>$3.19</td>
<td>Honda Fit</td>
<td>30</td>
<td>3.33</td>
<td>$12.17</td>
</tr>
<tr>
<td>Nissan Leaf (`12)</td>
<td>34</td>
<td>$3.74</td>
<td>Nissan Versa</td>
<td>35</td>
<td>2.86</td>
<td>$10.43</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>32.50</strong></td>
<td><strong>$3.58</strong></td>
<td><strong>Average</strong></td>
<td><strong>31.5</strong></td>
<td><strong>3.17</strong></td>
<td><strong>$11.59</strong></td>
</tr>
</tbody>
</table>

¹ - Sources - 2013 Fuel Economy Guide Page
² - Assumes 11 cents per kWh and $3.65 gallon
Grid Connected Vehicle Charging Infrastructure Overview
Vehicle Electrification: Grid Impacts

- In the U.S., current grid capacity could supply electricity for 70% of our vehicles without adding capacity, but assumes:
  - Vehicles would only charge off-peak
  - “Perfect” distribution of electricity
  - No local impacts such as overburdening neighborhood transformers

- EVs and PHEVs will not cause a grid “meltdown” but we clearly need to work to reduce vehicle rollout impacts
- Smart charging will be key to lowering costs and minimizing impacts
- Time of day pricing also important
Build-out of Charging Infrastructure

• Key today: Home “Location” Charging
  – Cost and installation process established at single family homes
  – Currently a significant barrier in multi unit housing
  – Fleet charging needs good planning

• Public Charging
  – Expensive if not well utilized
  – Expansive to fully cover full driving patterns

• Ideally need market pull to determine public infrastructure build-out
  – PHEVs may be key to help initiate market pull for public infrastructure
Innovative Approaches

- Battery swapping
  - Requires OEM buy-in
- Fast Charging (becoming less innovative)
- Innovative Financing
- Secondary use of batteries
  - Utility ancillary services
  - Bulk energy storage
  - Present value
- Vehicle to Grid (V2G)
Level 1 Charging Level

- This method allows broad access to change an EV or PHEV by plugging into the most common grounded electrical outlet in the U.S.
- AC energy transfer to onboard charger
- Typical hardware includes portable cord set that must utilize a vehicle connector UL approved for the purpose, a GFCI, and otherwise meet NEC 625 requirements and SAE standards, including the J1772 connector:
  - Separate, commercial-grade circuit and commercial-grade wall socket even at home
    - Standard 120V/15A or 20A
    - Current 12 amps or 16 amps (80% of amp breaker)
    - Power 1.44 kW
- Charge Times (general approximation)
  - Battery EV 14 hours (20 kWh battery) to 39 hours (56 kWh battery)
  - PHEV 3 to 8 hours
Level 2 Charging Level

• The most common method for residential and commercial charging

• EVSE (electric vehicle supply equipment) for AC energy transfer to onboard charger

• Permanently attached wall box, GFCI, some vehicle communication, UL approved, NEC 625 requirements and SAE standards, including J1772 connector:
  – 240V single phase up to 100A
  – Current up to 80A (80% of amp breaker)
  – Power up to 19.2 kW
  – 3.3 kW or 6.6 kW

• Charge Times (general approximation)
  – 20 kWh Battery EV 3 hours (at 6.6 kW) to 56 kWh battery in 8.5 hours (at 6.6k kW)
  – PHEV 1.5 to 3.6 hours (at 3.3 kW)
DC Fast Charging (DCFC)

- Expected to be used in an intercity grid pattern or along travel routes between cities in commercial settings
- Off-board charger (high cost, large volume and weight)
- Used for DC energy transfer to vehicle
- Requires charger-to-vehicle communication and control
- Most U.S. fast chargers are using Japanese CHAdeMO protocol connector
- U.S. SAE standard connector not as common (change?)
- Up to 500VDC and 125A. 20 to 60 kW likely
- Charge Times are dependant on battery size
  - 20 kWh BEV is 50% recharge in 15 minutes and 80% recharge in 30 minutes
  - Charge times dependant on charger / battery relative sizing
  - Generally not used for PHEVs and NEVs due to small relative battery sizes
Charging Infrastructure Summary

• EVSE is a device that allows an electric vehicle to be charged from an off-board electricity source (home outlet, public charging station etc)

• AC Level 1
  – 120V/15-20A outlet typical
  – Typically portable
  – ~1.4 kW, ~16+ hours

• AC Level 2
  – 240V/20-40A outlet typical
  – Fixed location
  – ~3.3 or 6.6 kW, ~4-8 hours

• DC Level 2 (DC Fast Charge)
  – 480V 3phase (industrial power)
  – Large, fixed, $$$
  – 20 to 50kW, ~30 minutes
EV Project & National Results
EV Project Goal, Locations, Participants, and Reporting

• 50-50 DOE ARRA and ECOtality North America funded
• Goal: Build and study mature charging infrastructures and take the lessons learned to support the future streamlined deployment of grid-connected electric drive vehicles
• ECOtality is the EV Project lead, with INL, Nissan and Onstar/GM as the prime partners, with more than 40 other partners such as electric utilities and government groups
EV Project – EVSE Data Parameters Collected per Charge Event

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

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

- Additional data is received monthly from Car2go for the Smart EVs
EV Project Data Complexity

• The EV Project has 44 Databases (DB)
  – Nissan Leaf & GM/OnStar Volt
  – ECOtality Blink, Aerovironment & EPRI EVSE
  – Admin (look up tables, territories, zips codes, QA parameters, etc.)
    • Each of the above six DBs has three versions (process, stage & production) = 18 DBs
  – Four GIS DBs for the Leafs, Volts, Blink EVSEs, and Base (streets, utility service territory areas, etc.)
  – Above 22 (18 + 4) DBs exist on two systems = 44 DBs

• Hundreds of algorithms and thousands of lines of code required to populate 150 pages of public quarterly reports

• INL must blend multiple data streams, from multiple sources, all on different delivery schedules

• This is not a flat file, spreadsheet experience and this is NOT a simple task
Data Collection, Security and Protection

- All vehicle, EVSE, and PII raw data is legally protected by NDAs (Non Disclosure Agreements) or CRADAs (Cooperative Research and Development Agreements)
  - Limitations on how proprietary and personally identifiable information can be stored and distributed
  - Raw data, in both electronic and printed formats, is not shared with DOE in order to avoid exposure to FOIA
  - Vehicle and EVSE data collection would not occur unless testing partners trust INL would strictly adhere to NDAs and CRADAs
  - Raw data cannot be legally distributed by INL
## EV Project – National Data

### 2nd quarter 2013 Data Only

<table>
<thead>
<tr>
<th></th>
<th>Leafs</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vehicles</td>
<td>4,261</td>
<td>1,895</td>
</tr>
<tr>
<td>Number of Trips</td>
<td>1,135,000</td>
<td>676,000</td>
</tr>
<tr>
<td>Distance (million miles)</td>
<td>8.04</td>
<td>5.75</td>
</tr>
<tr>
<td>Average (Ave) trip distance</td>
<td>7.1 mi</td>
<td>8.3 mi</td>
</tr>
<tr>
<td>Ave distance per day</td>
<td>29.5 mi</td>
<td>41.0 mi</td>
</tr>
<tr>
<td>Ave number (#) trips between</td>
<td>3.8</td>
<td>3.3</td>
</tr>
<tr>
<td>charging events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave distance between</td>
<td>26.7 mi</td>
<td>27.6 mi</td>
</tr>
<tr>
<td>charging events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ave # charging events per day</td>
<td>1.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

* Note that per day data is only for days a vehicle is driven
EV Project – Leaf & Volt Charging

Leafs

Volts

- Battery State of Charge (SOC) at the Start of Charging Events
  - Home location
  - Away-from-home location

- Battery State of Charge (SOC) at the End of Charging Events
  - Home location
  - Away-from-home location

- Frequency of Charging by Charging Location
  - Home location: 20%
  - Away-from-home location: 6%
  - Unknown location: 74%

- Frequency of Charging by Charging Location and Type
  - Home location: 80%
  - Away from home: 14%
  - Unknown charge location: 7%
EV Project – EVSE Infra. Summary Report

- National Residential and Public Level 2 Weekday EVSE 2nd Quarter 2013
- Residential and public connect time and energy use are fairly opposite profiles. Note different scales

National Residential Connect Time

National Public Connect Time

National Residential Demand

National Public Demand
EV Project – EVSE Infra. Summary Report

- Residential Level 2 Weekday EVSE 2nd Quarter 2013
- San Diego and San Francisco, with residential L2 TOU rates, are similar to national and other regional EVSE connect profiles
EV Project – EVSE Infra. Summary Report

• Residential Level 2 Weekday EVSE 2nd Quarter 2013
• TOU kWh rates in San Diego and San Francisco clearly impact when vehicle charging start times are set

San Diego

Los Angeles

San Francisco

Washington State
EV Project – EVSE Connect & Power

Residential

Non Residential Public

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

Length of time connected per charging event (hr)

Distribution of Length of Time with a Vehicle Drawing Power per Charging Event

Length of time with vehicle drawing power per charging event (hr)

Distribution of Electricity Consumed per Charging Event

Electricity consumed per charging event (AC kWh)
EV Project Weekly Charge Events 5/19/13

- Note 5.4 to 1 weekly Residential EVSE use rate versus weekly Commercial EVSE use rate (last 5 weeks)
EV Project EVSE and DCFC – Usage, Deployment, Costs, and Some Lessons Learned
EVSE DCFC Use

- DC Fast Chargers Weekday 2\textsuperscript{nd} Quarter 2013
- 87 DCFC, 27,000 charge events and 223 AC MWh

- EV Project Leafs 25% charge events and 24% energy used
- Unknowns are Non EV Project vehicles
- 3.8 average charge events per day per DCFC
- 19.5 minutes average time connected
- 19.5 minutes average time drawing energy
- 8.3 kWh average energy consumed per charge
EV Project – DCFC Power Levels

- DC Fast Chargers Weekday 1\textsuperscript{st} Quarter 2013
- 72 DCFC, 13,500 charge events and 102 AC MWh
EV Project – DCFC Connect Time

- Distribution of time vehicle connected per DCFC charge event for all regions. **No charge events have occurred where connect time is greater than 60 minutes**
EV Project – DCFC Energy Delivered

- Distribution of energy delivered per DCFC event time for all regions. **No charge event delivered more than 18 kWh**
EV Project – DCFC Versus Level 2 Public

• Number of charge events per publicly accessible Level 2 EVSE versus per DCFC in the 1\textsuperscript{st} Quarter 2013

• Nationally, 17 events per public L2 and 188 per DCFC this quarter
DCFC Installation Costs / Issues

• Current installations range from $8,500 to $48,000 (99 units)
• Average installation cost to date is about $21,000
• Host has obvious commitment for the parking and ground space - not included in above costs
• Above does not include any costs that electric utility may have incurred in evaluating or upgrading service

• These are the preliminary costs to date. When all 200 DC Fast Chargers are installed, installation costs may be different
  – All the best (lower-cost) sites are installed first, so final costs may be higher
  – Lessons learned may help lower future costs and site selections, so final costs may be lower
## DCFC Installation Costs

- **Total installation costs (99 units)**
- **Includes everything EV Project has funded per DCFC installation except DCFC charging unit**

<table>
<thead>
<tr>
<th>Number per Region</th>
<th>National - 99</th>
<th>AZ - 17</th>
<th>WA - 12</th>
<th>CA - 37</th>
<th>OR - 15</th>
<th>TN - 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>$8,440</td>
<td>$8,440</td>
<td>$18,368</td>
<td>$10,538</td>
<td>$12,868</td>
<td>$14,419</td>
</tr>
<tr>
<td>Mean</td>
<td>$20,848</td>
<td>$15,948</td>
<td>$24,001</td>
<td>$21,449</td>
<td>$19,584</td>
<td>$23,271</td>
</tr>
<tr>
<td>Maximum</td>
<td>$47,708</td>
<td>$33,990</td>
<td>$33,246</td>
<td>$47,708</td>
<td>$26,766</td>
<td>$31,414</td>
</tr>
</tbody>
</table>
DCFC Individual Installation Costs

- Total installation costs (99 units)
- Does not include DCFC hardware

Mean - $20,848
Mode - $20,188
DCFC Individual Installation Costs

- Total installation costs (99 units)
- Does not include DCFC hardware
DCFC Installation Costs / Issues

- Items of concern associated with DCFC installations that drive costs
  - Power upgrades needed for site
  - Impact on local transformer
  - Ground surface material and cost to “put back” (e.g. concrete, asphalt, landscaping)
  - Other underground services that may affect method of trenching power to DCFC
  - Gatekeeper or decision-maker for the property is not always apparent
  - Magnitude of operating costs and revenue opportunities are still largely unknown
  - Time associated with permissions
    - Permits, load studies, and pre-, post-, and interim inspections
Demand and energy costs are significant for some utilities
- 25¢/kWh
- $25/kW

Some utilities offer commercial rates without demand charges

Others incorporate 20 kW to 50 kW demand thresholds

Nissan Leaf is demand charge free in some electric utility service territories
**DCFC Commercial Lessons Learned**

- Especially in California, DC fast charge demand charges are significant in many utility service territories

<table>
<thead>
<tr>
<th>Utility Demand Charges - Nissan Leaf</th>
<th>Cost/mo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td></td>
</tr>
<tr>
<td>Glendale Water and Power</td>
<td>$16.00</td>
</tr>
<tr>
<td>Hercules Municipal Utility:</td>
<td>$377.00</td>
</tr>
<tr>
<td>Los Angeles Department of Water and Power</td>
<td>$700.00</td>
</tr>
<tr>
<td>Burbank Water and Power</td>
<td>$1,052.00</td>
</tr>
<tr>
<td>San Diego Gas and Electric</td>
<td>$1,061.00</td>
</tr>
<tr>
<td>Southern California Edison</td>
<td>$1,460.00</td>
</tr>
<tr>
<td>AZ</td>
<td></td>
</tr>
<tr>
<td>TRICO Electric Cooperative</td>
<td>$180.00</td>
</tr>
<tr>
<td>The Salt River Project</td>
<td>$210.50</td>
</tr>
<tr>
<td>Arizona Public Service</td>
<td>$483.75</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Pacificorp</td>
<td>$213.00</td>
</tr>
<tr>
<td>WA</td>
<td></td>
</tr>
<tr>
<td>Seattle City Light</td>
<td>$61.00</td>
</tr>
</tbody>
</table>
L2 and DCFC Commercial Lessons Learned

- **ADA significantly drives cost**
  - Accessible charger
  - Van accessible parking
  - Accessible electric and passage routes to facility

- **Permit fees and delays can be significant**
  - Load studies
  - Zoning reviews
### Commercial Level 2 Permits Cost

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

<table>
<thead>
<tr>
<th>Region</th>
<th>Count of Permits</th>
<th>Average Permit Fee</th>
<th>Minimum Permit Fee</th>
<th>Maximum Permit Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>72</td>
<td>$228</td>
<td>$35</td>
<td>$542</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>17</td>
<td>$195</td>
<td>$67</td>
<td>$650</td>
</tr>
<tr>
<td>San Diego</td>
<td>17</td>
<td>$361</td>
<td>$44</td>
<td>$821</td>
</tr>
<tr>
<td>Texas</td>
<td>47</td>
<td>$150</td>
<td>$37</td>
<td>$775</td>
</tr>
<tr>
<td>Tennessee</td>
<td>159</td>
<td>$71</td>
<td>$19</td>
<td>$216</td>
</tr>
<tr>
<td>Oregon</td>
<td>102</td>
<td>$112</td>
<td>$14</td>
<td>$291</td>
</tr>
<tr>
<td>Washington</td>
<td>33</td>
<td>$189</td>
<td>$57</td>
<td>$590</td>
</tr>
</tbody>
</table>
Commerical Level 2 Installation Costs

- Nationally, commercially sited Level 2 EVSE average between $3,500 and $4,500 for the installation cost
  - Does not include hardware or permitting costs
- There is much variability by region and by installation
  - Multiple Level 2 units at one location drive down the per EVSE average installation cost
  - Tennessee and Arizona have average installation costs of $2,000 to $2,500
- Costs are significantly driven by poor sitting requests
  - Example: mayor may want EVSE by front door of city hall, but electric service is located at back of building
- These numbers are preliminary
Residential Level 2 EVSE Installation Costs

- Max - $8,429
- Mean $1,414
- Min $250
- Medium $1,265

- Count 4,466
- Total installation costs, does not include EVSE hardware
Residential Level 2 EVSE Installation Costs

- Regional results for 4,466 units
- Permit versus other install costs. No EVSE costs
Residential Level 2 EVSE Installation Costs

- Regional results for 4,466 units
- Permit versus other install costs. No EVSE costs
Signage Example
Ignoring Signage – See Ticket on Windshield

- Sing to the left is one of two Federal Highway Administration interim approved symbol

Ignoring Signage – See Ticket on Windshield
Other Testing Activities
Hasetec DC Fast Charging Nissan Leaf
• 53.1 AC kW peak grid power
• 47.1 DC kW peak charge power to Leaf energy storage system (ESS)
• 15.0 Grid AC kWh and 13.3 DC kWh delivered to Leaf ESS
• 88.7% Overall charge efficiency (480VAC to ESS DC)
EVSE Testing

• AC energy consumption at rest and during Volt Charging benchmarked

• Steady state charge efficiency benchmarked

![Image of EVSE chargers]

EVSE AC Watt Consumption Prior to & During Chevy Volt Charging

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

See http://avt.inel.gov/evse.shtml for individual testing fact sheets
INL Wireless Charging Bench Testing

Grid Power
480 & 240 VAC

Hioki Power Meter 3390

Chroma AC Load

Chroma DC Load

Fiberglass Unistrut Secondary Coil Support

Narda EM Field Meter (EHP-200)

Polycarbonate Primary Coil Support

Multi-Axis Positioning System

Custom LabVIEW Host and Data Acquisition
INL’s Wireless Power Transfer Test Results

http://avt.inel.gov/evse.shtml
Additional Infrastructure Work

- Initiated I-5 corridor DCFC study
- **Six Leaf DCFC and L2 charging study on battery life**
  - Two vehicles driven on road and L2 charged
  - Two driven identical routes DCFC charged
  - One L2 and one DCFC in battery lab
  - At 20k miles each Leaf similar minimal capacity fade
- **INL conducted with NFPA and US DOT, traction battery fire first responder suppression burns.** See avt.inl.gov
- INL initiated ~400 New York EVSE data collection with NYSERDA, NYPA, Port Authority of NY/NJ, and Energetics
- 30 EVSE and 10 vehicle conductive interoperability testing with SAE scheduled for January
- **INL receiving data from six NYC Nissan Leaf taxis, six Level 2 EVSE, three DCFCs, and Taxi & Limo Commission**
- If I only had another 30 minutes I could have 100 slides….
Acknowledgement
This work is supported by the U.S. Department of Energy’s EERE Vehicle Technologies Program

More Information & Sources

- INL Fact Sheets and Presentations
  - http://avt.inl.gov
- Twenty EV Project lessons learned papers
  - http://avt.inl.gov
Questions? & Things We Have Not Tested