eVMT Analysis of On-Road Data from Plug-In Hybrid Electric and All-Electric Vehicles

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Introduction

• Calculated electric vehicle miles traveled (eVMT) for plug-in hybrid electric vehicles
  – Ford Fusion Energi, Ford C-Max Energi, Honda Accord PHEV, Toyota Prius PHEV, Chevrolet Volt
• Calculated total vehicle miles traveled (VMT) for all electric vehicles (which is equal to eVMT since all the miles are electric)
  – Ford Focus Electric, Honda Fit EV, Nissan Leaf
• Data is from actual customer, on-road vehicle operation
  – 158,468,000 miles from 21,600 vehicles
  – Across the U.S. (i.e. widely varying regions and climates)
• Multiple methods to calculate eVMT were compared

• Project collaboration amongst several groups
  – Idaho National Laboratory, Honda North America, Ford Motor Company, Toyota Motor Engineering & Manufacturing NA, General Motors (NDAs signed)
Assumptions

• If the data format enables the analysis of “data completeness” (i.e. not too much missing data by comparing Odometer to sum of trip distances)
  – Data completeness was calculated on monthly basis
  – Further analysis was conducted on months of data, only if a minimum completeness criteria is met

• If the data format does not enable the analysis of data completeness
  – All data is analyzed with the assumption that the data completeness is acceptable

• for All-Electric Vehicles, by definition, eVMT = VMT

• To align results from the differing data formats, three calculation methods were used to calculate eVMT from the various PHEV data sets
  – eVMT calculation methods only differed by <2.5% for the 3 methods

• Final results (detailed in this presentation) are from two of the methods
  – based on EPA Label Fuel Economy and Elec. Energy Consumption
  – based on vehicle average Charge Sustaining fuel consumption
**eVMT Calculation based on Label Fuel Economy**

- Every trip is classified as All-Electric (EV), Blended, or Charge Sustaining mode of operation.

- From the EPA Label Fuel Economy and Elec. Energy Consumption:
  - The slope is determined from EV to CS (i.e. “A” to “C”)
    - \((\Delta \text{gal/mi} / \Delta \text{Wh/mi})\)

- For each Blended trip:
  - Fuel Displaced by Electrical Energy is determined
    - \(\text{Disp}_\text{Gal} = \text{Trip Wh consumed} \times (\Delta \text{gal/mi} / \Delta \text{Wh/mi})\)
  - Calculated Trip eVMT\text{\_Blended}
    - \(\text{eVMT\text{\_Blended}} = \text{TripLength} \times \frac{\text{Disp}_\text{Gal}}{(\text{Trip}_\text{Gal} + \text{Disp}_\text{Gal})}\)

- \(\text{eVMT} = \text{sum(EV trip miles)} + \text{sum(eVMT\text{\_Blended miles})}\)
eVMT Calculation based on Vehicle Average Charge Sustaining Fuel Consumption

- Every trip is classified as All-Electric (EV), Blended, or Charge Sustaining mode of operation
- \( \text{Dist}_{\text{Electrified}} \) is calculated using the following methodology:

\[
\text{Dist}_{\text{Electrified}} = \text{Dist}_{\text{CD}} - \frac{\text{Gasoline}_{\text{CD}}}{\text{FC}_{\text{CS}}}
\]

- For the amount of fuel consumed during the trip, \( \text{Dist}_{\text{Electrified}} \) is the distance driven in excess of what could have been driven in CS mode, as enabled mainly by grid energy

- Using a calculated average Fuel Consumption data (FCcs) for each vehicle, the \( \text{Dist}_{\text{Electrified}} \) (EV Equivalent) was calculated for every Blended trip.

- \( \text{eVMT} = \text{sum}(\text{EV trip miles}) + \text{sum}(\text{Dist}_{\text{Electrified}}) \)
Nissan Leafs & Chevy Volts Regional Distribution

Nissan Leafs and Chevrolet Volts Reporting Data in The EV Project through December 2013

Legend
- Green: Nissan Leafs
- Blue: Chevy Volts
- Yellow: Smart Electric Drives

Data Source:
- Idaho National Laboratory
- INL/MYS-12-20073

Map Shows:
- Distribution of Nissan Leafs and Chevy Volts across the United States
- Cities with reported data: Dallas/Ft. Worth, Nashville, Knoxville, Chattanooga, Atlanta, San Francisco, Los Angeles, San Diego, Phoenix, Tucson, Houston, Chicago, Philadelphia, Washington D.C.
Ford C-Max Energi, Fusion Energi, and Focus Electric Regional Distribution

<table>
<thead>
<tr>
<th># of distinct Vehicles ever Driven in the Region</th>
<th>Region 1</th>
<th>Region 2</th>
<th>Region 3</th>
<th>Region 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford C-Max Energi</td>
<td>2500</td>
<td>2024</td>
<td>1890</td>
<td>1556</td>
</tr>
<tr>
<td>Ford Fusion Energi</td>
<td>2885</td>
<td>1571</td>
<td>2189</td>
<td>1393</td>
</tr>
<tr>
<td>Ford Focus Electric</td>
<td>1337</td>
<td>289</td>
<td>313</td>
<td>328</td>
</tr>
</tbody>
</table>
## Analysis Results

<table>
<thead>
<tr>
<th>Number of Vehicles</th>
<th>Nissan LEAF *</th>
<th>Chevrolet Volt *</th>
<th>Ford Focus Electric</th>
<th>Ford C-Max Energi</th>
<th>Ford Fusion Energi</th>
<th>Honda Fit EV</th>
<th>Honda Accord PHEV</th>
<th>Toyota Prius PHEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,039</td>
<td>1,867</td>
<td>2,193</td>
<td>5,368</td>
<td>5,803</td>
<td>645</td>
<td>189</td>
<td>1,523</td>
</tr>
<tr>
<td>Number of Vehicle Months</td>
<td>35,294</td>
<td>20,545</td>
<td>12,622</td>
<td>38,096</td>
<td>32,022</td>
<td>6,090</td>
<td>1,437</td>
<td>15,676</td>
</tr>
<tr>
<td>Total Vehicle Miles Traveled VMT (miles)</td>
<td>28,520,792</td>
<td>20,950,967</td>
<td>10,043,000</td>
<td>39,376,000</td>
<td>33,098,000</td>
<td>4,912,920</td>
<td>1,794,494</td>
<td>19,772,530</td>
</tr>
<tr>
<td>Total Calculated Electric Vehicle Miles Traveled eVMT (miles)</td>
<td>28,520,792</td>
<td>15,599,508</td>
<td>10,043,000</td>
<td>12,918,000</td>
<td>11,572,000</td>
<td>4,912,920</td>
<td>399,412</td>
<td>3,224,981</td>
</tr>
</tbody>
</table>

| Avg. Monthly VMT | 808.1 | 1,019.8 | 795.7 | 1,033.6 | 1,033.6 | 806.7 | 1,248.8 | 1,261.3 |
| Avg. Monthly eVMT | 808.1 | 759.3 | 795.7 | 339.1 | 361.4 | 806.7 | 278 | 207.0 |
| estimated Annual VMT | 9,697 | 12,238 | 9,548 | 12,403 | 12,403 | 9,680 | 14,986 | 15,136 |
| estimated Annual eVMT | 9,697 | 9,112 | 9,548 | 4,069 | 4,337 | 9,680 | 3,336 | 2,484 |

<table>
<thead>
<tr>
<th>Data Format Description</th>
<th>Key-On / Key-Off</th>
<th>Key-On / Key-Off</th>
<th>Enhanced Key-On / Key-Off</th>
<th>Trip Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic Characterization</td>
<td>CA, OR, WA, AZ, TX, TN, GA, D.C., PA, IL</td>
<td>CA, OR, WA, AZ, TX, TN, GA, D.C., PA, IL</td>
<td>Nationwide</td>
<td>CA, OR, NJ, MD, CT, MA, RI, NY</td>
</tr>
</tbody>
</table>


Minimally Charged Vehicles are Not Excluded from analysis. These data include 14% of Accord PHEVs that achieve between 0-50 monthly eVMT.
eVMT and VMT

Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.
eVMT (monthly electric vehicle miles traveled)

Vehicle Average Monthly eVMT

Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.
VMT (total monthly vehicle miles traveled)

Vehicle Average Monthly VMT

Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.
Summary

• On-road data from customer operation was analyzed
  – 158,468,000 miles from 21,600 vehicles
  – eVMT analysis
    • Annual eVMT ranged from
      – BEV: 9,548 to 9,697 mi
      – PHEV / E-REV: 2,484 to 9,112 mi
• Data from all vehicle models were from varying regions and climates
• Multiple eVMT calculation methods were compared
  – eVMT calculation methods only differed by <2.5%
Acknowledgement

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More Information
http://avt.inl.gov