EVMT ANALYSIS OF ON-ROAD DATA FROM PLUG-IN HYBRID ELECTRIC AND ALL-ELECTRIC VEHICLES
Matt Shirk, Barney Carlson, Idaho National Laboratory
Idaho National Laboratory (INL) leads U.S. DOE’s Advanced Vehicle Testing Activity (AVTA) for light duty vehicles

On-Road data collection and analysis (since 1994)
   27,400 Advanced Technology Vehicles
   • EV, PHEV, HEV, and Alt. Fuel vehicles
     232 million miles of data

Charging Infrastructure data collection and analysis
   17,000 EVSE (through out the U.S.)
   44,300 MWh (AC charge energy)
Collaborative groups

Idaho National Laboratory
Honda North America
Ford Motor Company
Toyota Motor Engineering & Manufacturing NA
General Motors

Calculated electric vehicle miles traveled (eVMT) for:

Ford Fusion Energi
Ford C-Max Energi
Honda Accord PHEV
Toyota Prius PHEV
Chevrolet Volt
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)
Data completeness was calculated on monthly basis

- Check for missing data when able
- eVMT analysis conducted only for months with high data completeness
- If data format does not enable completeness check, all data is used

To align results from the differing data formats, three calculation methods were evaluated

eVMT calculation methods only differed by <2.5% for the 3 methods

Final results are from two of the methods

- Based on EPA Label Fuel Economy and Elec. Energy Consumption
- Based on vehicle average Charge Sustaining fuel consumption

For All-Electric Vehicles, by definition, eVMT = total VMT
Every trip is classified as one of three types:
- All-Electric
- Blended
- Charge Sustaining mode of operation

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

For each blended trip
- Fuel Displaced by Electrical Energy is determined
  \[ \text{Disp\_Gal} = \text{Trip Wh consumed} \times \left( \frac{\Delta \text{gal/mi}}{\Delta \text{Wh/mi}} \right) \]
- Calculated Trip eVMT_Blended
  \[ \text{eVMT\_Blended} = \text{TripLength} \times \frac{\text{Disp\_Gal}}{\text{Trip\_Gal} + \text{Disp\_Gal}} \]
  
\[ \text{eVMT} = \text{sum(All-Electric trips miles)} + \text{sum(eVMT\_Blended miles)} \]
Every trip is classified as:

- All-Electric
- Blended
- Charge Sustaining

Dist$_{\text{Electrified}}$ is calculated using the following methodology for trips that consume both fuel and electricity:

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

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

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

$$\text{eVMT} = \text{sum}(\text{EV trip miles}) + \text{sum}(	ext{Dist}_{\text{Electrified}} \text{ of Blended Trips})$$
Nissan Leaf and Chevrolet Volt Geographic Distribution
# of distinct Vehicles ever Driven in the Region

<table>
<thead>
<tr>
<th>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>

![United States map with regions labeled 1 to 4](image-url)
## Analysis Results

<table>
<thead>
<tr>
<th></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>Number of Vehicles</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>

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

Average Monthly eVMT and VMT by Model

Vehicle Average Monthly eVMT and VMT

Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.
Average Monthly eVMT by Model

Vehicle Average Monthly eVMT

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

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

More Information

http://avt.inl.gov