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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)

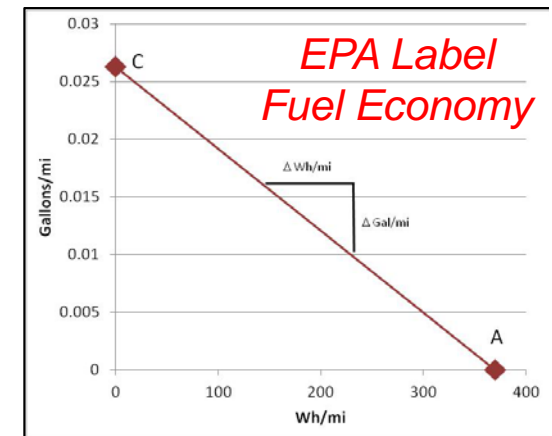


Assumptions

- 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”)
 - $(\Delta gal/mi / \Delta Wh/mi)$
- For each Blended trip
 - Fuel Displaced by Electrical Energy is determined
 - $Disp_Gal = Trip\ Wh\ consumed \times (\Delta gal/mi / \Delta Wh/mi)$
 - Calculated Trip eVMT_Blended
 - $$eVMT_Blended = TripLength \times \frac{Disp_Gal}{(Trip_Gal + Disp_Gal)}$$
- $eVMT = \text{sum}(\text{EV trip miles}) + \text{sum}(\text{eVMT_Blended miles})$



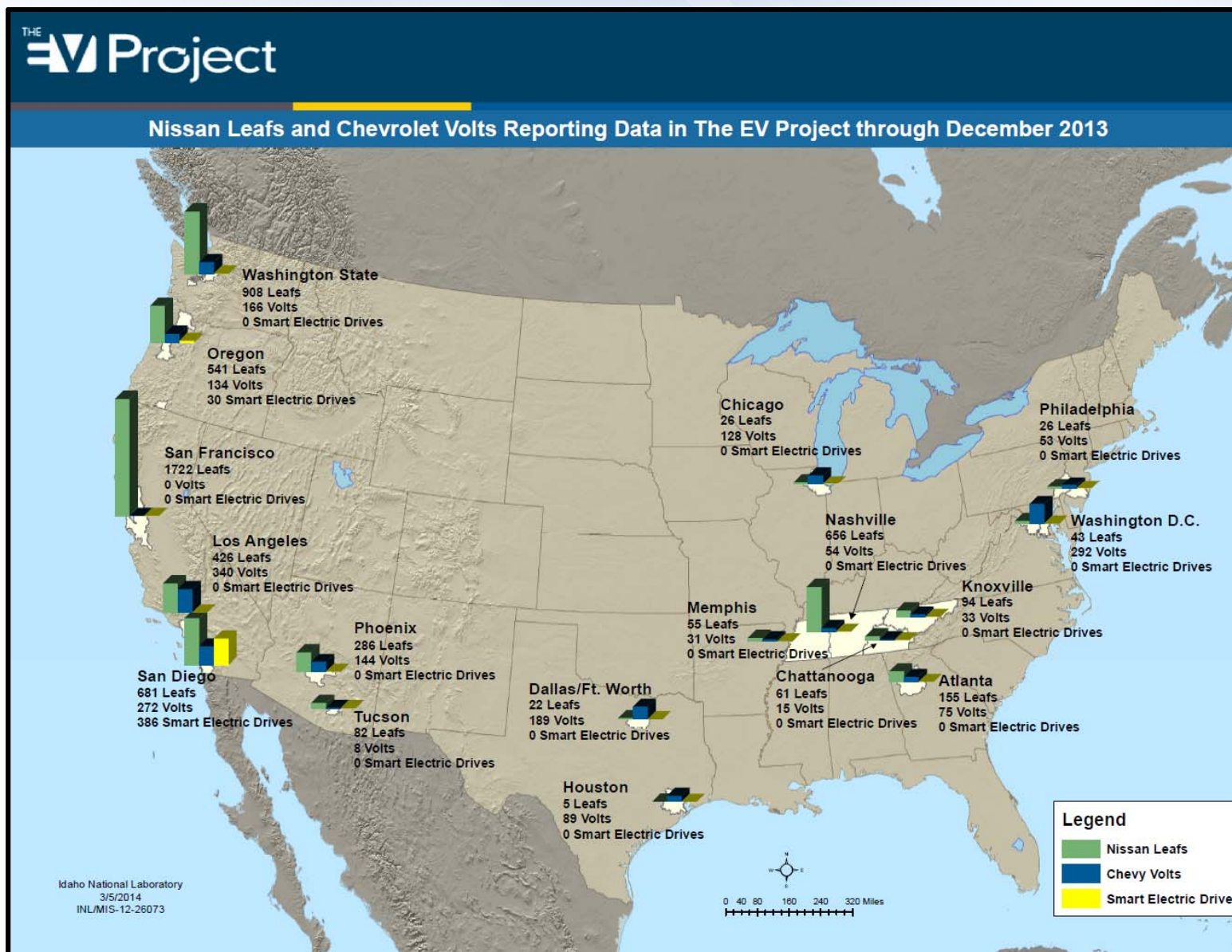
eVMT Calculation based on Vehicle Average Charge Sustaining Fuel Consumption

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

$$Dist_{Electrified} = Dist_{CD} - \frac{Gasoline_{CD}}{FC_{CS}} \longrightarrow Dist_{Electrified} = Dist_{Total} - \frac{Gasoline_{Total}}{FC_{CS}}$$

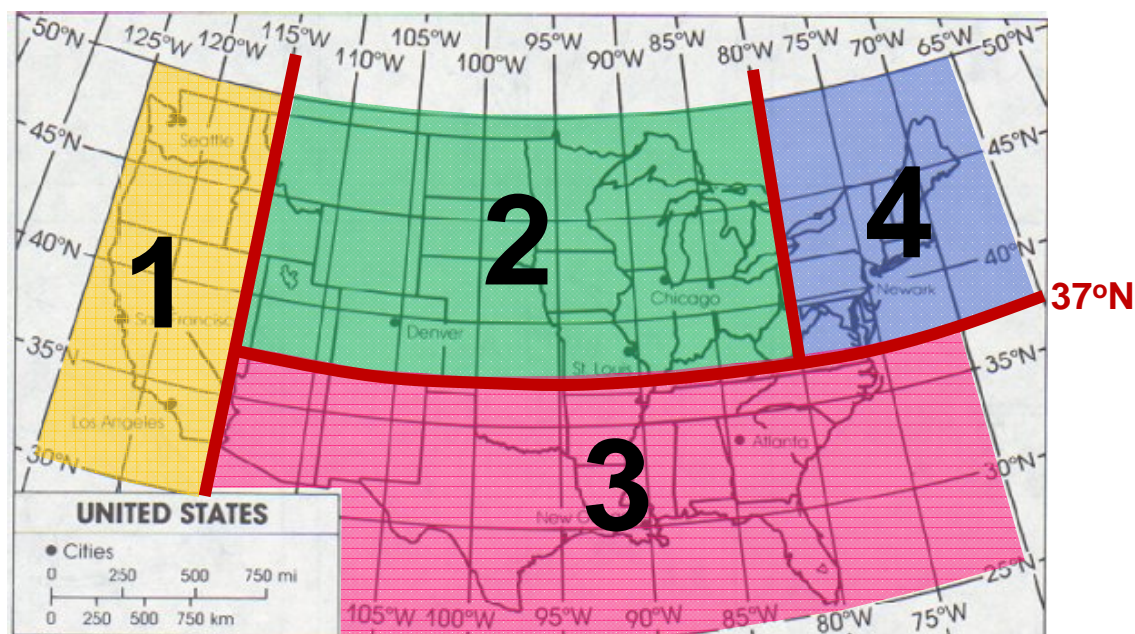
- For the amount of fuel consumed during the trip, $Dist_{Electrified}$ is the distance driven in excess of what could have been driven in CS mode, as enabled mainly by grid energy
 - Using a calculated average Fuel Consumption data (FCcs) for each vehicle, the $Dist_{Electrified}$ (EV Equivalent) was calculated for every Blended trip.
- $eVMT = \text{sum}(\text{EV trip miles}) + \text{sum}(Dist_{Electrified})$

Nissan Leafs & Chevy Volts Regional Distribution



Ford C-Max Energi, Fusion Energi, and Focus Electric Regional Distribution

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



Analysis Results

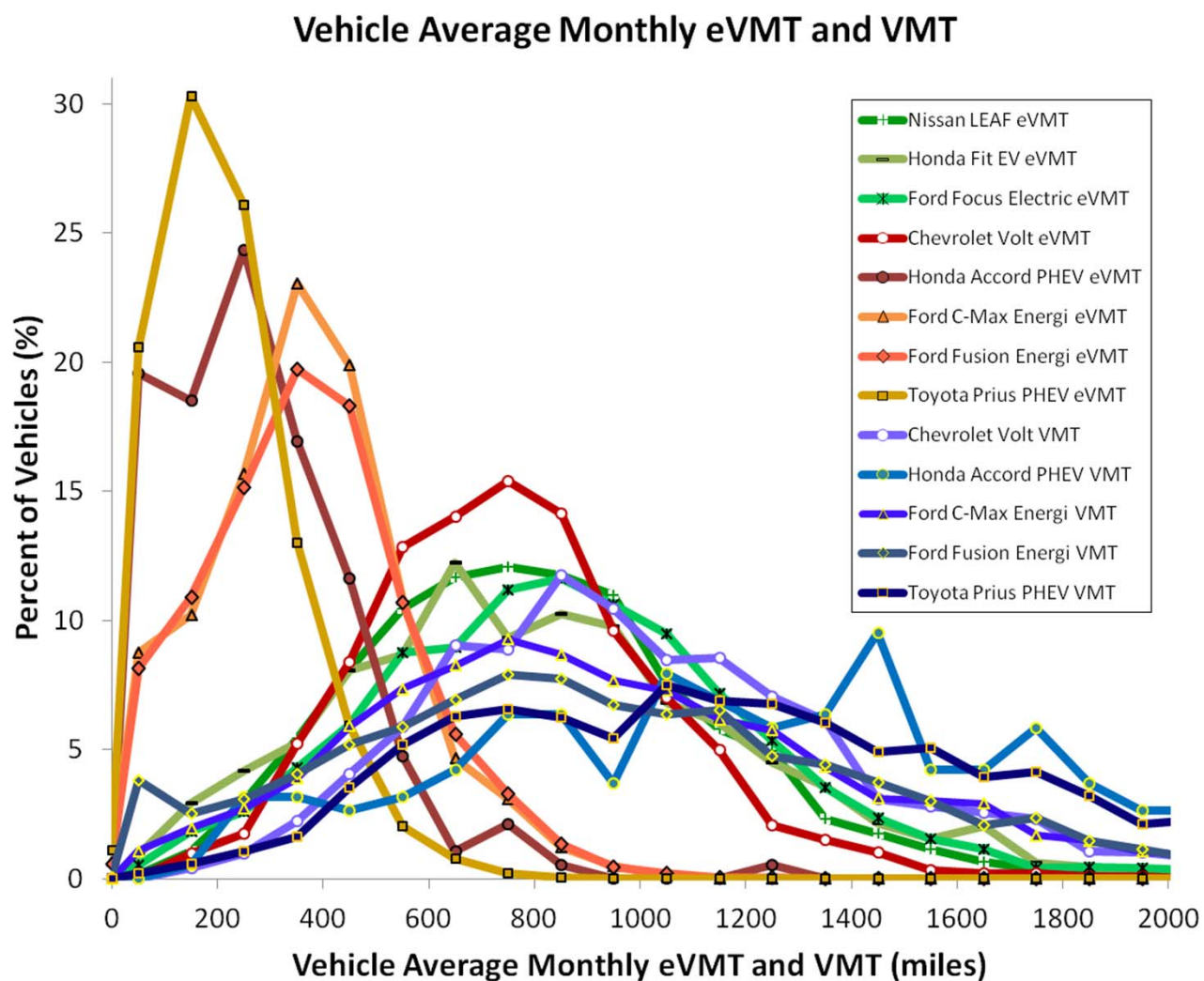
	Nissan LEAF *	Chevrolet Volt *	Ford Focus Electric	Ford C-Max Energi	Ford Fusion Energi	Honda Fit EV	Honda Accord PHEV	Toyota Prius PHEV
Number of Vehicles	4,039	1,867	2,193	5,368	5,803	645	189	1,523
Number of Vehicle Months	35,294	20,545	12,622	38,096	32,022	6,090	1,437	15,676
Total Vehicle Miles Traveled VMT (miles)	28,520,792	20,950,967	10,043,000	39,376,000	33,098,000	4,912,920	1,794,494	19,772,530
Total Calculated Electric Vehicle Miles Traveled eVMT (miles)	28,520,792	15,599,508	10,043,000	12,918,000	11,572,000	4,912,920	399,412	3,224,981
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
Data Format Description	Key-On / Key-Off	Key-On / Key-Off	Enhanced Key-On / Key-Off			Trip Summary		Trip Summary
Geographic Characterization	CA, OR, WA, AZ, TX, TN, GA, D.C., PA, IL	CA, OR, WA, AZ, TX, TN, GA, D.C., PA, IL	Nationwide			CA, OR, NJ, MD, CT, MA, RI, NY	CA, NY	ZEV States and other states

* <http://avt.inel.gov/pdf/EVProj/eVMTMay2014.pdf>

Minimally Charged Vehicles are Not Excluded from analysis.

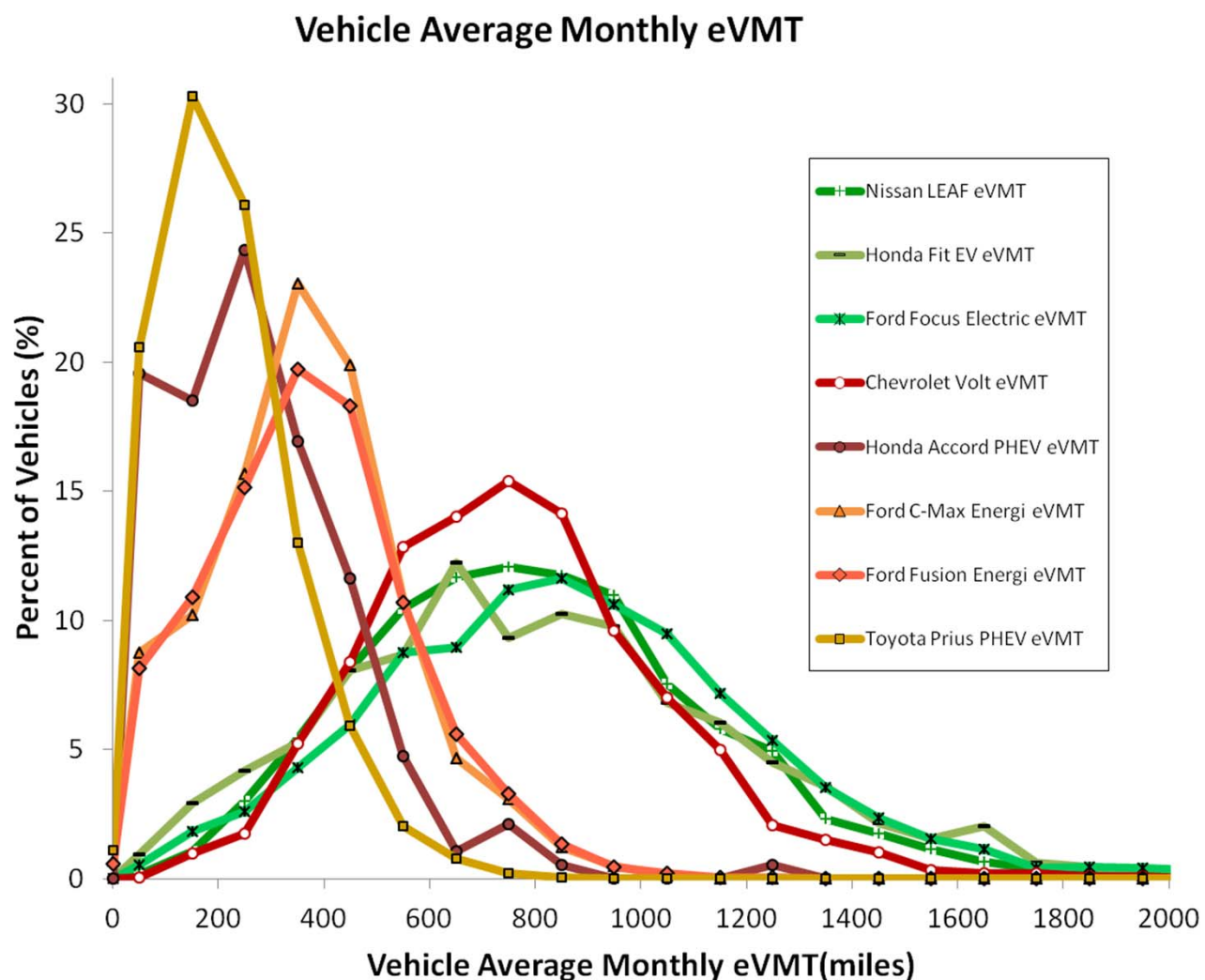
These data include 14% of Accord PHEVs that achieve between 0-50 monthly eVMT

eVMT and VMT



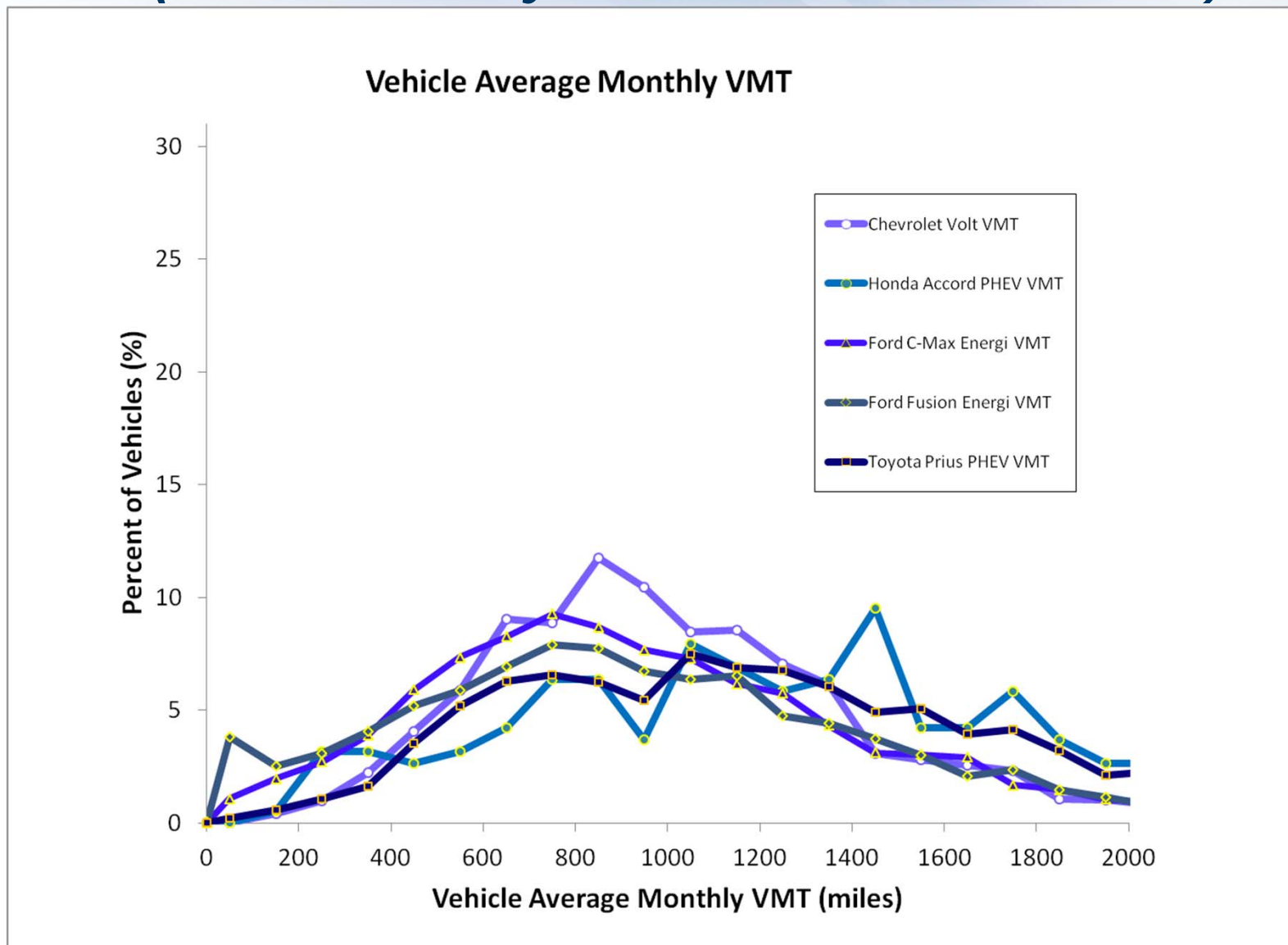
Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.

eVMT (monthly electric vehicle miles traveled)



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

VMT (total monthly vehicle miles traveled)



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>