Electric Vehicle Mile Traveled (eVMT): On-road Results and Analysis

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Overview

Idaho National Laboratory

Timeline

FY15:

- Arrange NDAs
- Obtain driving and charging data from multiple OEMs
- Conduct analysis
- Report on results

Barriers

- Lack of availability of real world data from electric drive vehicles
  - Need to quantify Electric vehicle miles traveled for plug-in hybrid electric as well as all-electric vehicles
- Lack of concise analysis method to determine eVMT of blended PHEV operation

Budget

- FY15: $ 120k

Partners

- Honda North America
- Ford Motor Company
- Toyota Motor Engineering & Manufacturing NA
- General Motors

Objective / Relevance

- Analyze real world data from eight vehicle models to determine the
  - Electric Vehicle Miles Traveled (eVMT)

- Present the findings to:
  - Automotive manufacturers
  - U.S. DOE
  - California Air Resources Board
  - Universities / Academia

- Analysis results used by California Air Resources Board for consideration of amendments to the Zero Emissions Vehicles (ZEV) credit regulations for the mid-term review in 2016

Milestones

Completed :

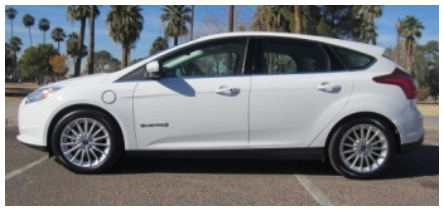
- Non disclosure agreements (NDA) signed with multiple automotive OEMs
  - necessary for data sharing of privately owned vehicles
- Data transfer from multiple OEMs
- Data was organized and loaded into SQL database
- Quality Analysis of the data was conducted
  - trip by trip data validity
  - monthly data completeness
- eVMT was calculated for BEVs and PHEVs / EREVs
  - PHEVs / EREVs: three calculation methods were compared
  - BEVs: one calculation method was used
- eVMT results were presented to California Air Resources Board

Approach:

- Data is from real customer, on-road vehicle operation
  - 158,468,000 miles from 21,600 vehicles
  - From across the U.S. (i.e. widely varying regions and climates)
- 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





Approach: Analysis Methods

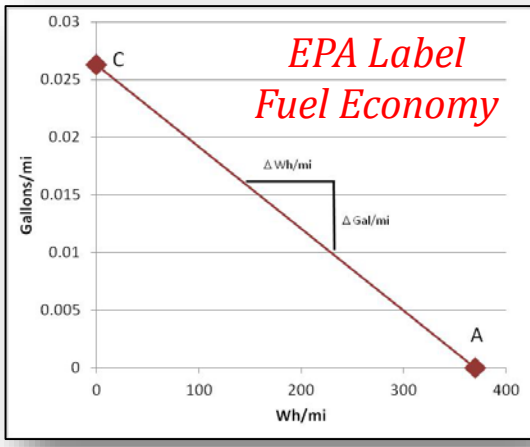
- Data completeness was calculated on monthly basis
  - Ensure minimal missing data
    - data logger error, telematics disruption, etc.
  - eVMT analysis conducted only for months with acceptable data completeness

- To align results from the differing data formats, three calculation methods were evaluated to determine eVMT from blended trips
  - 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

- Note: for All-Electric Vehicles, by definition, eVMT = total VMT

Approach: eVMT Calculation based on Label Fuel Economy

- Every trip is classified as one of the following:
  - 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”)
    - *(Δgal/mi / ΔWh/mi)*
- For EV trips: $eVMT_{EV}$ = TripLength (mi)
- For each Blended trip
  - Fuel Displaced by Electrical Energy is determined
    - *Disp_Gal = Trip Wh consumed x (Δgal/mi / ΔWh/mi)*
  - Calculated Trip $eVMT_{Blended}$
    - $eVMT_{Blended} = TripLength \times \frac{Disp\_Gal}{(Trip\_Gal + Disp\_Gal)}$
- For Charge Sustaining: $eVMT_{ChrgSustain} = 0$
- $eVMT = sum(eVMT_{EV}) + sum(eVMT_{Blended})$



Approach: 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
- For EV trips: $eVMT_{EV}$ = TripLength (mi)
- For Blended trips: $Dist_{Electrified}$ is calculated using the following:

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

  - 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.
- For Charge Sustaining: $eVMT_{ChrgSustain} = 0$

- $eVMT = sum(eVMT_{EV}) + sum(Dist_{Electrified})$

Accomplishment:

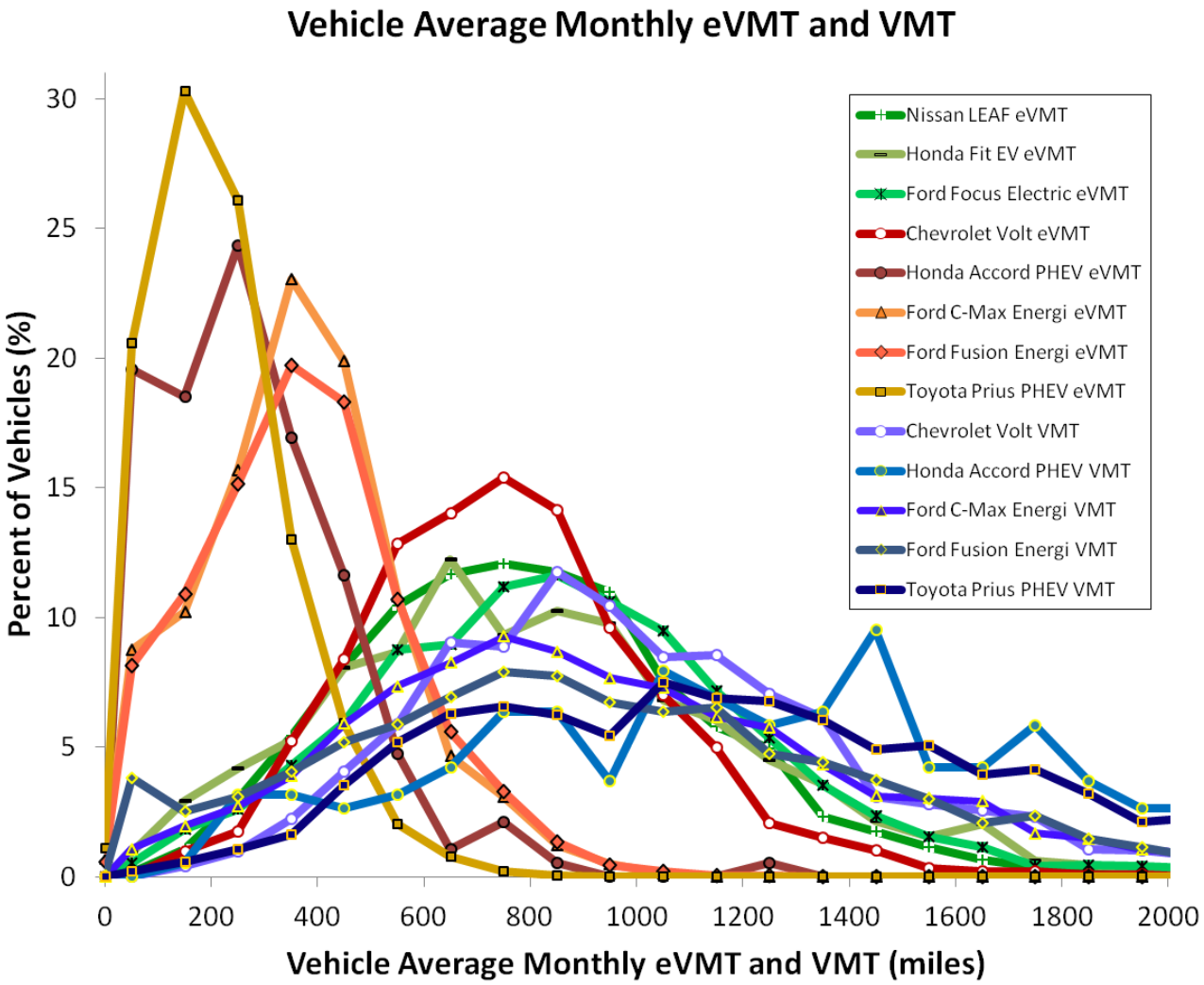
	Nissan LEAF *	Chevrolet Volt *	Ford Focus Electric	Ford C-Max Energi	Ford Fusion Energi	Honda Fit EV	Honda Accord PHEV	Toyota Prius PHEV
Number of Vehicles	4,039	1,867	2,193	5,368	5,803	645	189	1,523
Number of Vehicle Months	35,294	20,545	12,622	38,096	32,022	6,090	1,437	15,676
Total Vehicle Miles Traveled *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
Est. Annual VMT	9,697	12,238	9,548	12,403	12,403	9,680	14,986	15,136
Est. 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

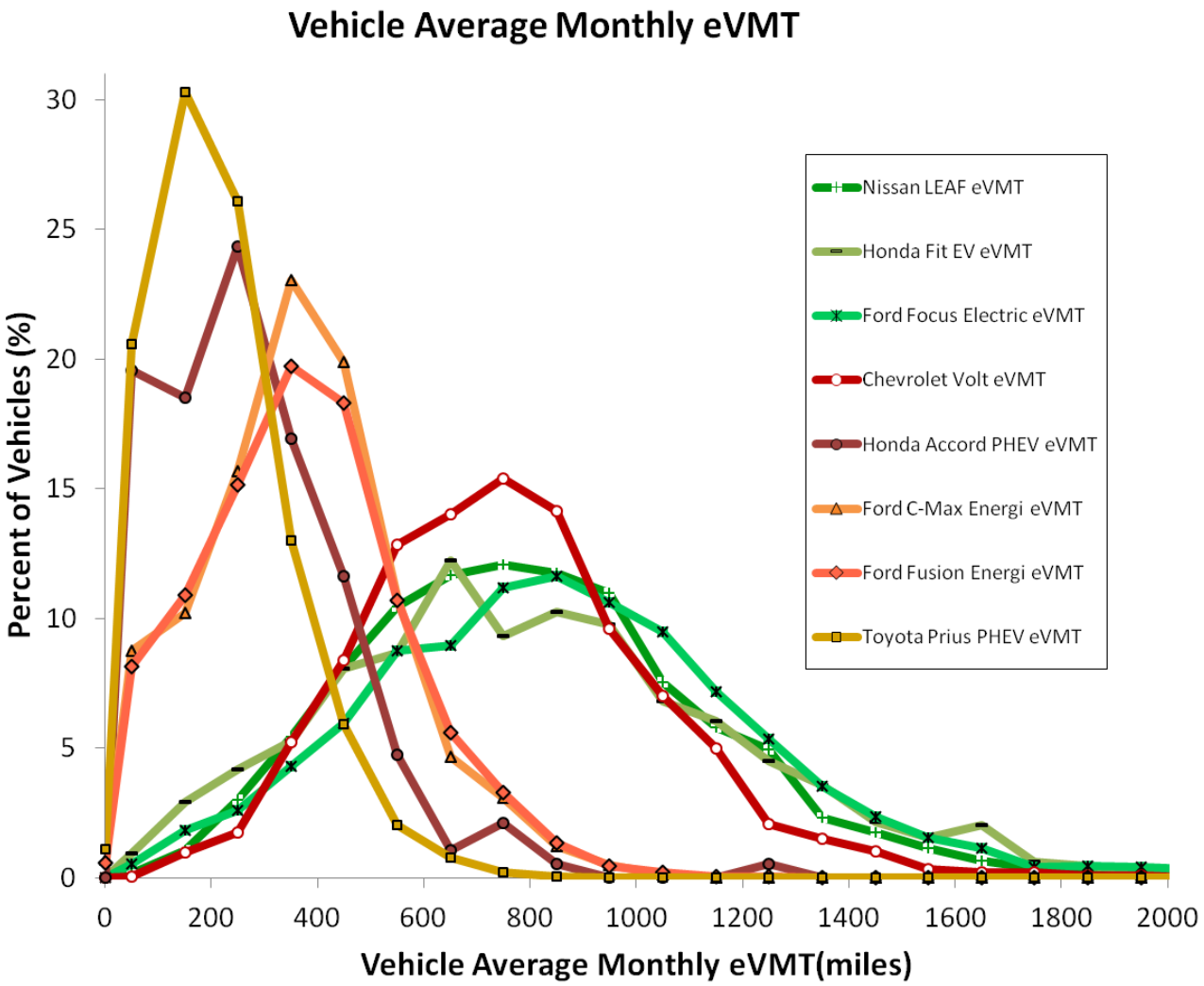
Minimally Charged Vehicles are Not Excluded from analysis.
These data include 14% of Accord PHEVs that achieve between 0-50 monthly eVMT

Accomplishment: eVMT and VMT



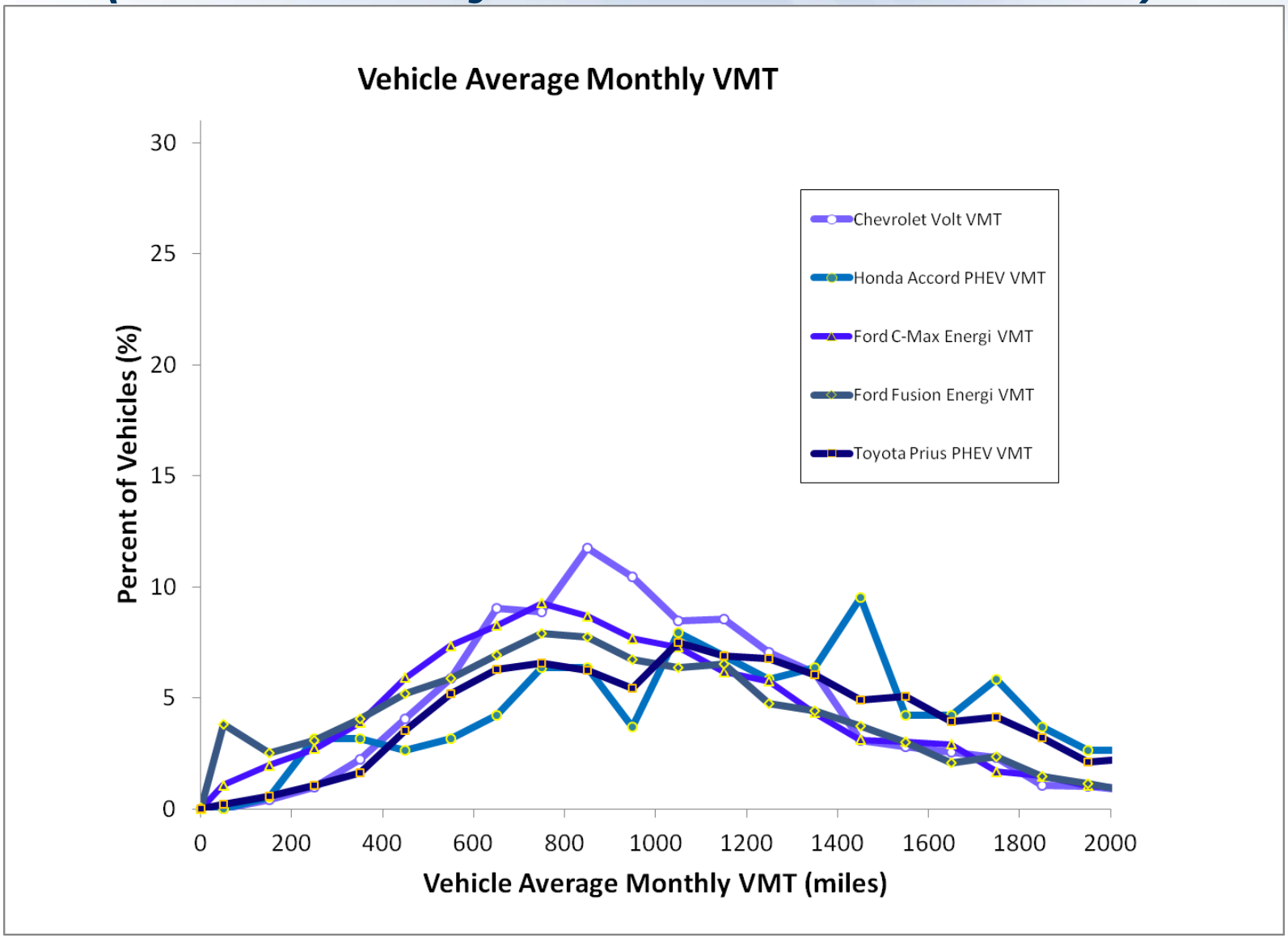
Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.

Accomplishment: eVMT (monthly electric vehicle miles traveled)



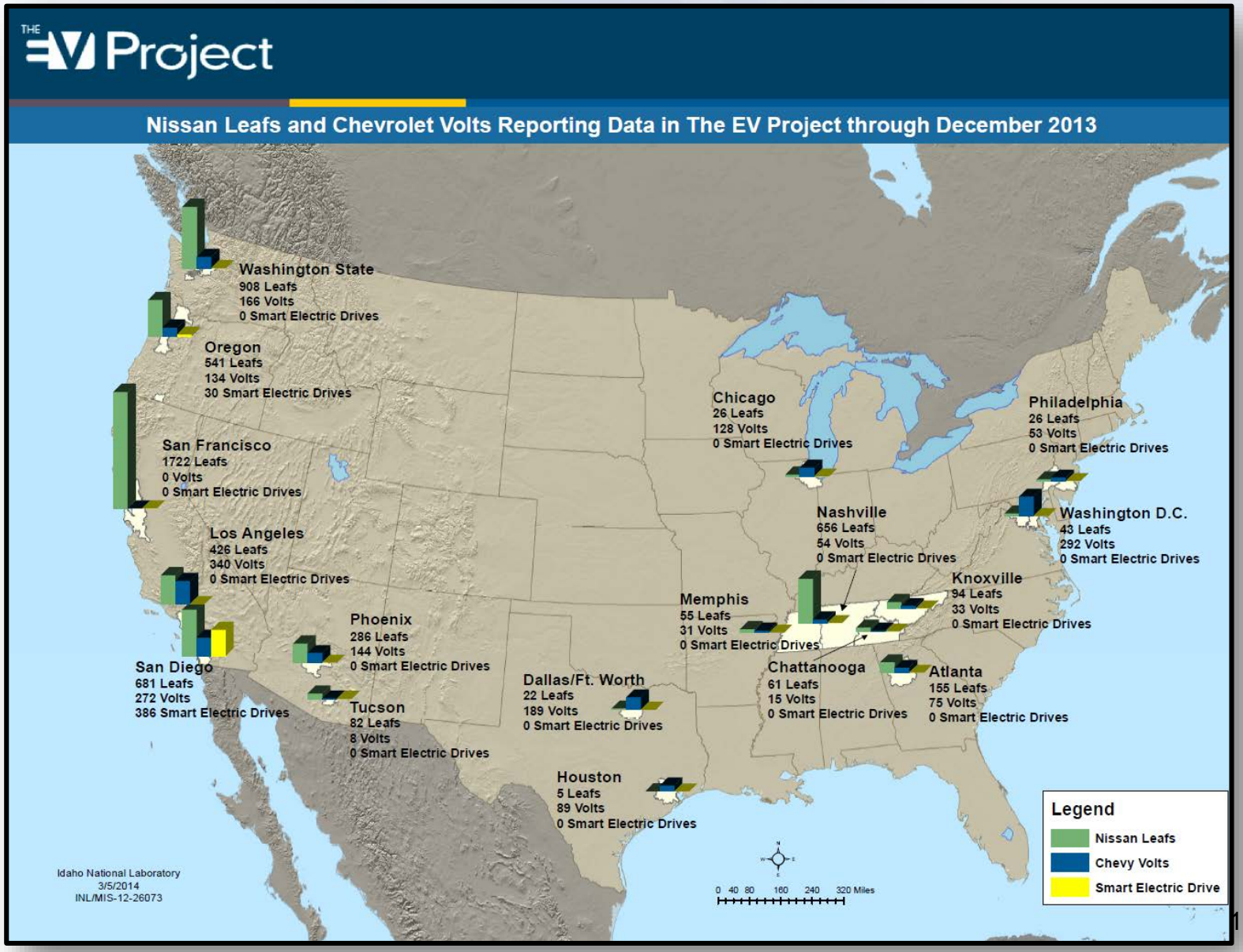
Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.

Accomplishment: VMT (total monthly vehicle miles traveled)



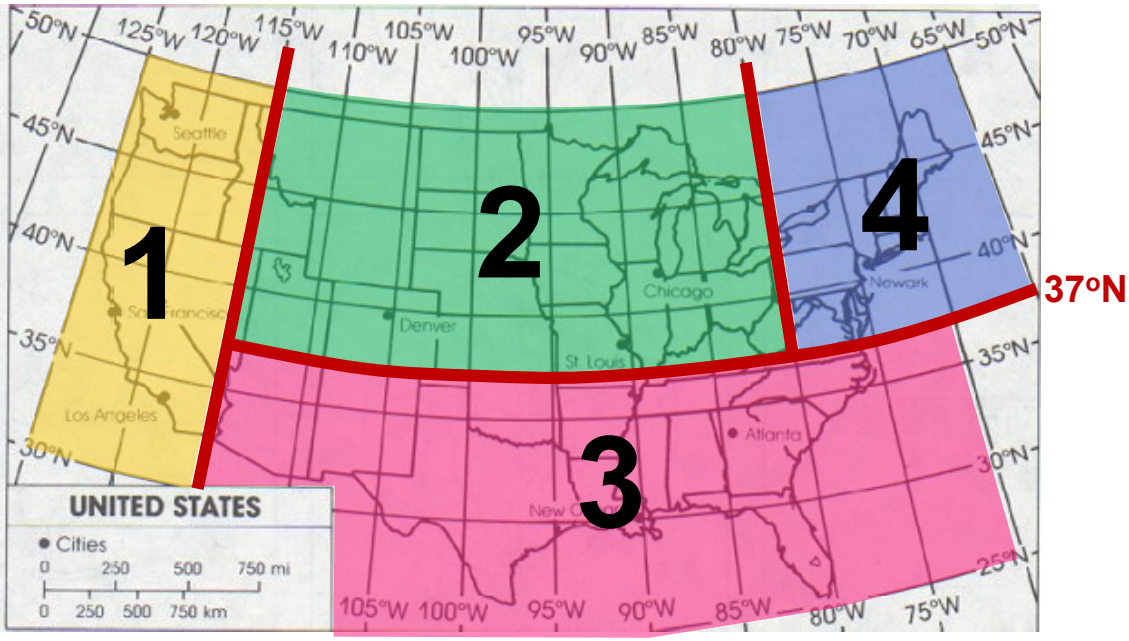
Distance Bins: =0, >0 to 100, >100 to 200, >300 to 400, >400 to 500, etc.

Accomplishment: Nissan Leafs & Chevy Volts Regional Distribution



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

# of distinct Vehicles ever 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



Response to Previous Year Reviewer Comments

- This project is New for this year

Future Work

- Analyze impact to eVMT of the following:
  - Seasonal variation (ambient temperature)
  - Regional variation
    - especially CA and New England ZEV states
  - Impact of workplace charging
    - How much does this extend or enable ZEV driving?
  - Electric vehicle miles traveled (eVMT)
    - Per charge event
    - Pre calendar day
  - Understanding of household vehicle utilization
    - i.e. when is second vehicle used in the same household
      - for trips greater than EV range?
      - other functions

Summary

- On-road data from privately owned vehicles 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
- Three eVMT calculation methods for blended operation were compared
  - eVMT calculation methods differed by < 2.5%
- For PHEVs / EREVs a correlation can be observed between eVMT and battery capacity
- Results were presented to California Air Resources Board at Oct 2014 board meeting with respect to Zero Emissions Vehicles (ZEV) credit regulations prior to the mid-term review

Acknowledgement

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More Information

http://avt.inl.gov