

BEV Consumer Household Travel Behavior Decisions in Practice: Comparison of BEV Usage to ICE Usage in Multi-Vehicle Household

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of the Institute of Transportation Studies



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of the Institute of Transportation Studies



2017 marks 10 years of the Plug-In Hybrid & Electric Vehicle Research Center

Dr. Tom Turrentine, Director
Dahlia Garas, Program Director
Dr. Gil Tal, Research Director



PH&EV Center 2017

Researchers

Dr. Tom Turrentine, World Market, supply and demand

Dr. Gil Tal, PEV Markets, Travel Behavior

Dr. Ken Kurani, Consumer Studies

Dr. Alan Jenn, PEV Regulations and Market Models

Dr. Angela Sanguinetti, Energy Feedback Systems

Dr. Chris Nitta, Professor of Computer Science

Postdoctoral Researchers

Dr. Scott Hardman, Global Policy, Consumer adoption

Dr. Jaehyun Lee, GIS and travel data analysis

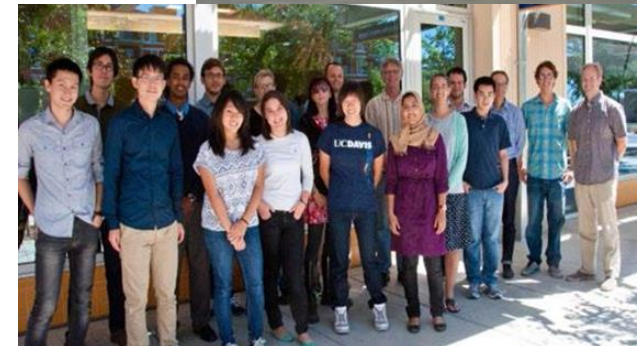
Dr. Yan Xing, China and PH&EV Centers

5 Research Staff, programmers, visiting scholars

9 Graduate Students

15 Undergraduate Students

161 publications, 29 papers in 2016, 31 under review



2015-17 SUPPORTERS



U.S. DEPARTMENT OF
ENERGY



PH&EV Center Data Collection



24,000 New car Buyers surveys

- 2010-2017
- 12 US states
- Focus groups
- Interviews



27,000 Electric car buyer surveys

- 2010-2017
- 12 US states, China, Germany
- Used PEV buyers
- Focus groups and Interviews



PEV and ICE on road data collection

- OBD data 264+ vehicles over a year
- GPS data 54,000 vehicles over 2.5 years (4 OEMs)
- 4,000 Vehicles second by second dataset for California



US Infrastructure Charging data 2012-2017

- 9,000,000 Level 2 charging events
- 1,700,000 DC fast charging events
- Vehicle reported charging events

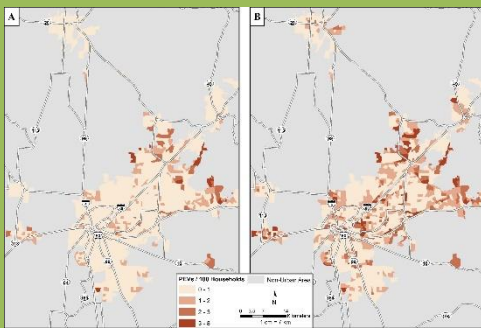
PEV Travel & Charging Behavior (eVMT) project

- Led by Dr. Gil Tal, and previously Mike Nicholas.
- Funded by CARB, CEC, US DOE
- This project is fully underway with a complete two years of data on the first 144 households. Will include 348 households by 2017
- Current project will include PHEV's, BEVs, and BEVx models in households throughout California.
- Models include: Toyota Prius Plug-In, Nissan Leaf, Chevrolet Volt (Ampere), Ford C-max and Fusion Energi models, Tesla Model S, BMW i3-Rex. Could potentially expand to include Fuel Cell models.

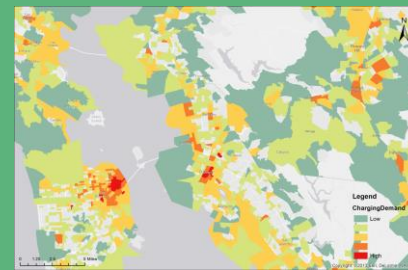


EV Infrastructure planning toolbox: CEC Grant 2010-2014

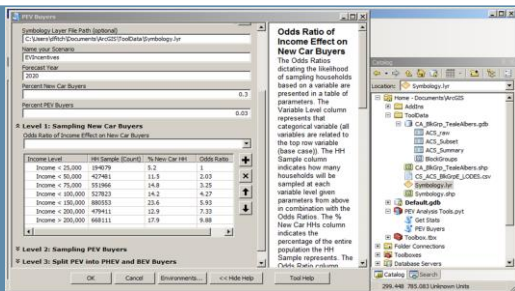
Market Forecast Using
Census Data



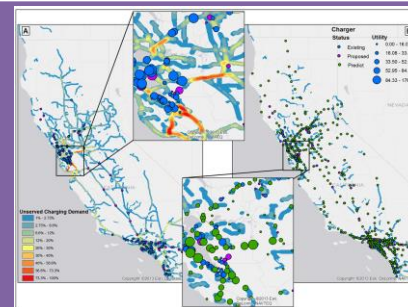
Work Charging Based on
Market Scenario



EV Planning Toolbox

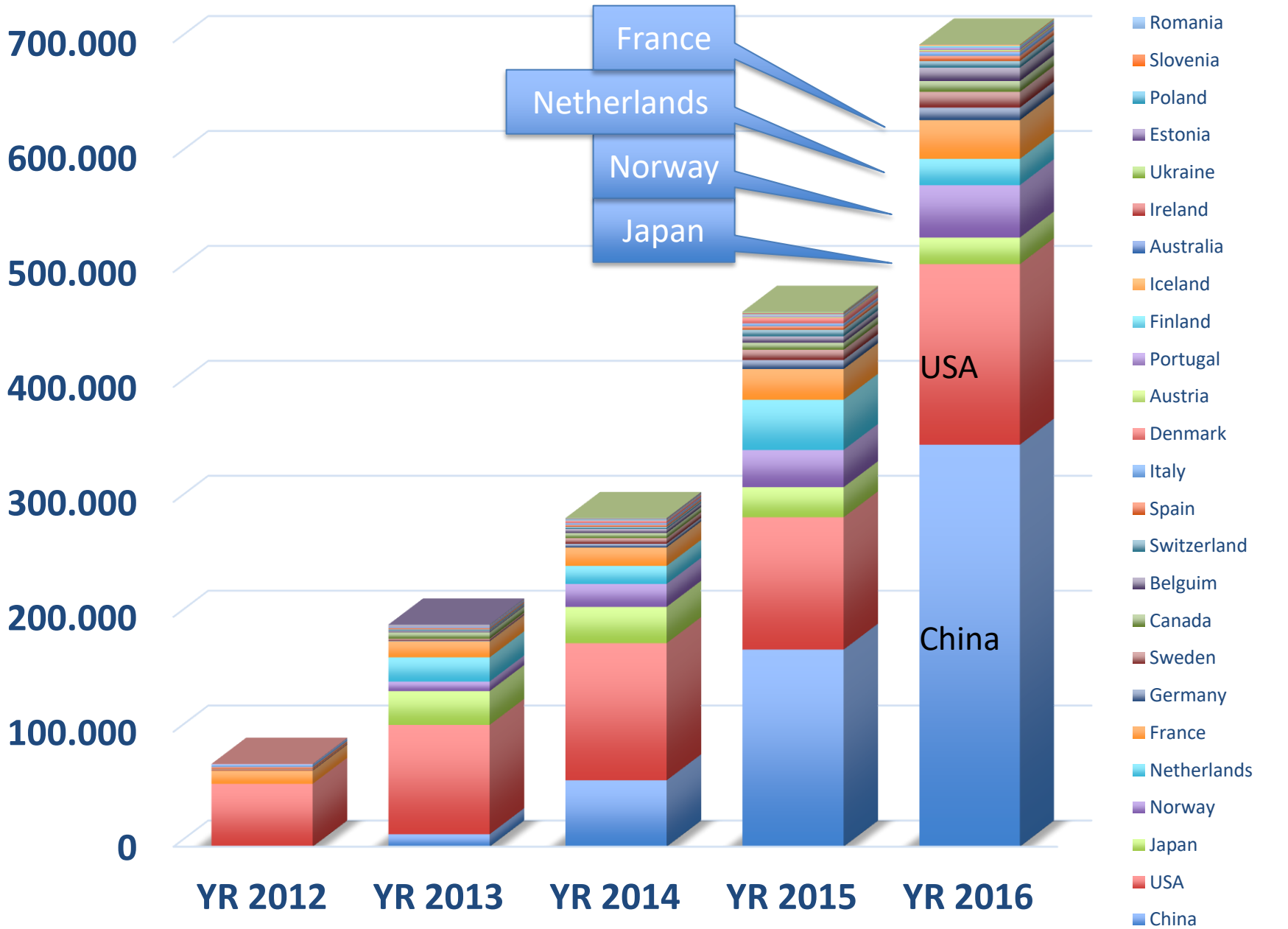


ArcGIS Interface Allows You
To Make Your Own
Scenarios



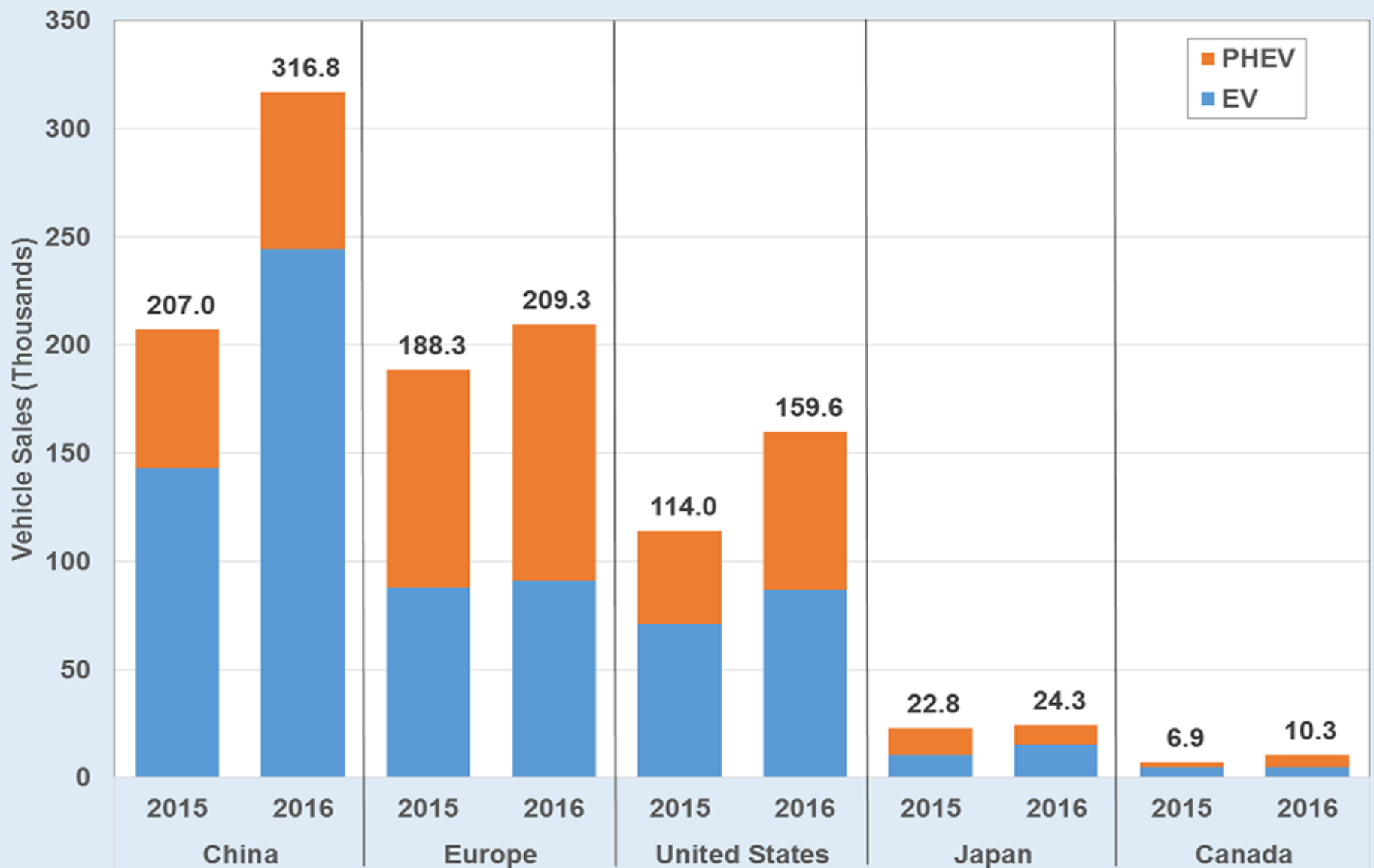
Fast Charging - Estimates
Take into Account Existing
Chargers

Global PEV Sales by Country



There was 37% growth worldwide in 2016.

Plug-in Vehicle Sales by Vehicle Type



BEV 80 HOUSEHOLDS VS ICEV HOUSEHOLDS

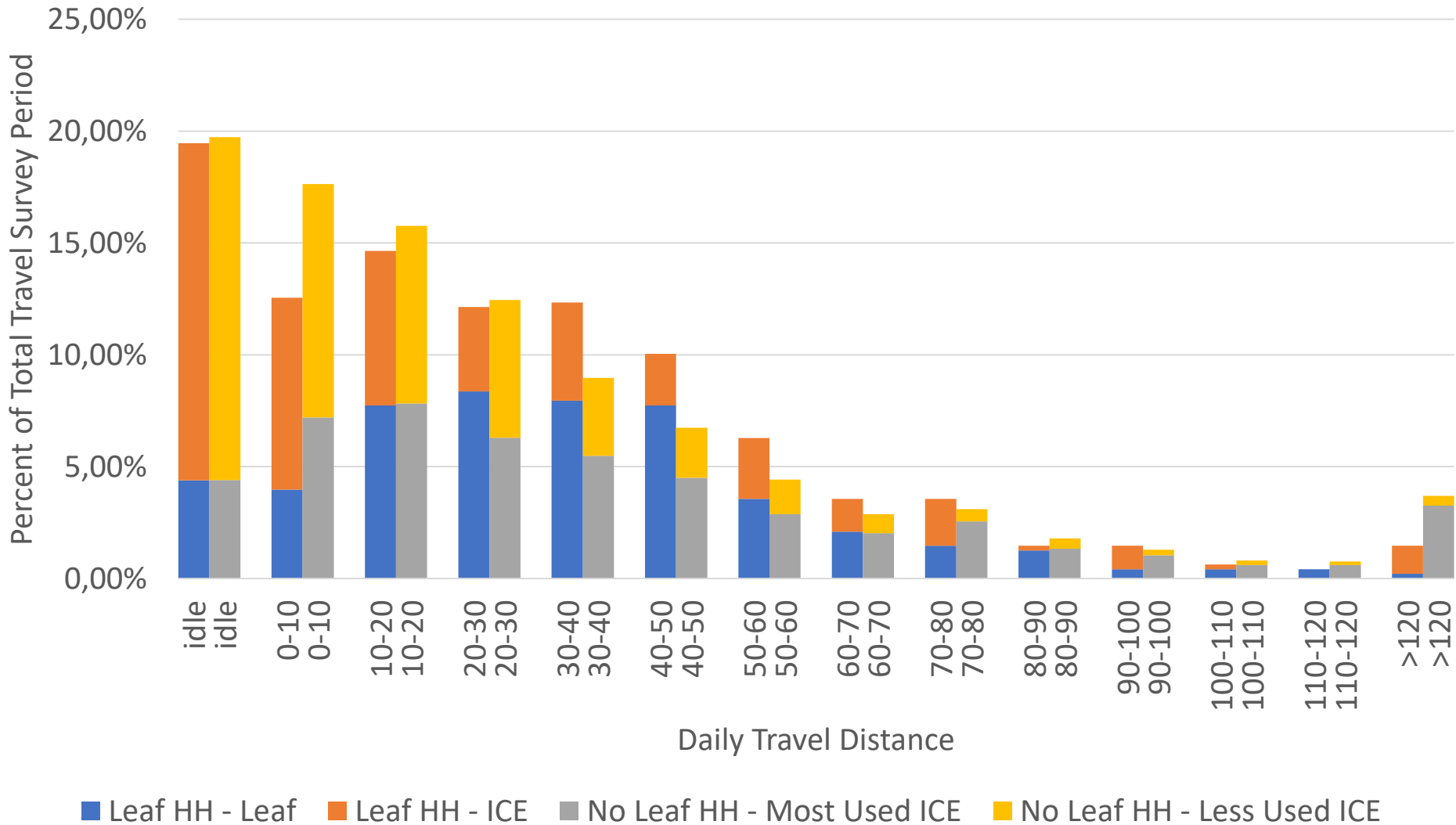
40 LEAF and ICEV households

40 2 ICEVs households

Day-based Comparison of Driving Behavior of household owning or not owning Leaf

	Leaf HH		Non-Leaf HH	
	ICE	Leaf	Most Used ICE	Less Used ICE
Avg. Daily Travel Time (min)	66.4	70.7	82.2	52.0
Max. Daily Travel Time (min)	289.8	173.8	790.4	358.9
Avg. Travel Time Per Tour (min)	38.7	43.7	48.5	32.7
Max. Travel Time per tour (min)	281.0	173.8	789.2	357.6
Avg. Daily Travel Distance (mile)	35.2	37.5	48.2	25.8
Max. Daily travel Distance (mile)	255.0	123.3	851.6	215.3
Avg. Travel Distance per tour (mile)	21.5	22.7	28.4	16.2
Max. Travel Distance per tour (mile)	249.4	123.3	851.5	215.3
Avg. Speed (mph)	28.8	29.9	30.8	26.7
Weighted avg. speed (mph)	24.8	26.8	27.1	24.3
Max. Speed (mph)	89.5	88.4	103.9	107.7

Daily Travel Distance and Vehicle Usage Comparison



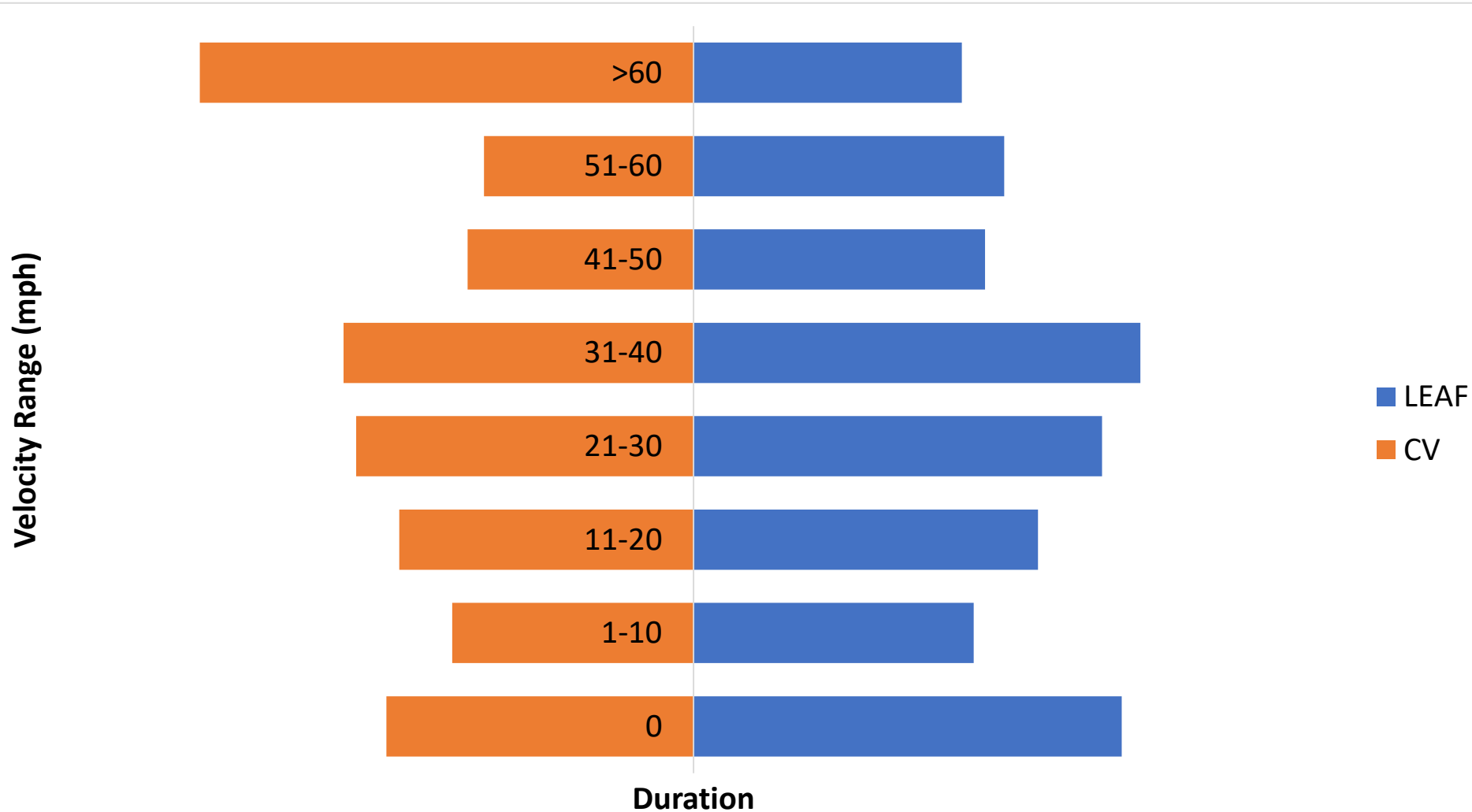
BEV 80 Households LEAF to ICEV Comparison

40 LEAF and ICEV households

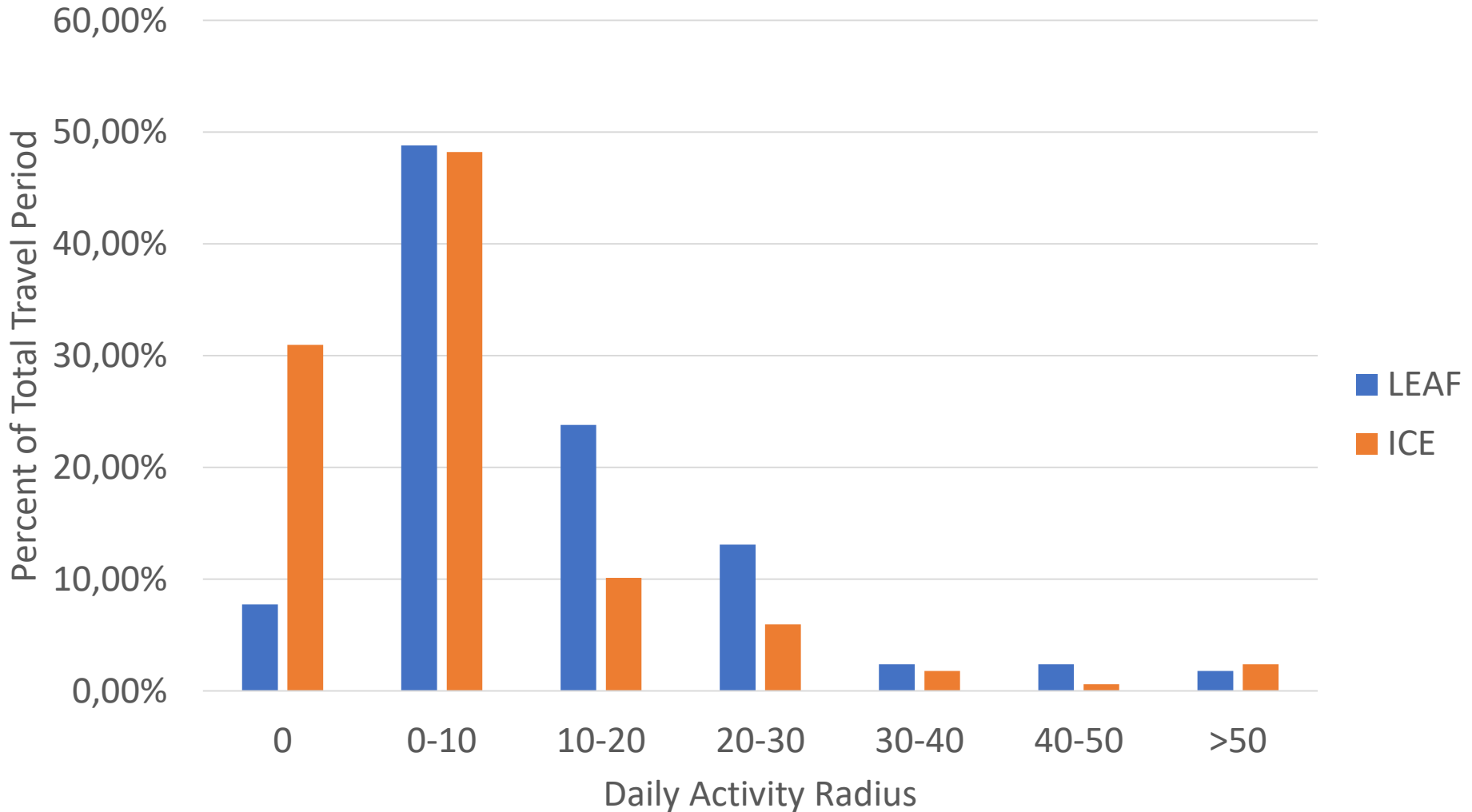
Comparison of travel radius distribution of Leafs vs. ICE vehicles belonging to the same households

		Travel Radius (mile)		Daily Travel Distance (mile)	
		ICE Vehicles	Leaf	ICE Vehicles	Leaf
Quartile	100%	94.48	78.54	254.98	123.29
	90%	22.16	25.06	77.97	70.30
	75%	8.33	16.51	47.38	49.39
	50%	3.20	7.70	22.65	32.90
	25%	0.00	3.66	9.48	18.85
	0%	0.00	0.00	0.00	0.00
	Mean	7.71	11.87	35.15	37.51
	Std. Dev	14.65	12.24	41.21	25.18
	Std. Err Mean	1.13	0.94	3.83	2.02
	Upper 95% Mean	9.94	13.74	42.73	41.51
Lower 95% Mean	5.48	10.01	27.57	33.52	

Distribution of Travel Duration at Different Velocity



Distribution of Daily Activity Radius

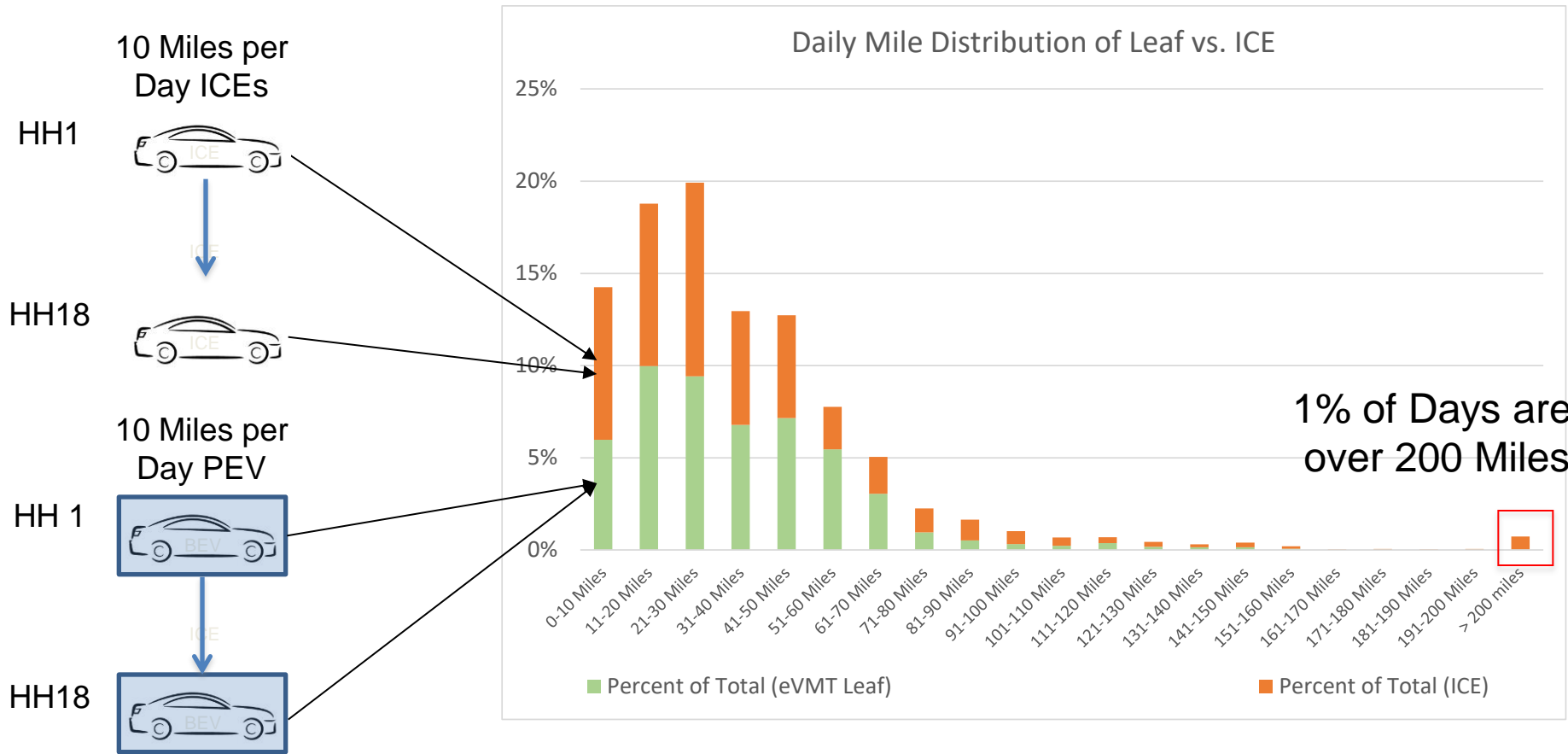


Leaf Usage Optimization Results

	Avg. Daily Travel Distance (mile)		Total Travel Distance (mile)	
	Leaf	ICE Vehicle	Leaf	ICE Vehicle
Original	37	35	8029	6157
Case 1	40	32	8801	5385
Case 2	38	33	8376	5810
Case 3	41	31	9137	5049
Case 4	41	31	9132	5054

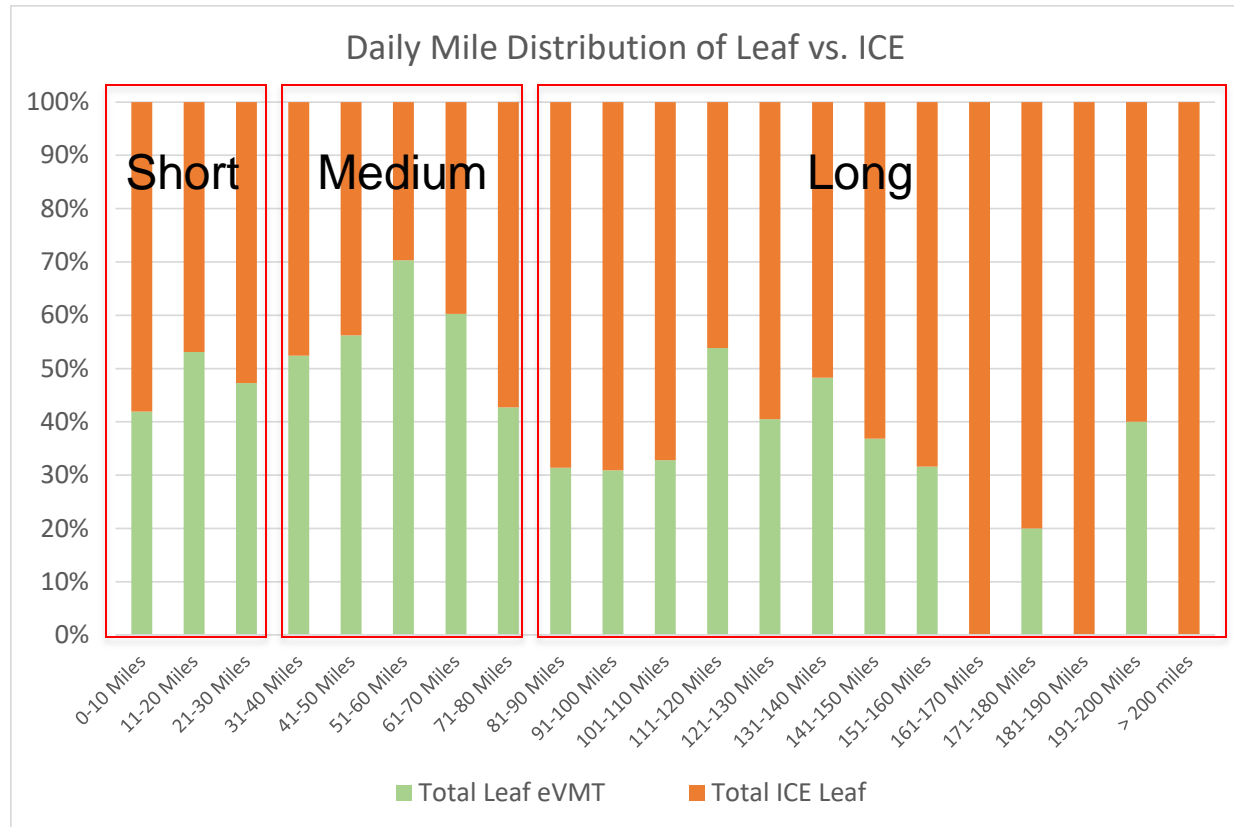
Leaf Households can (maybe) improve Household eVMT from 56% to 64%

Long Distance Travel Makes Up Only a Small Part of Travel



Daily Miles Travel of LEAFs Vs ICE (18 HH over one year)

- Short – Indifference between ICE and BEV
- Medium – Preference for BEV within one way range
- Long – Mixed within 2 way range



Source: eVMT Study in-Use Data

Leaflets Appear to Have a “Leash”: One Way Distance of Battery



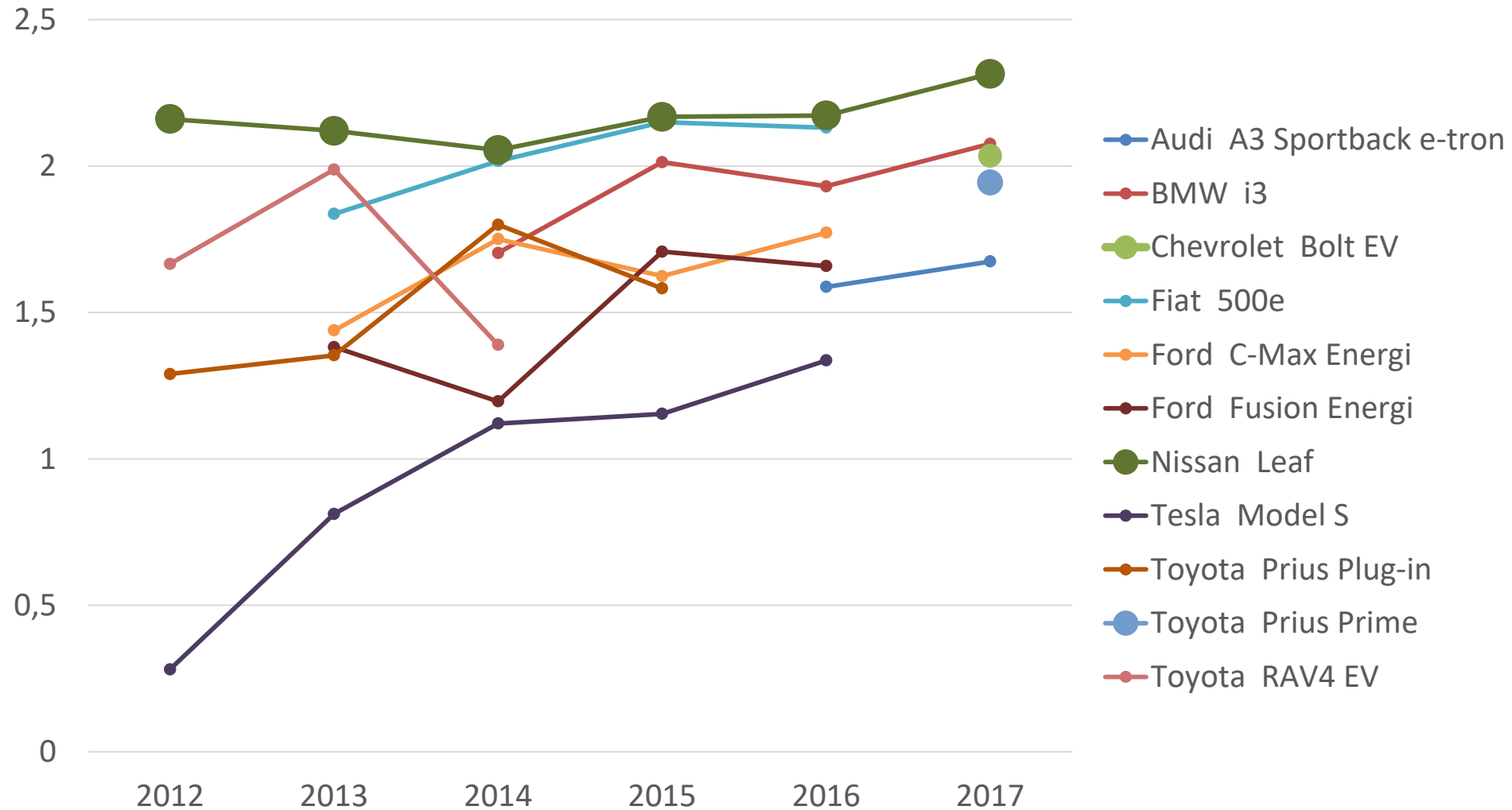
BEV MARKET

PURCHASE PREFERENCE AND INCENTIVES

The Impact of \$1000 per vehicle Federal Tax Credit (Actual Incentive \$2,500-\$7,500)

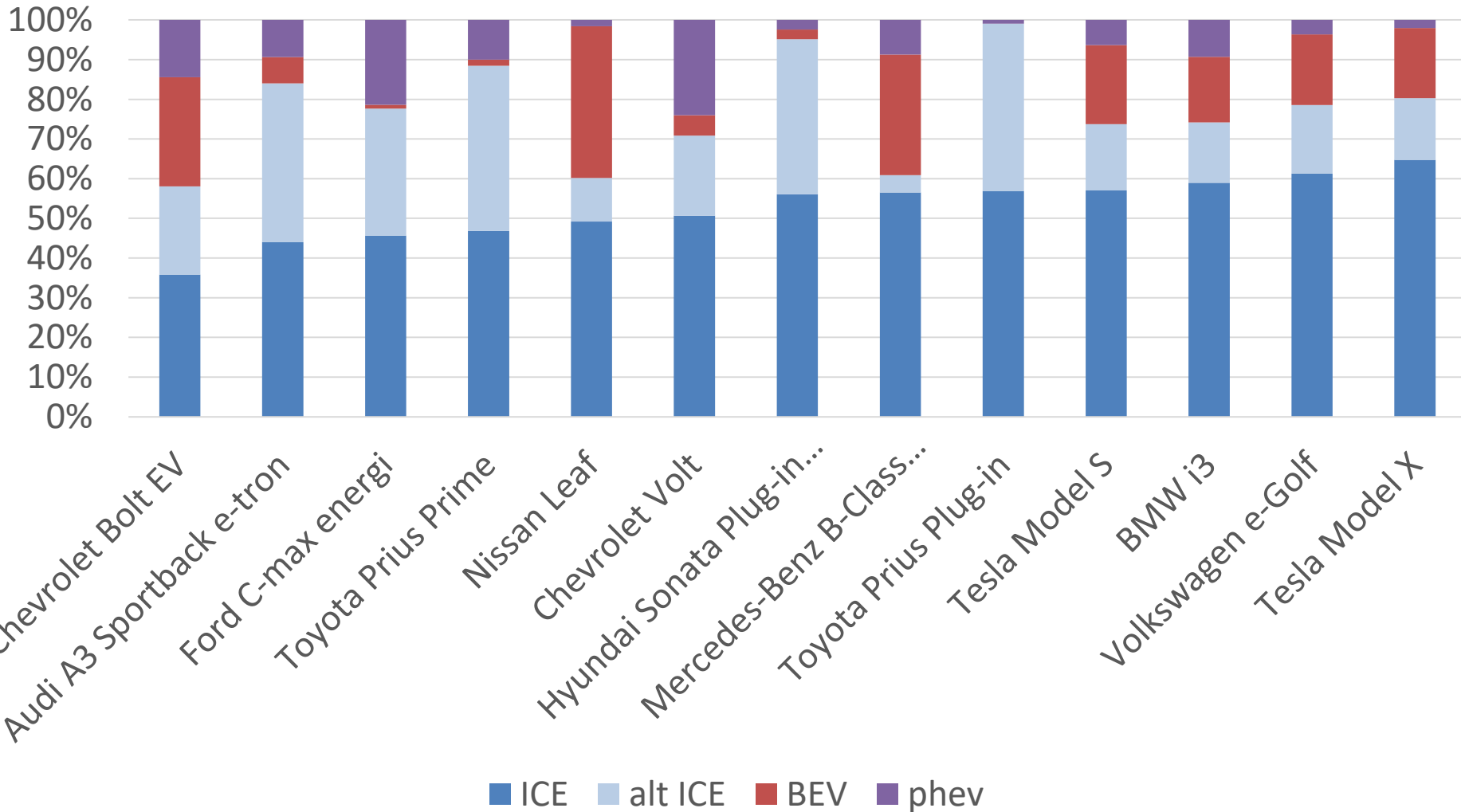
	What is the Impact of \$1000 per vehicle Federal Incentive?		
	Additional PEV sales	Battery Capacity (kWh)	eVMT per year (miles)
NISSAN LEAF	0.068	1.6	658
FORD C-MAX ENERGI	0.062	0.5	252
TOYOTA PRIUS PLUG-IN	0.061	0.3	152
CHEVROLET VOLT	0.057	1.0	517
FORD FUSION ENERGI	0.047	0.4	204
TESLA MODEL S	0.019	1.6	240

How important are state incentives?

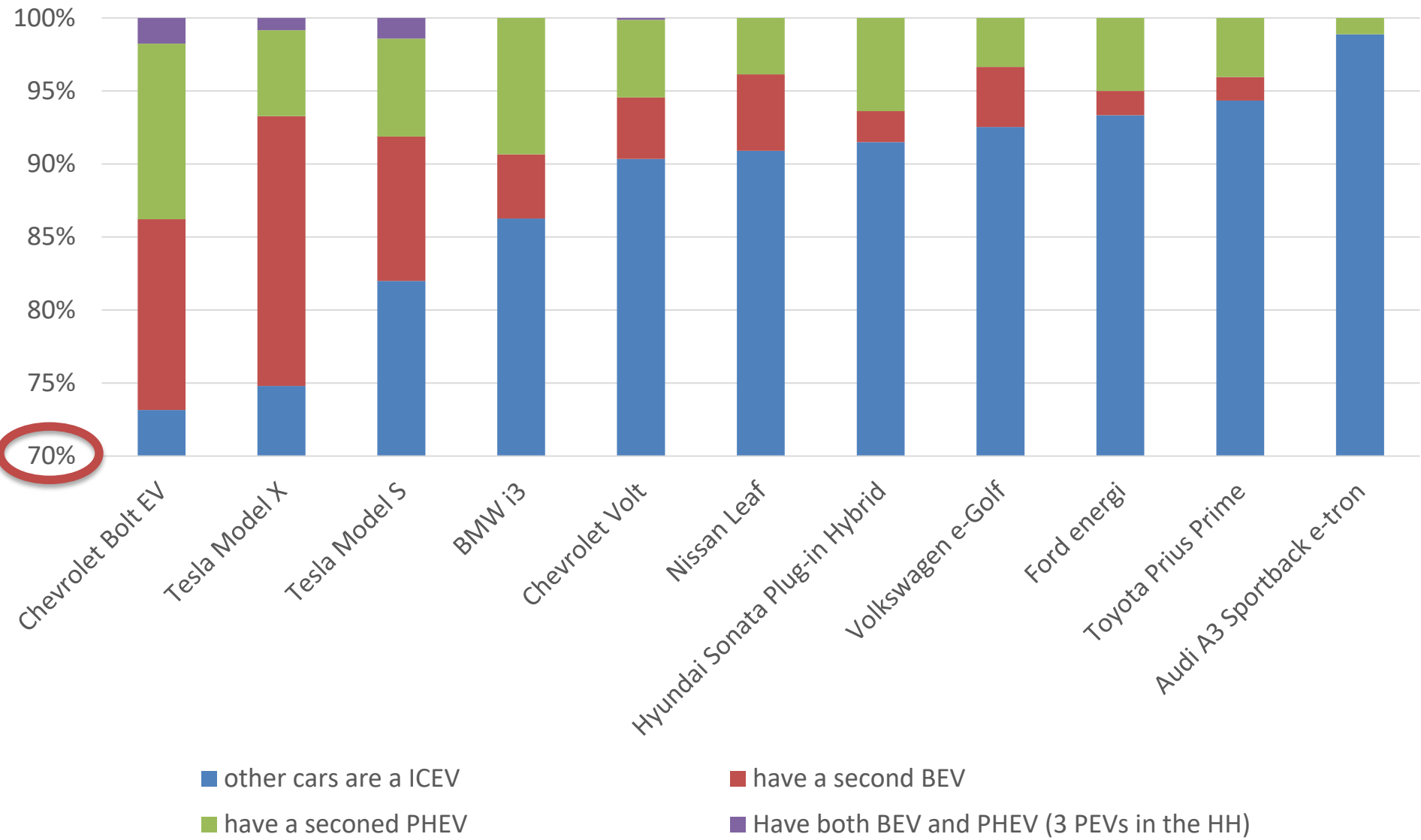


Vehicle Replaced by PEV

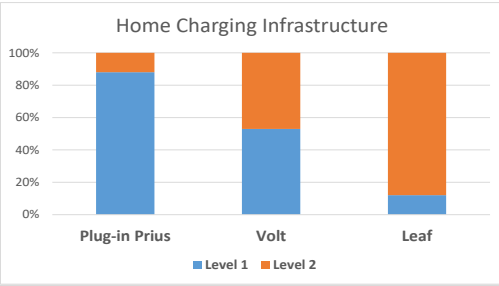
2015-2017



Other Vehicles in the Household

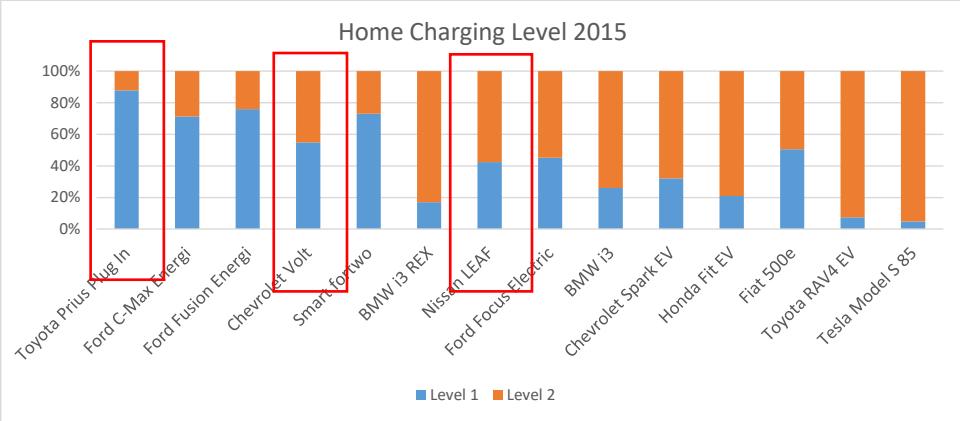


Home Charging 2013-2017



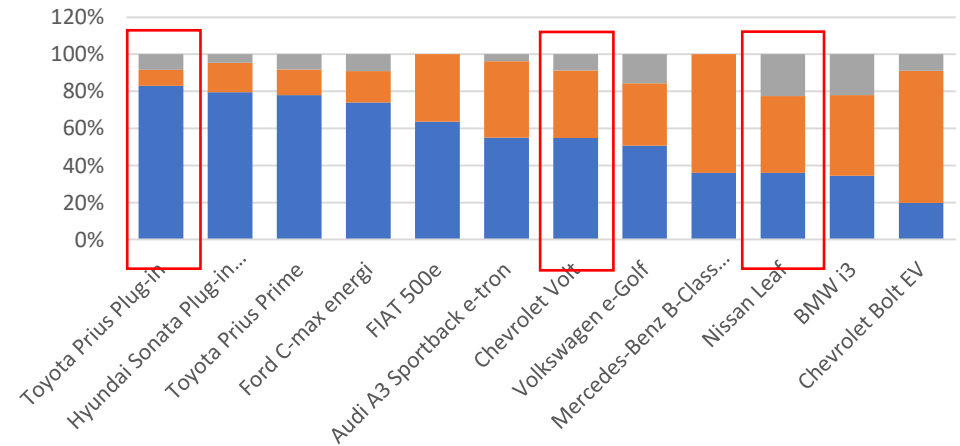
2013 Survey

Nissan LEAF Level 2 home Charging 86%



2015 Survey

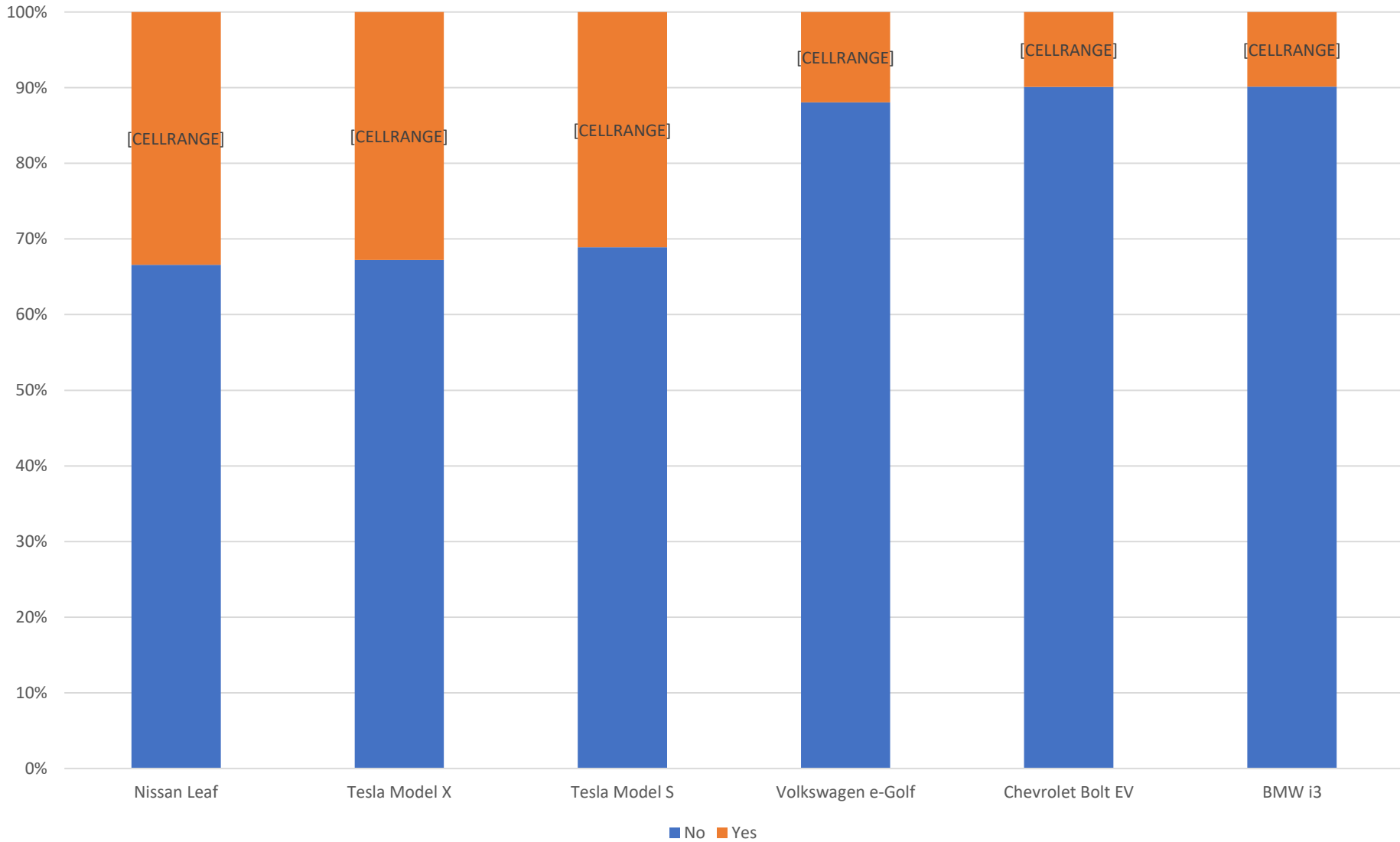
Nissan LEAF Level 2 home Charging 60%



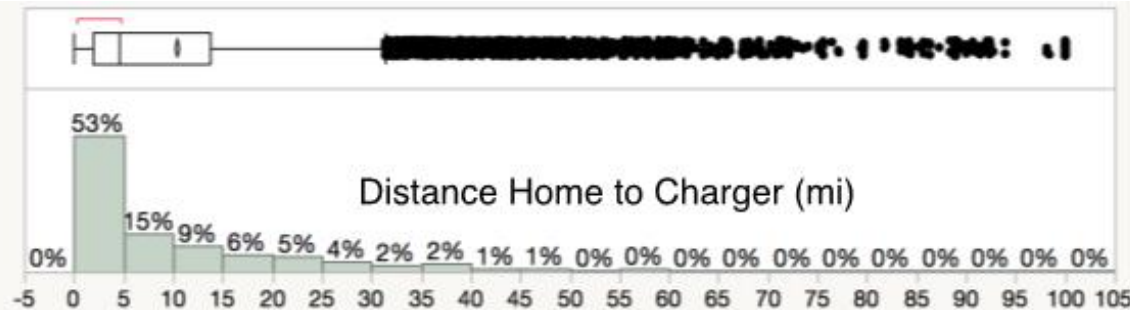
2017 Survey

Nissan LEAF Level 2 home Charging 42%

Who is using DC Fast?

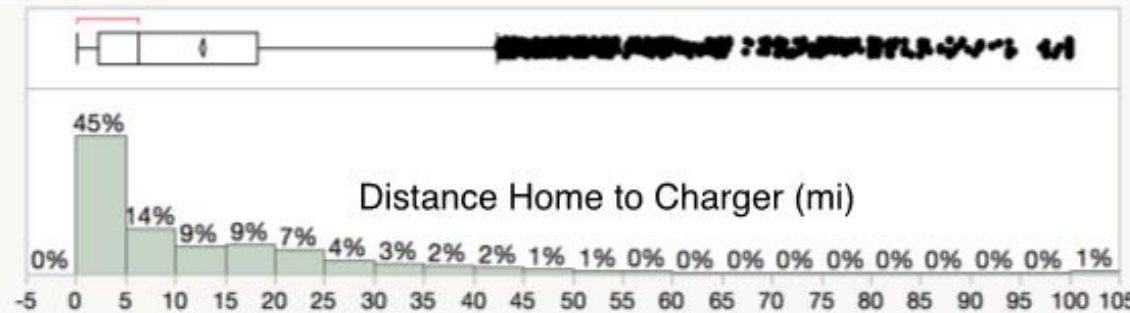


Comparison of free-prepaid and paid charging for the BEV80 Nissan Leaf and the BEV200+ Chevrolet Bolt



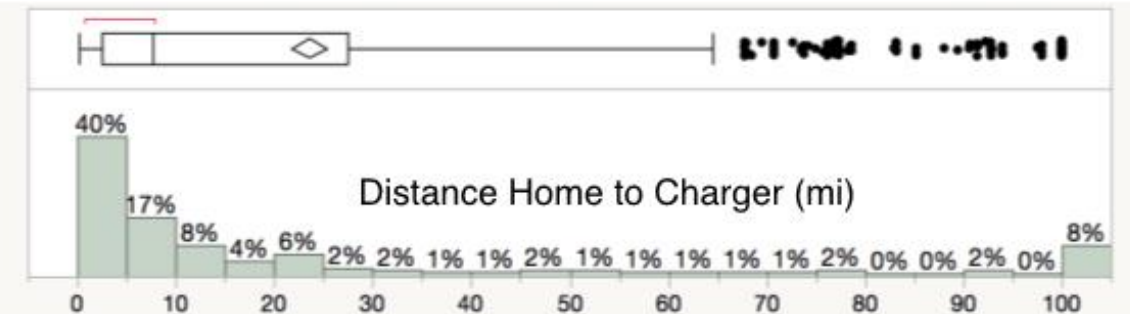
Quantiles		Summary Statistics		
100.0%	maximum	100	Mean	10.371438
99.5%		88.93386476	Std Dev	13.904554
97.5%		46.3848667	Std Err Mean	0.0884761
90.0%		27.31054511	Upper 95% Mean	10.544856
75.0%	quartile	13.69021586	Lower 95% Mean	10.198019
50.0%	median	4.549218743	N	24698
25.0%	quartile	1.8783327		
10.0%		0.895947791		
2.5%		0.428089318		
0.5%		0.110198598		
0.0%	minimum	0		

Nissan Leaf 24kWh
Free-Prepaid Charging



Quantiles		Summary Statistics		
100.0%	maximum	100	Mean	12.726319
99.5%		100	Std Dev	15.852251
97.5%		54.08354755	Std Err Mean	0.1258631
90.0%		31.22237444	Upper 95% Mean	12.973025
75.0%	quartile	18.31553927	Lower 95% Mean	12.479613
50.0%	median	6.183704148	N	15863
25.0%	quartile	2.302309716		
10.0%		0.80850276		
2.5%		0.354319314		
0.5%		0.121123892		
0.0%	minimum	0.051639793		

Nissan Leaf 24kWh
Paid Charging
10-20 cents per min



Quantiles		Summary Statistics		
100.0%	maximum	100	Mean	23.468792
99.5%		100	Std Dev	31.884689
97.5%		100	Std Err Mean	0.9095074
90.0%		91.50674441	Upper 95% Mean	25.253152
75.0%	quartile	27.45581963	Lower 95% Mean	21.684431
50.0%	median	7.685912084	N	1229
25.0%	quartile	2.410203146		
10.0%		1.277362008		
2.5%		0.693749586		
0.5%		0.095352576		
0.0%	minimum	0.095352576		

Chevrolet Bolt
Paid Charging
10-20 cents per min

BEVs 80 and the future of the PEV market? (US perspective)

- BEV with 80 mile range are not desirable for most users.
- Can be great for self selection households
- Usage patterns suggest that EV range is not the only factor when selecting what car to drive
- BEV 80 data may not be the best of TOC analysis or market modeling

- What is the right range?

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Thank you

