In the Slow Lane: ZEV Markets in California, June 2014 to June 2017

STEPs Symposium

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8 December 2017

Brief summary of data sources

Pre-2014

- 1990s: BEV, PHEVs: Ride-n-drive clinics, focus groups, surveys
- Early 2000s: FCEVs, HEVs: Interviews, field tests
- Late 2000s: PHEVs, BEVs: Surveys, field tests, interviews

2014-15

- All-CA car-owning households: June; November: Surveys n ~ 1,700 each
- CA and twelve other states new-car buyers: Dec. '14 to March '15: Survey CA n~1,700 (total n ~5,500); Post-survey interviews CA n = 36 (total n ~ 70)

2017

- All-CA car-owning households: February, June: Surveys, n ~ 1,700
- Buyers of ICEV/HEV/PEV variants: Winter '17: Interviews, n = 24
- PEV buyers: Spring '17: Interviews, n = 24

?

Have car-owning households in California considered BEVs?

"Battery electric vehicles (BEVs) run only on electricity; they plug-in to charge their batteries. Have you considered buying a BEV for your household?

- ❑ I have not—and would not—consider buying a vehicle that runs on electricity
- ❑ I have not considered buying a vehicle that runs on electricity—but maybe some day will
- ❑ The idea has occurred, but no real steps have been taken to shop for one
- ❑ Started to gather some information, but haven't really gotten serious yet
- ❑ Shopped for an electric vehicle, including a visit to at least one dealership to test drive
- ❑ I already have, or have had, a vehicle powered by electricity"

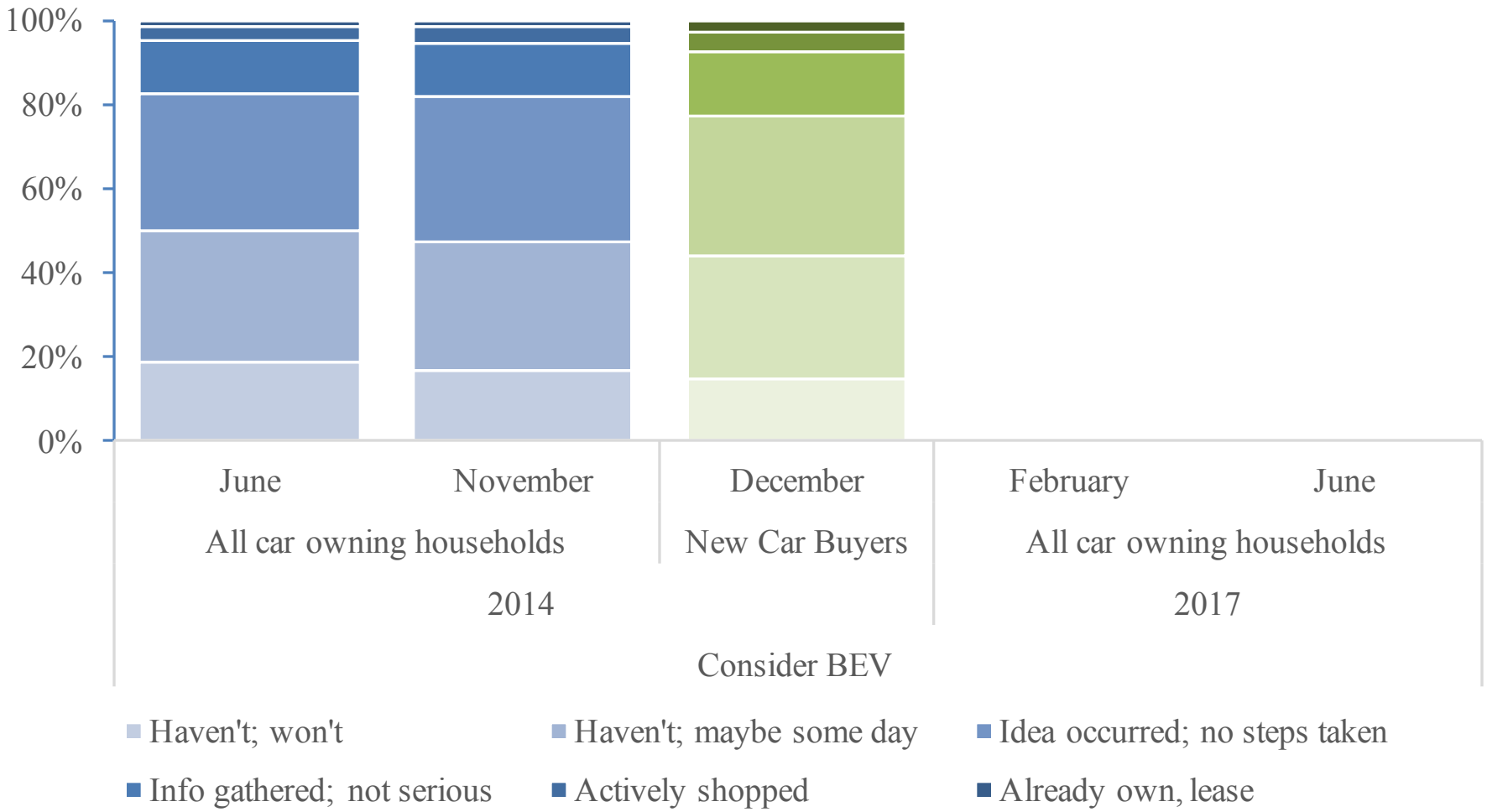
- ➢ Starting February 2017 similar questions were added for PHEVs and FCEVs.
- ➢ Starting June 2017 the last answer was changed to include the possibility they previously had a PEV or FCEV, but no longer did.

PEV sales in California

- September 2014
  - ~ **106,000**

    http://www.pevcollaborative.org/sites/all/themes/pev/files/CPEV_annual_report_web.pdf

Have car-owning and new car buying households in California considered BEVs?



PEV sales in California

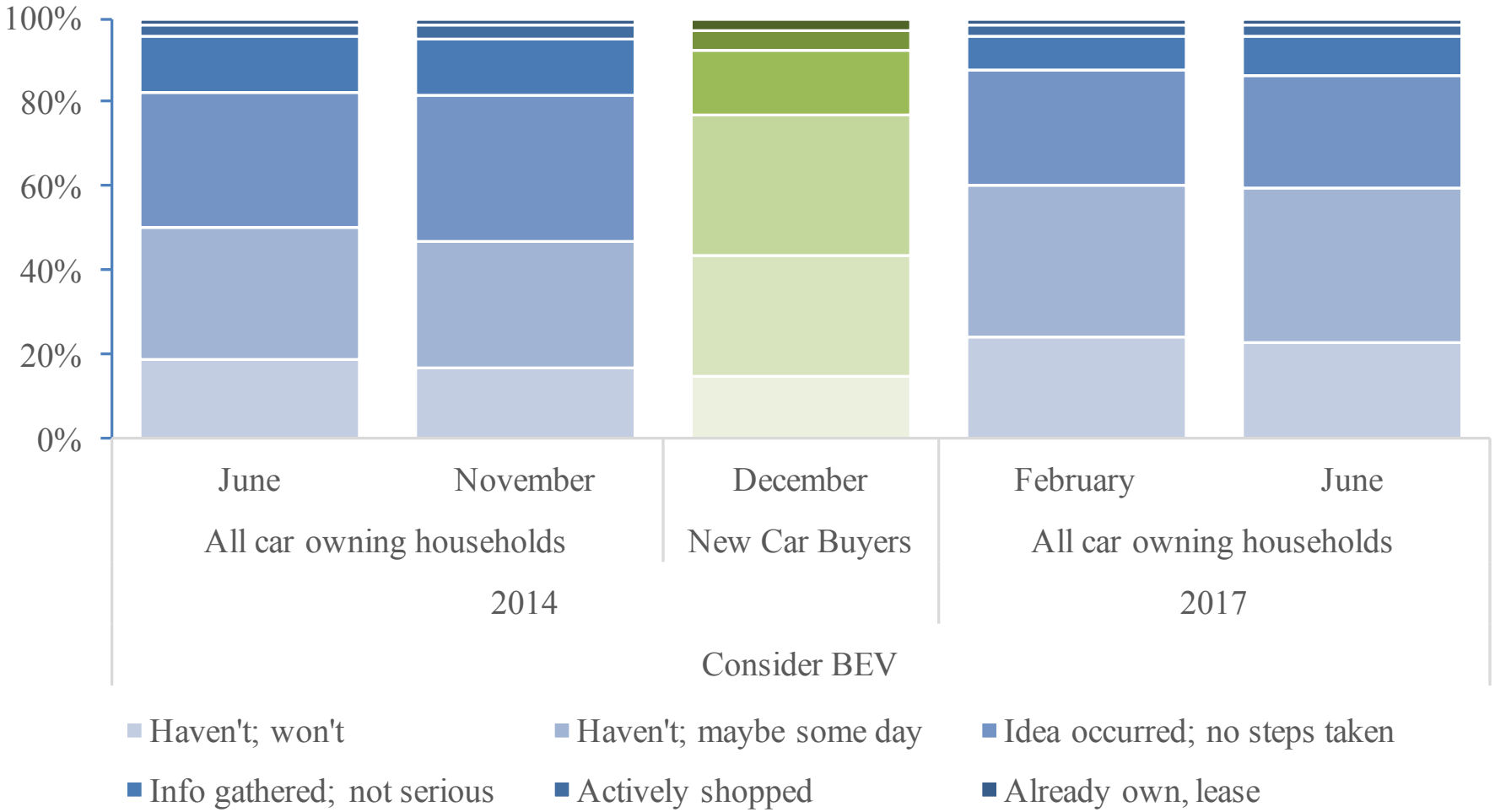
- September 2014
  - ~ **106,000**

    http://www.pevcollaborative.org/sites/all/themes/pev/files/CPEV_annual_report_web.pdf
- December 2016
  - ~ **246,000**

    http://www.pevcollaborative.org/sites/all/themes/pev/files/2016_AR_web.pdf
- May 2017
  - ~ **300,000** "ZEVs and PHEVs"

    http://www.energy.ca.gov/renewables/tracking_progress/documents/electric_vehicle.pdf

Have car-owning and new car buying households in California considered BEVs?



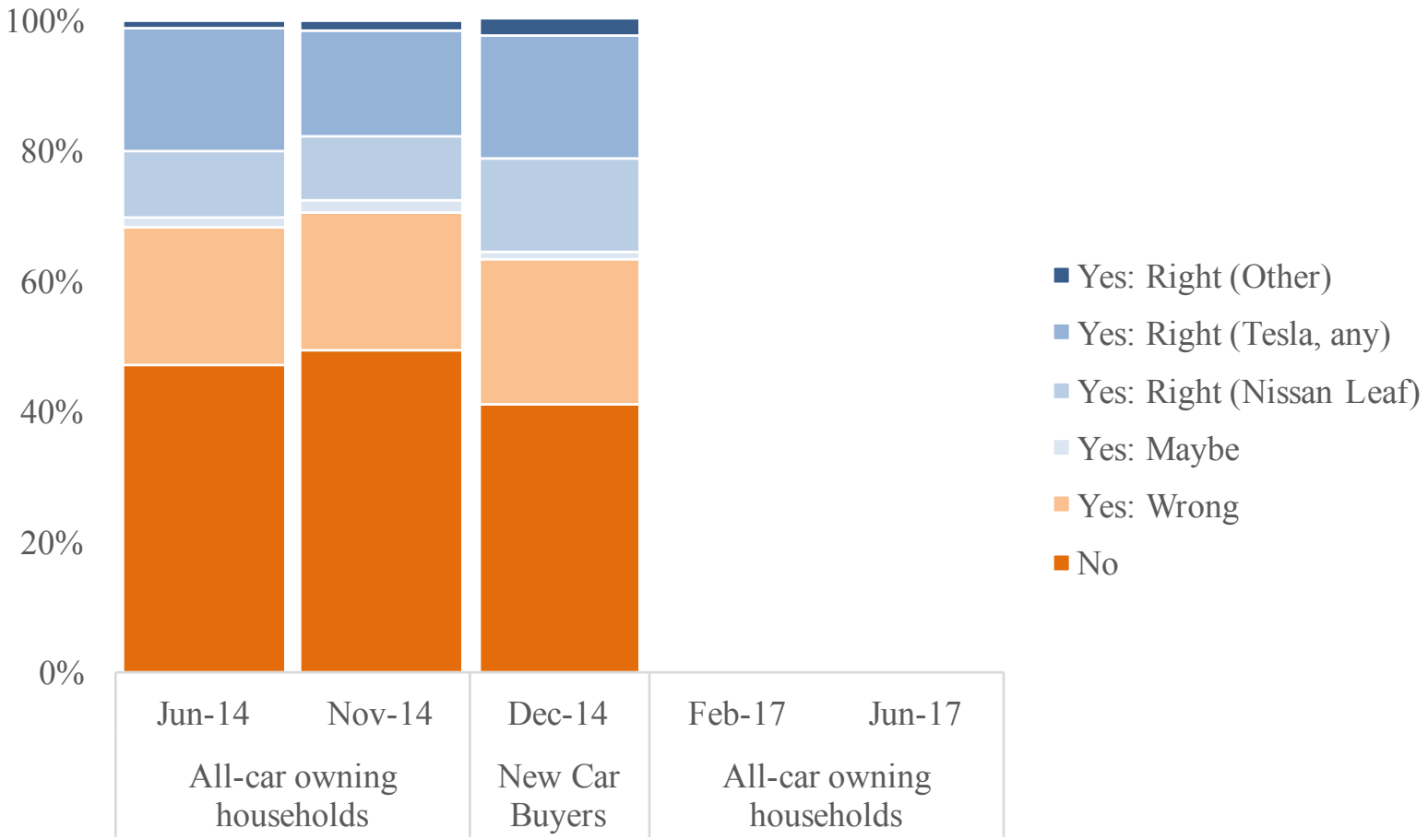
Number of PEV makes and models (that have been) for sale in consumer retail markets in California since 2010

2010 through 2014: **23**

- **10 PHEVs**: Volt, Prius Plug-in, C-Max Energi, Fusion Energi, Panamera S E-hybrid, ELR, i8; *Karma, 918 Spyder, Accord PHEV*
- **13 BEVs**: Leaf, fortwo, iMEV, Focus Electric, Model S, Spark EV, 500e, i3, B-class; *Roadster, RAV4 EV (2nd Gen.), Fit EV, iQ EV*

https://www.driveclean.ca.gov/pev/Plug-in_Electric_Vehicles/Makes_and_Models.php

“Can you name a BEV that is being sold in the US?”



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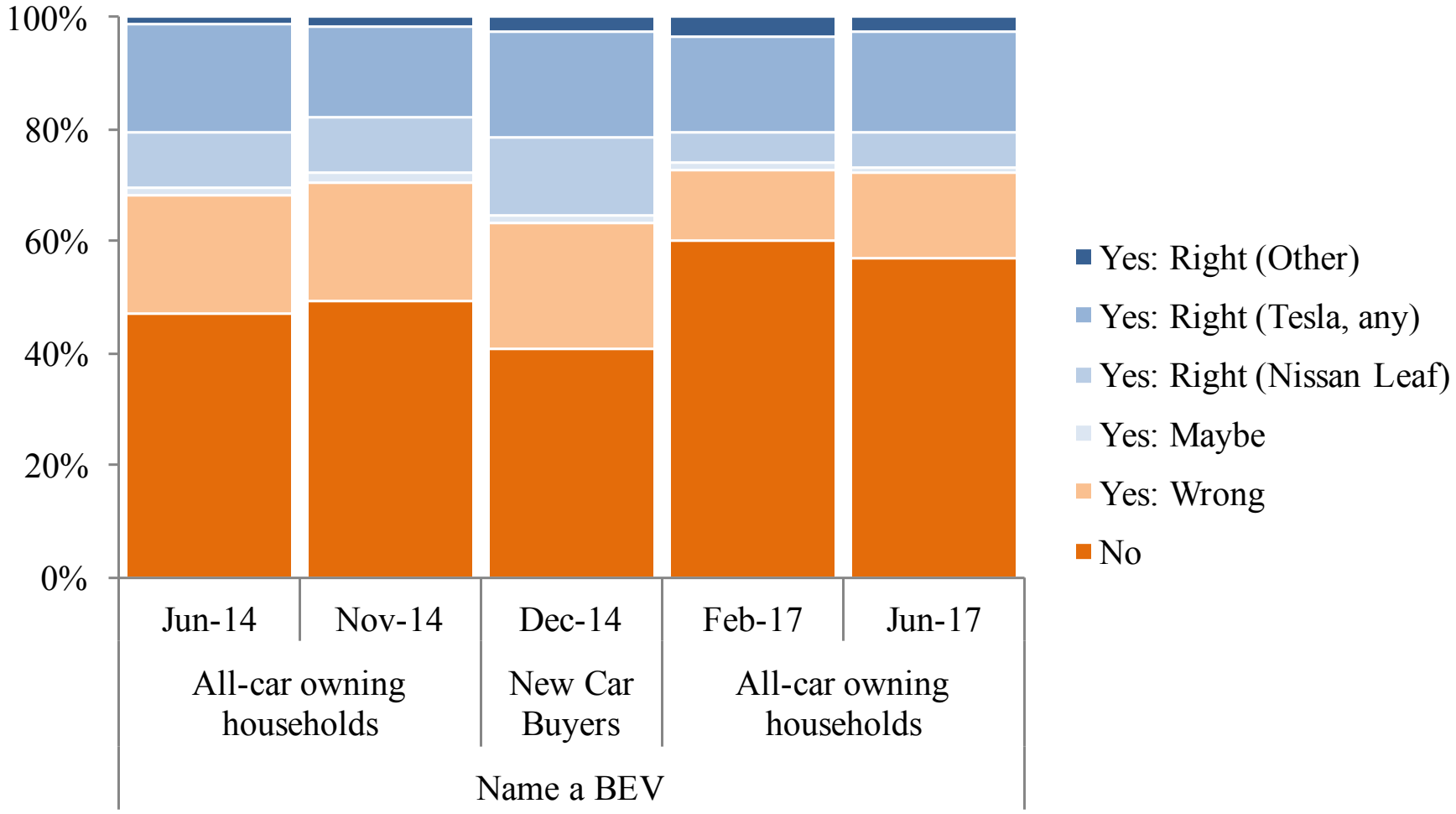
- **13 BEVs**: Leaf, fortwo, iMEV, Focus Electric, Model S, Spark EV, 500e, i3, B-class; *Roadster, RAV4 EV (2nd Gen.), Fit EV, iQ EV*

+ 2015 through 2017: 40

- **+ 12 PHEVs**: Cayenne S E-hybrid, S500e, GLE 550e, XC90 T8, X5 xDrive40e, Sonata PHEV, Audi A3 e-tron, 330e iPerformance, 740e xDrive, Pacifica Hybrid, Optima, CT6,
- **+ 5 BEVs**: Soul EV, e-Golf, Model X, Bolt, Ioniq

https://www.driveclean.ca.gov/pev/Plug-in_Electric_Vehicles/Makes_and_Models.php

“Can you name a BEV that is being sold in the US?”



PEV Charging Infrastructure

- August 2014: **5,700** nonresidential charging stations

  http://www.energy.ca.gov/transportation/zev/pev/

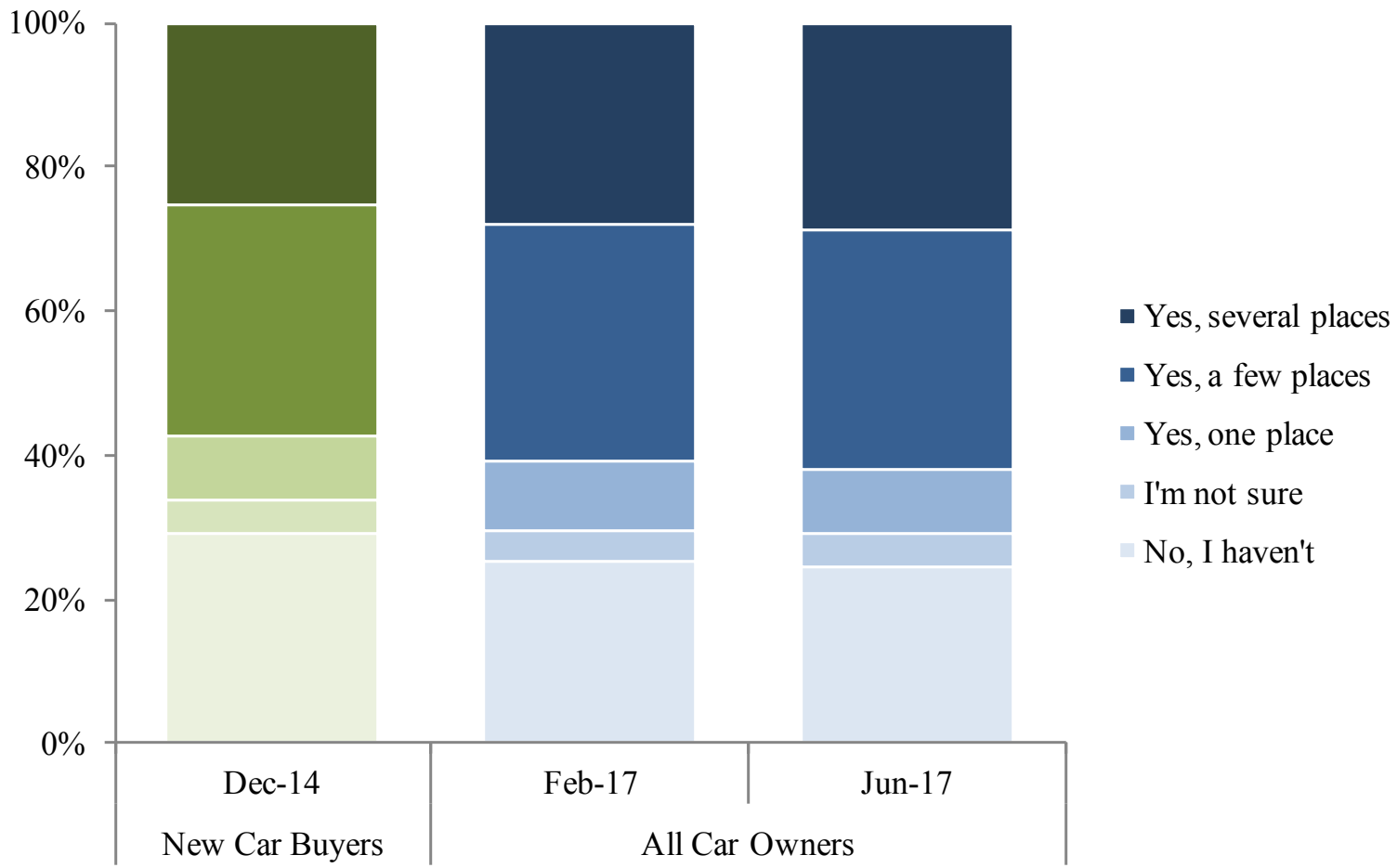
- August 2017: "More than **10,000** Level 2 and **1,500** direct current fast charger (DCFC) connectors"

  http://www.energy.ca.gov/renewables/tracking_progress/documents/electric_vehicle.pdf

- December 2017: **13,846 chargers; 3,967 locations**
  - 567 Level 1; 11,730 Level 2; 1,549 DC Fast

  https://www.afdc.energy.gov

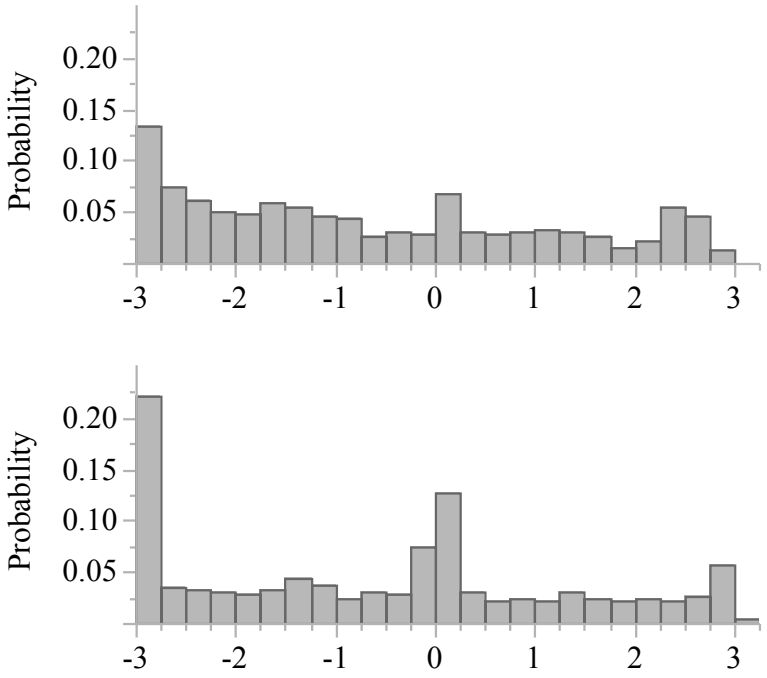
“Have you seen any electric vehicle charging spots in the parking garages and lots you use?”



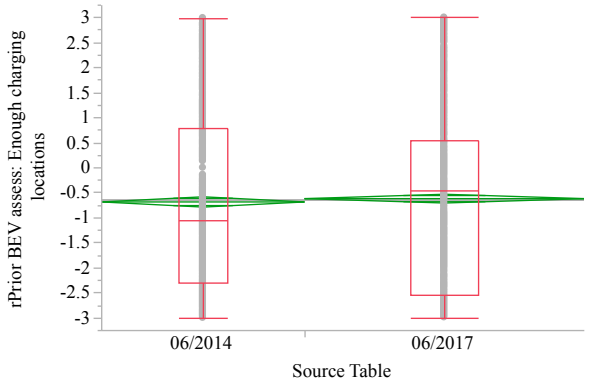
“There are enough places to charge battery electric vehicles.”

Scale: -3 = strongly disagree; 3 = strongly agree

June 2014 (top)
June 2017 (bottom)



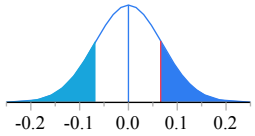
No difference in means: slight disagreement there are enough



t Test

06/2017-06/2014
Assuming equal variances

Difference	0.06609	t Ratio	0.959362
Std Err Dif	0.06888	DF	2939
Upper CL Dif	0.20115	Prob > |t|	0.3375
Lower CL Dif	-0.06898	Prob > t	0.1687
Confidence	0.95	Prob < t	0.8313



Analysis of Variance

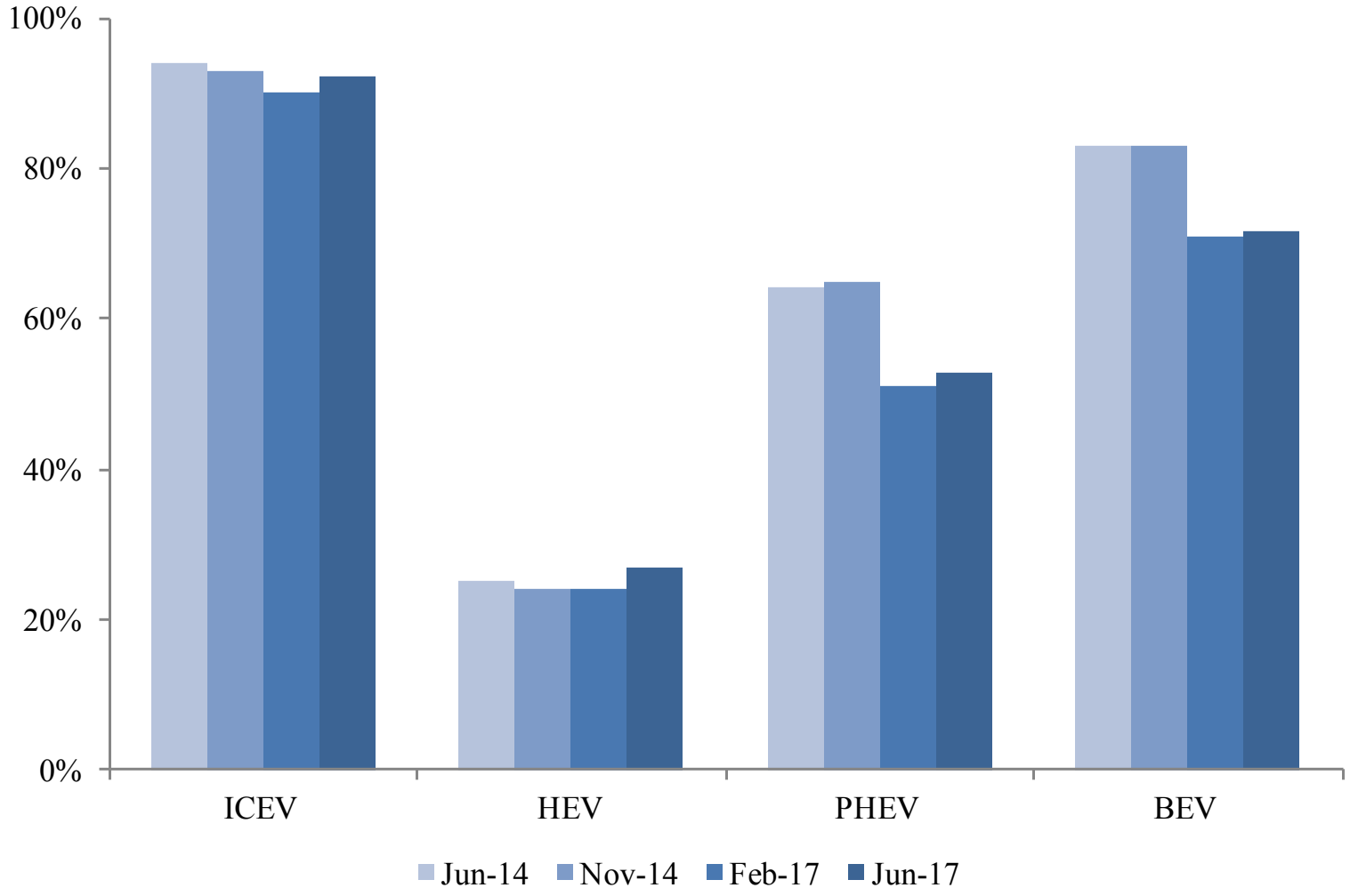
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Source Table	1	3.1294	3.12939	0.9204	0.3375
Error	2939	9992.9560	3.40012		
C. Total	2940	9996.0854			

Means for Oneway Anova

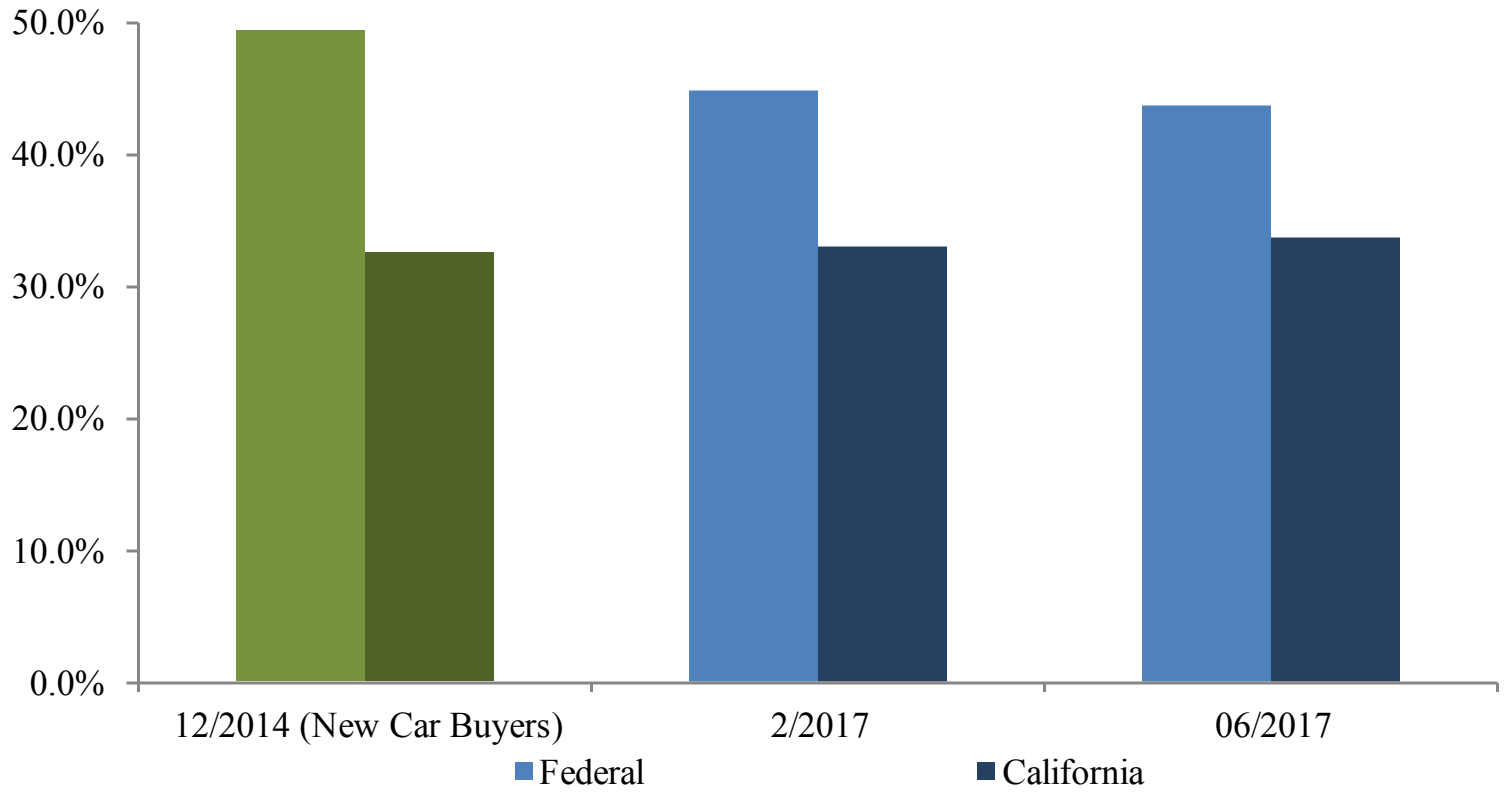
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
06/2014	1236	-0.68080	0.05245	-0.7836	-0.5780
06/2017	1705	-0.61472	0.04466	-0.7023	-0.5272

Std Error uses a pooled estimate of error variance

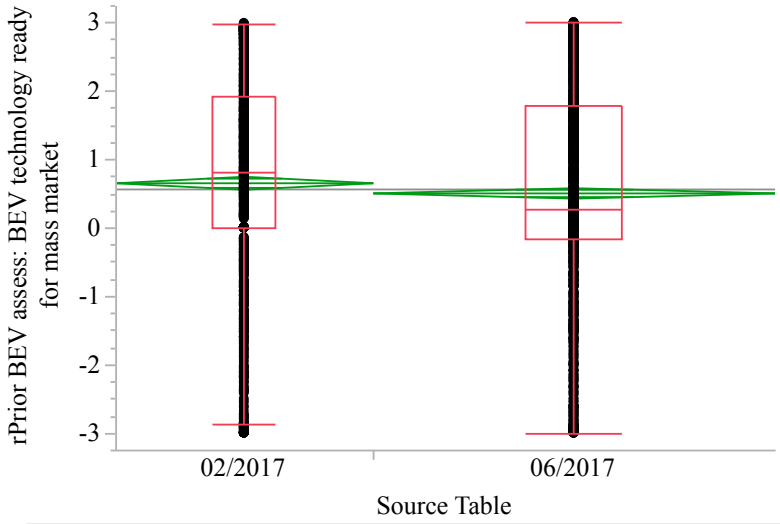
“From what you understand, which of these vehicles are fueled with gasoline and which are plugged in to charge with electricity?” Percent correct.



"As far as you are aware, is each of the following offering incentives to consumers to buy and drive vehicles powered by alternatives to gasoline and diesel?"



“Battery electric vehicle technology is ready for mass automotive markets.” Scale: -3 = no, 3 = yes.

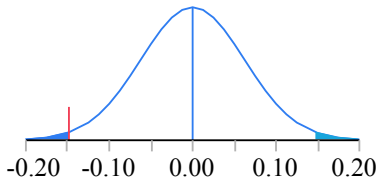


t Test

06/2017-02/2017

Assuming equal variances

Difference	-0.14838	t Ratio	-2.38619
Std Err Dif	0.06218	DF	2793
Upper CL Dif	-0.02645	Prob > |t|	0.0171*
Lower CL Dif	-0.27032	Prob > t	0.9915
Confidence	0.95	Prob < t	0.0085*



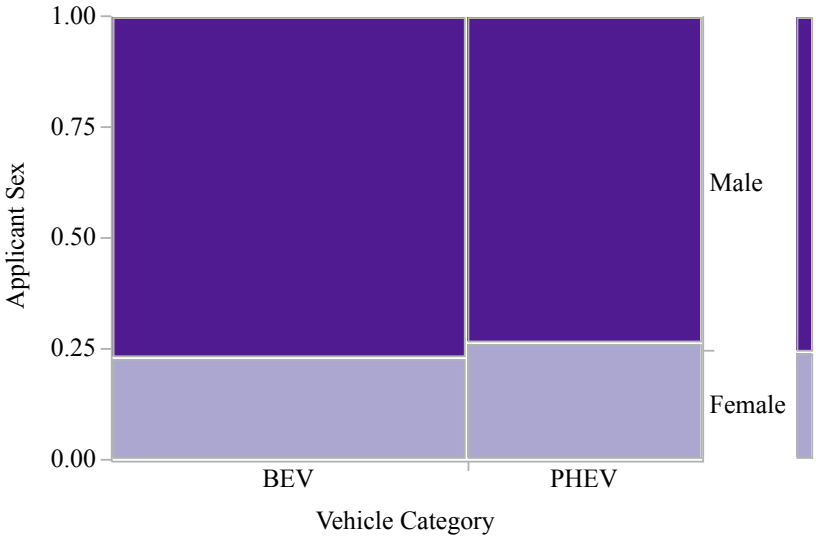
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
02/2017	1090	0.657275	0.04857	0.56204	0.75251
06/2017	1705	0.508891	0.03883	0.43275	0.58504

Std Error uses a pooled estimate of error variance

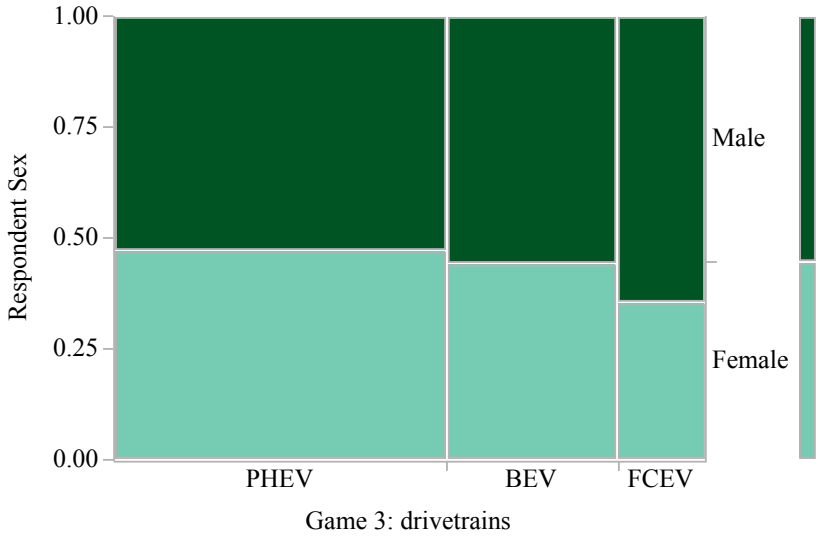
We're hardwiring gender differences in markets for ZEVs

California Clean Vehicle Rebate Applicants, 9/1/12 to 5/31/2015



Center for Sustainable Energy (2016). California Air Resources Board Clean Vehicle Rebate Project, EV Consumer Survey Dashboard. Retrieved 9/29/2017 from http://cleanvehiclerebate.org/survey-dashboard/ev.

New-car buyers, CA; 12/2014; "ZEV designers"



What distinguishes consideration to date of PEVs?
All car owners, Feb. 2017

Variable group	Model 1	Model 2	Model 3	Model 4
Socio-economic, demographics	Age, sex, income	Age, sex	Age, sex	
Context: Residence, Vehicles, Daily Travel	—	Home parking loc. and electricity, new vehicles	Home parking location and electricity	Home parking electricity
General attitudes: environment, orientation to time, new technology	—	—	Air Quality; CFCS-I, CFCS-F; EBB, EIS	Air Quality
PEV-Specific Awareness, Knowledge, Experience, Assessment	—	—	—	Know PEV owner, Interest in ZEV tech., range, charge duration, seen charging

Key		
Not included in model	No statistically significant variables	Multiple statistically significant variables, at least some <0.01
—		

New Car Buyers' Prospective Interest in ZEVs, Dec. 2014. Base Model.

Whole Model Test				
Model	-LogLikelihood	DF	Chi-Square	Prob. > ChiSq
Difference	375.6638	112	751.3276	<.0001
Full	2047.6542			
Reduced	2423.318			

Lack of Fit			
Source	DF	-LogLikelihood	Chi-Square
Lack of Fit	6524	2047.6542	4095.308
Saturated	6636	0	Prob. > ChiSq
Fitted	112	2047.6542	1.000

Effect Likelihood Ratio Tests

Source	**DF**	**Likelihood Ratio Chi-Square**	**Prob. > ChiSq**
Replacement: Electricity	4	31.4484106	<0.0001
Replacement: Hydrogen	4	10.2745216	0.0360
Highest Home PEV Charging Access	12	32.6172477	0.0011
Home natural gas	4	10.3376525	0.0351
Familiarity Factor1: HEVs, PEVs, FCEVs	4	12.9592756	0.0115
Familiarity Factor2: ICEVs	4	15.7699371	0.0033
Driving Experience Factor1: ZEVs	4	15.0889216	0.0045
Driving Experience Factor2: HEVs	4	18.3296375	0.0011
Prior BEV Evaluation Factor 1: safety, reliability	4	11.5805438	0.0208
Prior BEV Evaluation Factor 2: driving range, charging time	4	13.4185287	0.0094
Prior FCEV Evaluation Factor2: driving range, fueling time	4	12.2441157	0.0156
Prior Consideration of PEV	12	52.076929	<0.0001
Prior Consideration of FCEV	12	26.7270647	0.0085
Government offer incentives	16	30.9529399	0.0136
Seen Public EVSEs	4	9.44515586	0.0509
Personal interest in ZEV tech	12	40.0566242	<0.0001
Environmental Factor: air pollution regional threat, personal worry	4	22.5081516	0.0002

- Highest Home PEV Charging Access; Home natural gas
- Replacement for Gasoline and Diesel: Electricity; Hydrogen
- Environmental Factor: air pollution regional threat, personal worry
- Familiarity Factors: (HEVs, PEVs, FCEVs); ICEVs
- Driving Experience Factors: ZEVs; HEVs
- Prior BEV Evaluation Factors: (safety, reliability); (driving range, charging time)
- Prior FCEV Evaluation Factor: (driving range, fueling time)
- Prior Consideration: PEV; FCEV
- Should government offer incentives
- Seen Public EVSEs
- Personal interest in ZEV tech

Base Model plus Respondent Sex? No.

	AICc	BIC	DF
Base model	4356.18	4967.33	112
Base + Respondent sex	**4337.96**	4968.76	116
Base + Respondent sex + Respondent sex crossed by the following, one at a time:			
Prior Consideration of a PEV	4353.18	5044.82	128
Replacement: electricity	4340.76	4991.88	120
Personal interest in ZEV tech	4347.39	5039.02	128
Environmental factor: air pollution regional threat, personal worry	4346.38	4997.5	120
Driving experience factor 2: HEVs	4346.48	4997.6	120
Prior BEV Evaluation Factor 1: safety, reliability	4340.35	4991.47	120
Prior BEV Evaluation Factor 2: driving range, charging time	4343.61	4994.74	120
Highest Home PEV Charging Access	4353.67	5045.30	128
Familiarity Factor 1: HEVs, PEVs, FCEVs	4344.02	4995.14	120
Familiarity Factor 2: ICEVs	**4337.71**	4988.83	120

Majority of consumers are unaware of and unengaged with ZEVs

- PEV and ICEV/HEV buyers are answering different questions
  - PEV buyers: **"How do I get a PEV?"**
  - ICEV/HEV buyers: **"Why would I buy a PEV?"**
    - They likely have not asked themselves this question until we ask them
- ICEV/HEV buyers:
  1. **Unaware and unengaged**: Don't know PEVs are a possibility: **"What PEVs?"**
  2. **Aware but unengaged**: Have no impetus to solve even their first (imagined) problem with PEVs; no impetus to ask if there are other problems.

Take-away messages

- First barrier to growing ZEV markets continues to be the vast majority of households—even in CA—knows nothing about ZEVs, including:
  - Sales of PEVs started over six years ago;
  - An increasing variety of ZEV makes and models for sale;
  - Falling PEV prices;
  - Increasing BEV driving range;
  - Growing extent of PEV charging infrastructure, and nascent H_2 fueling; and,
  - Incentives.
- Financial incentives and declining PEV prices may be necessary, but are not sufficient conditions
  - In the absence of *engagement* they result only in ZEVs remaining an expensive unknown.
- While we're contemplating how to grow ZEV markets, solve the riddle of why we are leaving women out

With thanks to participants and funders…

~ 8,500 CA Survey Respondents and 82 Interviewees

- California Energy Commission: Sustainable Transportation Energy Pathways; National Center for Sustainable Energy
  - 2014 and 2017 Surveys of California Car-owning households
- California Air Resources Board
  - 2014-15 Survey and interviews of California New-car buying households
  - 2017 Interviews with PEV owners
- Sustainable Transportation Energy Pathways
  - 2017: Interviews of buyers of ICEV/HEV/PEV variants
- National Center for Sustainable Transportation
  - Gender research: re-analysis of survey and interview data