California's Electric Vehicle Rebates: Exploring Impact

BECC, 17 October 2017, Sacramento

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Thanks to Nick Pallonetti, Michelle Jones, Jamie Orose, John Anderson, and others at CSE

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Outline

- Objectives
- Introduction
- Impact:
  - Outputs: Vehicles and Consumers Rebated
  - Outcomes: Behaviors Influenced
  - Implications: Market and Emissions
- Summary and Next Steps
- Additional Online Resources

Objectives

- To explore the impact of a statewide rebate program for clean-vehicle adoption
- CARB (Sep 2017)[1]

  "…conservatively estimates the emission reductions…"

  "anticipates updating and revising… as new data becomes available and methodologies are refined."
- This work
  - aims to inform that process and causal studies by assessing the use of program-specific data
  - is not an official CARB position

[1] Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives: Discussion Draft, California Air Resources Board Staff, Released 26 Sept 2017, online here.

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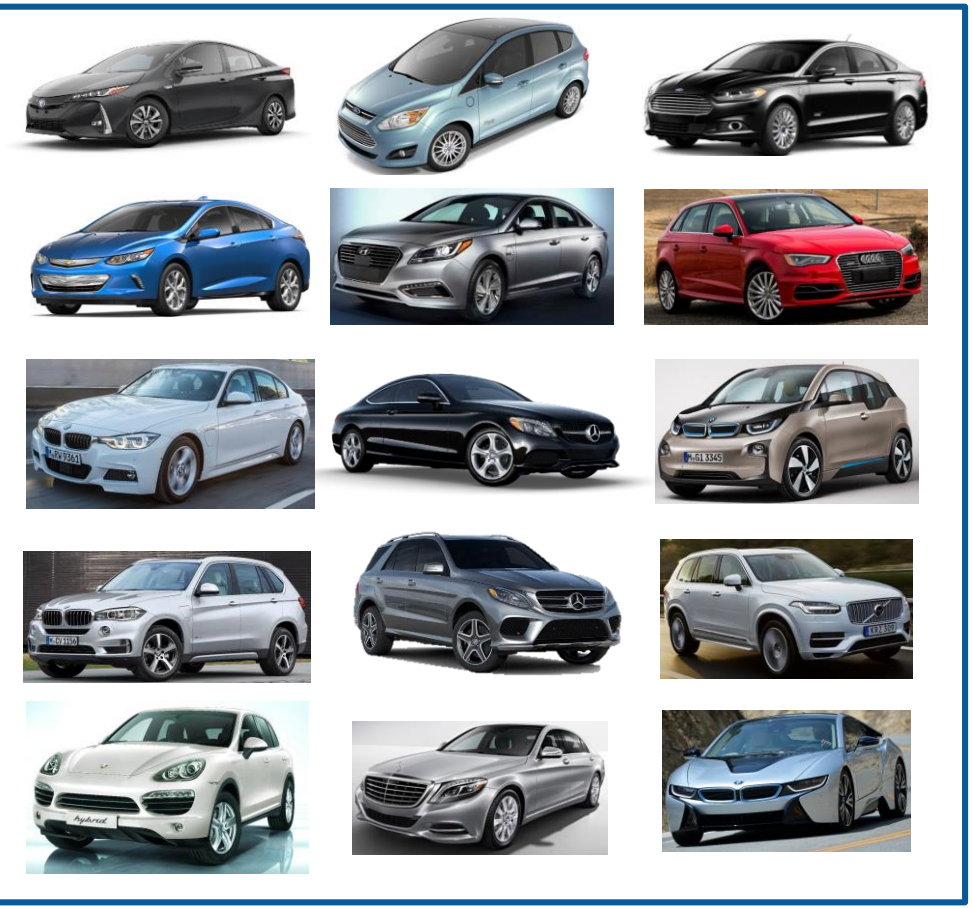
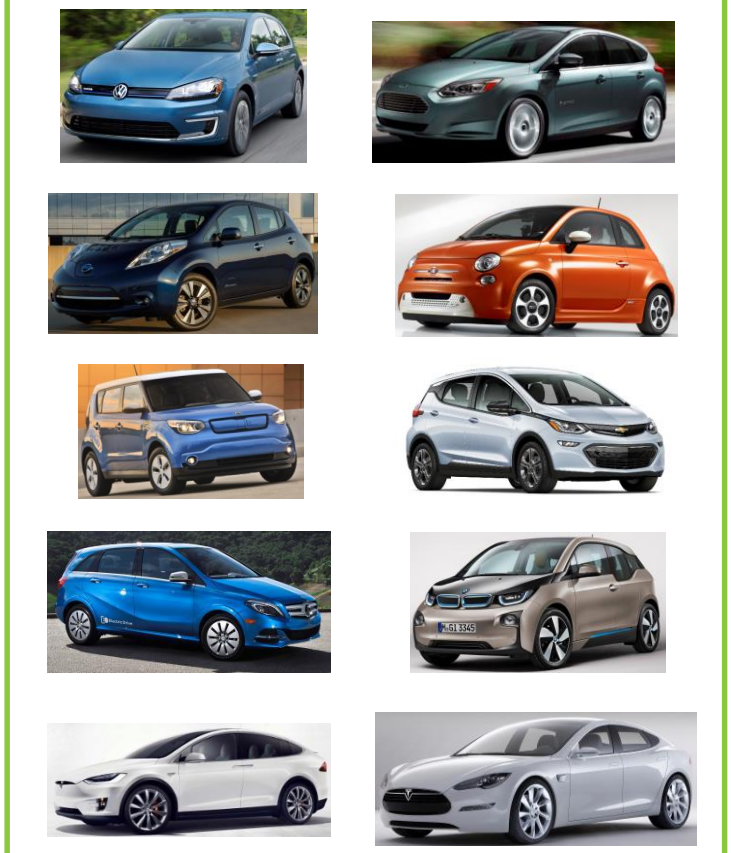
Introduction:
Electric Vehicles & Rebates

Getting Up to Speed: More Choice

Plug-in hybrid EVs



All-battery EVs



Fuel-cell EVs

All models pictured had > 100 national sales in Q1 2017
(http://insideevs.com/monthly-plug-in-sales-scorecard/)

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EV Incentive Programs: Rebate Design

	CALIFORNIA CLEAN VEHICLE REBATE PROJECT℠	MOR-EV Massachusetts Offers Rebates for Electric Vehicles	CHEAPR Connecticut Hydrogen and Electric Automobile Purchase Rebate	NEW YORK STATE
Fuel-Cell EVs 	$5,000	$2,500	$5,000	e-miles ≥ 120 $2,000 ≥ 40 $1,700 ≥ 20 $1,100 < 20 $500
All-Battery EVs 	$2,500	$2,500	e-miles ≥ 175 $3,000 ≥ 100 $2,000 < 100 $500	
Plug-in Hybrid EVs 	$2,500 (i3 REx) $1,500	≥10 kWh $2,500 <10 kWh $1,500	≥ 40 $2,000 < 40 $500	
Zero-Emission Motorcycles 	$900	$750		
	e-miles ≥ 20 only; Consumer income cap and increased rebates	MSRP ≥ $60k = $1,000 max.	MSRP ≤ $60k only; dealer assignment; $300 dealer incentive	MSRP > $60k = $500 max.; point-of-sale

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Data Summary (Rebates to Individuals Only)

CVRP Consumer Survey

	2013–2015 Edition	2015–2016 Edition	Total
Responses	n = 19,460	n = 11,611	n = 31,071
Vehicle Purchase/Leases	Sep 2012 – May 2015	April 2015 – May 2016	Sep 2012 – May 2016

CVRP Program Population (Application Data)

Participants survey was weighted to represent*	N = 91,081	N = 45,698	N = 136,779

Note: Before Income Cap. These results are conservative.

* Along the dimensions of vehicle model, county, and buy vs. lease (raking method)

Program Outputs

Rebated Vehicles and Consumers

Majority Characteristics of CVRP Participants

	CVRP 2015–2016 Survey
40–59 years old	53%
$50–200k/y household income	58%
White/Caucasian	65%
Male	74%

CVRP Consumer Survey, 2015–16 edition: weighted, n = 11,611

Majority Characteristics of Car Buyers

	CVRP 2015–2016 Survey	New-vehicle "intenders" (CHTS 2012)
40–59 years old	53%	52%
$50–200k/y household income	58%	58%
White/Caucasian	65%	76%
Male	74%	49%

CVRP Consumer Survey, 2015–16 edition: weighted, n = 11,611
California Household Travel Survey, 2012: weighted, n = 42,431

Majority Characteristics: Comparison

	CVRP 2015–2016 Survey	New-vehicle "intenders" (CHTS 2012)
40–59 years old	53%	52%
$50–200k/y household income	58%	58%
White/Caucasian	65%	76%
Male	74%	49%
≥ Bachelor's ≥ Postgraduate	83% 50%	66% 34%
Detached homes	80%	75%

CVRP Consumer Survey, 2015–16 edition: weighted, n = 11,611
California Household Travel Survey, 2012: weighted, n = 42,431

How can consumer research help us grow markets for electric vehicles?

- **Disadvantaged Communities**
  - (AEA pres 2016)
  - (CVRP DAC infographic, 2017)

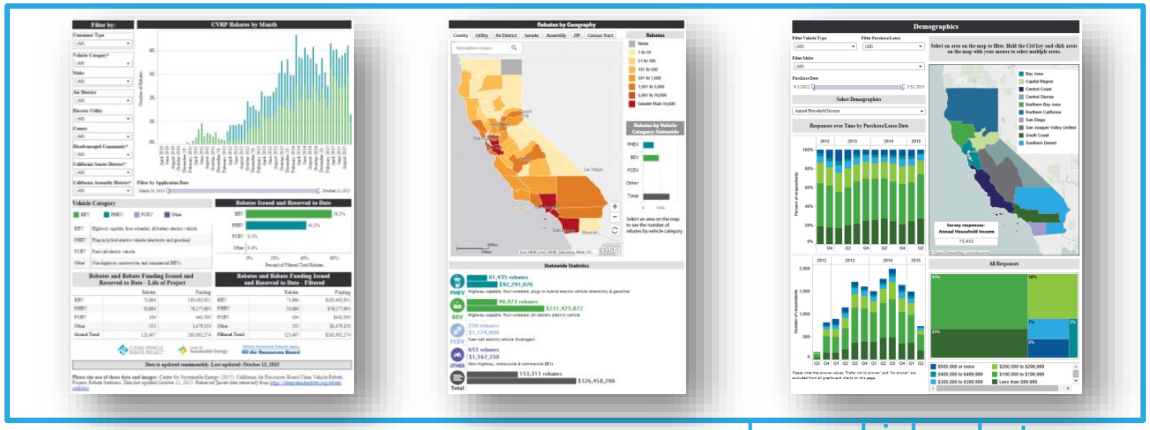
- **Information Channels**
  - (EV Roadmap pres, 2016)

- **Target Segments**
  - (TRR 2016 research paper)
  - (AEA 2016 pres)
  - (TRB 2017 poster)

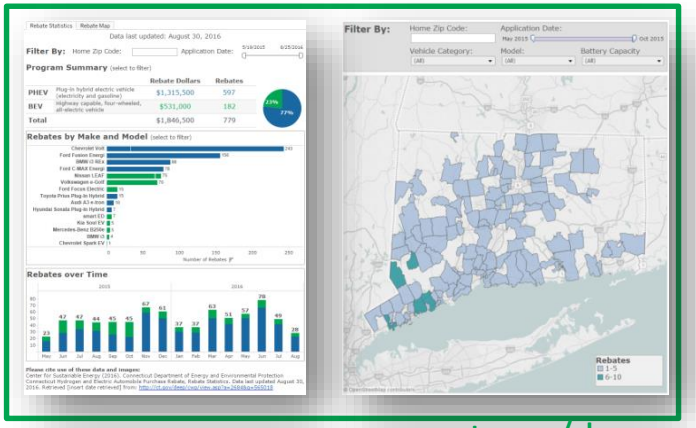
Where can I get the data?: Transparency Tools

Public dashboards facilitate informed action

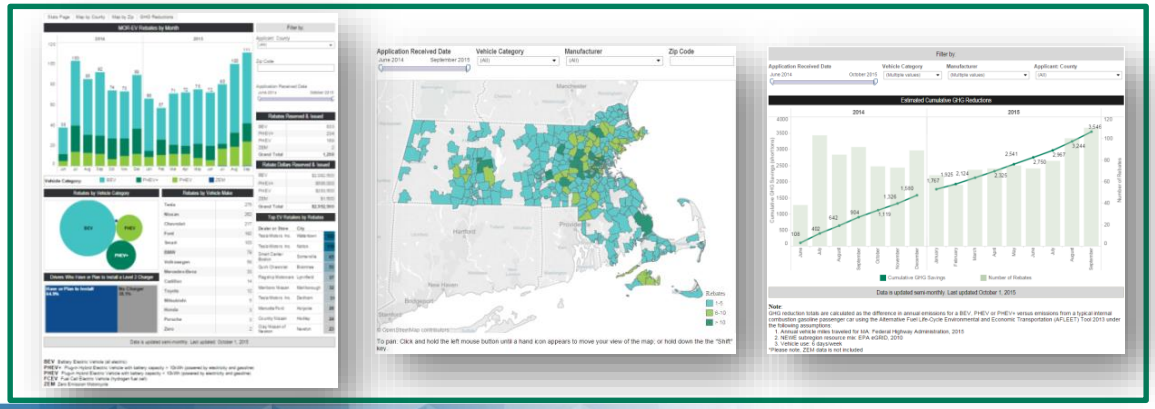
- >215,000 EVs and consumers
- >19,000 survey responses statistically represent >91,000 consumers
- >$470M in rebates processed



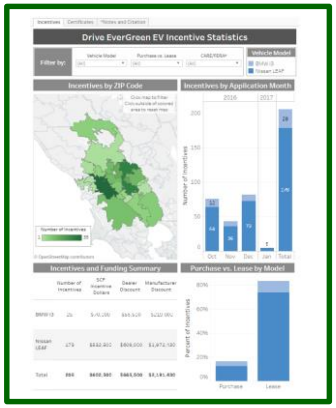
cleanvehiclerebate.org



ct.gov/deep



mor-ev.org



sonomacleanpower.org

zevfacts.com

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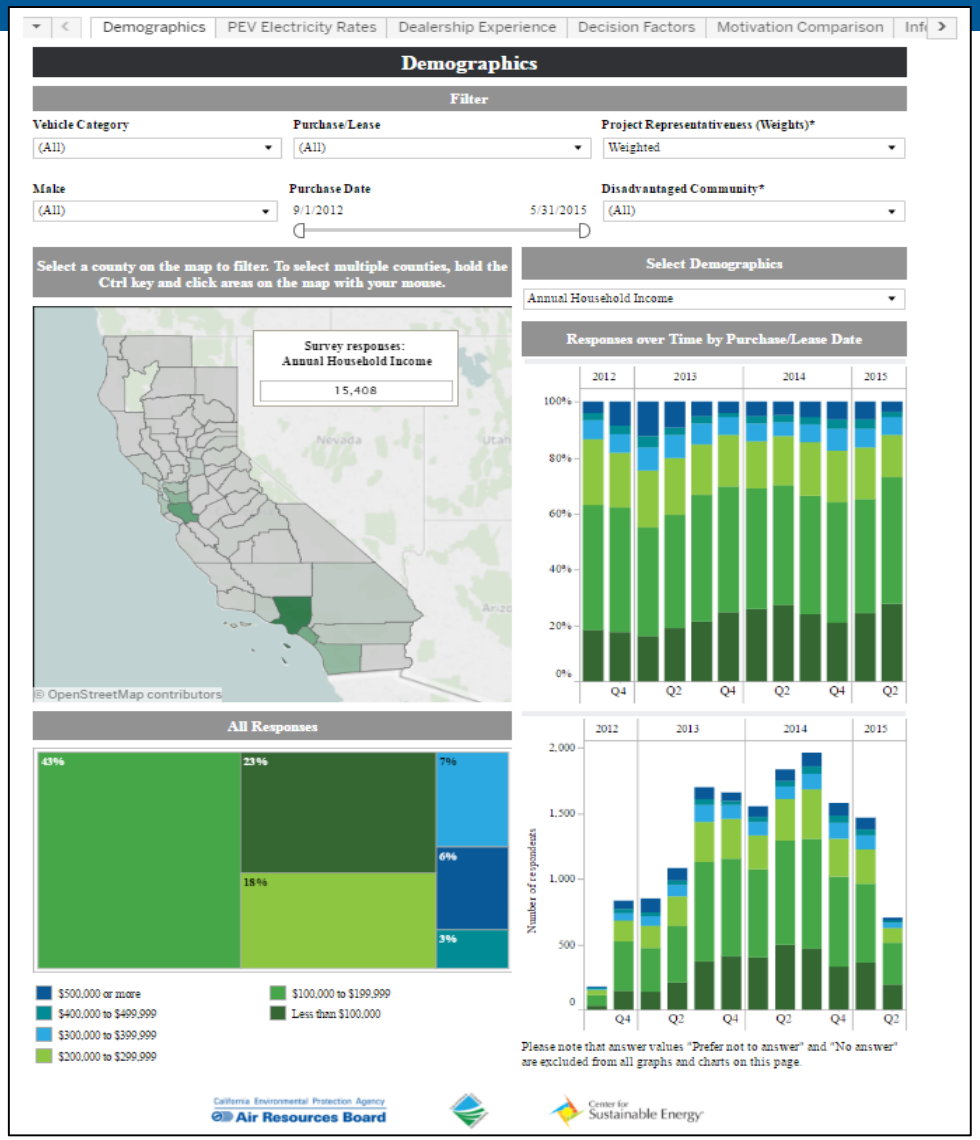
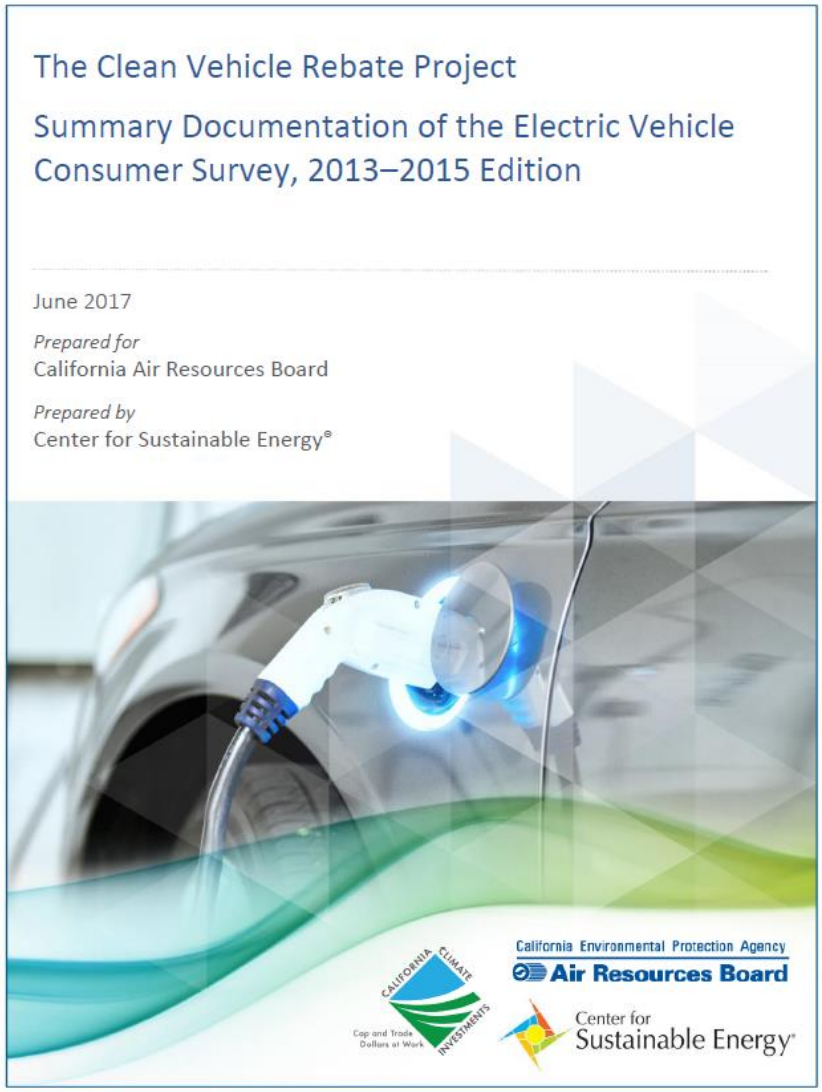
2013–2015 Survey: Dashboard and Summary Documentation





https://cleanvehiclerebate.org/eng/survey-dashboard
https://cleanvehiclerebate.org/eng/program-reports

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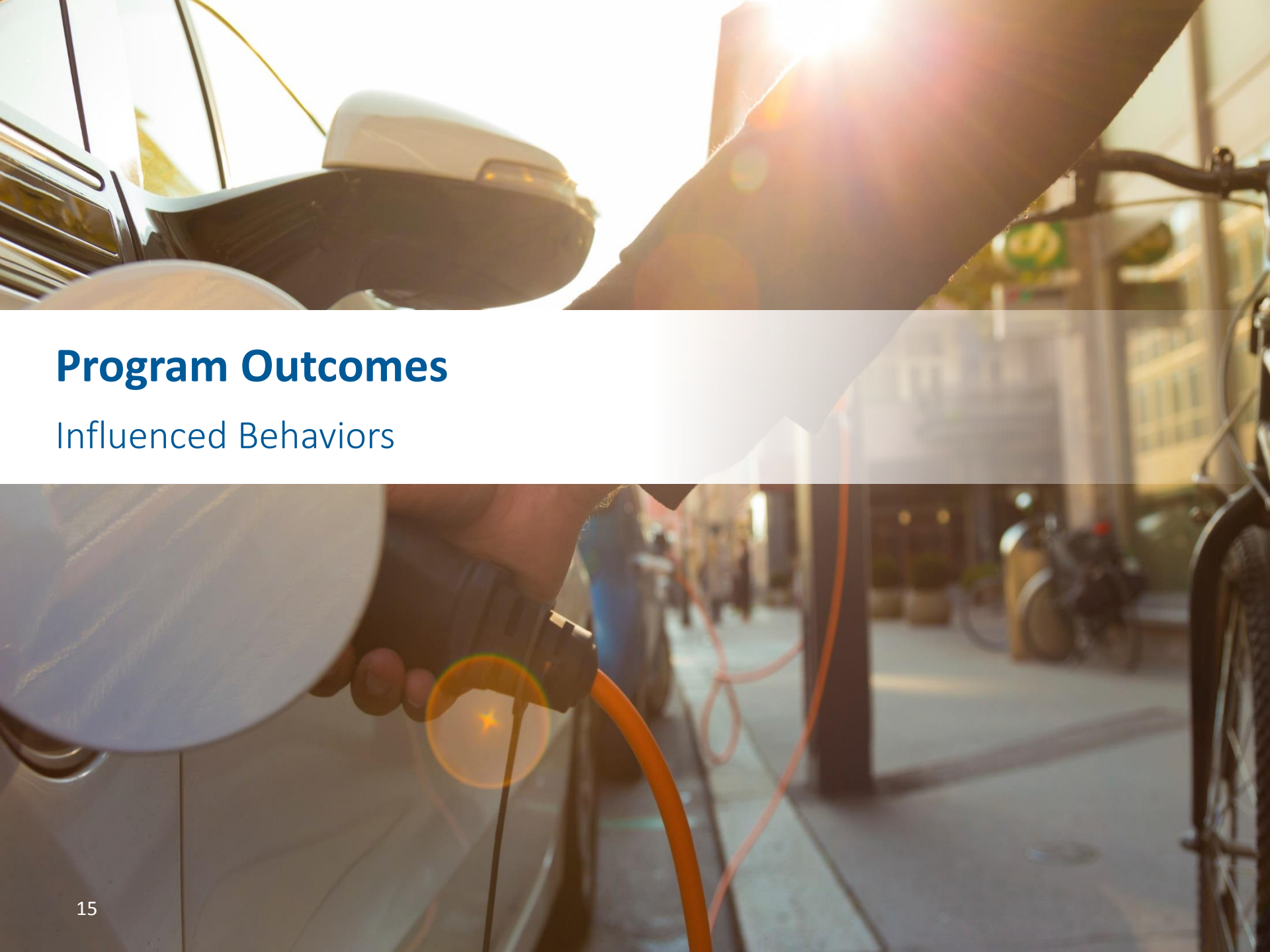
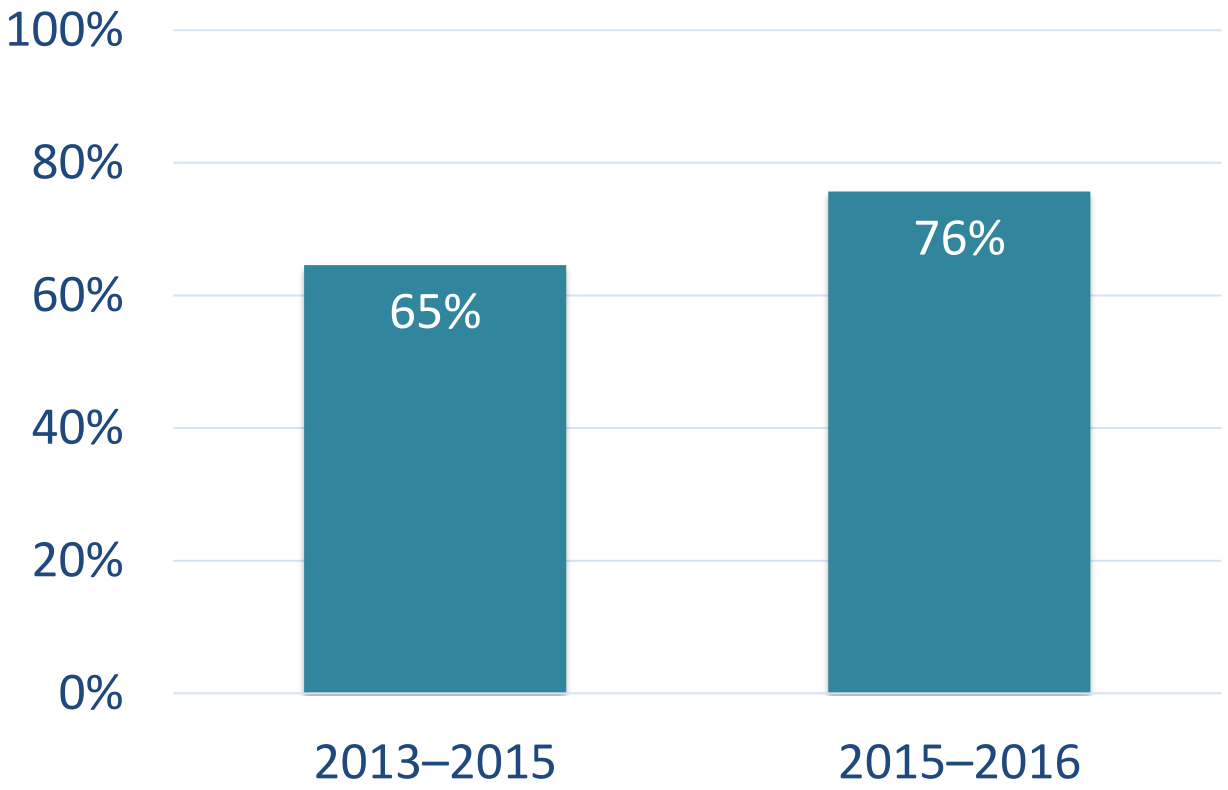


Program Outcomes

Influenced Behaviors

Do EVs get used?

Replaced a vehicle with their rebated EV



CVRP Consumer Survey. 2013–2015 edition: weighted, n=19,247
2015–2016 edition: weighted, n=11,449

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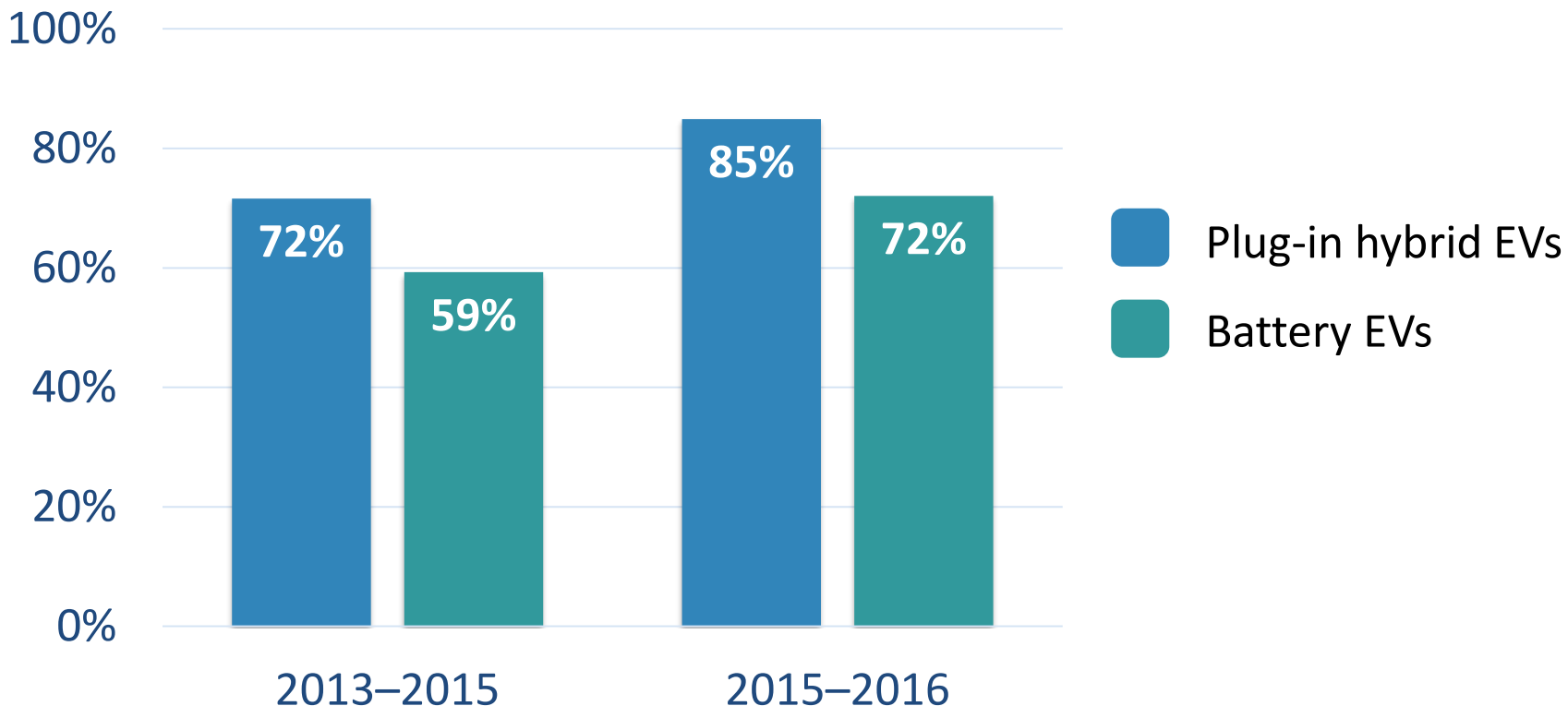

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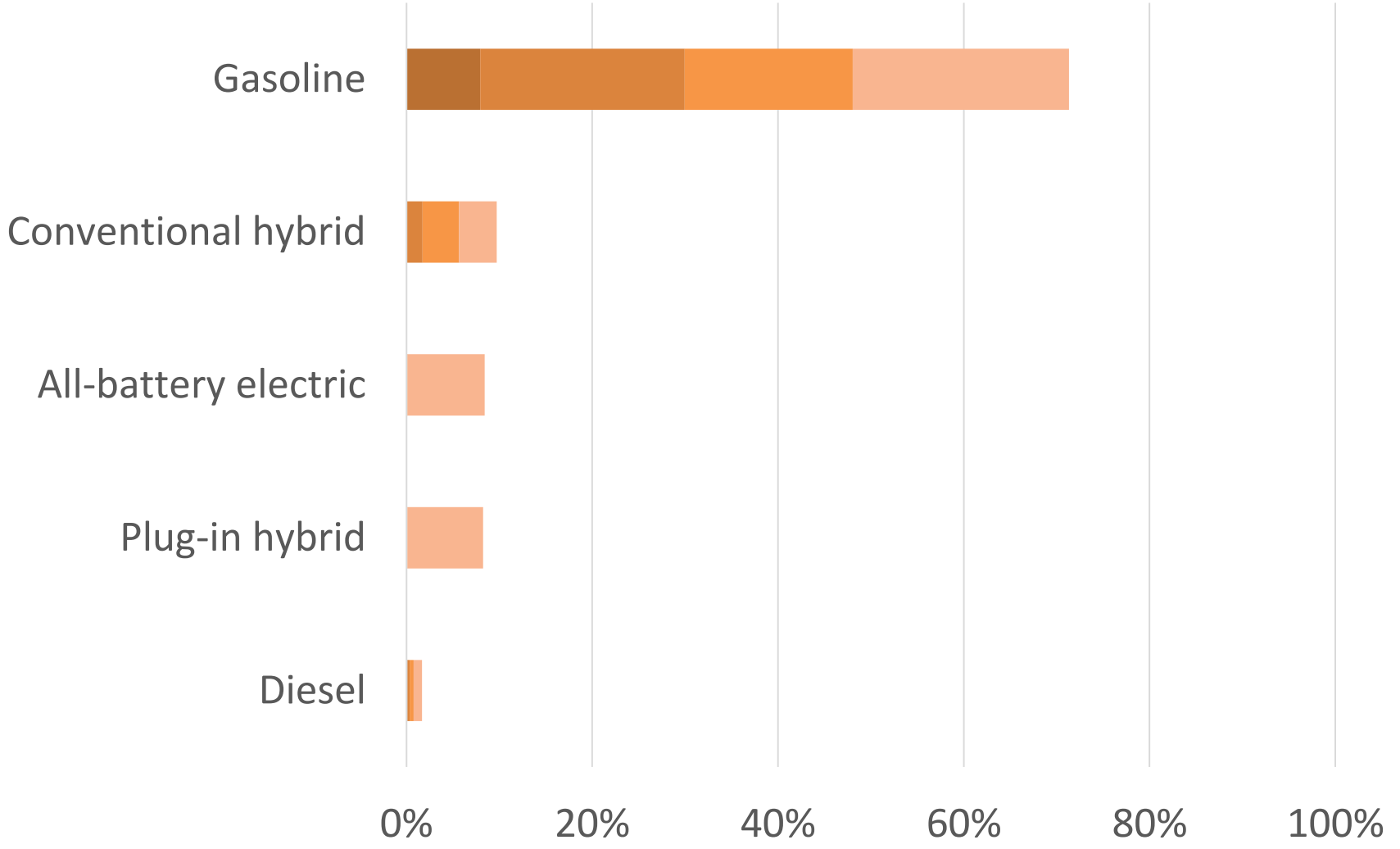
What vehicles have rebates helped replace?



CVRP Consumer Survey. **2015–2016 edition**: weighted, n=8,532

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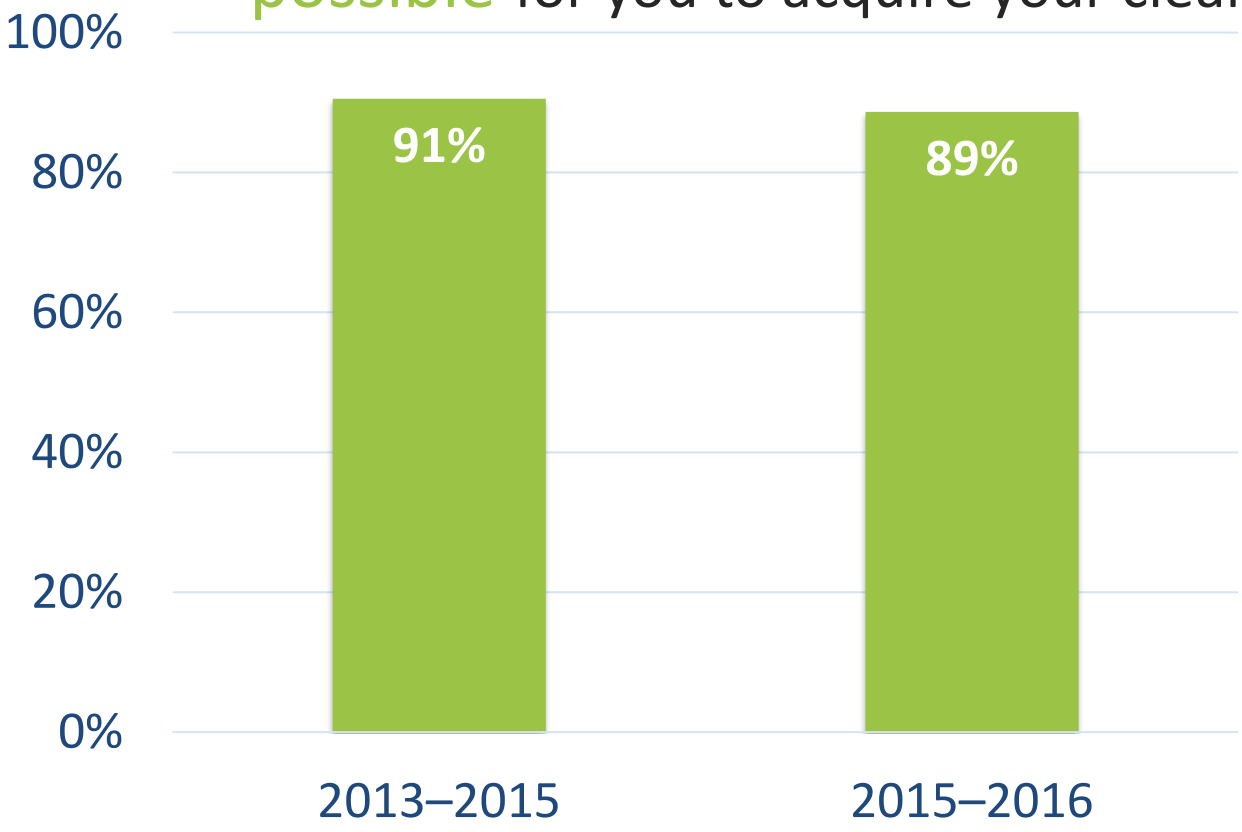
What are indicators of rebate influence?: Importance

How important was the State Rebate (CVRP) in making it possible for you to acquire your clean vehicle?



Rebate "Important" =

Moderately Important + Very Important + Extremely Important

CVRP Consumer Survey. 2013–2015 edition: weighted, n=19,152
2015–2016 edition: weighted, n=11,390
Difference statistically significant (Chi-2, ***)

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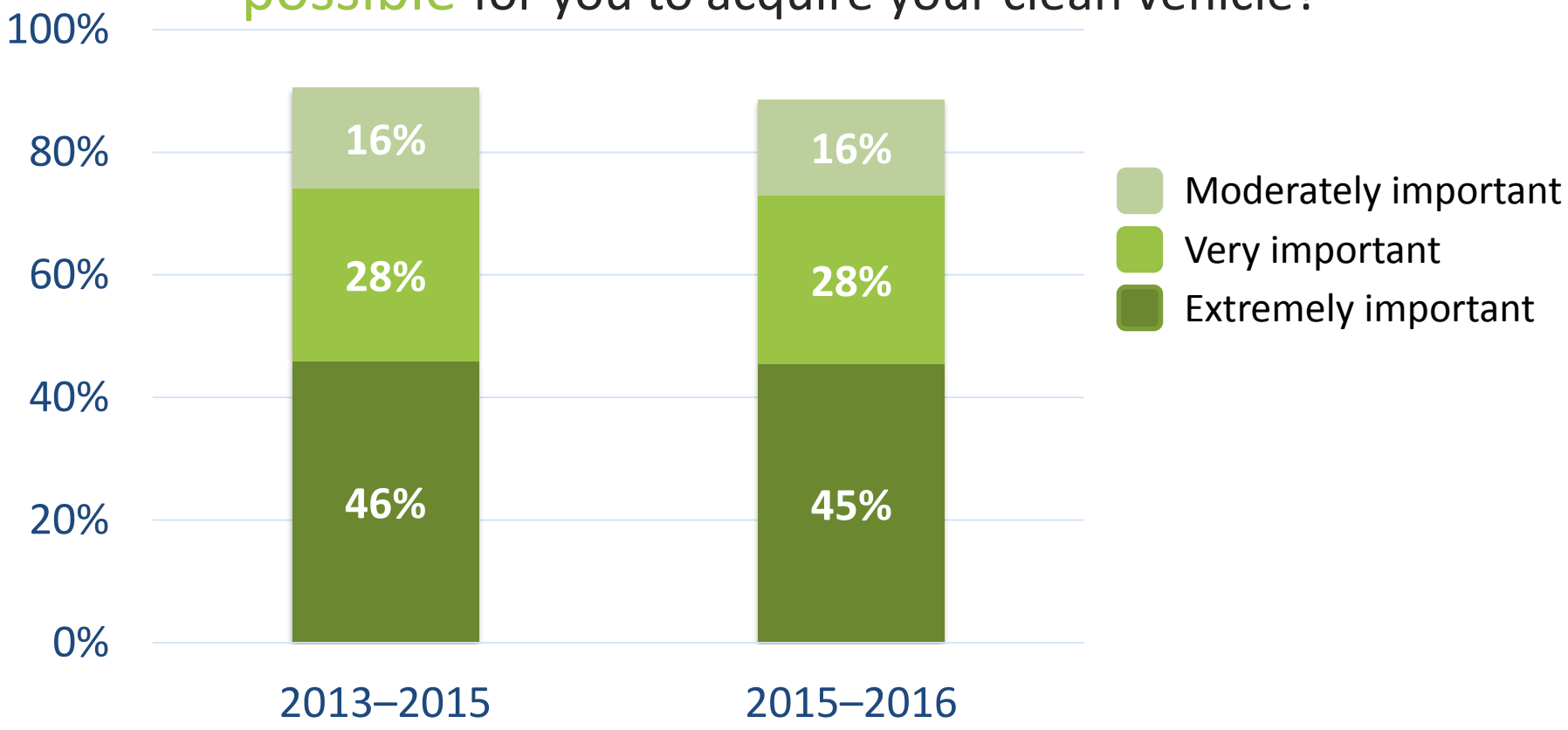
How important was the State Rebate (CVRP) in making it possible for you to acquire your clean vehicle?



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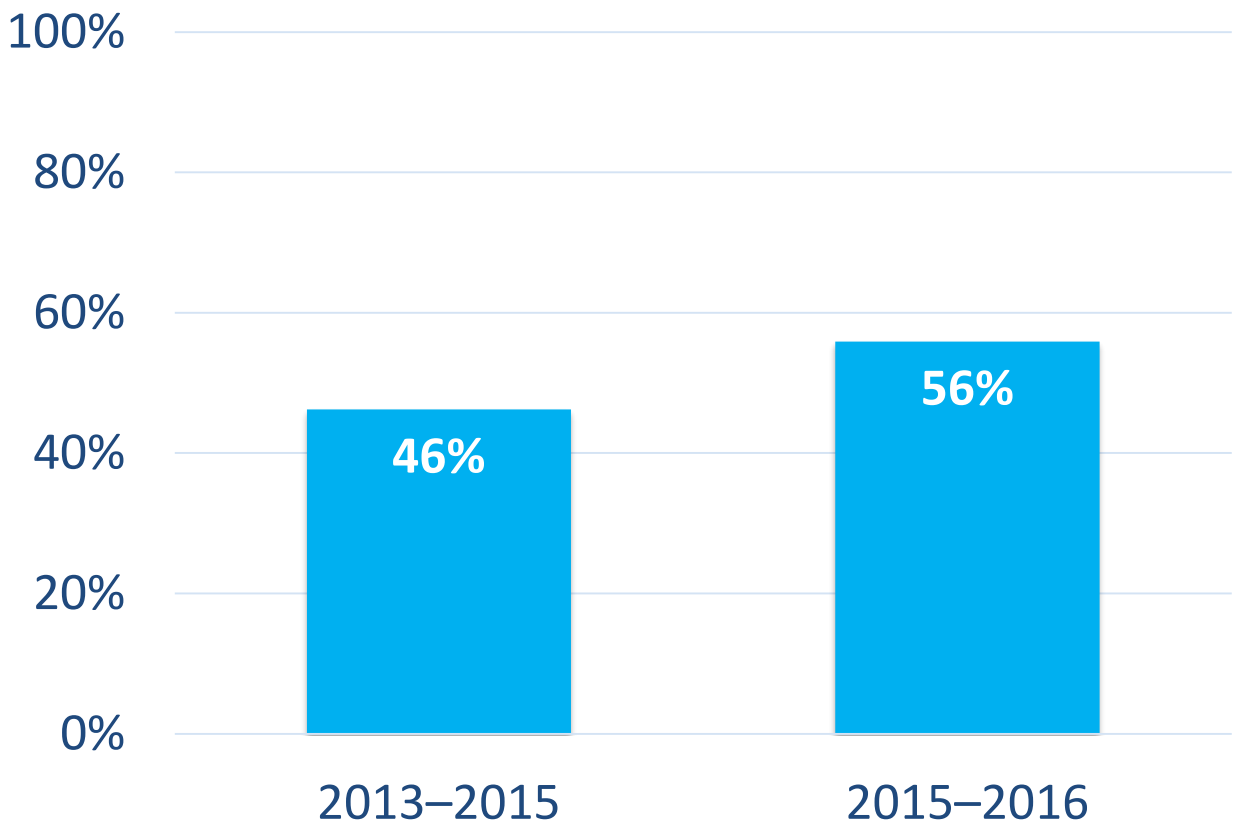
Getting the most out of stated-preference data

- "Importance" can be a useful indicator
  - High response rate
- But it is difficult to define and encapsulates a complex array of factors
- Keep marching toward an even more conservative metric
  - Difficult to avoid truthfulness bias in stated-preference data, but do have a metric that is:
  - Even less subject to recall bias
  - More clear cut
  - More "counterfactual"…

What are indicators of rebate influence?: Essentiality

Would not have purchased/leased their EV without rebate



Rebate Essential

CVRP Consumer Survey. 2013–2015 edition: weighted, n=19,208
2015–2016 edition: weighted, n=11,457

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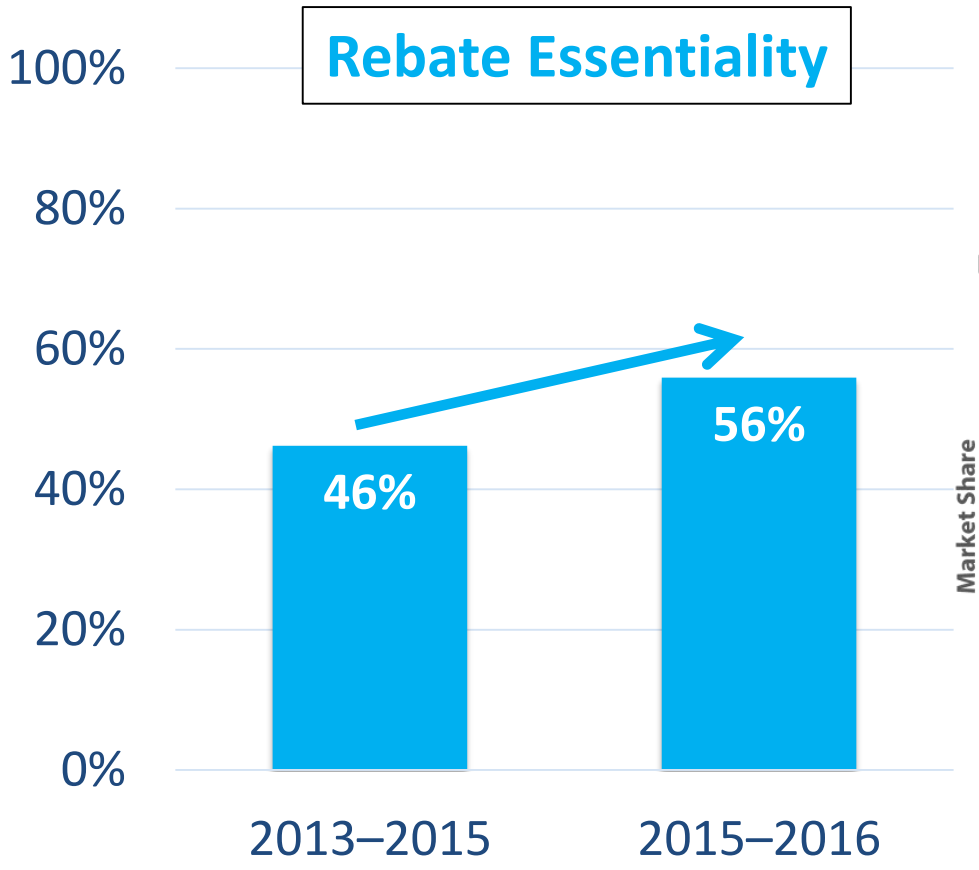
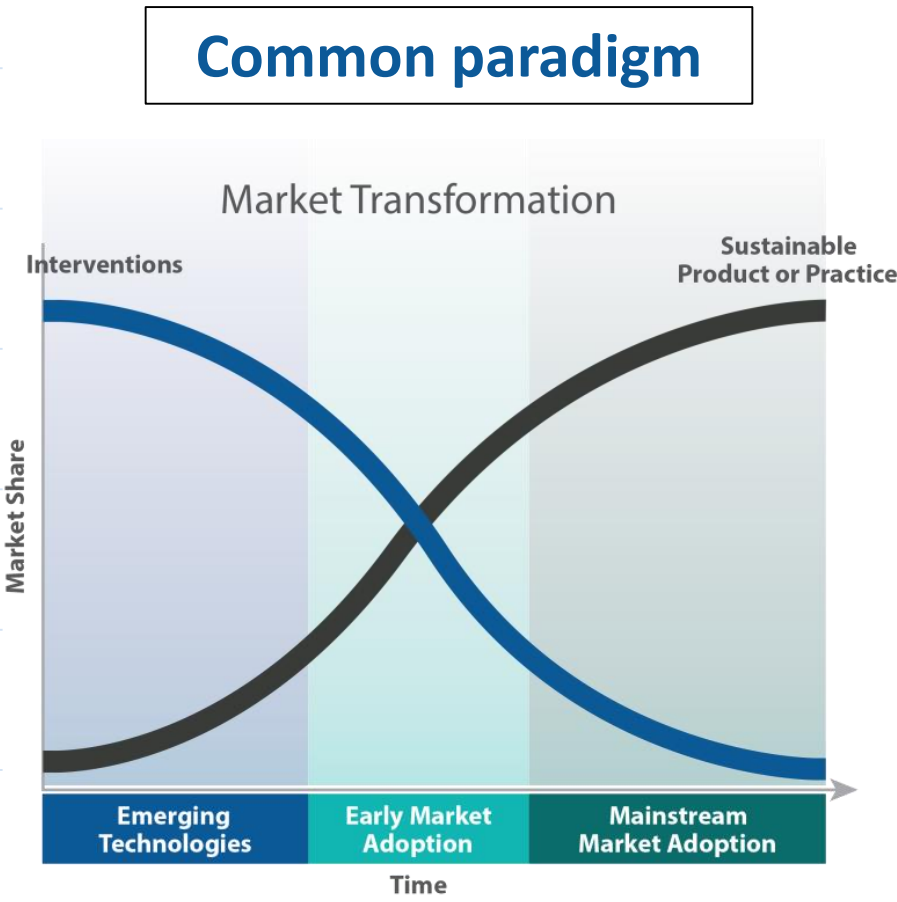
Rebate essentiality is growing; phase-out appears premature





CVRP Consumer Survey. 2013–2015 edition: weighted, n=19,208
2015–2016 edition: weighted, n=11,457

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Rebate Essential Consumers are Different

- 2016 BECC talk
- 2017 TRB paper and poster…

Target Consumers: "Rebate Essentials"

Consumers most influenced by the rebate:

Demographics: male, non-white, higher education, lower household income, perhaps younger and larger households

Motivations and interest: less motivated by environmental impacts, more motivated by saving money on fuel, carpool lane access, and perhaps energy independence; lower initial interest in EVs

Information gathering: found it more difficult to find info on EVs, spent more time researching online, learned about the rebate before going to the dealer

Vehicle characteristics: lower price, bought (vs. lease)

Differences – PHEV Consumers

The odds are higher for PHEV consumers that are younger, more motivated by energy independence and buying rather than leasing.

Differences – BEV Consumers

The odds are higher for BEV consumers in larger households and MUDs, with no solar or workplace charging, and living in central California.

PHEV Odds Ratio	BEV Odds Ratio	Explanatory Variable
		Consumer demographics
1.38	1.18	Male
1.25	1.23	Non-white ethnicity
1.08	1.11	Graduate degree (vs. 2nd-highest: Bachelor's)
–	–	Bachelor's degree (vs. 2nd: some college or less)
1.05	1.04	Lower household income ($50k)
1.007	–	Younger (years)
–	1.07	More people in household (#)
		Housing and region
–	1.19	Multi-unit dwelling (vs. non-MUD)
–	1.003	No solar (vs. 2nd-highest: planning solar)
–	1.18	No workplace charging (vs. 2nd-highest: WPC)
–	1.51	Central CA (vs. 2nd-highest: Far South CA)
–	–	No workplace charging (vs. access to WPC)
–	–	Central CA (vs. 2nd-highest: South CA)
		Reasons and interest
1.24	1.33	More motivated by saving money on fuel
1.04	1.12	More motivated by carpool lane access
1.08	1.08	Less motivated by reducing environmental impacts
1.09	–	More motivated by energy independence
–	–	More motivated by vehicle performance
1.41	1.29	Lower initial interest in EVs
Yes	Yes	Rebate essential
		Information gathering
1.22	1.18	Found it more difficult to find information on EVs
1.19	1.15	Spent more time researching EVs online
1.18	1.17	Did not hear about the rebate from the dealer
		Transactional factors
1.000019	1.000016	Vehicle price is lower ($)
1.27	–	Buy (vs. lease)
1.14	–	Chevy PHEV (vs. 2nd-highest: Toyota)
–	1.04	Nissan BEV (vs. 2nd-highest: FIAT)
–	–	Ford (vs. 2nd-highest: other)
–	–	FIAT (vs. 2nd-highest: Nissan)
–	1.001	Acquisition date (days)
–	–	First EV
–	–	Replacing a vehicle

https://cleanvehiclerebate.org/eng/content/infographic-characterizing-california-electric-vehicle-consumer-segments-trb-poster

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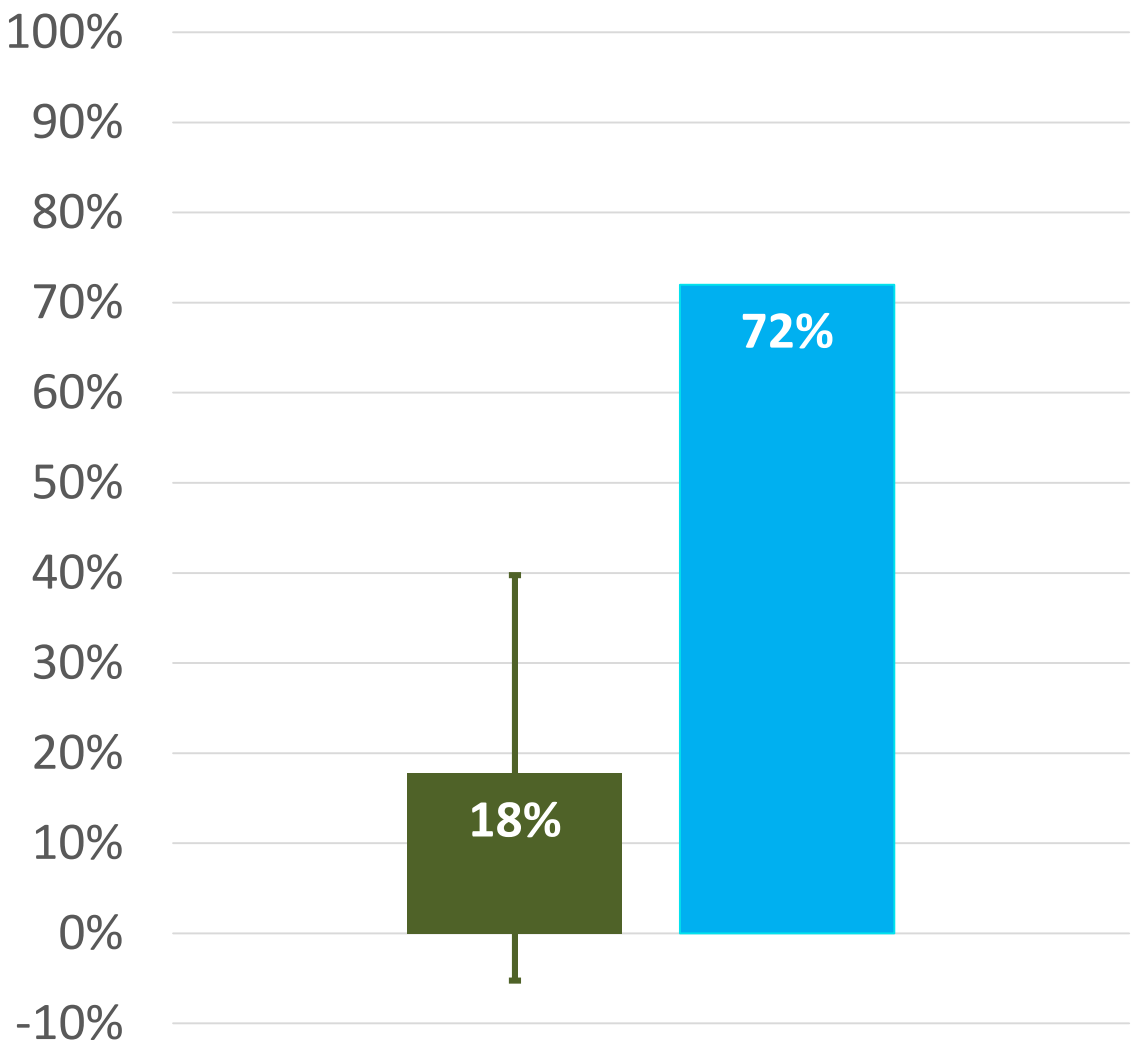
Program Implications

Market and Emissions

Literature: Market Impacts

Author/Year	Variables Examined	Effect/Size
Sierzchula et al. (2014)	Country financial incentives – Global PEV market share	+ **
Jin et al. (2014)	Monetized non-financial BEV incentives – BEV sales	+ ***
	BEV financial subsidies – BEV sales	+
	Monetized non-financial PHEV incentives – PHEV sales	Not significant
DeShazo et al. (2014)	CA state rebate design – PEV sales	+
Narassimhan & Johnson (2014)	Purchase rebate – BEV registrations	+ *
	Purchase rebate - PHEV registrations	Not significant
Lutsey et al. (2015)	Monetized BEV benefits - BEV share	+ **
	Monetized PHEV benefits - PHEV share	Not significant
Clinton et al. (2015)	State rebate - BEV sales (Tesla & LEAF)	Not significant
	State rebate - BEV sales (LEAF)	Not significant
	State rebate - BEV sales (Tesla Only)	- **
Zhou et al. (2016)	Purchase incentives - BEV: Total Market	+ ***
	Purchase incentives - BEV: Mass Market (<$40,000)	+ ***
	Purchase incentives - BEV: Mid Market ($40-50,000)	Not significant
	Purchase incentives - BEV: Luxury (>$60,000)	- ***
	Purchase incentives - PHEV: Total Market	+ **
	Purchase incentives - PHEV: Mass Market (<$40,000)	+ **
	Purchase incentives - PHEV: Mid Market ($40-50,000)	Not significant
	Purchase incentives - PHEV: Luxury (>$60,000)	Not significant
Lutsey et al. (2016)	State incentive (top 50 MSA) - BEV vehicle shares	Not significant
	State incentive (top 50 MSA) - PHEV vehicle shares	+ **
	State incentive (top 50 MSA) - PEV vehicle shares	Not significant
	State incentive (top 200 MSA) - BEV vehicle shares	+ **
	State incentive (top 200 MSA) - PHEV vehicle shares	+ **
	State incentive (top 200 MSA) - PEV vehicle shares	+ **
Jenn et al. (2017)	Individual credit (rebate or tax credit) - EV registrations	Not significant
	Individual credit (rebate or tax credit) w/knowledge of incentives - EV registrations	+**

External vs. Internal Perspectives on Rebate Impact



- U.S.: Rebate Impact on Non-Tesla Battery EV Sales (Clinton et al. 2015)
- CA: Rebate Essentiality for Non-Tesla Battery EVs (CVRP 2015–2016)

National Renewable Energy Laboratory (NREL). February 2015. CVRP Consumer Survey. 2015–2016 edition: weighted, n=11,457

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Why are added vehicle volumes important?

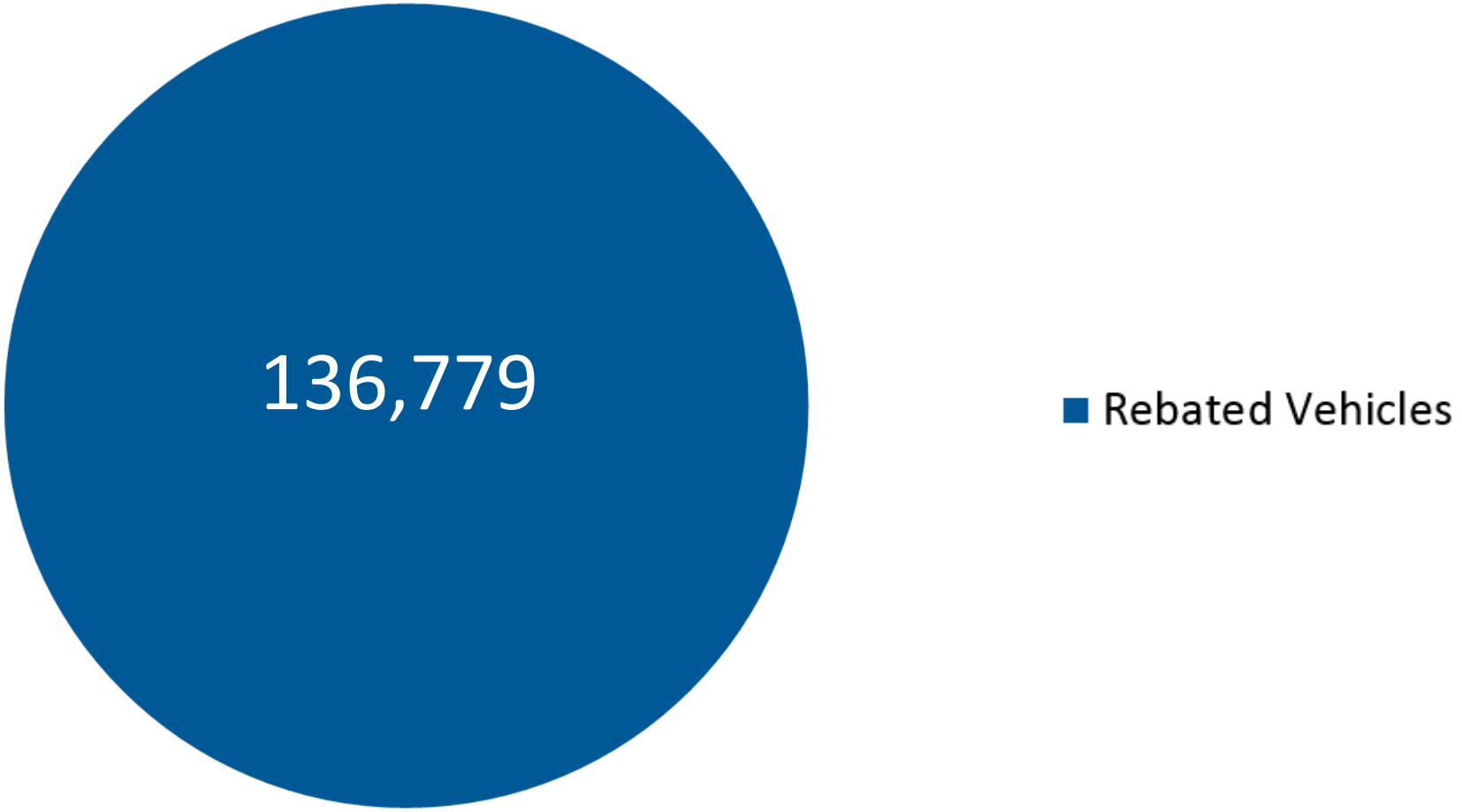
Volume is a proxy for a variety of market benefits, e.g.:

- For producers
  - Economies of scale
  - OEM learning-by-doing
  - Supply-chain creation
- For consumers
  - Consumer awareness and understanding
    - Parking lots as “second showrooms”
  - Information spillovers
  - Consumer learning-by-doing
    - Charging confidence
  - Adoption network effects
- For society
  - Use potential
    - Positive environmental externalities

How many vehicles has CVRP induced into the market?

Rebated, rebate-“important,” and rebate-essential

How many EVs did CVRP rebate? *(during this period)*



Total number of vehicles rebated corresponding to Consumer Surveys 13–15 & 15–16 [purchase/lease dates Sep 2012 thru May 2016] = 136,779

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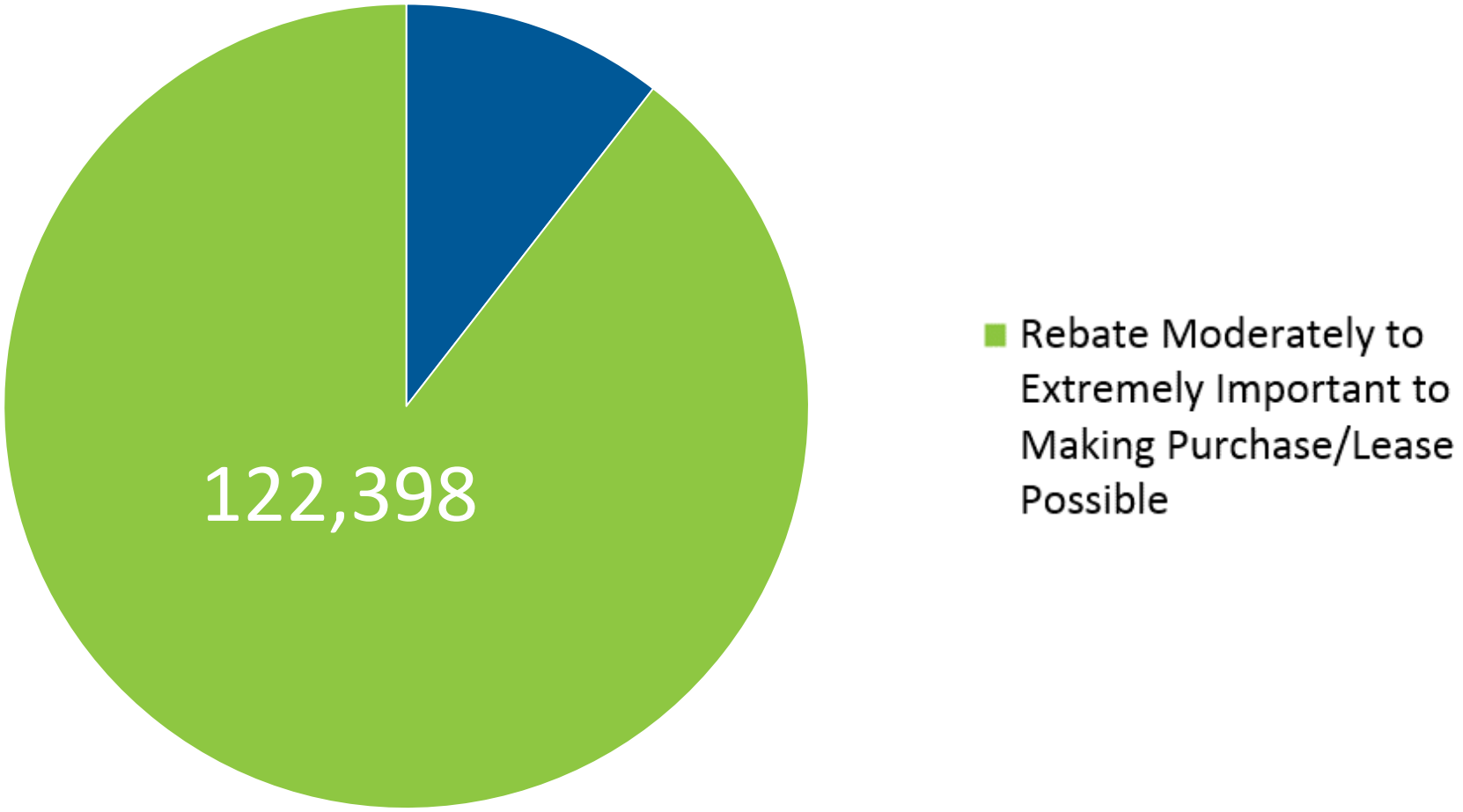
How many EVs has CVRP enabled in a moderately to extremely important way? (calc. by tech. type, *during this period)*



Total number of vehicles rebated corresponding to Consumer Surveys 13-15 & 15-16 [with purchase/lease dates Sep 2012 thru May 2016] = 136,779

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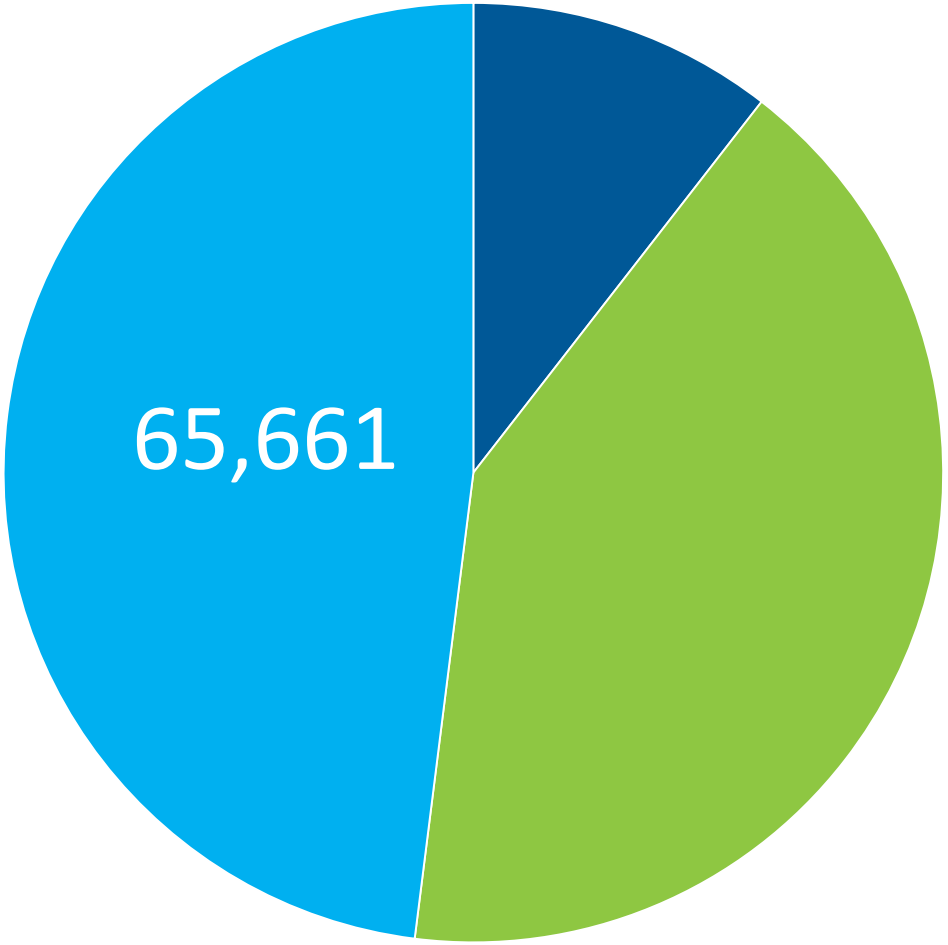
For how many vehicles has CVRP been essential?

(calc. by tech. type, *during this period)*

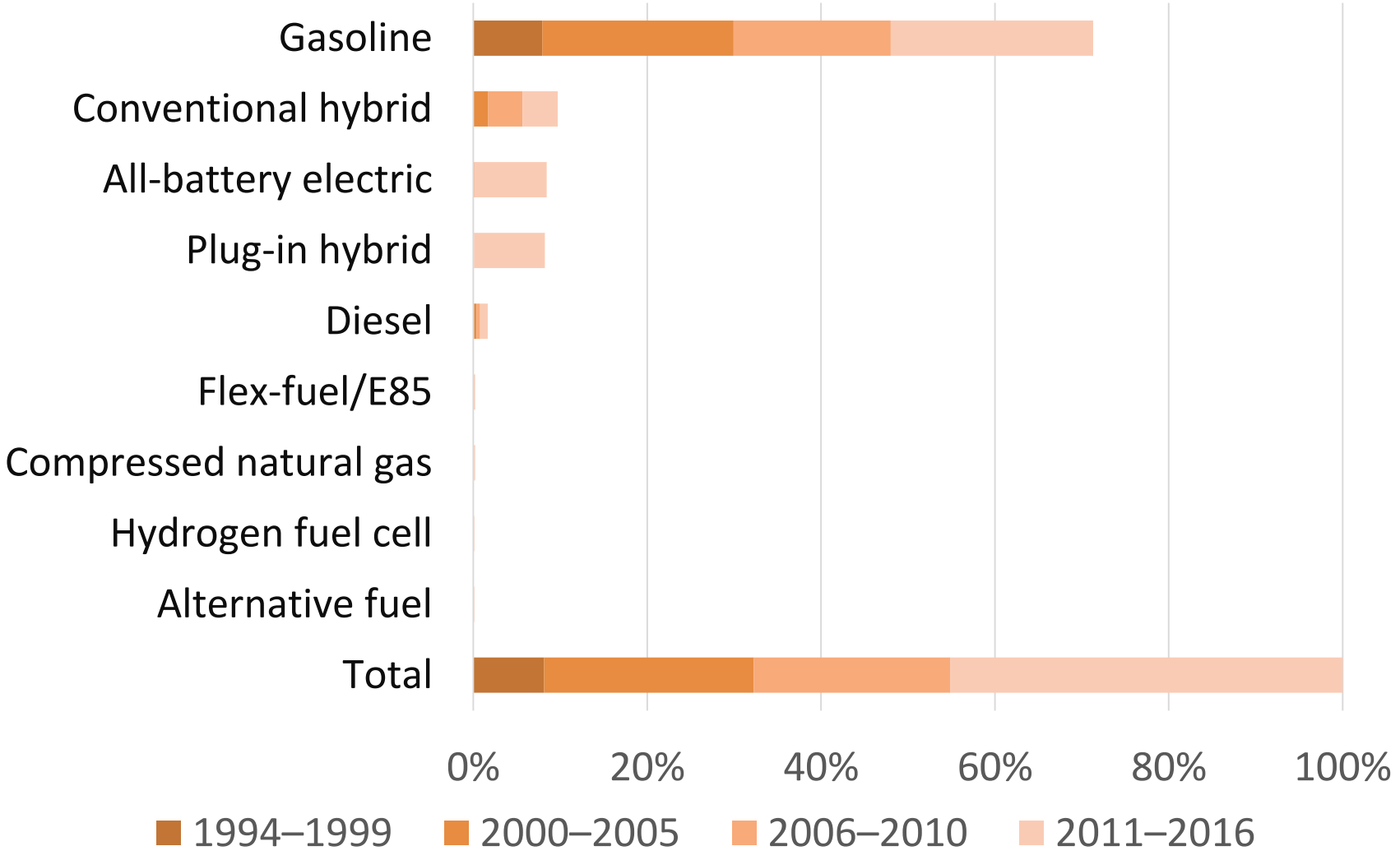


Total number of vehicles rebated corresponding to Consumer Surveys 13–15 & 15–16 [purchase/lease dates Sep 2012 thru May 2016] = 136,779

What vehicles have rebates removed from the market?

Replacing older, more polluting vehicles

What vehicles have rebates helped replace?



CVRP Consumer Survey. **2015–2016 edition**: weighted, n=8,532

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How many emissions has CVRP reduced?

Greenhouse-gas savings

Carbon prepared three ways

	1. CARB FP	2. CARB in AFLEET	3. Enhanced AFLEET
Approach	Vehicle emissions factor (EF) difference		
Rebated Vehicle	Average by tech. type		
Comparison Vehicle	Ave. new 2016 gasoline (EMFAC)		

CA-GREET 2.0: https://www.arb.ca.gov/fuels/lcfs/ca-greet/CA-GREET2.0-suppdoc-060415.pdf
The 2016-2017 AQIP Funding Plan provides a description of their quantification methodology for emissions reduction calculations at: https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_appa.pdf
AFLEET: https://greet.es.anl.gov/afleet

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Rebated Vehicle	Average by tech. type		
Comparison Vehicle	Ave. new 2016 gasoline (EMFAC)		
Electric Grid	CA-GREET ?		
Gasoline	CA-GREET CaRFG?		

CA-GREET 2.0: https://www.arb.ca.gov/fuels/lcfs/ca-greet/CA-GREET2.0-suppdoc-060415.pdf
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Carbon prepared three ways

	1. CARB FP	2. CARB in AFLEET	3. Enhanced AFLEET
Approach	Vehicle emissions factor (EF) difference	Counterfactual fleet – rebated fleet	
Rebated Vehicle	Average by tech. type	Actual CVRP models	
Comparison Vehicle	Ave. new 2016 gasoline (EMFAC)	Ave. new 2016 gasoline (AFLEET)	
Electric Grid	CA-GREET ?	CA-GREET 2.0	
Gasoline	CA-GREET CaRFG?	GREET 1_2015	

CA-GREET 2.0: https://www.arb.ca.gov/fuels/lcfs/ca-greet/CA-GREET2.0-suppdoc-060415.pdf
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Approach	Vehicle emissions factor (EF) difference	Counterfactual fleet – rebated fleet	Counterfactual fleet – rebated fleet
Rebated Vehicle	Average by tech. type	Actual CVRP models	Actual CVRP models
Comparison Vehicle	Ave. new 2016 gasoline (EMFAC)	Ave. new 2016 gasoline (AFLEET)	MY-specific, sales-weighted ave. new gasoline
Electric Grid	CA-GREET ?	CA-GREET 2.0	CA-GREET 2.0
Gasoline	CA-GREET CaRFG?	GREET 1_2015	GREET 1_2015

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The 2016-2017 AQIP Funding Plan provides a description of their quantification methodology for emissions reduction calculations at: https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_appa.pdf
AFLEET: https://greet.es.anl.gov/afleet

Per-vehicle Year-1 Reductions by Model

Metric tons of CO_2e *reductions* (percent change from 1., percent change from 2.)

	1. CARB FP	2. CARB in AFLEET	3. Enhanced AFLEET
Average **PEV** savings	2.56	2.41 **(-6%)**	2.67 **(4%, 11%)**

Based on 136,779 rebated vehicles (55,307 PHEV: 81,472 BEV)

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Per-vehicle Year-1 Reductions by Influence

Metric tons of CO_2e *reductions* (percent change from Rebated)

	Rebated	Rebate "Important"	Rebate Essential
Average **PEV** savings	2.67	2.68 **(0%)**	2.72 **(2%)**
Average **BEV** savings	2.80	2.82 **(1%)**	2.84 **(1%)**
Average **PHEV** savings	2.48	2.48 **(0%)**	2.49 **(1%)**

Survey Data = 31,071 responses (12,462 PHEV: 18,609 BEV), scaled to represent 136,779 participants

Year-1 Emissions Reductions

Thousand metric tons of CO_2e *reductions* (percent change from CARB in AFLEET)

Assumptions	Low GHG Savings	CARB in AFLEET	High GHG Savings	Enhanced AFLEET
VMT	245 **(-26%)**	330	379 **(15%)**	365 **(11%)**
PHEV eVMT%	302 **(-8%)**		368 **(12%)**	
Electric Grid	295 **(-11%)**		483 **(47%)**	

Based on 136,779 rebated vehicles (55,307 PHEV: 81,472 BEV)

Summary and Next Steps

Summary

- Participant demographics are *similar* to car buyers, but…
  - Less frequently white, more frequently male, and changing
- >3/4th of rebated EVs replace older, more polluting vehicles (more so for PHEVs)
- Rebate influence may be significantly higher than indicated in literature to date, is growing
- Utilizing program-specific data:
  - Increases market impacts significantly
  - Increases emissions reductions 11+%
    - So far; more to come (next slide)
- Emissions reduction sensitivity to individual inputs examined range -26% to 15%
  - Upside potential of 100% renewable grid is 47%

Next Steps: Conservatisms to Address

- Pre-income-cap
- Majority demographic summary (segments elsewhere)
- Vehicle volumes used as a proxy for other benefits that could be quantified
- Counterfactual fleet assumed all rebated consumers would have bought new ”comparison vehicle” rather than kept old vehicle
- Lower-C gasoline
- No cleaning of grid over time
- Focused on Year-1 benefits, not 30-month program requirements, or 6–15-year vehicle lifetimes
- Other inputs based on conservative CARB inputs

Other Next Steps, Program Data to Utilize

- Finish harmonization with latest CARB inputs to establish consistent baseline
- Explore
  - Time-dependent gasoline content
  - Gasoline substitute for BEV VMT make-up
- Incorporate
  - 2016–2017 survey data when available
  - Specific vehicles replaced
  - Continue reducing aggregation with case-specific values
- Use Monte Carlo analysis to prioritize areas with greatest uncertainty

Thank You for Your Attention

What would you like to know more about?
What decisions are you facing?

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We work nationally in the clean energy industry and are always open to collaboration.

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Sensitivity Testing: Details

	Low GHG *Reductions*	CARB in AFLEET	High GHG *Reductions*
VMT	BEV: 7,916 PHEV: 11,778	BEV: 11,059 PHEV: 14,855	BEV: 13,494 PHEV: 15,283
PHEV eVMT%	15% Electric	40% Electric	74.5% Electric
Electric Grid	WECC	CA-GREET 2.0	100% renewable

Electricity Mix	WECC	CA-GREET 2.0	EIA - CA	100% renewable
Coal	25.4%	7.15%	0.16%	
Oil (Residual oil)	0.2%	1.38%	0.05%	
Gas (Natural gas)	32.5%	50.75%	49.00%	
Biomass	0.2%	2.62%	3.05%	
Nuclear	7.9%	15.18%	9.50%	
Renewable	33.8%	22.92%	38.24%	100%

CARB. California's Advanced Clean Cars Midterm Review: Summary Report for the Technical Analysis of Light Duty Vehicle Standards. January 18, 2017.
CA-GREET 2.0: https://www.arb.ca.gov/fuels/lcfs/ca-greet/CA-GREET2.0-suppdoc-060415.pdf
The 2016-2017 AQIP Funding Plan provides a description of their quantification methodology for emissions reduction calculations at: https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_fy16-17_fundingplan_appa.pdf
AFLEET: https://greet.es.anl.gov/afleet

Additional Online Resources

Additional Participant Evaluation Examples

- Progress in **Disadvantaged Communities** (AEA pres 2016)
- **Information Channels** (EV Roadmap pres, 2016)
  - Exposure & importance of various channels, consumer time spent researching various topics
- **Infographics**
  - Overall (CVRP infographic, 2016)
  - Disadvantaged Communities (CVRP DAC infographic, 2017)
- Characterization of **Participating Vehicles and Consumers** (CVRP research workshop pres, 2015)
- **Program Participation** by Vehicle Type and County (CVRP brief 2015)
- **Dealer services**: Importance and Prevalence (EF pres 2015)

http://energycenter.org/resources?combine=&resource=All&technology=248&target=All

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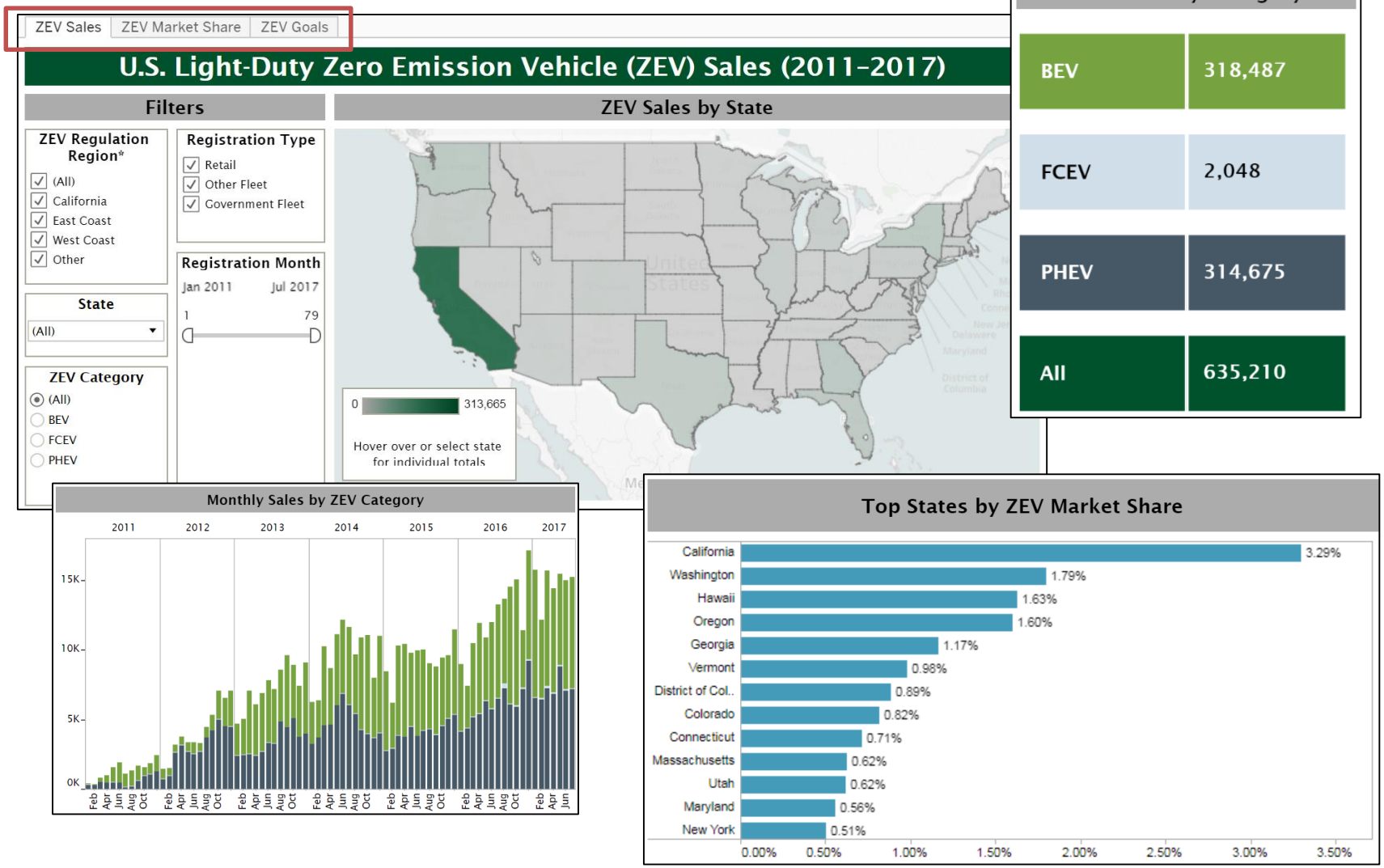
Zero Emission Vehicle Dashboard



thru July 2017, https://autoalliance.org/energy-environment/zev-sales-dashboard/

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