

# What Vehicles Are Electric Vehicles Replacing and Why?

BECC Conference, “Charging Into the Future” Session, 19 November 2019, Sacramento CA

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with thanks to Keir Havel and others at CSE

Version: January 2020



# CSE Areas of Expertise

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## **Clean Transportation**

Adoption of electric vehicles  
and deployment of charging  
infrastructure



## **Built Environment**

Advancing energy efficiency  
and renewable resources



## **Technology Convergence**

Interconnecting systems to  
achieve decarbonization

# State EV Cash Rebate Programs Administered by CSE

(as of 30 Sep. 2019)



## Oregon CVRP

	CALIFORNIA CLEAN VEHICLE REBATE PROJECT	MOR-EV Massachusetts Offers Rebates for Electric Vehicles	CHEAPR Connecticut Hydrogen and Electric Automobile Purchase Rebate	NEW YORK STATE	Oregon CVRP
<b>Fuel-Cell EVs</b>	\$5,000	\$1,500	\$5,000		
<b>All-Battery EVs</b>	\$2,500	\$1,500	≥ 200 e-miles \$2,000 ≥ 120 e-miles \$1,500 < 120 e-miles \$500	≥ 120 e-miles \$2,000 ≥ 40 e-miles \$1,700 ≥ 20 e-miles \$1,100 < 20 e-miles \$500	≥ 10 kWh \$2,500 < 10 kWh \$1,500
<b>Plug-in Hybrid EVs</b>	\$2,500 (i3 REx) \$1,500	BEVx only: \$1,500	≥ 45 e-miles \$1,000 < 45 e-miles \$500		
<b>Zero-Emission Motorcycles</b>	\$900	\$450			\$750 (and NEVs)
	<ul style="list-style-type: none"> <li>≥ 20 UDDS e-miles</li> <li>Income cap</li> <li>Increased rebates for lower-income households (+\$2,000)</li> </ul>	<ul style="list-style-type: none"> <li>Purchase price ≤ \$50k</li> <li>No fleet rebates</li> </ul> Program ended 9/30/19	<ul style="list-style-type: none"> <li>BEVs &amp; PHEVs ≤ \$50k base MSRP, FCEVs ≤ \$60k</li> <li>Point-of-sale option</li> <li>\$150 dealer incentive</li> </ul>	<ul style="list-style-type: none"> <li>Base MSRP &gt; \$60k = \$500</li> <li>Point-of-sale</li> </ul>	<ul style="list-style-type: none"> <li>Base MSRP &lt; \$50k</li> <li>Point-of-sale option</li> <li>Increased rebates for lower-income households (+\$2,500), used EVs also qualify</li> </ul>

# Outline: Vehicle Replacement Over Time

- Context
- Are EVs\* Replacing Older Vehicles?
- What Vehicles are Plug-in EVs\*\* Replacing?
- What Motivated Vehicle Replacement?
- What Might Have Happened Without the Rebated Plug-in EV?
- Wrap Up

# Outline: Vehicle Replacement Over Time

- Context
  - Research aims and data (for reference)
- Are EVs\* Replacing Older Vehicles?
  - Replacement rates across states, by tech type
- What Vehicles are Plug-in EVs\*\* Replacing?
  - Replaced-vehicle model year, tech type
- What Motivated Vehicle Replacement?
  - Replacement decision factors, push vs. pull, and by tech type
- What Might Have Happened Without the Rebated Plug-in EV?
  - Counterfactual behaviors
- Wrap Up
  - Summary, additional resources, and supplementary details

A close-up photograph of a person's hand plugging a charging cable into the port of an electric vehicle. The scene is set outdoors at sunset, with warm, golden light and lens flare effects. In the background, a public charging station with multiple charging cables is visible, along with a blurred city street scene.

# Replaced Vehicles

Context, Replacement Rates, Vehicle Details, Decision Factors, Incentive Counterfactuals



# Context

Research Aims and Data

# Research Aims, Disclaimer, and Thanks

- This study was conducted to inform the California Clean Vehicle Rebate Project (CVRP) and, in doing so, inform broader assessments
  - *It does not necessarily represent the views of the California Air Resources Board*
  - *Nor does it represent a final determination for project-reporting purposes*
- We thank CARB staff for the opportunity to contribute to, and foster, the conversation

# 4-State Consumer Survey Data

(Shows Rebates to Individuals Only)

	 CALIFORNIA CLEAN VEHICLE REBATE PROJECT™	 <b>MOR-EV</b> Massachusetts Offers Rebates for Electric Vehicles	 <b>CHEAPR</b> Connecticut Hydrogen and Electric Automobile Purchase Rebate	 <b>NEW YORK STATE</b>	<b>Total</b>
<b>Vehicle Purchase/ Lease Dates</b>	Dec. 2010 – Dec. 2018	Jun. 2014 – Oct. 2018	May 2015 – Sep. 2018	Mar. 2017 – Jul. 2018	Dec. 2010 – Dec. 2018
<b>Survey Responses (total n)*</b>	62,092	4,555	1,565	1,808	70,020
<b>Program Population (N)</b>	278,538	10,920	3,510	8,651	301,619

\* Weighted to represent the program population along the dimensions of vehicle category, vehicle model, buy vs. lease, and county (using raking method)

# CA Consumer Survey Data

(Shows Rebates to Individuals Only)



	2013–15 Edition	2015–16 Edition	2016–17 Edition	2017–18 Edition	Total
	PHEVs, BEVs	PHEVs, BEVs	PHEVs, BEVs, FCEVs	PHEVs, BEVs, FCEVs	
<b>Vehicle Purchase/ Lease Dates</b>	Sep. 2012 – May 2015	April 2015 – May 2016	Dec. 2010 – May 2017	June 2017 – Dec. 2018	PHEVs and BEVs: Sep. '12 – Dec. '18 FCEVs: Dec. '10 – Dec. '18
<b>Survey Responses (total n)*</b>	19,460	11,611	9,367	21,654	62,092
<b>Program Population (N)</b>	91,081	45,698	48,588	93,171	278,538

\* Weighted to represent the program population along the dimensions of vehicle category, vehicle model, buy vs. lease, and county (using raking method)

# CA Consumer Survey Data: Plug-in EVs\*

(Shows Rebates to Individuals Only)



	2013–2015 Edition	2015–2016 Edition	2016–2017 Edition	2017–2018 Edition	Total
<b>Vehicle Purchase/ Lease Dates</b>	Sep. 2012 – May 2015	April 2015 – May 2016	May 2016 – May 2017	June 2017 – Dec. 2018	Sep. 2012 – Dec. 2018
<b>Survey Responses (total n)**</b>	19,460	11,611	8,957	20,864	60,892
<b>Program Population (N)</b>	91,081	45,698	46,839	89,944	273,562

\* PHEVs and BEVs

\*\* Weighted to represent the program population along the dimensions of vehicle category, vehicle model, buy vs. lease, and county (using raking method)

# EV Rebate Designs

(As of Sept. 2018; Reflective of Most of the Data Gathered)



**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

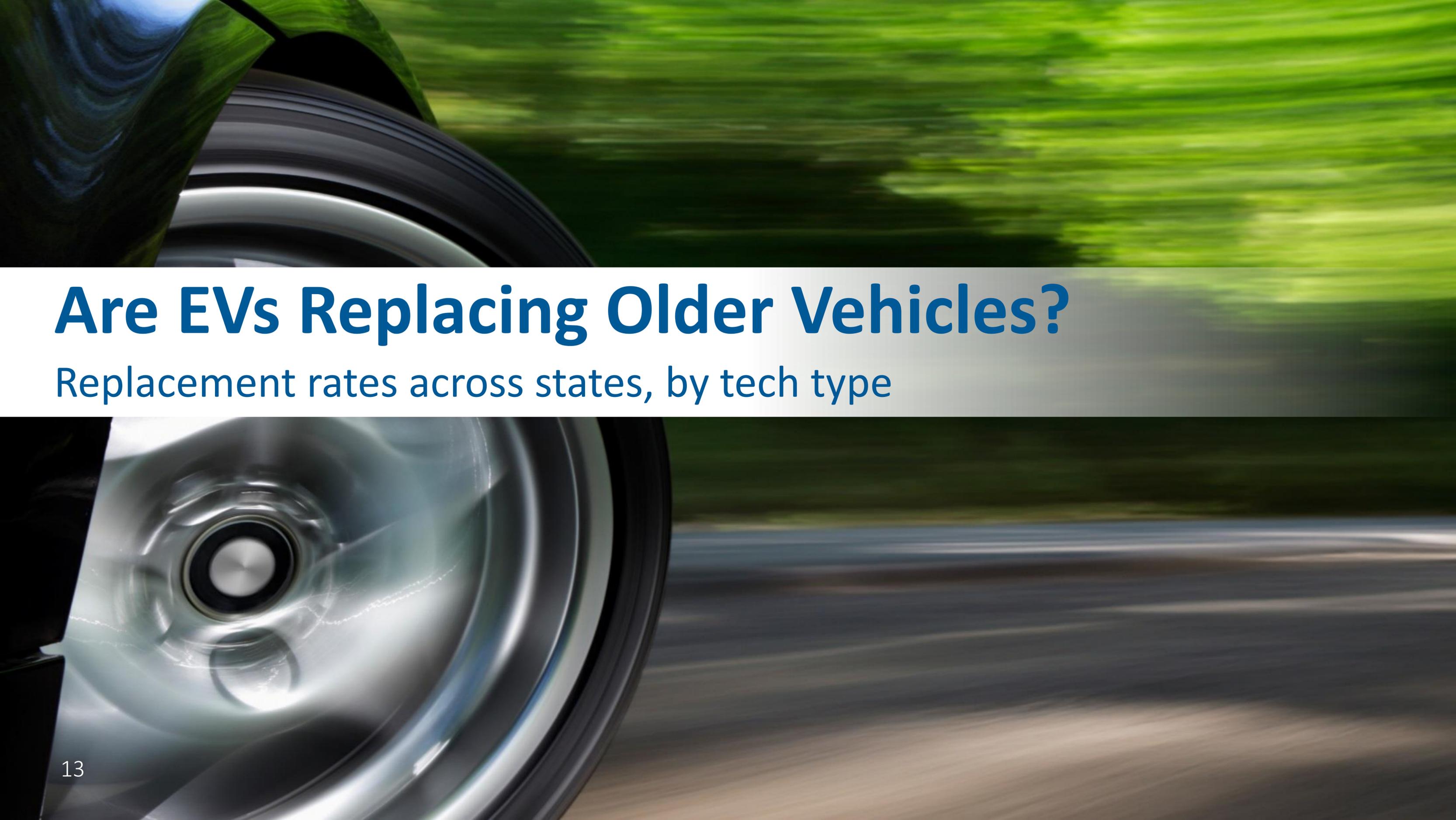
- e-miles ≥ 20 only
- Consumer income cap
- increased rebates for lower-income households

- Base MSRP ≥ \$60k = \$1,000 max.
- no fleet rebates

Program ended 9/30/19

- Base MSRP ≤ \$60k only
- dealer assignment
- \$150 dealer incentive (\$300 previous)

- Base MSRP > \$60k = \$500 max.
- point-of-sale via dealer

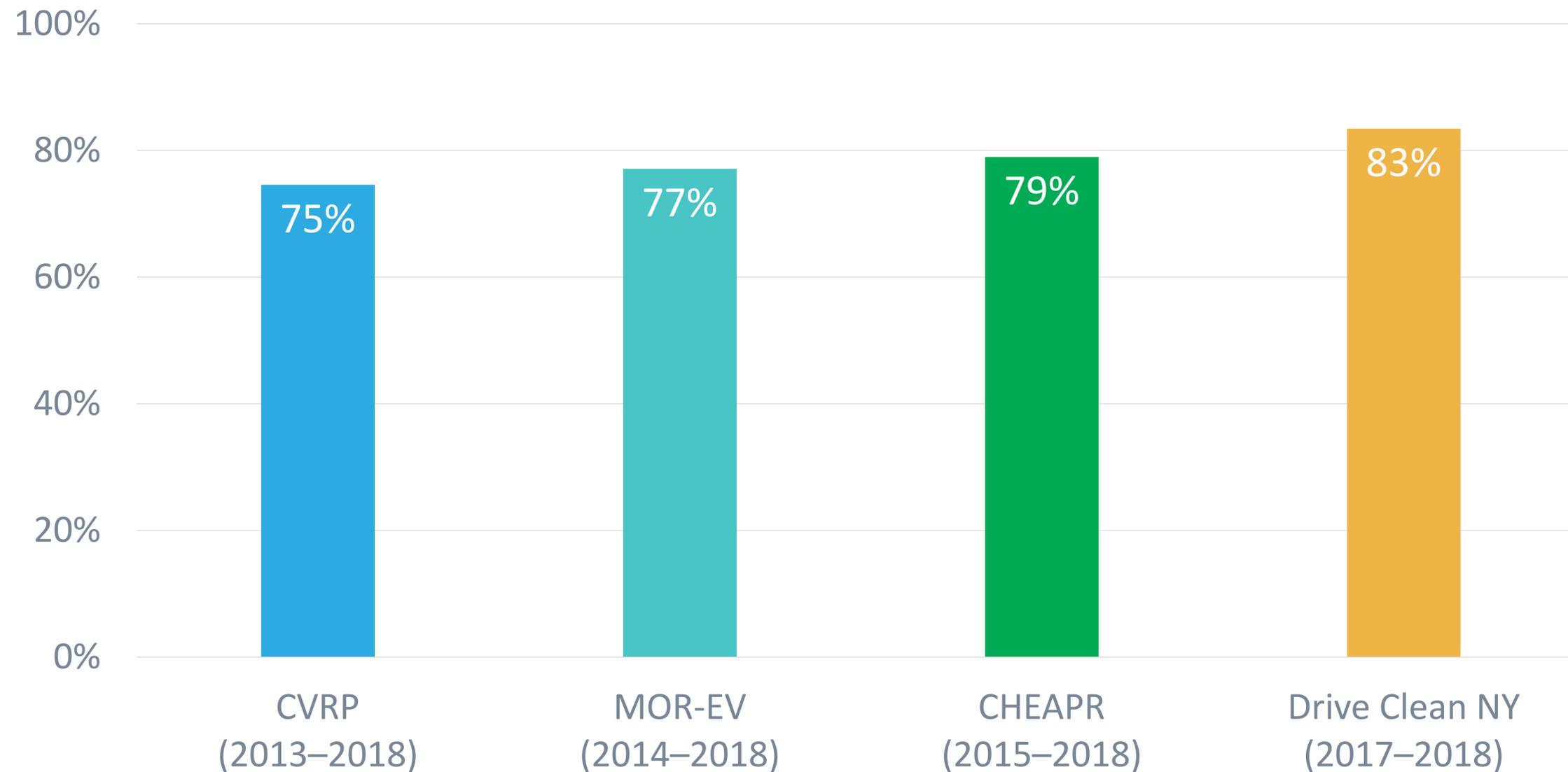


# Are EVs Replacing Older Vehicles?

Replacement rates across states, by tech type

# Do EVs Get Used?

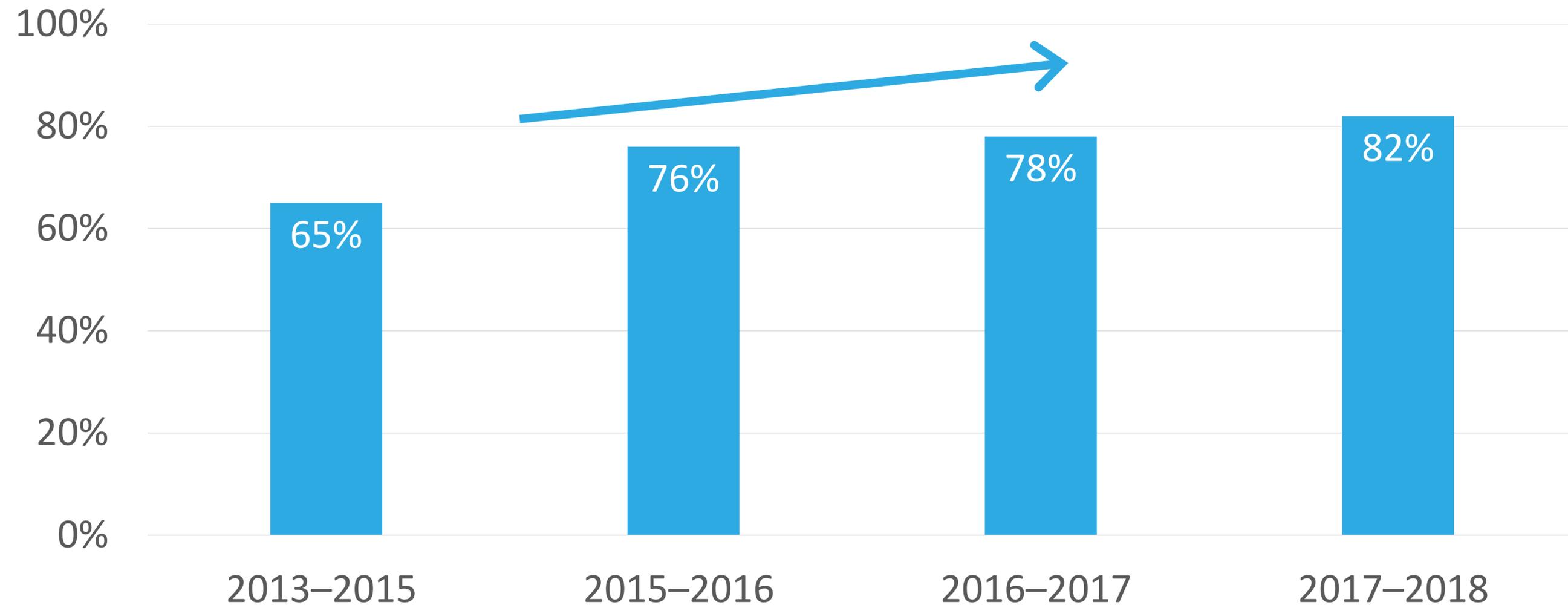
## Replaced a vehicle with their rebated **clean vehicle**



*Overall datasets: 70,020 total survey respondents weighted to represent 301,619 rebate recipients*

# Vehicle Replacement is Increasing

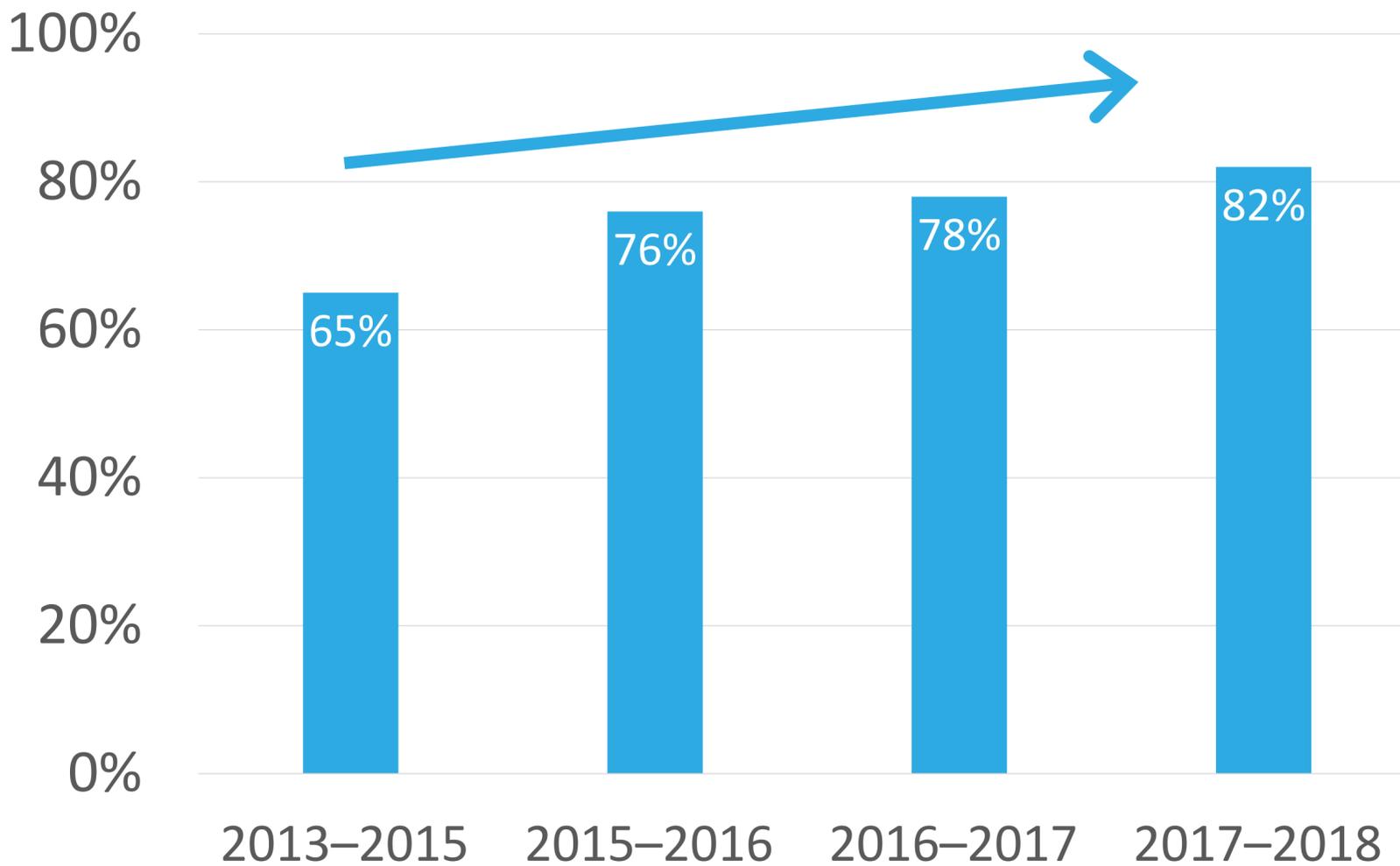
Replaced a vehicle with their rebated *plug-in EV*



CVRP Consumer Survey: 2013–2015 edition: weighted, question n=19,247  
2015–2016 edition: weighted, question n= 11,583  
2016–2017 edition: weighted, question n= 9,006  
2017–2018 edition: weighted, question n= 20,847

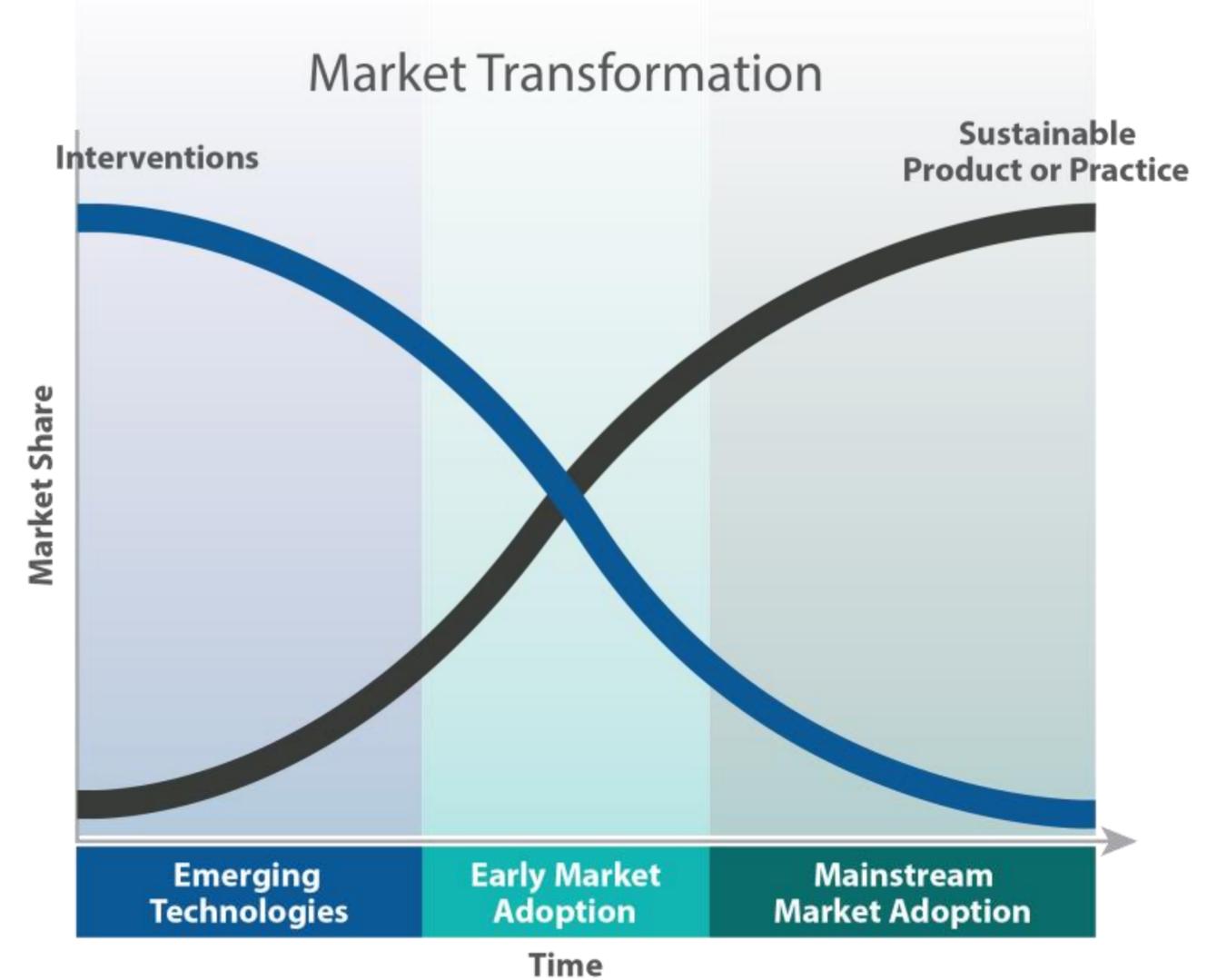
# Vehicle Replacement is *Increasing* Over Time, Contradicting a Common Paradigm About Phasing Out Incentives

Replaced a vehicle with their *plug-in EV*



≠

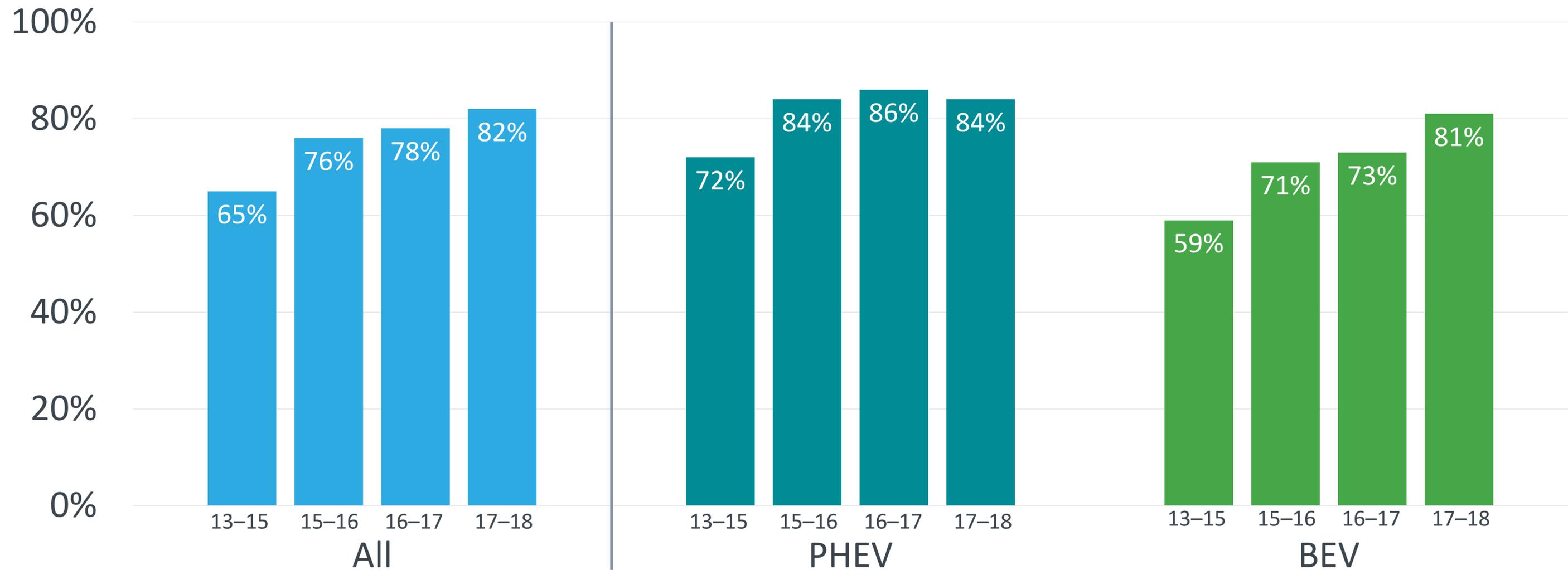
Common paradigm



CVRP Consumer Survey: 2013–2015 edition: weighted, question n=19,247  
 2015–2016 edition: weighted, question n= 11,583  
 2016–2017 edition: weighted, question n= 9,006  
 2017–2018 edition: weighted, question n= 20,847

# Vehicle Replacement Has Long Been High for PHEVs, Is Growing for BEVs

Replaced a vehicle with their rebated *plug-in EV*



CVRP Consumer Survey: 2013–2015 edition: weighted, question n=19,247  
2015–2016 edition: weighted, question n= 11,583  
2016–2017 edition: weighted, question n= 9,006  
2017–2018 edition: weighted, question n= 20,847

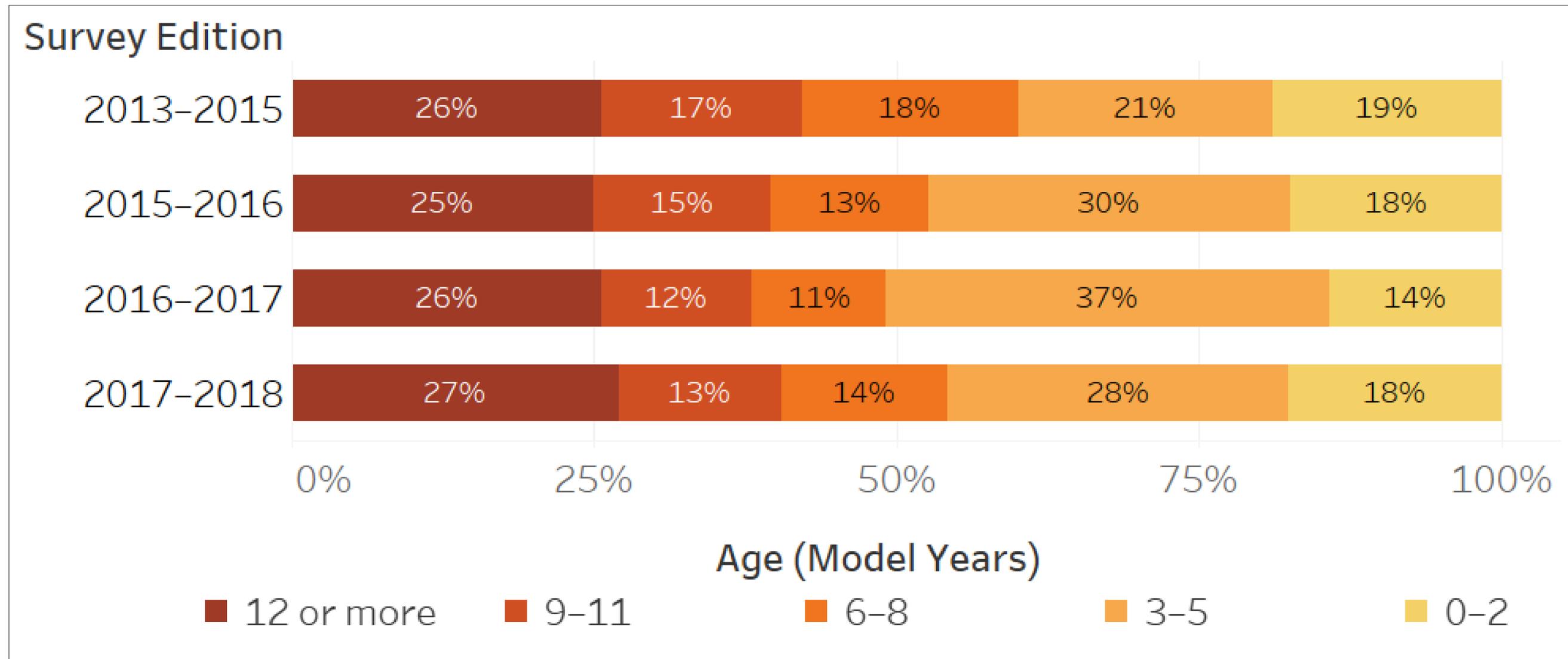


# What Vehicles are EV Replacing?

Replaced vehicle details

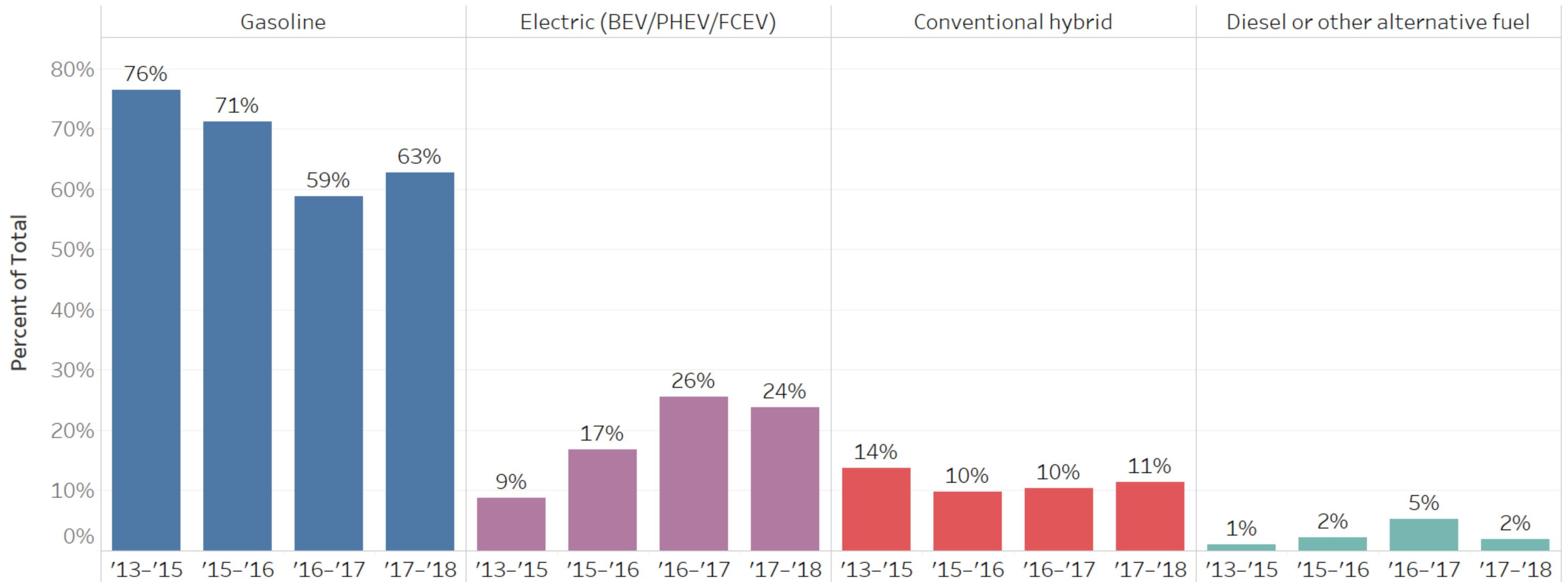
# Replaced Vehicle Age

Age = Rebated EV model year – Replaced vehicle model year



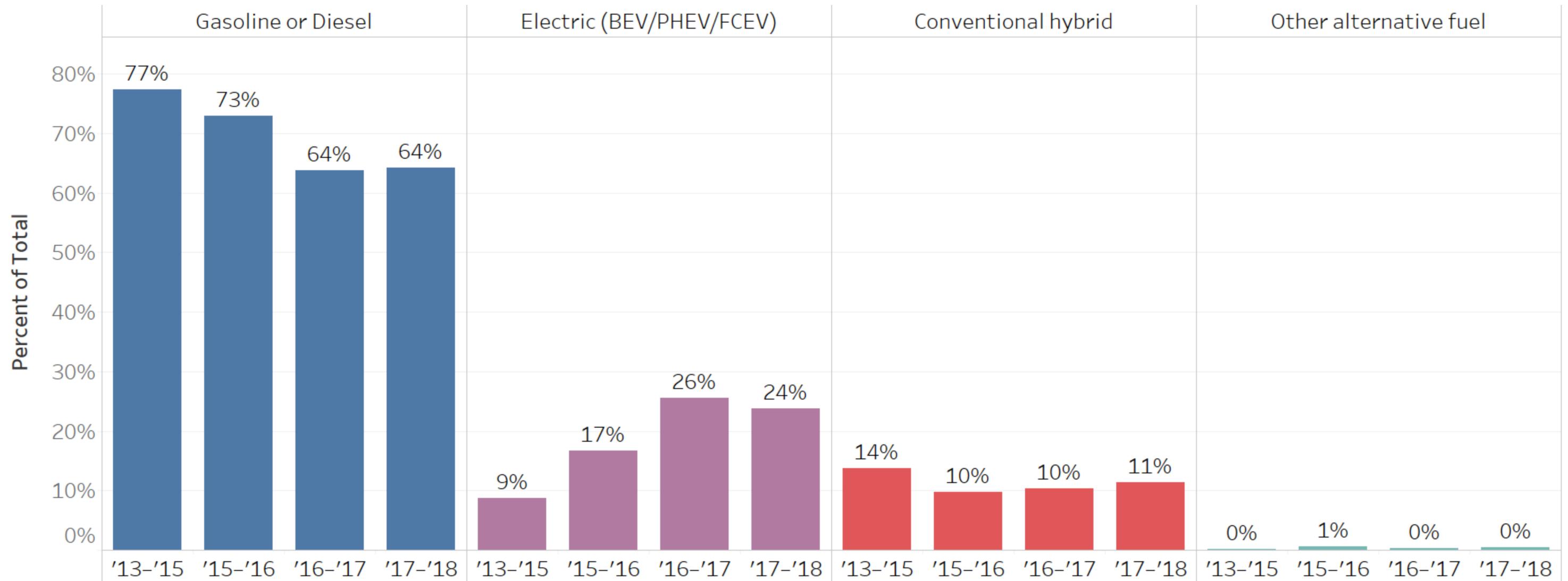
CVRP Consumer Survey: 2013-2015 edition: weighted, question n= 12,252  
 2015-2016 edition: weighted, question n= 8,627  
 2016-2017 edition: weighted, question n= 6,933  
 2017-2018 edition: weighted, question n= 14,696

# What Vehicle Types Have Rebates Helped Replace?



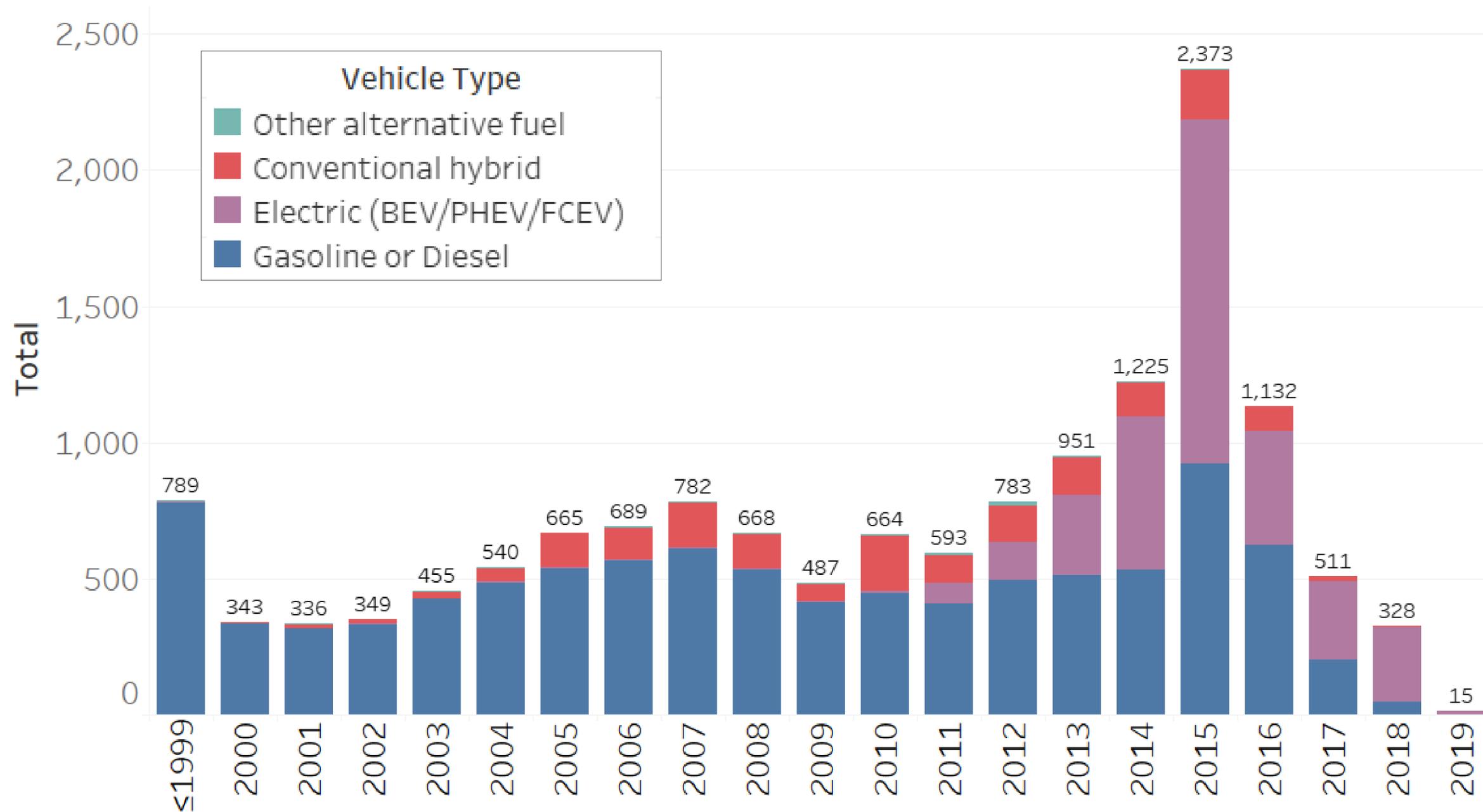
CVRP Consumer Survey: 2013–2015 edition: weighted, question n= 12,332  
 2015–2016 edition: weighted, question n= 8,594  
 2016–2017 edition: weighted, question n= 6,925  
 2017–2018 edition: weighted, question n= 17,021

# What Vehicle Types Have Rebates Helped Replace?

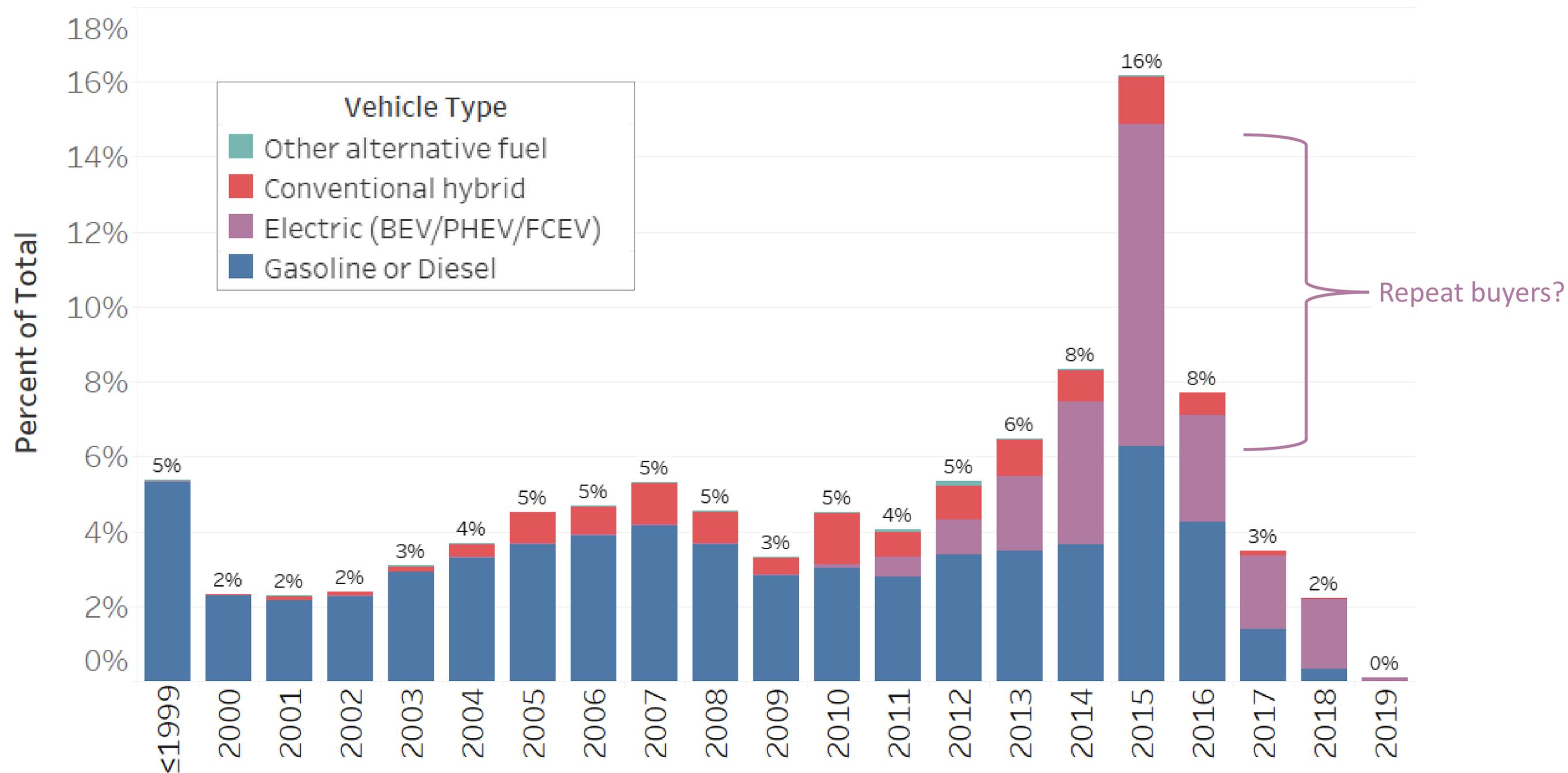


CVRP Consumer Survey: 2013–2015 edition: weighted, question n= 12,332  
 2015–2016 edition: weighted, question n= 8,594  
 2016–2017 edition: weighted, question n= 6,925  
 2017–2018 edition: weighted, question n= 17,021

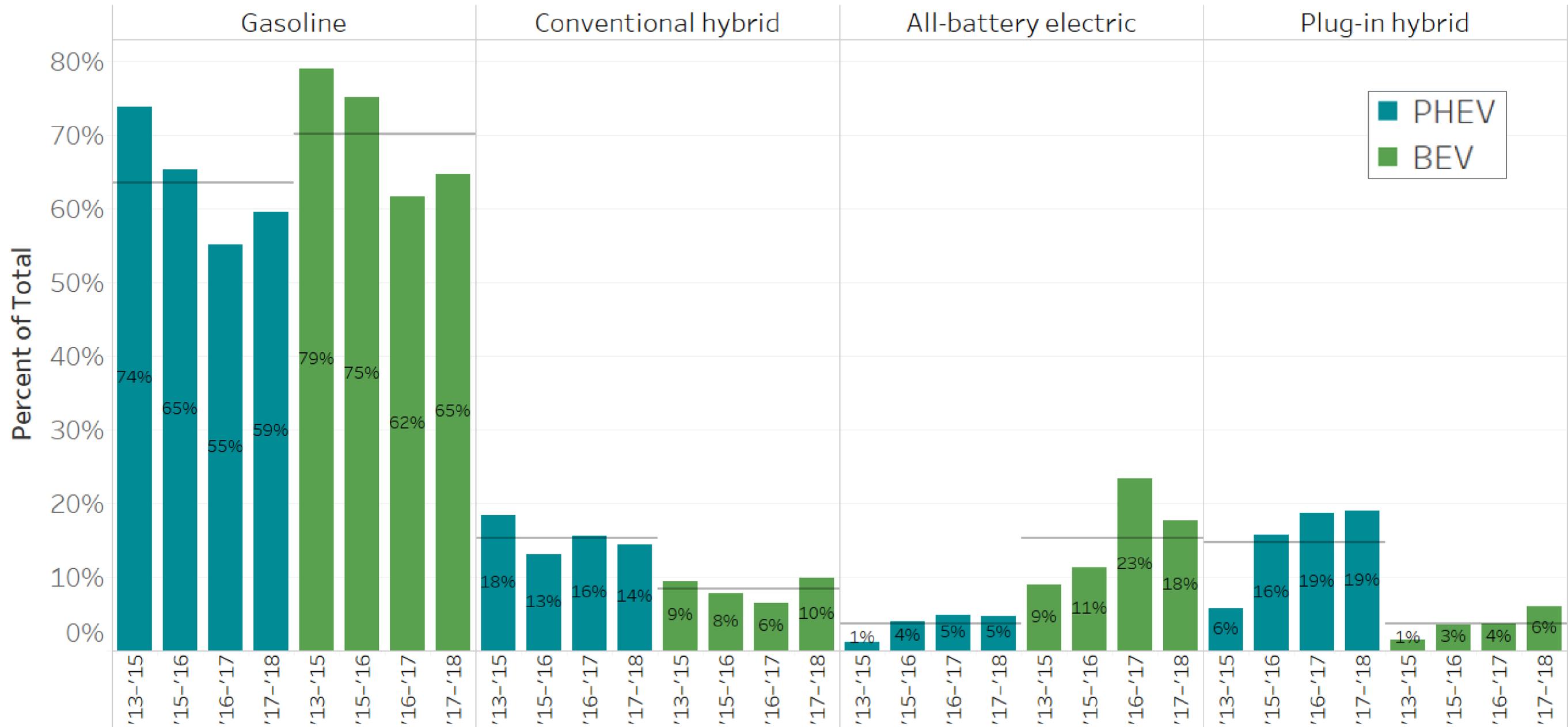
# Model-Year Distribution of Vehicles Replaced by 2017–18 Edition Survey Respondents



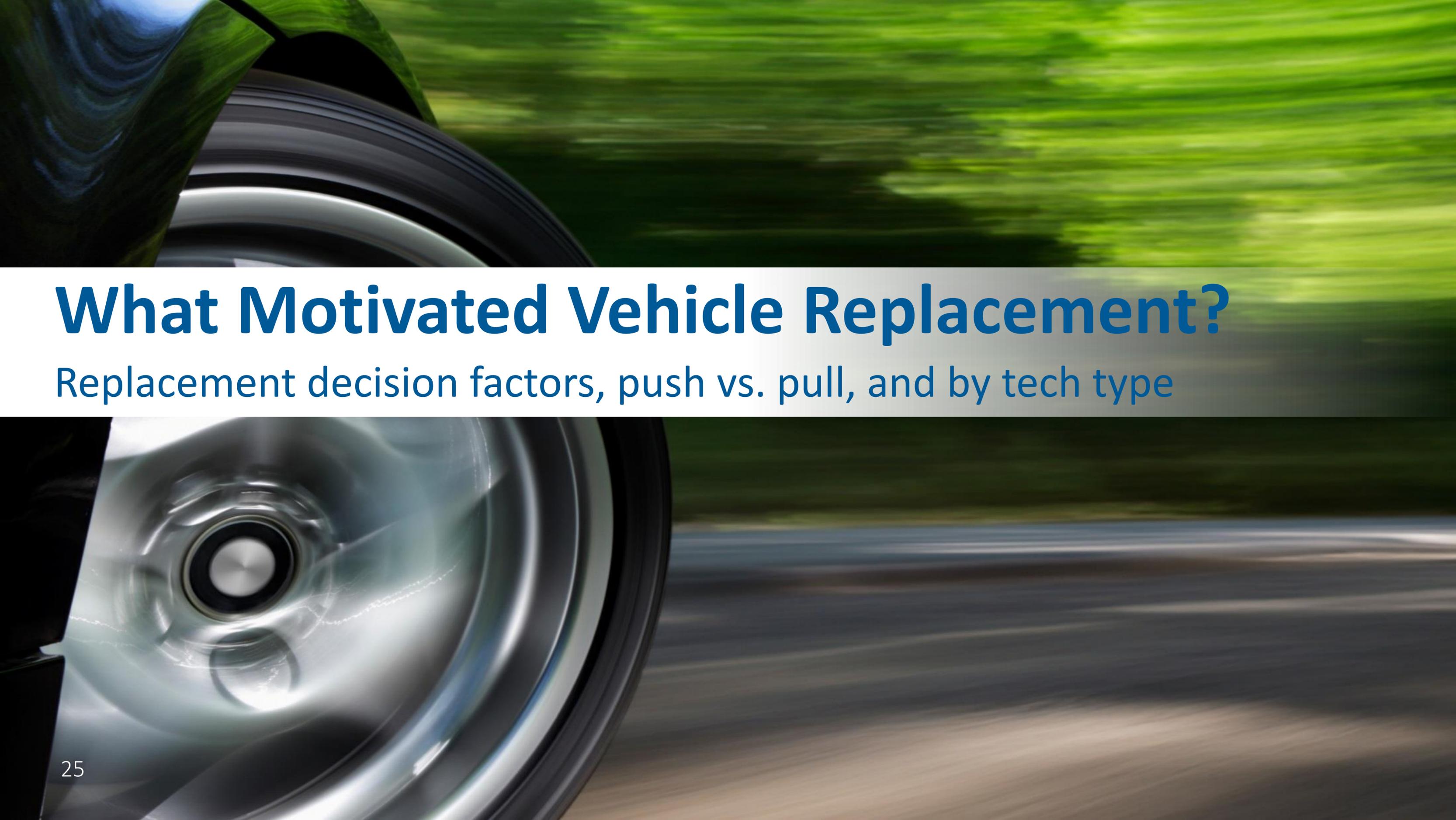
# Model-Year Distribution of Vehicles Replaced by 2017–18 Edition Survey Respondents



# Top Replaced-Vehicle Technology Types, by Rebated-Vehicle Technology Type



CVRP Consumer Survey: 2013–2015 edition: weighted, question n= 12,199  
 2015–2016 edition: weighted, question n= 8,398  
 2016–2017 edition: weighted, question n= 6,557  
 2017–2018 edition: weighted, question n= 16,673



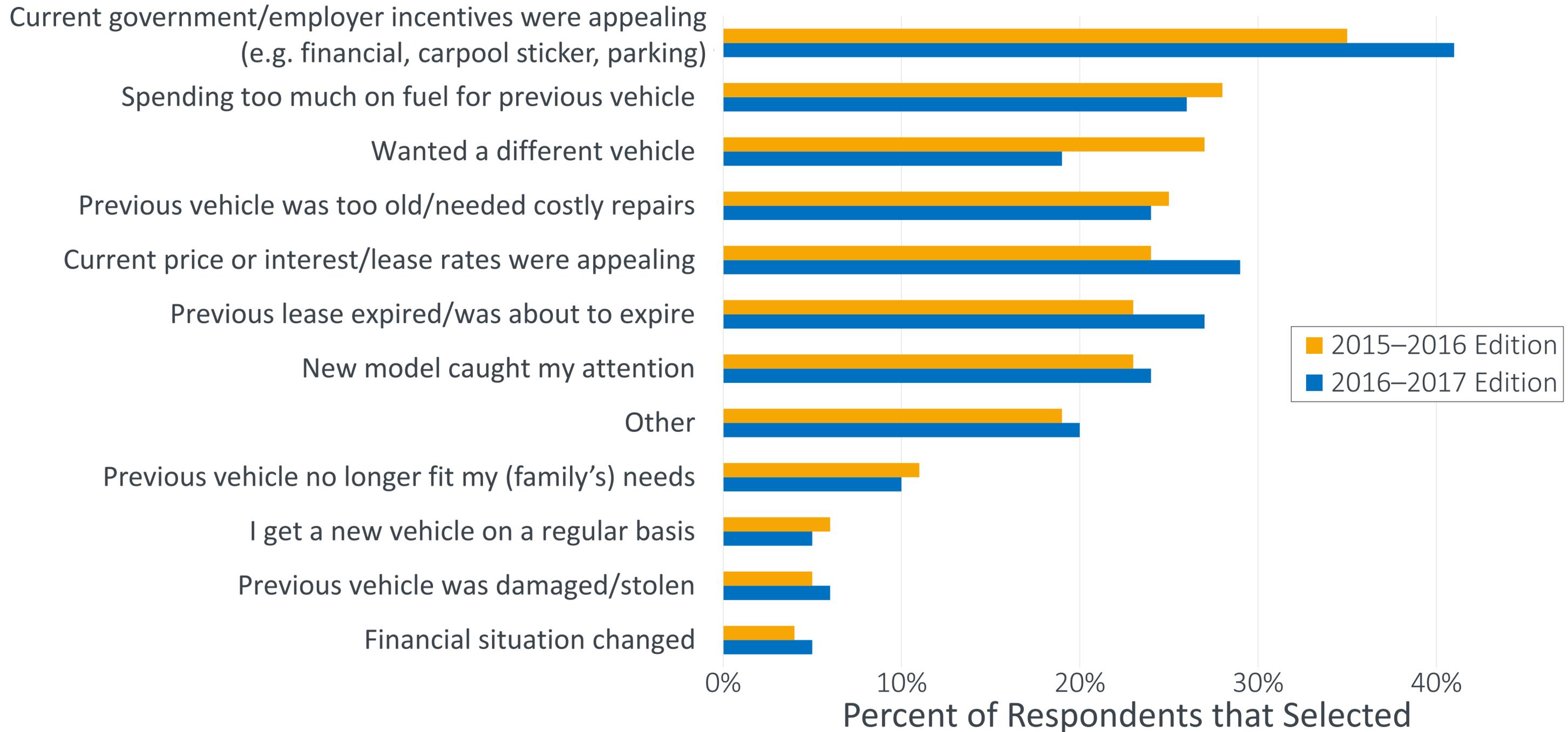
# What Motivated Vehicle Replacement?

Replacement decision factors, push vs. pull, and by tech type

# Why Now? - Factors Influencing the Decision to Replace



*Select all that apply:*



# “Push” vs. “Pull” Factors Influencing the Decision to Replace

*Select all that apply:*

Current government/employer incentives were appealing  
(e.g. financial, carpool sticker, parking)

Spending too much on fuel for previous vehicle

Wanted a different vehicle

Previous vehicle was too old/needed costly repairs

Current price or interest/lease rates were appealing

Previous lease expired/was about to expire

New model caught my attention

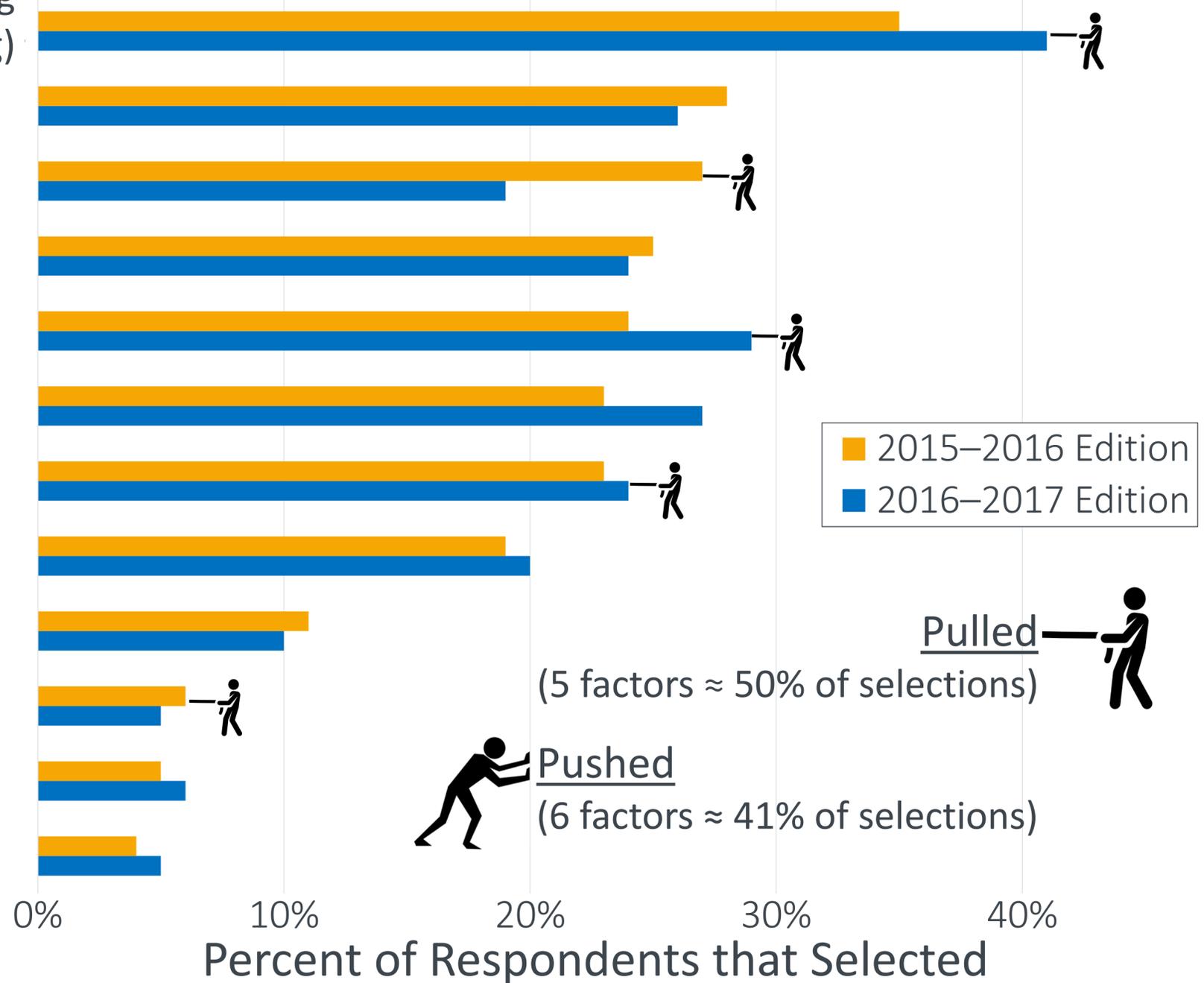
Other

Previous vehicle no longer fit my (family’s) needs

I get a new vehicle on a regular basis

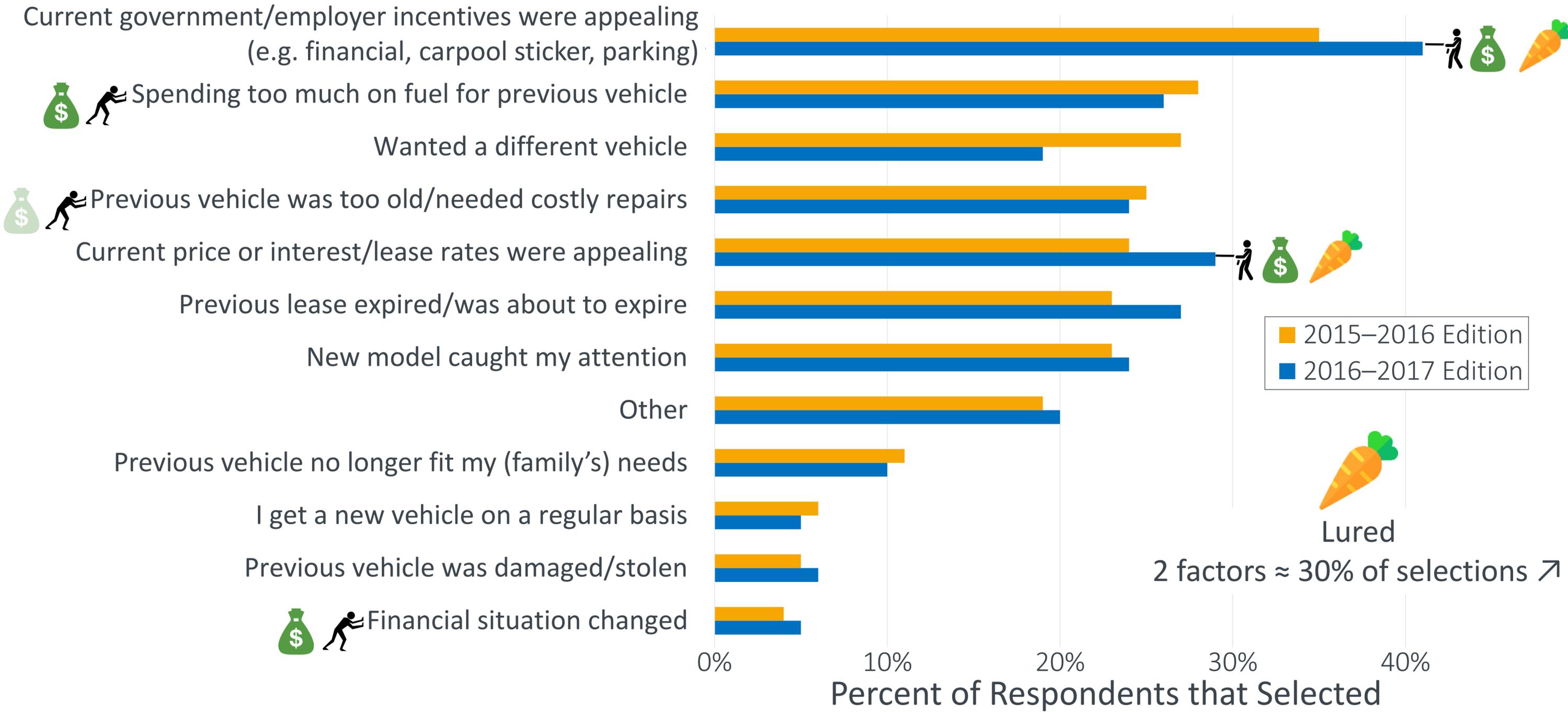
Previous vehicle was damaged/stolen

Financial situation changed



# Financial Factors Influencing the Decision to Replace

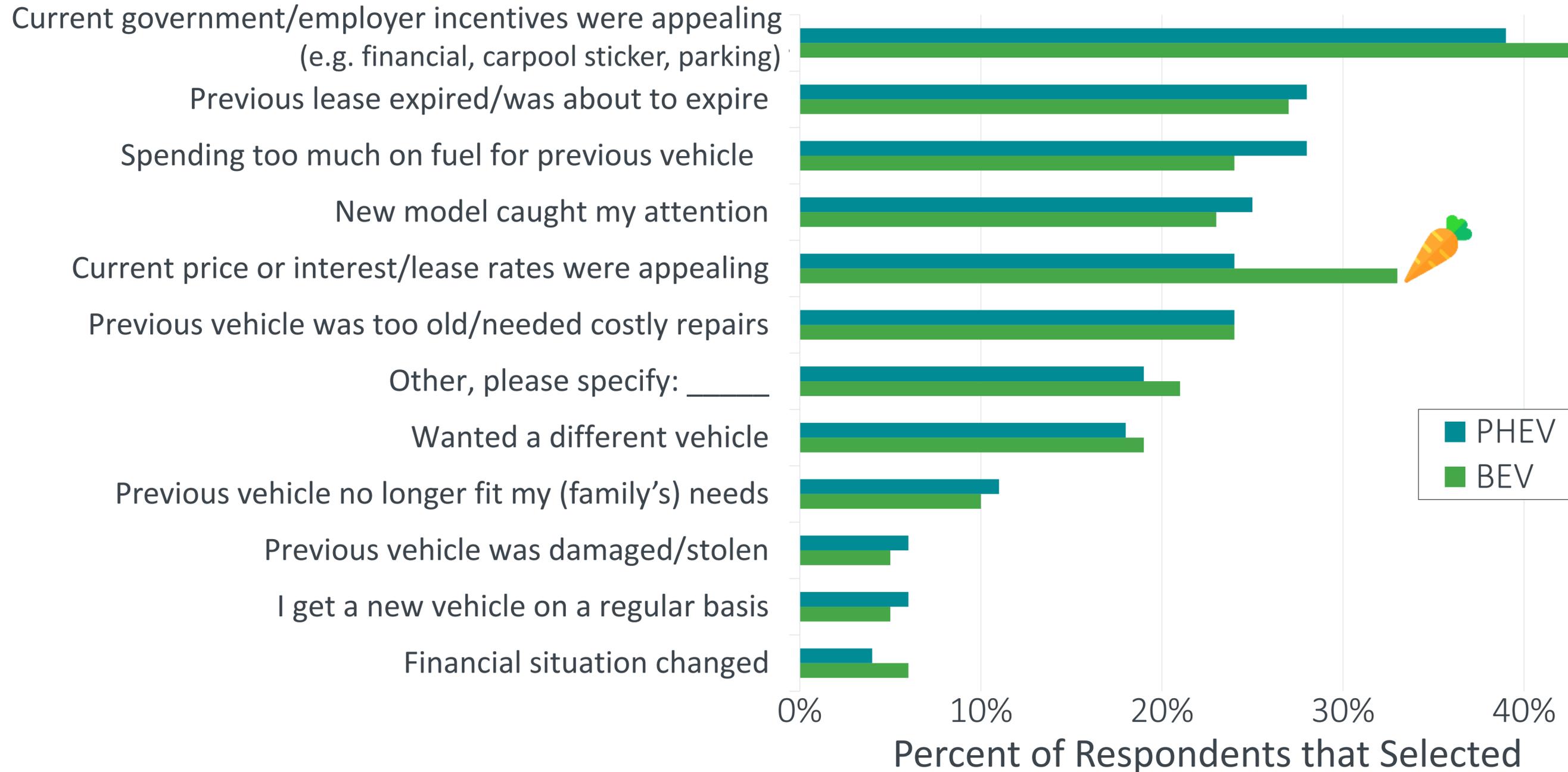
*Select all that apply:*



Lured  
2 factors ≈ 30% of selections ↗

# Financial lures are important to entice replacement with BEVs

*Select all that apply:*



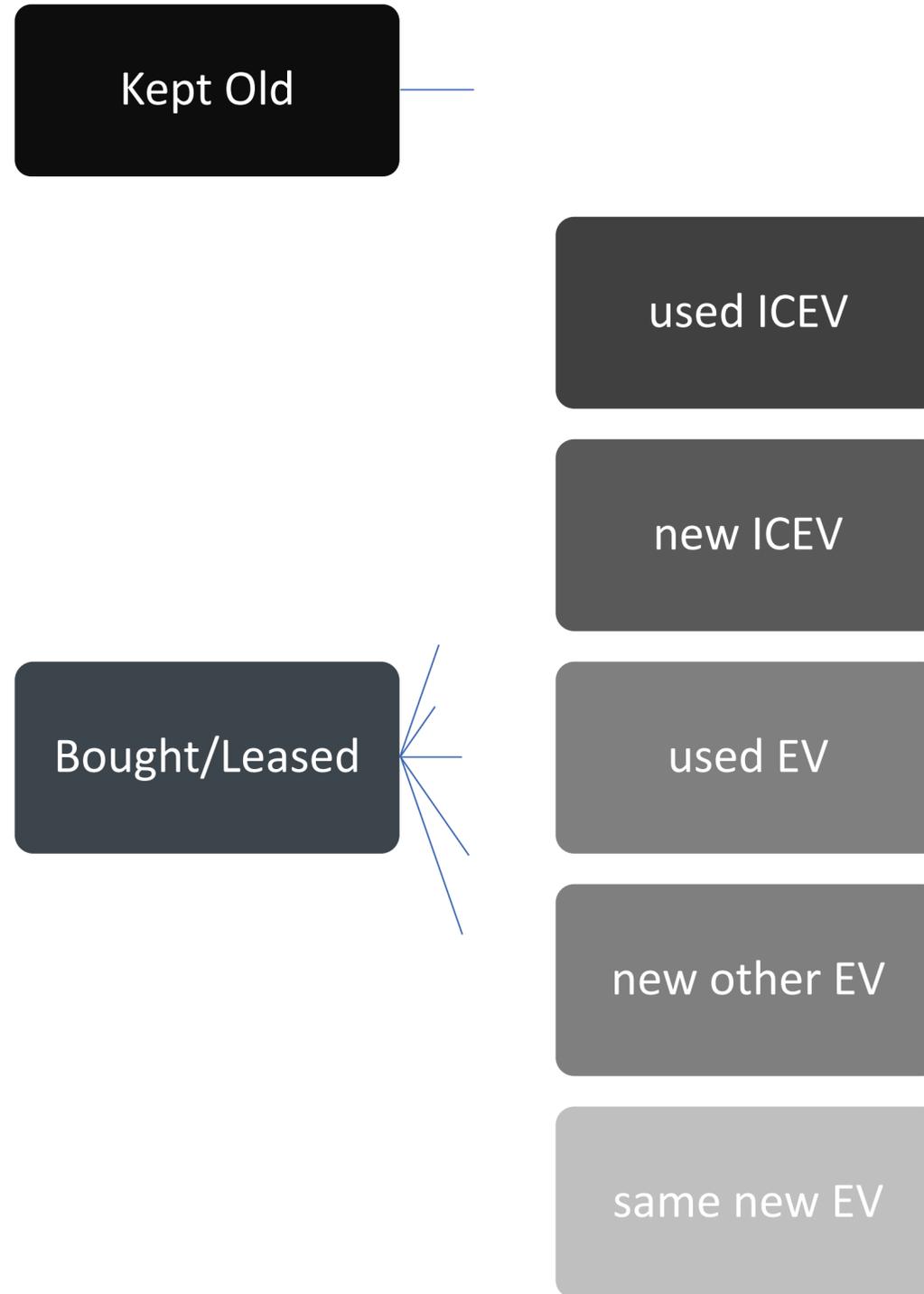
CVRP Consumer Survey, 2016–2017 edition: weighted, question n= 7,000



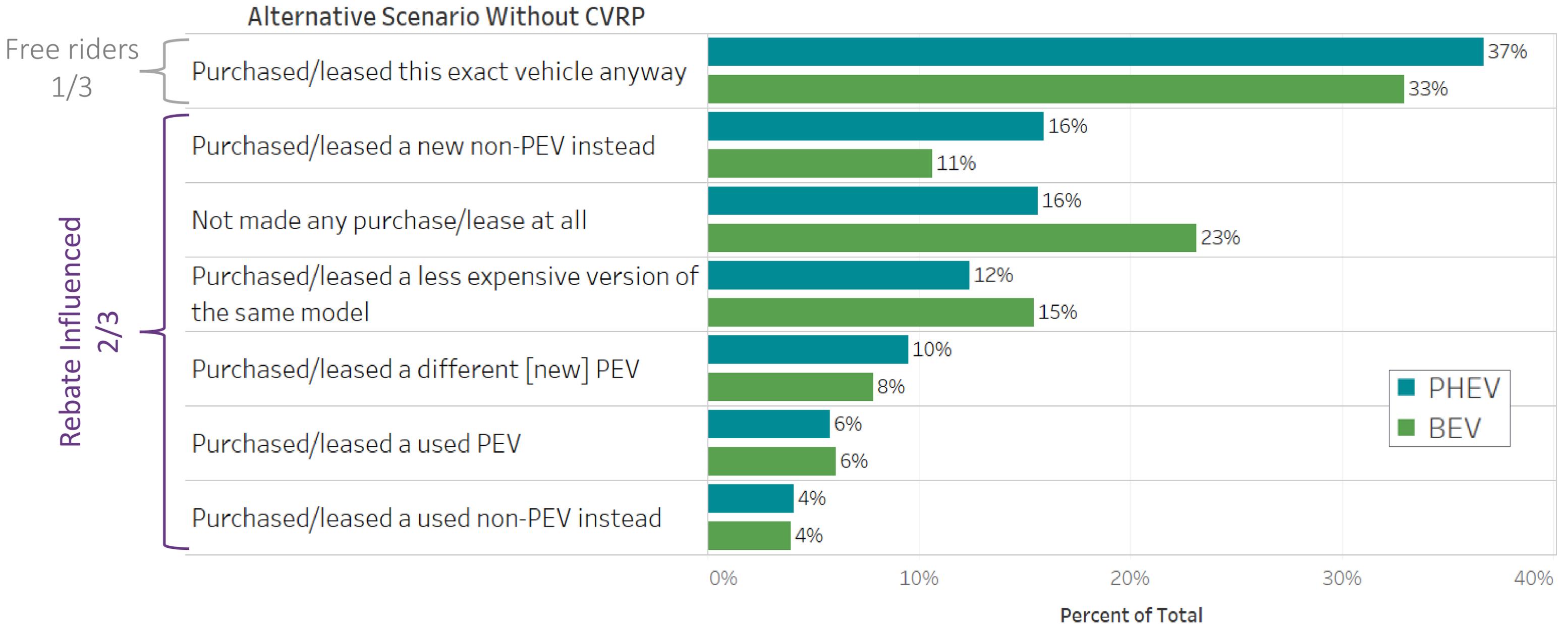
# What Might Have Happened Without the Rebated EV?

Counterfactual behaviors

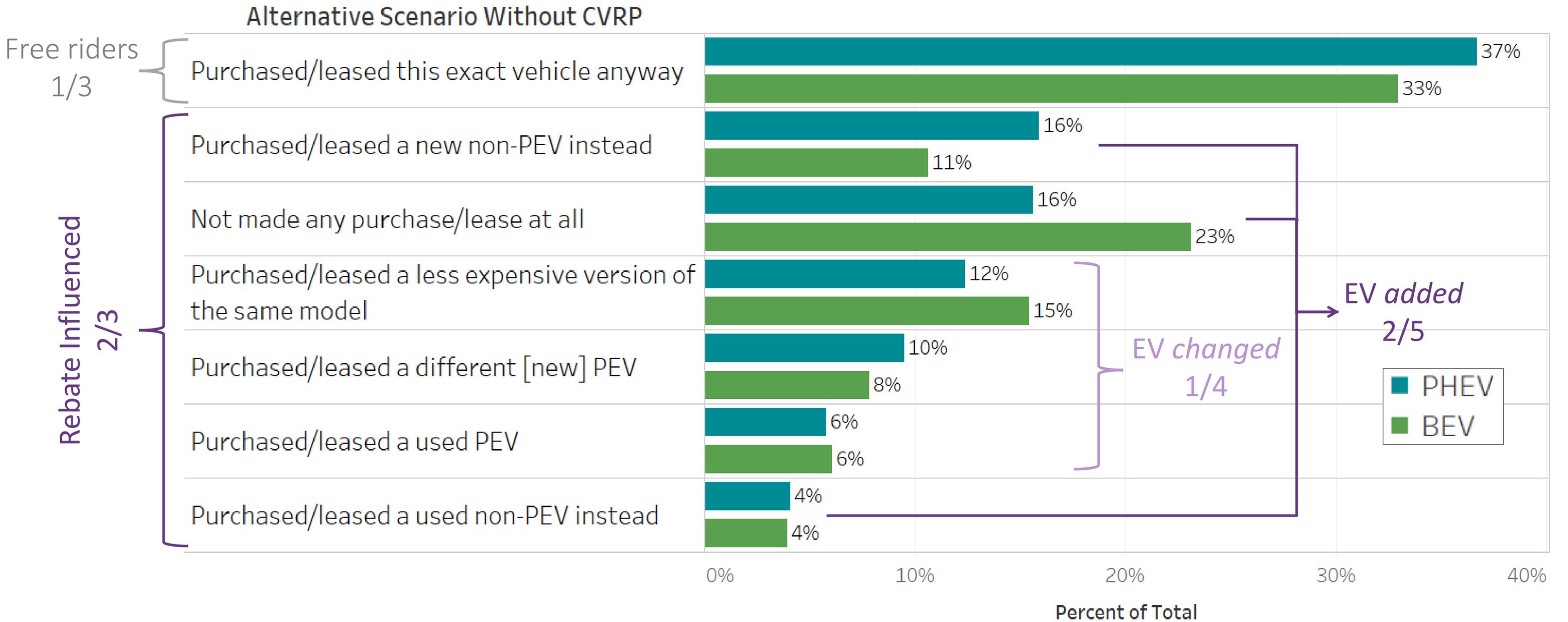
# Counterfactual Alternative Behaviors



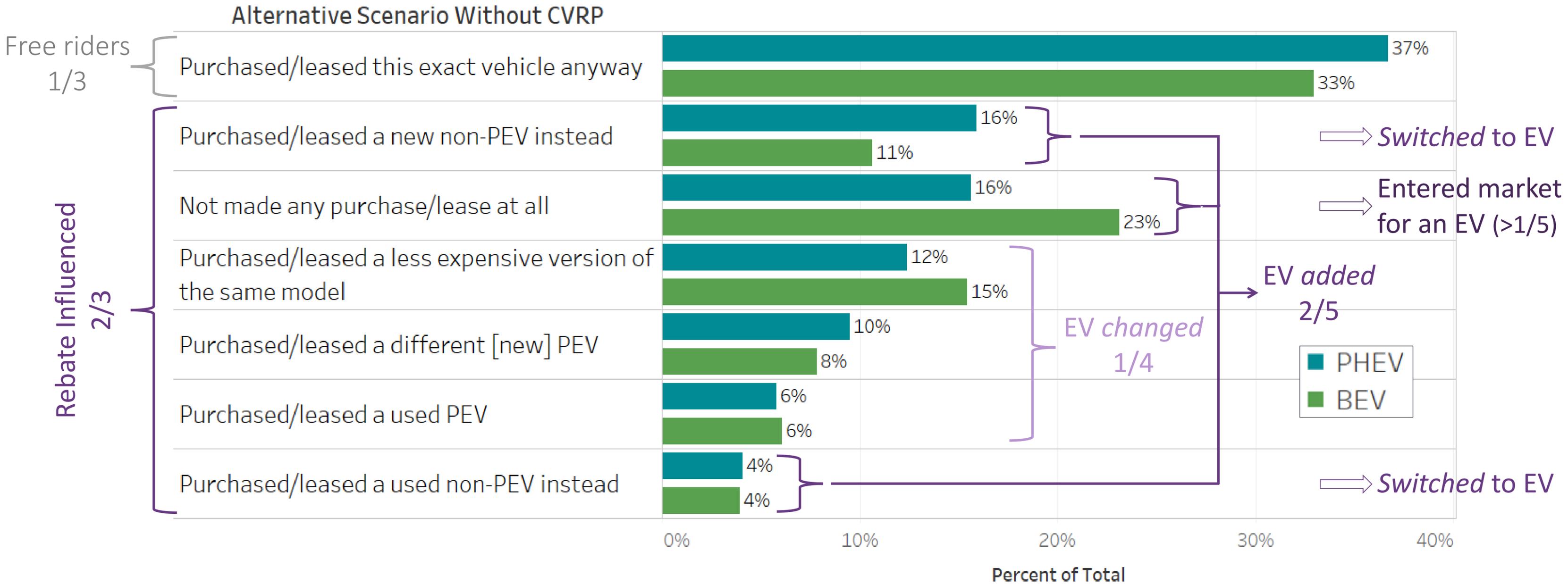
If the state vehicle rebate (CVRP) were not available for a [model] or any other plug-in electric vehicle (PEV), what do you think you would have done?



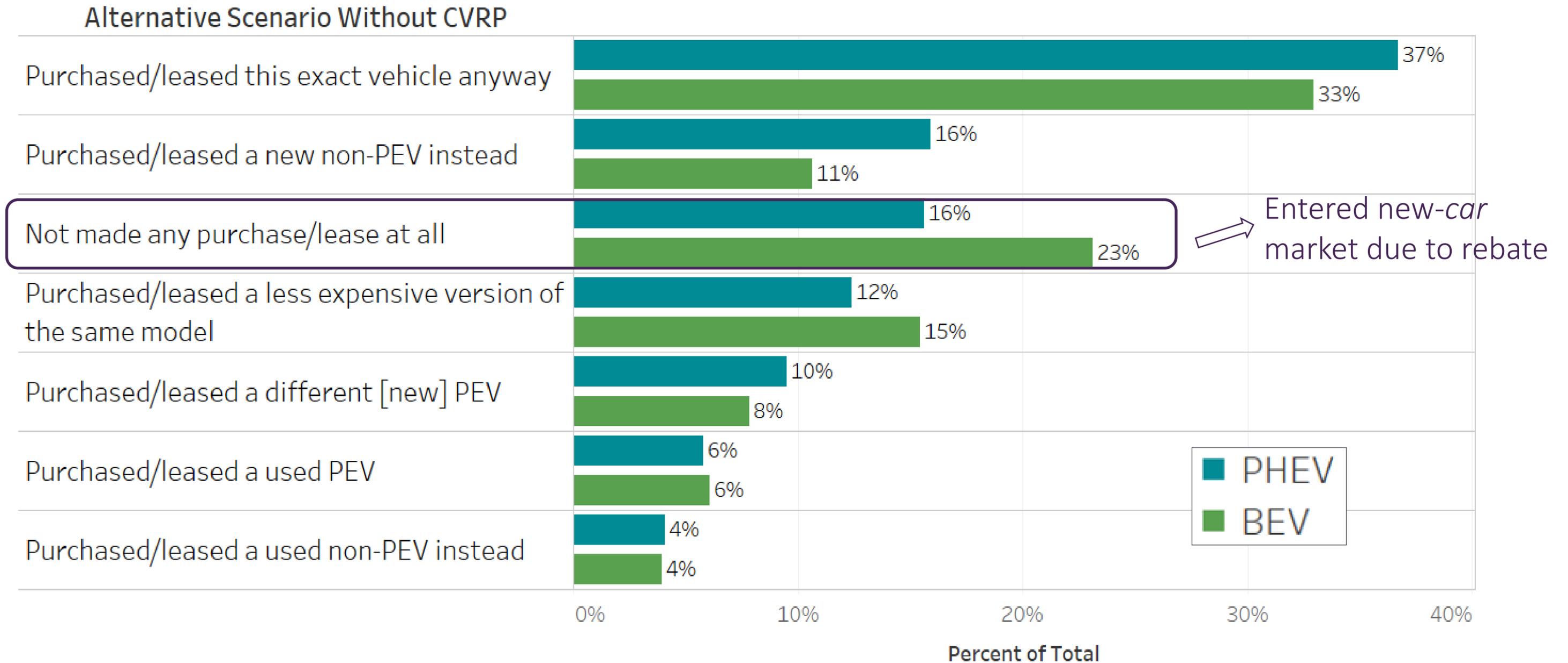
# If the state vehicle rebate (CVRP) were not available for a [model] or any other plug-in electric vehicle (PEV), what do you think you would have done?



# If the state vehicle rebate (CVRP) were not available for a [model] or any other plug-in electric vehicle (PEV), what do you think you would have done?



# In particular, rebates appear to encourage new BEV purchases/leases





# Wrap Up

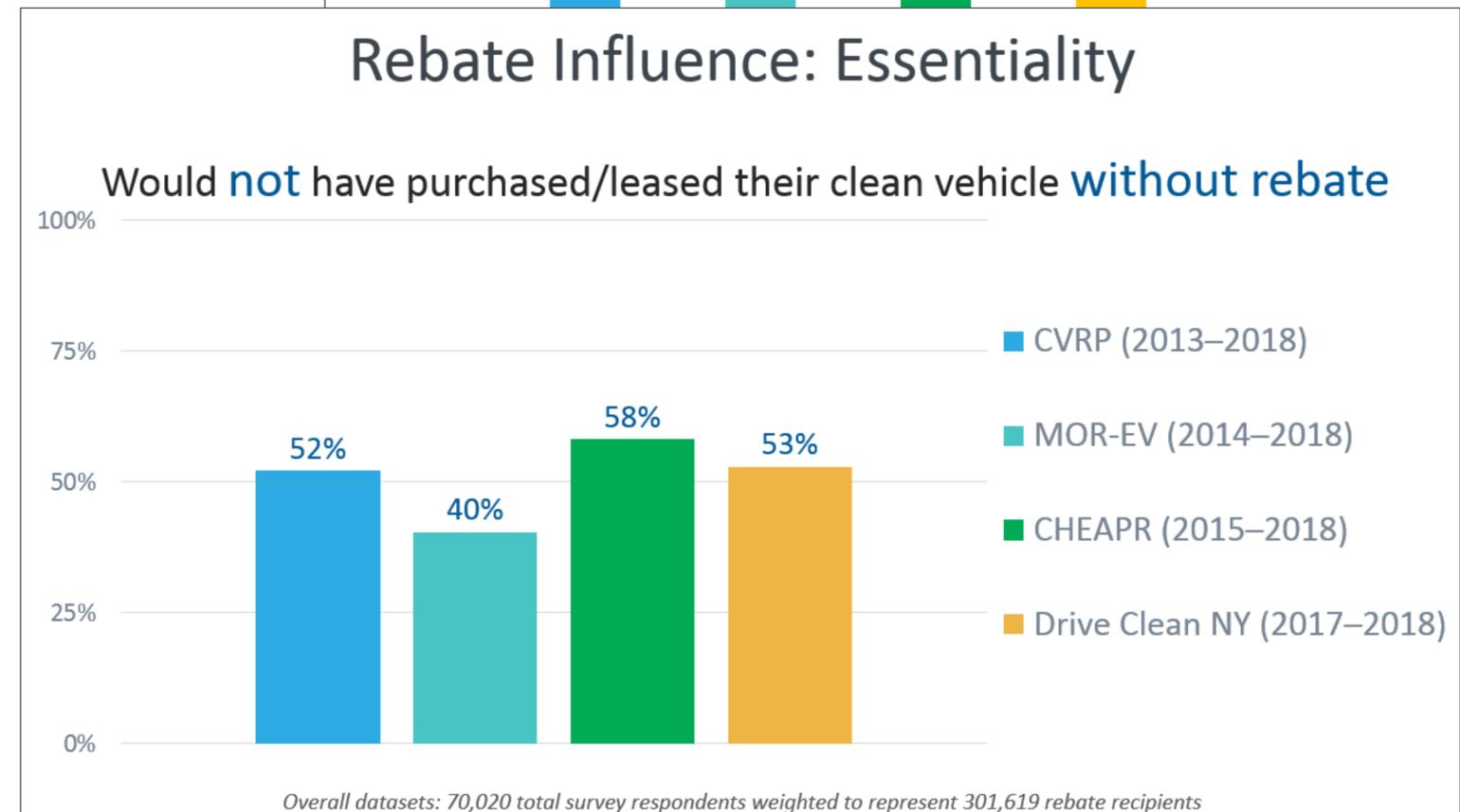
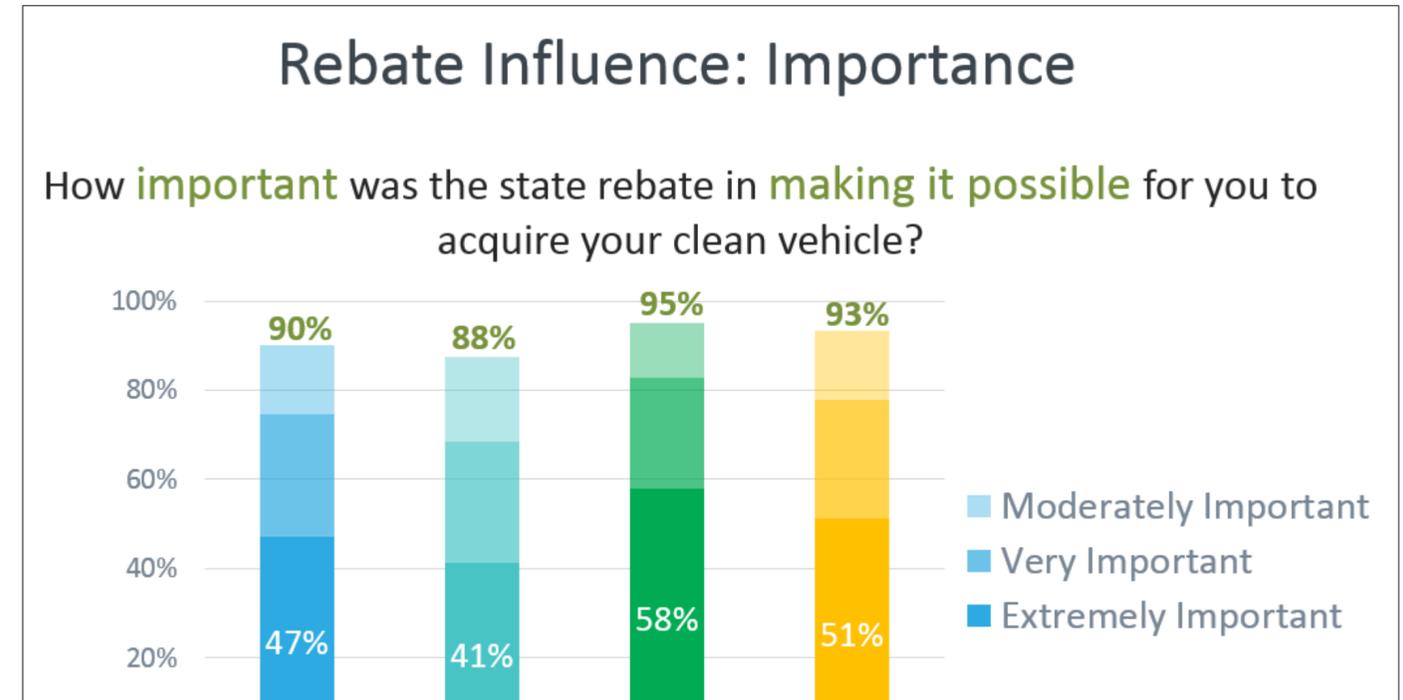
Summary, additional resources & supplemental details

# Select Findings: Vehicle Replacement

- ~4/5<sup>ths</sup> of rebated EVs **replaced** older, more polluting vehicles
- PHEVs produced strong replacement rates early, BEVs catching up
- These and other impacts tend to be **increasing** over time
- Replaced vehicles:
  - 1/4<sup>th</sup> are **≥12 years old**, 1/2 are **>5 years old**
  - 2/3<sup>rds</sup> are **gasoline**, down from 3/4<sup>ths</sup>, but *stabilized/rebounding*
- In absence of the rebate, 2/3<sup>rds</sup> of consumers **may have used a different vehicle than rebated**, 1/3<sup>rd</sup> a non-EV, and 1/5<sup>th</sup> **their old vehicle**
- Related research: when compared to buying a *new* non-EV, rebated EVs may be saving >30 tons of GHG emissions per vehicle (12-year life) at costs <\$100/ton

# Next Steps

- Refine GHG calculations with case-specific data
- Differentiate free riders from influenced consumers
  - characteristics, vehicles, behaviors, and impacts
- Compare to characterization of Rebate Essential consumers (BECC 2016 and [subsequent analysis](#))...





# Additional Resources & Details

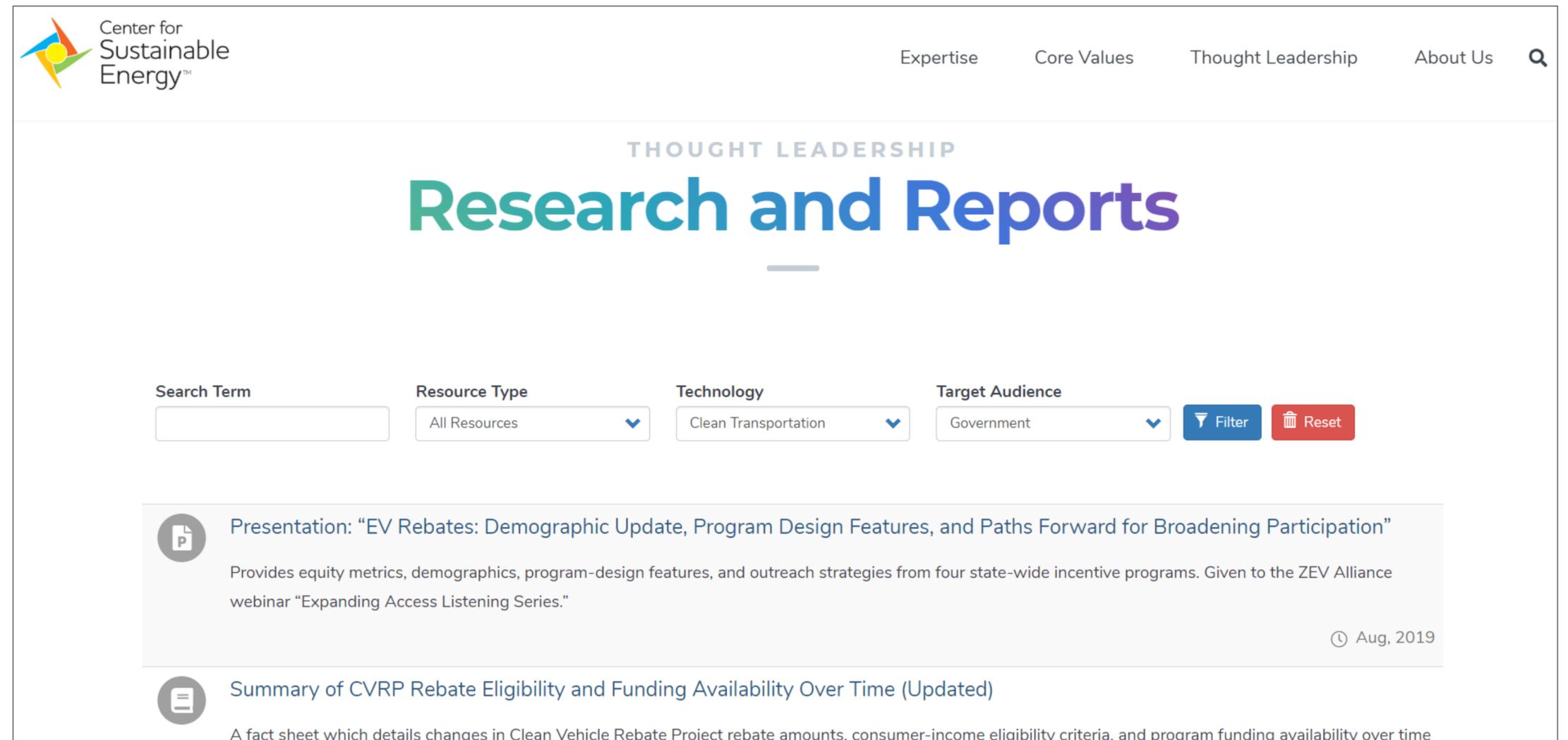
# Evaluation: CVRP Analysis

## Program reports, fact sheets, infographics & presentations

	<b>Summary Documentation of the Electric Vehicle Consumer Survey, 2013-2015 Edition</b> June 15, 2017
	<b>Infographic: Characterizing California Electric Vehicle Consumer Segments - TRB Poster</b> January 16, 2017
	<b>Infographic: Plug-in Electric Vehicle Owners in California's Disadvantaged Communities</b> January 11, 2017
	<b>CVRP Final Report 2014-2015</b> November 21, 2016
	<b>Characterizing Plug-In Hybrid Electric Vehicle Consumers Most Influenced by CVRP</b> November 15, 2016
	<b>Presentation: "Electric Vehicle Rebates in Disadvantaged Communities: Evaluating Progress with Appropriate Comparisons"</b> October 26, 2016

# CSE Clean Transportation Resources

Reports, analysis,  
infographics,  
presentations, ...



Center for Sustainable Energy™

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THOUGHT LEADERSHIP

## Research and Reports

Search Term

Resource Type: All Resources

Technology: Clean Transportation

Target Audience: Government

Filter Reset

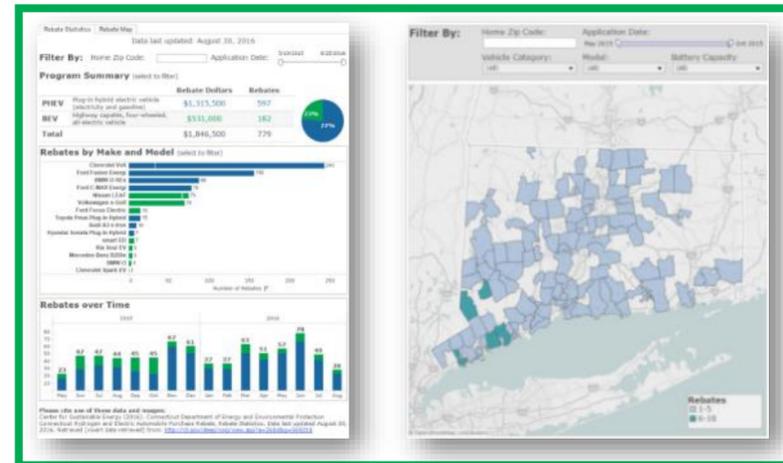
**P** Presentation: “EV Rebates: Demographic Update, Program Design Features, and Paths Forward for Broadening Participation”  
Provides equity metrics, demographics, program-design features, and outreach strategies from four state-wide incentive programs. Given to the ZEV Alliance webinar “Expanding Access Listening Series.”  
Aug, 2019

**E** Summary of CVRP Rebate Eligibility and Funding Availability Over Time (Updated)  
A fact sheet which details changes in Clean Vehicle Rebate Project rebate amounts, consumer-income eligibility criteria, and program funding availability over time

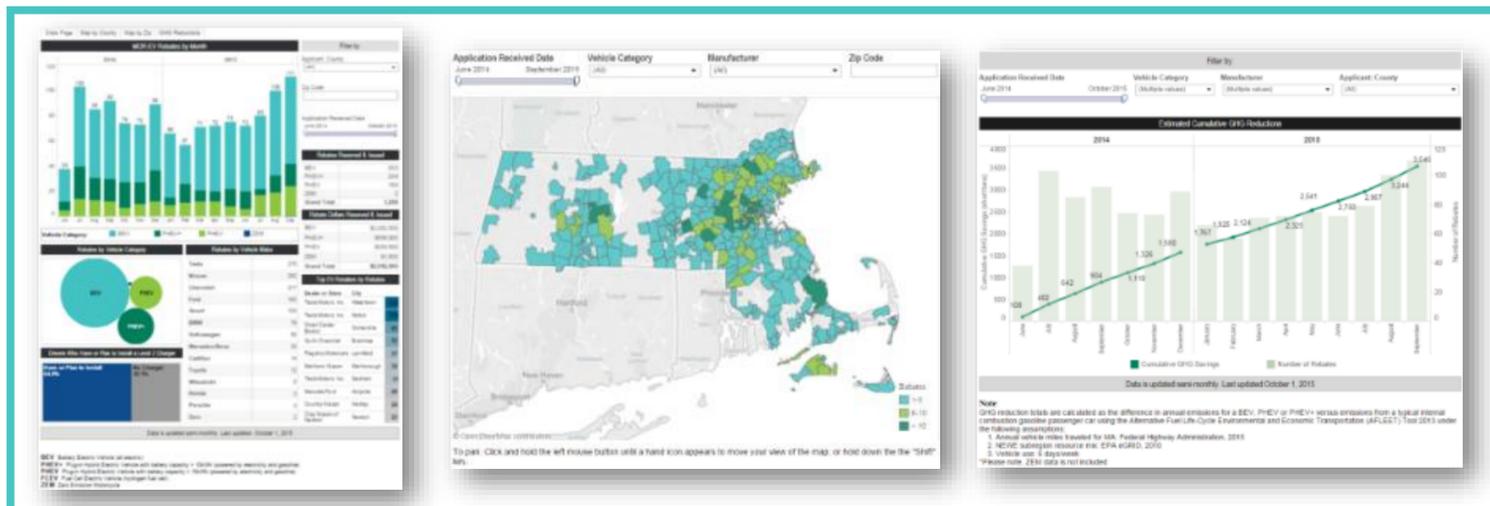
# Where Are EV Rebates Going? Public Dashboards and Data Facilitate Informed Action



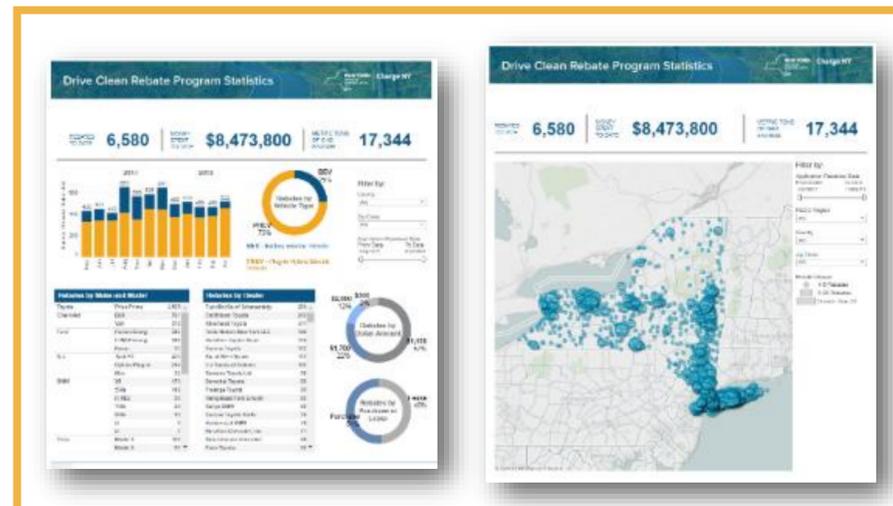
[cleanvehiclerebate.org](http://cleanvehiclerebate.org)



[ct.gov/deep](http://ct.gov/deep)



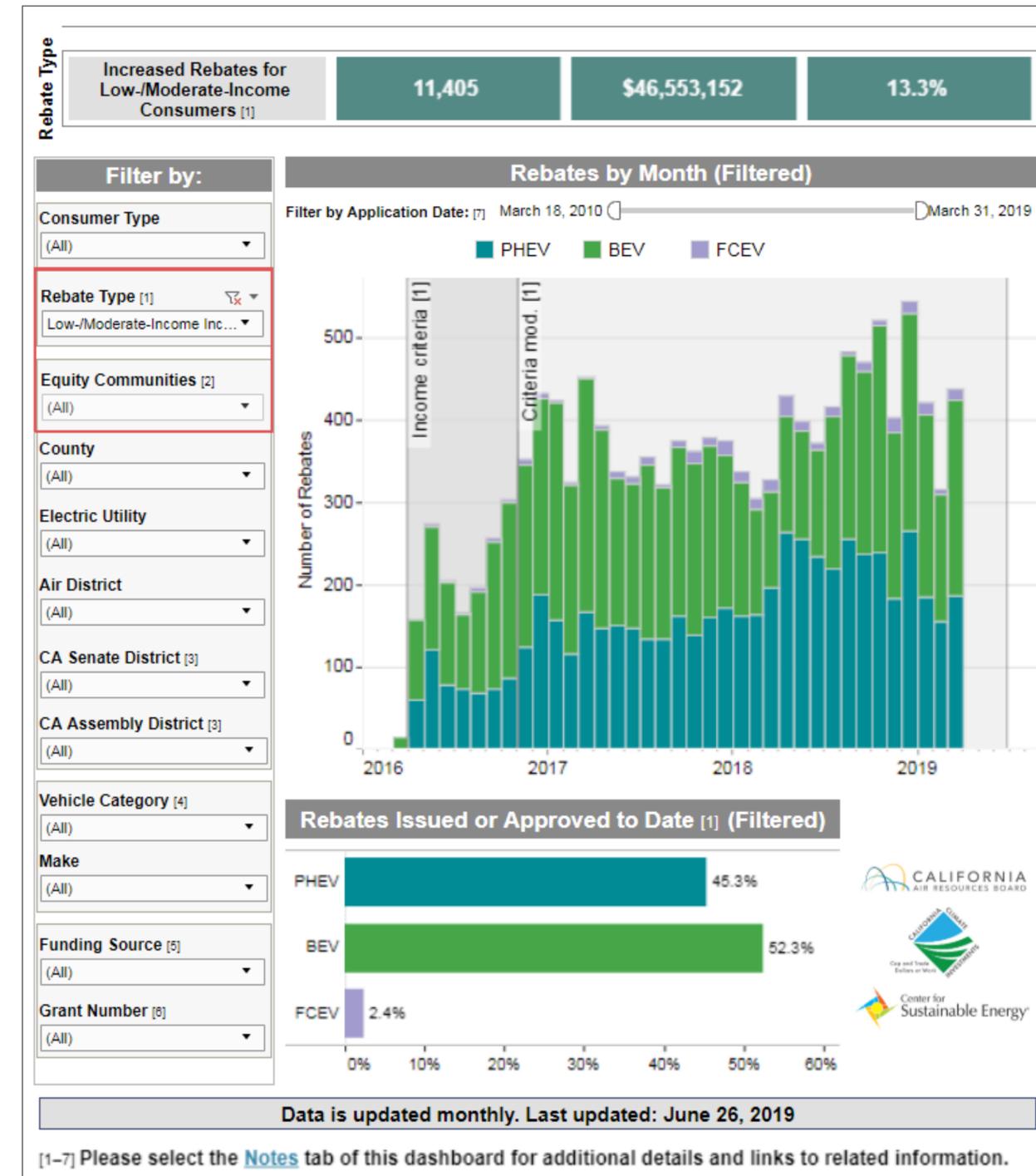
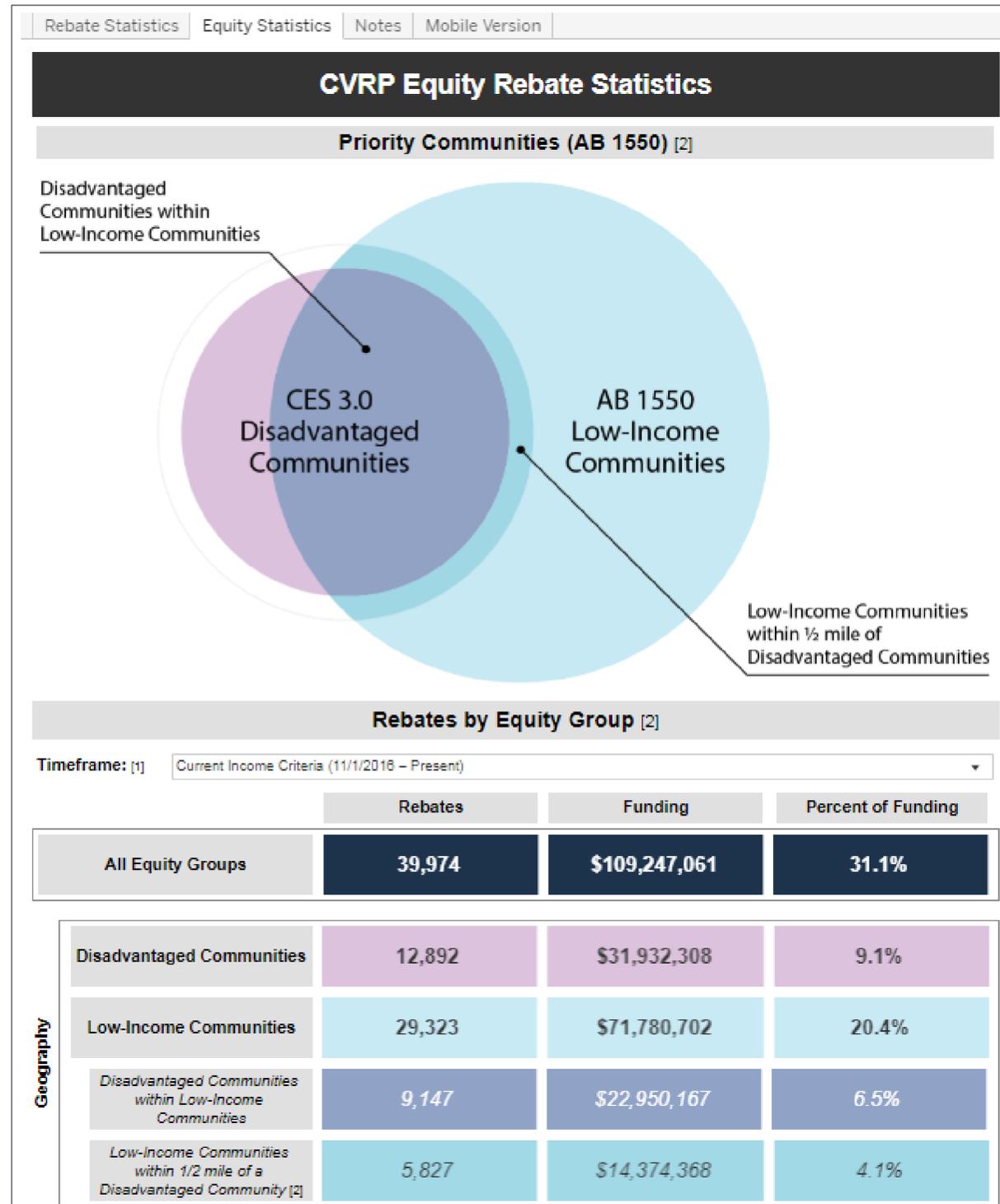
[mor-ev.org](http://mor-ev.org)



[nyscrda.ny.gov](http://nyscrda.ny.gov) (dashboards done by NYSERDA)

- > 350,000 EVs and consumers have received > \$720 M in rebates
- > 70,000 survey responses being analyzed so far, statistically represent > 300,000 consumers
- Reports, presentations, and analysis growing

# Equity Statistics Dashboard



# Rebated EV Consumer Characteristics: 2017

	<b>“Buying Age”</b> <i>21+ Years Old</i> U.S. Population (Census 2017)	<b>New-Vehicle Buyers</b> U.S. MYs 2016–17 (2017 NHTS)	 CALIFORNIA CLEAN VEHICLE REBATE PROJECT™ CY 2017 weighted n = 9,539	 MOR-EV Massachusetts Offers Rebates for Electric Vehicles CY 2017 weighted n = 1,285	 CHEAPR Connecticut Hydrogen and Electric Automobile Purchase Rebate CY 2017 weighted n = 501	 NEW YORK STATE Mar.–Dec. 2017 weighted n = 1,014
Selected solely White/Caucasian	65%	74%	58%	85%	88%	86%
≥ 50 Years Old	47%	51%	52%	61%	59%	60%
≥ Bachelor’s Degree in HH	30%*	56%*	82%	90%	85%	73%
Own Residence	64%	75%	79%	92%	89%	90%
≥ \$150k HH Income	12%	23%	40%	58%	41%	34%
Selected Male	49%	51%	72%**	74%	71%	68%

*“Prefer not to answer,” “I don’t know,” and similar responses are excluded throughout.*

*Census 2017: 2013–2017 American Community Survey, <http://factfinder2.census.gov>.*

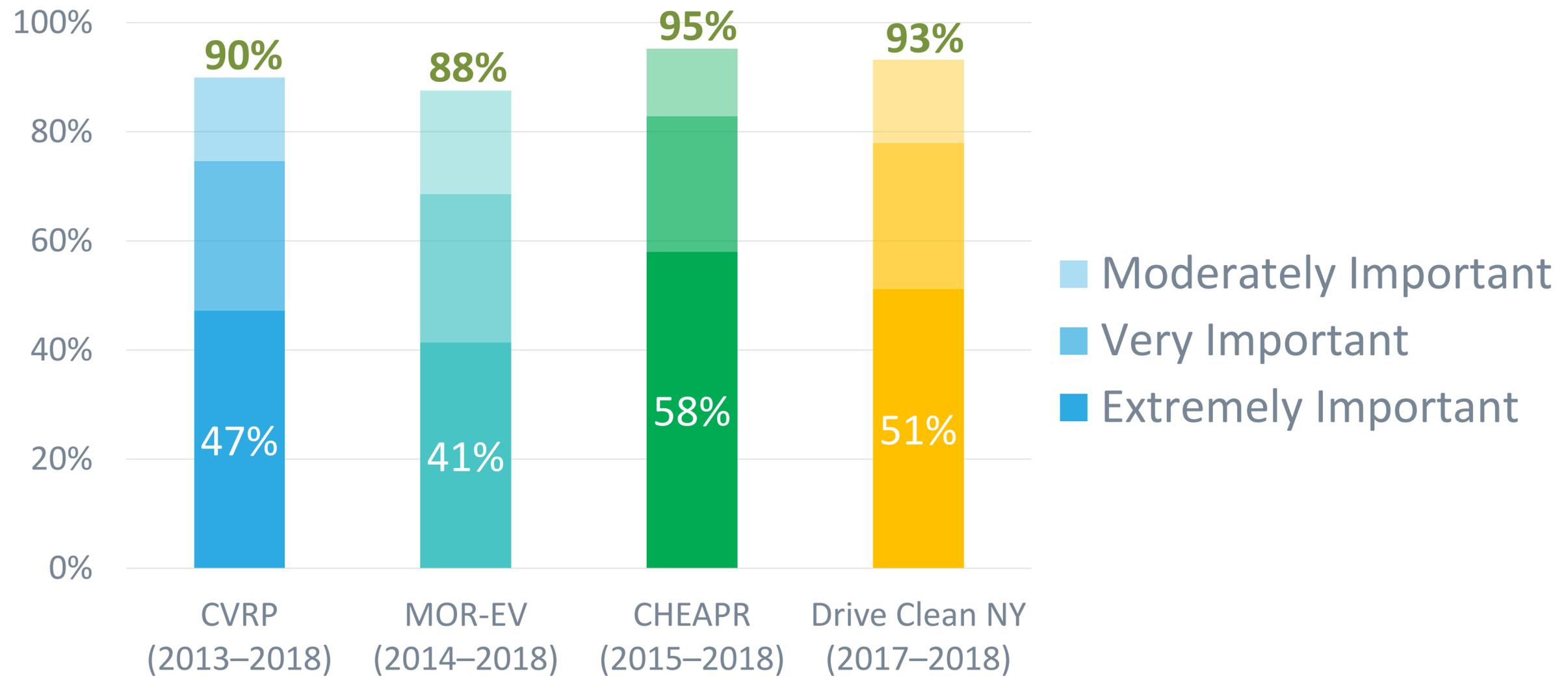
*NHTS weighted to represent population, not new-vehicle subset. New-vehicle buyers identified based on within-100-mile match between odometer and miles driven while owned.*

*\* Census & NHTS data characterize individual educational attainment, whereas other data characterize highest household attainment.*

*\*\* 100% includes non-binary options.*

# Rebate Influence: Importance

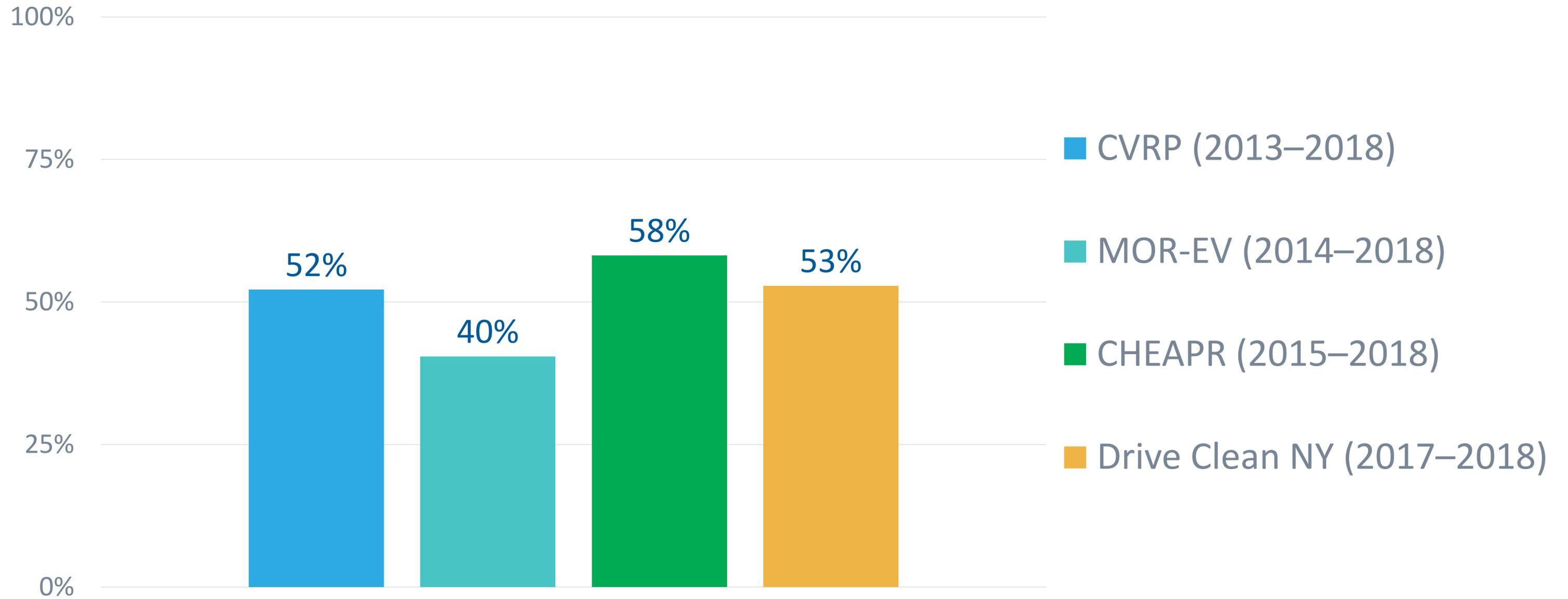
How **important** was the state rebate in **making it possible** for you to acquire your clean vehicle?



Overall datasets: 70,020 total survey respondents weighted to represent 301,619 rebate recipients

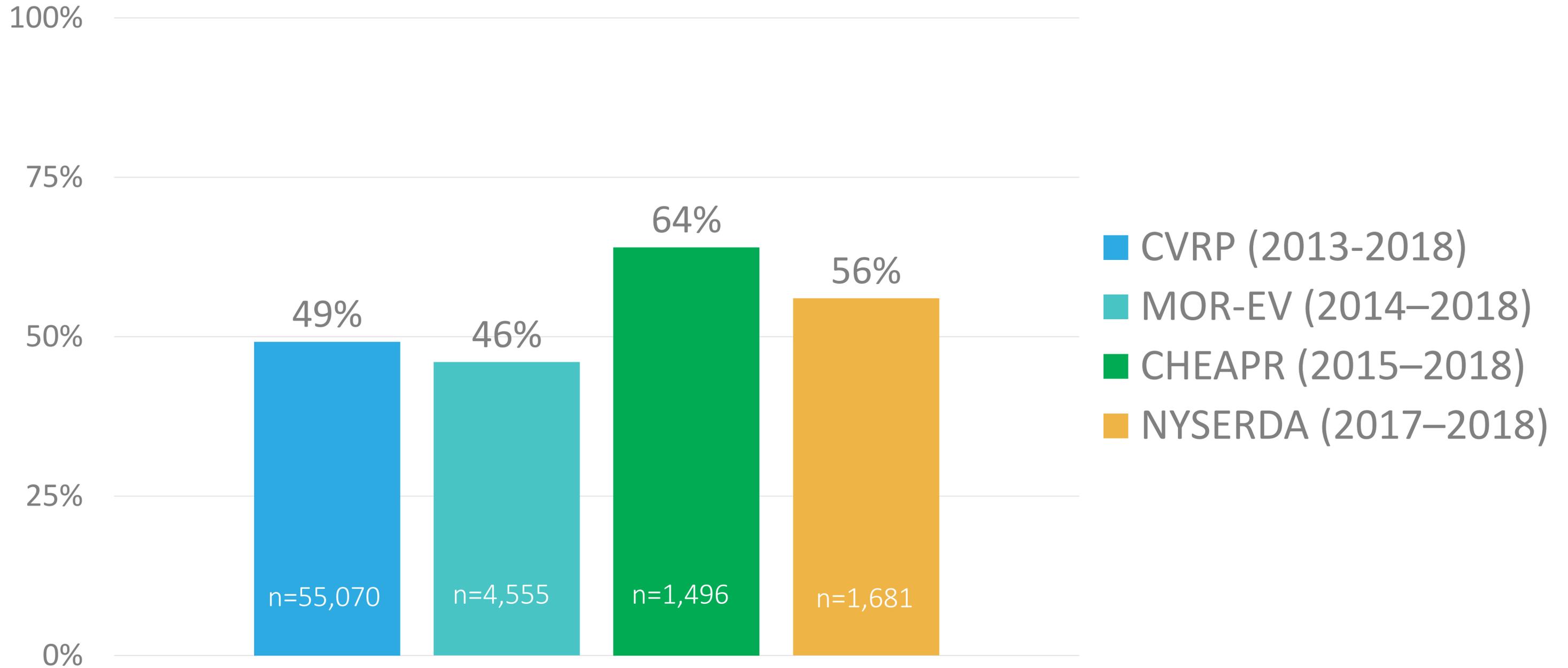
# Rebate Influence: Essentiality

Would **not** have purchased/leased their clean vehicle **without rebate**



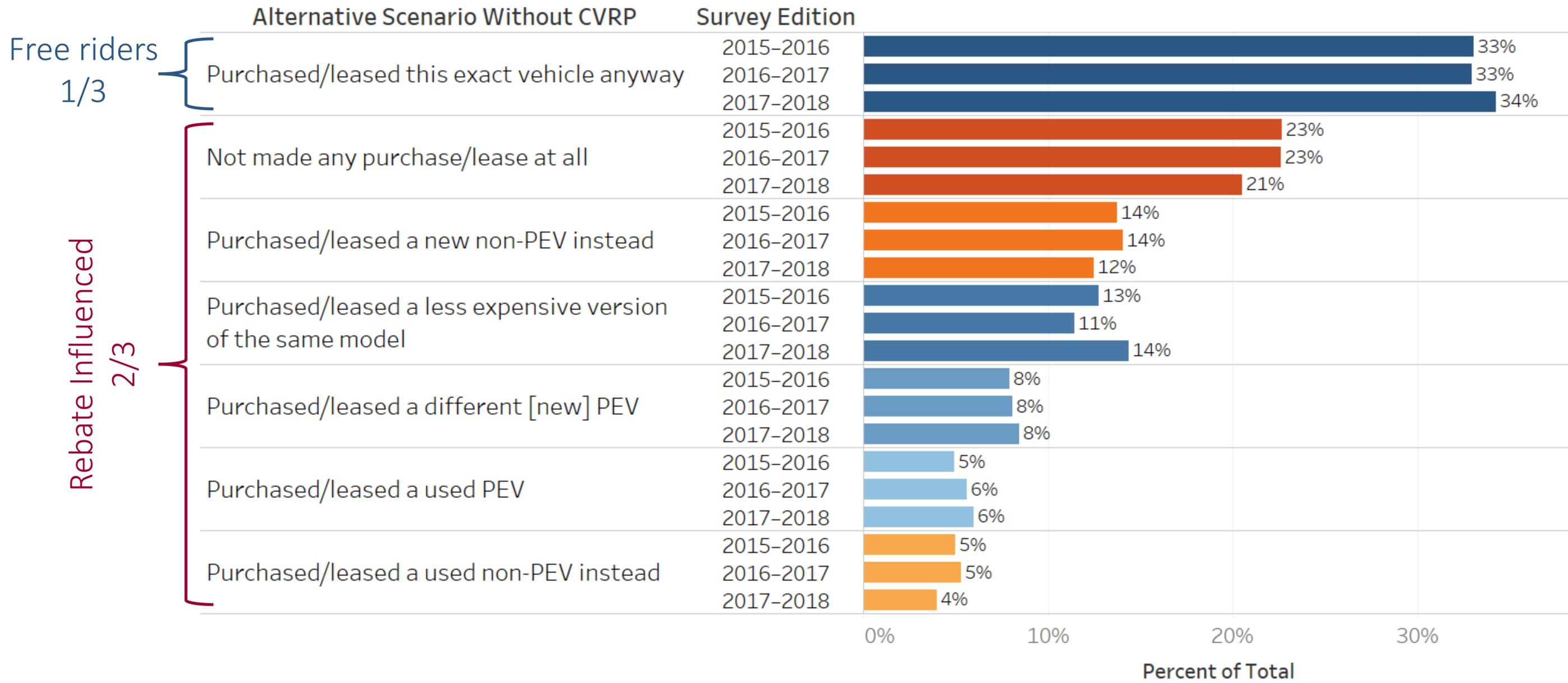
Overall datasets: 70,020 total survey respondents weighted to represent 301,619 rebate recipients

# Percent Rating the Federal Tax Credit “Extremely Important” (“...in making it possible to acquire” plug-in EVs)



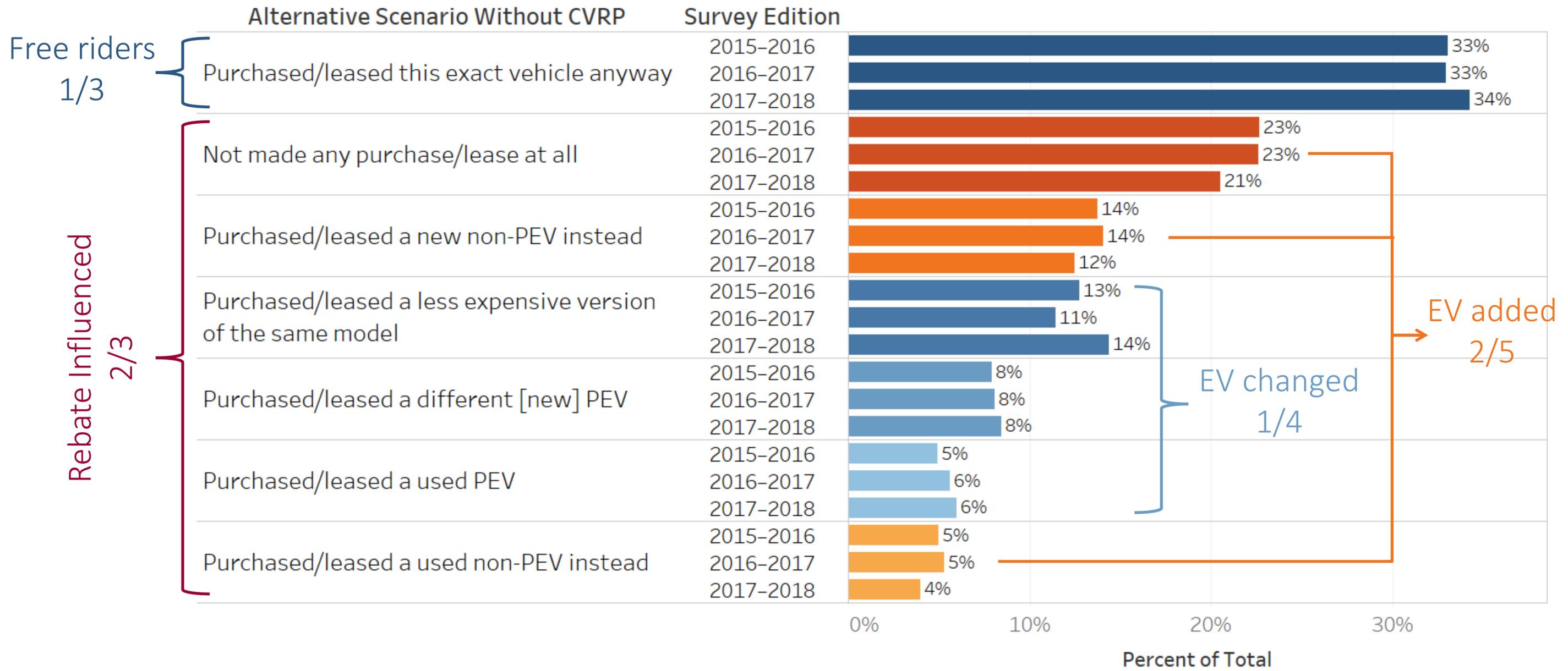
Overall datasets: 70,020 total survey respondents weighted to represent 301,619 rebate recipients

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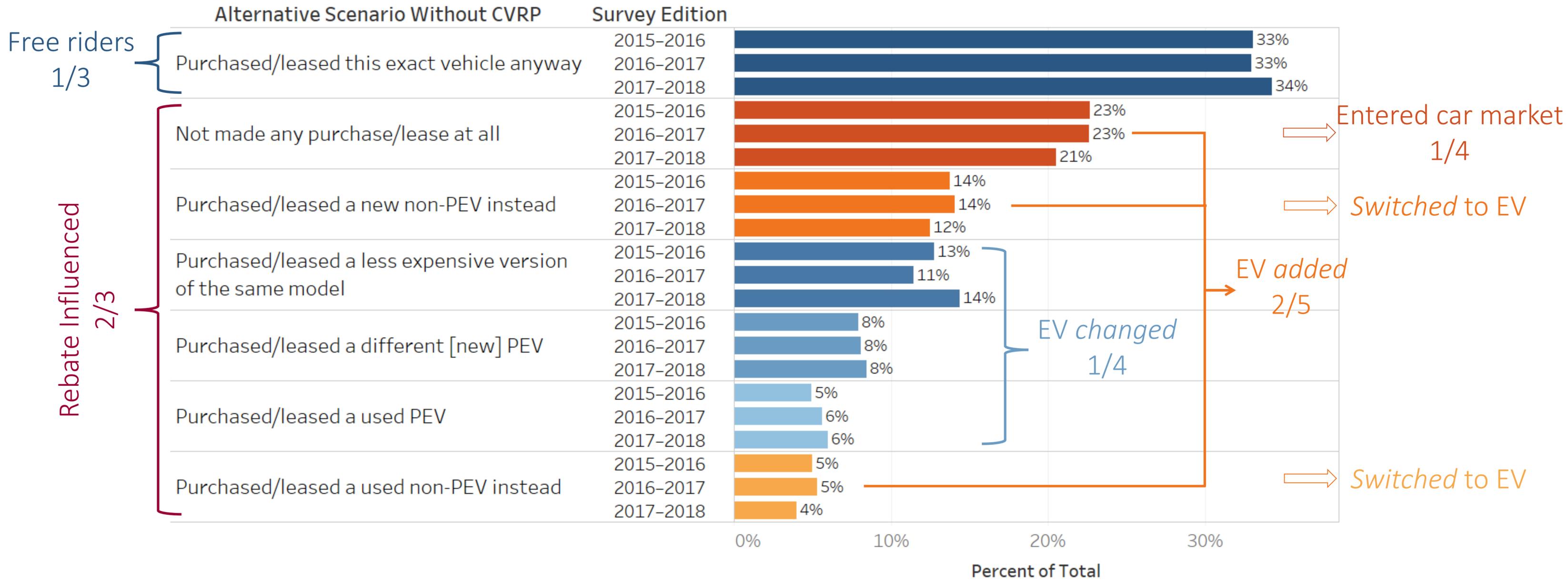
CVRP Consumer Survey: 2015–2016 edition: weighted, question n= 11,461  
 2016–2017 edition: weighted, question n= 8,930  
 2017–2018 edition: weighted, question n= 17,880

# If the state vehicle rebate (CVRP) were not available for a [model] or any other plug-in electric vehicle (PEV), what do you think you would have done?



CVRP Consumer Survey: 2015–2016 edition: weighted, question n= 11,461  
 2016–2017 edition: weighted, question n= 8,930  
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 2016–2017 edition: weighted, question n= 8,930  
 2017–2018 edition: weighted, question n= 17,880

This presentation supplements the following linked resources, which contain additional content:

- [Summary Documentation of the EV Consumer Survey, 2013–2015 Edition](#)
- [Summary of Disadvantaged Community Responses to the Electric Vehicle Consumer Survey, 2013–2015 Edition](#)

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