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2017 Transportation Energy Demand Forecast

IEPR Commissioner Workshop on the Revised Transportation Energy Demand Forecast

December 4, 2017

Transportation Energy Forecasting Unit
Demand Analysis Office
Energy Assessments Division

OVERVIEW OF TRANSPORTATION ENERGY DEMAND FORECAST

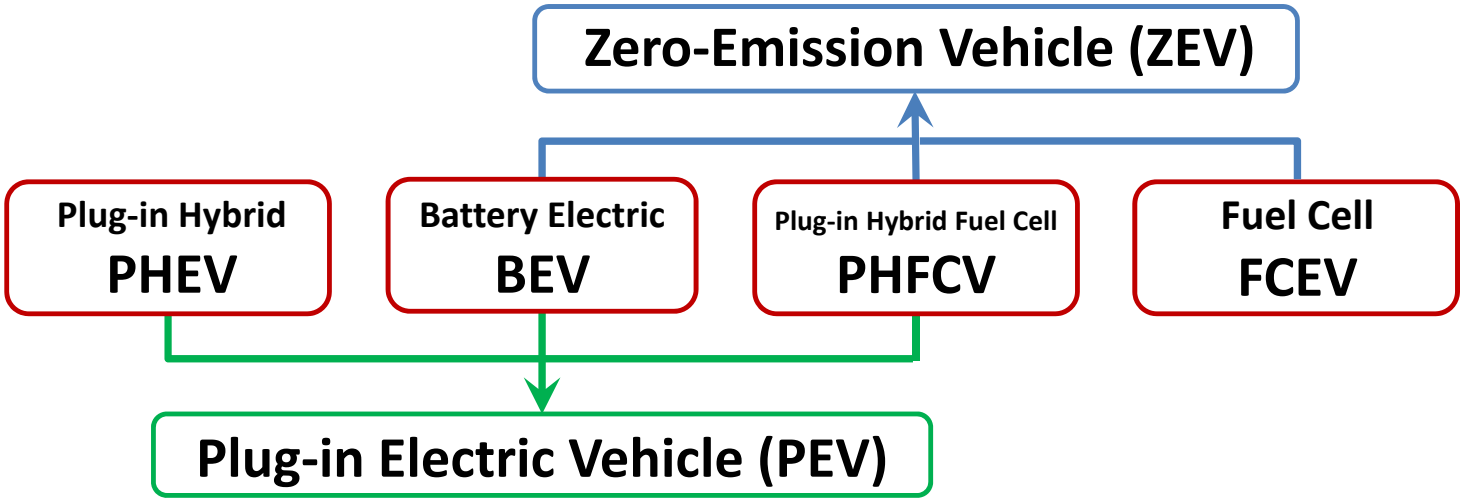
Key Takeaways

- Electric vehicles continue to gain popularity in California.
- Cost of driving zero-emission vehicles will continue to decline.
- Battery prices will continue to decline; Battery electric vehicle range will continue to increase.
- Hydrogen vehicle and fuel demand are expected to increase.
- Electricity consumption in the transportation sector is projected to increase.
- Overall fuel economy will continue to rise.
- Gasoline demand will decline.

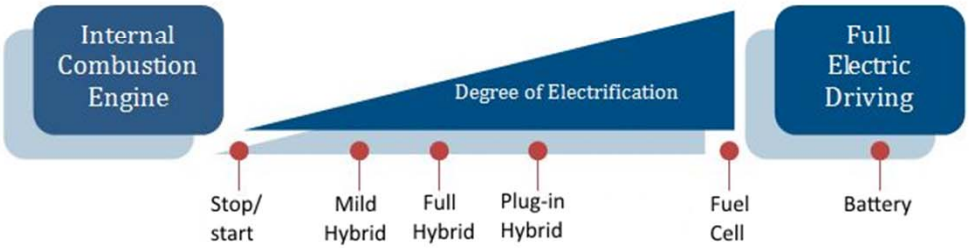
Key Activities Since Preliminary Forecast

- Increased consumer preferences for ZEVs
- DAWG-transportation subgroup
  - Incorporated feedback from stakeholders
- Updated Inputs to the model
  - Economic and demographic forecasts
  - Medium- and heavy-duty vehicle attributes
  - Light-duty vehicle attributes
  - Incorporated new automaker announcements

Electric Vehicle Terminology



Degree of Drivetrain Electrification



Source: IEEE

Transportation Demand Cases

Cases represent different levels of transportation <u>electricity</u> demand

- **<u>Transportation Demand Cases</u>**
  - ❑ **High Electricity Demand (High Case)**
    - Inputs selected to represent high level of electricity demand
  - ❑ **Mid Electricity Demand (Mid Case)**
  - ❑ **Low Electricity Demand (Low Case)**
    - Inputs selected to represent low level of electricity demand
- **Inputs**
  - Income, population, fuel prices, vehicle attributes

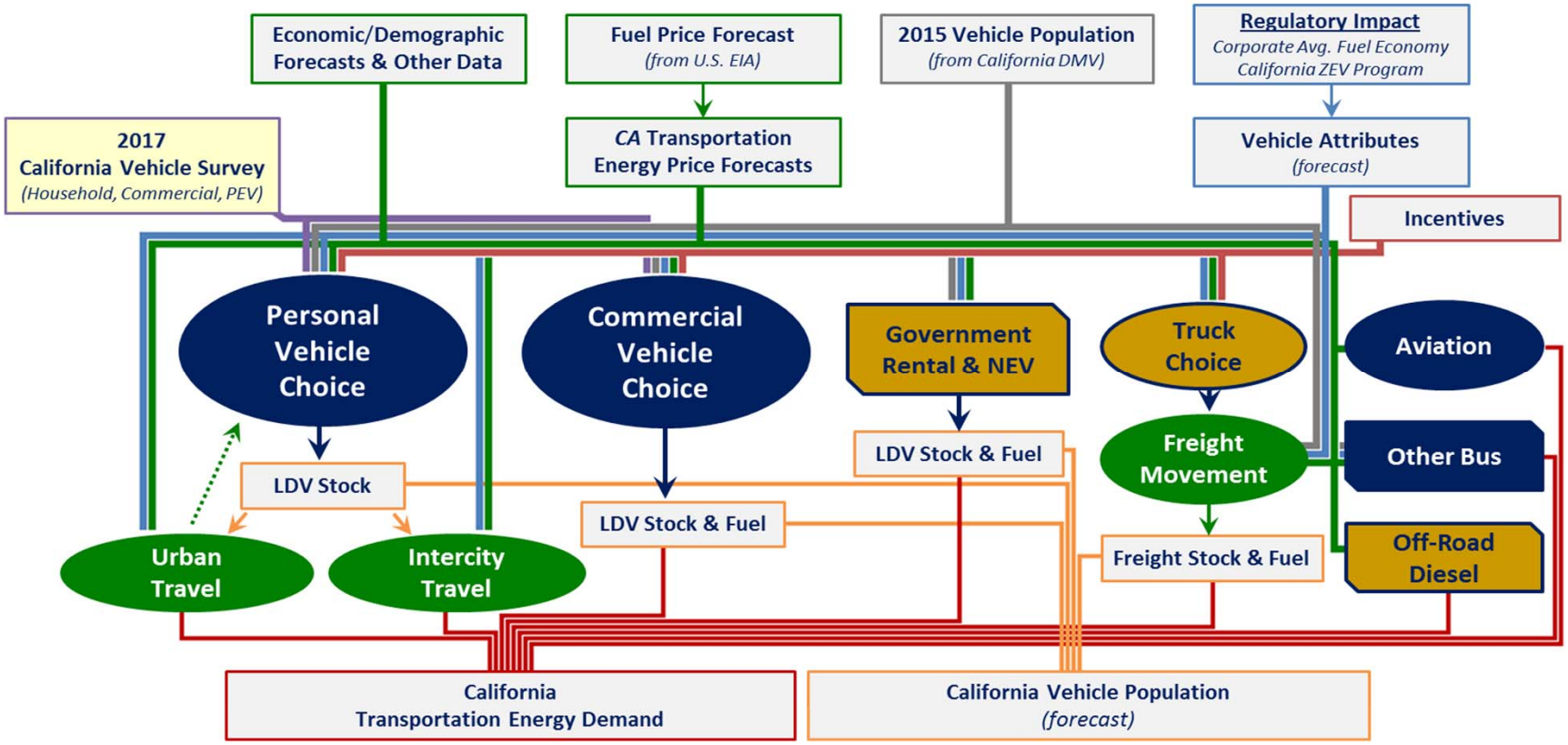
MODEL INPUTS	DEMAND CASE		
	HIGH	MID	LOW
Population	High	Mid	Low
Income	High	Mid	Low
Fuel Prices			
Petroleum Fuels	High	Mid	Low
Electricity / Natural Gas / Hydrogen	Low	Mid	High

Plug-in Electric Vehicle Scenarios

	PEV SCENARIOS				
INPUTS	**Low**	**Mid**	**High**	**Aggressive**	**Bookend**
PREFERENCES					
Consumers' PEV Preference	Constant at 2017 Level	Increase with PEV market growth	Increase with PEV market growth	Increase with PEV market growth	Increase with PEV market growth
INCENTIVES					
Federal Tax Credit	Eliminated after 2019	Decreasing starting 2019	Decreasing starting 2019	Constant through 2030	Constant through 2030
State Rebate	To 2019	To 2025	To 2025	To 2030	To 2030
HOV Lane Access	To 2021	To 2025	To 2025	To 2025 for PHEV / 2030 for BEV	To 2025 for PHEV / 2030 for BEV
ATTRIBUTES					
Availability of PEVs (in 2030)	PEV models available in **11** of 15 CEC LDV classes	PEV models available in **11** of 15 CEC LDV classes	PEV models available in **11** of 15 CEC LDV classes	PEV models available in **13** of 15 CEC LDV classes	PEV models available in all CEC LDV classes
Vehicle / Battery Price (by 2030)	PEV prices based on battery price declining to **~$120/kWh**	PEV prices based on battery price declining to **~$100/kWh**	PEV prices based on battery price declining to **~$89/kWh**	PEV prices based on battery price declining to **~$73/kWh**	PEV prices reach parity with gasoline vehicles
Avg. Range (2030)	~230 miles	~230 miles	~270 miles	~270 miles	~270 miles
Refuel Time (2030)	15 -21 min	15 -21 min	10-16 min	10-16 min	Same as gasoline
Time to Station (2030)	7-8 min	Same as gasoline	Same as gasoline	Same as gasoline	Same as gasoline by 2025
FORECAST RESULTS					
PEV STOCK in 2030	**2.6 million**	**3.3 million**	**3.9 million**	**5.3 million**	**5.9 million**
Cost of State Rebate, 2018-2025	**$577 million**	**$4.2 billion**	**$4.6 billion**	**$5.2 billion**	**$5.4 billion**
Cost of State Rebate Extension, 2026-2030	**-**	**-**	**-**	**$7.1 billion**	**$8.2 billion**

Transportation Models

Key Inputs & Outputs



Global Trends Show Increasing Vehicle Electrification

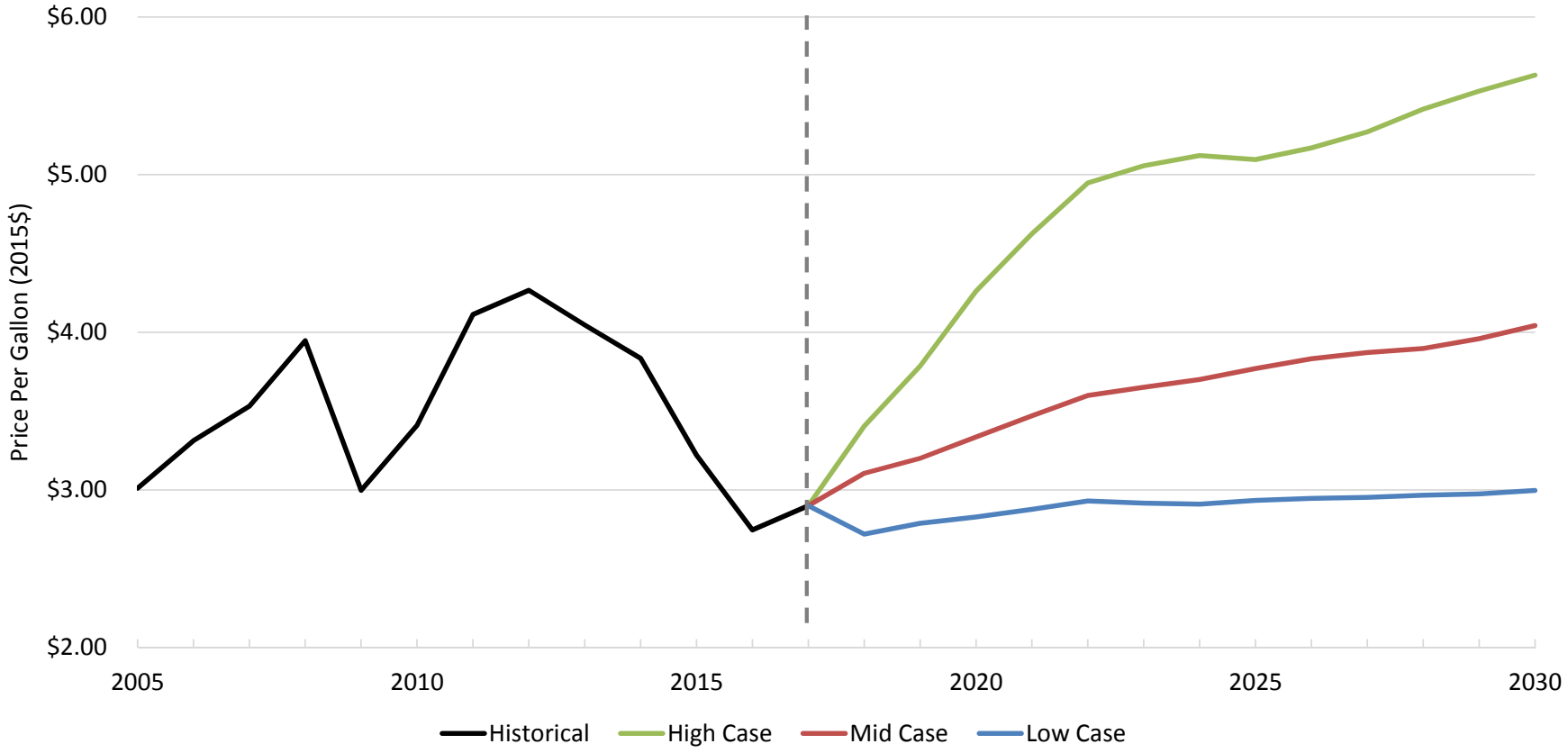
- Global Vehicle Market
  - Light-duty
    - Automakers increase electrified vehicle offerings
  - Heavy-duty
    - Tesla semi
    - Nikola One and Two
    - Toyota fuel cell truck
- Global Transportation Policies
  - California
  - China
  - India
  - Europe

VEHICLE DEMAND FORECAST

Overview of Vehicle Demand Forecast

- Historical and Projected Gasoline Prices
- Cost Per Mile Analysis
- Vehicle Stock
  - Light-Duty Vehicle Stock
  - Medium- and Heavy-Duty Vehicle Stock

Historical and Projected California Gasoline Prices



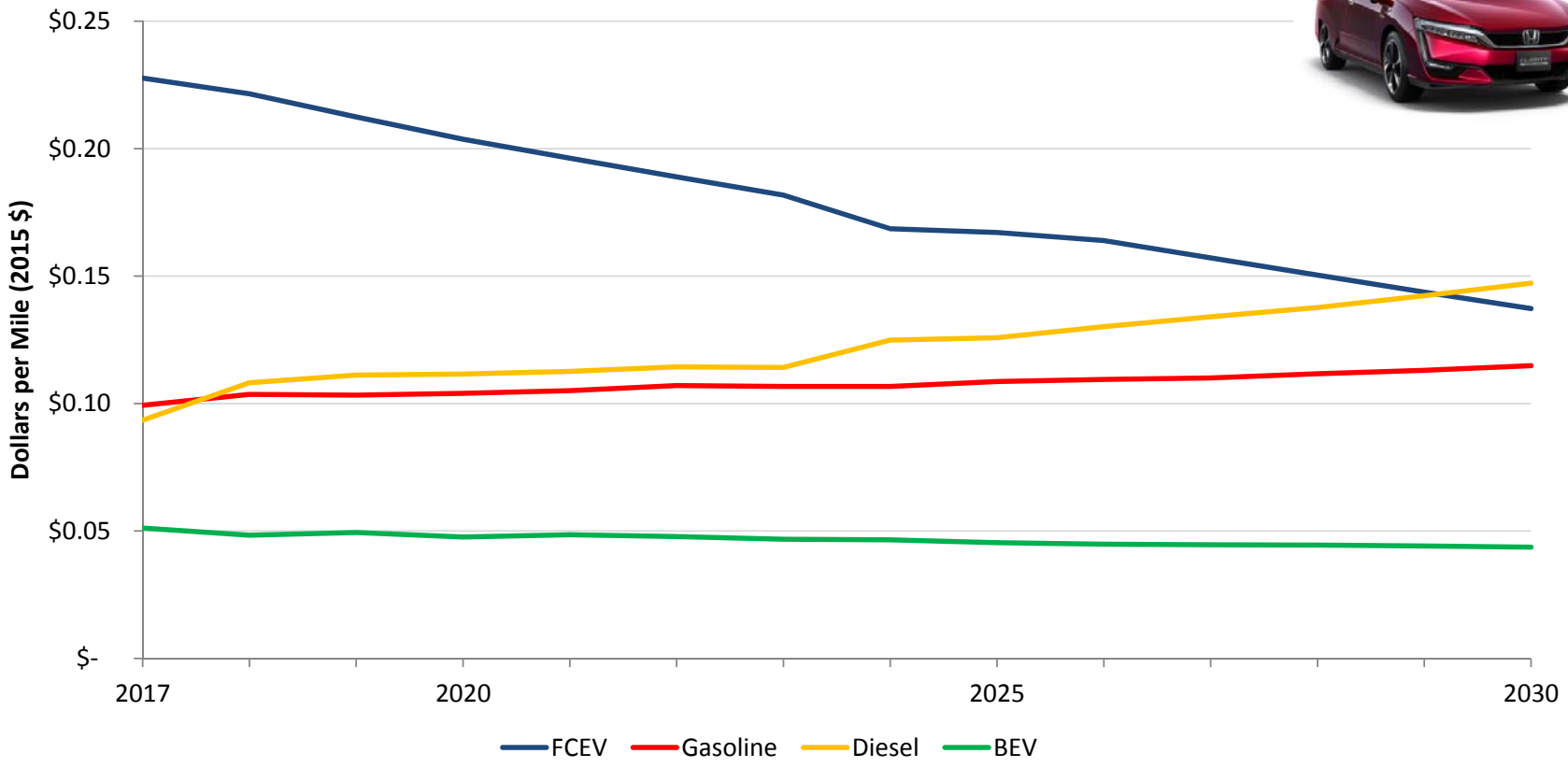
Source: Energy Information Administration (Historical), California Energy Commission (Projected)

Fuel Cost per Mile Trends

- Light Duty Vehicles
  - Electricity is projected to have the lowest cost per mile among fuel types throughout the forecast period
  - Hydrogen fuel costs are projected to decrease over the forecast period
- Medium Duty Trucks
  - Electricity fuel cost per mile remains relatively flat and offers the lowest cost per mile among fuel types
- Heavy Duty Straight (No Trailer) Trucks
  - Diesel-electric hybrid is the fuel type with the lowest cost per mile
  - Natural gas has increasing fuel cost advantage over diesel after 2018
- Heavy Duty Tractor-Trailers
  - Natural gas is the lowest cost per mile of trucks included
  - Tesla is guaranteeing electricity at 7 cents per kWh, announced too late for forecast
  - Nikola offers free hydrogen for a million miles; market price for hydrogen is highest but declines over forecast

Light-Duty Vehicle Fuel Cost per Mile Trends

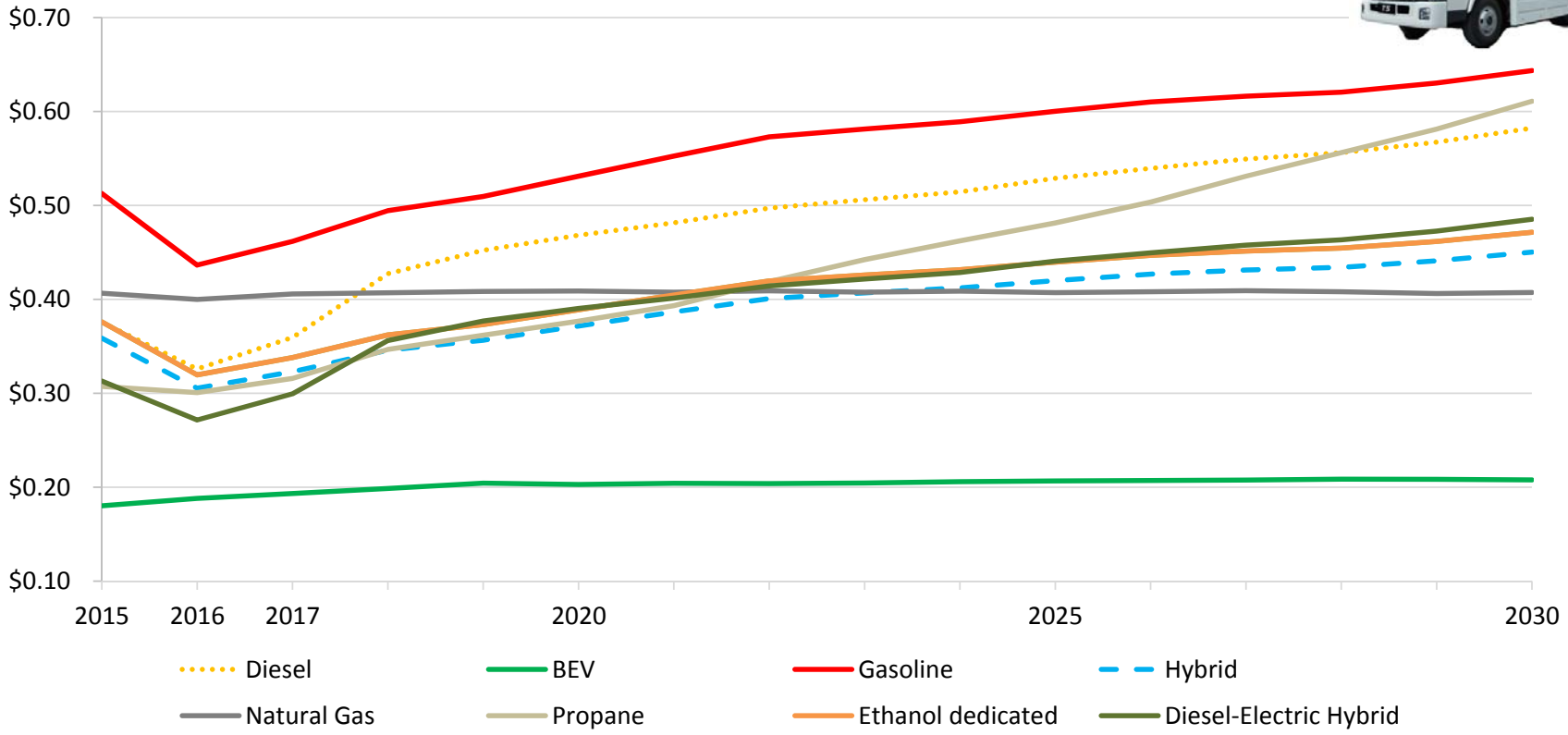
Midsize Cars, Mid Case



Source: California Energy Commission

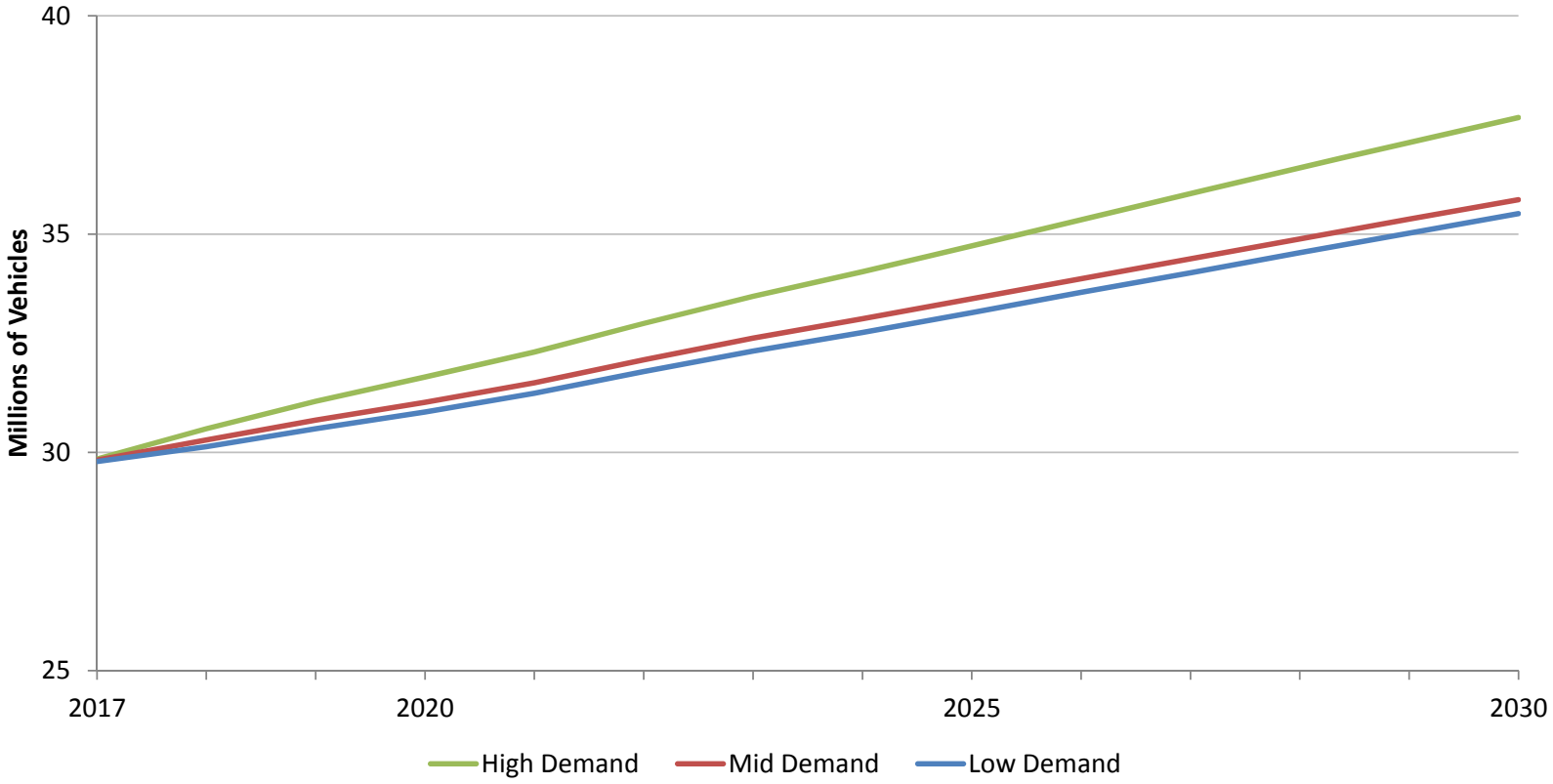
Truck Fuel Cost per Mile Trends

Medium-Duty (Class 4-6) Vehicles, Mid Case



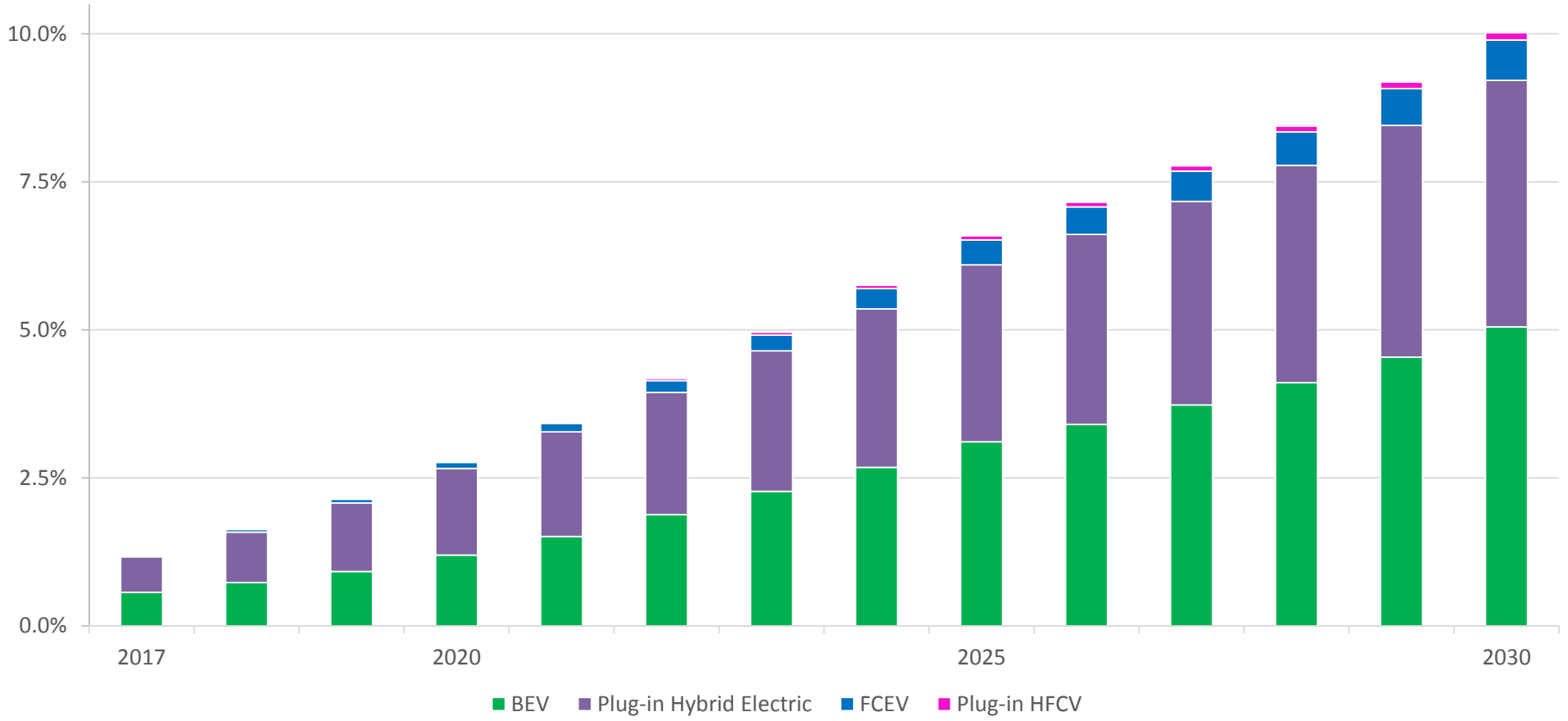
Source: California Energy Commission

Light-Duty Vehicle Stock Grows with Population and Economy



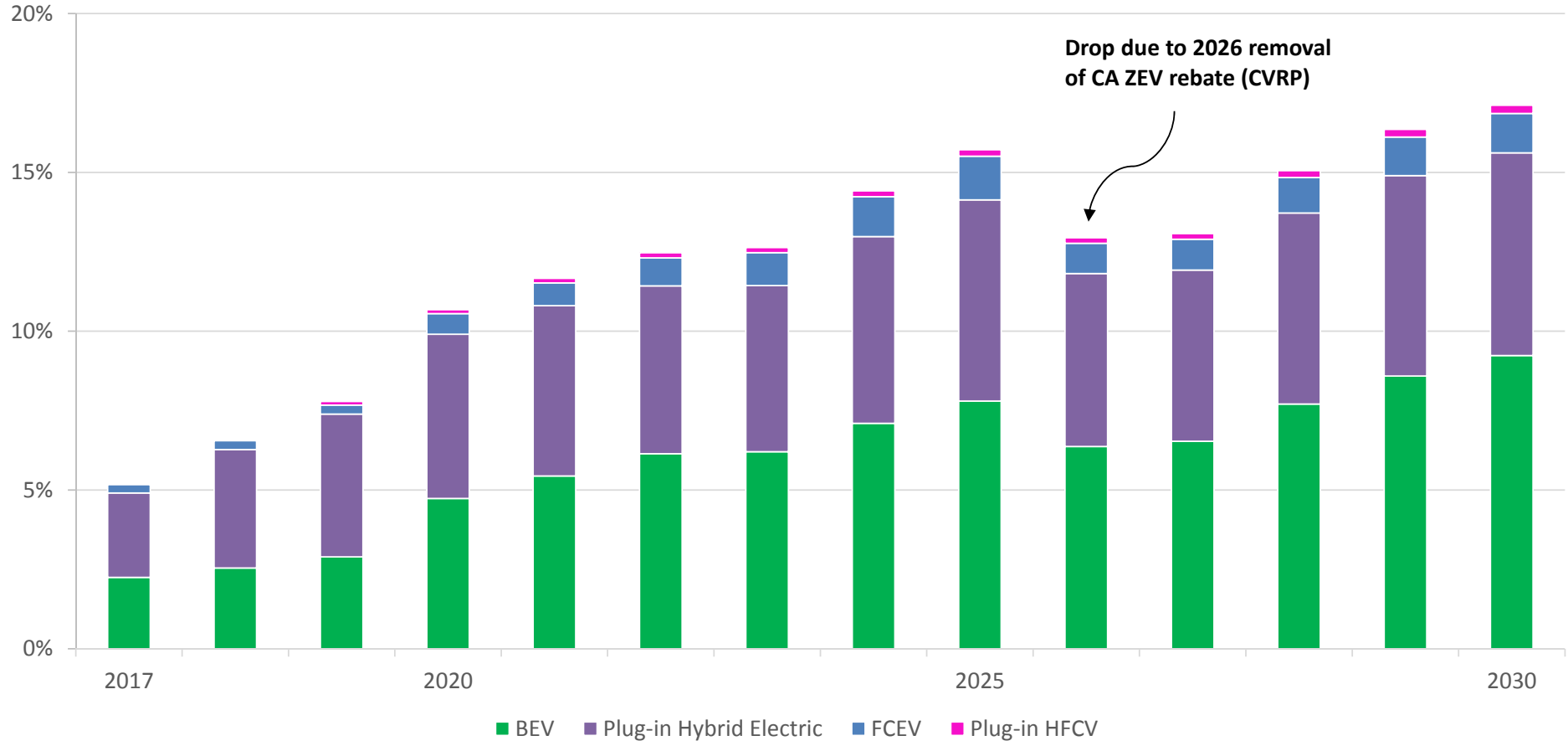
ZEV and PHEV Share of Stock Increases

Share of Light-Duty Vehicle Stock, Mid Case



ZEV and PHEV Share of New Vehicle Sales Grows

Share of Light-Duty Vehicle Sales, Mid Case



Medium & Heavy-Duty Truck Technologies

Powertrains considered in Truck Choice model (at least one truck class)

- Battery electric
- Catenary electric
- Compressed natural gas
- Diesel
- Diesel-electric hybrid
- Diesel-hydraulic hybrid
- Gasoline (including flex-fuel)
- Gasoline-electric hybrid
- E85 (Ethos)
- Hydrogen fuel cell
- Liquefied natural gas
- Propane (LPG)

Hydrogen fuel cell

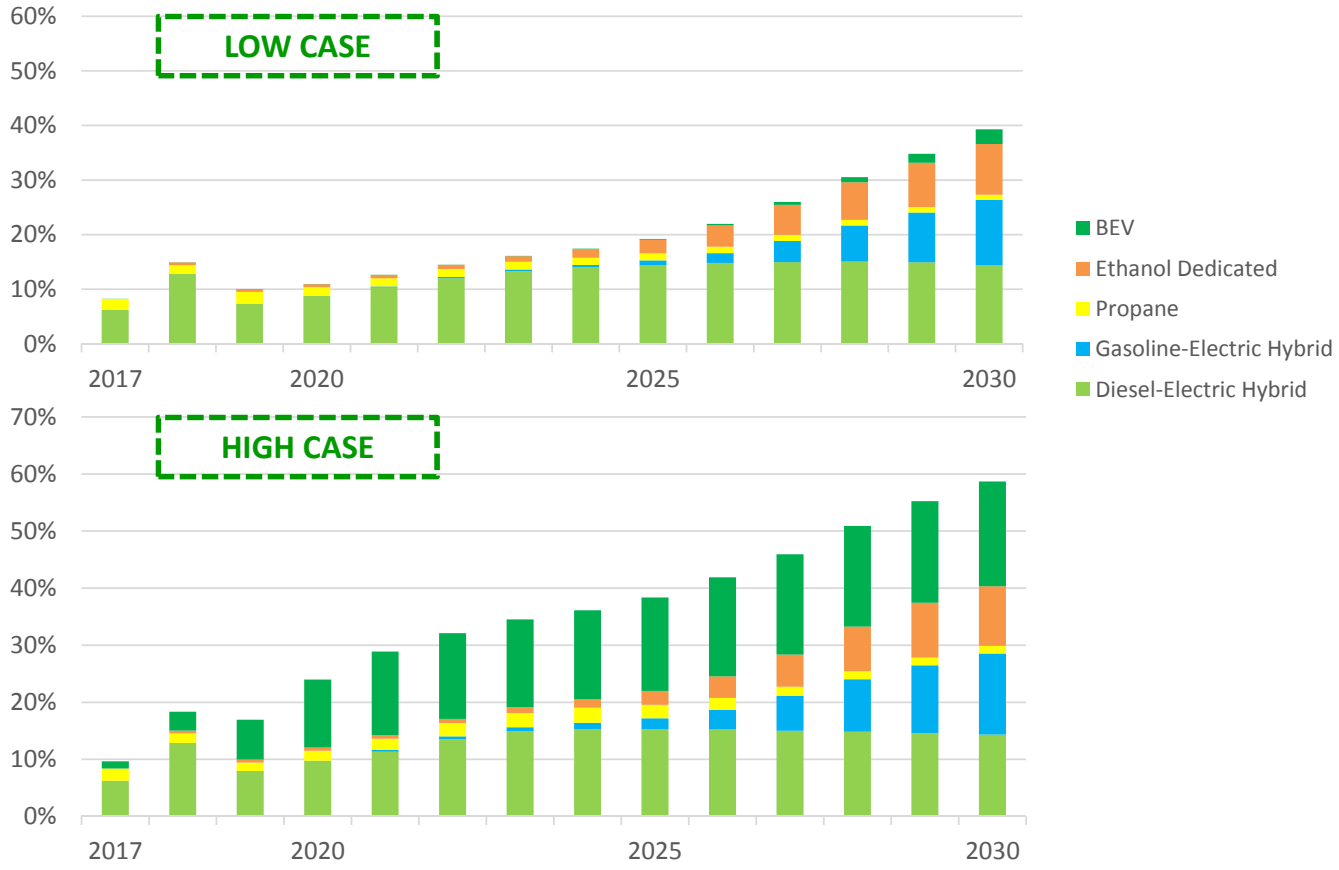
Diesel-hydraulic hybrid

Battery Electric

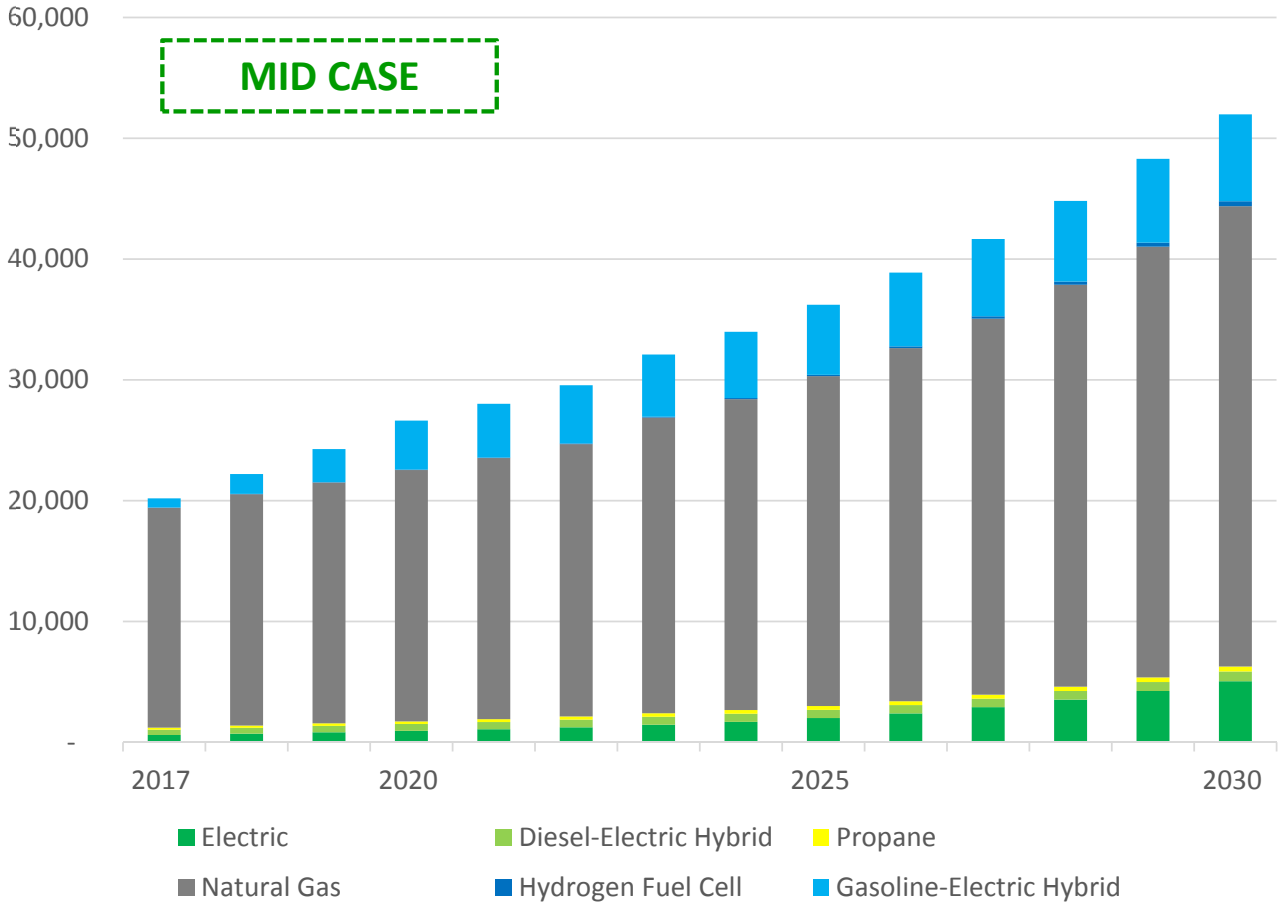
Catenary Electric

New Alternative Fuel MDV Sales Increase

Medium Duty Truck Share by Fuel Type



Alternative Fuel Heavy Duty Vehicle Stock Increases



LIGHT-DUTY ZEV ANALYSIS

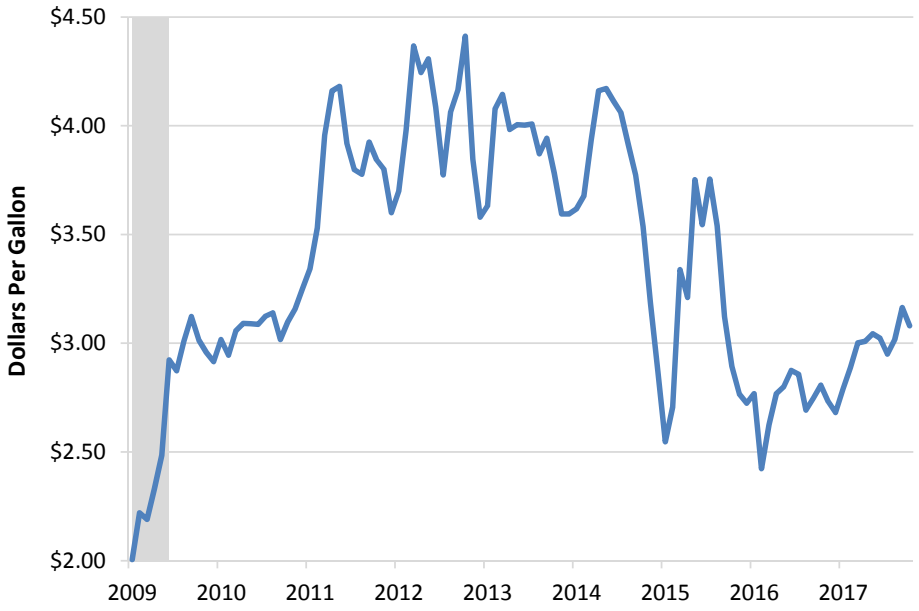
Overview

- Trends in light-duty vehicle (LDV) electrification
- Battery electric vehicle (BEV) range
- Battery electric vehicle prices
- Zero-emission vehicle (ZEV) forecast and regulatory compliance

Recent Trends in LDV Electrification

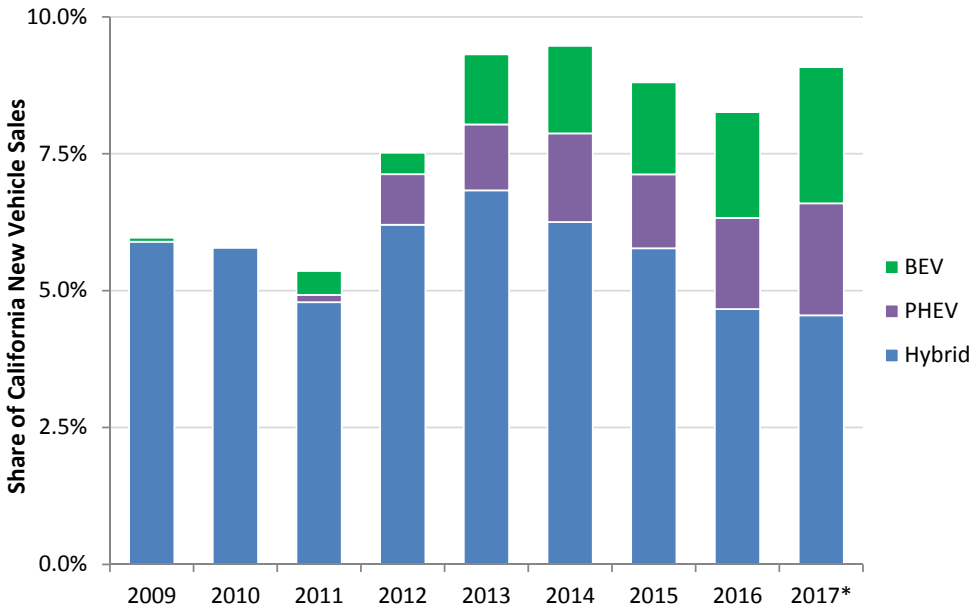
- PEV share is increasing: up to 4.5% of new vehicle sales in 2017.
- NOTE: each powertrain has a different degree of electrification (see slide 5)

Historical California Gasoline Prices



Note: Gray bars indicate economic recessions
Sources: U.S. Energy Information Administration, Federal Reserve Bank of St. Louis

Hybrid, Plug-in Hybrid, & BEV Sales Share



Source: California Energy Commission analysis of California Auto Outlook by Auto Outlook, IHS Markit. *Sales through Sept 2017.

Automaker Announcements

- Manufacturers are planning to offer more electrified models.
  - Electrification plans include hybrids.

- Major automaker announcements in 2017 are shown below:

Company	Target Year	Announcement
BMW	2025	will offer 25 electrified vehicles – 12 will be fully-electric
Mercedes Benz	2022	10 plug-in electric vehicles, rest will have hybrid option
Fiat Chrysler	2022	More than half of Maserati models will use some form of electric powertrain
Ford	2022	13 new electric (and plug-in hybrid) models
Volvo	2019	every ***new*** model will be electric, plug-in hybrid, or hybrid
GM	2023	20 new fully electric models
Hyundai Kia	NA	electric cars at the center of future product stategy
Jaguar Land Rover	2020	every ***new*** model will be electric, plug-in hybrid, or hybrid
Renault - Nissan	2022	12 pure electric models to be launched
Volkswagen Group	2030	will electrify (electric, plug-in hybrid, and hybrid)entire model portfolio by 2030

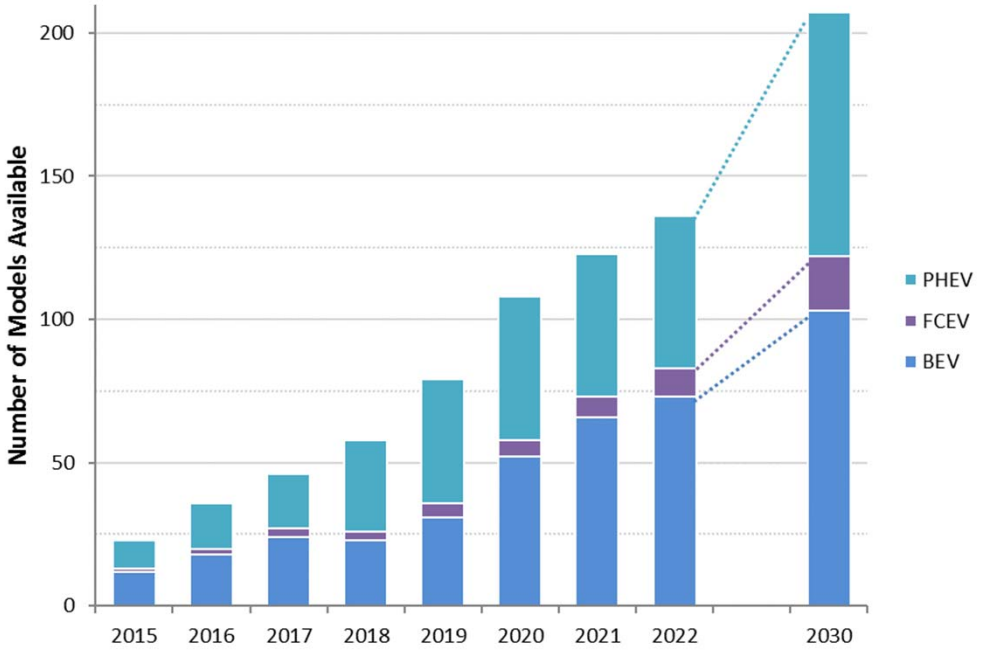
Source: OEM Announcements as of October 1st 2017. Note: These announcements refer to OEMs global strategy. Not all models will be available in the United States.

Number of Projected ZEV Models

- Energy Commission staff collected media reports and OEM announcements to project number of ZEV and PHEV models through 2022.

- CARB projected about 80 models by 2021 in ZEV Midterm review (released Jan 2017).
  - OEM announcements accelerated through 2017.

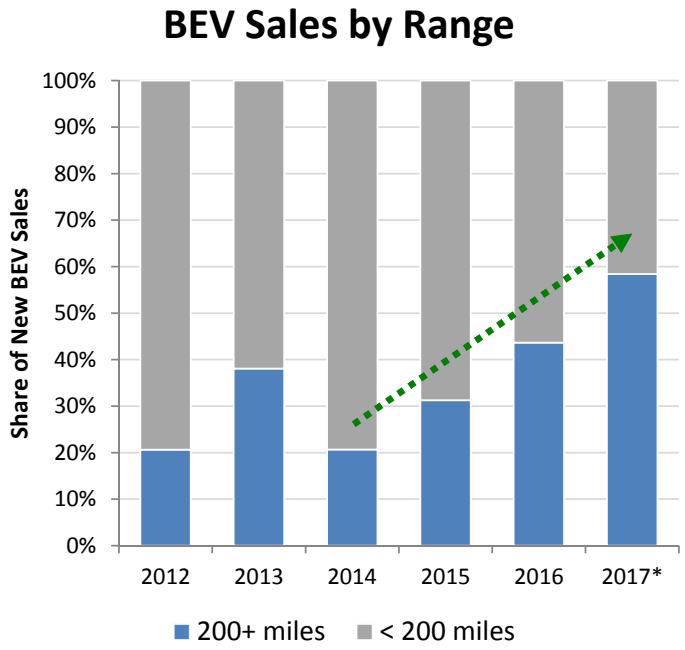
Projected Number of Light-Duty ZEV Models, Mid Case

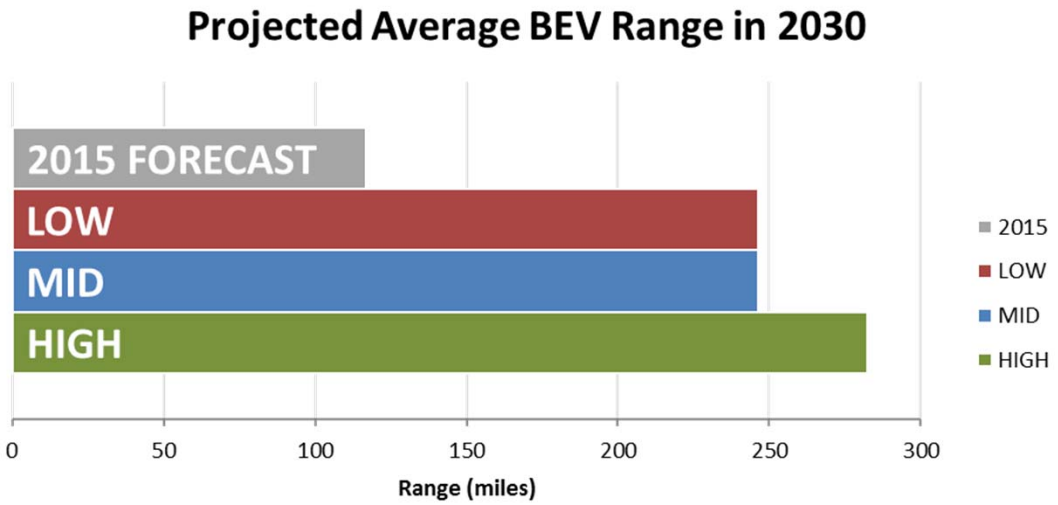


Source: California Energy Commission and NREL.

BEV Range is Increasing

- Sales of longer range BEVs are increasing.
- Projected average BEV range in 2017 Forecast increases significantly.





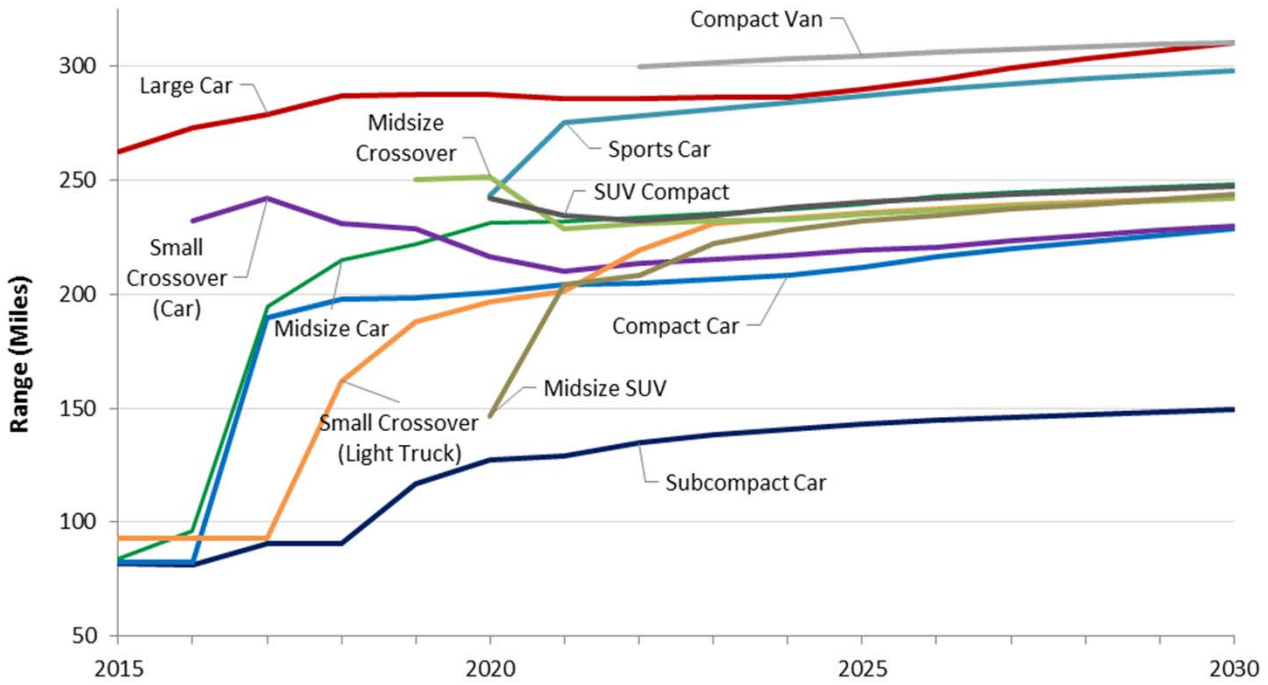
Source: California Energy Commission analysis of California Auto Outlook by Auto Outlook, IHS Markit. *Sales through Sept 2017.

BEV Range is Projected to Grow

Projected BEV Range by Class

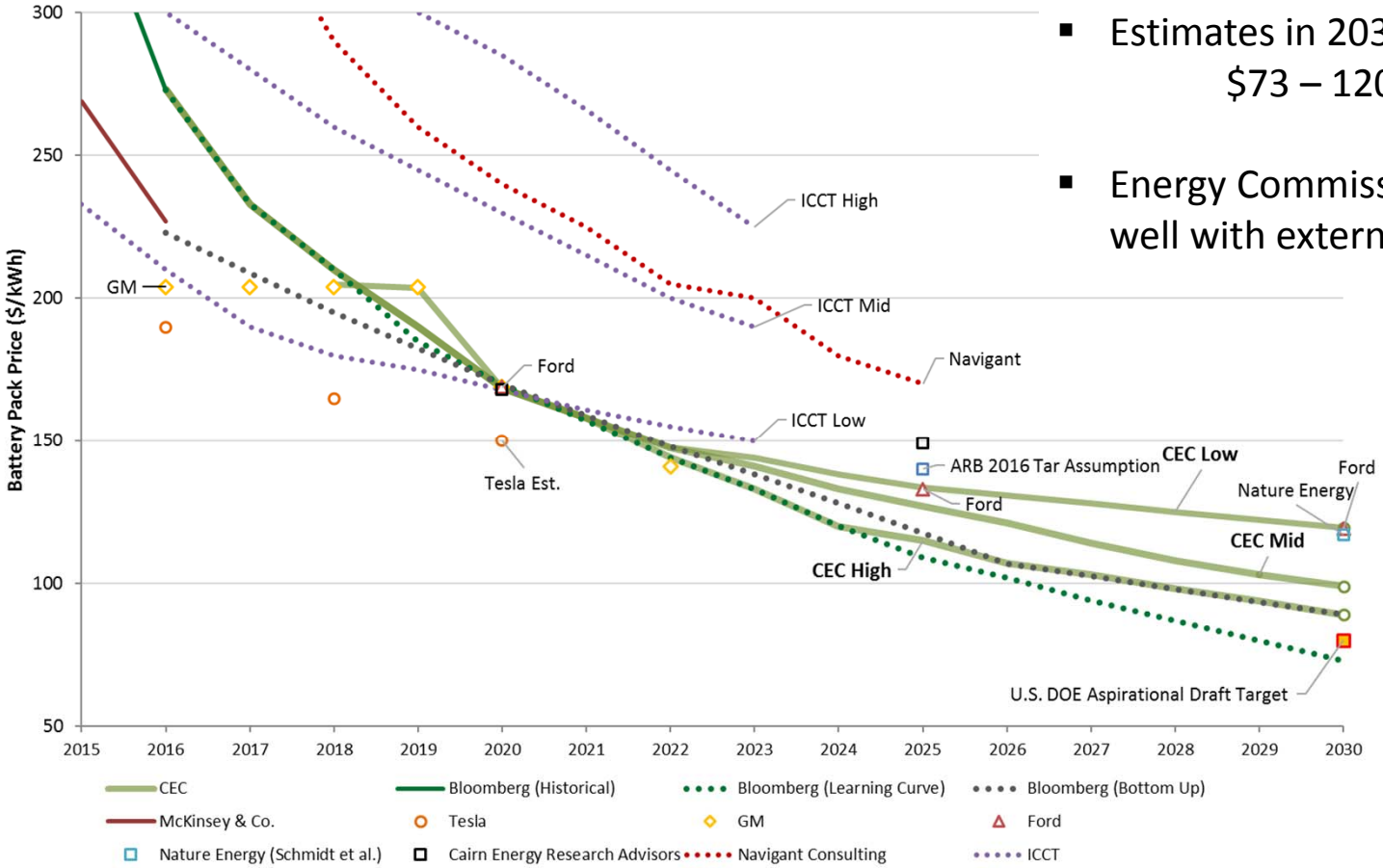
- Swings in BEV range (up or down) are due to expected introduction of new models.

MID CASE



Source: California Energy Commission

Battery Pack Cost Estimates

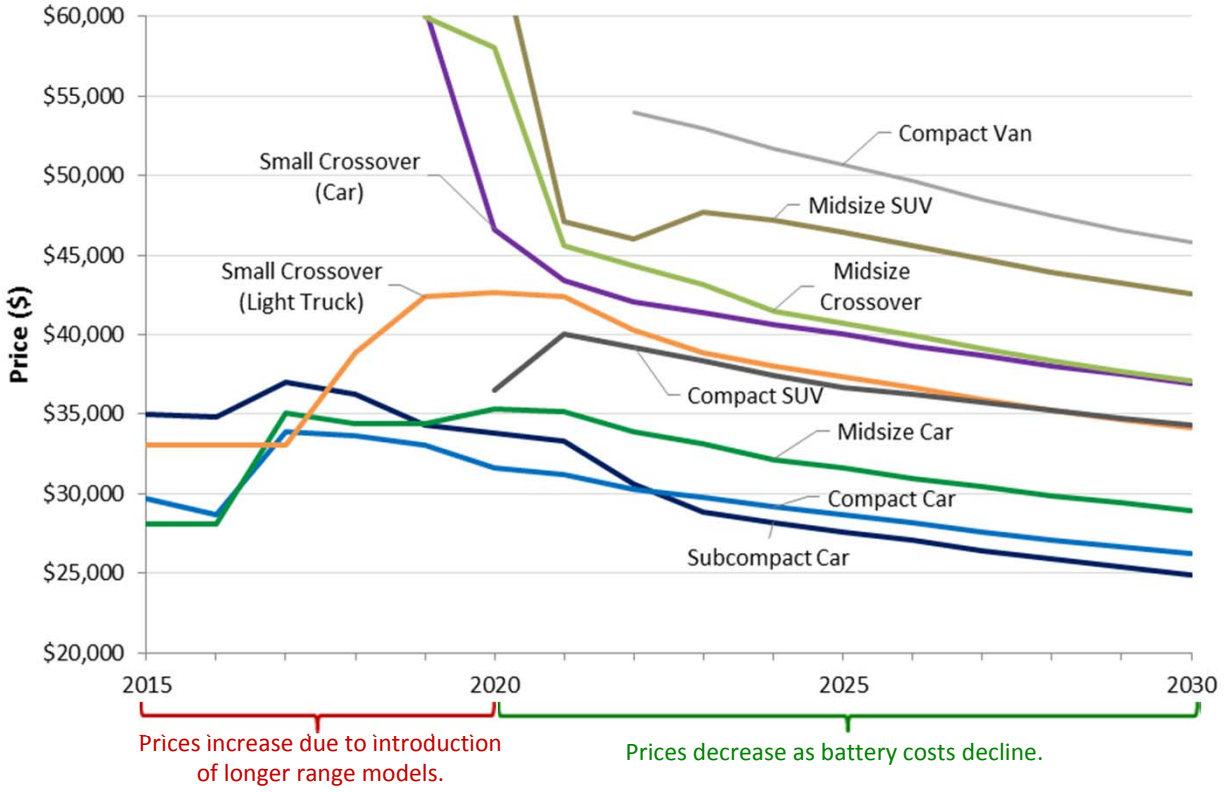


- Estimates in 2030 range from $73 – 120 per kWh.
- Energy Commission estimates align well with external sources.

BEV Prices Decline Over Time

Projected BEV Prices by Class

MID CASE



Source: California Energy Commission. “Large Car” and “Sports Car” prices, which are dominated by luxury vehicles, are above the displayed axis for the forecasted period.

BEV Range and Price

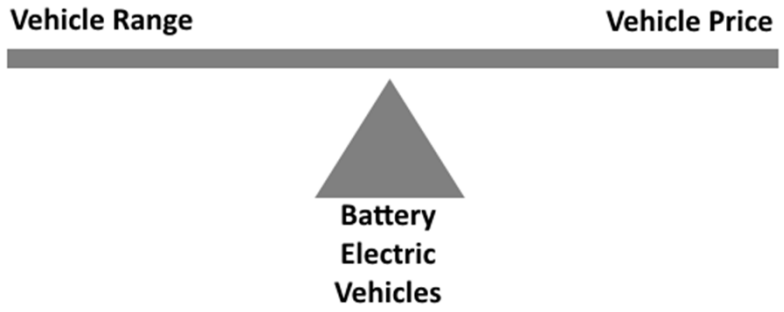
- Battery costs are falling…
- But average price of BEVs rose…

  "The average price of EVs rose again in 2016, but this reflects faster growth in more expensive models and does not take account of increases in driving range…reductions in battery costs are translating into longer ranges rather than lower vehicle prices"

  - International Energy Agency

- TEFU is using a new metric to show relative decline in BEV prices.

- CEC Forecast of Avg. BEV Range:
  - 2015 forecast: Flat at ~115 miles
  - 2017 forecast: Rising to 240-280 miles

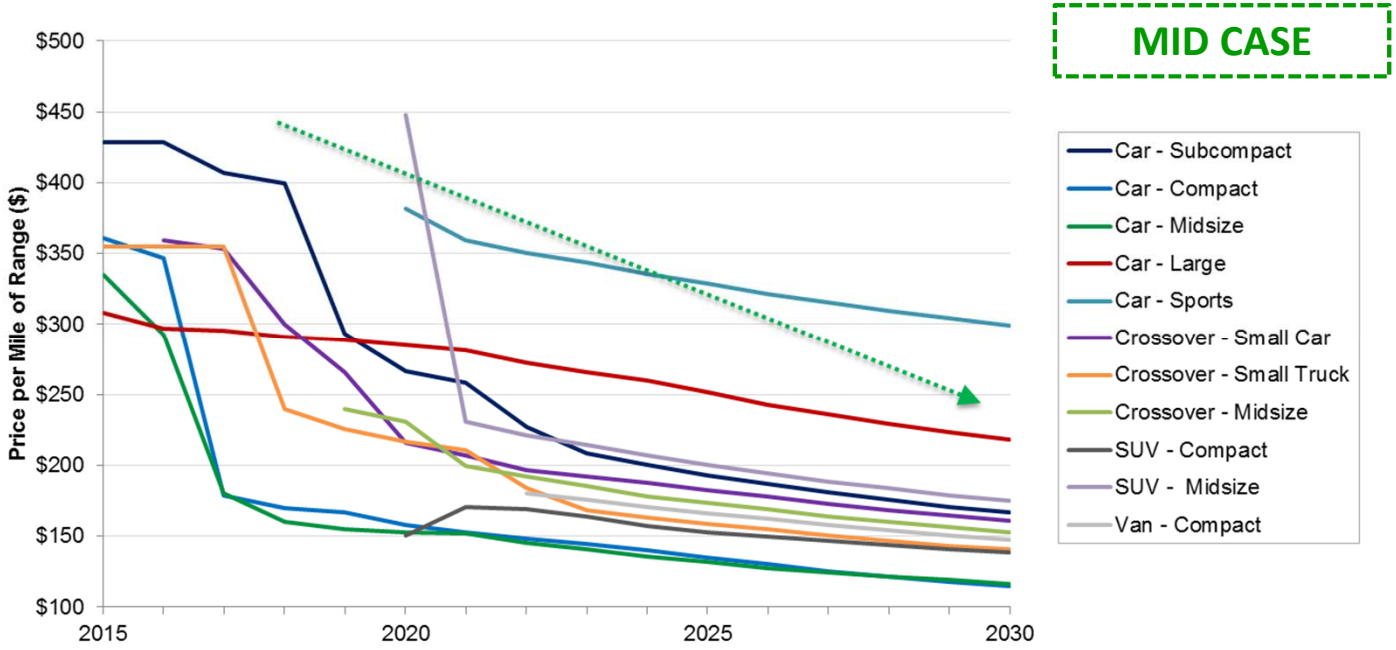


Source: www.iea.org/newsroom/energysnapshots/average-ev-price-and-range.html

BEV Price per Mile of Range is Decreasing

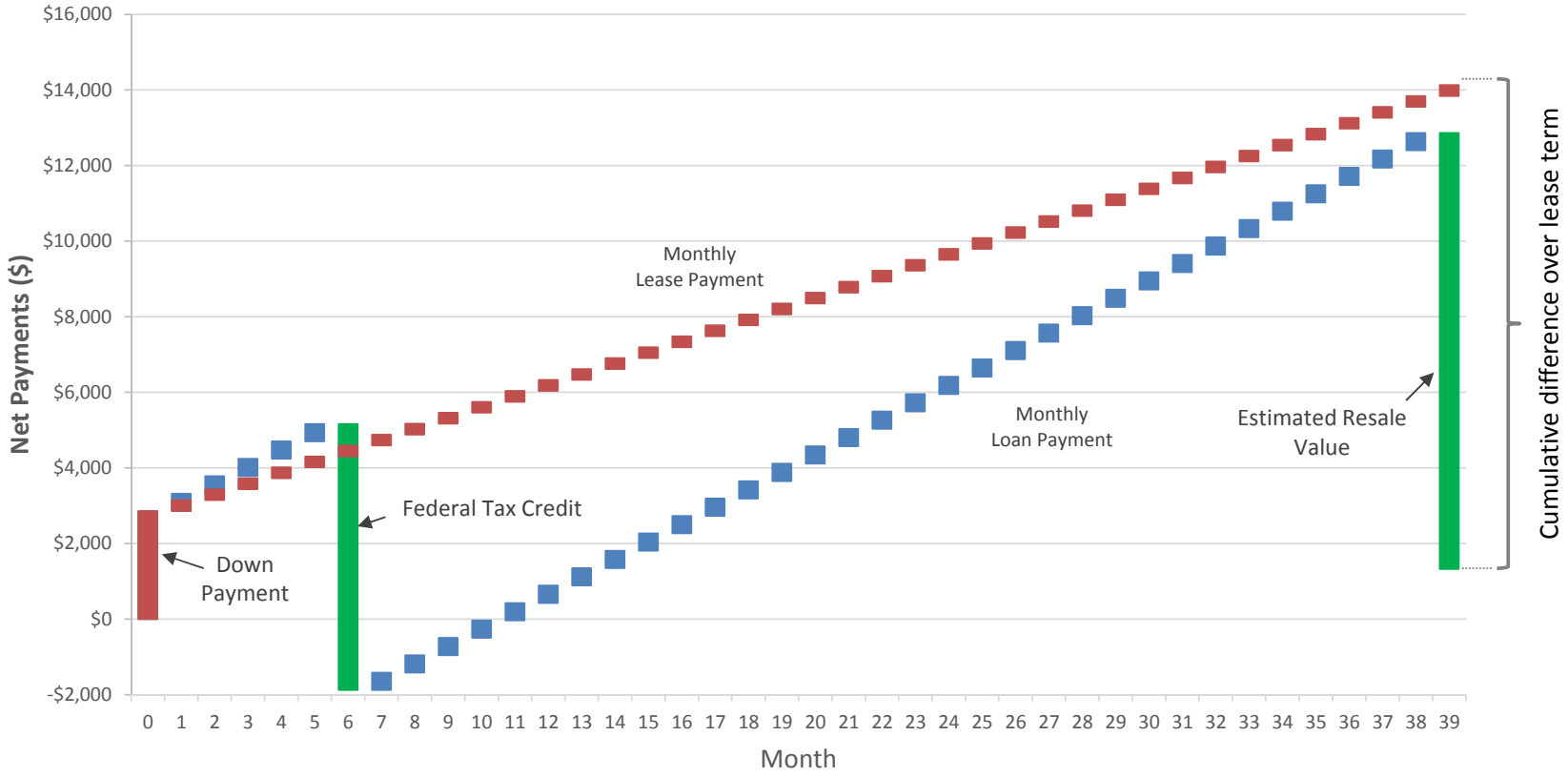
$$Price\ per\ Mile\ of\ Range = \frac{BEV\ Price}{BEV\ Range}$$

- The "relative" price of a BEV when holding range constant.
- Price per mile of range is projected to decline sharply over the forecast period for all BEV classes.



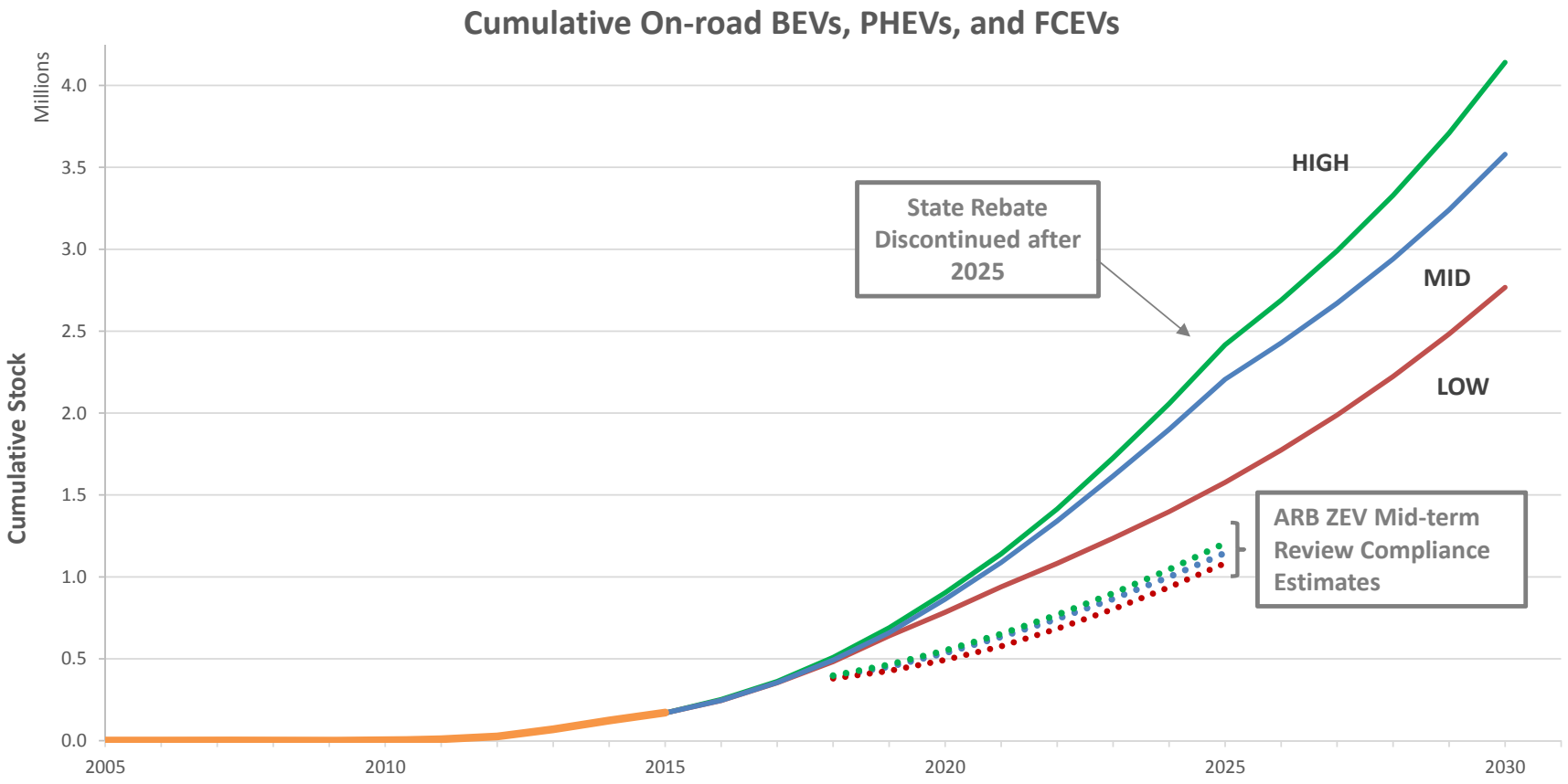
Source: California Energy Commission Analysis

Loan vs 3 year Lease for Chevrolet Volt



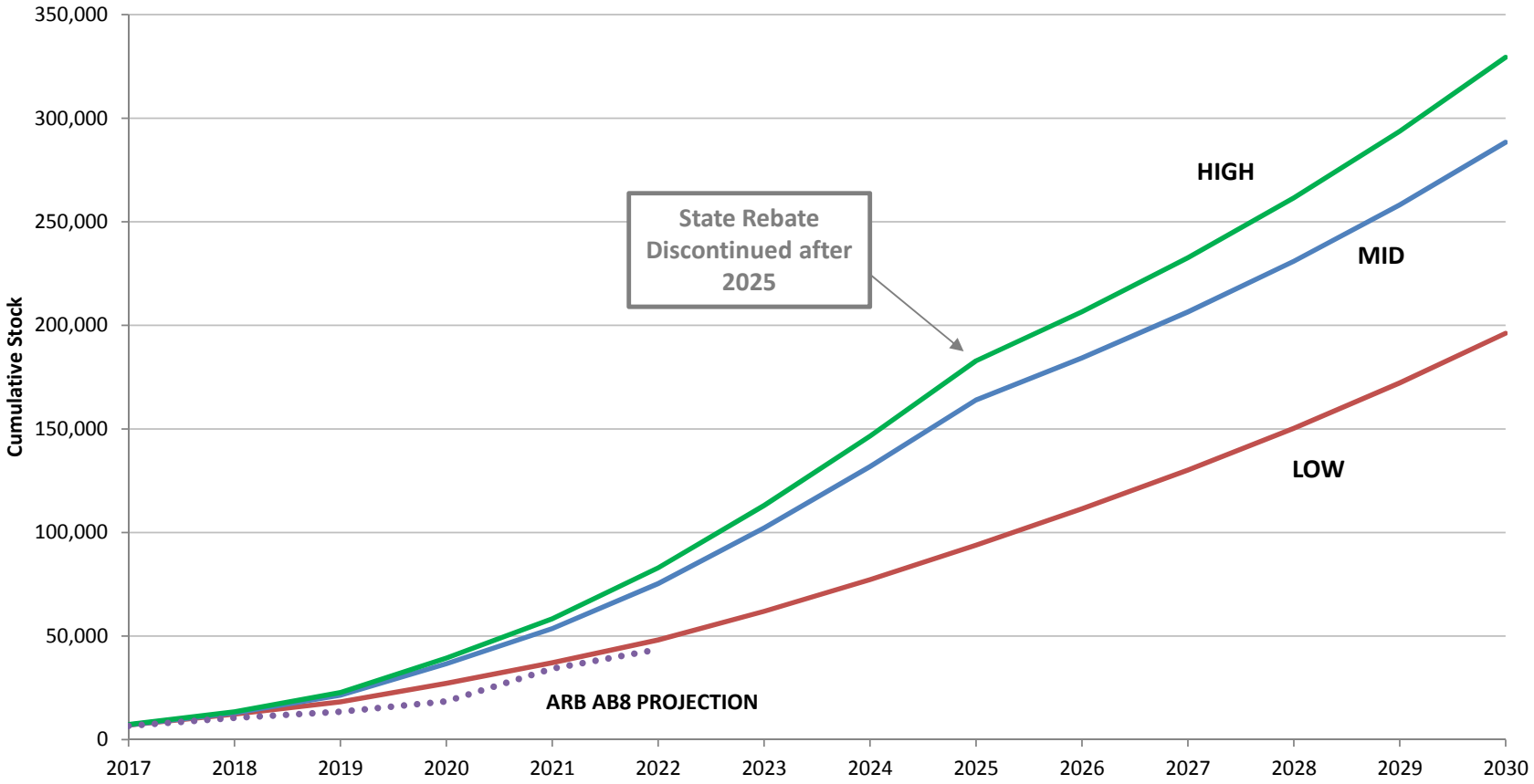
- Lease terms and loan payment information from Chevrolet.com, October 2017
- Estimated resale value for three year old (2014 MY) Volt from Kelly Blue Book, October 2017

ZEV and PHEV Stock Continues to Grow



Source: California Energy Commission, California Air Resources Board

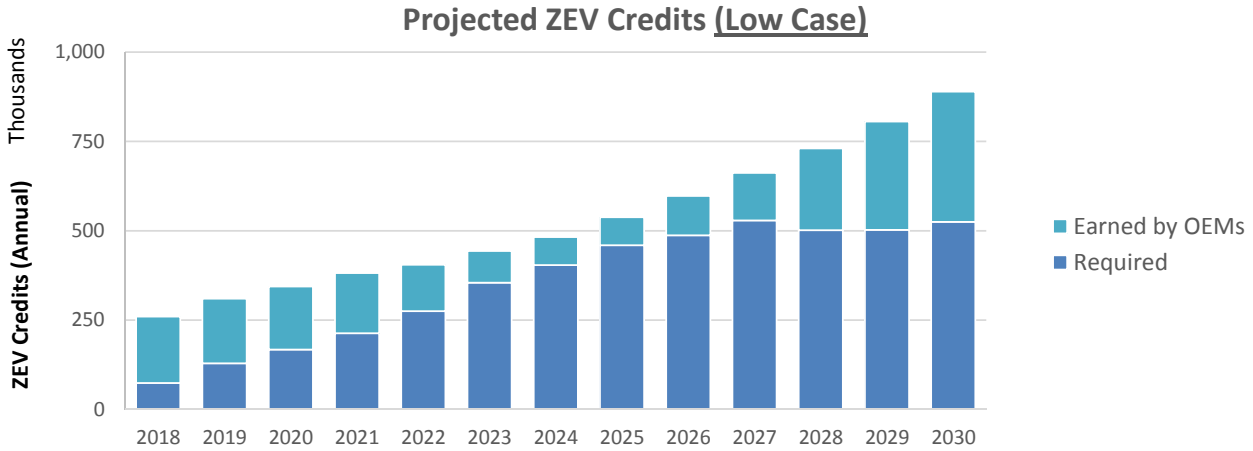
Fuel-Cell Vehicle Stock is Projected to Grow



Source: California Energy Commission, California Air Resources Board

Meeting the ZEV Regulation

- CEC's Transportation Demand Forecast assesses market demand for ZEVs, and generates a forecast of sales.
- By converting forecast of ZEV sales to ZEV credits, staff can check the forecast results for compliance with CARB's ZEV regulations.

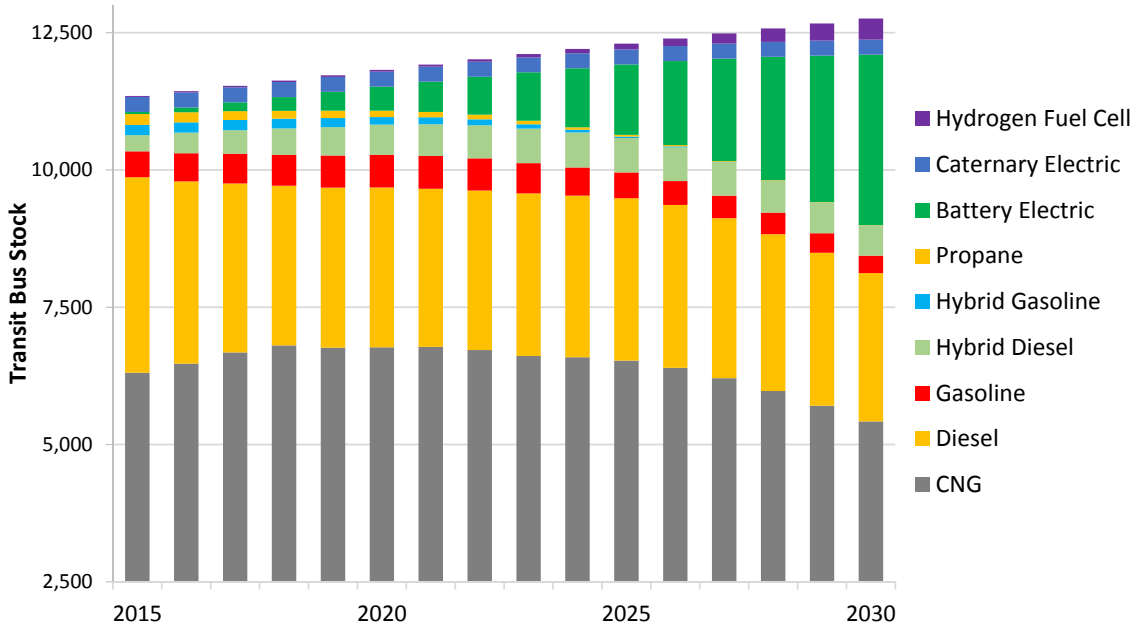


Source: California Energy Commission

- Result: **Forecast projects compliance in all cases**

Transit Bus Stock

- ZEV share grows for transit buses.
- Replacement takes time because stock is replaced every 12-18 years.
- Replacement driven by:
  - Competitive pricing
    - Federal policy covers 80% of vehicle cost for all transit buses.
  - State & local policy



Note: Forecast of active fleet vehicles only.
Source: California Energy Commission, National Transit Database.

Key Takeaways

- BEVs are expected to have more favorable characteristics such longer range and lower prices, due in part to:
  - California's ZEV Program
  - Decreasing cost of lithium-ion battery packs
- Statewide shift toward transportation electrification is underway.
- Given a stable policy and regulatory environment,
  - Transportation forecast projects that California is making progress toward its clean energy goals.

TRANSPORTATION FUEL DEMAND FORECAST

Fuel Demand Overview

- Fuel Economy Forecast
- Fuel Demand Forecast
  - Conventional Fuels (Gasoline, Diesel, Jet Fuel)
  - Alternative Fuels (Electricity, Natural Gas, Hydrogen, E85)
  - High-Speed Rail

Overall Fuel Economy Increases

Compact Car MPG by Fuel Type, Mid Case

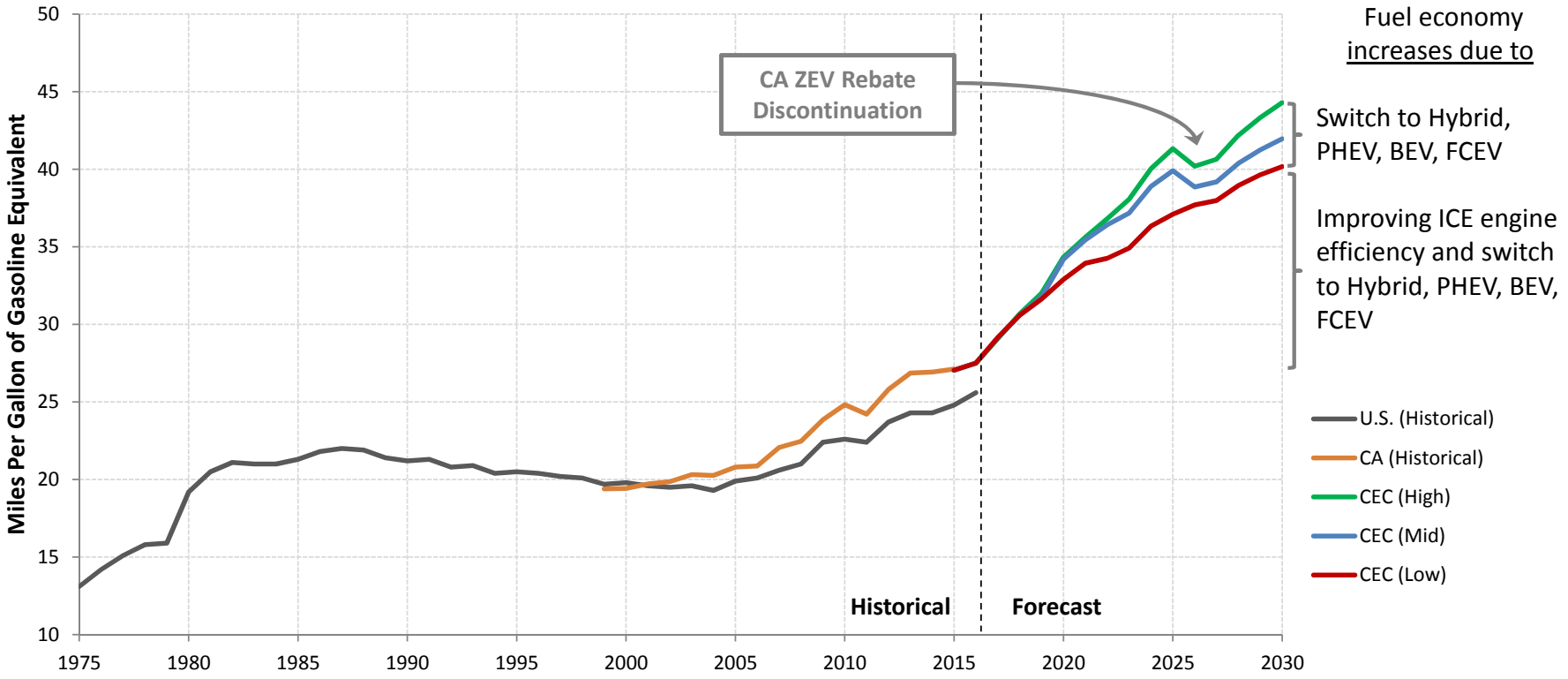
	2017 MPG	2030 MPG	Increase	Percent Change
Diesel	33	44	12	35.4%
BEV	116	129	13	11.2%
Flex Fuel	23	25	2	10.5%
Gasoline	30	38	8	24.9%
Hybrid	47	56	8	17.6%
FCEV	68	73	6	8.6%
Plug-in Hybrid Electric	74	87	13	18.1%

Source: National Renewable Energy Laboratory, California Energy Commission

Sales-Weighted Fuel Economy Also Increases

Sales-Weighted Average Light-Duty Vehicle Fuel Economy by Model Year, All Fuel Types

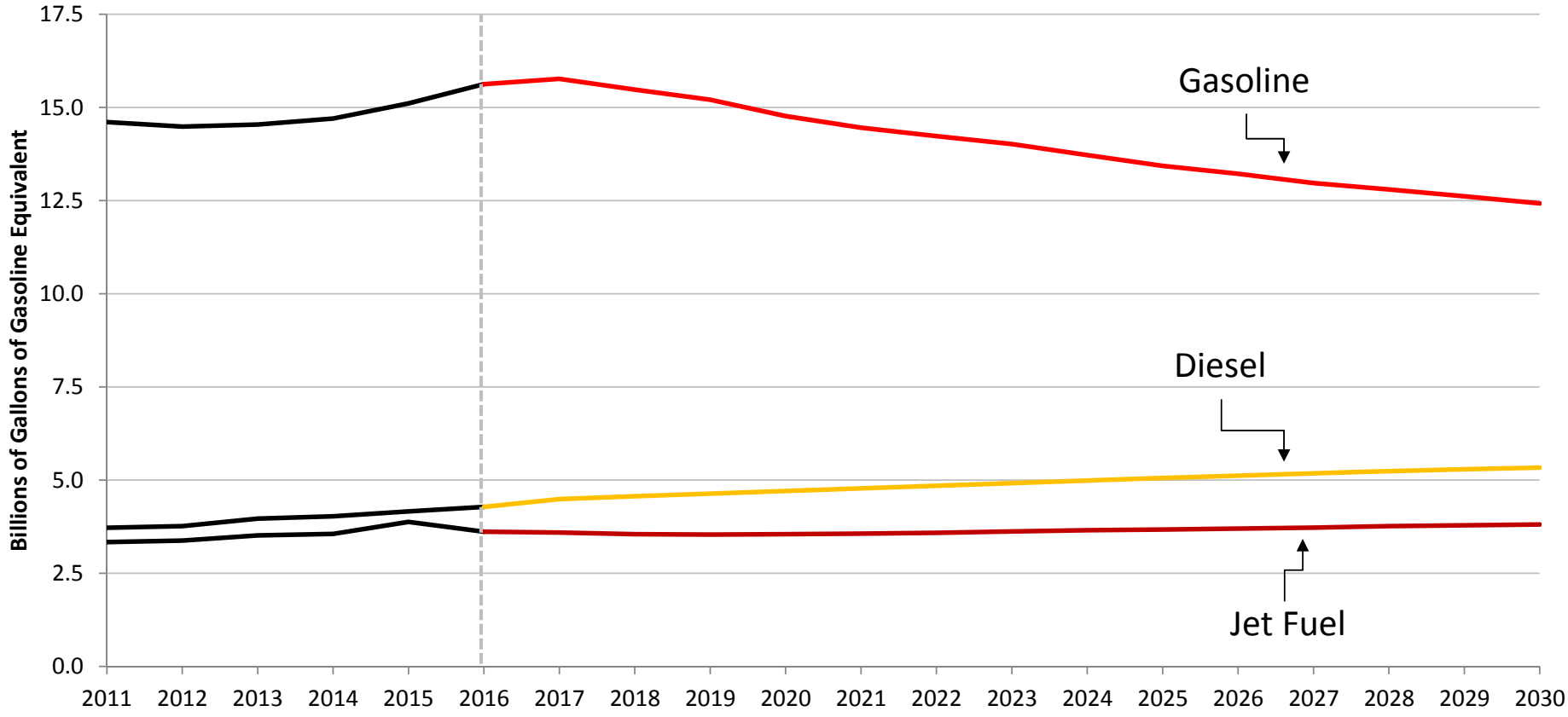
- NOTE: "54.5 MPG" CAFE standard is actually ~35-36 MPG EPA label fuel economy in 2025.



Source: United States Environmental Protection Agency, California Energy Commission

Sustained Drop in Gasoline Demand

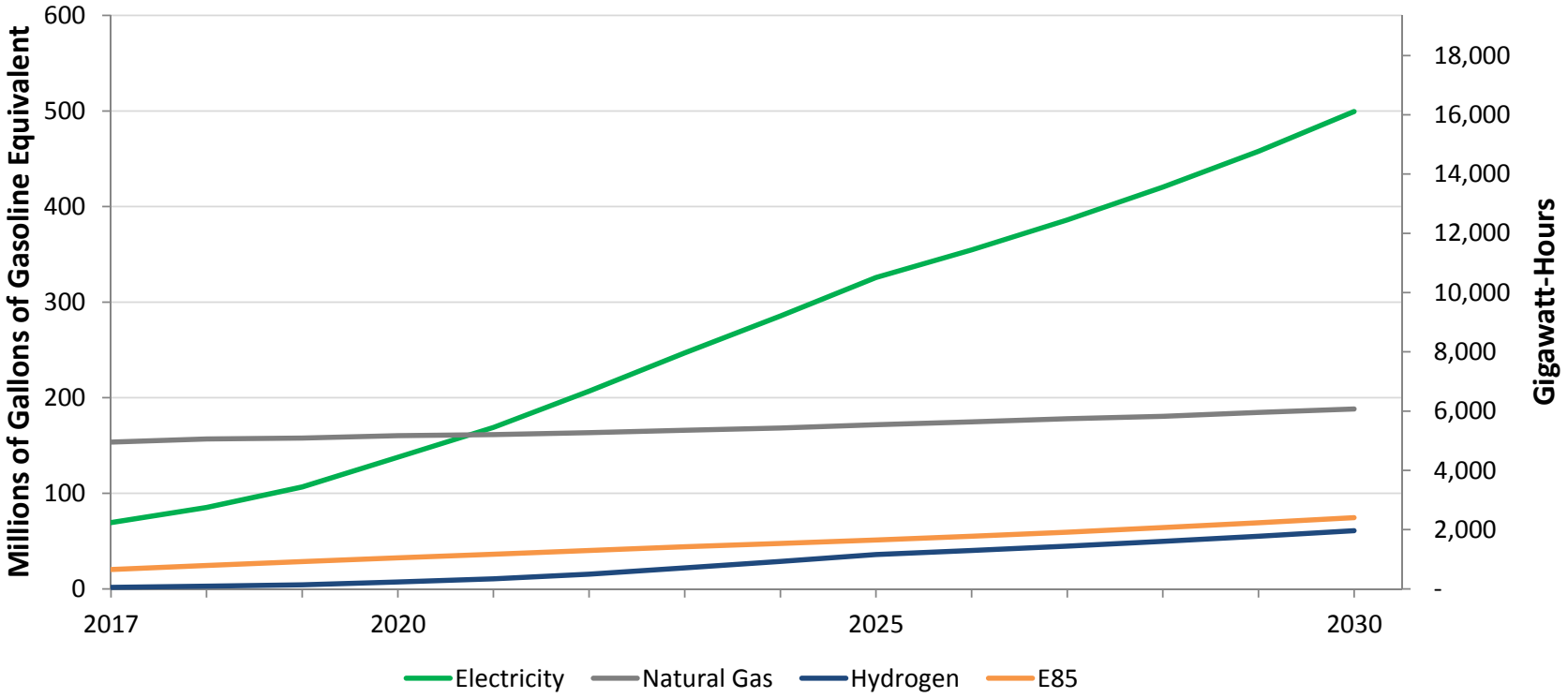
Conventional Fuel Demand Forecast, Mid Case



Source: California Energy Commission

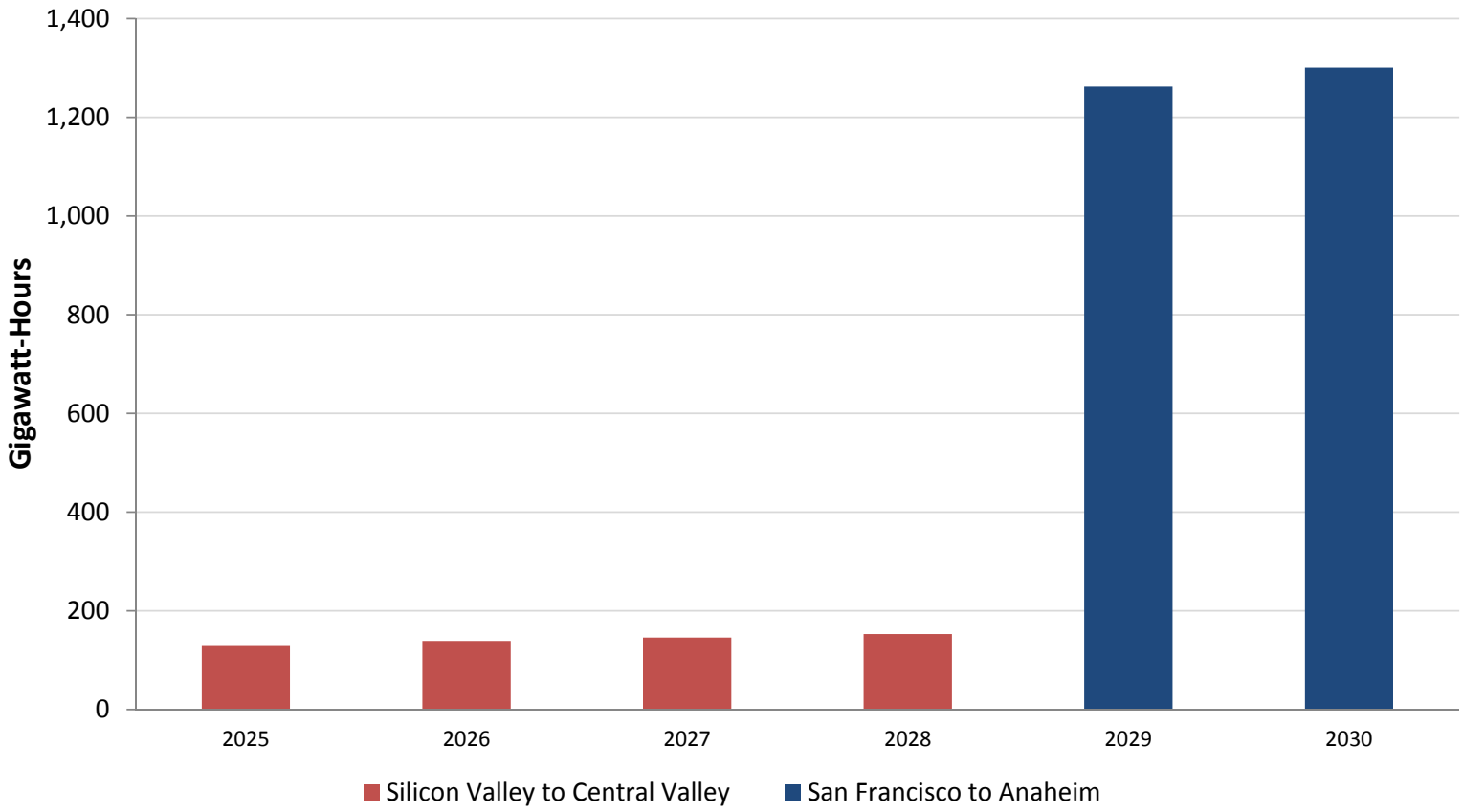
Transportation Electricity Demand Increases

Alternative Fuel Demand Forecast, Mid Case
All Vehicles and Modes, Excluding High-Speed Rail



Source: California Energy Commission

Projected High-Speed Rail Electricity Consumption



Source: California High-Speed Rail Authority

Thank You

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