DOE Hydrogen and Fuel Cell Technical Advisory Committee
April 1-2, 2014, Radisson Hotel Reagan National Airport

Achieving Climate and Air Quality Goals: *Transforming California's Vehicle Fleet*

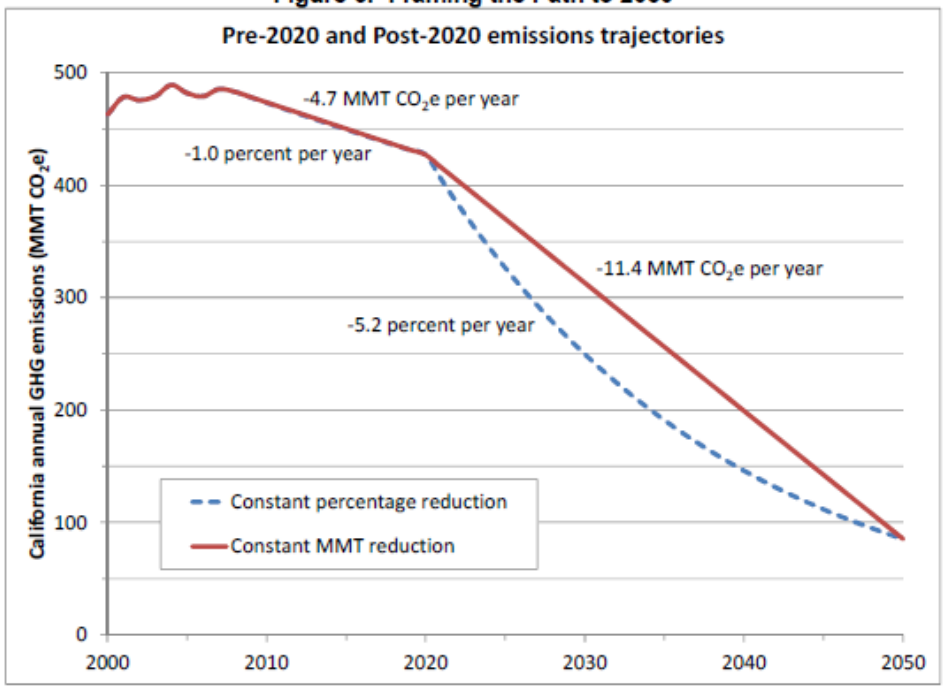
California Air Resources Board

Three defining targets

- Achieving health-based ambient air quality standards for ozone in 2023 and 2032
- Rolling back GHG emissions to 1990 levels by 2020 (~30% reduction)
- 80% reduction in GHG emissions by 2050

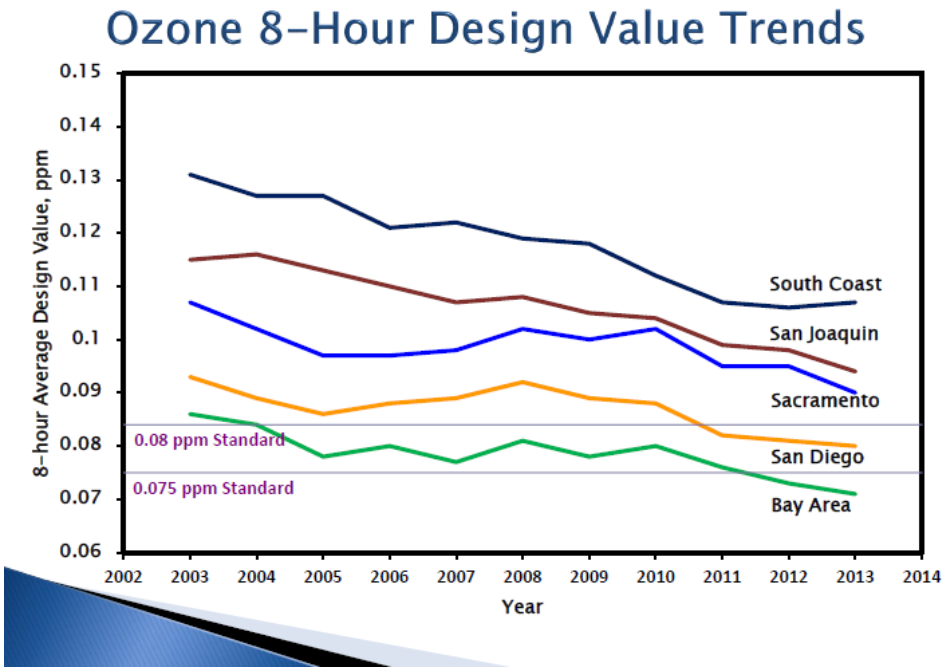
Scoping Plan - our climate and air protection policy framework for the path to 2050

Figure 6: Framing the Path to 2050



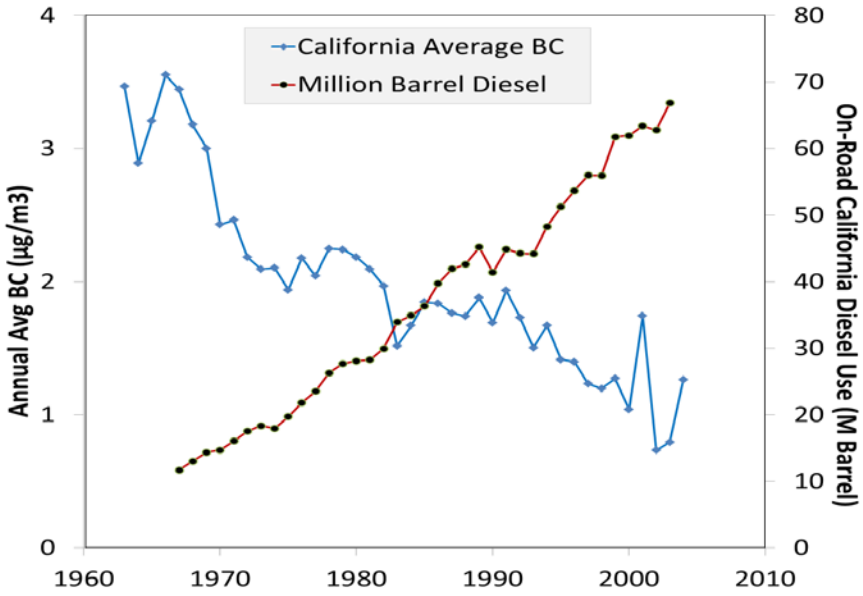
California's Climate Change Scoping Plan First Update, Oct. 2013

Tremendous progress for clean air over last several decades towards attainment…



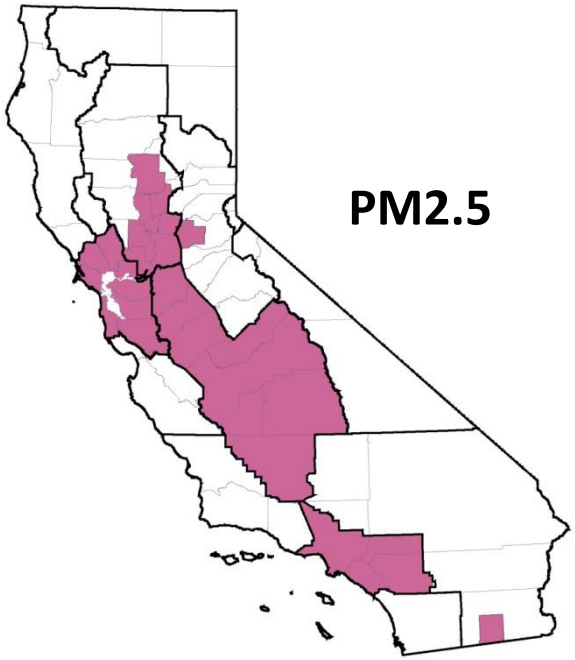
Staff report to the Board, "Air Quality Progress," California Air Resources Board Hearing, January 14, 2014.
http://www.arb.ca.gov/board/books/2014/012314/14-1-3pres.pdf

40 Years of Progress on Diesel Soot

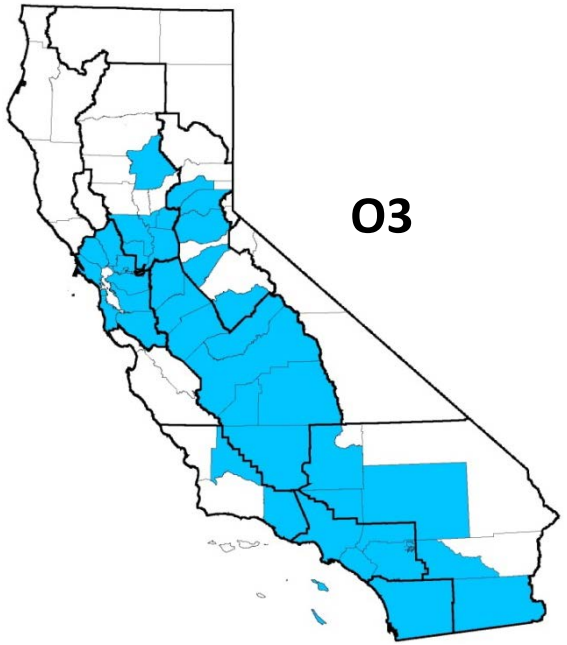


Kirchstetter et al. (2011) Black Carbon and the Regional Climate of California, CARB Contract No. 08-323.

Nonattainment Areas



PM2.5

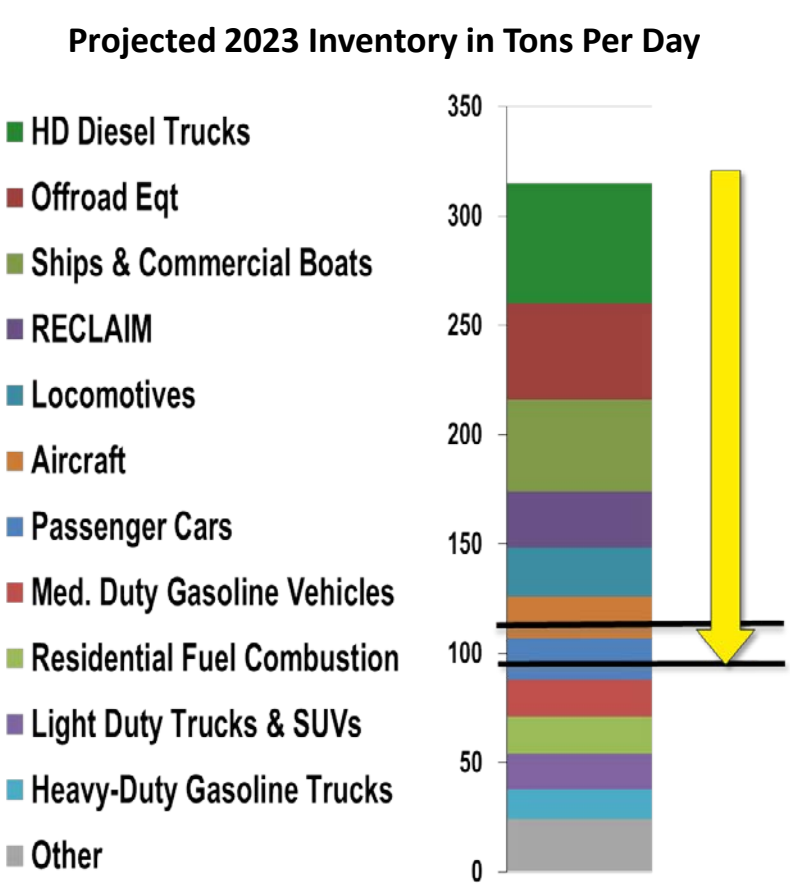


O3

PM2.5	→ CLEANER AIR / MORE PROTECTIVE →			
Metropolitan Area	(1997) 24-Hour 65 µg/m³	(1997) Annual 15 µg/m³	(2006) 24-Hour 35 µg/m³	(2012) Annual 12 µg/m³
South Coast	✓	✓	2014	2021-2025
San Joaquin Valley	✓	2014	2019	2021-2025
Sacramento	✓	✓	2014	✓
Bay Area	✓	✓	✓	✓

Ozone	→ CLEANER AIR / MORE PROTECTIVE →		
Metropolitan Area	(1979) 1-Hour 0.12 ppm	(1997) 8-Hour 0.08 ppm	(2008) 8-Hour 0.075 ppm
South Coast	2022	2023	2032
San Joaquin Valley	2017	2023	2032
Sacramento	✓	2018	2027
Bay Area	✓	✓	✓

Very Deep NOx Control for Ozone Attainment

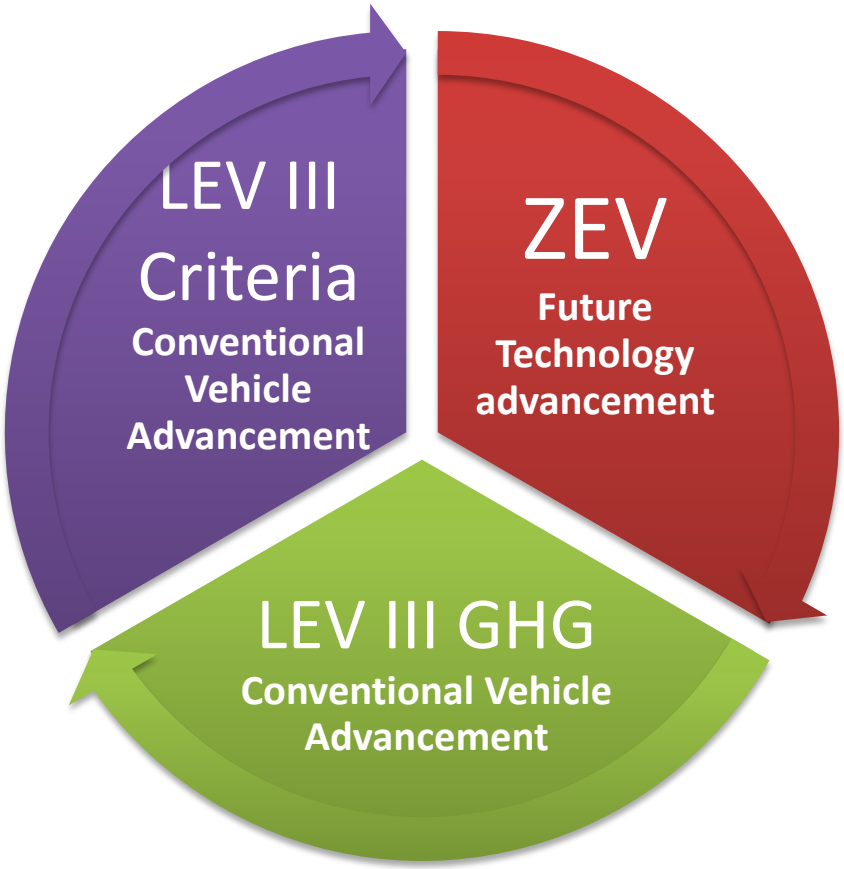


In 9 years (by 2023), need ~60% less NOx

In 18 years (by 2032), need ~80% less NOx

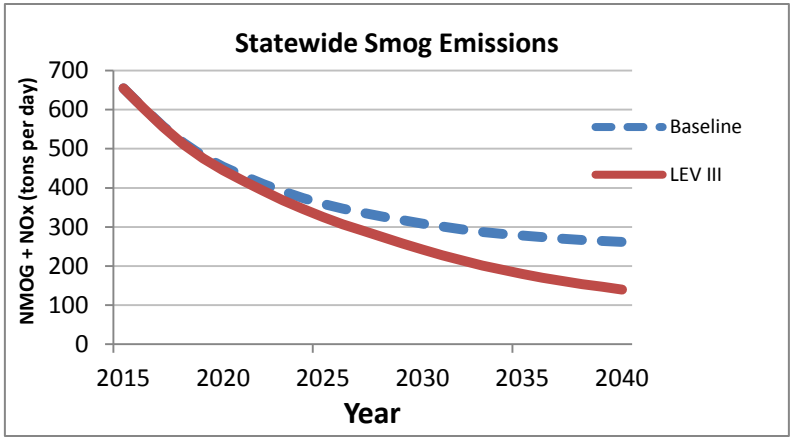
California's Advanced Clean Cars Program

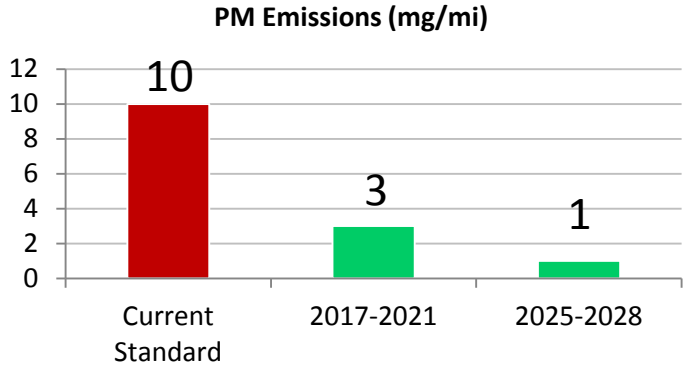
Three regulations, coordinated to achieve near-, mid-, and long-term transformation of the LDV fleet in CA

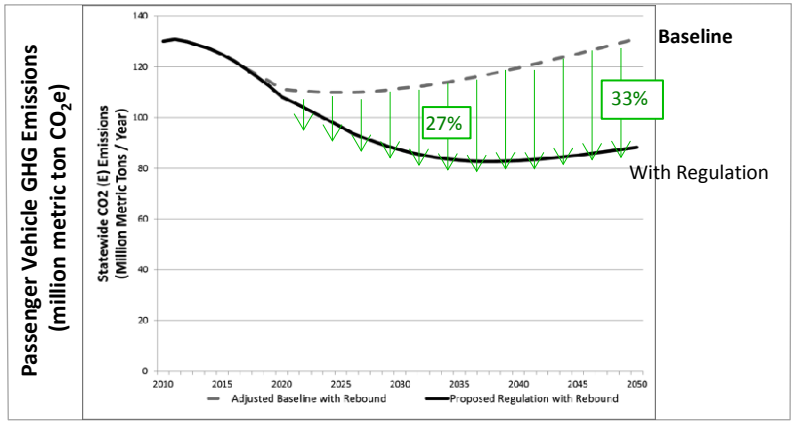


Reducing Air Pollution and Greenhouse Gas Emissions

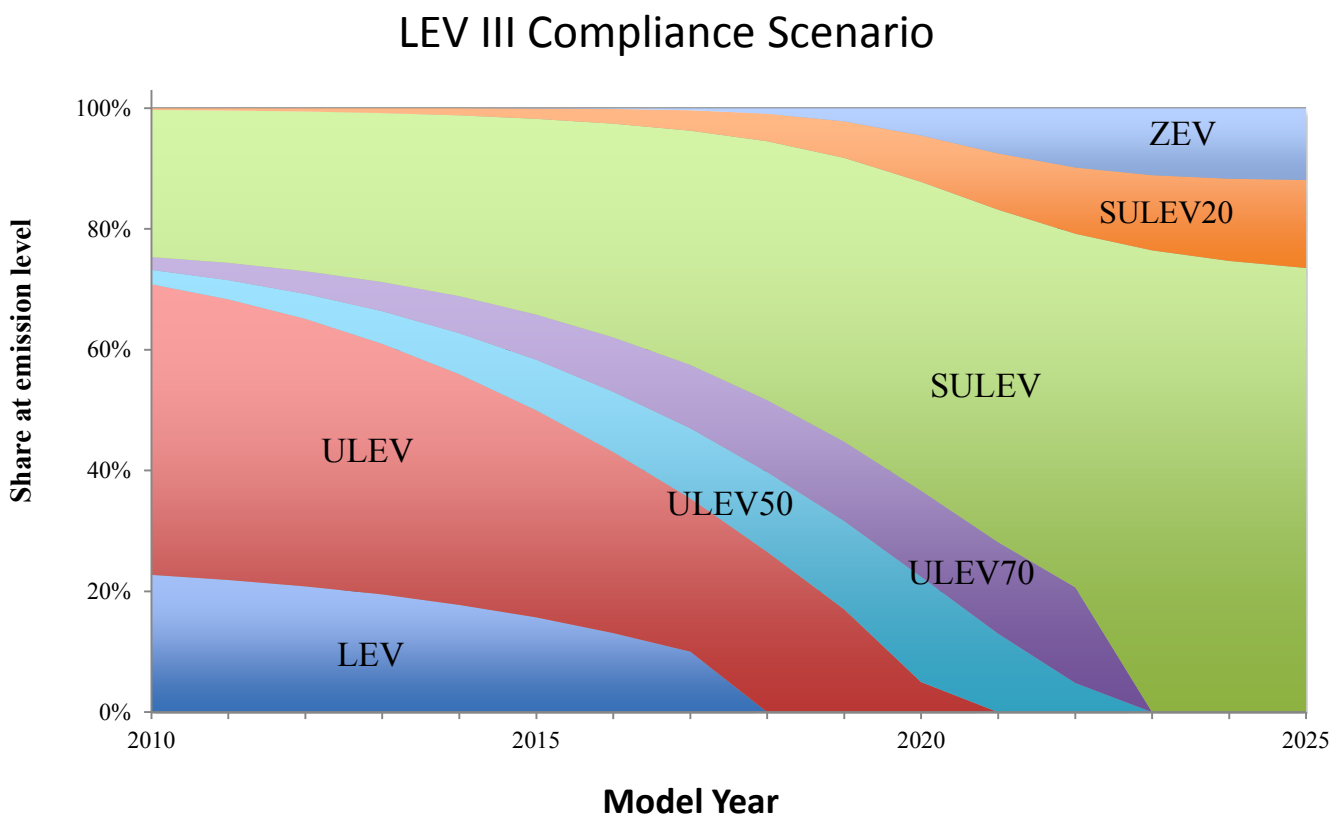
- Combines control of smog forming, PM, and GHG emissions
- Assures the development of environmentally superior cars
- Assures availability of ultra-clean fuels
- Sets the path to sustainable transportation







Rapid transition towards the cleanest possible vehicles

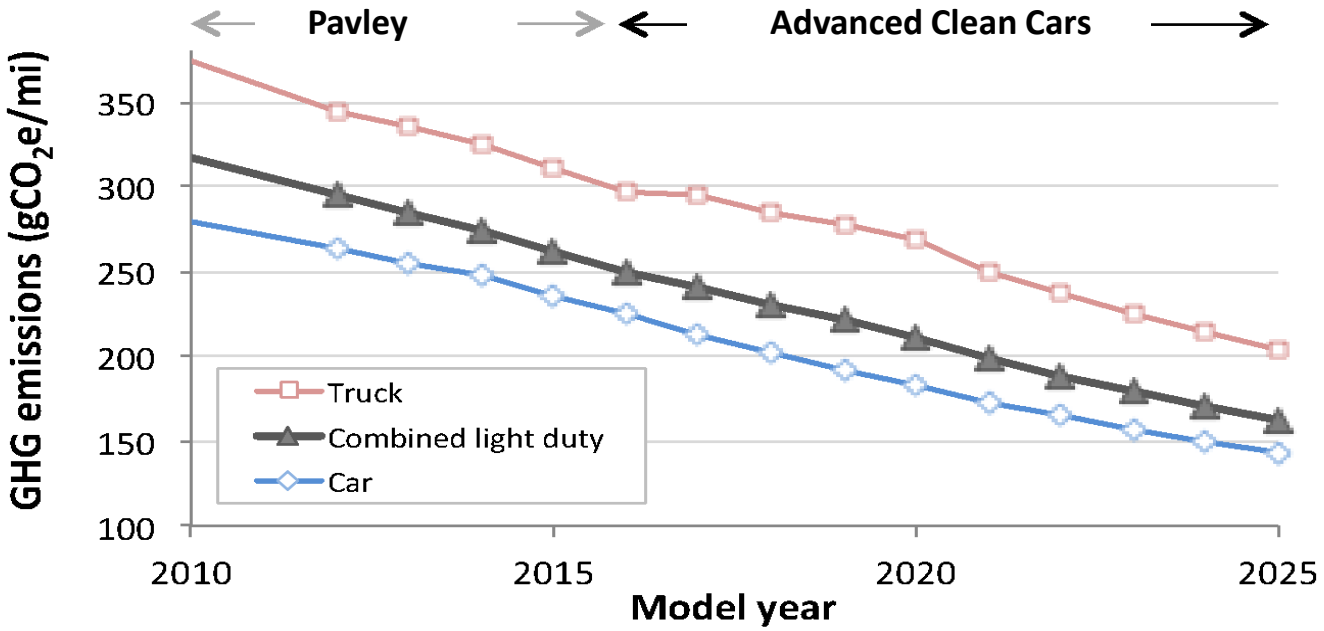


The first California SULEV20 already here (13 years ahead of requirement)

Limits on GHG Emissions

166 gCO_2e/mile by 2025

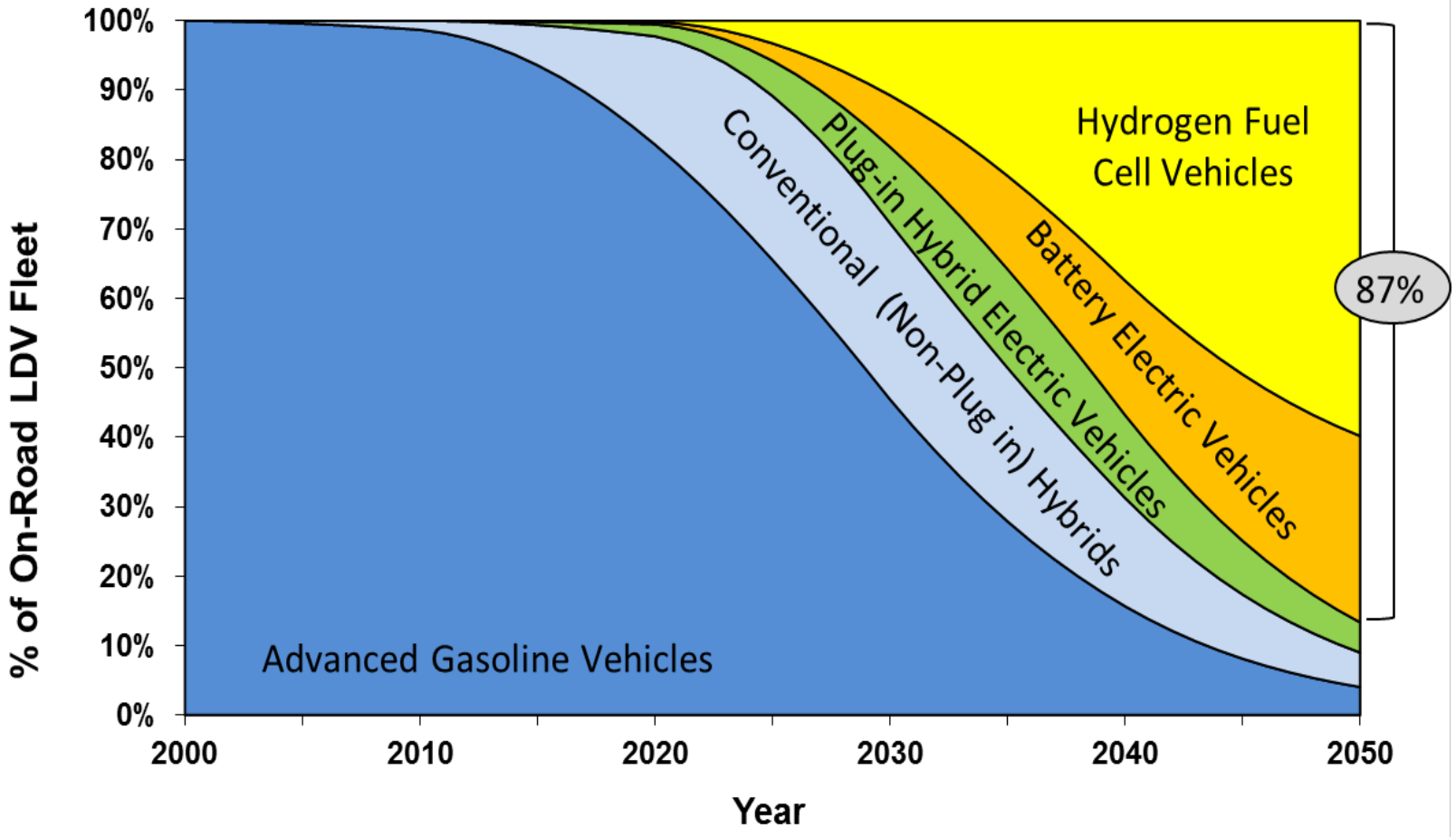
- Separate limits for car and truck categories
- GHG reduction of 4.6%/year for 2017-2025 model years
- GHG reduction of 34% from 2016 to 2025



California's Zero Emission Vehicle Regulation

- Original (1990) rationale still applies:
  - Improvements in ICE technology not sufficient to meet ambient air quality standards
- Need for significant smog-forming, PM, and GHG emission reduction can only be met with ZEVs
- Or else risk defaulting on clean air and GHG commitments

Driving towards zero light-duty vehicle emissions



- In ~10 years (2025), 1 out of 7 new vehicles is a ZEV
- In ~25 years (2040), all new vehicles sold are ZEVs
- In ~36 years (2050), 9 out of 10 vehicles on the road are ZEVs

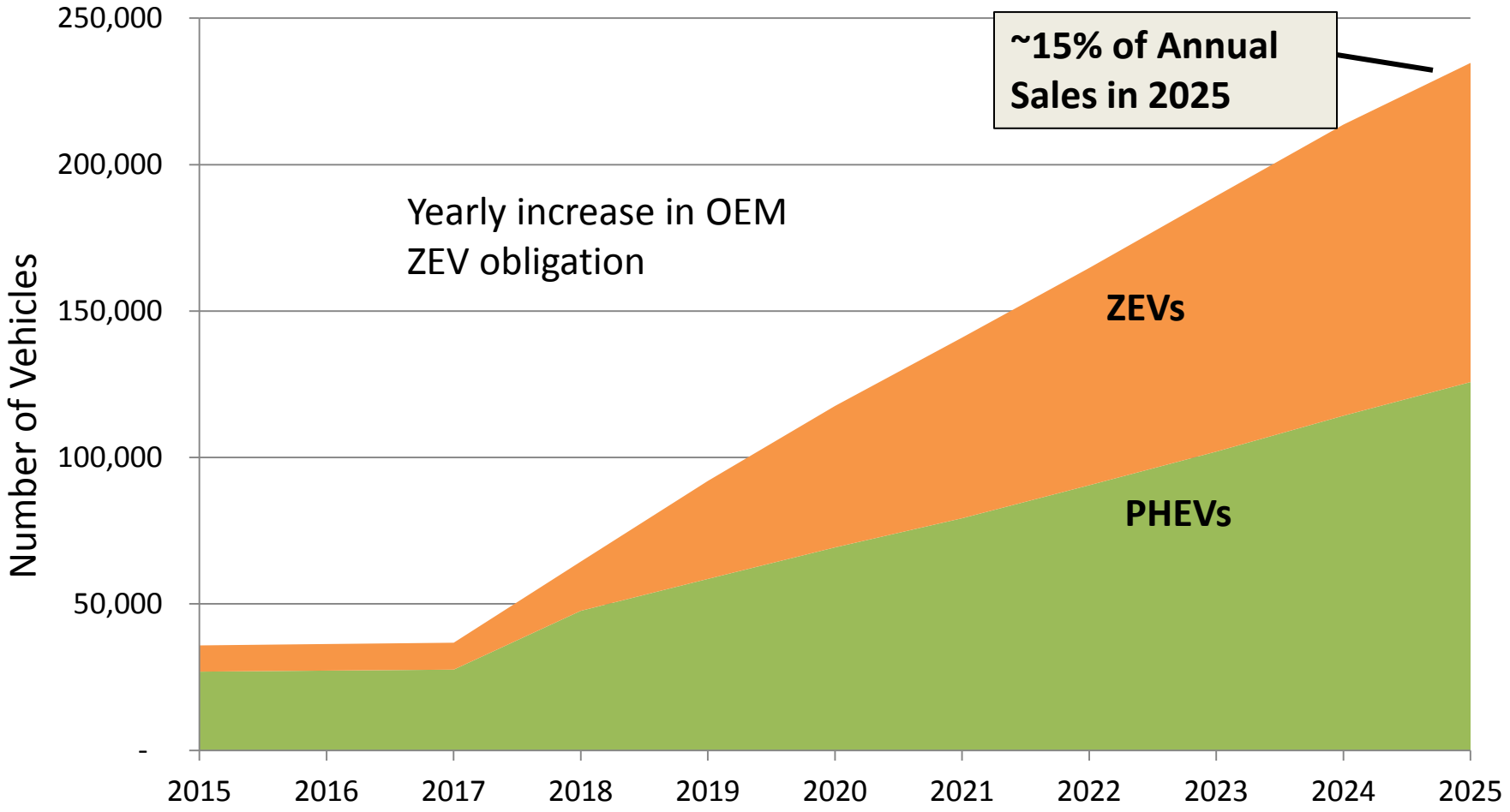
Hydrogen and electricity, the “no compromise” alternative to fossil fuel combustion

- **California is investing heavily in incentives and infrastructure for ZEVs**
- **California has committed support for 100 H2 fueling stations**
- **ZEV Policy promotes specifically BEVs and FECVs**

How the ZEV regulation works

- Requires OEMs to produce a minimum quantity of ZEVs
  - Battery Electric Vehicles
  - Hydrogen Fuel Cell Vehicles
- OEMs may satisfy a portion of requirement with advanced technology non-zero emission vehicles
  - PZEVs = very clean and durable ICEs, or hybrids
  - For 2018MY+, limited to Transitional ZEVs
    - E.g., plug-in hybrid electric vehicles (PHEVs)
    - Varying amount of ZEV credit based on capability of PHEV

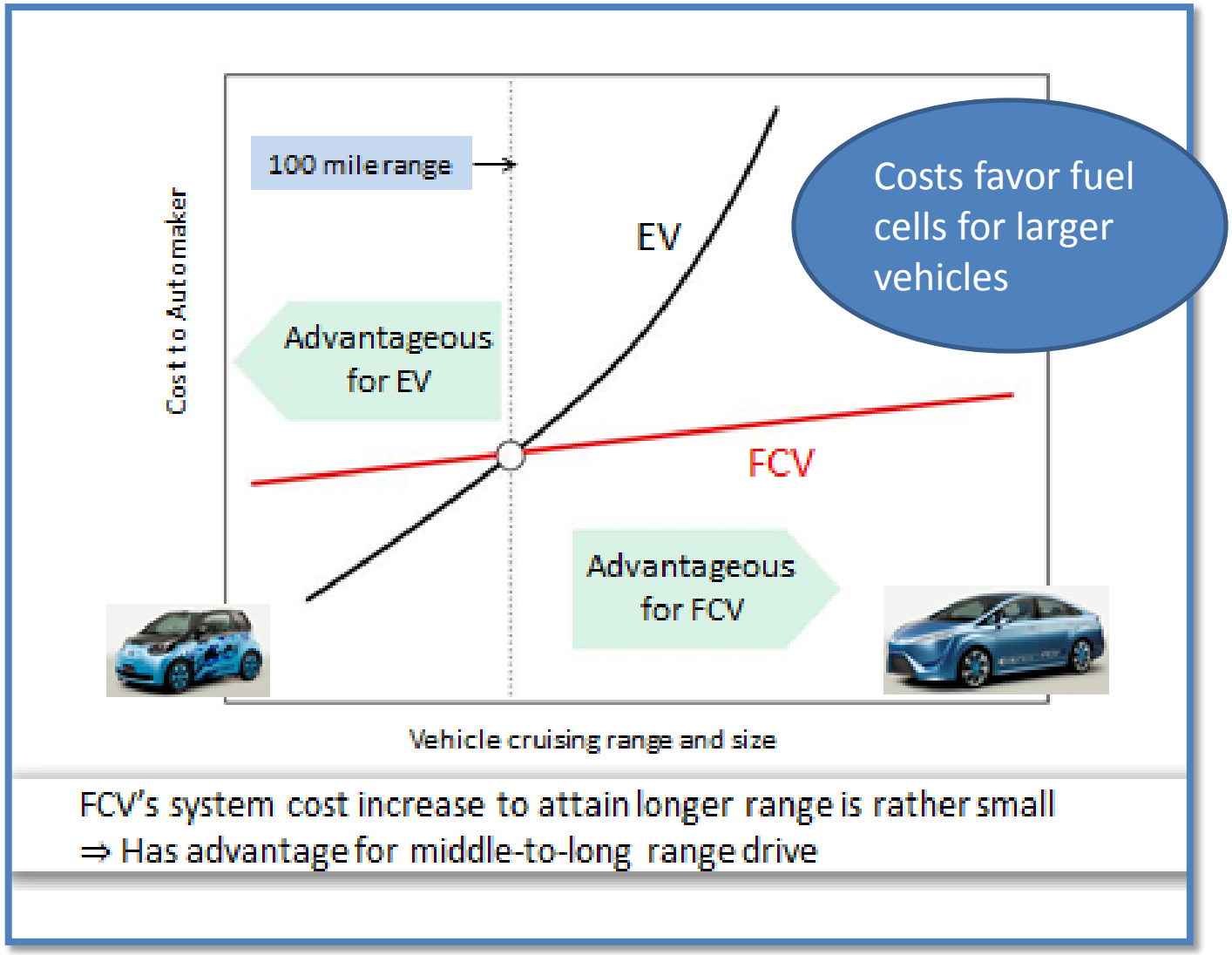
Implementation of ZEV Requirements



even a 15% new sales in 2025, a very aggressive transition until 2040 is needed

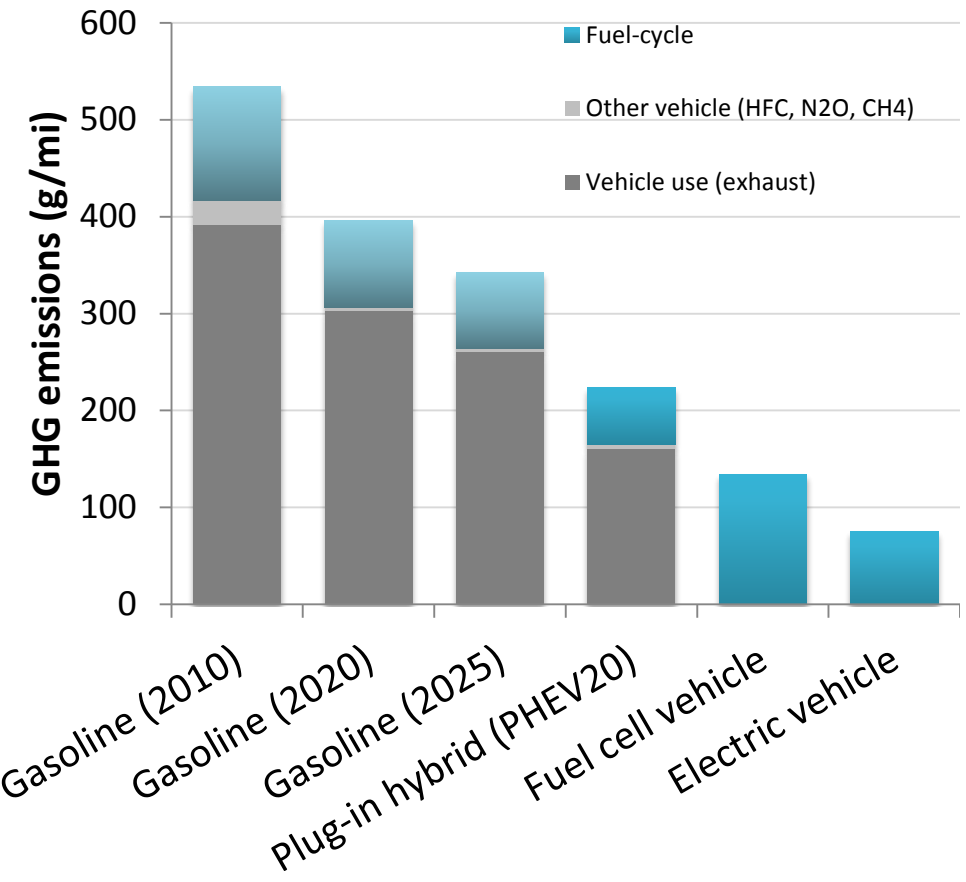
Both plug-ins and Fuel Cell EVs are needed

Car companies are developing a portfolio of ZEV technologies to match their full product lines

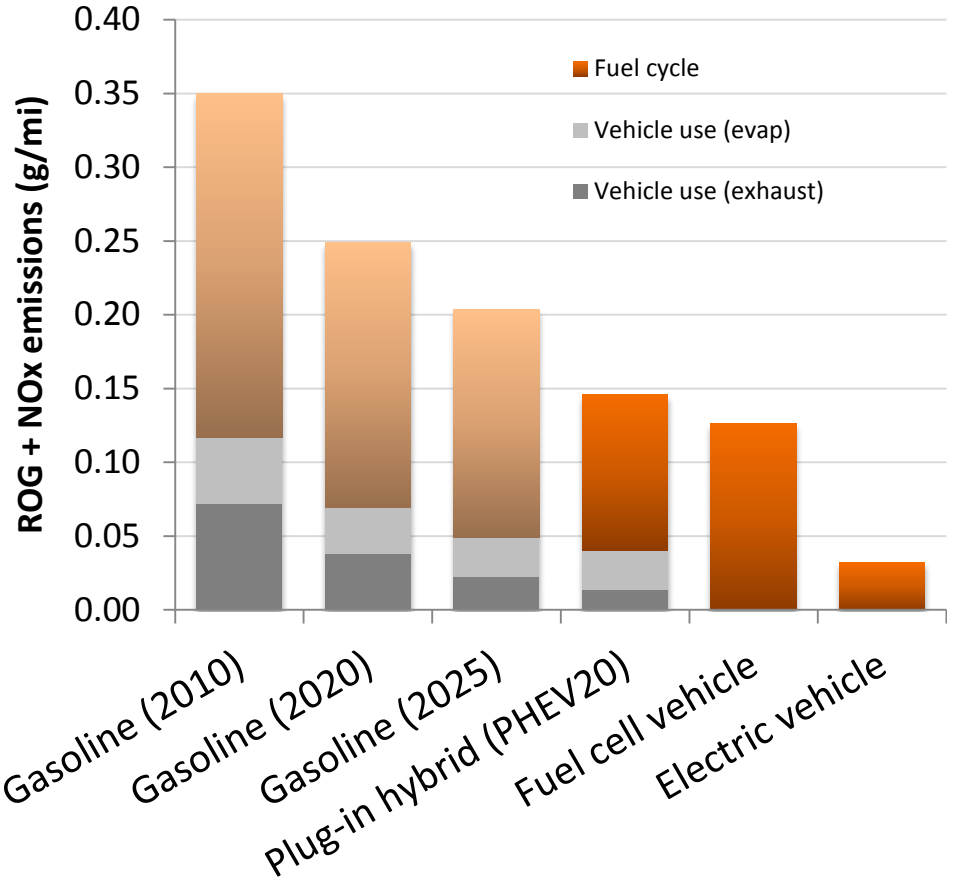


Cleaner than Advanced Gasoline Cars

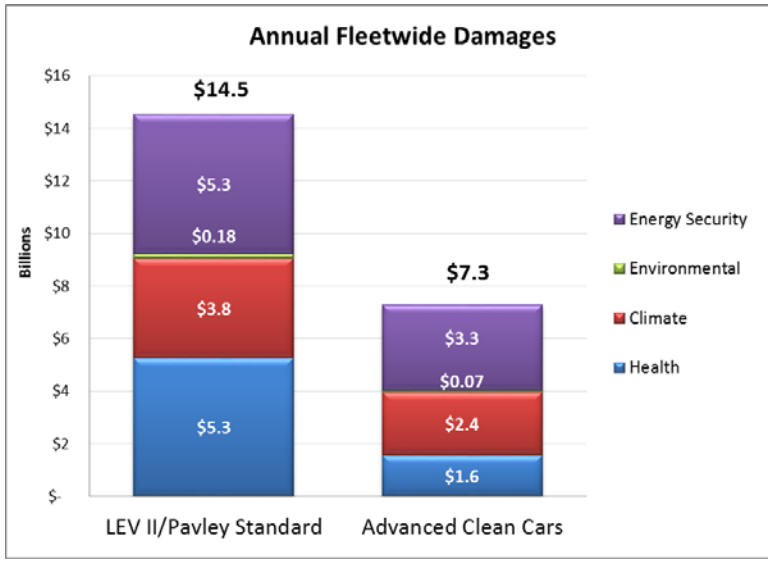
GHGs

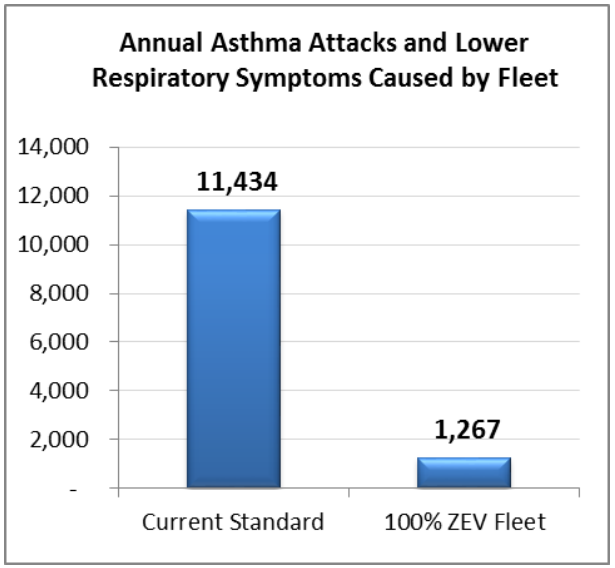


Criteria Pollutants



The benefits of the Adv. Clean Cars and ZEVs





~$7 billion in avoided health and other damages

- Avoidance of premature deaths, asthma and other respiratory ailments, lost work and school days
- ~$13 billion in total health, climate, and energy security costs

Source: American Lung Association

Based on EPA regulatory analysis of health endpoints/costs for CAA and NAAQS, federal estimates of societal costs of carbon emissions, and federal estimates of macro-economic impact of importing oil, disruptions in supply.

Incremental technology package prices above MY 2016 baseline (gasoline IC) technology (2009$)

Vehicle Class	Technology Package (energy capacity)	Incremental Vehicle Price in 2016	Incremental Vehicle Price in 2025	2025 NAS[3]
Midsize car / Small MPV (EPA #3)	PHEV20 (7.7 kWh)	13,807	8,876	
	PHEV40 (15.5 kWh)	17,818	11,043	
	BEV75[1] (27 kWh)	17,562	9,794	
	BEV100 (35 kWh)	20,785	11,551	~5,000-6,500[4]
	FCV[2] (3.8 kg H_2)	23,472	9,334	~3,000-4,500

[1] For BEVs and PHEVs, the residential charging equipment costs are included in these technology packages.
[2] FCV costs include the fuel cell system, the hydrogen storage system, the hybrid battery module, and other EV components and power electronics similar to the BEV technology package.
[3] "Transitions to Alternative Vehicles and Fuels", 2013
[4] NAS projections are for a 'BEV130' (22-26 kWh) instead of a BEV100 (35 kWh) and a 2.6-3.1 kg H_2 FCV instead of 3.8 kg H_2 and incremental over 2010 baseline, not 2016.

Advanced Clean Cars Program: Consumer Impact

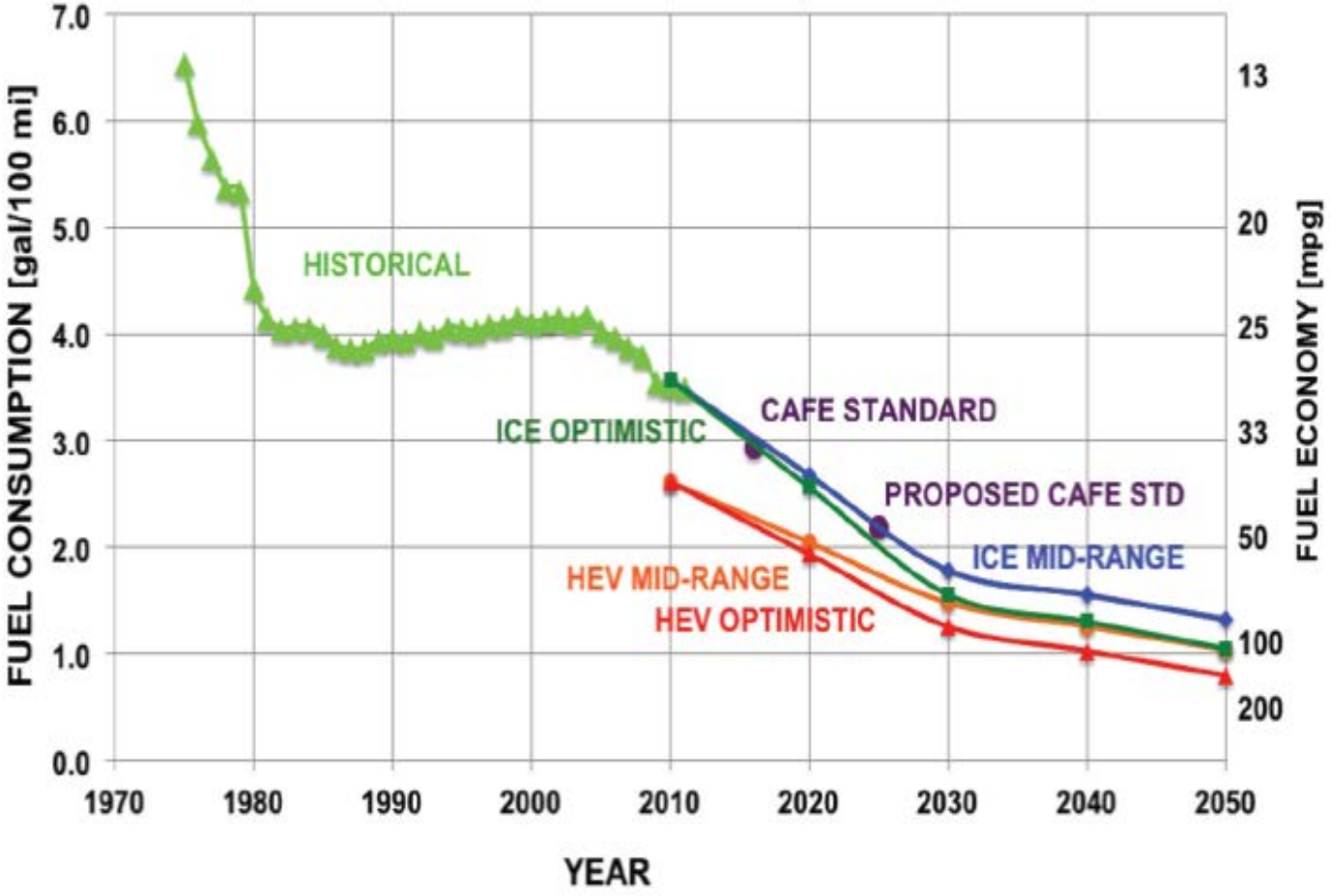
Average 2025 vehicle consumer impact:

- Consumer savings greatly outweigh the cost (by 3-to-1 margin)
- "Off the lot" savings from the first month
- Overall payback within first vehicle purchaser

Lifetime effect per vehicle	Incremental technology price	$1,900
	Lifetime savings	$5,900
	Net lifetime savings	$4,000
	Payback period	3 years
Monthly effects for financed vehicle purchase	Increased monthly payment	$35
	Monthly fuel savings	$48
	Net monthly savings	$12

Note: values may not match due to rounding

Post-2025 continue at GHG reductions of ~5% per year



Historical and projected LDV FE. “Transitions to Alternative Vehicles and Fuels.” National Research Council. 2013.