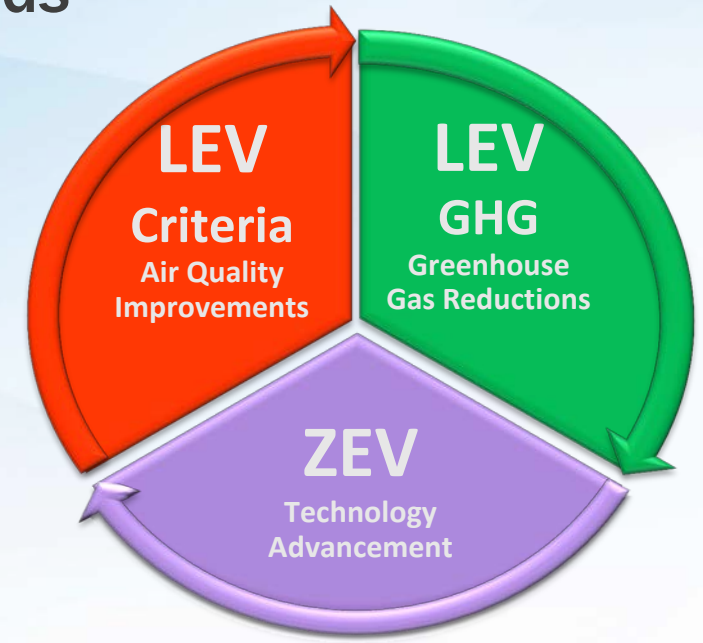
California's Advanced Clean Cars Midterm Review

March 24, 2017

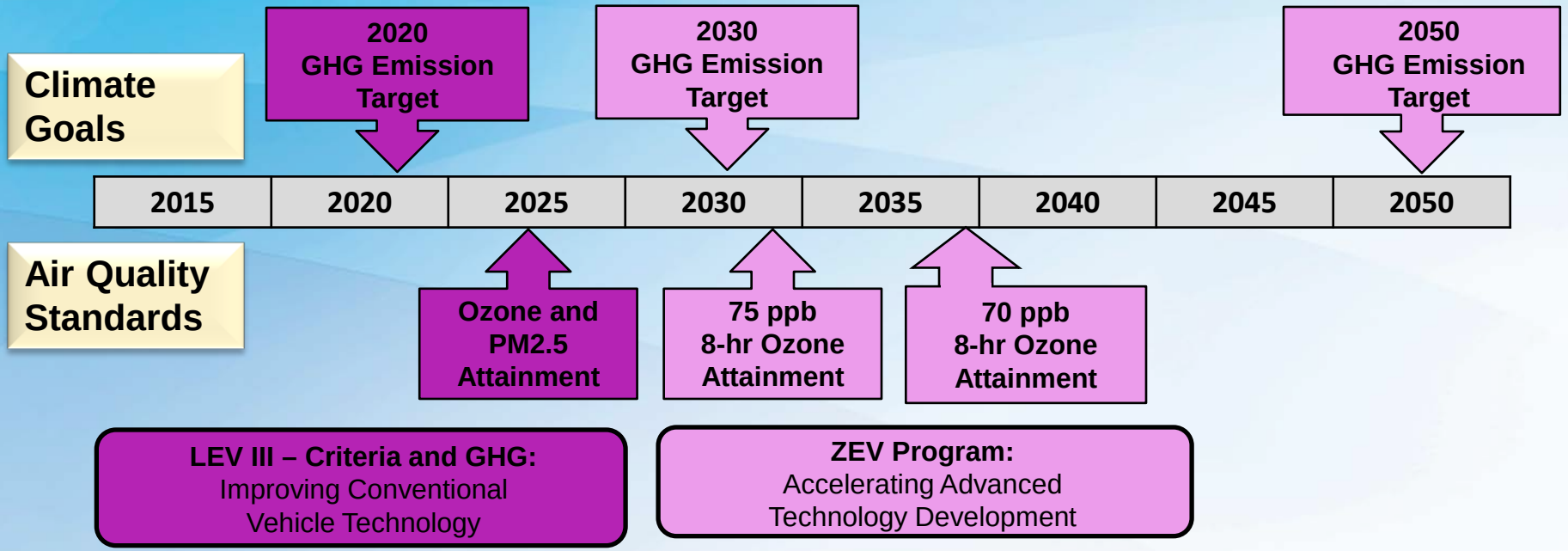
Advanced Clean Cars

Approved as an integrated regulatory package in 2012

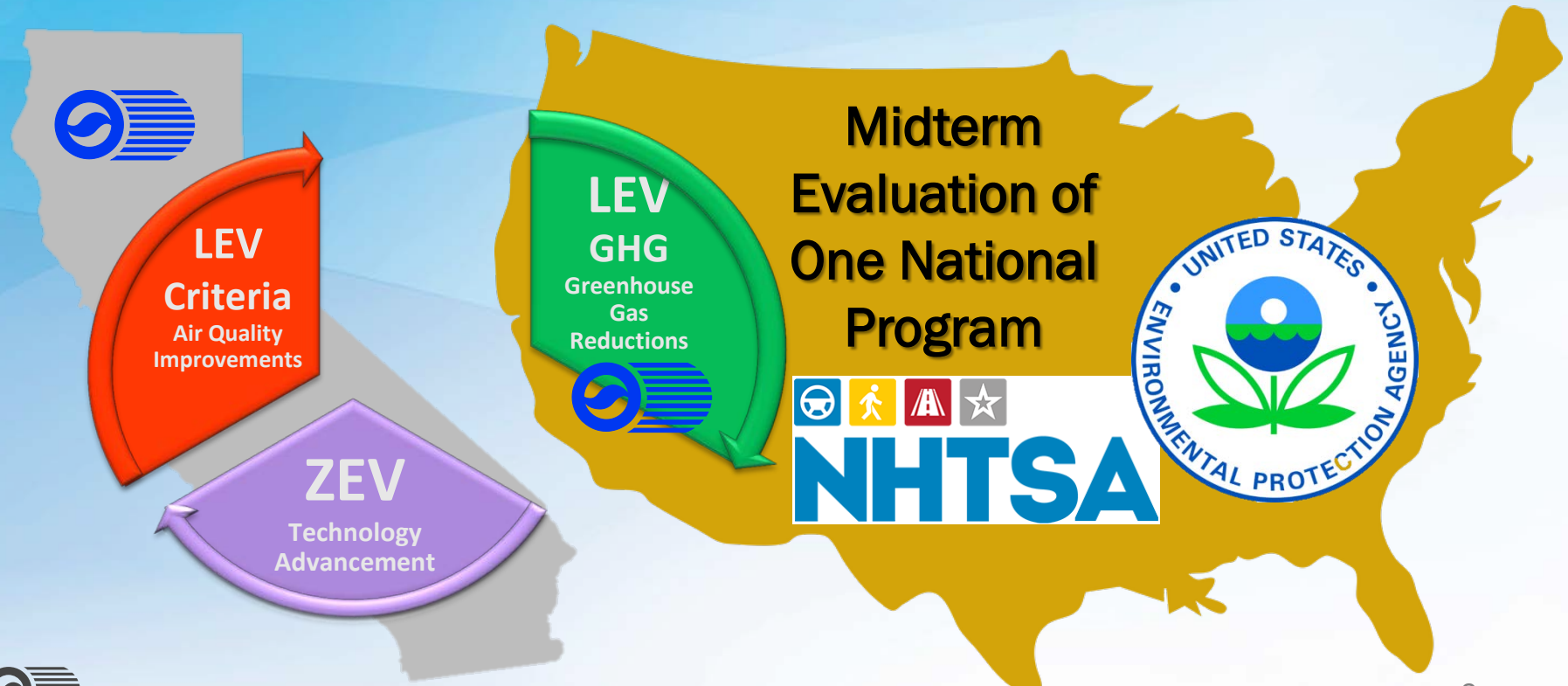
- **LEV III Criteria and GHG Standards**
  - ✓ 75% reduction in fleet average NMOG + NOx emissions
  - ✓ 90% reduction in PM emission standard
  - ✓ 34% reduction in GHG emissions
- **ZEV**
  - ✓ More ZEVs and PHEVs



Meeting long term emissions targets



Advanced Clean Cars Midterm Review and the Federal Process



Inter-agency Coordination on Midterm Evaluation of One National Program

LEV GHG

2012

January:
- ACC 2017-2025 standards

October:
- Federal 2017-2025 GHG standards

November:
- CA GHG "deemed to comply" adopted

2013-2016

External Research, Survey and Analysis, In-House Testing

Inter-agency coordination

2016

July:
- Joint Technical Assessment Report (TAR)

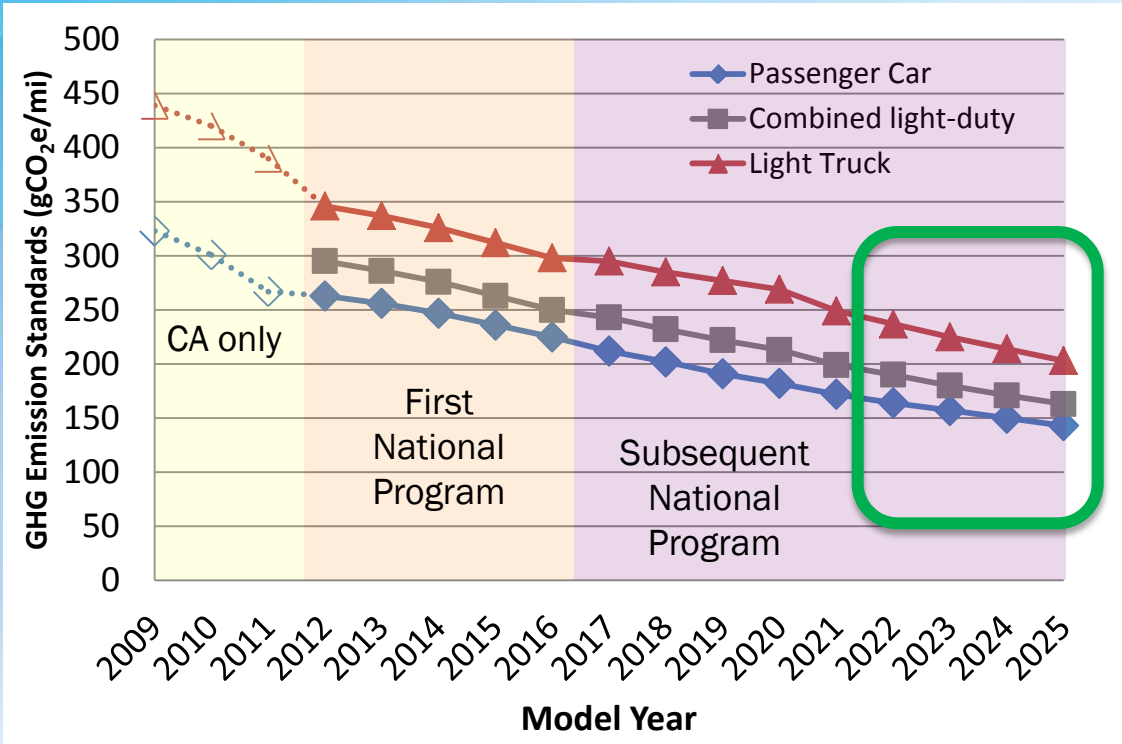
September:
- ACC Symposium

2017

January:
- EPA Final Determination
- MTR Report

March:
- Announced Reconsideration of Final Determination

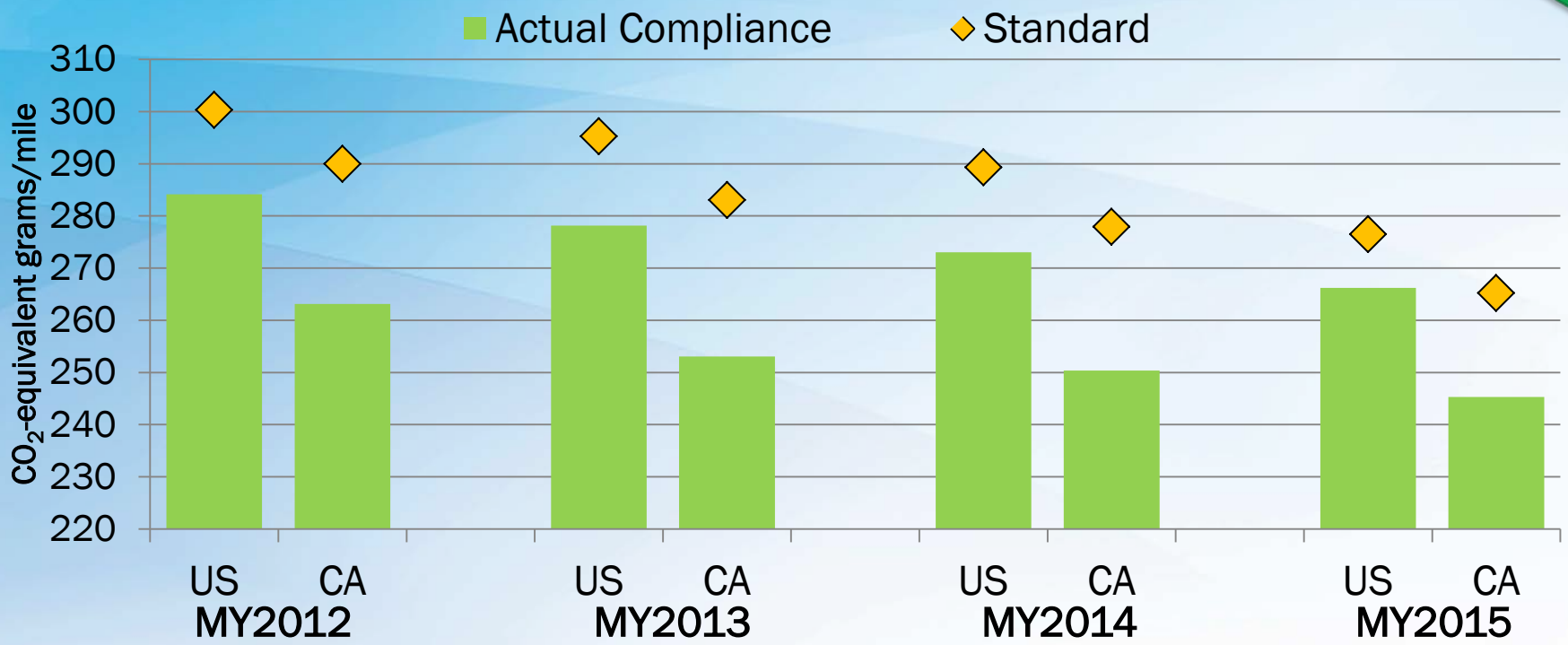
Light-duty GHG Standards



Midterm Review:

Focus on the MY2022 - 2025 Federal GHG standards

Manufacturers are over-complying with current GHG standards

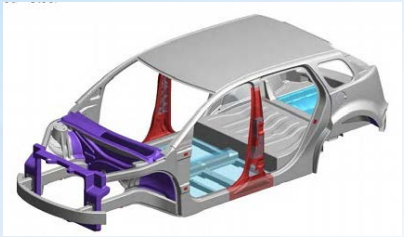


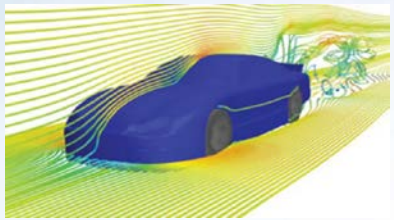
Standards calculated based on sales from the six large volume manufacturers subject to CA GHG regulations for MY 2012-2015 including credits.

Technology has evolved rapidly to meet the standards

LEV
GHG

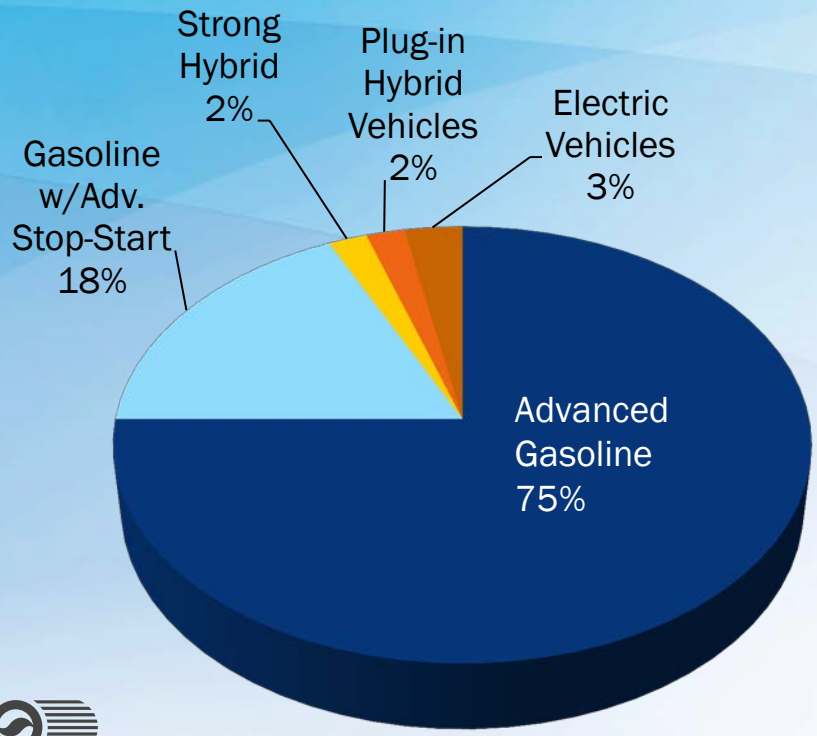
- Advanced engines and transmissions
- Vehicle light-weighting
- Improved aerodynamics
- Low rolling resistance tires
- Stop-start and advanced stop-start (e.g., 48 Volt) technology





~21% of the 2016 fleet already complies with 2020 standards

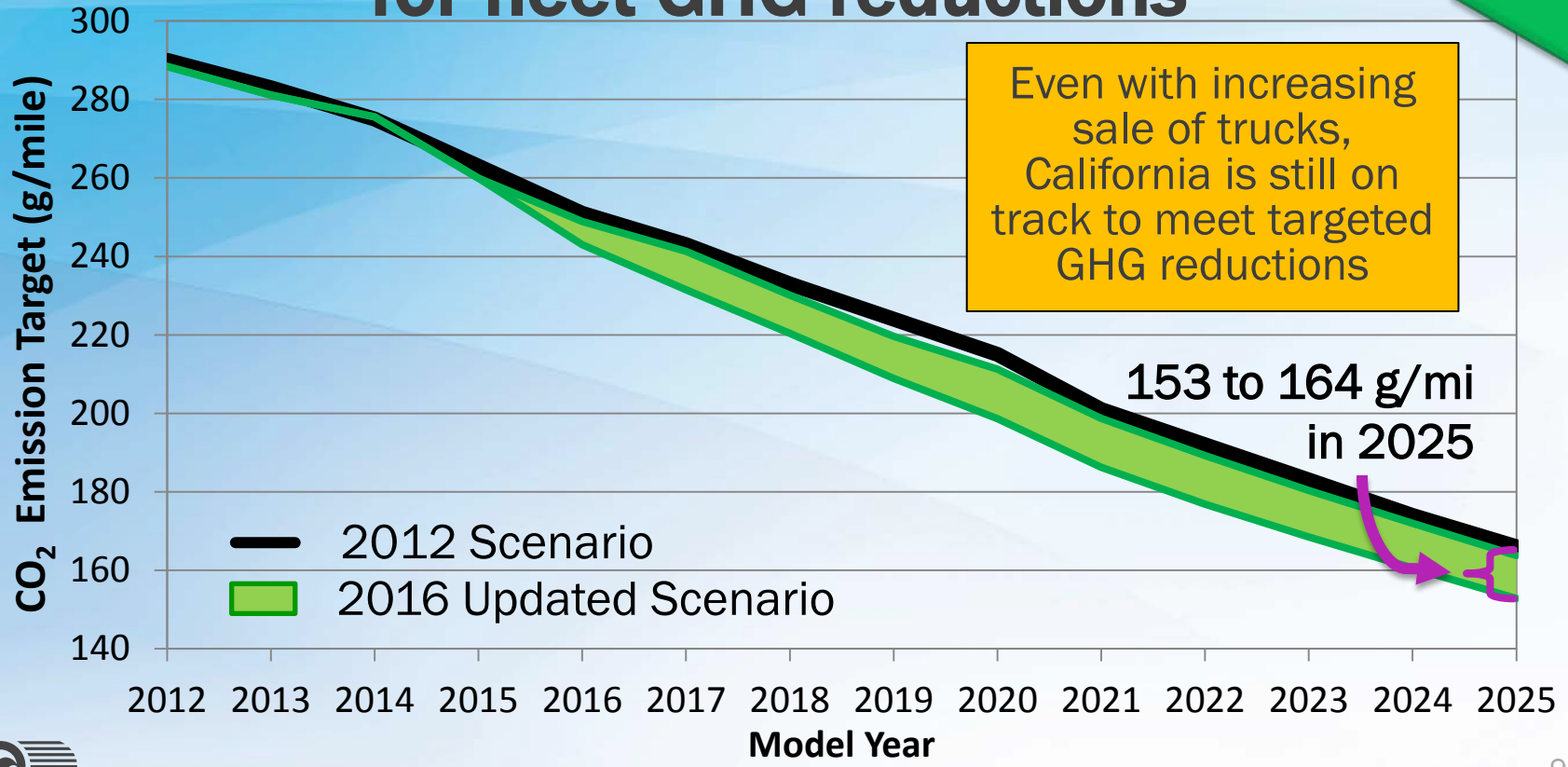
Future standards can be met with conventional technology at reduced cost



Incremental vehicle costs to meet 2025 stds	
2012 EPA Rulemaking	2016 Proposed Determination
$1,163	$875

Costs in 2015$
Proposed Determination costs represent most recent analysis, using newer data and assumptions than used for the draft TAR

California on target for fleet GHG reductions



Issues Raised by Industry

Industry: Analysis overestimates efficiency/underestimates needed technology

- More technology required, including stronger electrification, which means higher costs
- Consumer acceptance/demand, especially of stronger electrification, is inadequate

CARB Response: Data well grounded in actual testing and analysis concluded higher levels of technology are not needed

- Alternative technology evaluations confirmed strong electrification not needed
- Electrified sales in CA already near levels projected for 2025

Staff Recommendation

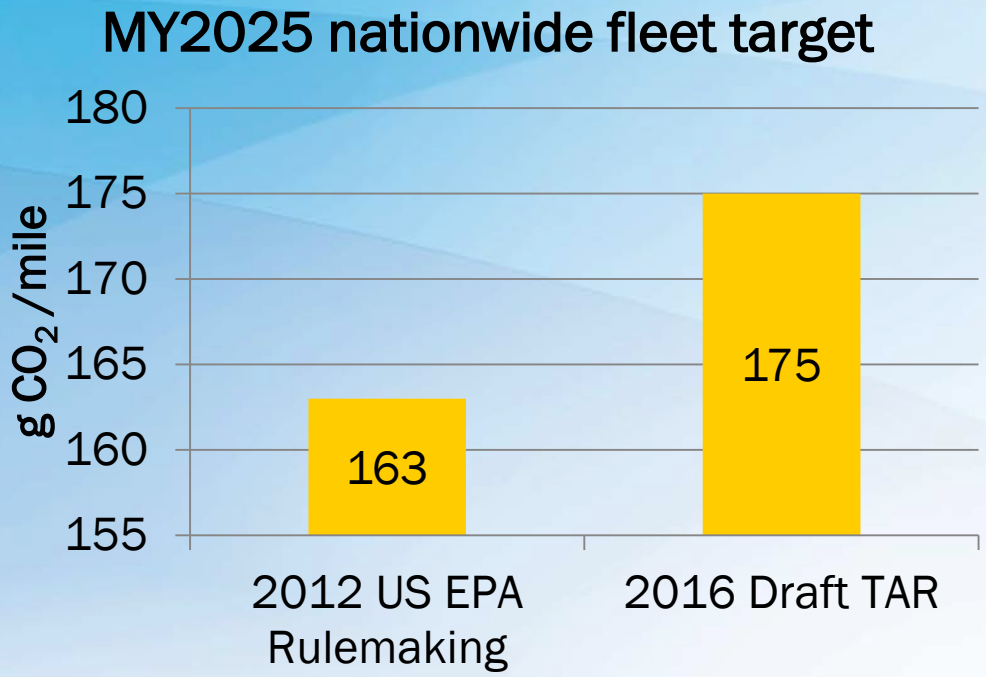
Review Question: *Are the model year 2022 - 2025 Federal GHG standards appropriate?*

Recommendation: *Yes, analysis affirmed current federal standards are appropriate, and CARB recommends continued participation in the National Program through 2025, provided no future changes weaken expected benefits in California.*

Continue monitoring other activities

- Reconsideration of federal re-opening of Final Determination
- Canada's midterm review
- Global activities

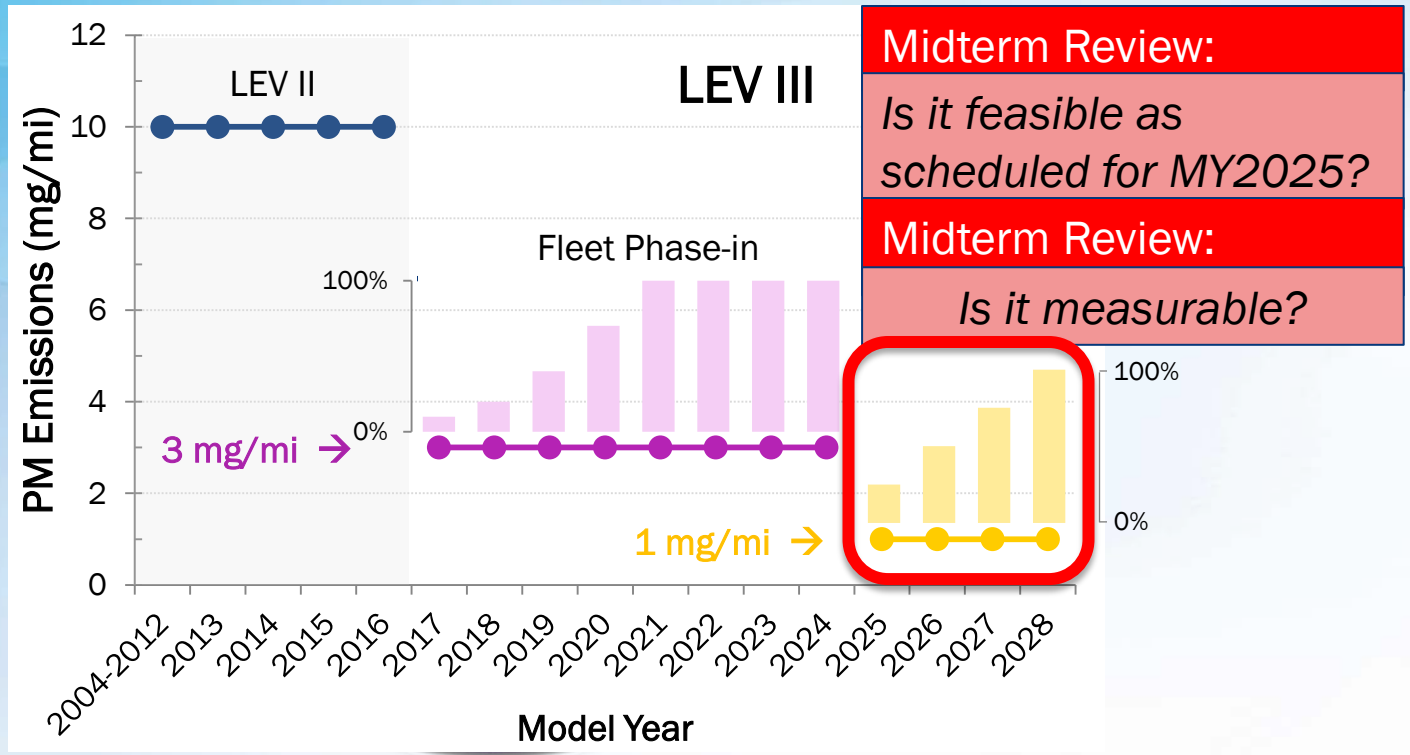
Analysis of National Fleet



Larger fraction of truck sales projected in 2025 results in a higher fleet CO_2 target.

2025 Fleet Average	Incremental Vehicle Costs
~~175 g/mi~~	~~$875~~
163 g/mi	~$1,375

1 mg/mi Particulate Matter (PM) Standard



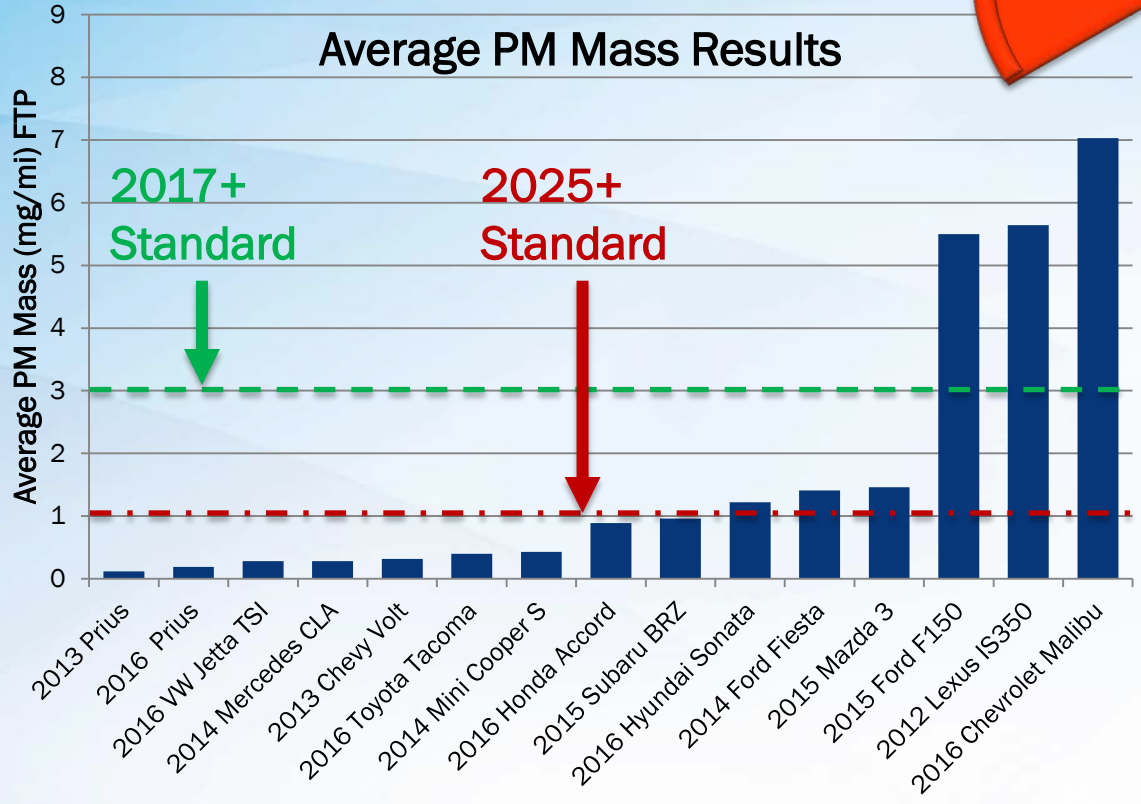
PM Measurement Evaluation
Staff Recommendation

Review Question: *Can we accurately measure PM emissions at 1 mg/mi?*

Recommendation: *Yes, as reported to Board in 2015, mass-based measurement method is accurate and most appropriate*

Some vehicles already meeting future PM standards

- Many already meeting 3 mg/mi
- Further refinement needed for many to meet 1 mg/mi

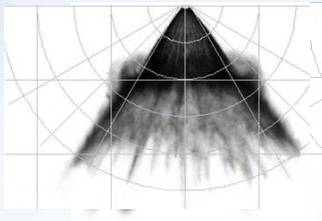


Combustion technology evolving to meet 1 mg/mi standard

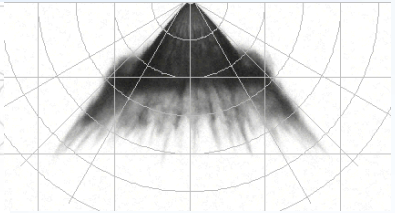
LEV Criteria

Focus on fuel injection system and combustion chamber design

Standard Spray



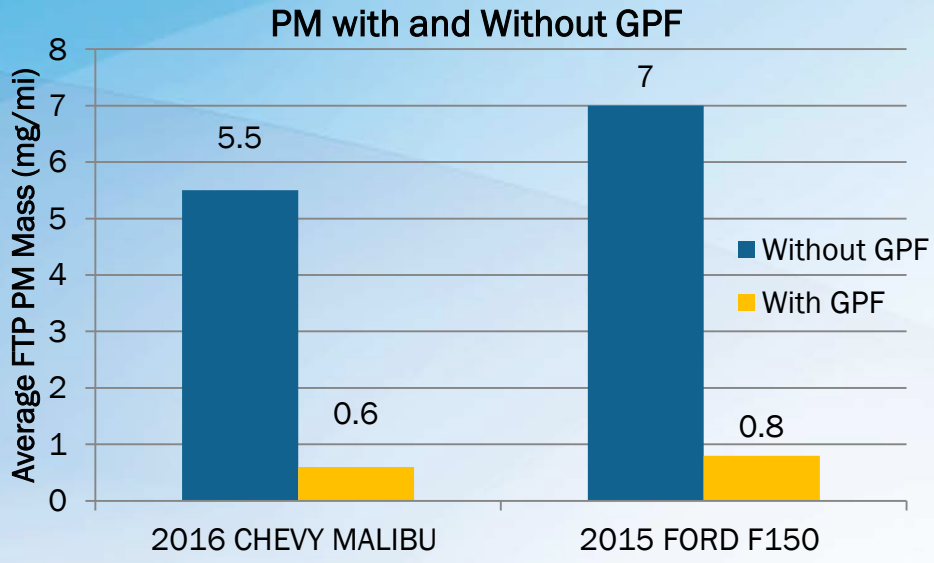
Optimized Spray



Gasoline particle filters provide additional technology path

LEV Criteria

- Prototype catalyzed GPFs tested
  - Can control PM levels below 1 mg/mi on FTP
  - Limited use worldwide



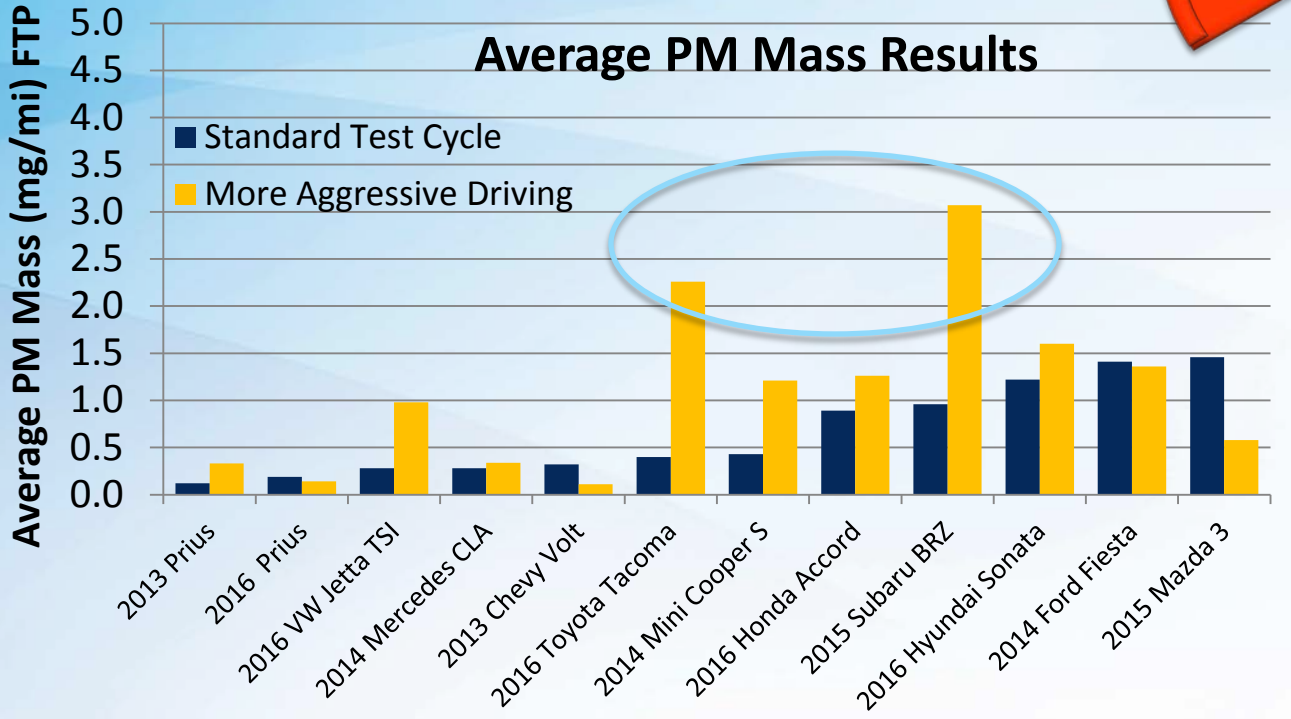
PM Removal Efficiencies

	FTP	US06
F-150	88%	72%
Malibu	88%	54%

Real-world PM control varies

LEV Criteria

More aggressive driving can result in higher emissions



PM Staff Recommendations

Review Question: *Is the 1 mg/mi standard feasible by 2025?*

Recommendation: *Yes, the standard is feasible and the current implementation schedule maintains necessary lead time to refine engine and injection system designs*

Additional Recommendation: *Develop additional PM standards, to supplement the 1 mg/mi standard, to better ensure robust PM control in real world driving conditions*

Zero Emission Vehicle (ZEV) Regulation

Midterm Review:

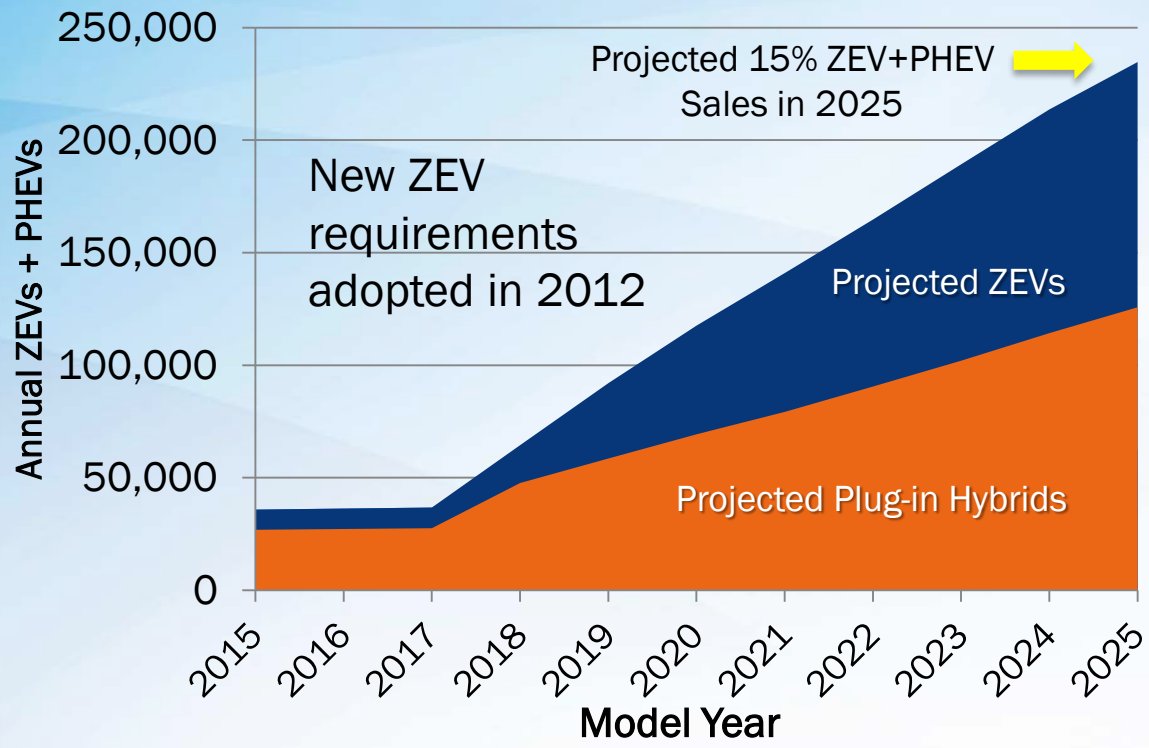
Are the ZEV requirements in California appropriate for continuing to help develop the ZEV market?

Midterm Review:

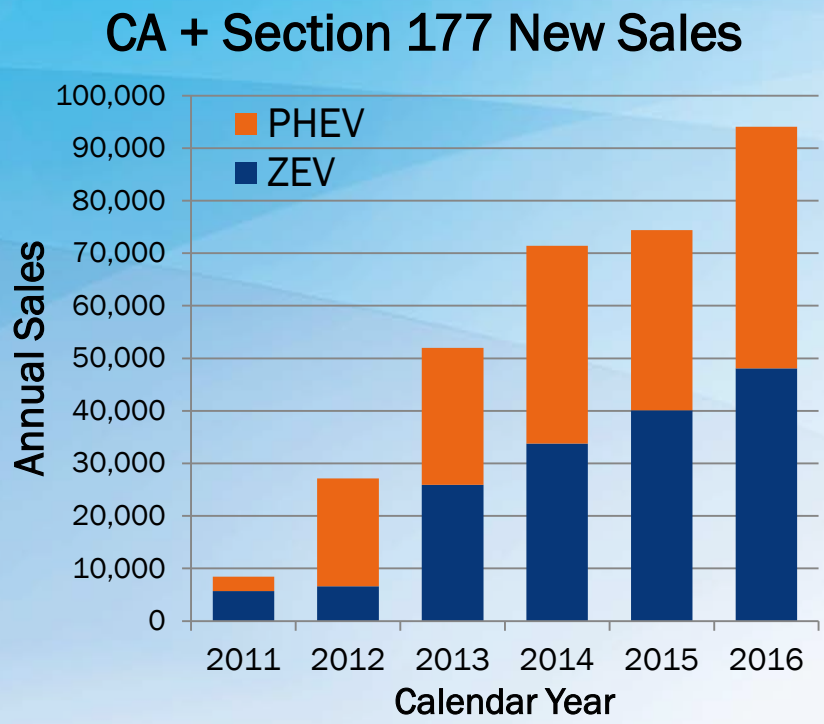
Are the ZEV requirements in Section 177 ZEV states appropriate for continuing to help develop the ZEV market?

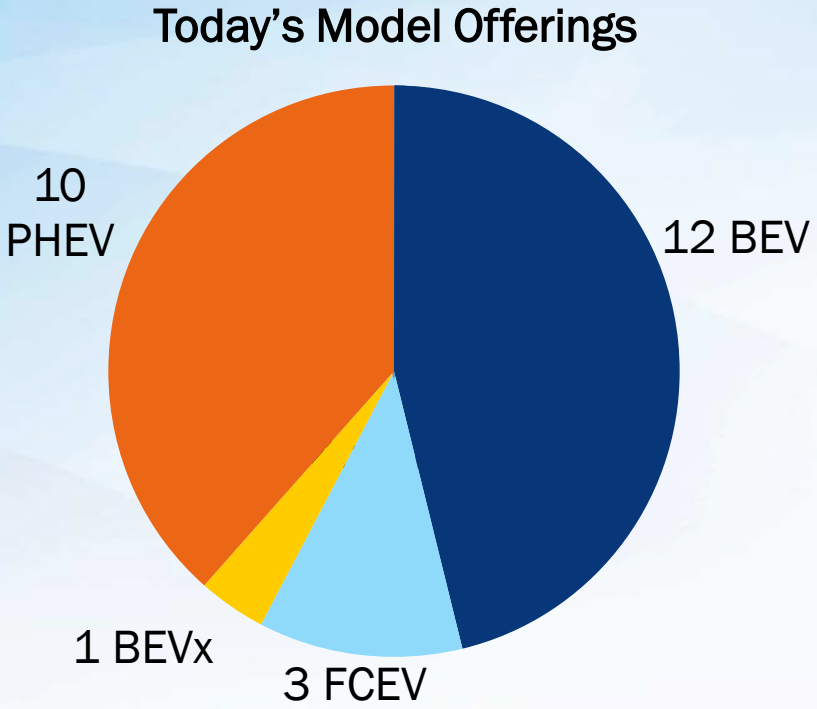
Midterm Review:

How should PHEVs be treated in the ZEV regulation?

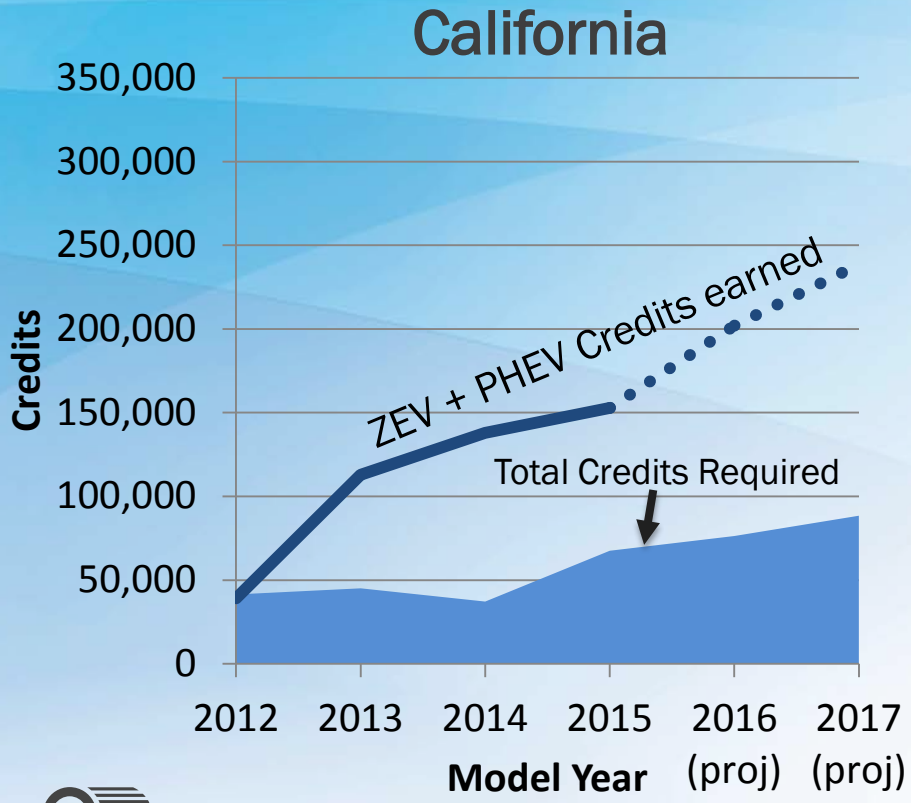


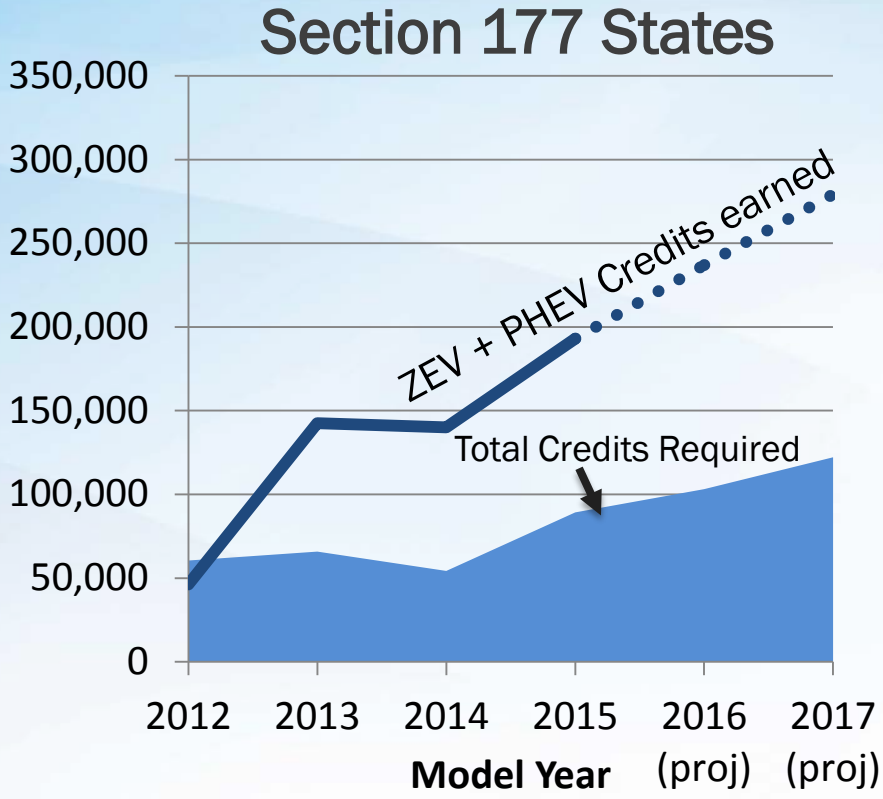
A growing ZEV market



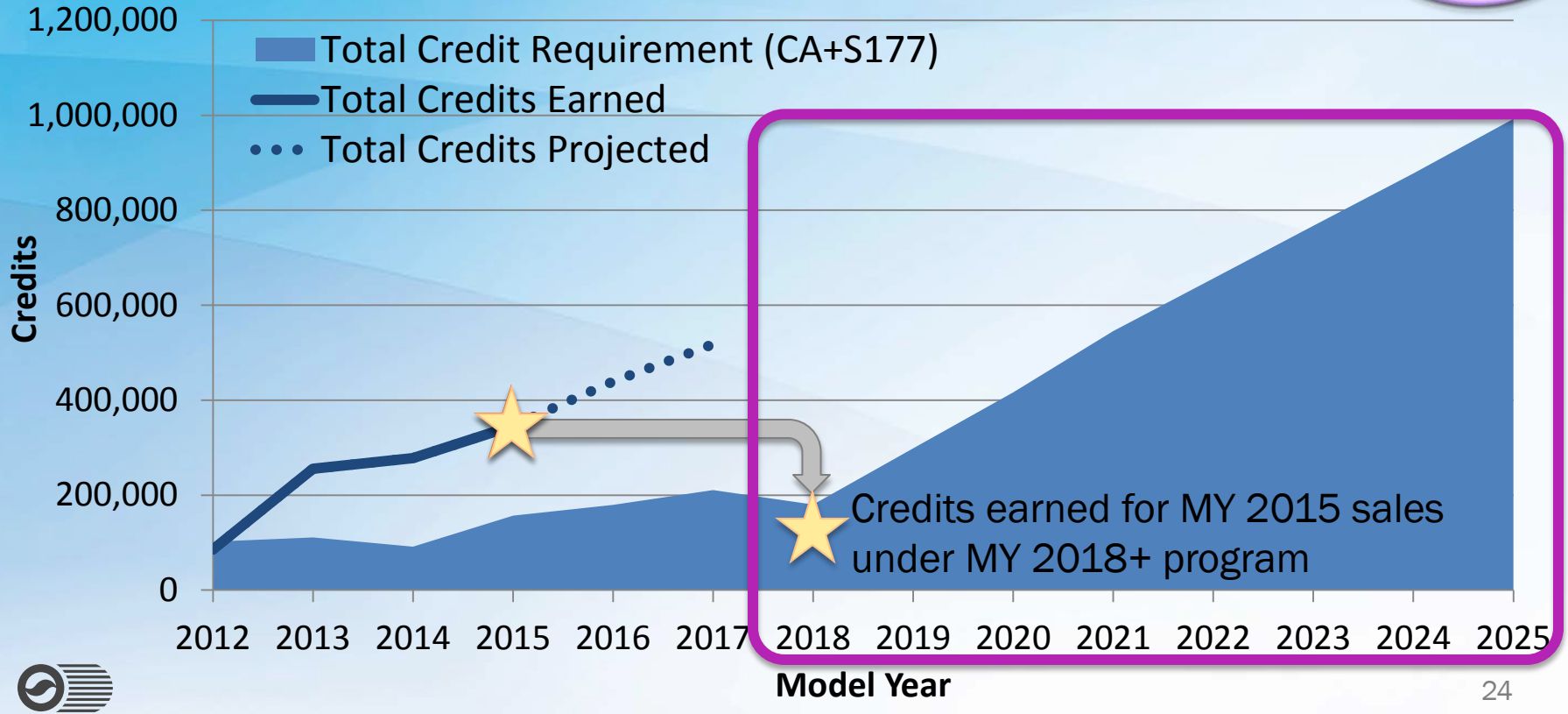


Manufacturers are over-complying

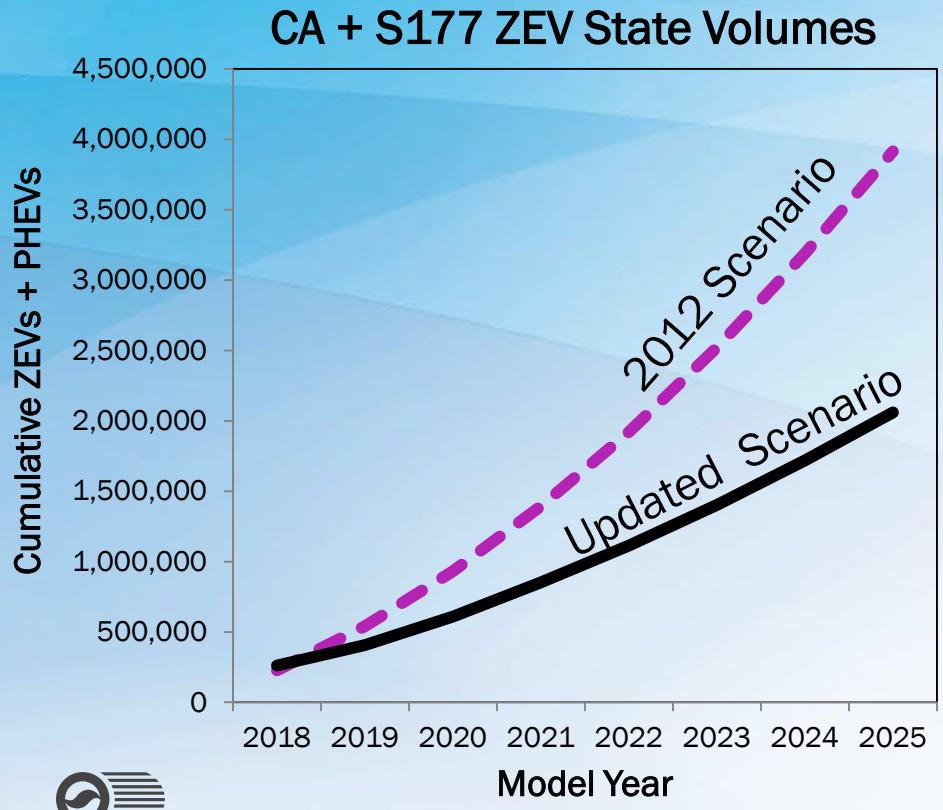




Credit banks provide insurance against future requirements



Updated ZEV Compliance Scenarios



Updates reflect:

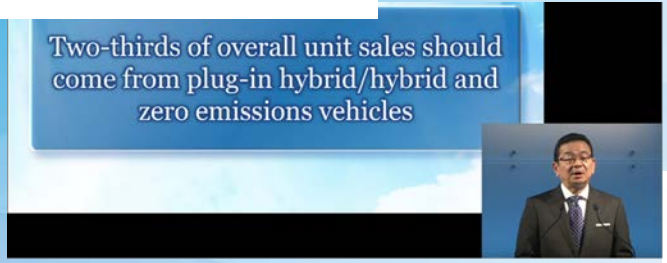
- ✓ Increased electric range on BEVs and PHEVs
- ✓ Use of regulatory flexibilities
- ✓ Use of banked ZEV credits
- ✓ Misc. other updates (e.g., total new vehicle sales)

OEMs appear committed to electrification

ZEV

REUTERS Daimler to make more than 10 electric cars by 2025

Daimler to make more than 10 electric cars by 2025



VOLVO

Volvo Cars announces new target of 1 million electrified cars sold by 2025

Ford

Dec 10, 2015 | DEARBORN, Mich.

Ford Investing $4.5 Billion in Electrified Vehicle Solutions, Reimagining How to Create Future Vehicle User Experiences

2

VOLKSWAGEN AKTIENGESELLSCHAFT

Honda CEO – Takahiro Hachigo
Press Conference - February 2016

THE ELECTRIFICATION INITIATIVE OF THE VOLKSWAGEN GROUP

- >30 new pure-electric vehicles by 2025
- Annual unit sales of 2 to 3 million e-cars by 2025, equivalent to 20–25 percent of total sales

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Hyundai-Kia's grand electrification plan

Korean brands aim to leapfrog past competitors with 26 models by 2020

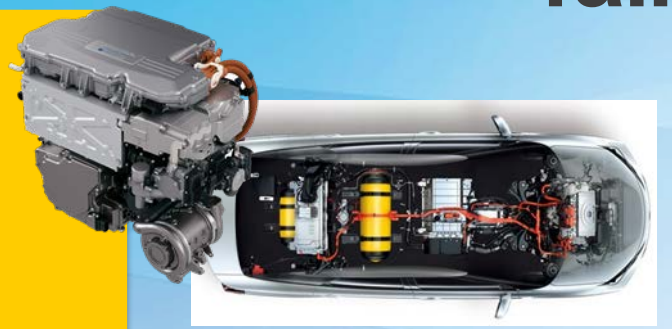
Bloomberg Markets Tech Pursuits Politics Opinion Businessweek

Toyota Targets 90% Emissions Reduction by 2050 on Fuel Cells

by Craig Trudell and Yuki Hagiwara
October 13, 2015, 10:14 PM PDT *Updated on* October 13, 2015, 10:49 PM PDT

Technology costs falling fast

ZEV



Fuel cell system costs have fallen 57% from 2006 to 2015

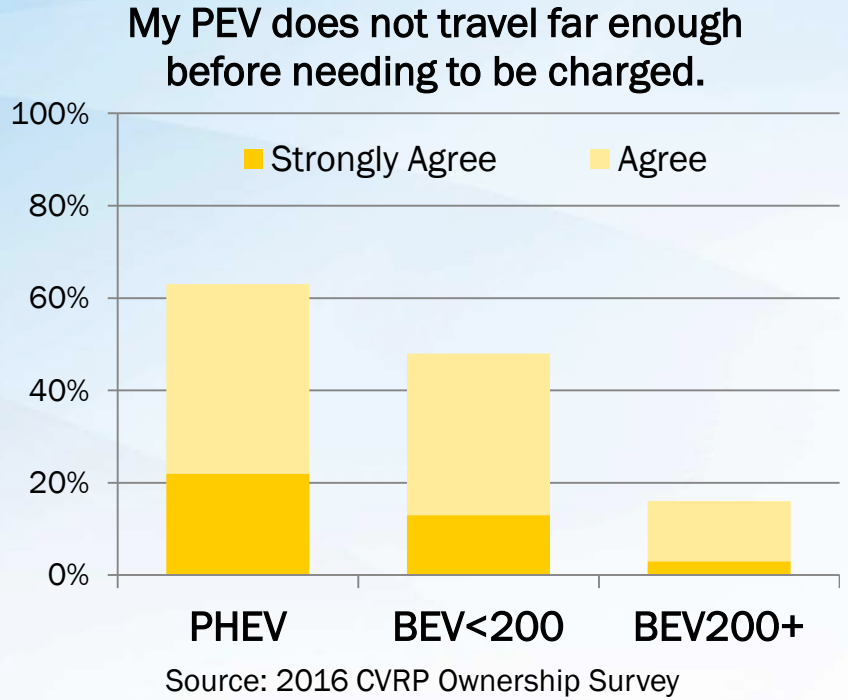
Battery costs have fallen 73% from 2006 to 2015

Neither FCEV nor BEV cost parity anticipated with conventional gasoline technology by 2025

Consumers still need more all-electric range

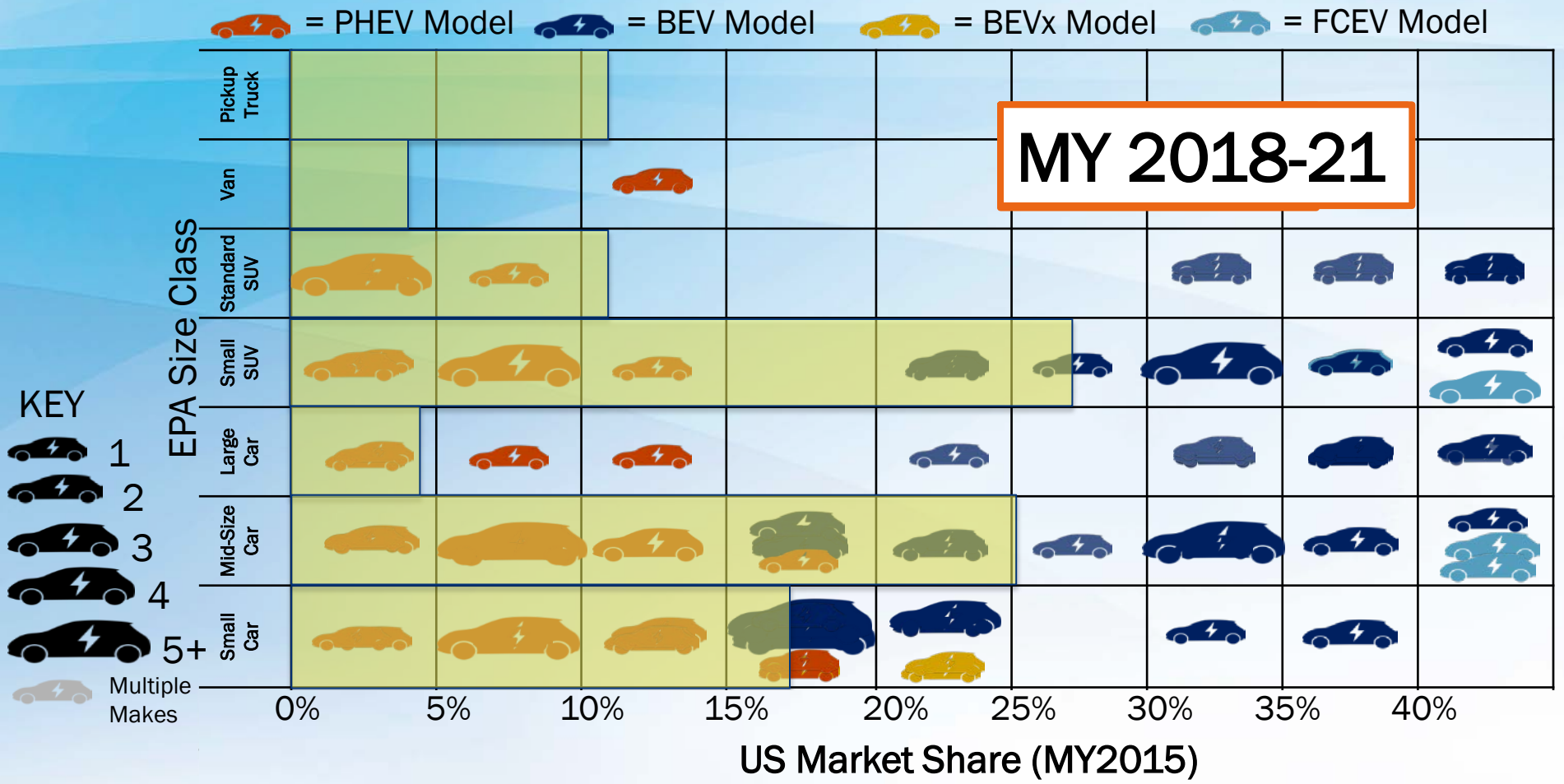
"Range is the most important feature to customers buying EVs, and we know that consideration increases significantly as range goes up."

– *Pam Fletcher, General Motors Executive Chief Engineer*



Source: 2016 CVRP Ownership Survey

Current and Future ZEV/TZEV Models by MY Year



Section 177 State Flexibilities

- CA BEVs allowed to “travel” to S177 states through MY2017, creating credit banks for compliance
- Reduced requirements for PHEVs and BEVs through MY2020
  - Allowed if a few BEVs are delivered prior to 2018
- Pooling amongst states through MY2021 for compliance credits

Intermediate Volume Manufacturers (IVMs) can comply

SUBARU VOLVO JAGUAR LAND ROVER mazda

- 2014: Board adopted flexibilities to ease requirements for IVMs
- 2017: All IVMs (Mazda, Subaru, Jaguar Land Rover, and Volvo) have announced electrified products (BEVs and PHEVs) to be released by MY2020

The overall industry is now shifting its electrification focus toward EVs. We are in the age where we cannot just go on launching EVs only as regulation compliance cars.
-Yasuyuki Yoshinaga, CEO, Fuji Heavy Industries (which owns Subaru)

Sunsetting policies

Further costs reductions needed

200-mile BEV:	40-mile PHEV:
$13,000+ incremental cost	$10,000+ incremental cost

Estimated MY2025 costs relative to MY2016 conventional ICE vehicle

2018-2025 ZEV Requirements Staff Recommendation

Review Question: *Is the ZEV regulation appropriate as adopted for model year 2018 through 2025?*

Recommendation: *Yes. Maintain the current ZEV stringency through model year 2025 including the existing regulatory and credit structure in California, the Section 177 States, and for IVMs.*

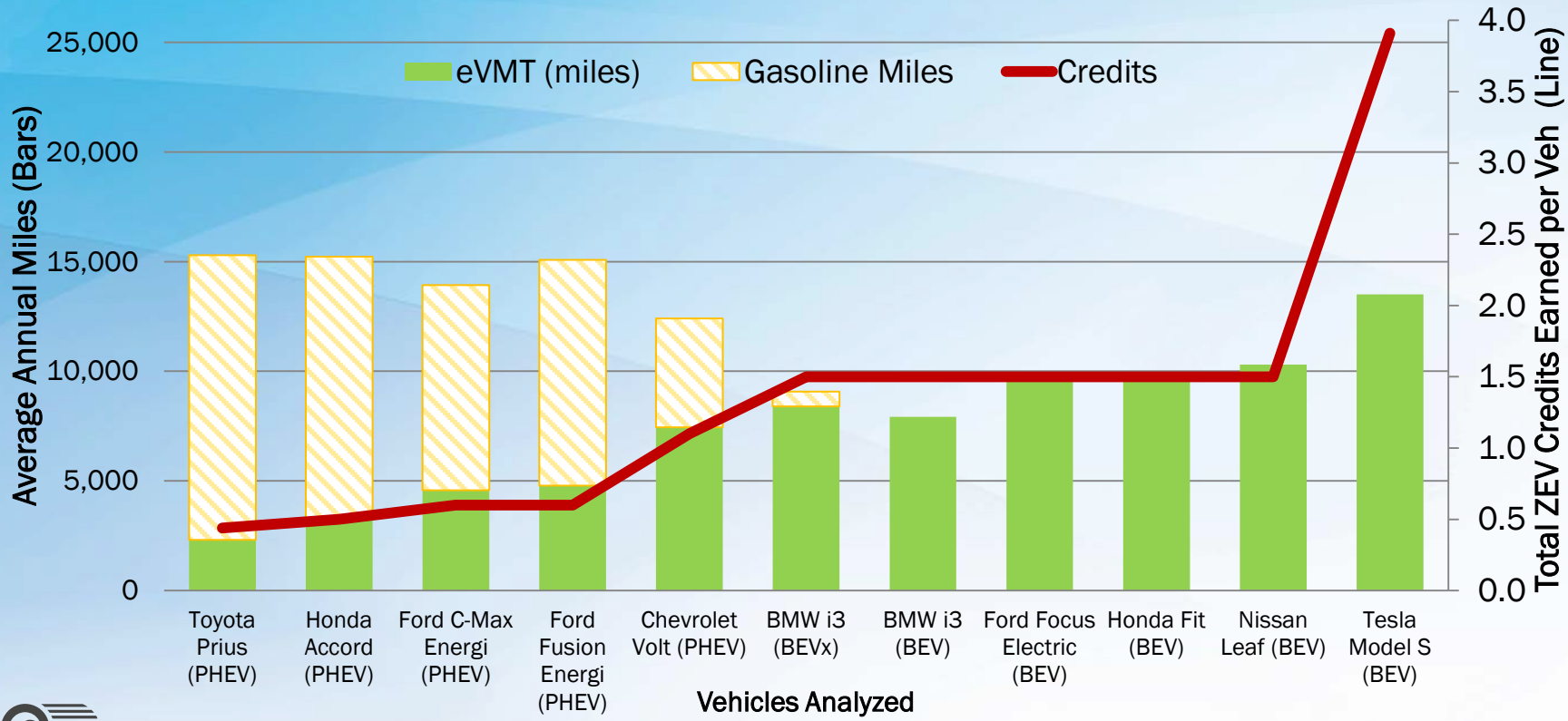
Plug-In vehicles and eVMT

Board direction

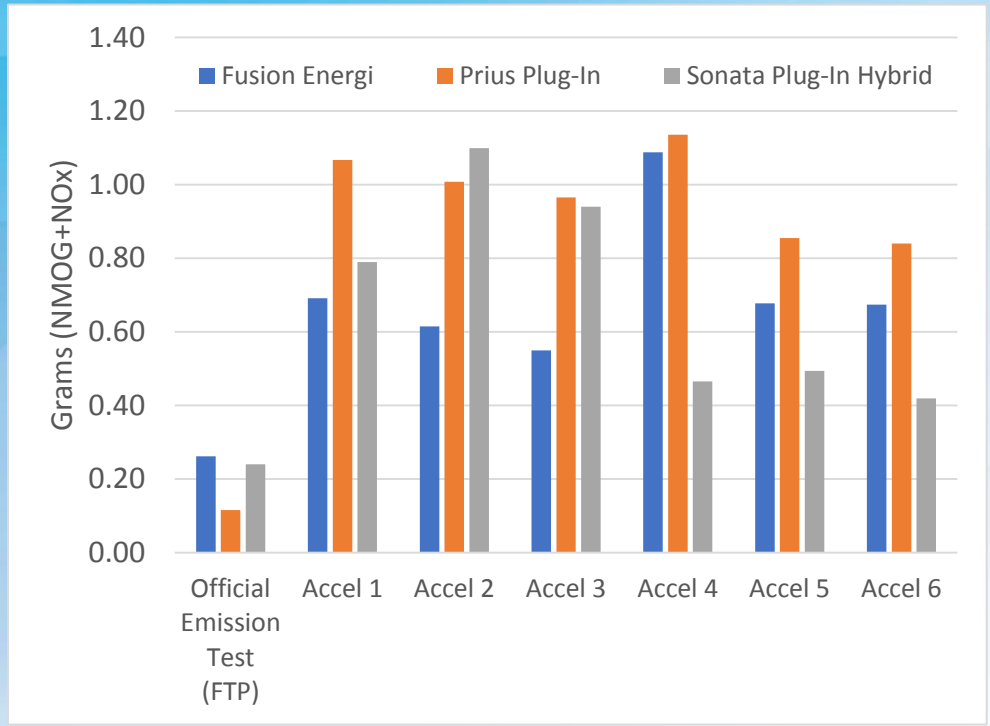
- How are plug-in vehicles used?
- Are they credited appropriately?
  - What are the criteria pollutant impacts?
  - What are the greenhouse gas impacts?

- Data collected from 8 OEMs
- Over 90,000 vehicles
- 11 different models
- Over 20 million miles of trip-level data

Credits are consistent with usage



Criteria Pollutant Considerations for PHEVs



- Testing found some real world engine starts can have significant emissions
  - 2-5x higher
- Vehicle technology improvements are needed to minimize emissions

PHEV eVMT usage depends on consumer behavior

"My main purpose for purchasing it was the HOV sticker. I'm very happy with the car, but I don't charge it very often. If it got more mileage off a charge, I would charge it more."

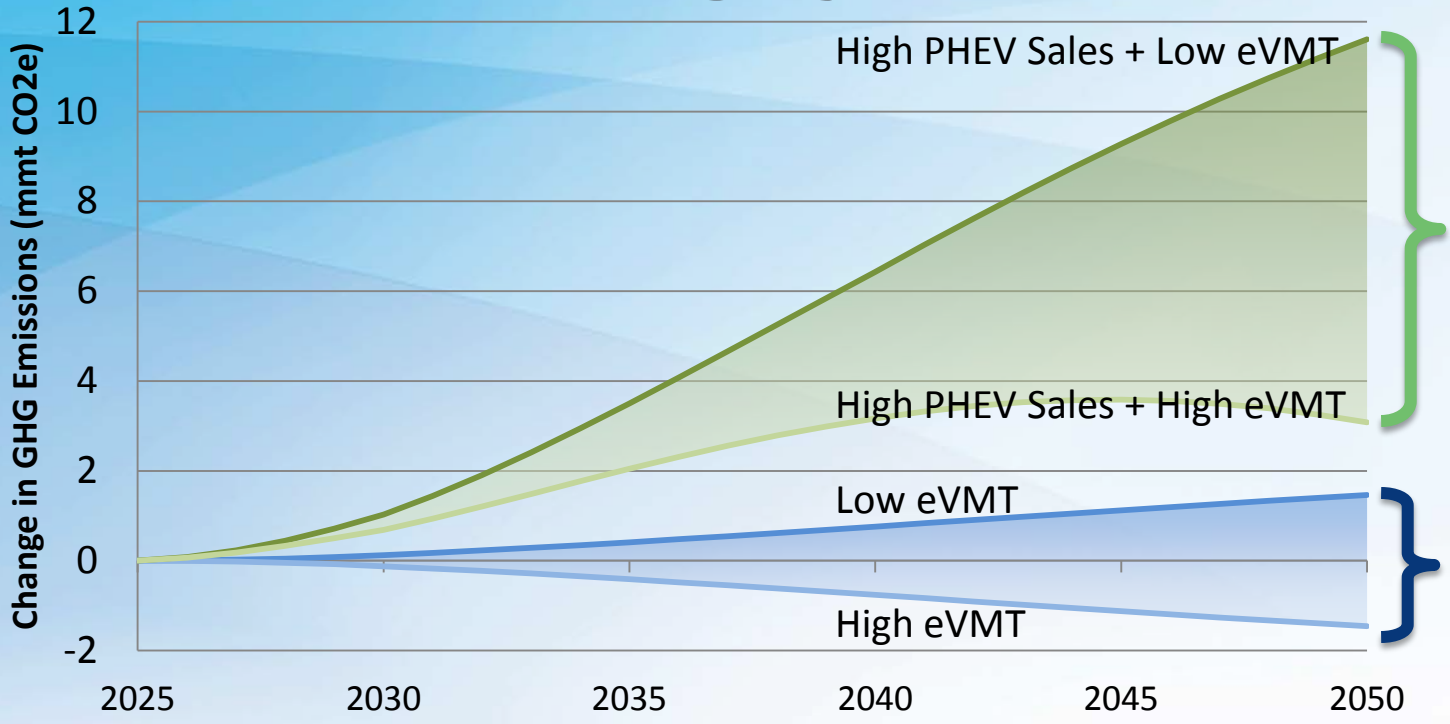
-2013 Ford C-MAX Driver

"Love the car, more Level 2 destination chargers and ability to charge at home without pushing into the highest rate tiers are my biggest issues. Currently the price of gas is less than comparable charging cost (break even around $3-4/gal) so I don't charge much right now."

-2013 Toyota Prius Plug-in Driver

Source: 2016 CVRP Ownership Survey, open-ended final comments

PHEV GHG emissions can be highly variable



+15 to 60% GHG increase if much larger PHEV sales

±8% in GHG emissions based on driver habits

PHEVs Role and Usage Staff Recommendation

Review Question: *Are PHEVs credited and treated appropriately in the ZEV regulation?*

Recommendation: *Yes. Maintain existing credit structure and credit caps for PHEVs through MY 2025*

ZEV: Stakeholder Concerns

- Section 177 Dealers: concerned OEMs will require them to take delivery of more ZEVs than they can readily sell
- Auto Industry: concerned about PHEV credits, S177 state markets, support for complementary policies

Alternatives for increased ZEV stringency

MY 2022 through 2025:

- Increase stringency with focus on pure ZEVs (BEVs, FCEVs)
- Require PHEVs with greater all-electric functionality
- Add credit usage restrictions

New complementary policy actions needed to accelerate ZEV Market

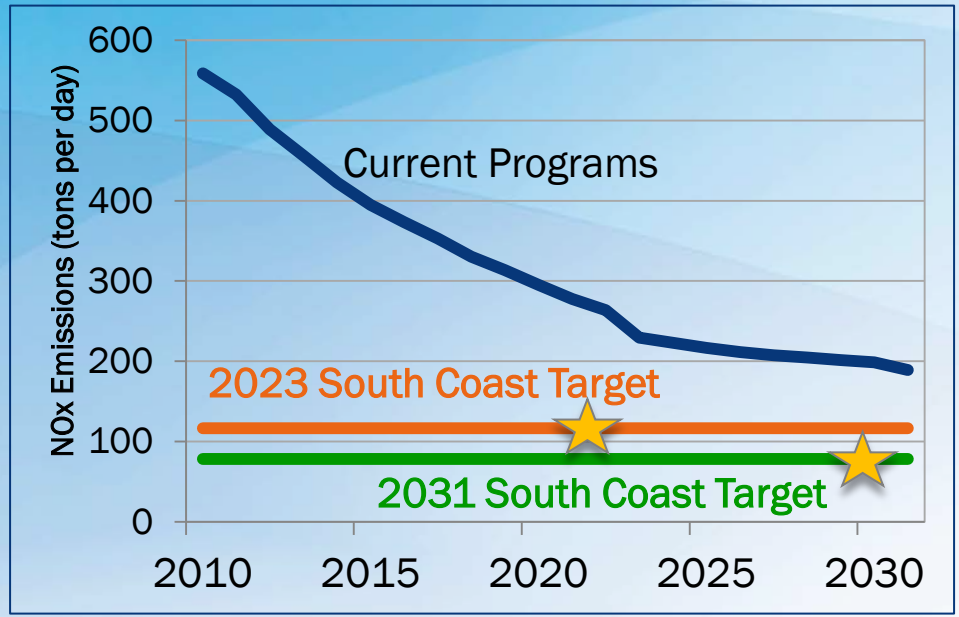
Challenge	Complementary Policy
Low consumer awareness	• New consumer education campaigns • VW Appendix C: ZEV awareness campaign
Shortage of fueling infrastructure	• SB 350: Electric utility investments • VW Appendix C: Electric infrastructure investments • Hydrogen grants for traditional energy firms

2026 and beyond

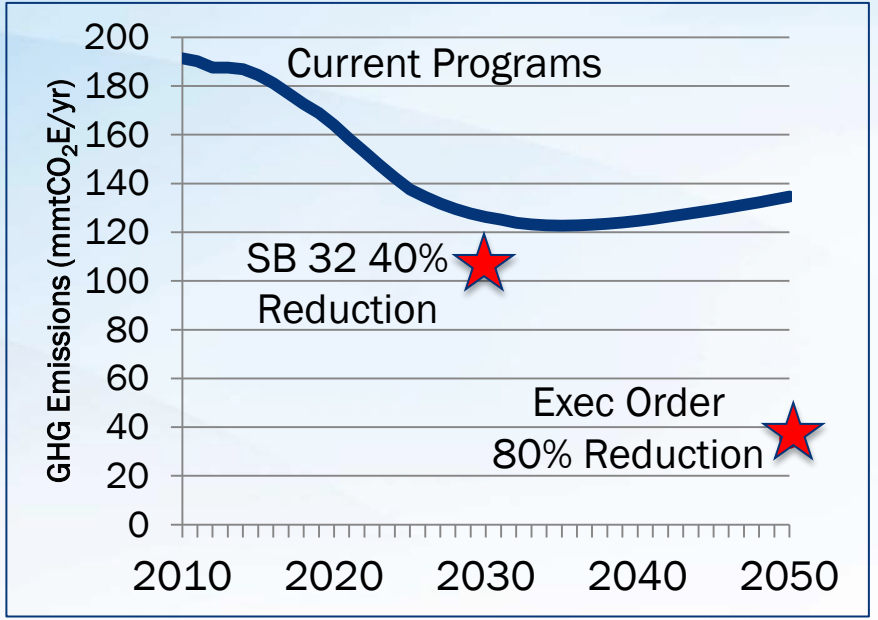
Evolution of the light-duty vehicle emission program

Need large emission reductions beyond current programs

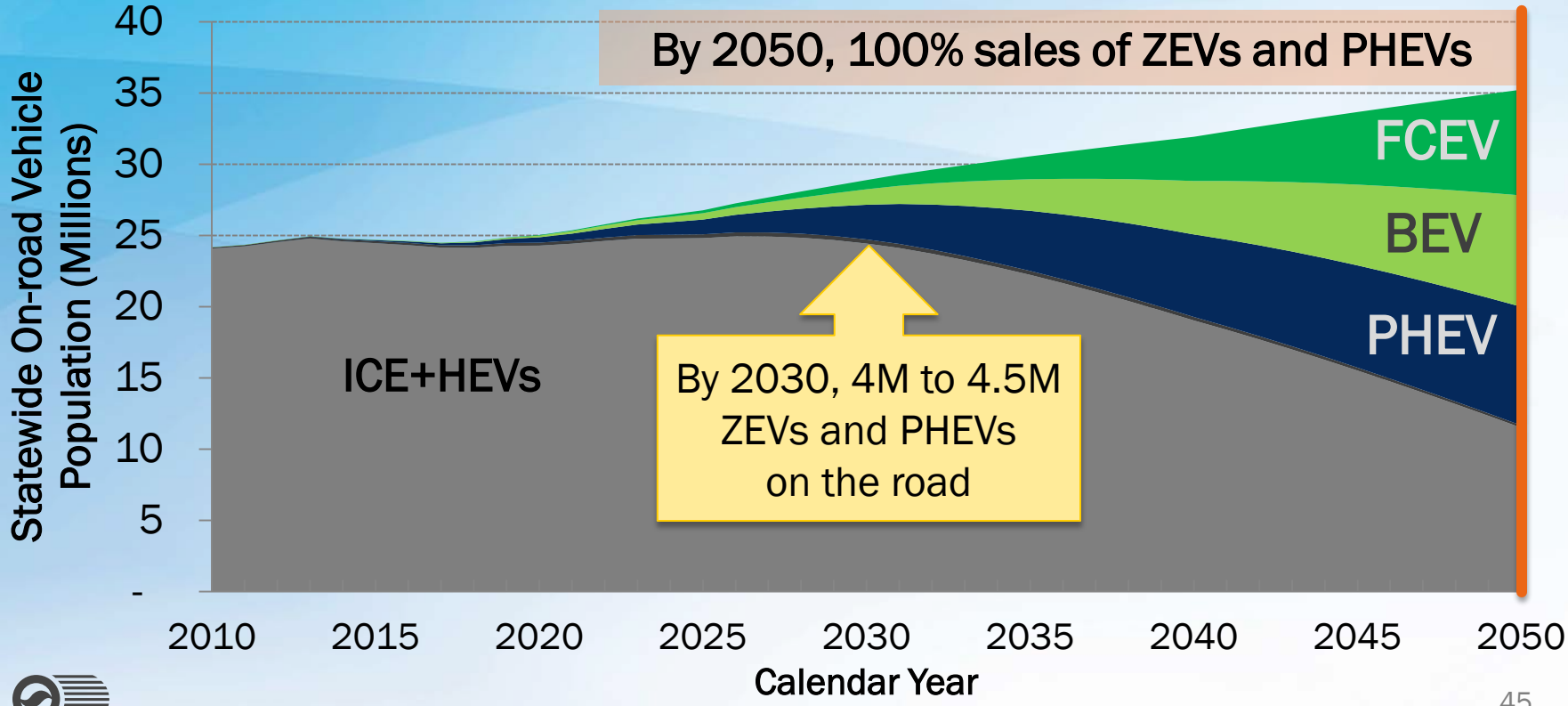
NOx, South Coast, All Sources



GHGs, Statewide LDV & HDV



Mobile Source Strategy & Scoping Plan
Re-affirm Need for ZEVs & Clean Cars



Tracking published literature for 2026 and Beyond

American Lung Association (Oct 2016)

- Large public health and climate benefits from ZEV fleet expansion

Environmental Defense Fund (Feb 2017)

- Feasibility of 10-90 gCO2/mi reductions between 2025 and 2030

International Council on Clean Transportation (Mar 2017)

- Feasibility of 4%-6% annual reductions in GHG emissions by 2030

Indiana University (Mar 2017)

- Combined GHG and ZEV regulations can have long-run positive economic impacts

2026 and beyond: Thinking "Outside the Box"

Early considerations:

- Should fuels be addressed in the regulations?

Broader considerations:

- What is best structure of GHG and criteria emission stds to accelerate necessary technologies like ZEVs?
- Should vehicle regulations include elements for new transportation systems?
- Should the ZEV regulation be expanded to include heavier vehicles?

2026 and beyond: Guiding Principals and Approach

- Maximize emission reductions long-term cost effectively
- Maintain tech forcing requirements as long as barriers exist
- Learn from other jurisdictions, including Europe & Asia
- Consider transition from current rule to new rule
- Leverage partnerships
- Board proposal within 3-4 years for model year 2026 start

Midterm Review Recommendations Summary

- Adopted MY 2022-2025 GHG standards remain appropriate
- PM standard is feasible but further action needed to ensure robust control
- Continue with existing technology-forcing ZEV requirements to develop the market
- Direct staff to immediately begin rule development for MY 2026 and beyond