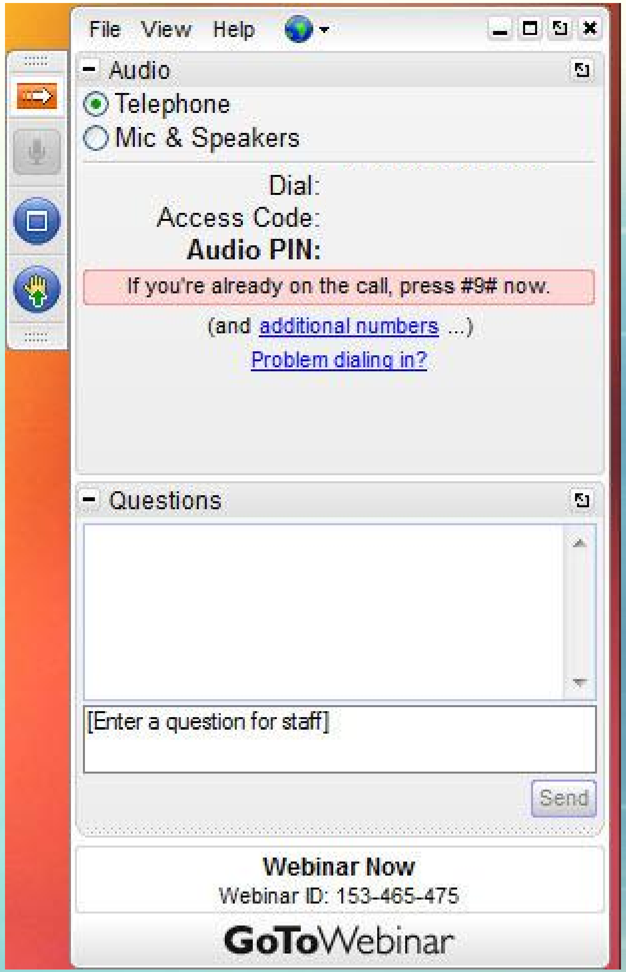
CALIFORNIA
AIR RESOURCES BOARD

Advanced Clean Cars (ACC) II Workshop

September 16, 2020

Today's Workshop Logistics

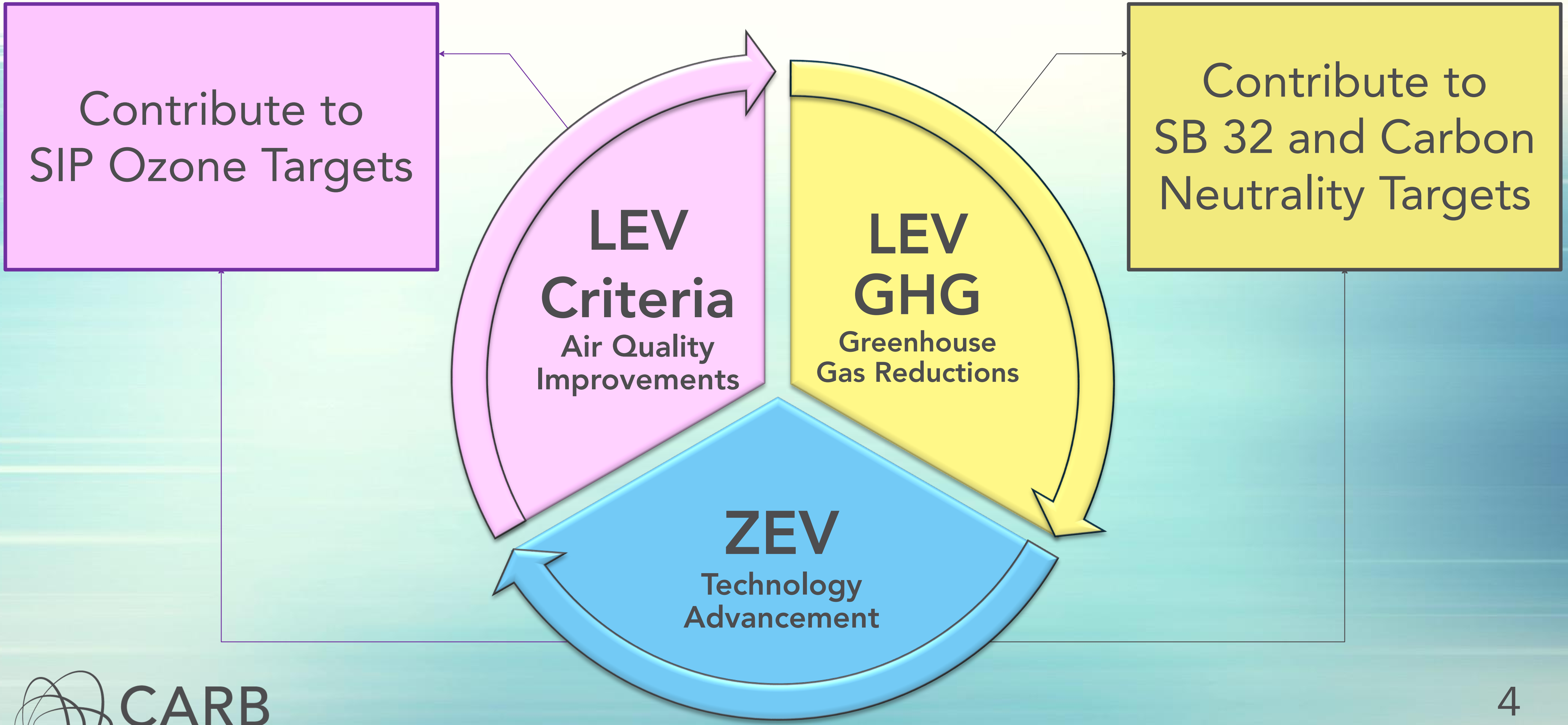
- Slides are posted at: https://ww2.arb.ca.gov/advanced-clean-cars-ii-meetings-workshops
- All webinar attendees will remain muted
- Questions can be sent via the GoToWebinar question box
  - Please include slide numbers



Agenda

1. Background
2. GHG Refrigerant Provision Proposal
3. LEV Criteria Emission Proposals
4. Break
5. ZEV-related Proposals
6. Update on BEV Costs

Role of Advanced Clean Cars II

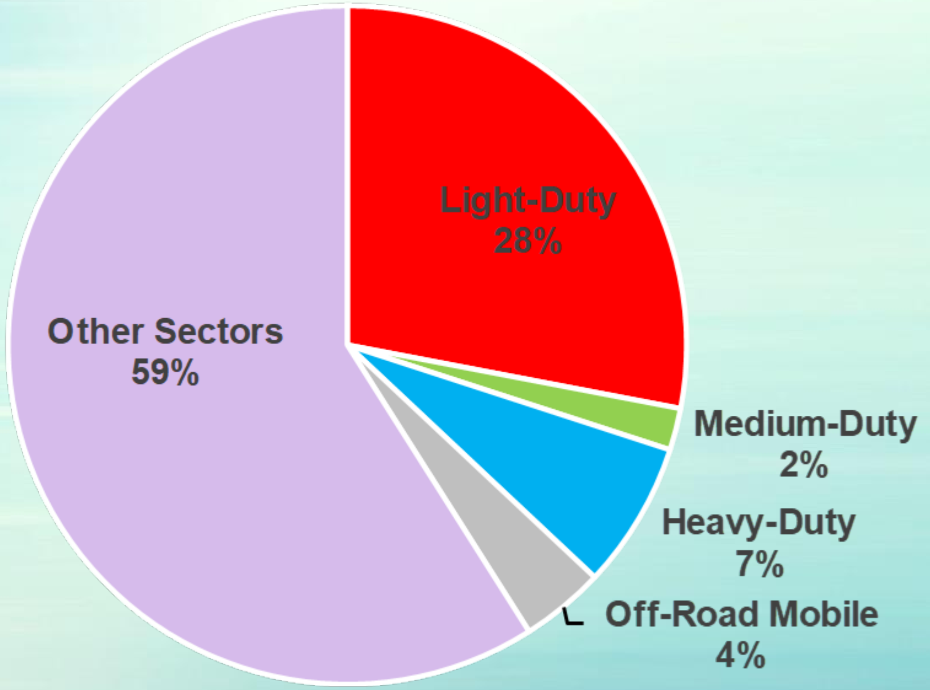


ACC II Rules Are Needed

California's climate and air quality challenges still require deep reductions from light-duty vehicles

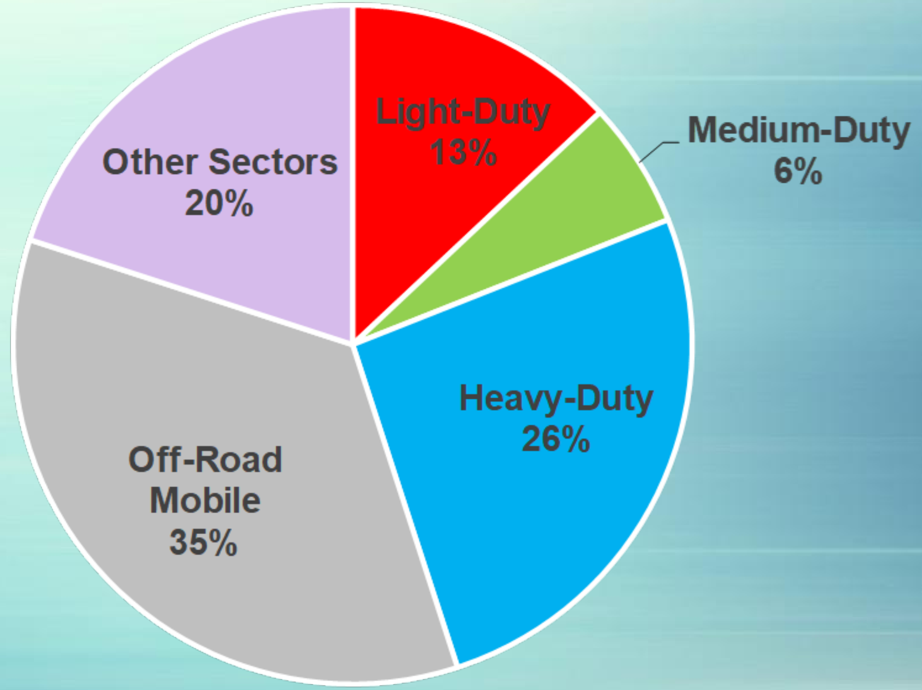
2017 Statewide GHG Emissions

Total = 424 MMTCO2e



2017 Statewide NOx Emissions

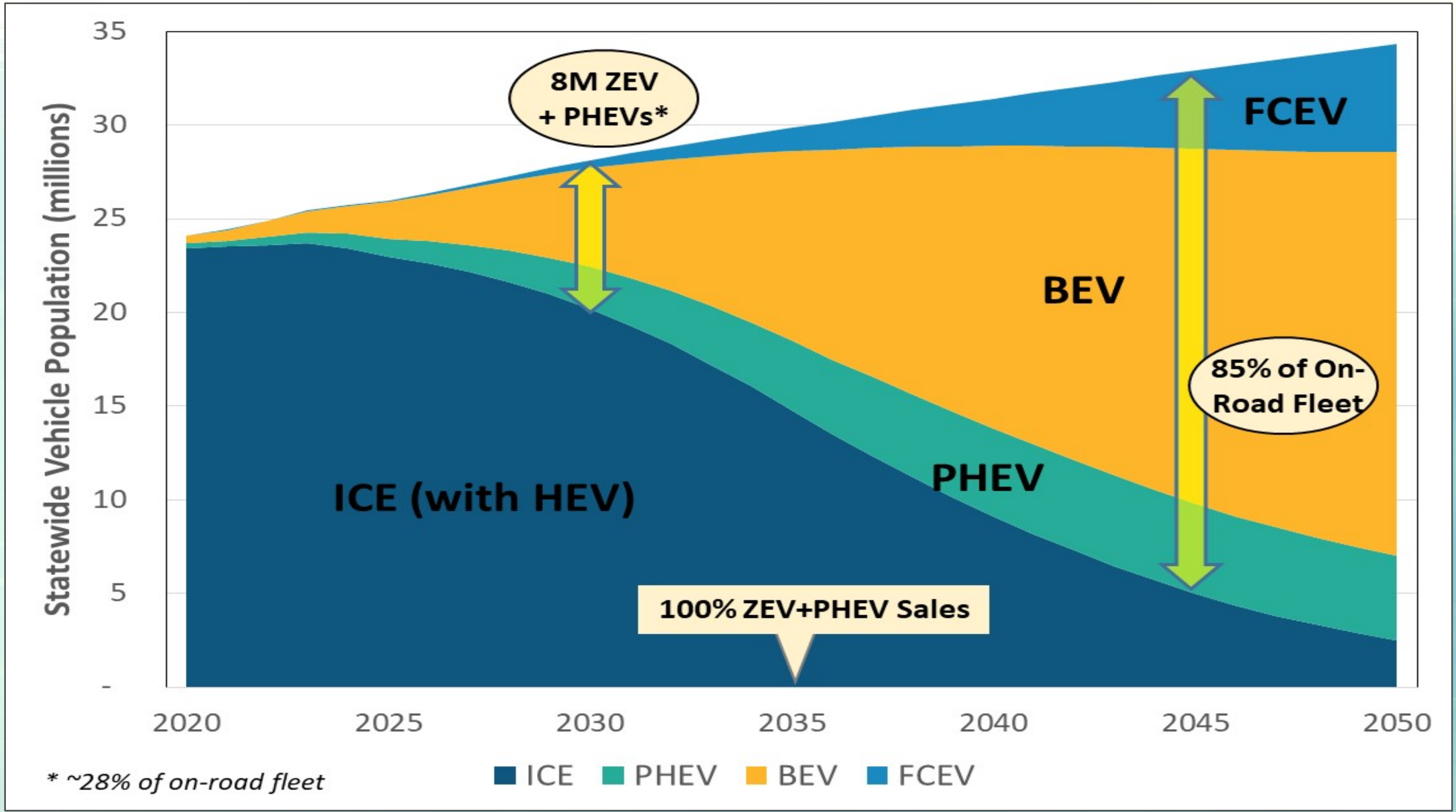
Total = 1294 tons per day



2020 Mobile Source Strategy

- Forthcoming light-duty vehicle scenarios assume aggressive new ZEV sales and continued emission reductions from combustion vehicles
  - Include aggressive assumptions on decarbonizing electricity and hydrogen fuel
- Strong electrification is essential for emission reductions from the light-duty sector
  - Combination of multi-sector regulatory and non-regulatory policies will be needed to achieve these reductions

LDV Scenario* Fleet Mix for Deep Emission Reductions



CARB ** Forthcoming 2020 Mobile Source Strategy*

GHG Refrigerant Provision

Hydrofluorocarbon (HFC) Reductions

- Hydrofluorocarbons (HFCs): a class of chemicals replacing Ozone-Depleting Substances (ODS) such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs)
  - Example: HFC-134a (R-134a) – being used as refrigerant in motor vehicle air conditioning (MVAC, or A/C) systems
- Many HFCs are potent GHGs with high Global Warming Potential (GWP) values – significant climate change contributors
  - Worldwide efforts to reduce HFC emissions
  - SB 1383 requires California HFC reduction of 40% below 2013 levels by 2030

Low-GWP LDV A/C Refrigerants – Current Regulations

- CARB and U.S. EPA's current LDV GHG rules (MY 2017-2025) provide credit incentives for the use of low-GWP refrigerants, low-leak, and efficiency-improvement A/C technologies.
- CARB A/C Direct (Leakage) Credit for low-GWP A/C

	MaxCredit (gCO_2e/mi)	***HiLeakPenalty**** (gCO_2e/mi)
Car	13.8	0-1.8
Truck	17.2	0-2.1

****HiLeakPenalty*** is calculated based on SAE J2727-evaluated A/C leak rate.

- CARB A/C Indirect (Efficiency) Credit for efficiency-improvement A/C technologies (e.g. reduced reheat with externally-controlled variable-displacement compressor; internal heat exchanger)

	MaxCredit (g/mi)
Car	5.0
Truck	7.2

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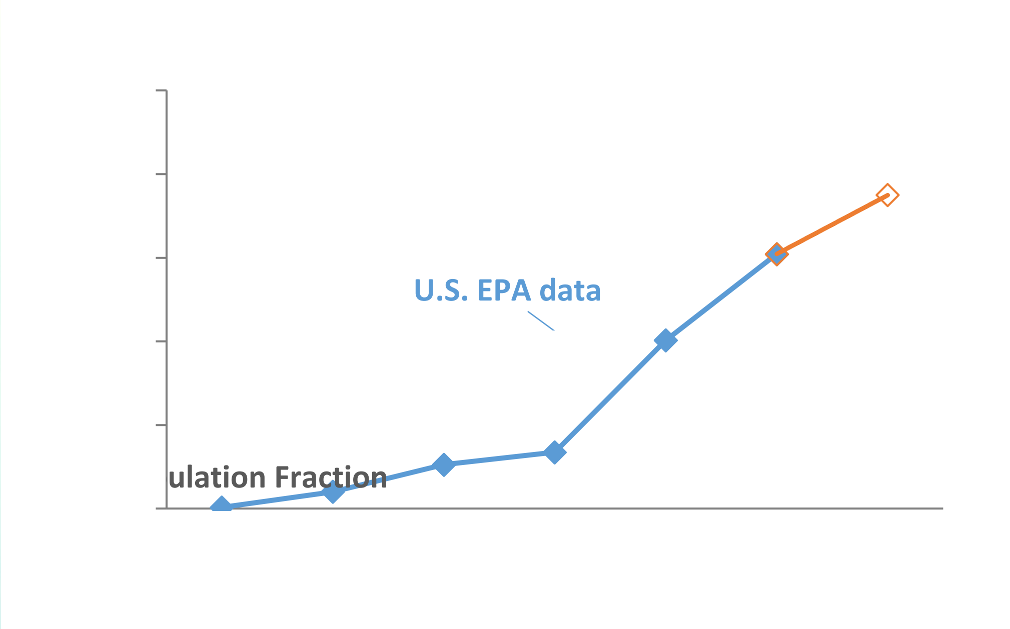
Low-GWP LDV A/C Refrigerants – Other Relevant Regulations

- A U.S. EPA Significant New Alternatives Policy (SNAP) rule changed HFC-134a and several other high-GWP LDV A/C refrigerants' status from acceptable to unacceptable (from MY 2021)
  - The rule has since been vacated and remanded by court ruling to the extent that it requires HFC replacement
- EU MAC Directive (GWP<=150 for new vehicles from 2017)

Low-GWP LDV A/C Refrigerants – Industry Status

- HFC-134a (GWP=1,430) still common in in-use LDV fleet, but being replaced by low-GWP alternatives in new LDVs
- U.S. EPA SNAP-approved low-GWP alternatives:
  - HFO-1234yf (GWP=4) being used in millions of new vehicles
  - CO_2 (R-744) (GWP=1) being offered in EU markets
  - HFC-152a (GWP=124) in secondary-loop configuration being developed by industry



Data sources:
The 2019 EPA Automotive Trends Report, EPA-420-R-20-006, U.S. EPA, March 2020
Global HFO-1234yf Regulatory Summary and Light Vehicle Conversion Update, Rick Winick, October 2019

ACC II A/C Refrigerant Concepts

- Prohibit high-GWP (>150) refrigerants in new LDV A/C systems (post-MY 2025)
  - Contribute to meeting State's HFC reduction goals
  - Ensure continued industry low-GWP transition
  - Align with EU MAC Directive
- Continue to offer A/C credits (Leakage or Efficiency or both)
  - Use best and latest knowledge to inform credit program update

LEV Criteria Emission Proposals

Criteria Emissions Reductions from Combustion Vehicles

Increase Stringency

- NMOG+NOx fleet average
- SFTP stand-alone standard
- Robust PM emission control
- Optimize emission control for heavier vehicles
- Evaporative emissions

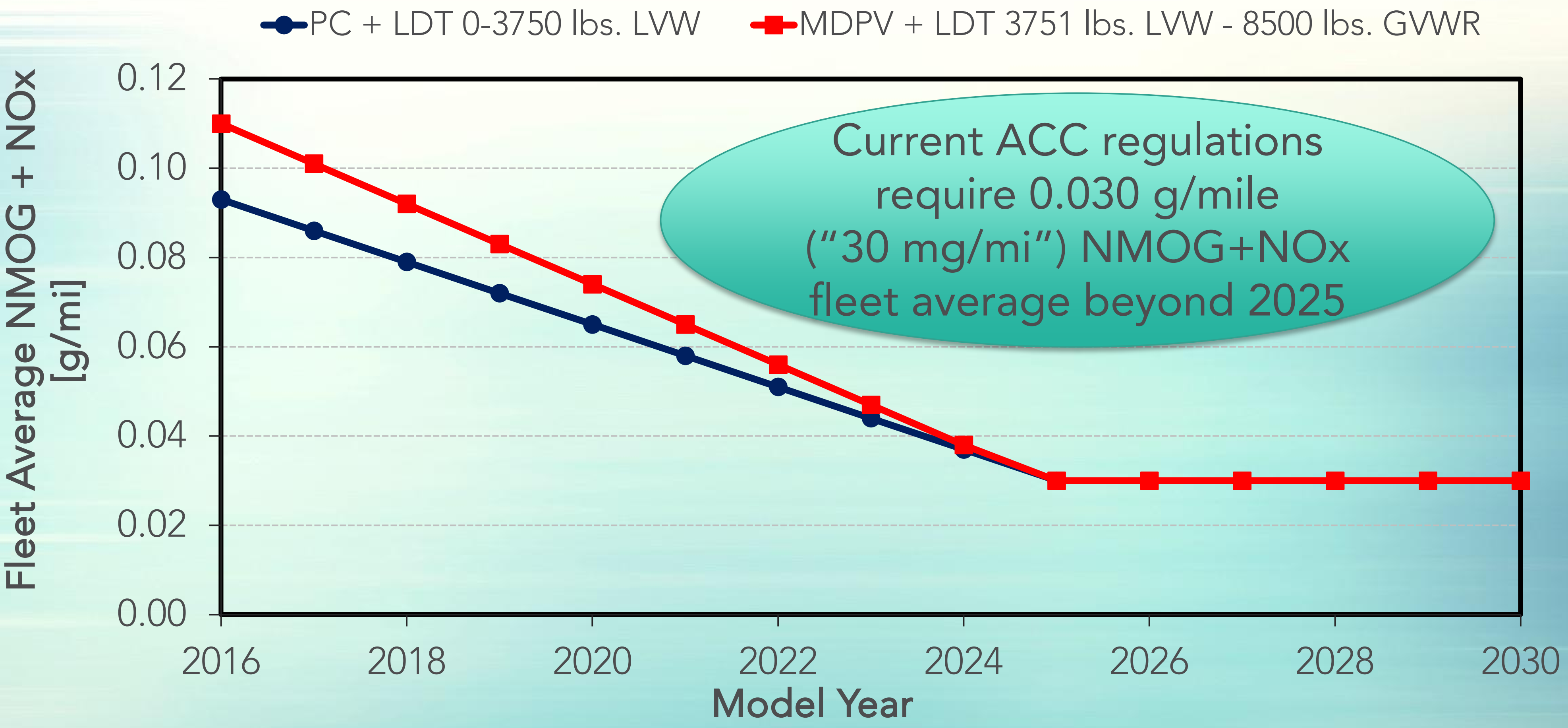
Real-World Reductions

- Better control of engine start emissions
- Address unique challenges for PHEV engine start emissions

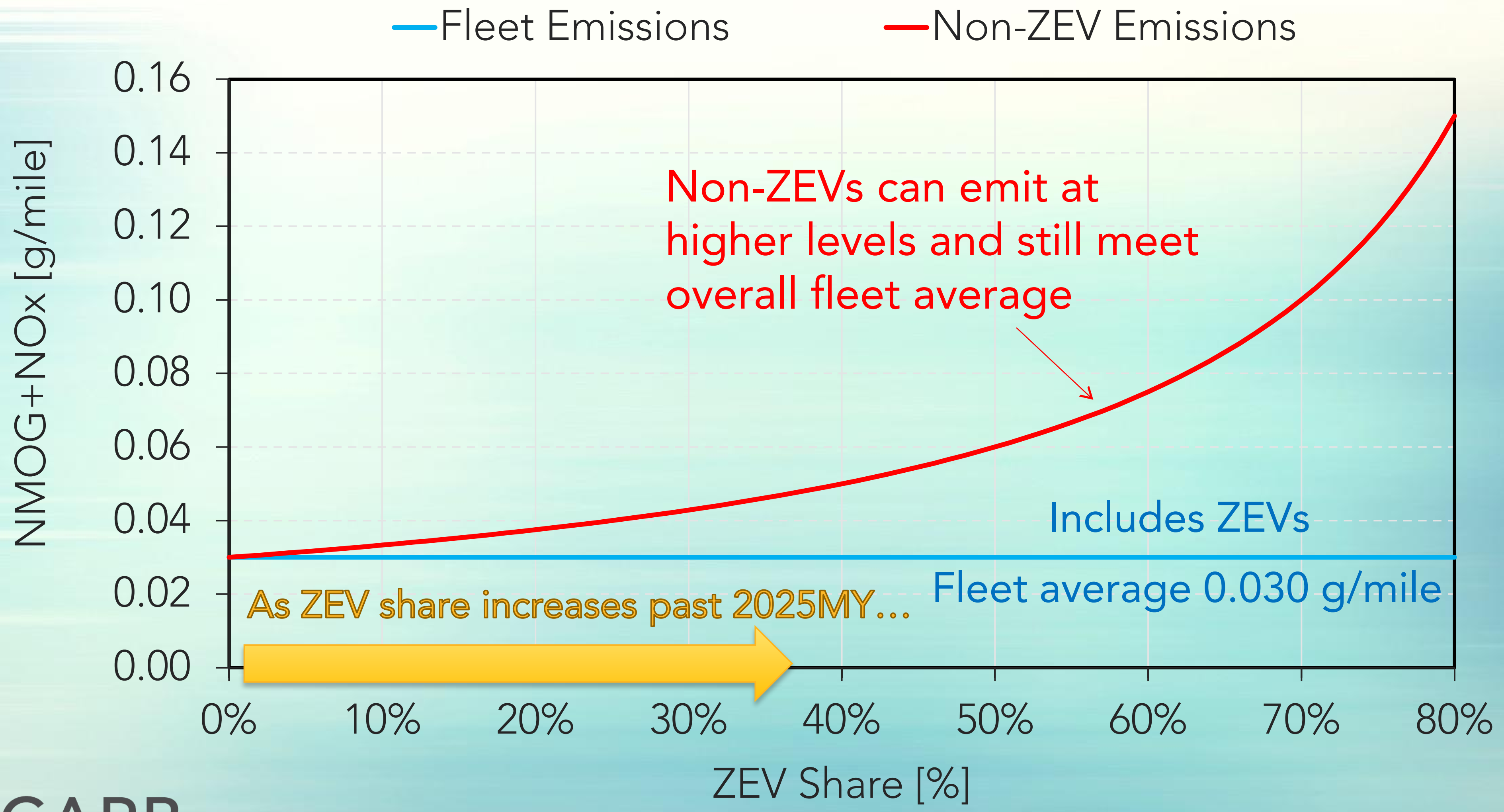
Future Workshop

- PHEV Test Procedures
- PHEV NMOG+NOx credits

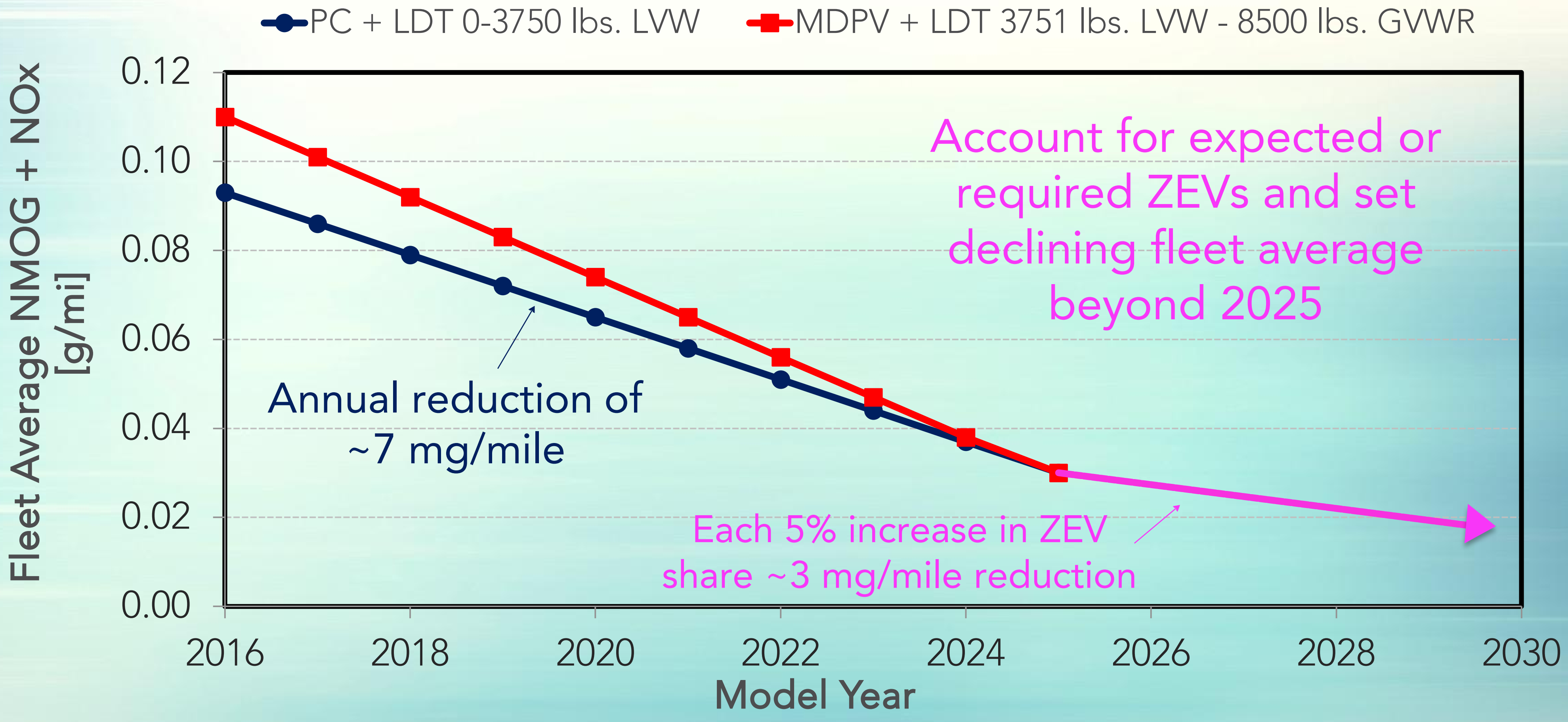
Current NMOG+NOx Fleet Average



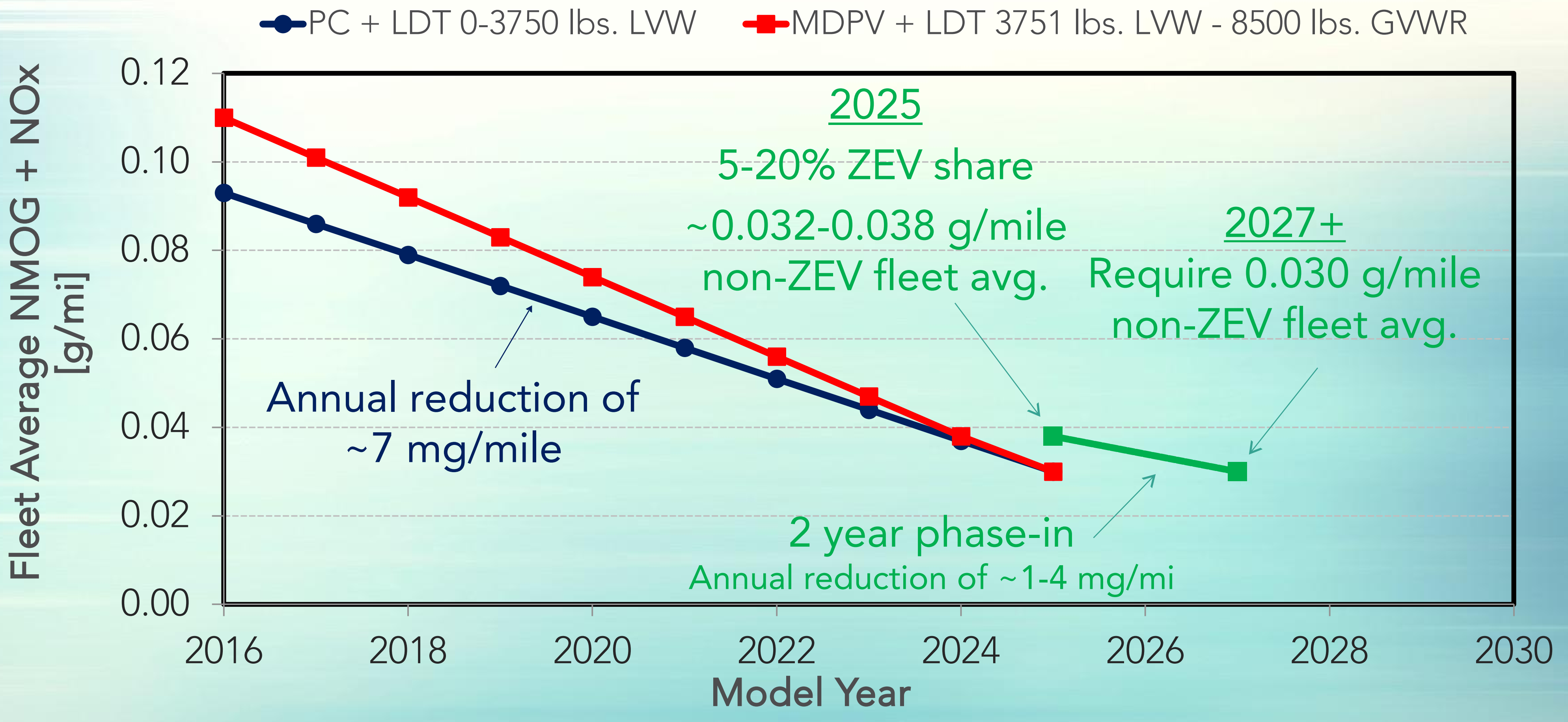
Item #1: Preserve Fleet Average of Non-ZEVs to Help Meet Future Ozone Targets



Option A: Keep ZEVs In but Lower the Fleet Average



Option B: Transition to Non-ZEV Fleet Average

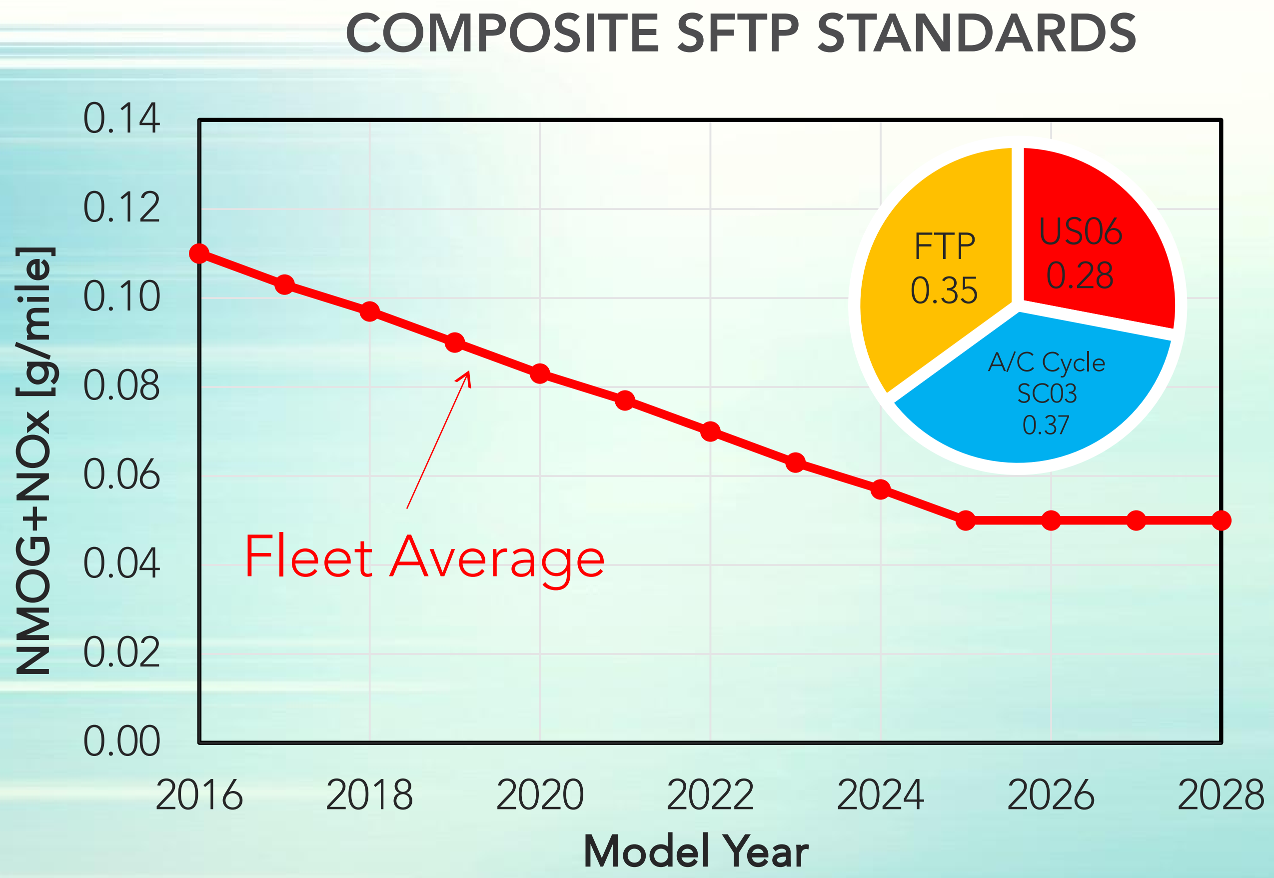


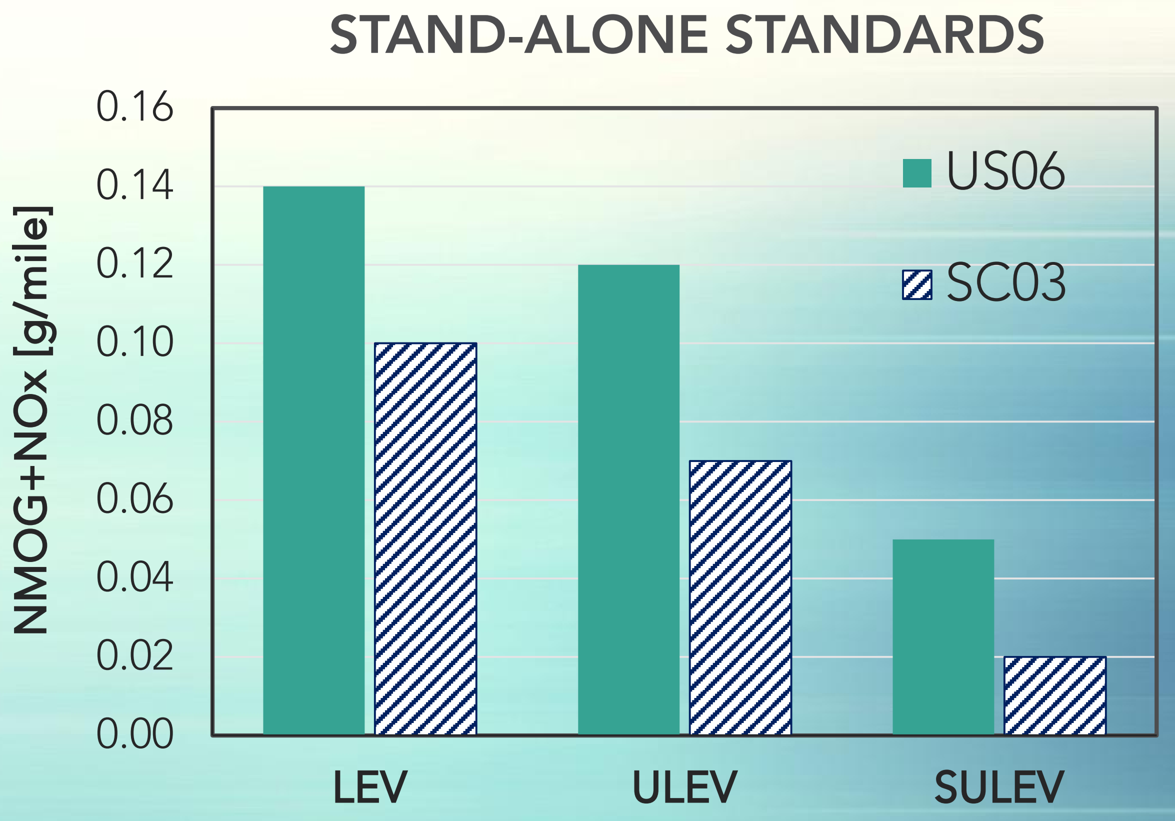
Item #2: Further Emission Reductions for Non-ZEVs

Additional Investigations

- Reduce NMOG+NOx fleet average from 0.030 to 0.020 g/mile for a larger portion of the fleet
- Evaluating elimination of highest emission bins to promote transition to cleaner conventional vehicles
  - LEV160 and ULEV125

Item #3: NMOG+NOx Standards for Aggressive Driving



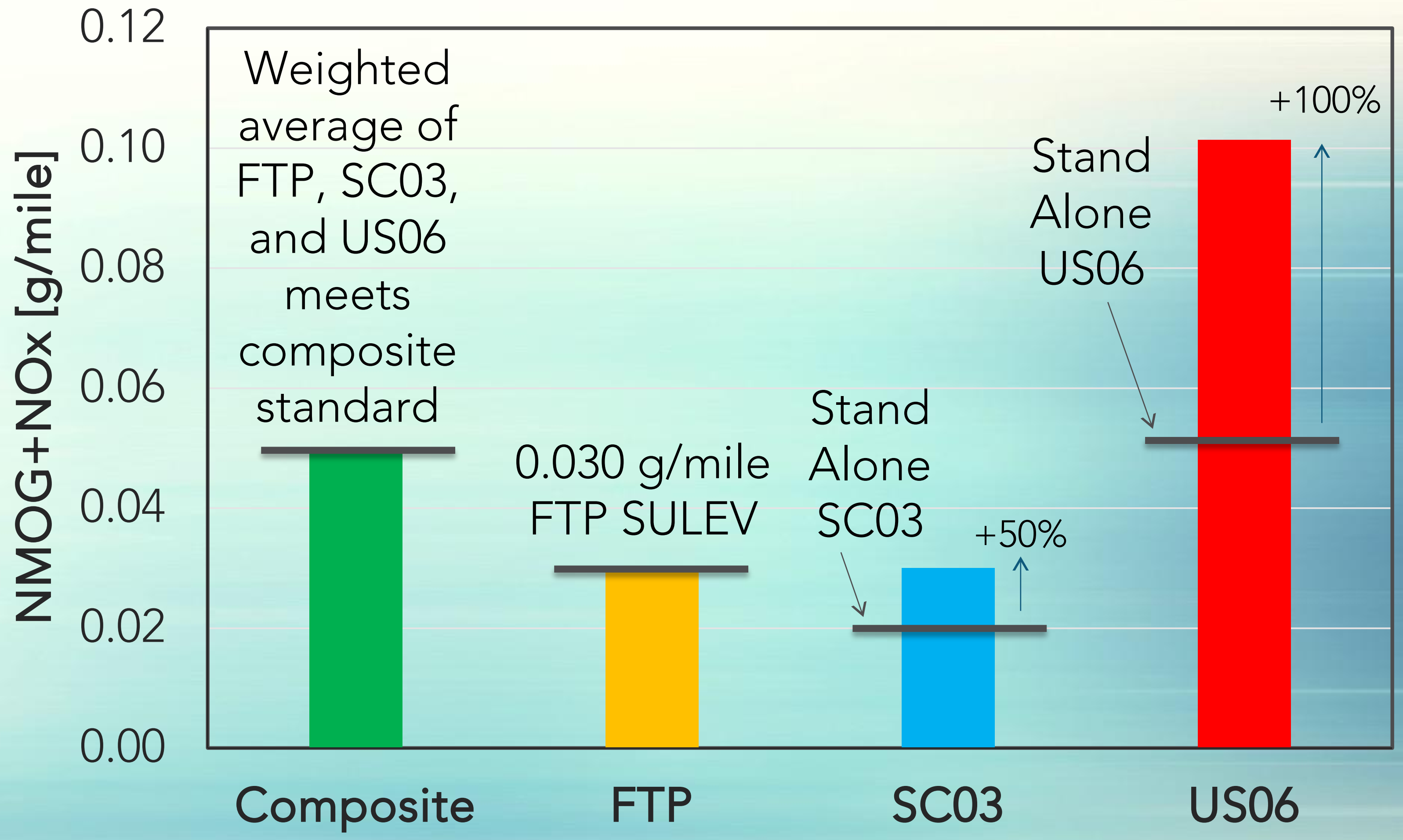


Less than 3% of vehicles are currently certified using stand-alone standards

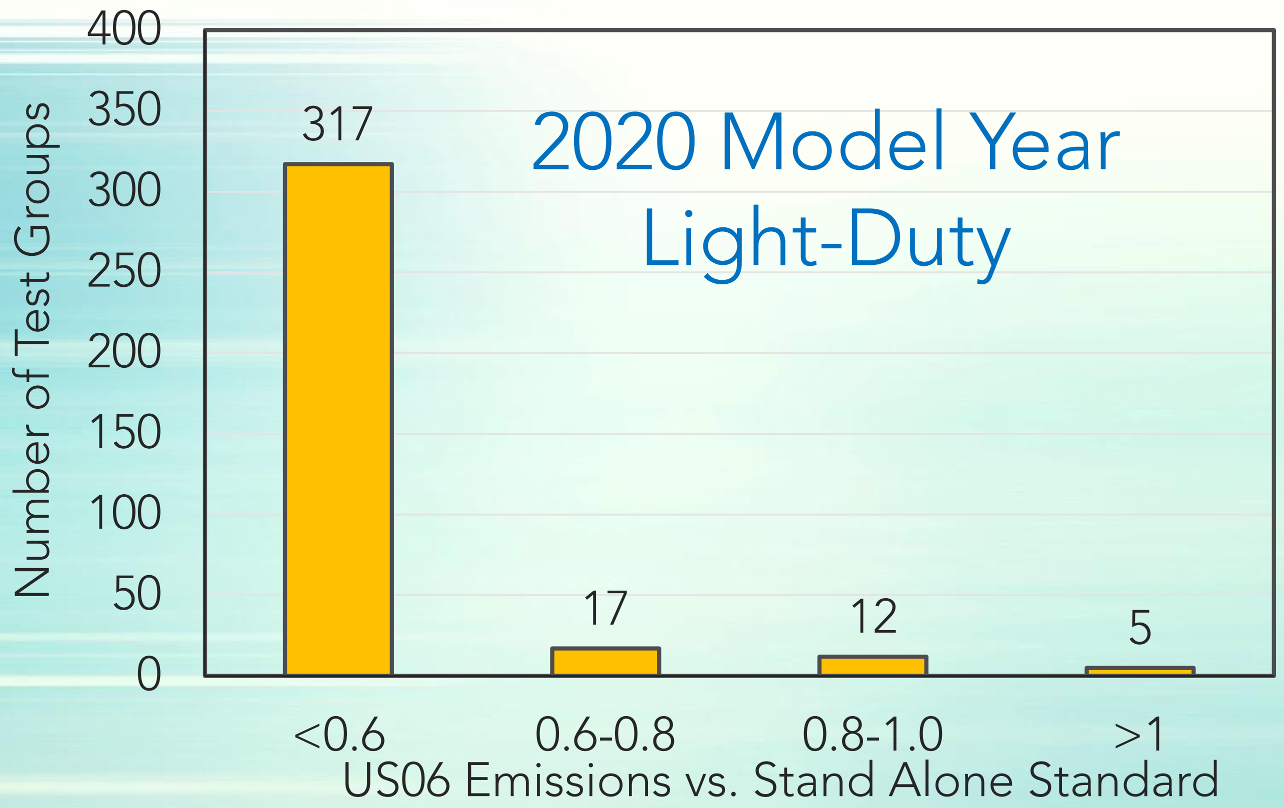
Composite Standards May Not Ensure Robust Control of Emissions

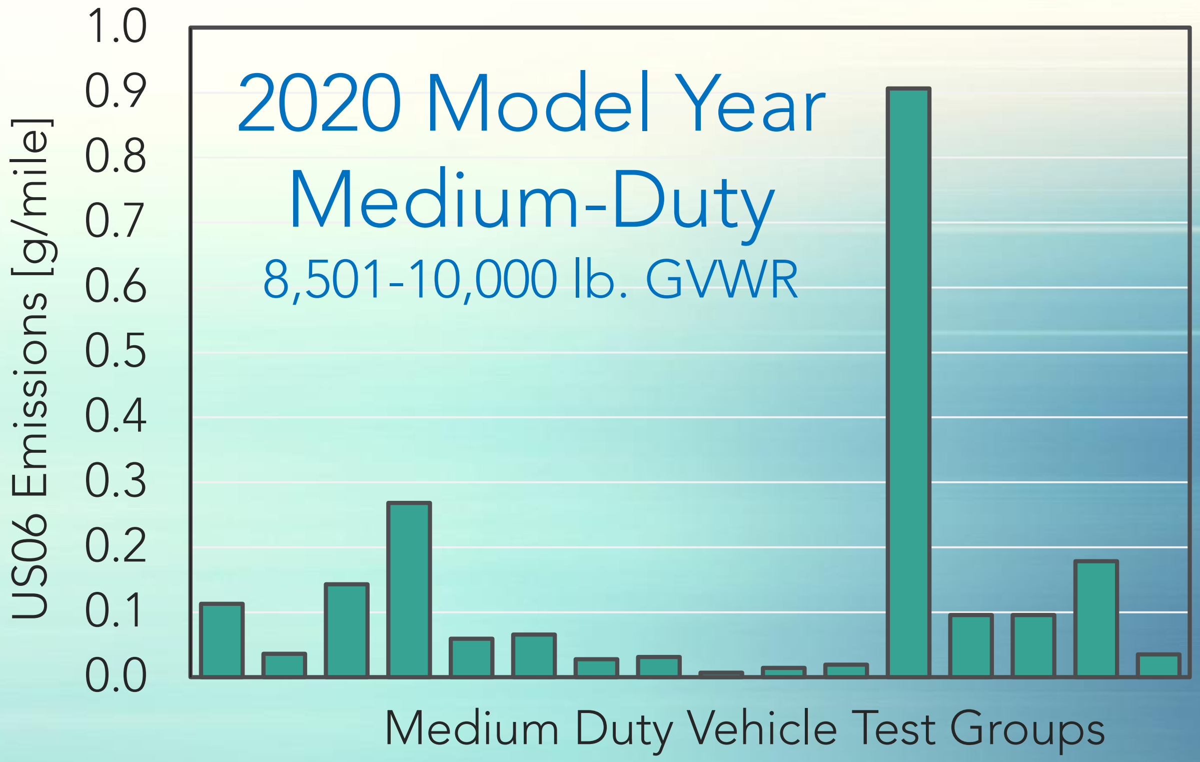
<u>Theoretical Example</u>

Composite SFTP standard can be met even with high emissions on SC03 and US06 cycles



Nearly all test groups already meet stand alone SFTP… but there are a few high emitters





ACC II Proposal: Require all to certify to stand-alone SFTP standards

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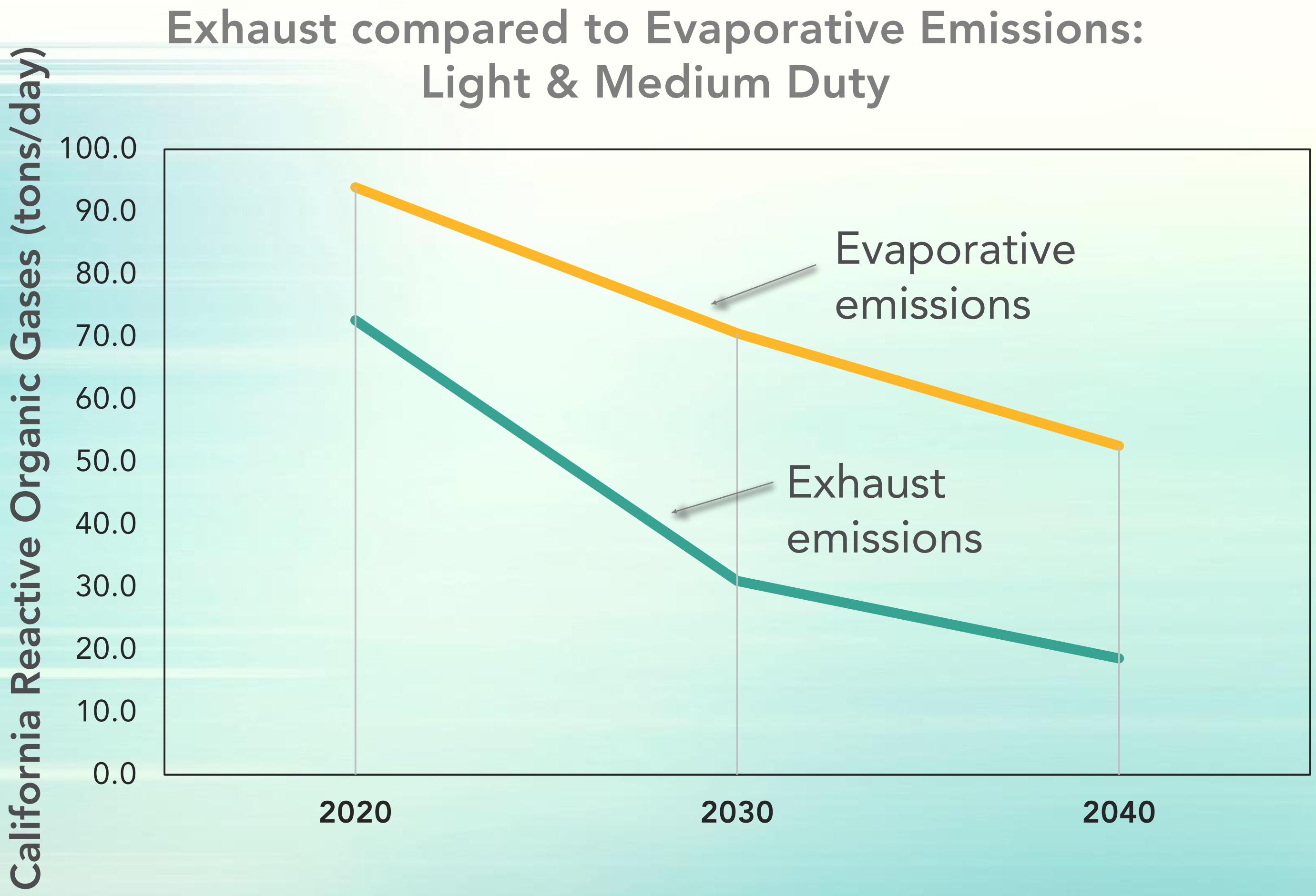
Item #4: Evaporative Emissions



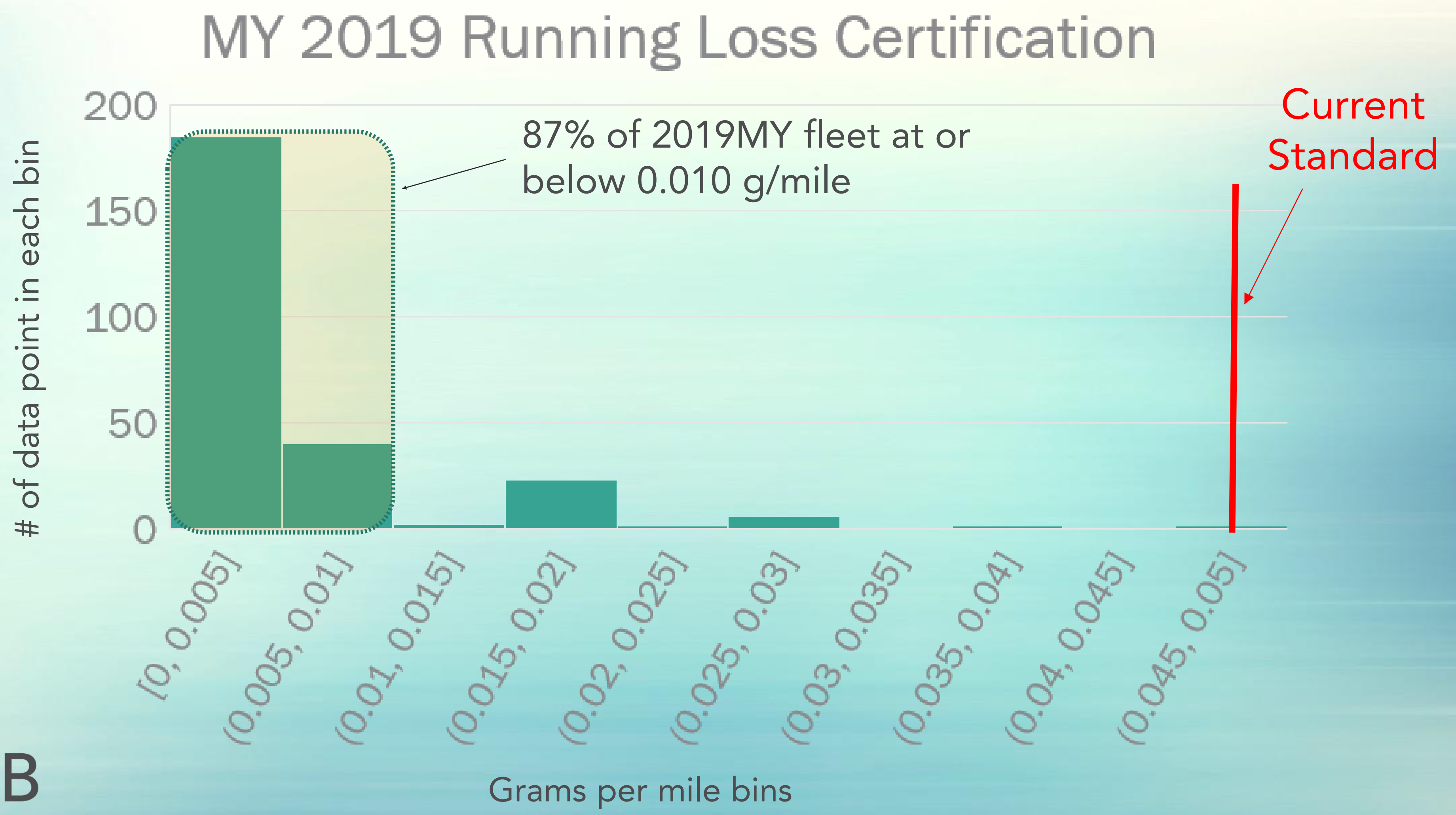
- Evaporative hydrocarbon emissions already exceed exhaust
- Diurnal and running loss expected to be equal share

Evaporative Emissions:
Current Standards & Emissions

Type of emissions:	Standard:	Last Revision:	Fleet Emissions: [1]
Diurnal + Hot Soak	0.300 g/day	MY 2018	26 Tons/day
Running Loss	0.05 g/mile	MY 1995	26 Tons/day

[1] Evaporative emissions in 2040, California,
Source: EMFAC 2017

Evaporative Running Loss Emissions:
Most Vehicles Well Below Standard



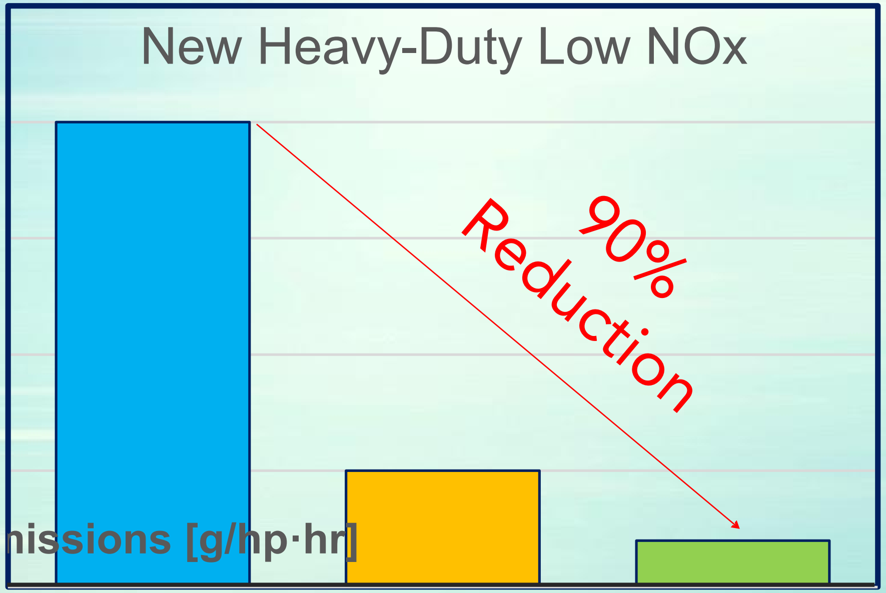
ACC II Proposal for Evaporative Emissions: Tighten Running Loss Standard

- Change standard from 0.05 g/mile to 0.010 g/mile
  - Eliminate remaining high emitters and ensure good designs remain the norm
  - Draft estimate of ~4 tons/day in HC reductions[1]

[1] Draft evaporative emissions in 2040, statewide, EMFAC 2017

Item #5: Emission Control for Heavier Vehicles

Recently adopted heavy-duty low NOx rules will apply to engine-certified medium-duty vehicles

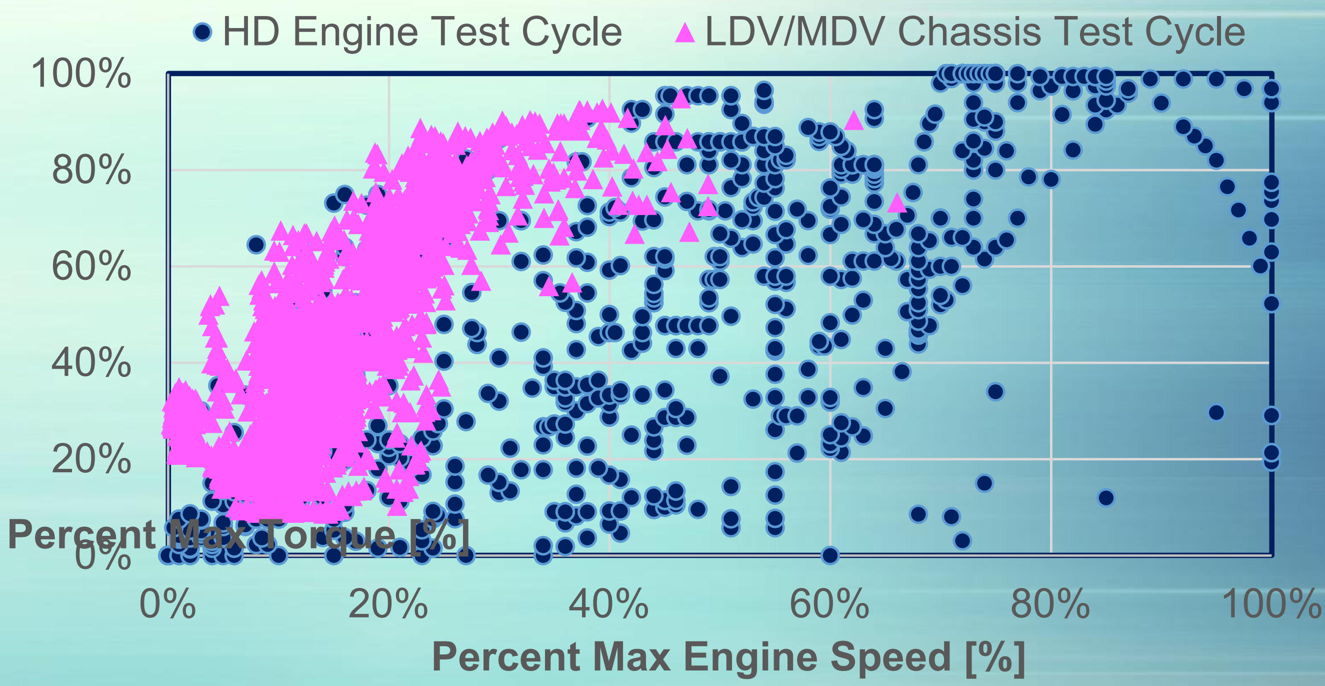


- Mix of chassis dyno certified and engine dyno certified in medium-duty vehicles
  - Options vary based on weight class, fuel, and type of vehicle
  - Intent was to allow primarily LD OEMs to certify MDVs similarly and vice versa for HD OEMs
- Need to look at corresponding stringency change for chassis standard to avoid inconsistency

Equivalency Complicated by Test Cycle Differences

- Chassis cycle, based on LD, focuses on speeds/loads more common in LD usage
  - Engine cycle, necessarily, focuses on speeds/loads more common in HD usage
- Option to use engine or chassis cert not tied to expected usage of vehicle
  - Creates a mismatch in medium-duty vehicles used more like HD but certified like LD and vice-versa
- Emission controls optimized for one cycle don't necessarily ensure good control in other operation

Chassis dyno testing covers different region of engine operation than HD engine dyno testing



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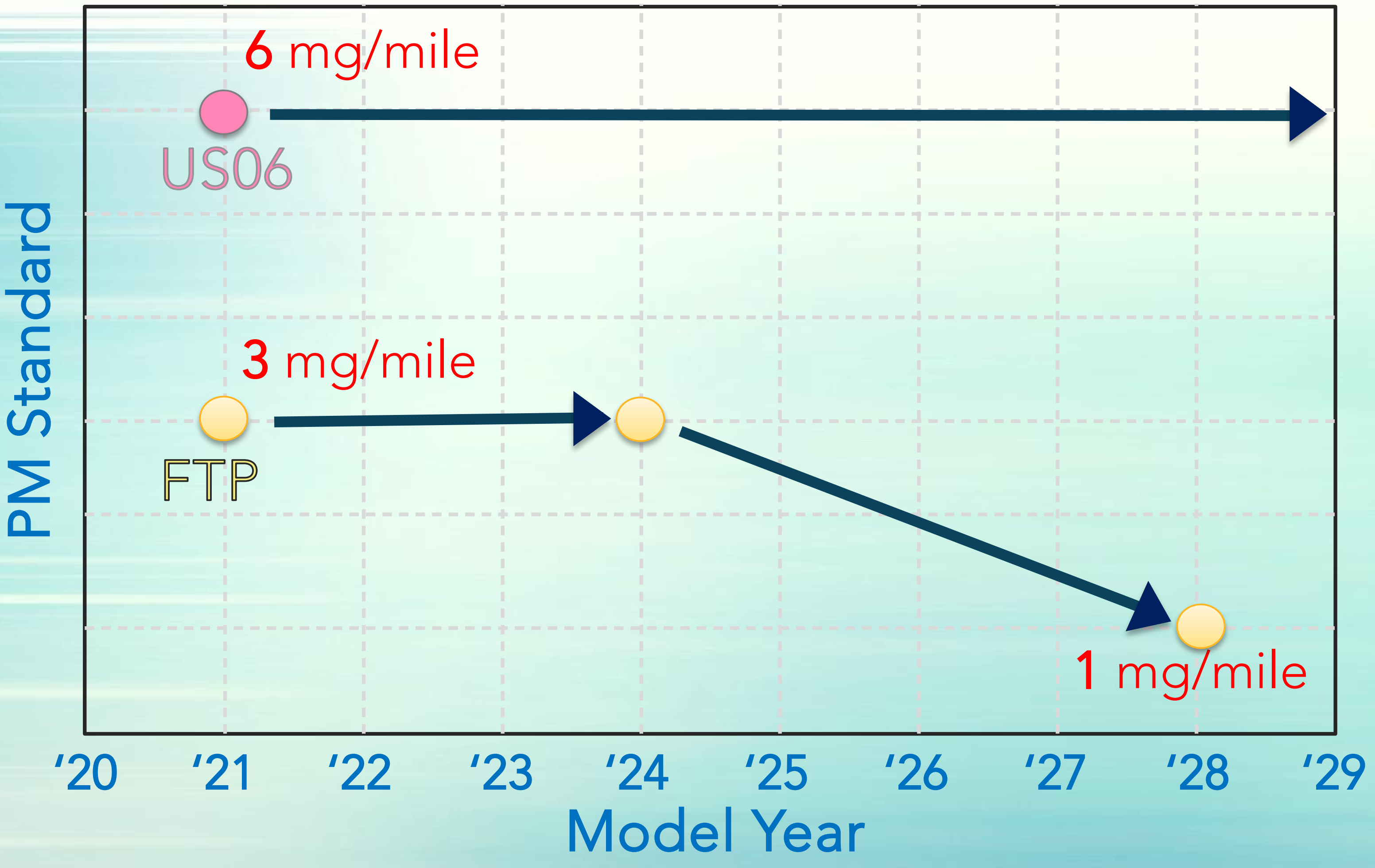
Ongoing Work to Better Ensure Equivalency

- **ACC II Target**: Better ensure equivalent in-use emission control between chassis and engine certification testing
- Ongoing work:
  - Chassis dyno + On-road PEMS testing of medium-duty vehicles
- Exploring effects of higher loads and towing on emissions
- Evaluating 'HD-like' in-use standards for this category
  - E.g., 3 bin moving average window using PEMS

Item #5: Current PM Emission Standards



For more robust emission control, PM emissions are regulated on two test cycles:

FTP and US06

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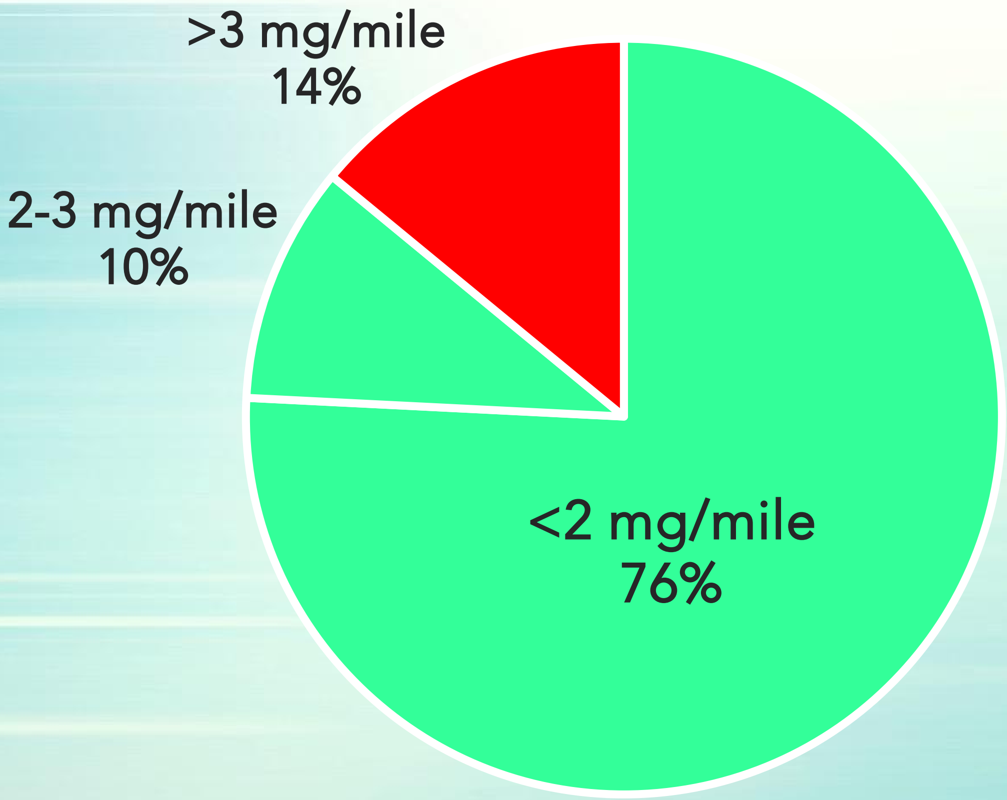
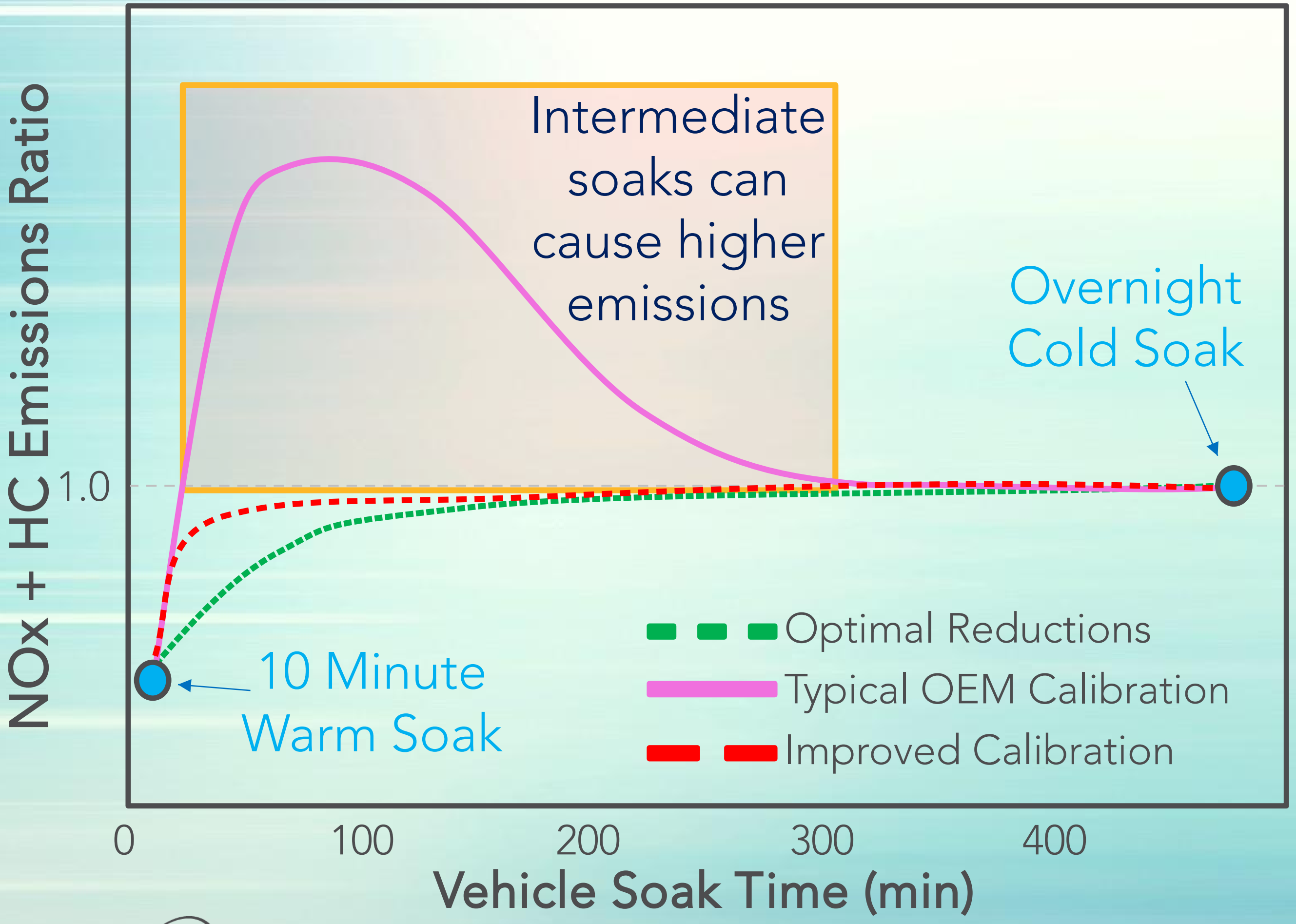
Ensure Robust PM Emission Control

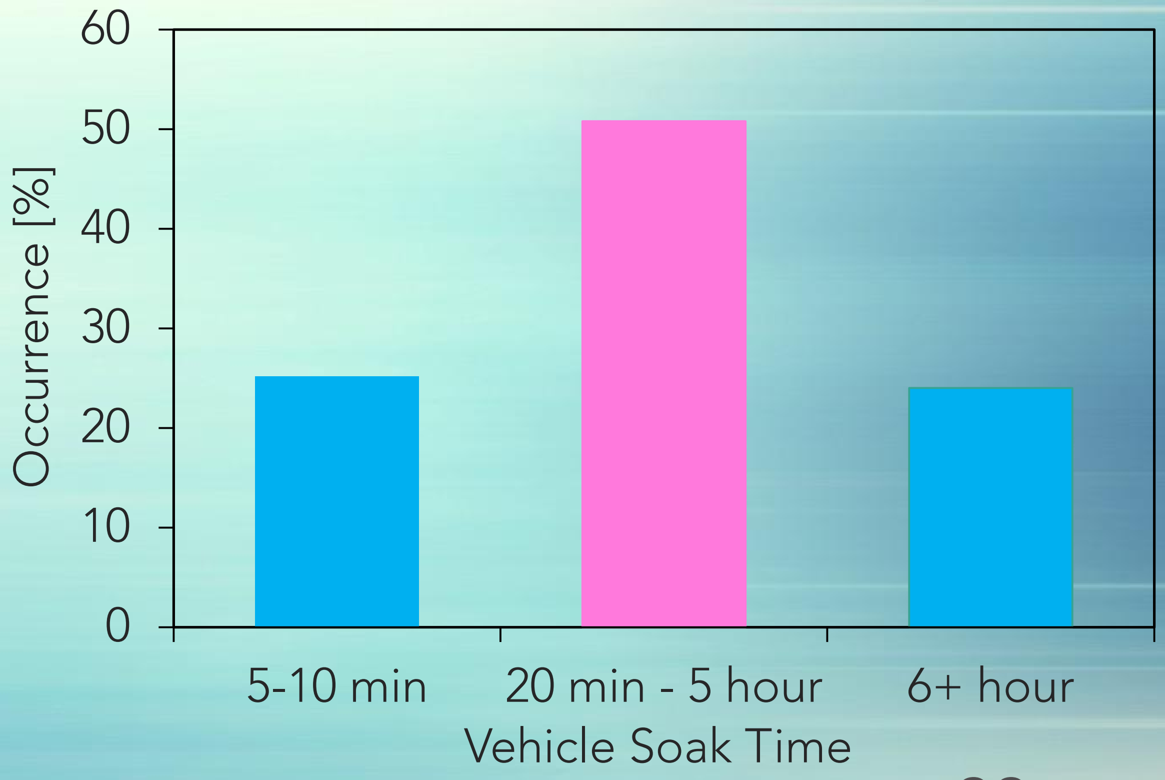


- > 80% of vehicles tested were below 3 mg/mile on US06
- Certification data reported 86% of test groups had US06 PM below 3 mg/mile
- **ACC II Proposal: Recognizing higher variability, phase-in more stringent US06 PM standard to ensure all vehicles can meet ~3 mg/mile standard**

Item #7: Clean Up the High Emissions from Cold Starts That Follow Intermediate Soaks



More than **40%** of real-world vehicle starts follow intermediate soaks of 20 minutes to 5 hours



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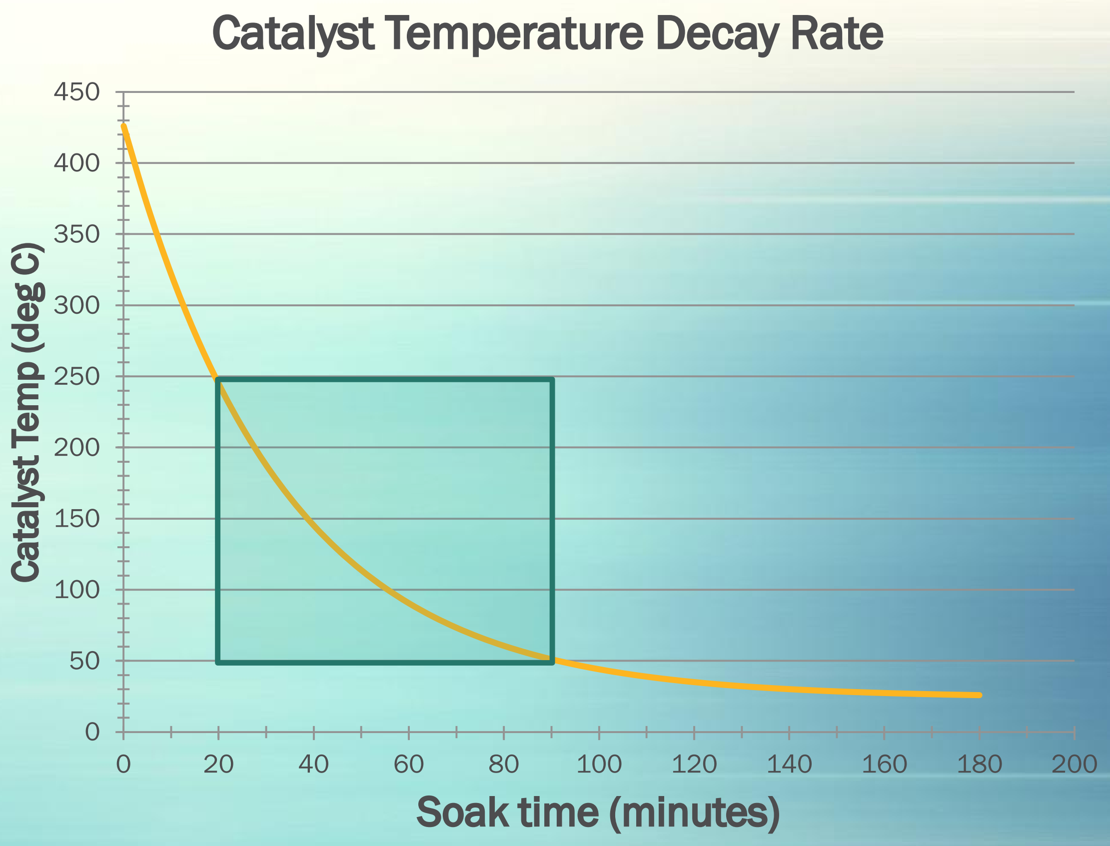
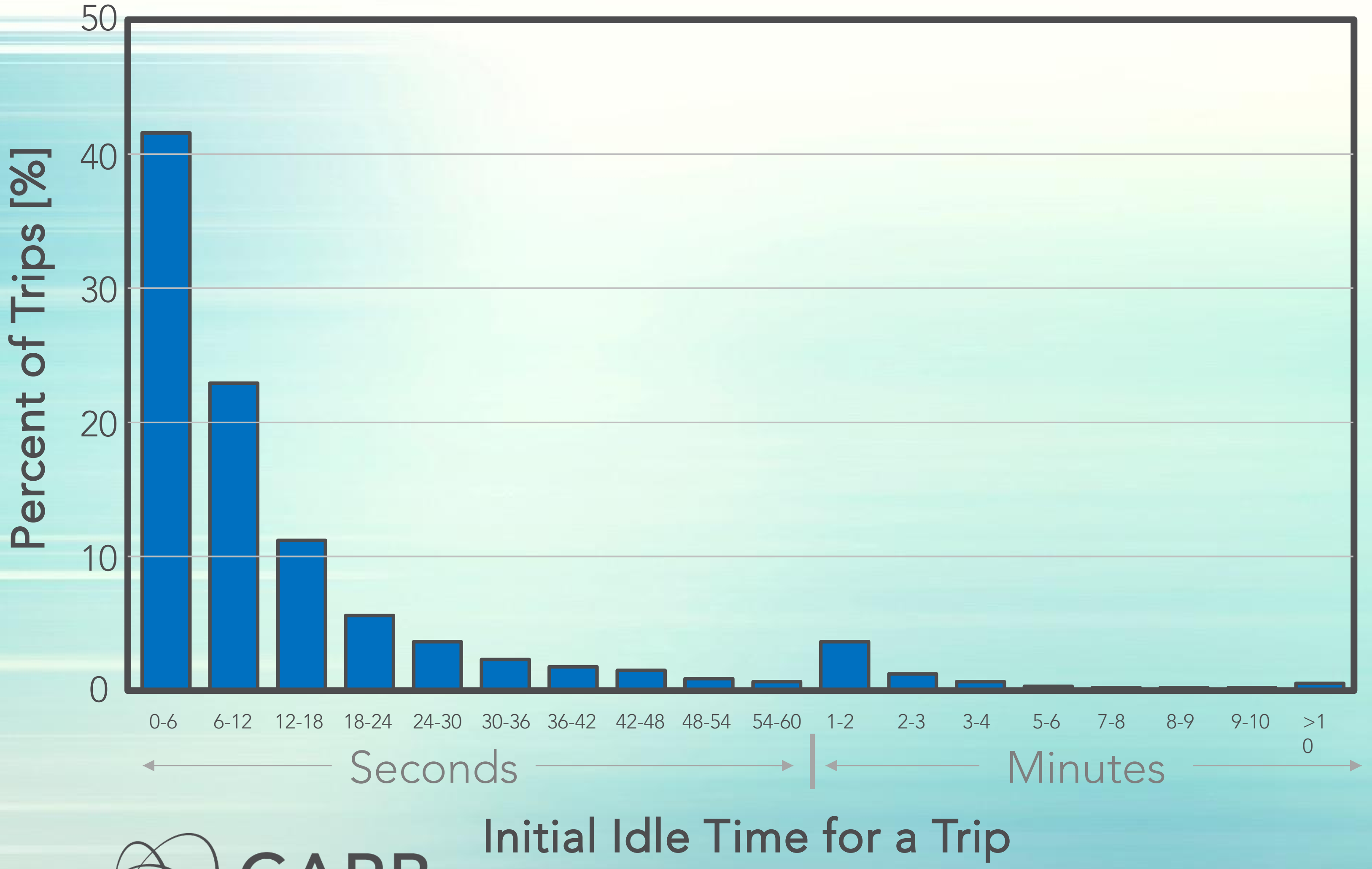
Regulatory Concepts Being Evaluated

- Modify official FTP test procedure to account for intermediate soaks
  - Require emissions to be below standards following any cold soak between 10 min. and 36 hours
- Considering additional requirements for shorter intermediate soaks
  - Catalyst (and engine) temperatures above ambient should allow quicker light-off
  - Targeting same rate of catalyst heating used on overnight soak



Item #8 Better Control of Engine Start Emissions: Initial Idle Real-World Data



Real-World vs. Lab Test

- FTP cycle has a 20 second initial idle to warm-up catalyst
- In-use data indicates median value for initial idle is ~7 seconds
- Due to shorter idle, real-world emissions may exceed FTP levels

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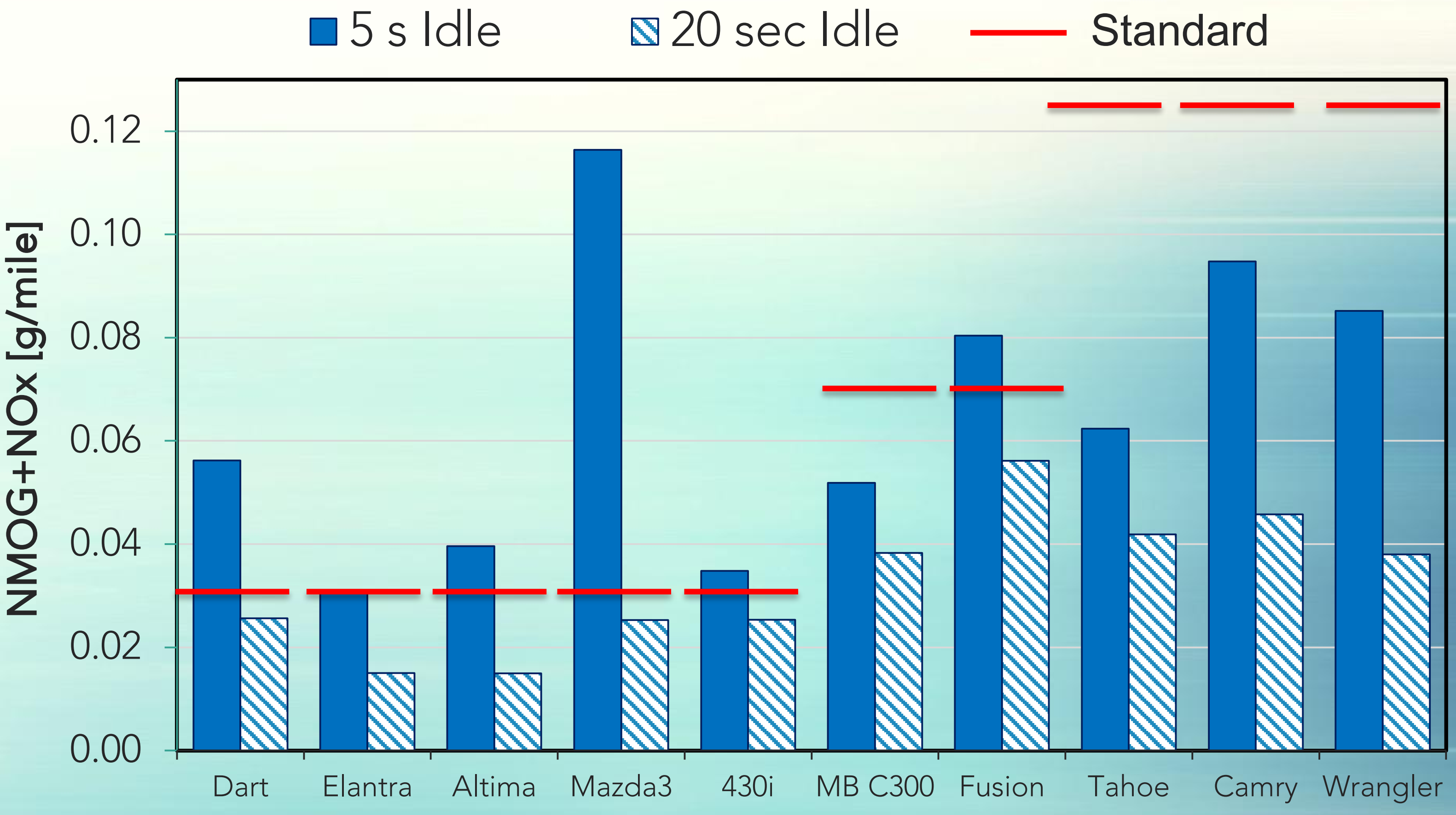
Better Control of Engine Start Emissions: Initial Idle Testing

Test Results

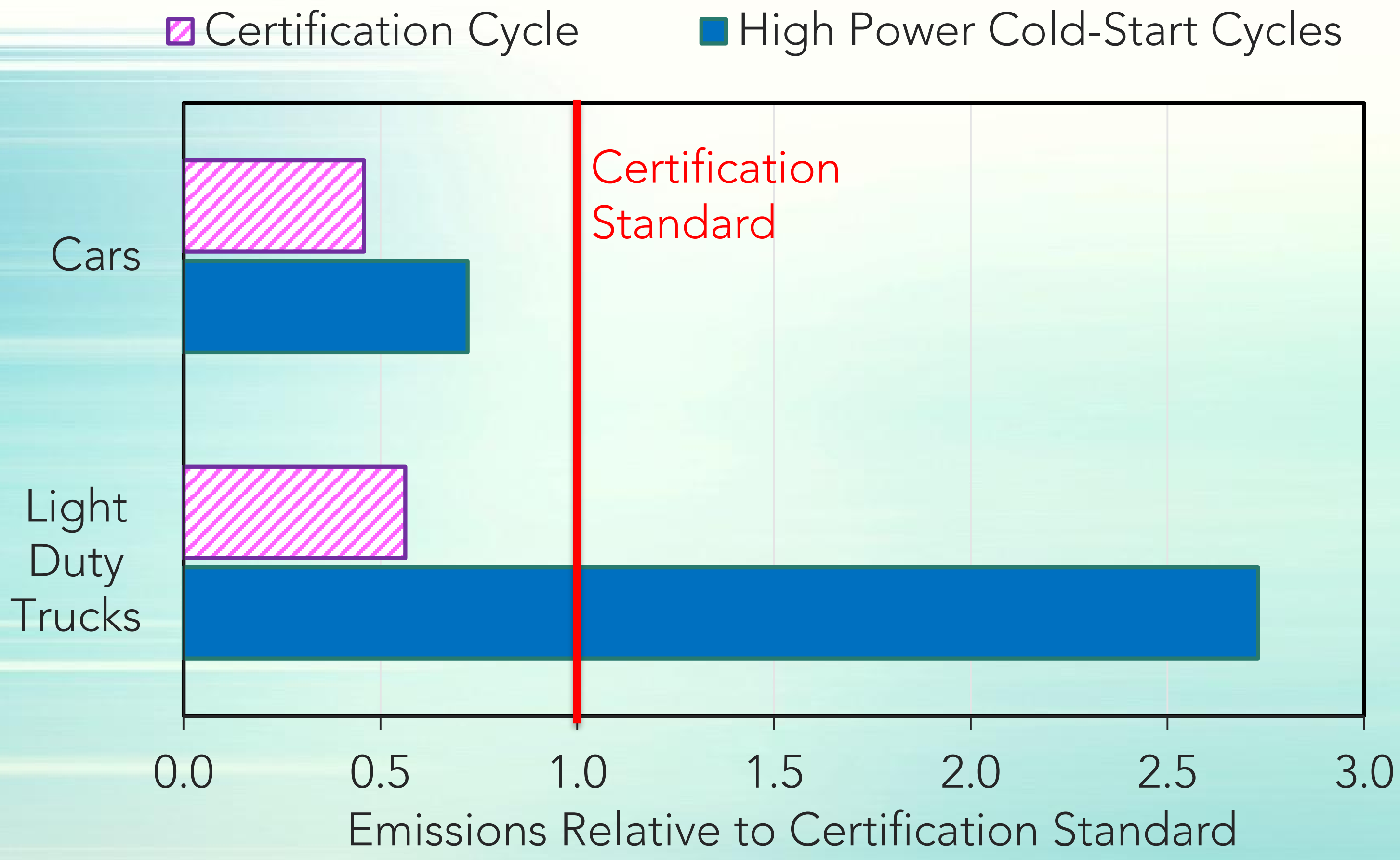
- Emissions with a 5 sec initial idle were double, on average, of the emissions observed with a standard 20 second initial idle
- With 20 sec idle, focus is clearly on warming up catalyst while engine out emissions are low
- With 5 sec idle, focus would need to be minimizing engine out emissions, while drive off is heating up catalyst



Consider Regulatory Proposal with Additional Testing for Shorter Initial Idles

- Establish unique emission limit for 5 sec idle FTP
  - Could link to current certification standard (e.g., limit is 1.x standard FTP)
  - Could be weighted 3-bag or single cold start bag
  - Need to ensure continuity between the two points
    - Require compliance for any initial idle from 5-20 secs?
- Require continuation of catalyst warm-up strategy during drive off
  - Data supports initial drive off is not aggressive so peak torque not necessary
  - But extra heat to catalyst could be minimal incremental benefit

Item #9 Unique Challenges for PHEV Starts



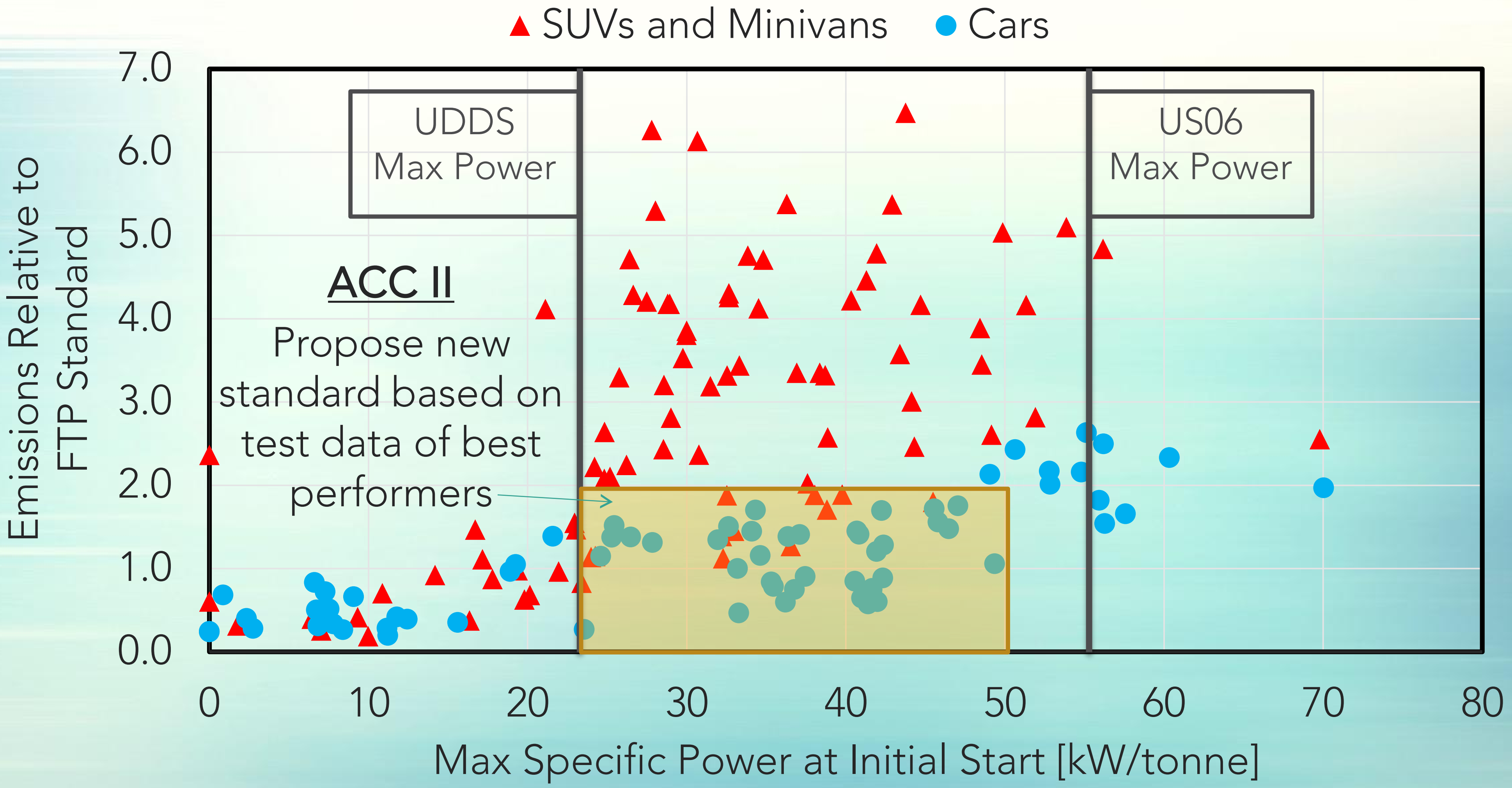
Car PHEVs

- High power cold start emissions are similar to certification value

Truck/SUV/Minivan PHEVs

- High power cold start emissions are significantly higher than certification standard

Controlling PHEV Starts Emissions



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ZEV-related Proposals

Building ZEV Assurance

What actions can we take to support success for wide-scale adoption?

- Consumers still hesitate to purchase ZEVs

Need to think more broadly and imagine a world where 50% of on-road fleet is a ZEV

- How long are these vehicles expected to be on the road?
- How and where would those vehicles be repaired? Under warranty? Out of warranty?
- What does the used vehicle market look like?

Staff Proposal: ZEV Assurance Measures

1. Standardized DC Fast Charge Inlet
2. Require vehicle and battery data standardization
3. Require consumer facing battery state of health (SOH) indicator
4. Add ZEVs into existing service info requirements

(to be discussed at future workshop)

5. *Add a useful life requirement*
6. *Add minimum warranty requirements*

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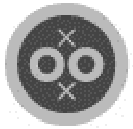
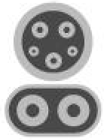
Fast Charge Inlet Standardization

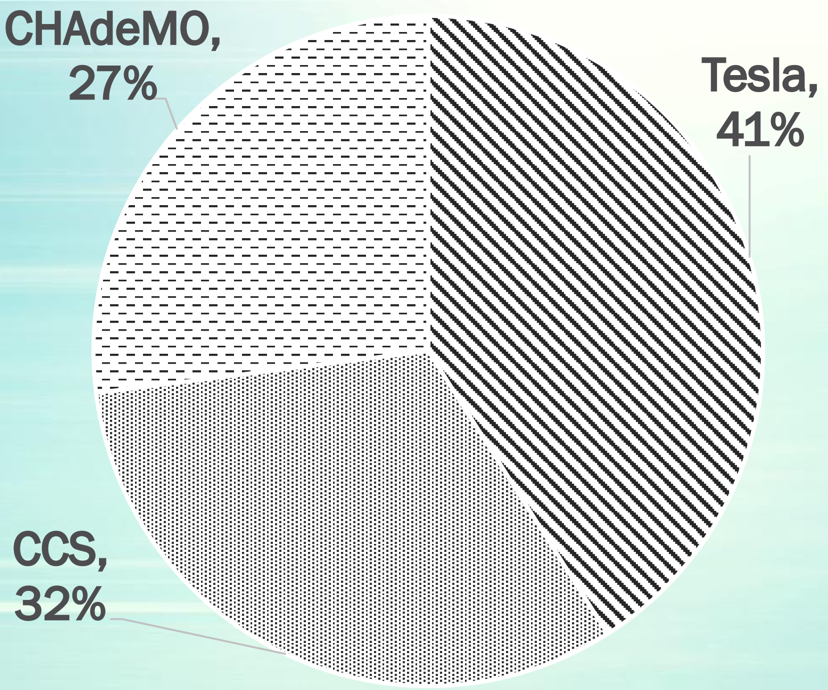
What problem are we solving?

- Current BEVs have one of three different fast charge ports
  - SAE Combo (CCS 1)
  - CHAdeMO
  - Tesla
- Causes uncertainty in:
  - consumers knowing where they can charge
  - infrastructure planning, adding unnecessary cost for EVSE suppliers

Connector	**CHAdeMO** 	**CCS1** 	**Tesla** 
Market Power	150kW	150 – 350kW	120 - 250kW
Comm. Protocol	CAN	PLC	CAN
Year	2009	2014	2012

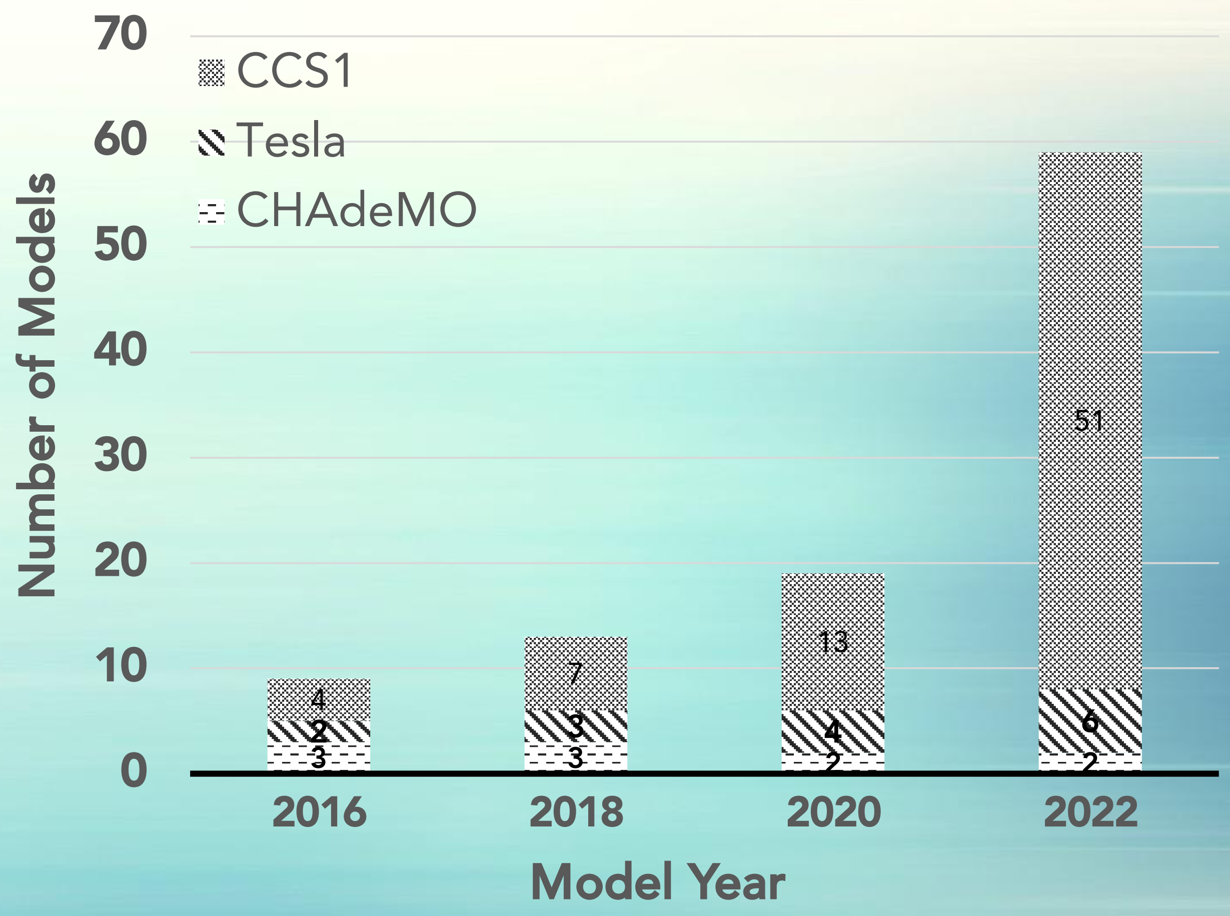
Fast Charging Landscape

DC Connector Market Share (California)[1]



[1]August 2020 AFDC Database for California

BEV Models by Fast Charging Inlet Standard (current and expected)



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Staff Proposal: Standardize on-vehicle DCFC Inlet

- Following market trends, staff proposes all 2026 and subsequent model year vehicles that are fast charge capable use SAE Combined Charging System (CCS) 1 standard
- Like the Level 2 charge connector standard we previously adopted (CCR 1962.3), OEMs may comply with requirement by providing an adapter

Unlocking and Standardizing Data

Access and standardization of vehicle data is crucial for many parties

- Current drivers: understanding warranty coverage or need for repair
- Prospective drivers: used car valuation for seller/purchaser
- Repair technicians: assessment of need for repair/rebuild
- Battery refurbishment or reuse industry: Assessment of remaining battery pack value for use in a second life application (e.g., grid storage)
- CARB: understanding compliance to applicable requirements (e.g., full useful life, warranty)

Staff Proposal: Battery State of Health

- Standardize what battery state of health represents:
  1. Usable battery capacity, as determined by SAE J1634 dyno testing, and within a defined accuracy and minimum update frequency
  2. Normalized (e.g., 0-100%) so understandable and relative to what it could do when new
- Require that it can be accessed by a consumer without the use of a tool

Staff Proposal: Data Standardization

- Staff proposes to require standardized data to address following purposes:
  1. SOH Metric
  2. Grid Energy Use
  3. Dynamometer Testing
  4. Battery Repairs
  5. Activity/Inventory
- Require vehicle to have standardized data connector and use standardized communication protocols (e.g., like conventional cars)

*See Appendix Slides for proposed data parameters

Staff Proposal: Adding Service Info Requirements for ZEVs

- Mimic what is done for conventional cars for service and repair information (CCR 1969)
- OEMs would be required to make ‘powertrain’ service and repair information available to independent technicians
  - Powertrain includes all components and systems related to refueling and propulsion (including regenerative braking)
- Also includes standardized reprogramming and licensing with aftermarket diagnostic tool providers

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Update on BEV Costs

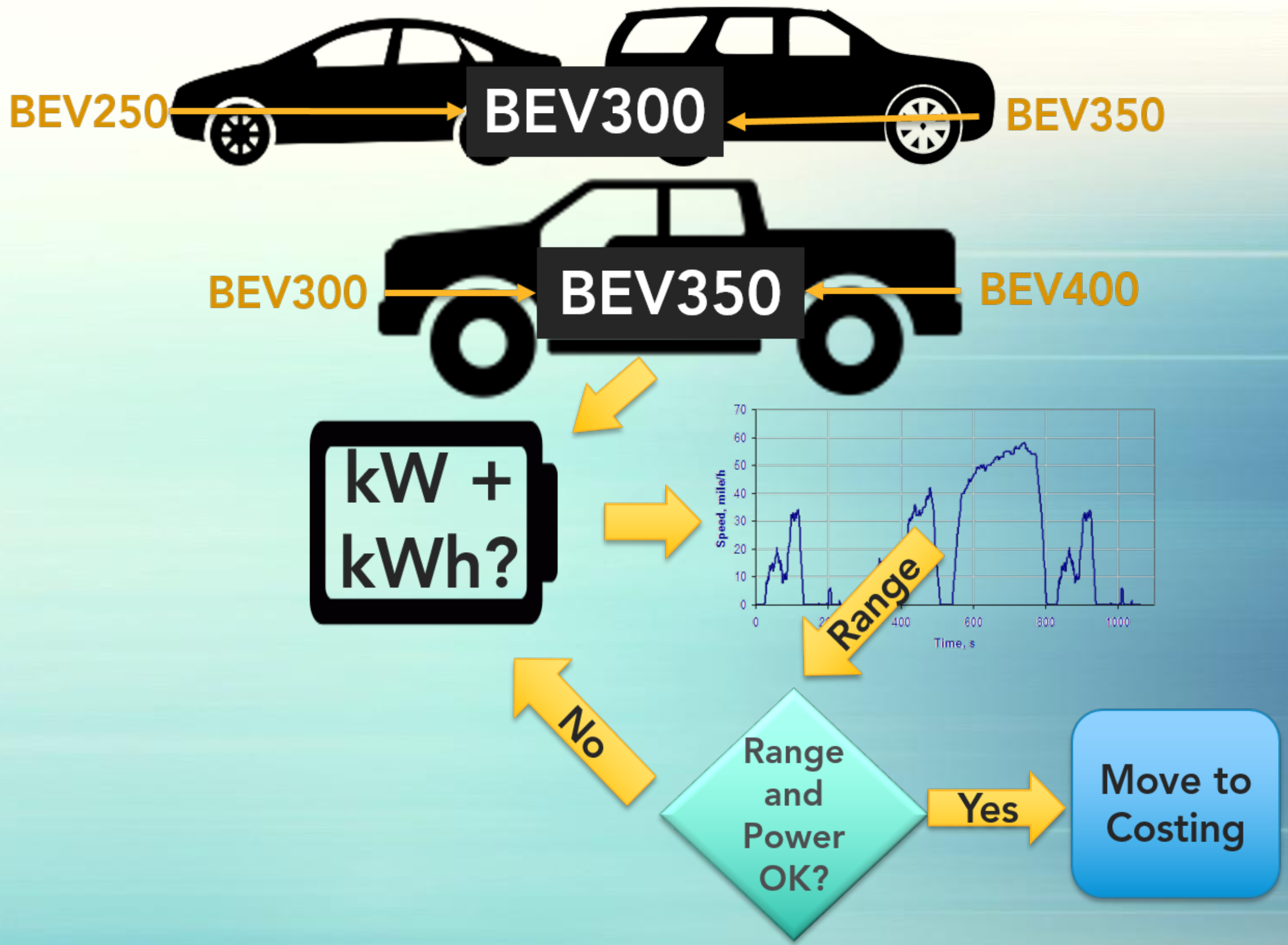
How Have BEV Costs Been Estimated Previously?

1. Define BEV performance specifications – range, vehicle mass, battery size, power, efficiency
2. Define costs for BEV specific components – battery, electric motor and gearbox, etc…

TAR 2025MY BEV200 Vehicle Type	Incremental Vehicle Costs (2013 $)
Subcompact	$ 12,001
MdC / SmMPV	$ 13,422
Large Car	$ 16,746

BEV Powertrain Modeling

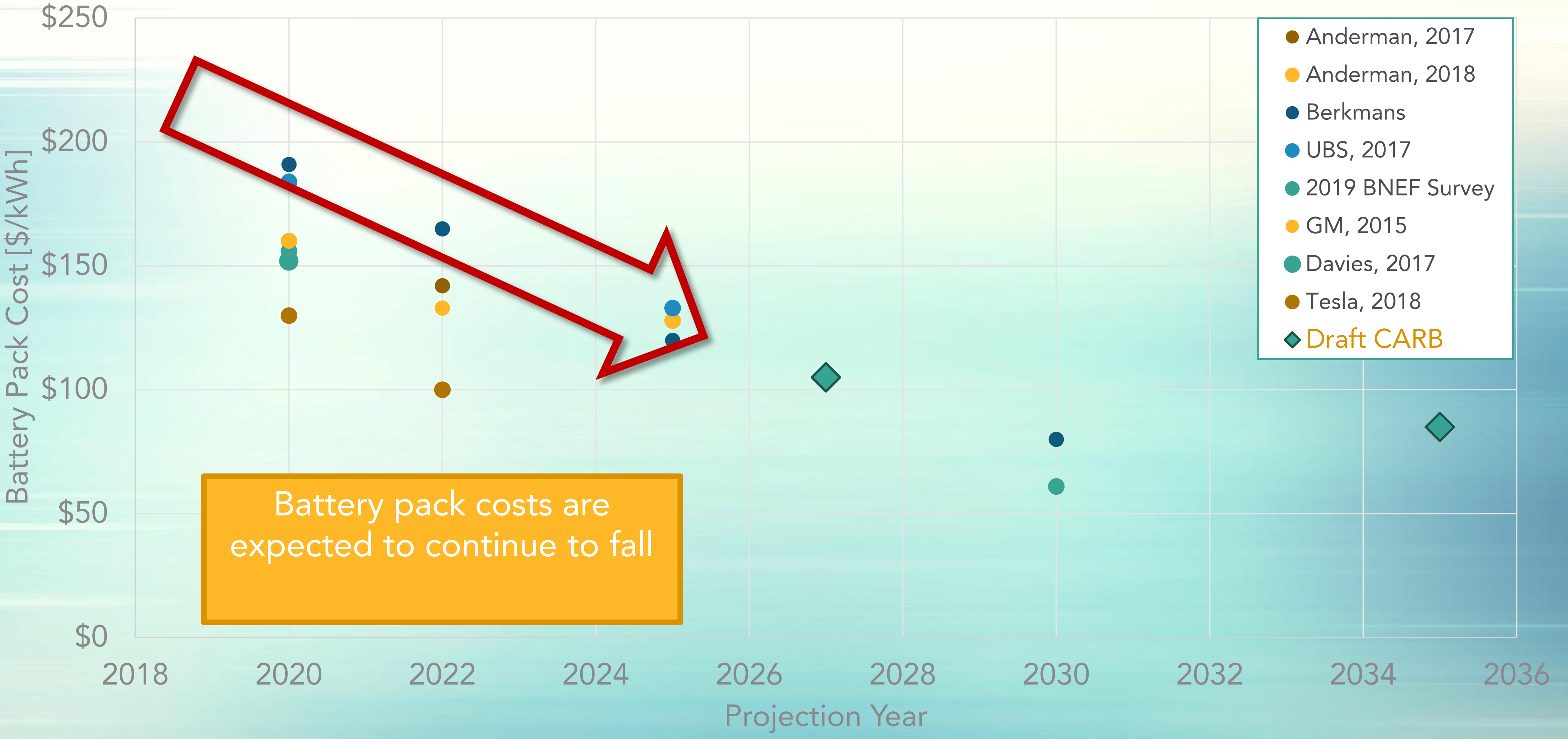
1. Decide on range and power requirements
2. Size battery pack capacity and electric motors across vehicle sizes
    a. Estimate vehicle road load
    b. Initial sizing
    c. Verify desired performance/range
    d. Iterate/resize as needed



Developing Battery Costs

- Work to date relying on multiple tools, reports, and projections including:
  - Argonne National Laboratory Battery Pack and Costing model (BatPaC)
  - U.S. DOE Targets and Projections
  - Total Battery Consulting, BNEF, UBS, and others
- General methodology has been:
  - Use BatPaC to generate initial starting point for now/near future
  - Account for additional learning/technology advancements projected for rulemaking timeframe
    - Battery chemistry
    - Design improvements
    - Manufacturing improvements

Battery Cost Projections



Non-Battery Component Cost Projections

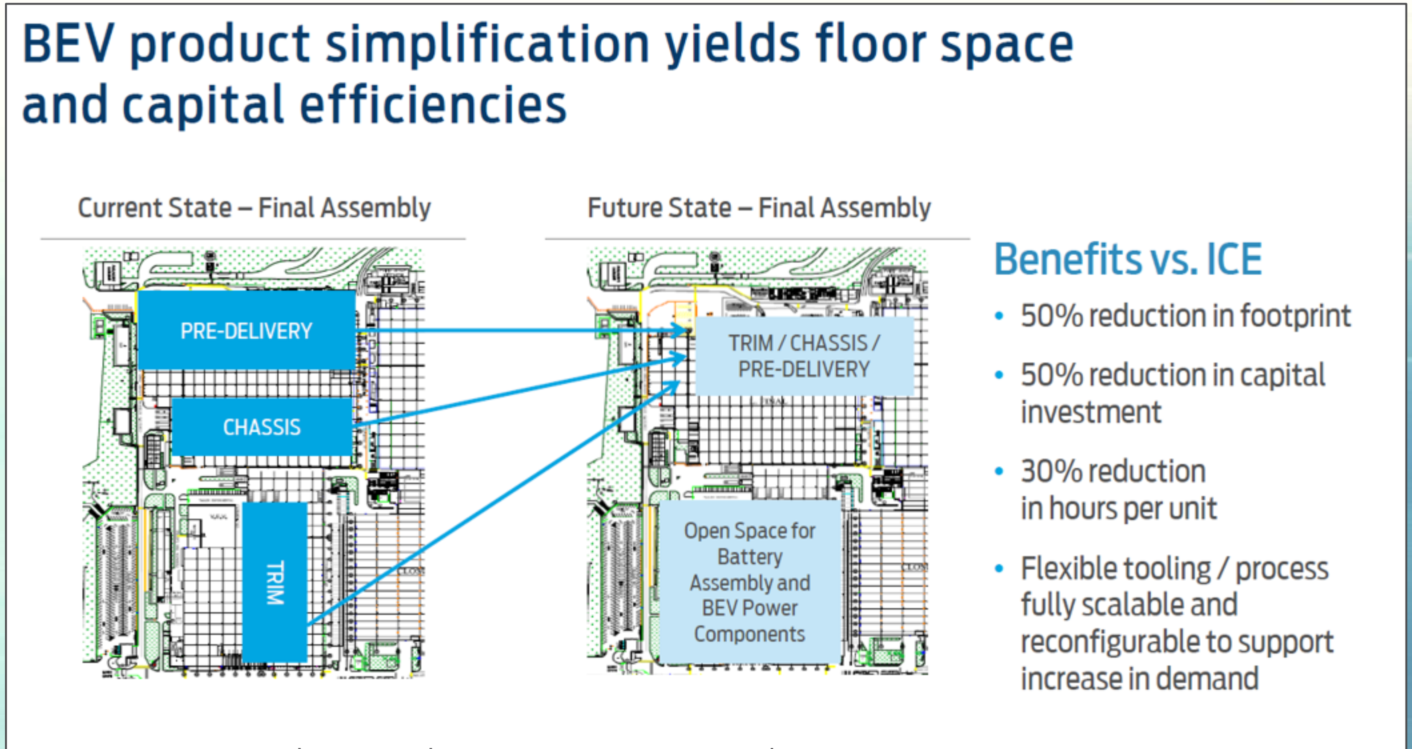
- Method:
  - Near term costs estimated from numerous teardowns and vehicle comparison reports
  - Additional 1.5% per year cost reduction projected for future years
- Example Cost:
  - BEV300 Passenger Car non-battery component costs start at ~$4,100 in 2027 and fall $500 from learning to ~$3,600 in 2035

Non-Battery Components:

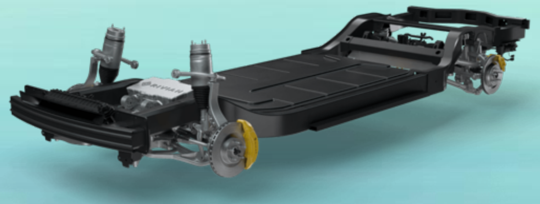
- Motor and gearbox
- Inverter
- DC-DC converter
- HV cabling
- HV control unit
- On-board charger
- Convenience cord

Ongoing Work

- Past modeling has not included any improvement in component efficiency over time
- Other areas of investigation
  - Manufacturing efficiency/cost differences
  - Capturing current/future criteria pollutant emission costs (e.g., design, calibration, hardware, compliance)
  - Capturing differences from BEV specific platform (e.g., design, calibration, assembly)



CEO Strategic Update, Ford Motor Company, October 3, 2017



Other Opportunities for Comments

- Written comments may be submitted through October 16, 2020 to: cleancars@arb.ca.gov
- Subscribe to the Clean Cars email list for updates on future workshops on:
  - Plug-in hybrid and fuel cell technology cost assessment
  - GHG fleet average stringency
  - ZEV credit requirements
  - And more…

Appendix Slides

Proposed Data Parameters

SOH Metric	Grid Energy Use	Vehicle Dyno testing	Data for Battery Repair/Rebuilders	Activity/Inventory
SOH	Total Grid Energy (DC) into battery[1,2]	Vehicle speed[1]	Total current throughput (amp-hr)[2]	odometer[1]
distance since last SOH update	Total Grid Energy (AC) into car°	Accelerator pedal position[1]	Individual cell active voltage°	Distance since code clear[1]
	Total Grid Energy Used during Cd[1,2]	SOC[1]	Individual module active voltage	ignition cycles since code clear[1]
	Total distance travelled in Cd[1,2]	Battery voltage[1]	Individual cell most recent OCV°	Ignition cycles[1,2]
	Total Propulsion System Active (PSA) time[1,2]	Battery current (cumul. current for last 1 sec)	individual module most recent OCV	Positive Kinetic Energy (PKE)[1,2]
	Total energy into battery from regen braking[2]	Power consumption (cumul. power for last 1 sec)	Individual cell most recent calculated resistance	Total PSA time at idle[1,2]
		AC inlet current (cumul current for last 1 sec)°	BMS detected faults	Total PSA time at city speeds[1,2]
		AC inlet voltage°	Battery temp sensors?	

° if equipped

1 Parameters that are already standardized in SAE J1979 and may be appropriate fits (typically Mode $09, InfoTypes $16-$1C and Mode $01)

2 Parameters that might need 'recent' and 'lifetime' values like already done for much of Mode $09 InfoTypes $16-$1C