EMFAC202Y:
An Update to California On-road Mobile Source Emissions Inventory
Mobile Source Analysis Branch
Air Quality Planning and Science Division

October 12, 2022

Workshop Instructions

- Telephone Call-In: 888-363-4734
- Access Code: 350021
- Workshop is being recorded
- Slides and recording will also be posted:
  https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-meetings-workshops

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Workshop Questions

- Breaks for questions in the middle and end of AM and PM sessions
- Please raise your hand if you would like to ask a question
  - Include slide numbers
  - In Zoom: Use "Raise Hand" feature
  - On phone:
    - #2 to "Raise Hand"
    - *6 to Unmute/Mute
- Additional questions may be submitted after the workshop to: emfac@arb.ca.gov

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Agenda for Today's Workshop

AM Session

- Executive Summary
- Regulations
- Fleet Characterization
- Vehicle Activity Profiles
- Transportation Network Company (TNC) Category

PM Session

- Updates to light-duty emission rates
- Updates to heavy-duty emission rates
- Energy Consumption
- Closing Remarks

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Agenda for AM Session

- **Executive Summary**
  - **Background**
  - User Survey Results
  - Major Updates to EMFAC202Y
- Regulations
  - Light-Duty
    - Advanced Clean Cars II
    - On-Road Motorcycle
  - Heavy-Duty
    - Heavy Duty Inspection and Maintenance
    - Advanced Clean Fleets
    - Federal Heavy-Duty Engine & Vehicle Standards
- Question & Answer

- Fleet Characterization
  - Light-Duty (Population and New Sales)
  - Heavy-Duty (Non-Gas Fueled)
    - Automated License Plate Reader (ALPR)
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  - Light-Duty Activity and Forecasting
  - Heavy-Duty Activity and Forecasting
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Background of EMFAC

EMFAC

Scoping plan

State Implementation Plan

Transportation Conformity

Regulatory Development

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Background of EMFAC (cont.)

- U.S. Environmental Protection Agency (EPA) approves <u>California specific</u> vehicle emission inventory model
  - Updated with most recent statewide population, activity and emission data
  - Reflects the latest California regulations
- More than three decades of data collection and methodology refinement
- Incorporates extensive laboratory and on-road emissions testing, activity, and emerging "big" data sources
- CARB staff collaborates with other state agencies, Air Districts, Metropolitan Planning Organizations (MPOs), community members, and researchers

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Recent EMFAC Updates

> - Single Package
> - Reflects key regulations, e.g., Advanced Clean Cars

> - New web-based interface
> - Reflects key regulations, e.g., Advanced Clean Trucks
> - **Pending U.S. EPA approval**

EMFAC2014
Released: 2014

EMFAC2017
Released: 2017

EMFAC2021
Released: 2021

EMFAC202Y
Release:
2024/2025
(*tentative*)

> - An extension of the EMFAC2014 framework
> - Reflects key regulations, e.g., Phase 2 GHG standards

> - Latest fleet technologies
> - High-resolution activity data
> - Reflecting regulations adopted before 2024

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EMFAC2021 & EMFAC202Y
User Survey Results

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Survey Scope and Summary*

- In Summer 2021, CARB staff collected feedback on EMFAC2021, with intent of incorporating suggestions into EMFAC202Y

- Received responses from both internal and external stakeholders, such as Air Quality Management Districts, MPOs, other state agencies and private companies

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Survey Results: Which EMFAC2021 Features Did Users Like Best?

EMFAC2021 Feature	Average Score*
Reflection of the latest adopted regulations	4.5
Web platform	4.4
Expansion of fuel technologies, e.g., plug in hybrid electric vehicles (PHEVs) and natural gas	4.2
Heavy-duty VMT forecasting using travel demand model	4.2
Expansion of truck vocational categories, e.g., delivery	4.2
Energy consumption from zero emission vehicles	3.9
Light-duty zero emission vehicle forecasting using vehicle choice model	3.7
Evaporative module	3.4
PL mode on EMFAC2021 web platform	3.2
Ammonia emissions	2.7

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* Average of score (1-5; 5 = best) for each feature following the release of EMFAC2021

Survey Results: Suggested EMFAC202Y Features

Suggested Feature for EMFAC202Y	Average Score*	
1. Updates with on-going test data (e.g. PEMS and OBD)	4.5	Covered in today's presentation + other updates
2. Updates to out-of-state fleet characteristics and activity	4.4	
3. Expand fleet and technology types (e.g, transportation network companies)	4.4	
4. Updates in fleet turnover considering more socioeconomic variables	4.3	
5. Updates in energy consumption by vehicle category (e.g., drayage)	4.1	
6. Higher spatial resolution activity and emissions	3.7	
7. Improve computational efficiency of desktop app	3.7	Potential topics for future workshops
8. Updates to brake and tire wear emission rates	3.6	
9. Improve graphical user interface of web platform	3.2	

* Average of score (1-5; 5 = highest priority) for each feature

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Overview and Summary

CARB Staff's Potential Major Updates to EMFAC202Y

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Update EMFAC202Y Light-Duty (LD) Emission Rates with In-Use Data

New Riverside Lab

Light-Duty Vehicle Surveillance Program *Dynamometer (Dyno) and Portable Emissions Measurement Systems (PEMS)*

#1 from survey

Federal In-Use Verification Program (IUVP)

Motorcycle dyno test data

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Update EMFAC202Y Heavy-Duty (HD) Emission Rates with In-Use Data

New Riverside Lab

Truck & Bus Surveillance
(Class 7 – 8 trucks)
Dynamometer and PEMS

#1 from survey

Medium Heavy-Duty Truck
(Class 4 – 6)
Dynamometer and PEMS

Light Heavy-Duty
(Class 2b – 3)
Dynamometer and PEMS

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Population and Fleet Characterization

#2 from survey

#5 from survey

STATE OF CALIFORNIA · DEPARTMENT OF MOTOR VEHICLES
DMV
DRIVING CHANGE...

INTERNATIONAL REGISTRATION PLAN, INC.

New to EMFAC202Y:
Automated license plate reader (ALPR) data

Update fleet characteristics (e.g. model year) of out-of-state trucks operating in California.

New to EMFAC202Y:
Split out heavy-duty battery electric and fuel cell populations in response to zero emission heavy-duty regulations.

Add hydrogen (H2) consumption estimates by fuel cell trucks and buses. Update battery electric energy consumption.

Updated from EMFAC2021: fleet characterization updates using registration databases and other sources

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Fleet Characterization and Activity Profiles

#3 from survey
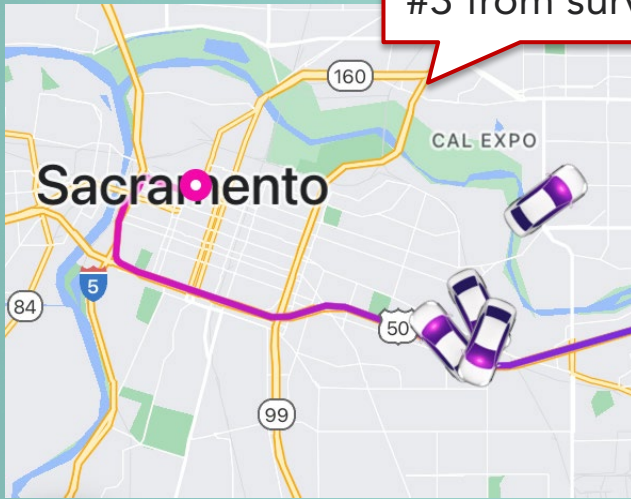
#6 from survey

New to EMFAC202Y: A new category for vehicles that drive for transportation network companies (TNC)

Activity data will be based on CPUC annual reports

New to EMFAC202Y: Develop more granular emissions inventory using high-resolution vehicle activity data

Enhanced information on where heavy-duty trucks operate based on vocation types

New to EMFAC202Y: Update Light-Duty mileage accrual rates using IHS data

Decoded vehicle specifications by VIN including make, model year, model, weight, etc.

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Population and Activity Forecasting

#4 from survey

dun & bradstreet

UC San Diego

CALIFORNIA
AIR RESOURCES BOARD

New to EMFAC202Y: Industrial and financial information about businesses

Connect fleet characteristics to their financial characteristics in order to distinguish disparate fleets and their activities

Update from EMFAC2021: Improve understanding of light-duty sales and retention and VMT forecasting.

Achieved through intramural contracts and in-house efforts.

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Recently-Adopted and Upcoming Light-Duty Regulations

Advanced Clean Cars II (ACC II)
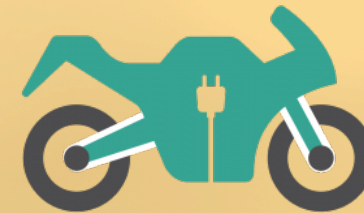
On-Road Motorcycle (ONMC) Regulation

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Recently-Adopted and Upcoming Medium and Heavy-Duty Regulations
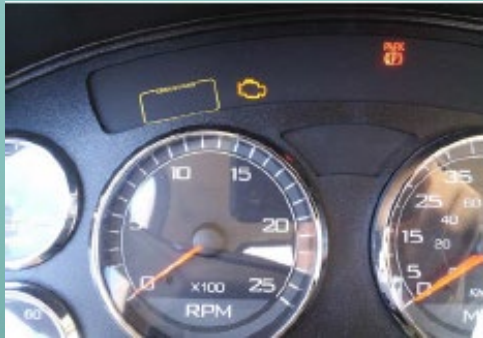
Heavy-Duty Inspection and Maintenance (HD I/M)

Advanced Clean Fleets (ACF)

Heavy-Duty Engine and Vehicle Standards

CARB Staff are Considering Other Survey Recommendations

#7 Improve computational efficiency of desktop app

- Currently exploring ways to reduce model run time for "By Speed" outputs.

#8 Update brake and tire wear emission rates

- Improve understanding of brake and tire wear emissions through in-house and extramural studies. Important factors may include braking materials and technology, tire materials, road conditions, etc.

#9 Improve graphical user interface of web platform

- Recently added multi-region selection, i.e., the ability to query multiple areas at the same time. Exploring others.

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Light-Duty Vehicles
Regulations

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Light-Duty Vehicles Regulations
Advanced Clean Cars II (ACC II)

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ACC II Regulation Requirements

- Established standards for new 2026+ Model Year (MY) California light-duty vehicles:
  - LEV Requirements (exhaust standards)
    - Phase-out ZEVs from <u>NMOG**+NOx</u> fleet average emission standard by MY 2029
    - Eliminate the high-emitting certification bins (set upper limit to 0.070 <u>NMOG+NOx</u> grams per mile) in the light-duty fleet
    - Reduced cold-start emissions from light-duty vehicles
  - ZEV Requirements
    - Annual ZEV percentage requirement: 68% of new vehicle sales by MY2030 and 100% by MY2035
    - Minimum ZEV and Plug-in Hybrid Electric Vehicle (PHEV) technical requirements, durability, battery warranty, and service information
- **Board Approved:** August 25, 2022 (expected effective date no later than January 2023)

* ZEV includes Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV)
** NMOG: Non-methane hydrocarbons and the oxygenated hydrocarbons
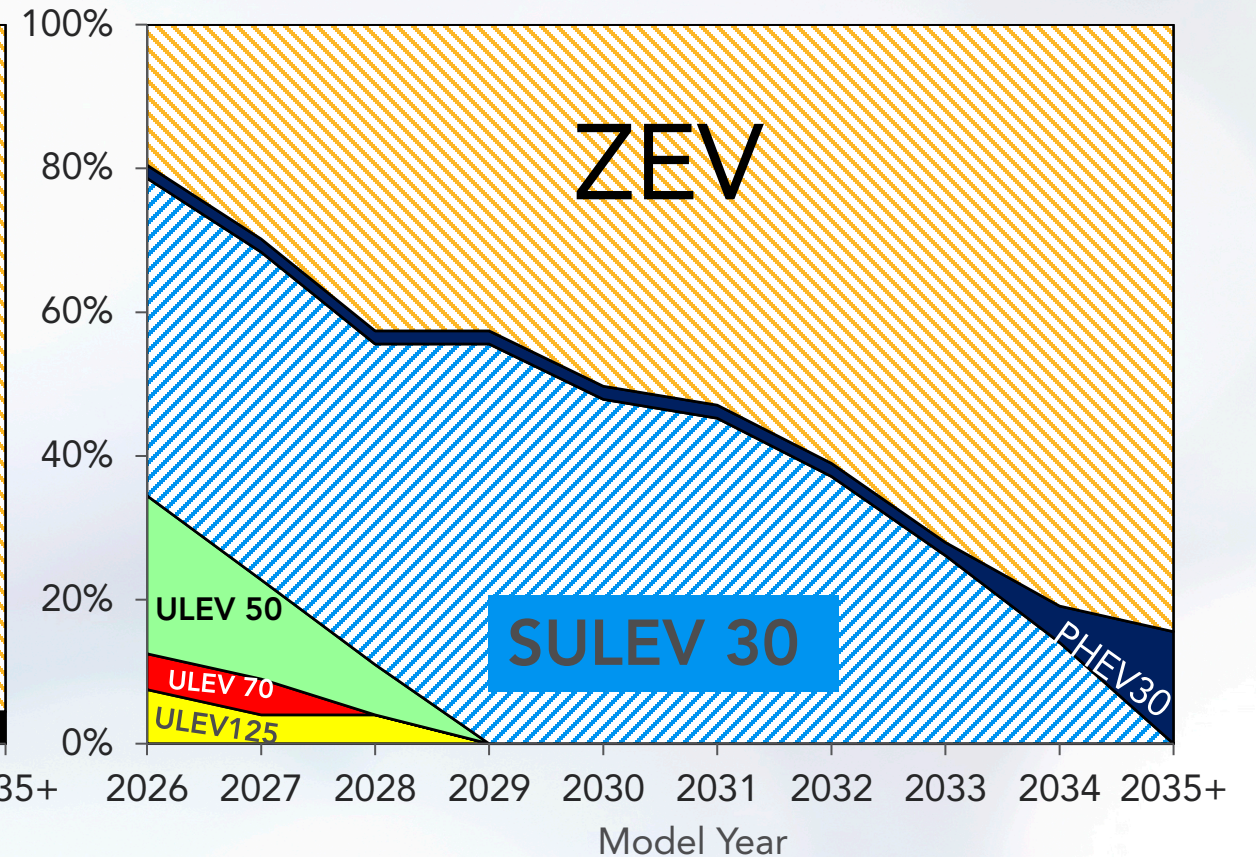
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ACC II ZEV and PHEV Sales Fractions
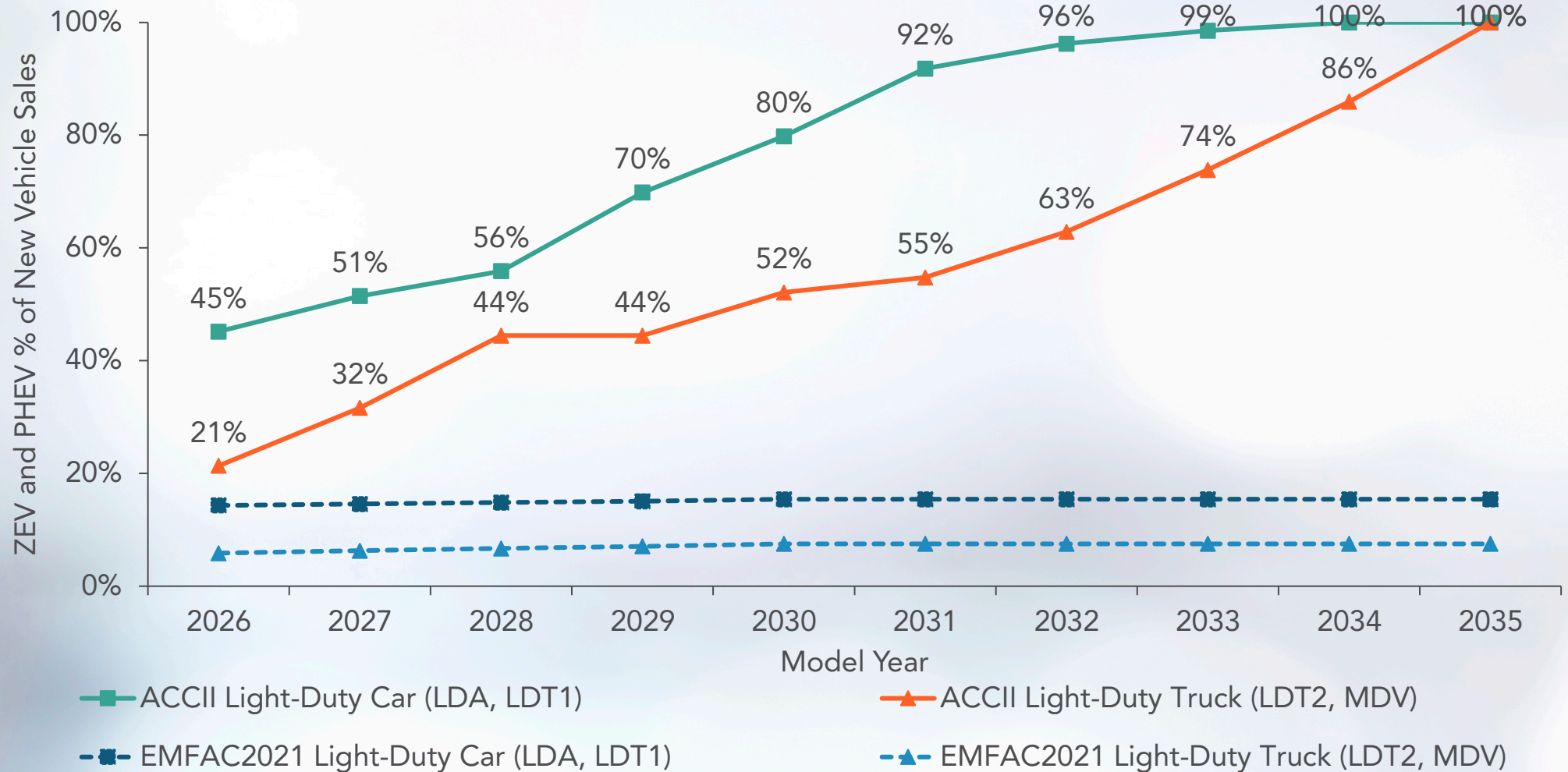
ACC II Light-Duty New Vehicle Sales Mix
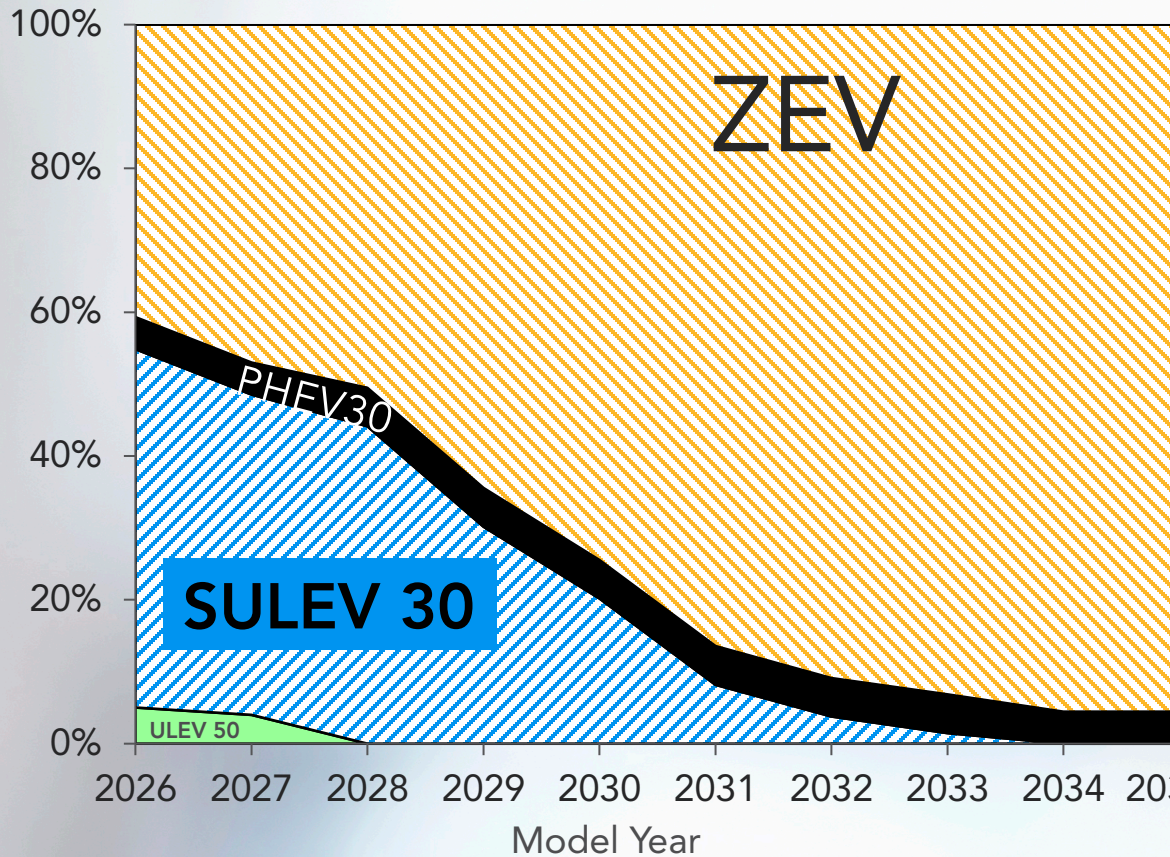
ACC II PHEV Sales Fractions

- EMFAC2021 assumes half blended and half non-blended sales

- A non-blended (or US06 capable) vehicle depletes its battery before turning on engine. Blended (or non-US06 capable) uses the engine to meet higher power demands.

- ACC II requires 100% non-blended PHEV sales by MY2029:

MY	LDA Blended (%)	LDT/MDV Blended (%)
Pre-2026	50	50
2026-2028	10	50
2029+	0	0

US06: An aggressive laboratory-based test cycle with high speed or high acceleration driving behavior

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# ACC II PHEV Fleet Utility Factors*

- Based on the proposed minimum technical range requirements
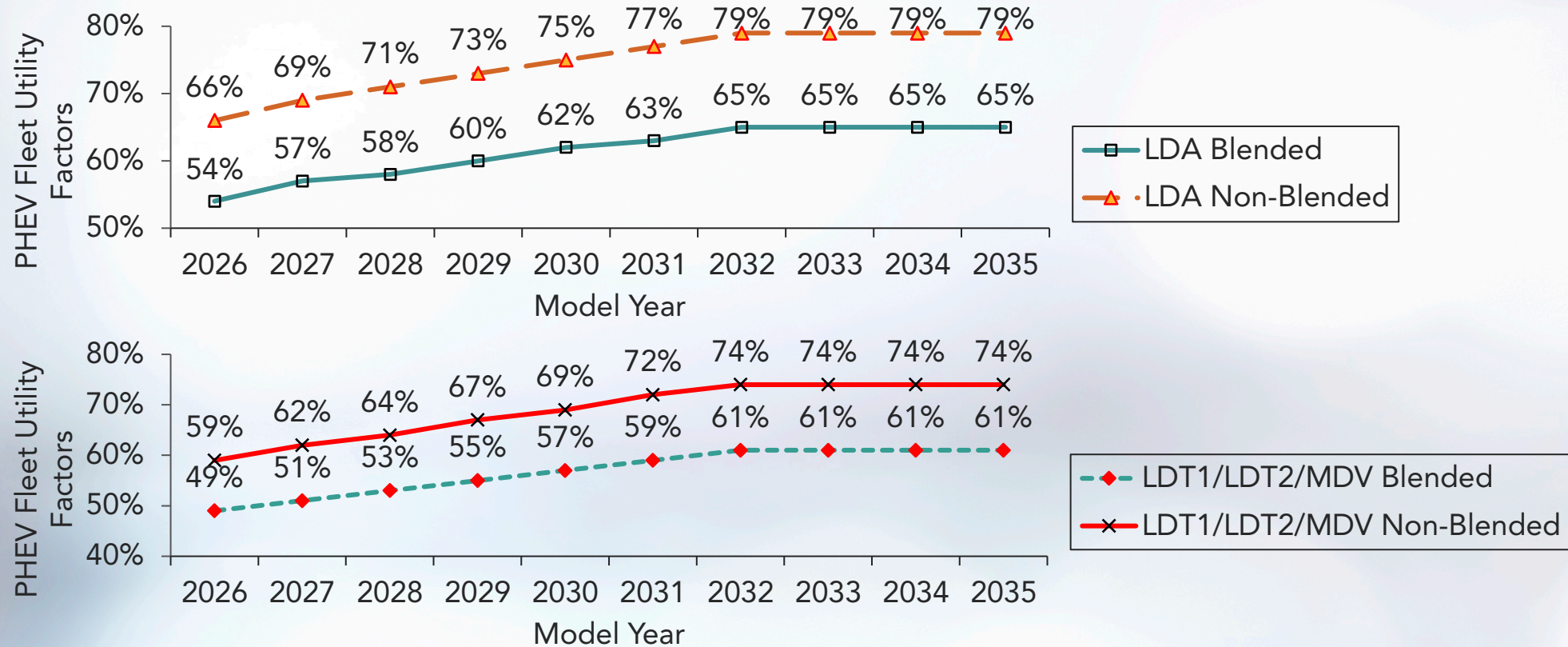
* Fleet Utility Factor: Fraction of fleet-average distance driven on electricity
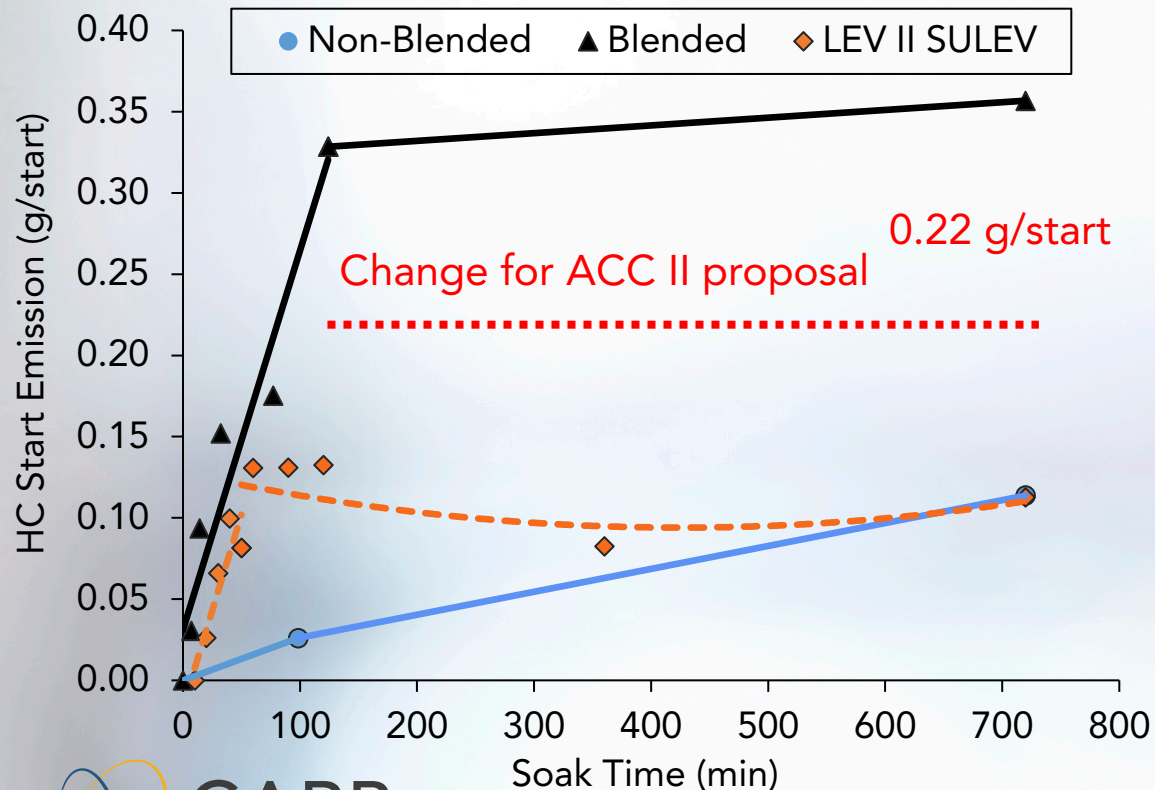
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Changes to HC and NOx Soak Correction Curves for Start Emissions

- Soak time is the duration an engine is at rest prior to being started

- Soak correction factors account for the ratio of cold start emissions as a function of soak time. Soak correction factors of 1 are equivalent to the cold start emissions

- "ACC II baseline" was derived from the EMFAC2021 SULEV30 curve based on in-house testing to account for calibration of vehicles with shorter idle that increased cold-start emissions

- "ACC II proposal" reflects the reduced cold-start emissions based on in-house testing of better performing Original Equipment Manufacturers (OEM) for intermediate soaks and shorter idle
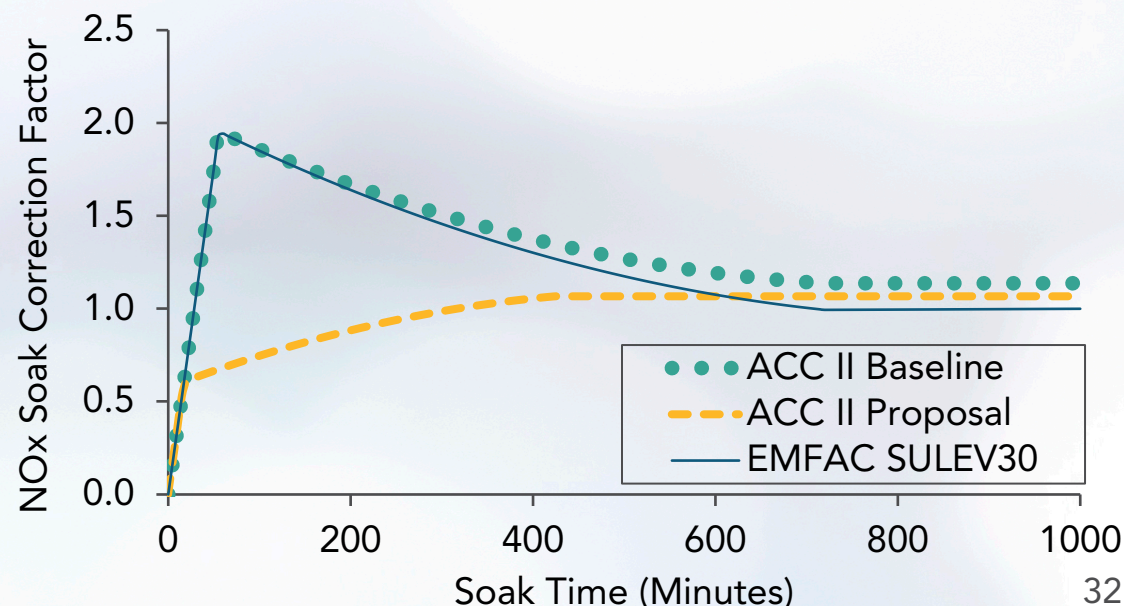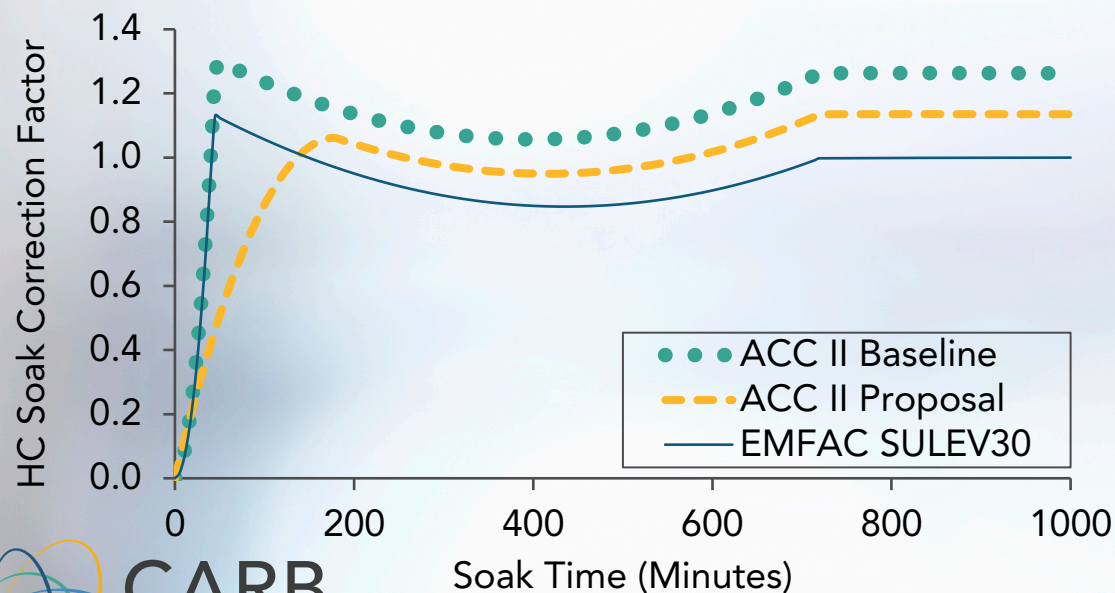
ACC II Standard for PHEV Cold-Start Emissions

- CARB set new standard based on in-house testing of lower-emitting vehicles
- ACC II limited blended PHEV cold-starts to 0.22 g/start for HC and 0.14 g/start for NOx for soak time ≥120 minutes
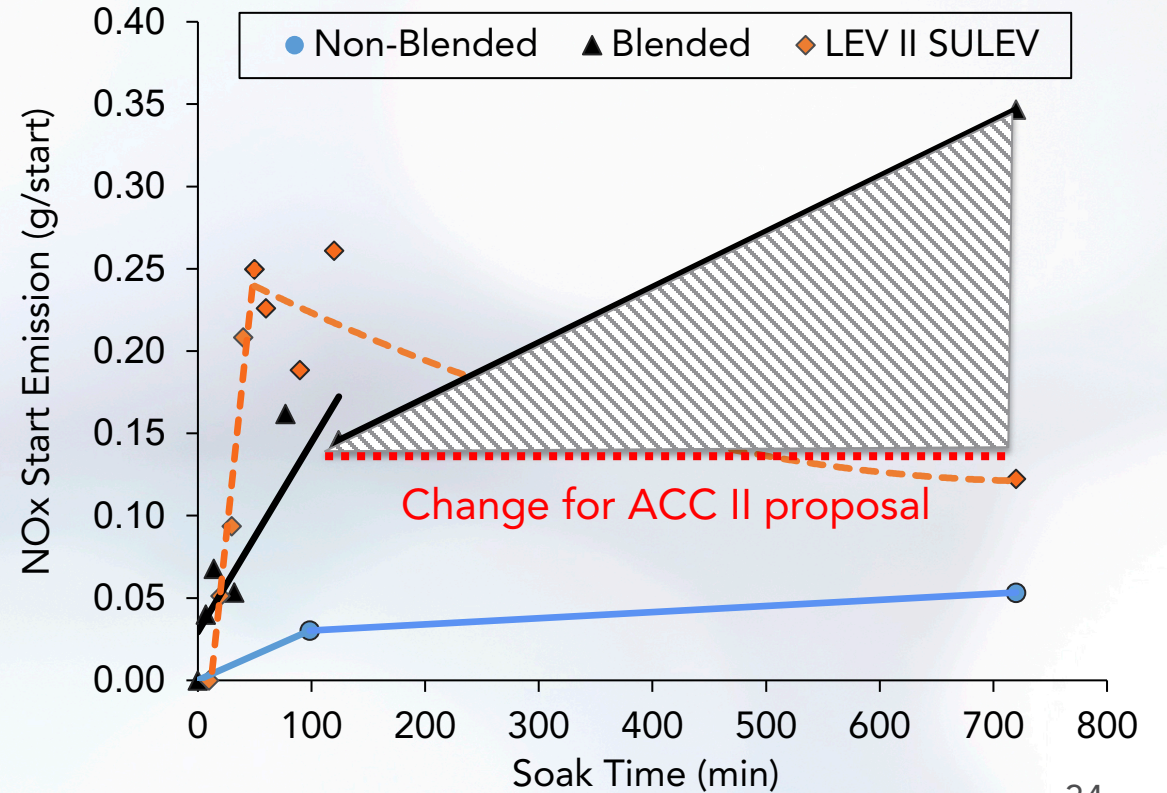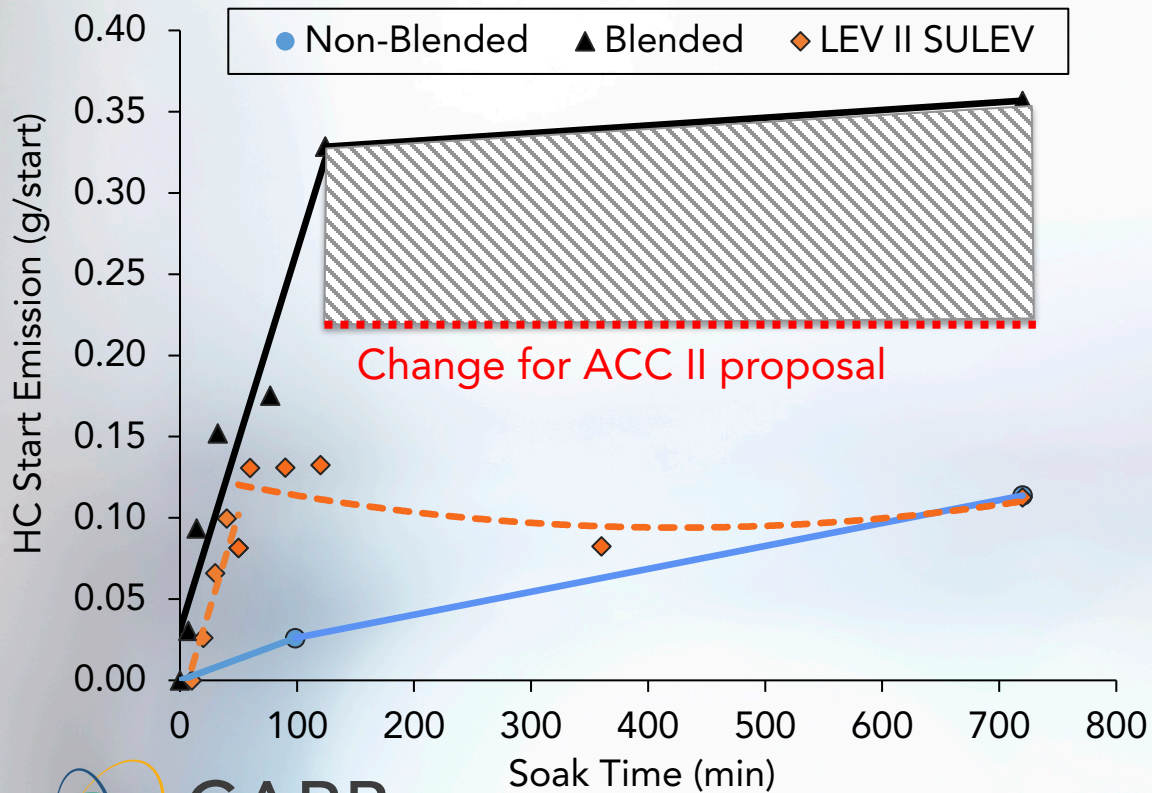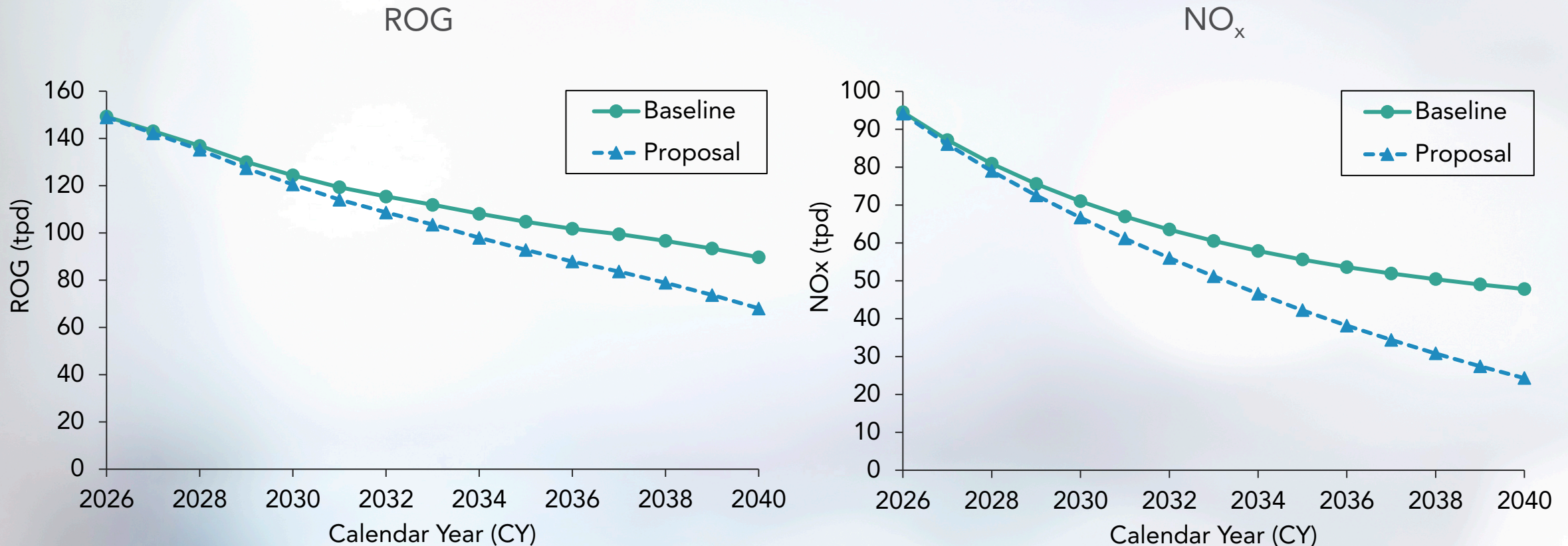

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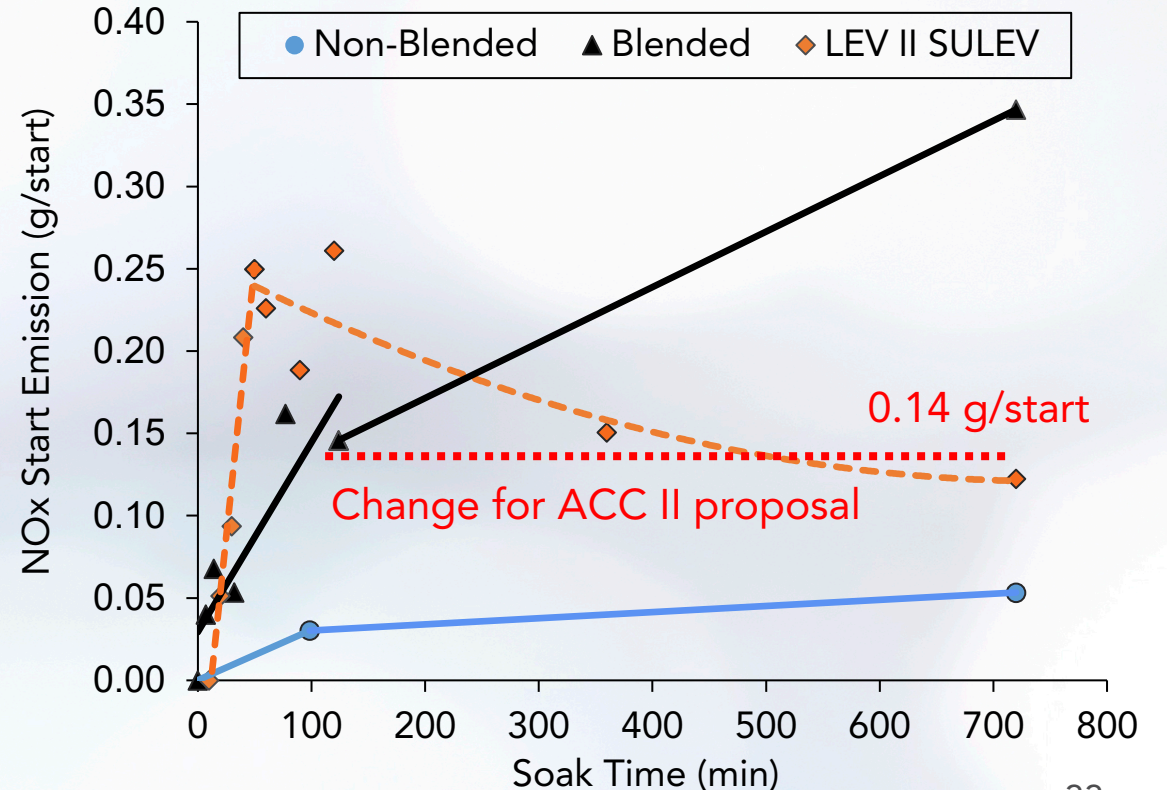
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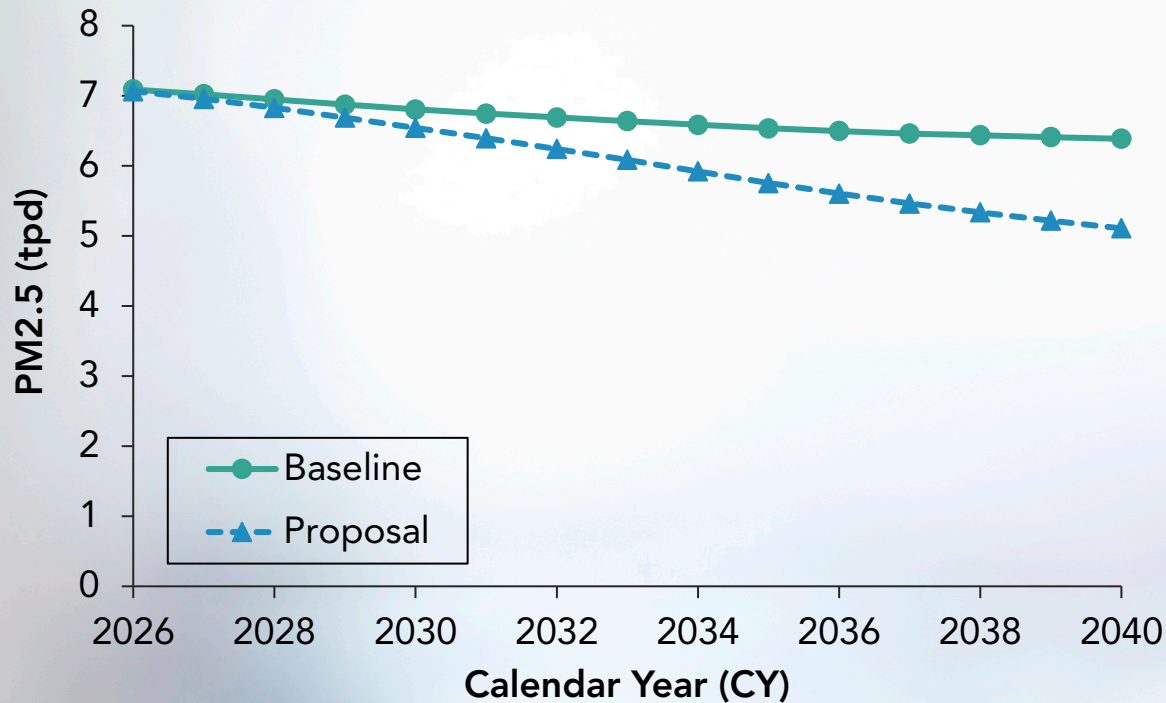
Anticipated Light-Duty Emission Benefits*

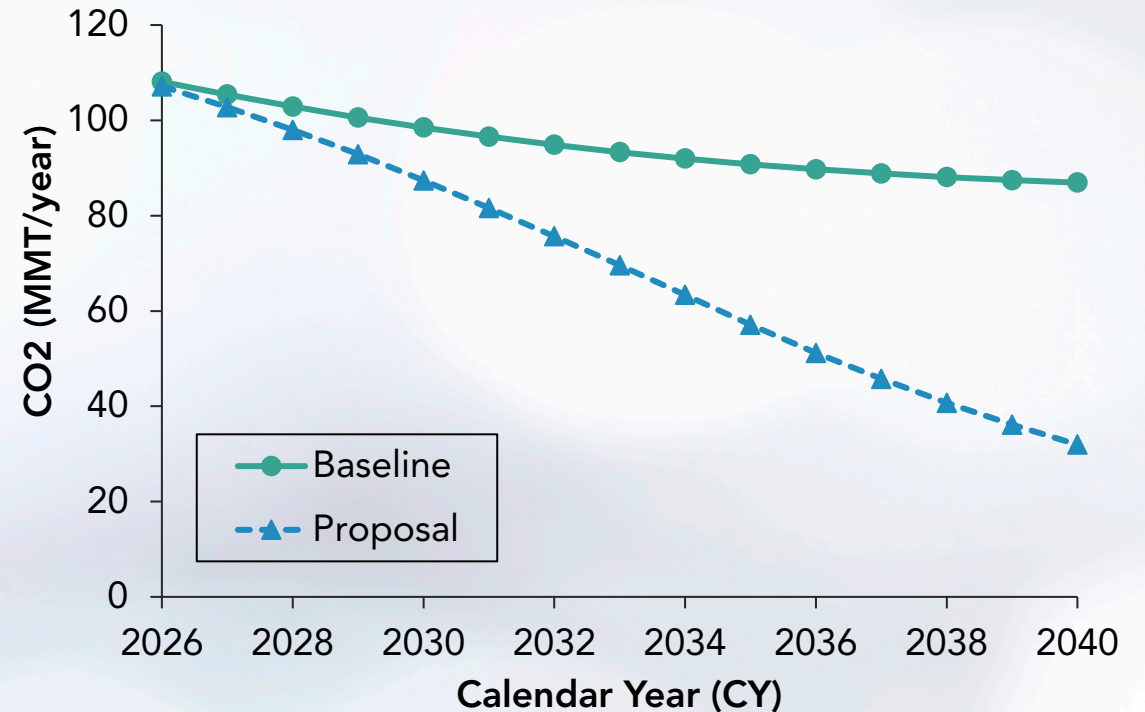

ROG

NO$_x$

* Projected statewide downstream tank-to-wheel emissions

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Anticipated Light-Duty Emission Benefits*

PM$_{2.5}$ (includes Exhaust, Brake Wear and Tire Wear)

CO$_2$

* Projected statewide downstream tank-to-wheel emissions

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Light-Duty Vehicles Regulations
On-Road Motorcycle

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Under Development:
On-Road Motorcycle (ONMC) Regulation

- **General Application**
  - Starting MY 2025, on-road gasoline emission standards
    - Class 1b (>= 50 to < 170 cc)
    - Class II (>= 170 to < 280 cc)
    - Class III (>= 280 cc)
  - Starting MY 2028
    - Class 1a (< 50 cc) must be zero emission models

- **Proposed Requirements**
  - MY 2025 Harmonize with European Union exhaust standards
    - HC, NOx, and CO
    - Adopt Test Procedures
    - World Motorcycle Test Cycle (WMTC)

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On-Road Motorcycle (ONMC) Regulation (cont.)

- **Additional Requirements**
  - 2024 Zero Emission Motorcycle (ZEM) credit program for manufacturers
    - Submit credits by percentage of sales
    - 10% new sales in 2028 increasing to 50% in 2035
  - MY 2028 Requirements
    - Increased useful life
    - On-board diagnostics (OBD) monitoring
    - New evaporative standards
      - 3-day Diurnal Test
    - All Class 1a equivalent new models must be ZEM

- **Board Hearing Date:** February 2023 (Tentative)

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Heavy-Duty Vehicles
Regulations

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Heavy Duty Inspection and Maintenance

General scope summary
- Adopted in Dec. 2021
- Periodic inspection for all non-gasoline vehicles (diesel and alternative fuel), gross vehicle weight rating (GVWR) 14,000+ pounds operating in CA, including out of state

Requirements
- OBD vehicles: periodic data submission
- Non-OBD vehicles: opacity periodic test
- Non-compliant vehicles: Registration hold

Expected Dates:
- **Phases 1&2 (CY 2023):**
  - Screening high-emitters, follow up testing
  - Link to California DMV registration
  - Compliance certificate enforcement
- **Phases 3&4 (CY 2024+):**
  - Periodic compliance testing

CARB, Heavy-Duty Inspection and Maintenance Program, Aug 2022
https://ww2.arb.ca.gov/our-work/programs/heavy-duty-inspection-and-maintenance-program

Projected Emissions from the Adopted HD I/M Program

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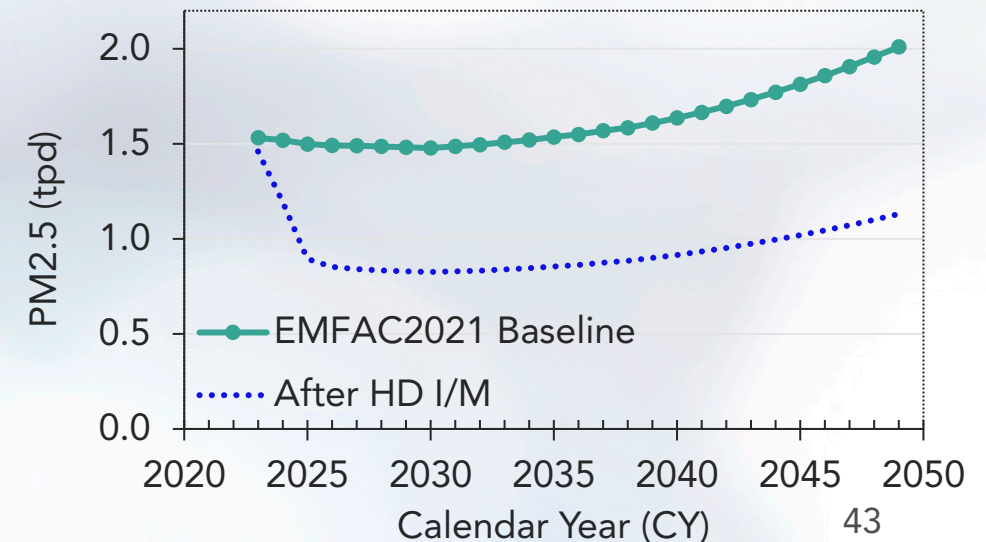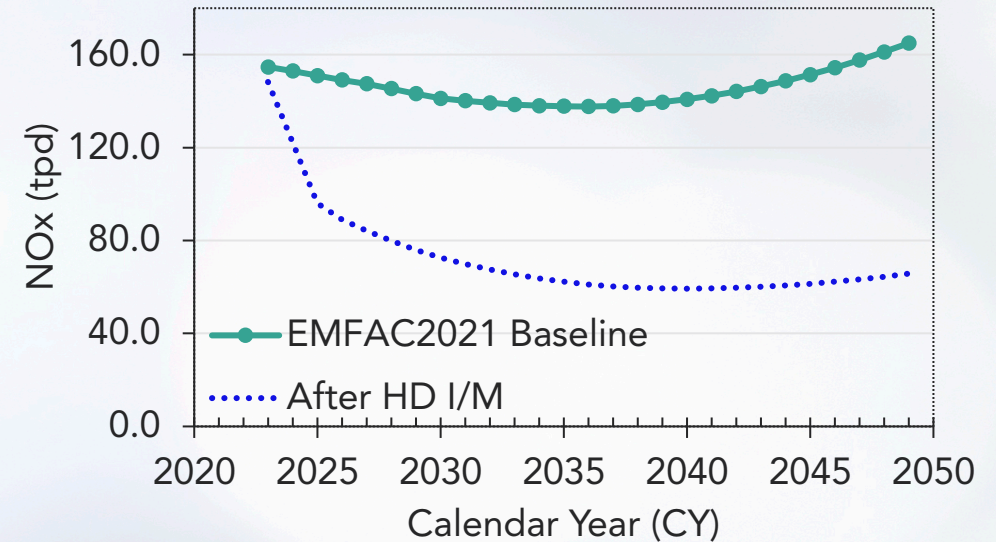
Advanced Clean Fleets Regulation (ACF)

General scope summary

- Any vehicle with a manufacturer's GVWR above 8,500 lbs;
- Off-road yard tractors[†];
- Light-duty package delivery vehicles

Proposed zero-emission requirements

- State and Local Government Fleets
- Drayage Fleets
- High Priority and Federal Fleets
- 100% ZEV Sales by 2040

First Board Hearing Date: Oct 27, 2022

[†] Does not apply to yard tractors operated at the ports and intermodal railyards that are subject to the Cargo Handling Equipment (CHE) requirements.

Statewide ZEV Population Forecast with the Proposed Regulation*
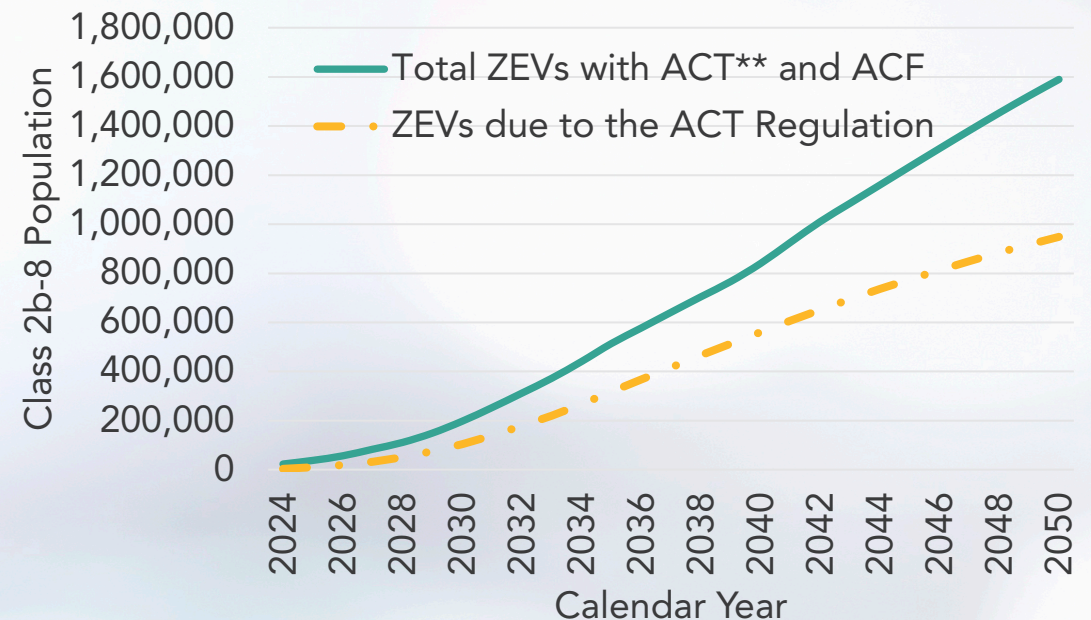
* Population projection based on EMFAC2021
** ACT: Advanced Clean Trucks

Federal Heavy-Duty Engine and Vehicle Standards

General scope summary

- Part of the Clean Trucks Plan
- Requires manufacturers to meet new certification standards for MY2027+ Federal-certified heavy-duty engines with GVWR > 8,500 lbs. Omnibus for CA-certified vehicles was reflected in EMFAC2021.
- Applies to trucks sold into US markets outside of CA

Requirements for heavy-duty engines

- Includes many elements of the Omnibus regulation
- Expands warranty, useful life, in-use emissions and compliance requirements.

Final Rule Expected: December 2022

EPA, Proposed Rule and Related Materials for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards, Aug 2022, https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-and-related-materials-control-air-1

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Question & Answer

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Light-Duty Vehicles
Fleet Characterization

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Major Data Sources

- California Department of Motor Vehicles (DMV) Registration Data (2000 – 2021) - fleet population & new sales

- Polk/IHS VINtelligence Web Service

  - Fills in missing data fields for vehicle characteristics

- CARB Certification Executive Orders (EO)

  - Identifies to which category the manufacturer certified the specific vehicle model

- VIN stems to identify fuel technologies (PHEV, BEV, FCEV)

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Latest Vehicle Registration Data

- CARB receives a snapshot of vehicle registration data every quarter (January, April, July, and October) from DMV

- EMFAC uses the counts of vehicle from the October snapshot

- EMFAC202Y will utilize DMV registration data at least from years <u>2000 through 2021</u>

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Selected Vehicle Classes Modeled in EMFAC202Y

Heavy-Heavy Duty Trucks

Medium Heavy Duty Trucks
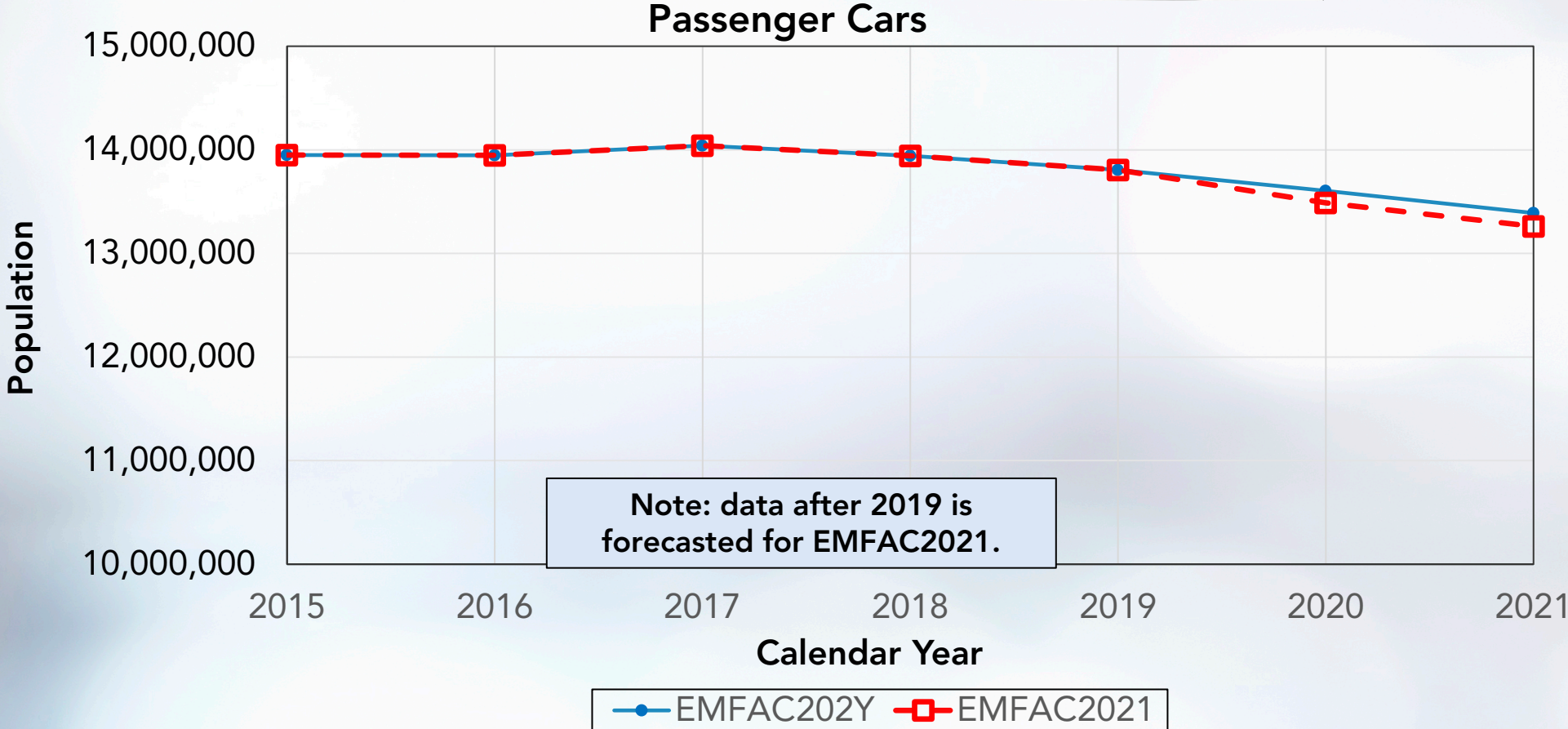
Pickups / Vans

Motorcycles

Passenger Vehicles

School Buses

Transit Buses

Motorhomes

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In the next slides you will hear about...

Vehicle Categories		Gross Vehicle Weight Rating
Light-Duty Vehicles	Passenger Cars	N/A
	Light-Duty Trucks	≤ 8,500 lbs.
Light-Heavy Duty Trucks		8,501 – 14,000 lbs.

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EMFAC202Y vs EMFAC2021 Population Gasoline

Passenger Cars

Note: data after 2019 is forecasted for EMFAC2021.

Legend: EMFAC202Y, EMFAC2021

X-axis: Calendar Year (2015–2021)
Y-axis: Population (10,000,000–15,000,000)
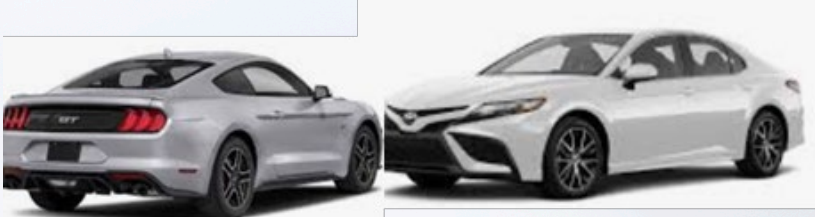
EMFAC202Y vs EMFAC2021 Population Gasoline

Light-Duty Trucks (GVWR ≤ 8,500 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.

Legend: EMFAC202Y, EMFAC2021

X-axis: Calendar Year (2015–2021)
Y-axis: Population (9,000,000–12,000,000)
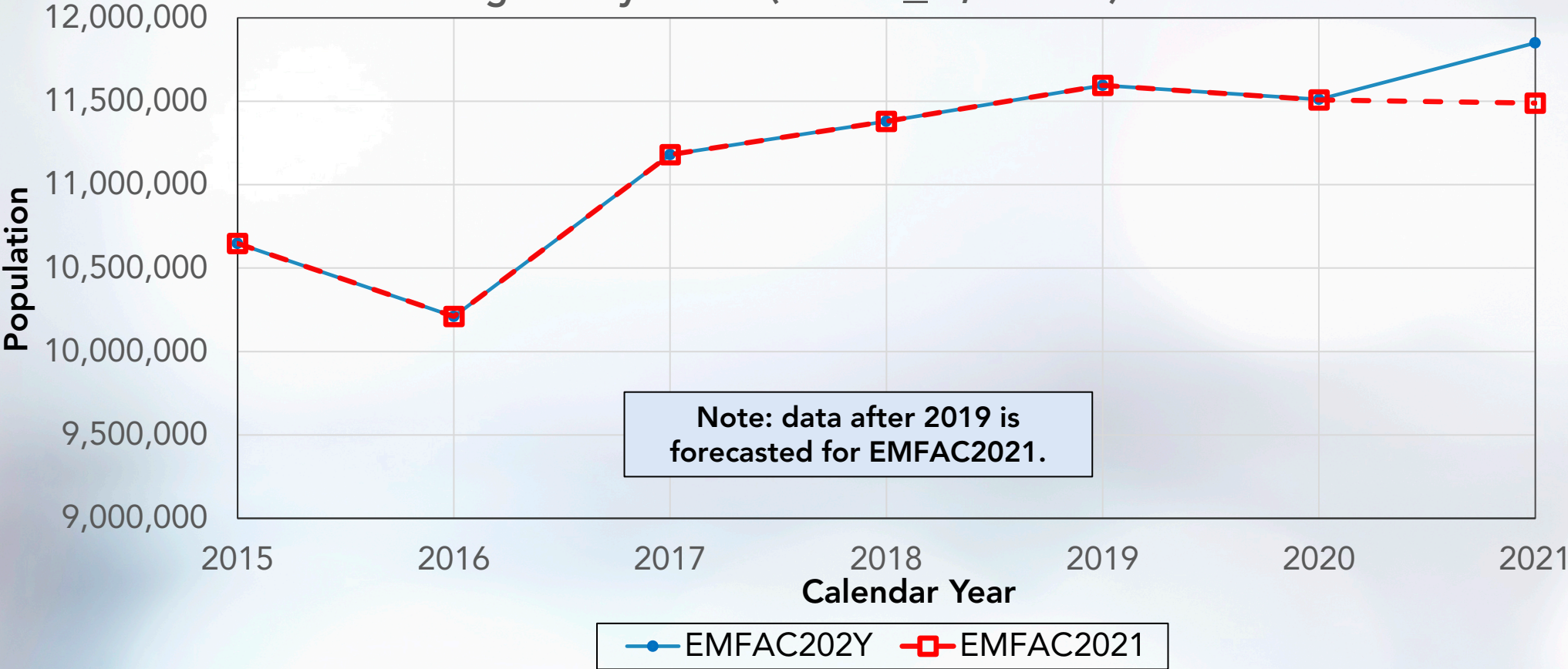
EMFAC202Y vs EMFAC2021 Population Gasoline

Light-Heavy Duty Trucks (GVWR 8,501 – 14,000 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.

EMFAC202Y — EMFAC2021

Population vs Calendar Year

CARB
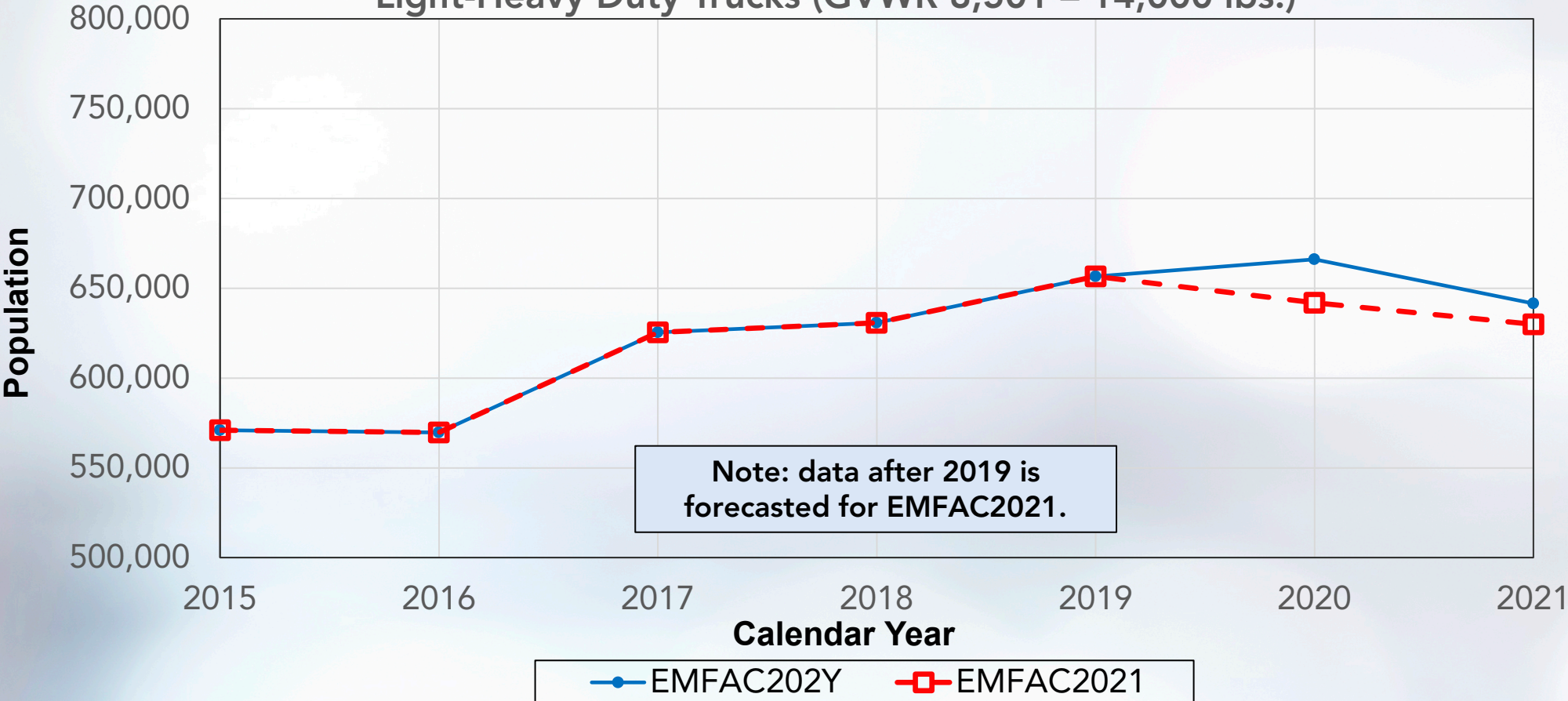
EMFAC202Y vs EMFAC2021 Population Diesel

Passenger Cars

Note: data after 2019 is forecasted for EMFAC2021.
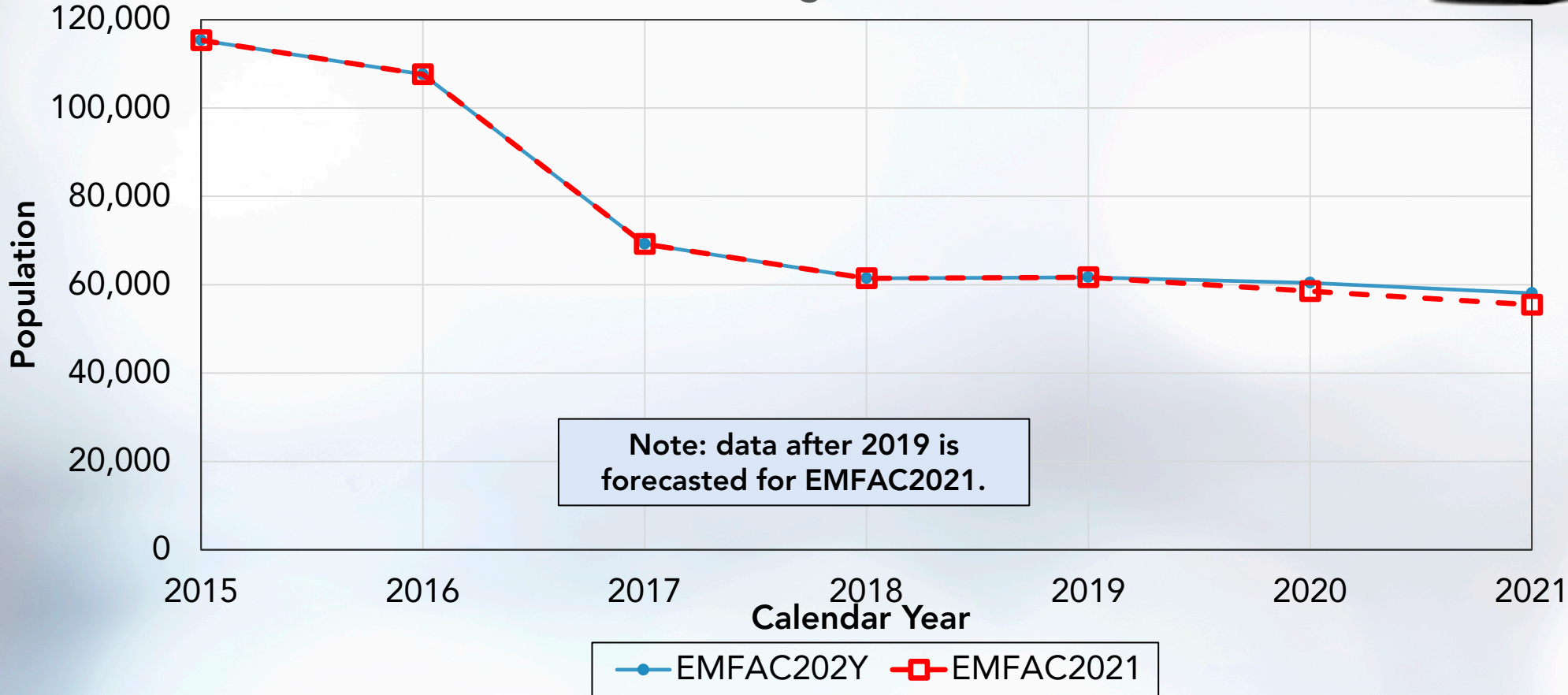
EMFAC202Y vs EMFAC2021 Population Diesel

Light-Duty Trucks (GVWR $\leq$ 8,500 lbs.)
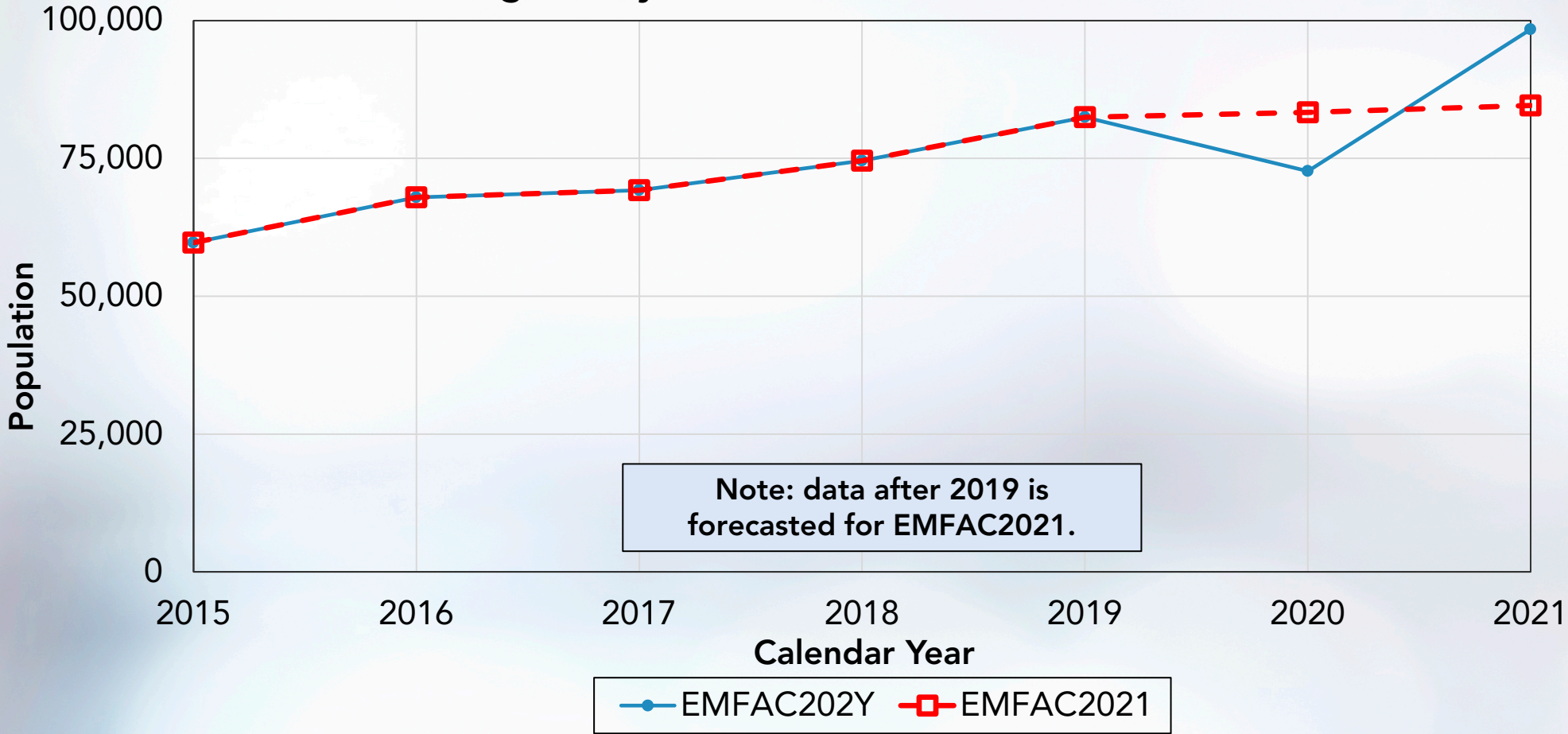
Note: data after 2019 is forecasted for EMFAC2021.

Legend: EMFAC202Y — EMFAC2021

Y-axis: Population (0, 25,000, 50,000, 75,000, 100,000)
X-axis: Calendar Year (2015, 2016, 2017, 2018, 2019, 2020, 2021)

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EMFAC202Y vs EMFAC2021 Population Diesel

Light-Heavy Duty Trucks (GVWR 8,501 – 14,000 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.
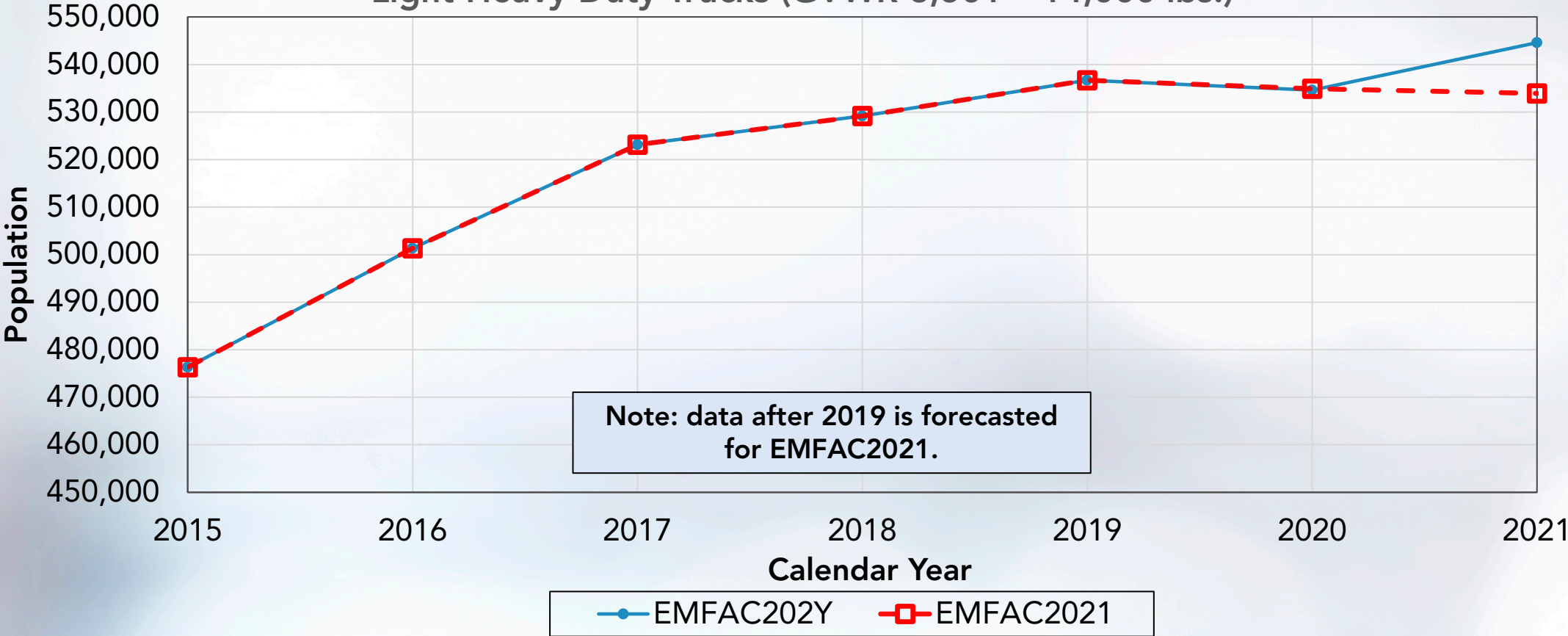
EMFAC202Y vs EMFAC2021 Population Electric*

Passenger Cars
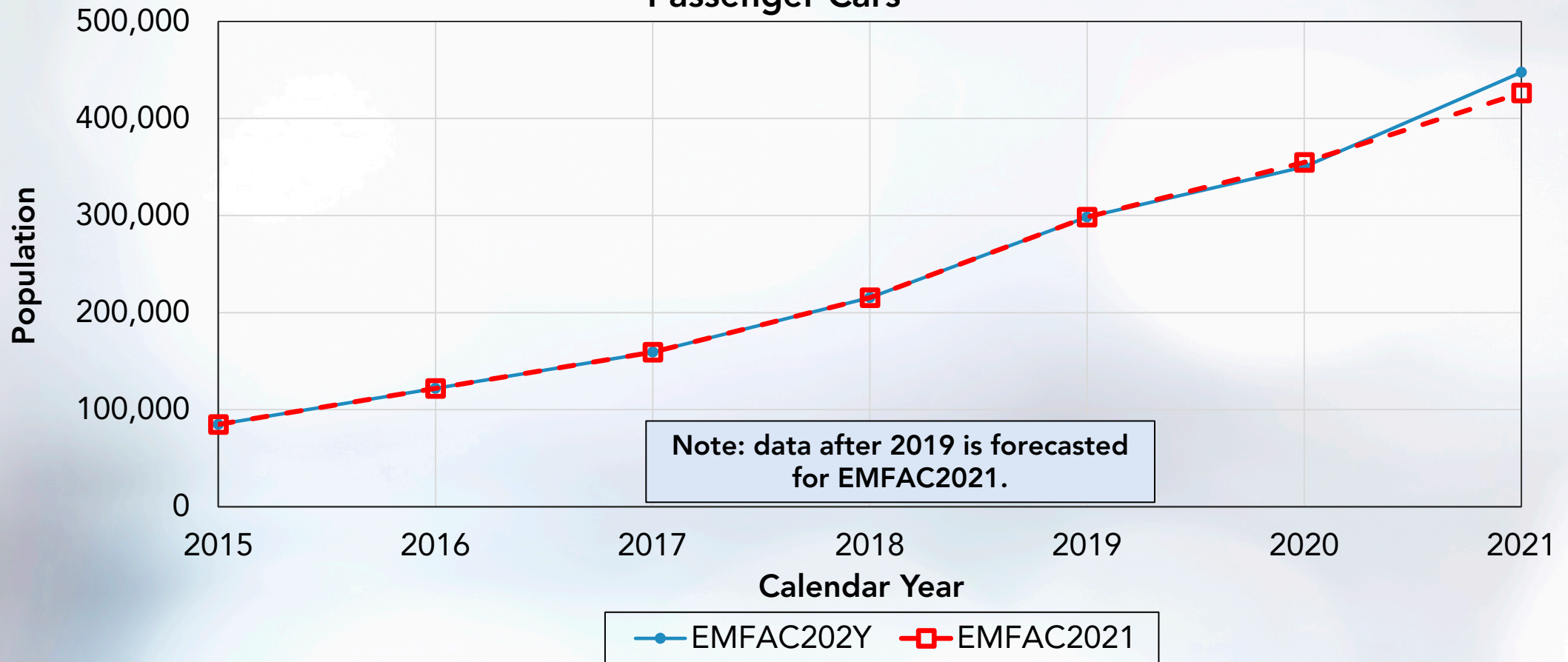
Note: data after 2019 is forecasted for EMFAC2021.

Legend: EMFAC202Y, EMFAC2021

*Electric Vehicles : Vehicles with Motive Power of Electric in DMV data (this may not include PHEVs)

CARB

EMFAC202Y vs EMFAC2021 Population Electric*

Light-Duty Trucks (GVWR ≤ 8,500 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.

Legend: EMFAC202Y, EMFAC2021

*Electric Vehicles : Vehicles with Motive Power of Electric in DMV data (this may not include PHEVs)
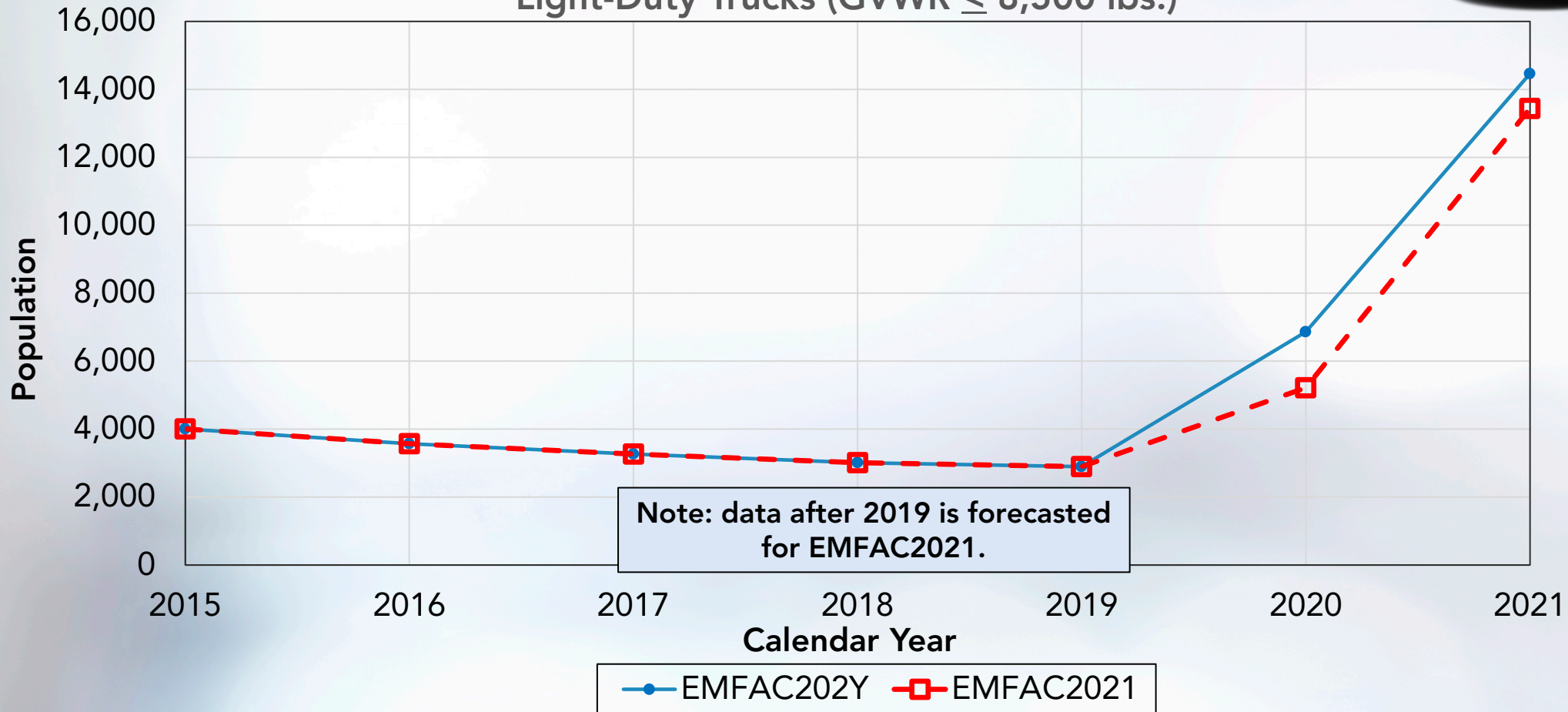
New Vehicle Category: Public Fleet* LHD1 & LHD2

Light-Heavy Duty Trucks (8,501-14,000 lbs.) with Exempt Plates**
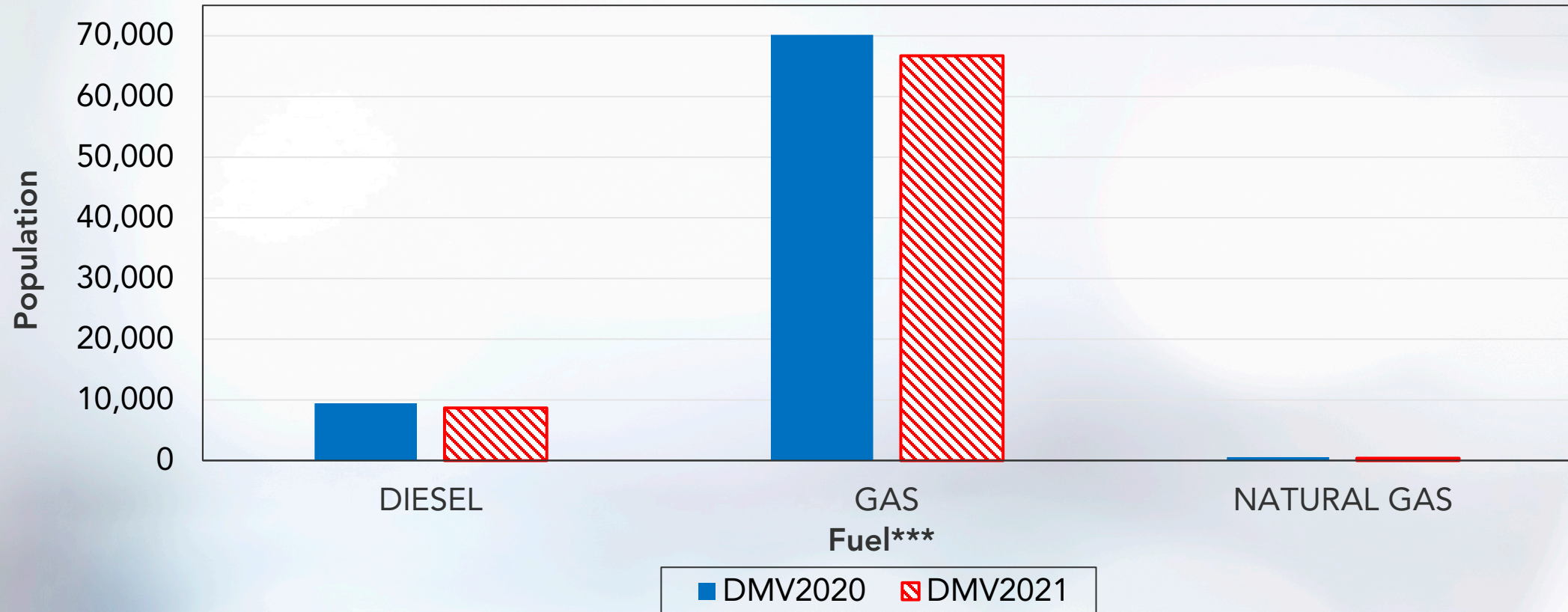
*Public fleet are permanent exempt vehicles that are usually assigned with an expiration date of 12/31/2099
**These totals are a subset of the diesel and gasoline populations from the earlier slides for this category.
***Electric trucks in this category will increase in population for future DMV years.

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New Sales – Gasoline Vehicles

Light-Duty Vehicles (Passenger Cars and Trucks with GVWR ≤ 8,500 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.
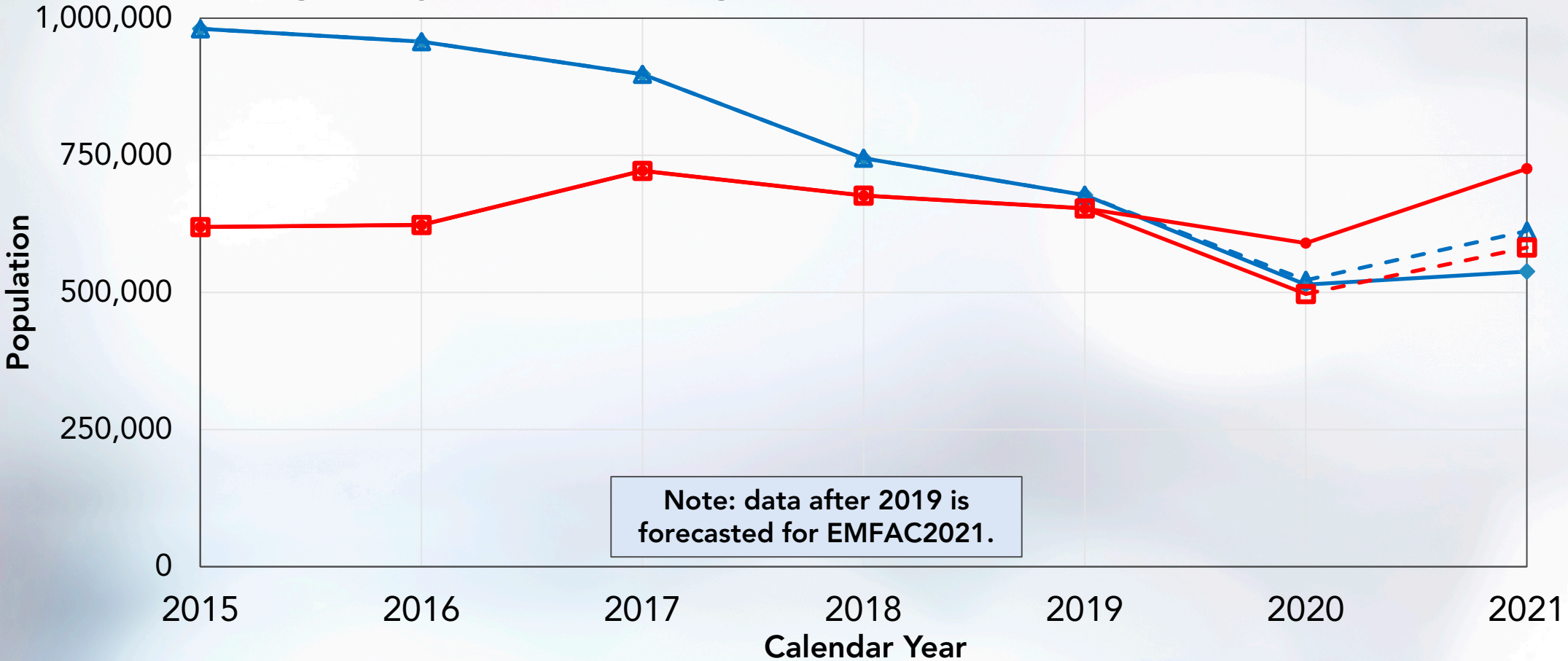
New Sales – Diesel Vehicles

Light-Duty Vehicles (Passenger Cars and Trucks with GVWR $\leq$ 8,500 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.

Legend: PC EMFAC202Y | PC EMFAC2021 | LDT EMFAC202Y | LDT EMFAC2021

CARB

64
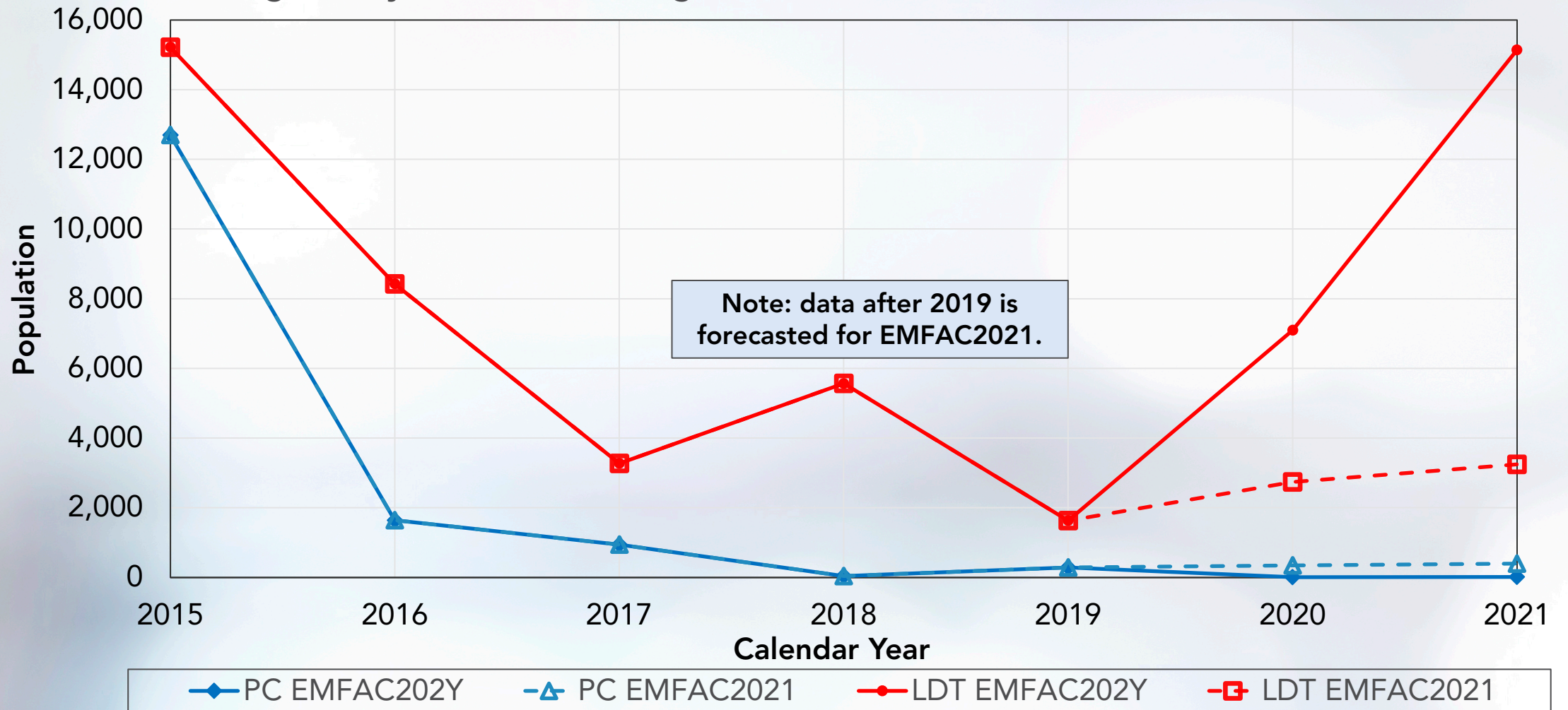
New Sales – Gasoline and Diesel

Light-Heavy Duty Trucks (GVWR 8,501 – 14,000 lbs.)

Note: data after 2019 is forecasted for EMFAC2021.

Legend: EMFAC202Y GAS · EMFAC2021 GAS · EMFAC202Y DIESEL · EMFAC2021 DIESEL

CARB
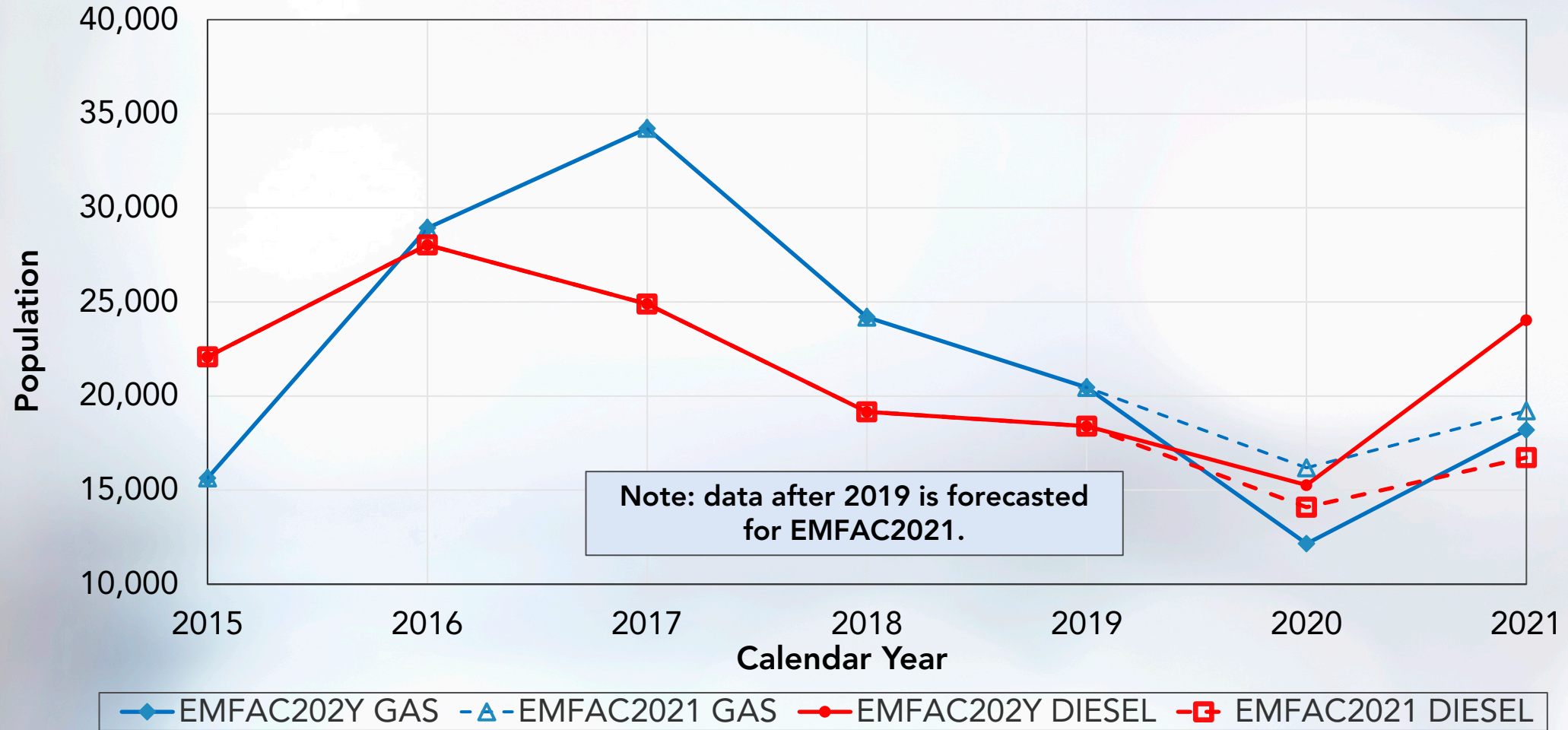
EMFAC202Y Model Year Distribution All Fuel Types

Passenger Cars

Note: EMFAC202Y model year distributions are calculated using snapshot of registration data as of October 2021.

Legend: DMV2019, DMV2021

CARB
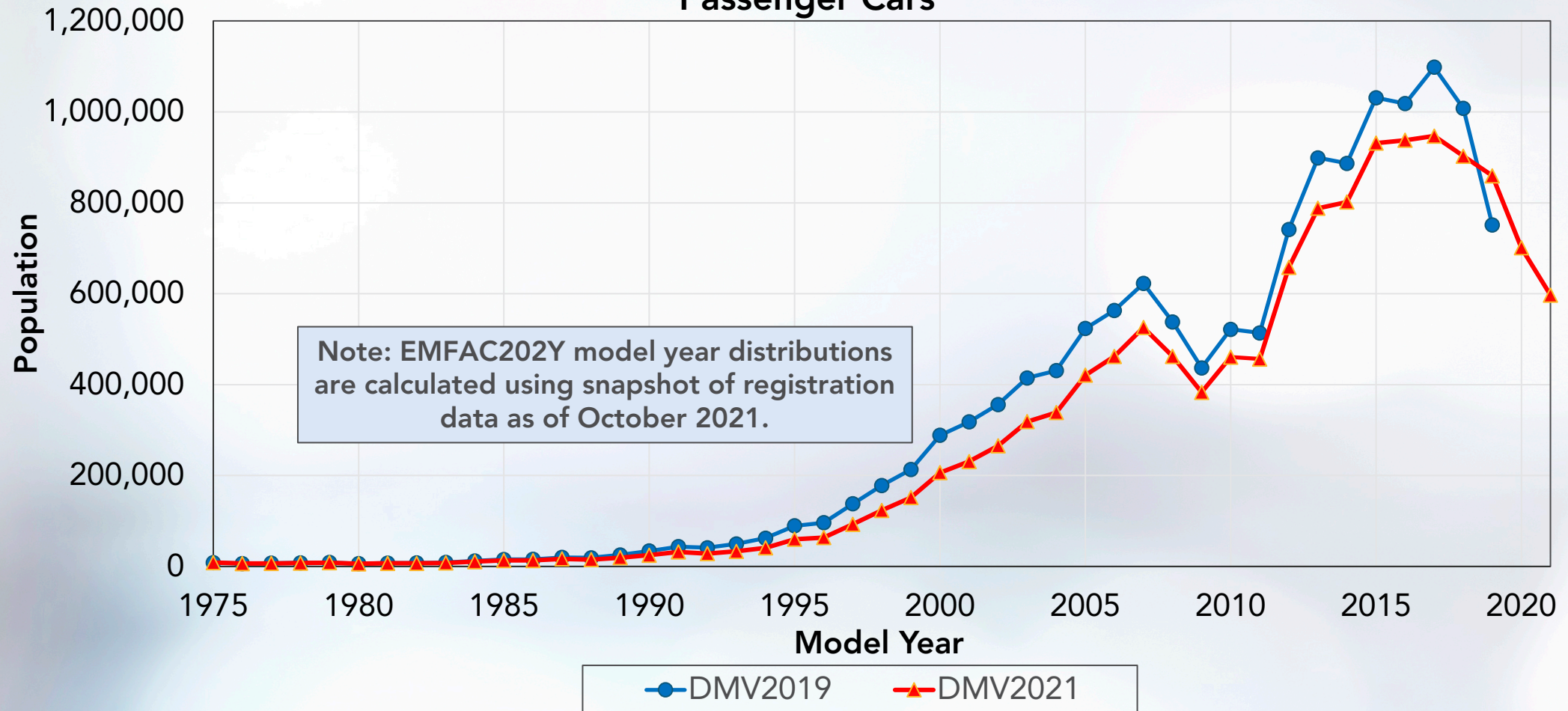
EMFAC202Y Model Year Distribution All Fuel Types

Light-Duty Trucks (GVWR $\leq$ 8,500 lbs.)

Note: EMFAC202Y model year distributions are calculated using snapshot of registration data as of October 2021.
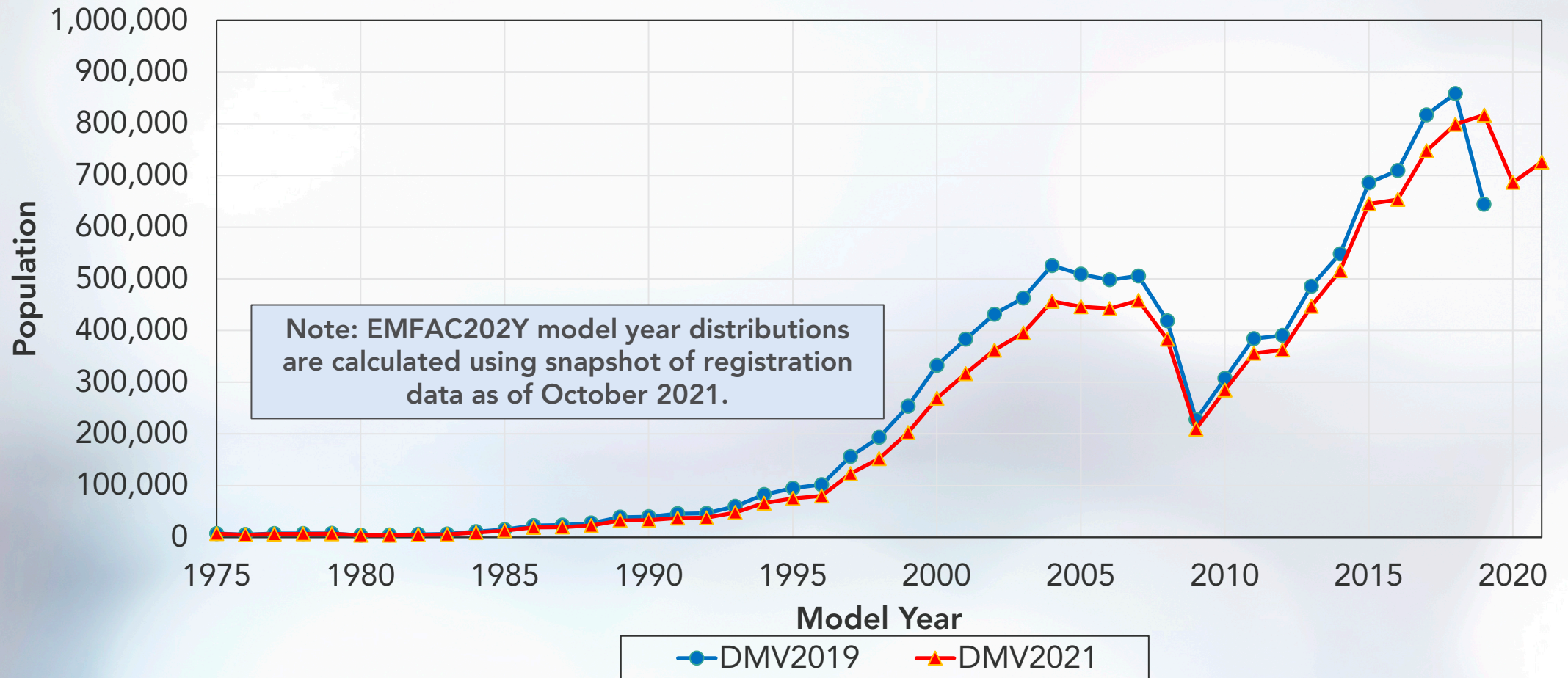
EMFAC202Y Model Year Distribution All Fuel Types

Light-Heavy Duty Trucks (8,501-14,000 lbs.)

Note: EMFAC202Y model year distributions are calculated using snapshot of registration data as of October 2021.
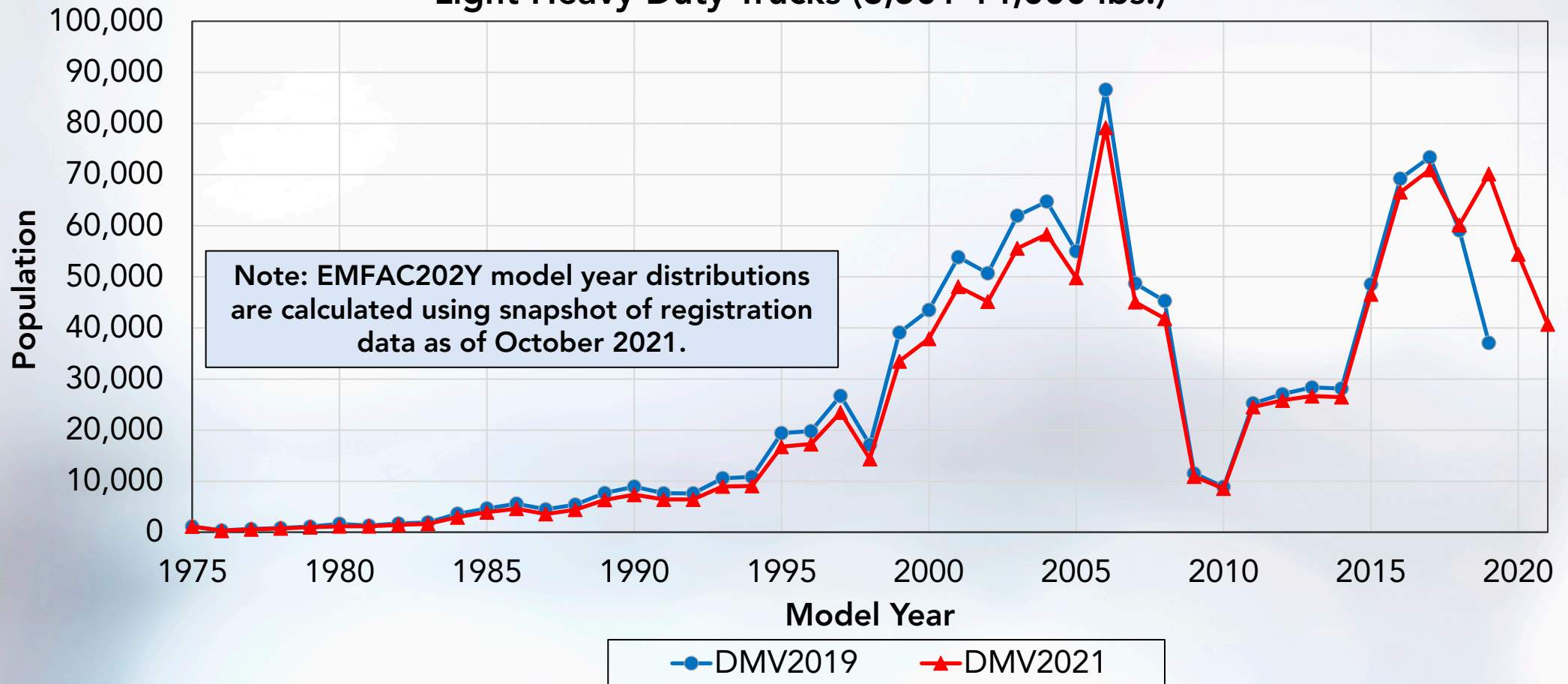
DMV2019 — DMV2021

On-Road Light-Duty Zero Emission Vehicles

Zero Emissions Vehicle Populations in DMV2018 through DMV2021
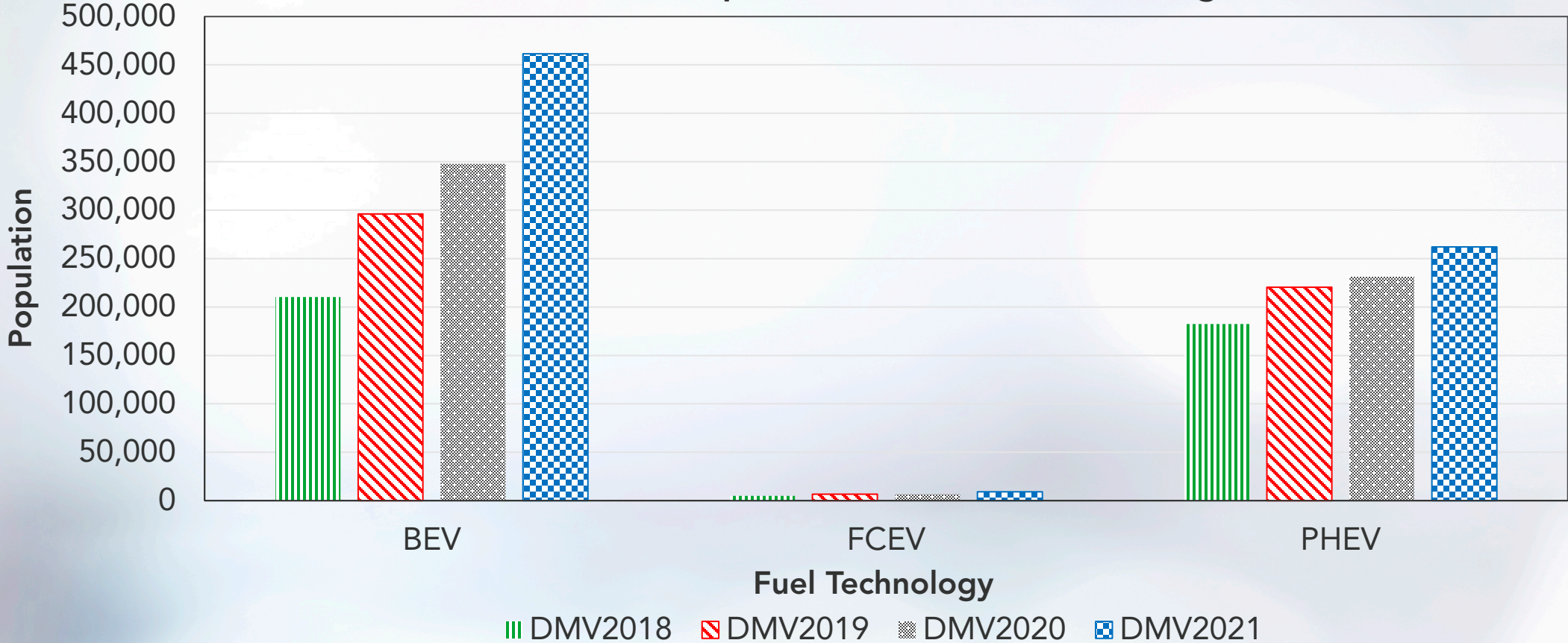
Please note this is the population of vehicles with "currently" registered status code in CA DMV data and is not equivalent to cumulative sales.

Population Counts for CA Registered Vehicles

Vehicle Category	Gross Vehicle Weight Rating	2018	2019	2020	2021
Passenger Cars	N/A	14.5M	14.5M	14M	13.9M
Light-Duty Trucks	GVWR < 6000 lbs.	7.1M	7.3M	7.3M	7.5M
	6,001 - 8,500 lbs.	4.3M	4.2M	4.3M	4.4M
Light-Heavy Duty Trucks	8,501-10,000 lbs.	918,000	939,000	987,000	947,000
	10,001-14,000 lbs.	201,000	212,000	216,000	240,000
Medium-Heavy Duty Trucks	14,001-16,000 lbs.	303,000	315,000	294,000	277,000
	16,001-19,500 lbs.				
	19,501-26,000 lbs.				
	26,001-33,000 lbs.				
Heavy-Heavy Duty Trucks	GVWR >33,000 lbs.	227,000	205,000	213,000	228,000
Buses	ALL	85,000	86,000	81,000	84,000
Total*		27.6M	27.8M	27.4M	27.6M

*Totals were obtained from actual data and does not reflect rounding for each category.

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Summary of Light-Duty Fleet Characteristic Changes Since Release of EMFAC2021

- Passenger car populations declined except for electric-powered vehicles

- Light-duty truck populations substantially grew especially for diesels and electrics

- Counts of BEVs are increasing at a rapid rate (slower rates of growth for PHEVs and FCVs)

- Total on-road population registration counts remain relatively constant since 2018

CARB

Agenda for AM Session

- Executive Summary
  - Background
  - User Survey Results
  - Major Updates to EMFAC202Y
- Regulations
  - Light-Duty
    - Advanced Clean Cars II
    - On-Road Motorcycle
  - Heavy-Duty
    - Heavy Duty Inspection and Maintenance
    - Advanced Clean Fleets
    - Federal Heavy-Duty Engine & Vehicle Standards
- Question & Answer

- **Fleet Characterization**
  - Light-Duty (Population and New Sales)
  - **Heavy-Duty (Non-Gas Fueled)**
    - Automated License Plate Reader (ALPR)
- Vehicle Activity Profiles
  - Light-Duty Activity and Forecasting
  - Heavy-Duty Activity and Forecasting
- Transportation Network Company (TNC) Category
- Question & Answer

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Heavy-Duty Vehicles *(Non-Gas Fueled)*
Fleet Characterization

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On-Road Vehicle Population Primary Sources

- Primary Data Sources for Vehicle Inventory Include:

    - DMV Vehicle Registration Database
        - For all Instate Registered Vehicles

    - International Registration Plan (IRP) Clearinghouse Data
        - For all Interstate Vehicles in Fleets with miles in California

    - International Fuel Tax Agreement (IFTA) Data
        - To apportion NOOS (neighboring out of state*) and NNOOS (non-neighboring out of state) Inventory based on the annual miles in CA per jurisdiction

            *Neighboring out of state includes Arizona, Idaho, Nevada, Oregon, Washington, and British Columbia (BC)

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On-Road Vehicle Population Other Sources

- <u>Other</u> Sources Used for HD Vehicle Characterization Include:
  - List of VINs from Major Ports to identify T7 POLA & T7 POAK vehicles

  - California Highway Patrol (CHP) School Bus Inspections list to identify School Buses
  - TRUCRS*/EDVR** data for diesel Truck and Bus Rule exemptions/exclusions
  - [NEW] Innovative Clean Transit (ICT) reporting data to identify Transit Buses
    - Replaces the use of the National Transit Database (NTD)

  - [NEW] Large Entity Fleet Reporting data for Advanced Clean Trucks (ACT) regulation
  - [NEW] Major intermodal railyard facilities to model Rail Truck Inventory

*Truck Regulation Upload, Compliance
 and Reporting System (TRUCRS)
**Excluded Diesel Vehicle Reporting (EDVR)

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Priority Sequencing for Assigning Fleet Categories

- An individual vehicle may have multiple Fleet Category Flags
- Processing Instate Fleet Categories uses this priority sequencing:

Sequencing	Fleet Group
Priority #1	T7 POLA (Port of San Pedro)
Priority #2	T7 POAK (Port of Oakland)
Priority #3	T6 CAIRP or T7 CAIRP (Interstate)
Priority #4	T6 Utility or T7 Utility (Private Companies)
Priority #5	T7 SWCV (Solid Waste)
Priority #6	T6 Public or T7 Public (Govt., Districts, etc.)
Priority #7	T6 Instate Tractor or T7 Instate Tractor
Priority #8 (mutually exclusive)	T6 Instate Delivery (Parcel Delivery, Step Vans, Non-Trailer Refrigerated & Vans)
	T7 Single Dump (non-Trailer)
	T7 Single Mix (Cement Mixers)
Priority #9	T6 Instate Other or T7 Single Other (Remaining T6/T7)

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California Registered Buses
(*Excludes Transit/UBUS*)

- CA registered bus counts in years 2020 and 2021 were very close to EMFAC2021 forecasts except for Motor Coach counts, which dropped due to COVID impacts on leisure activities
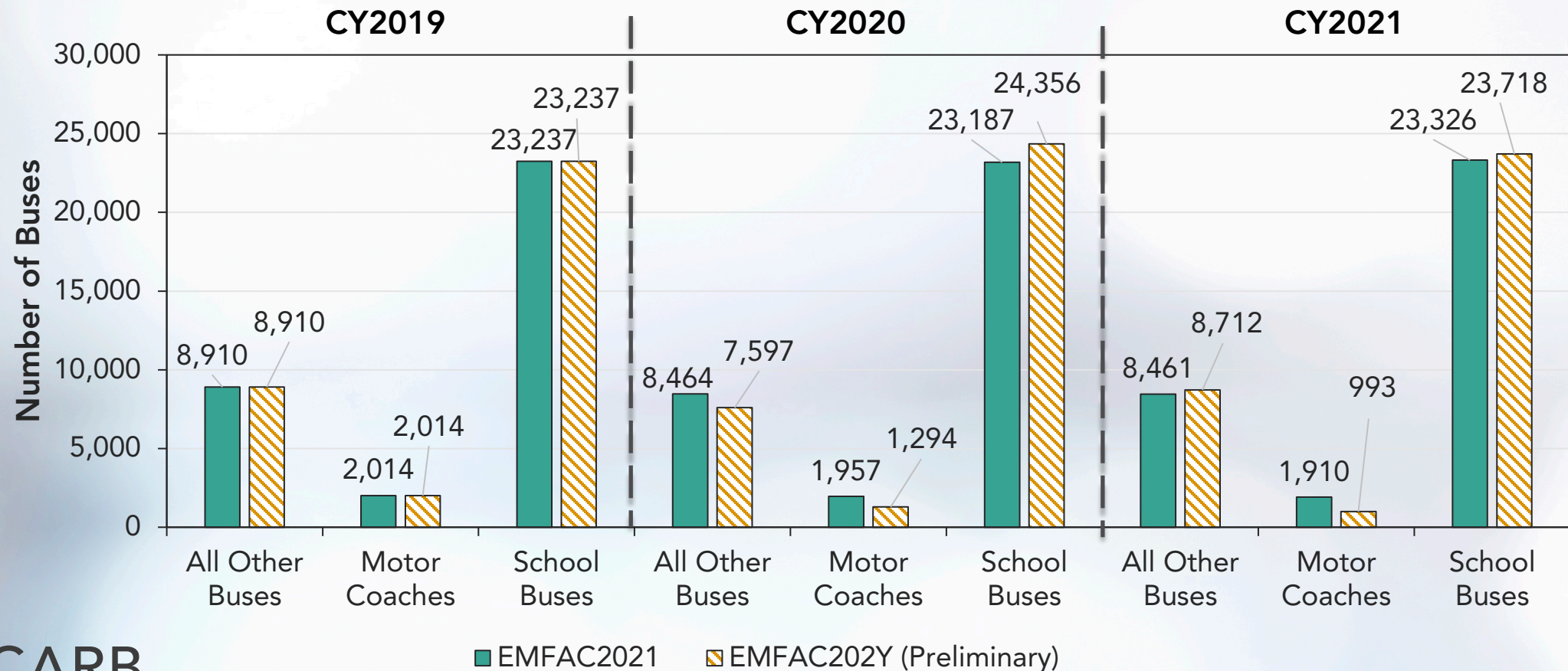
California Registered Buses - New Sales
(*Excludes Transit/UBUS*)

- New sales in 2020 exceeded EMFAC2021 forecasts for School Buses, but lagged for All other Buses and Motor Coaches
- New Sales in 2021 exceeded EMFAC2021 forecasts
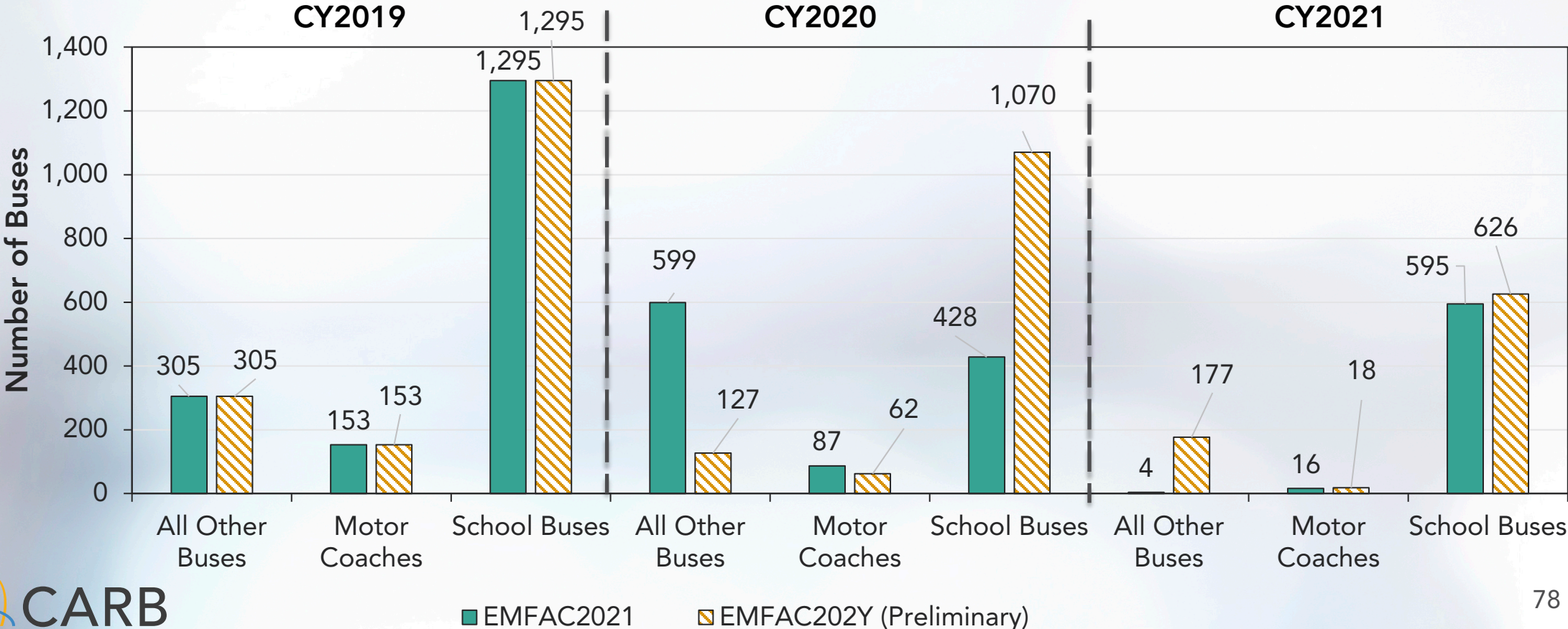
CA Registered Buses – Chassis MY Groups
(*Excludes Transit/UBUS*)

- EMFAC2021 forecasts were close to the updated values for EMFAC202Y, older proportions were a bit higher than predicted
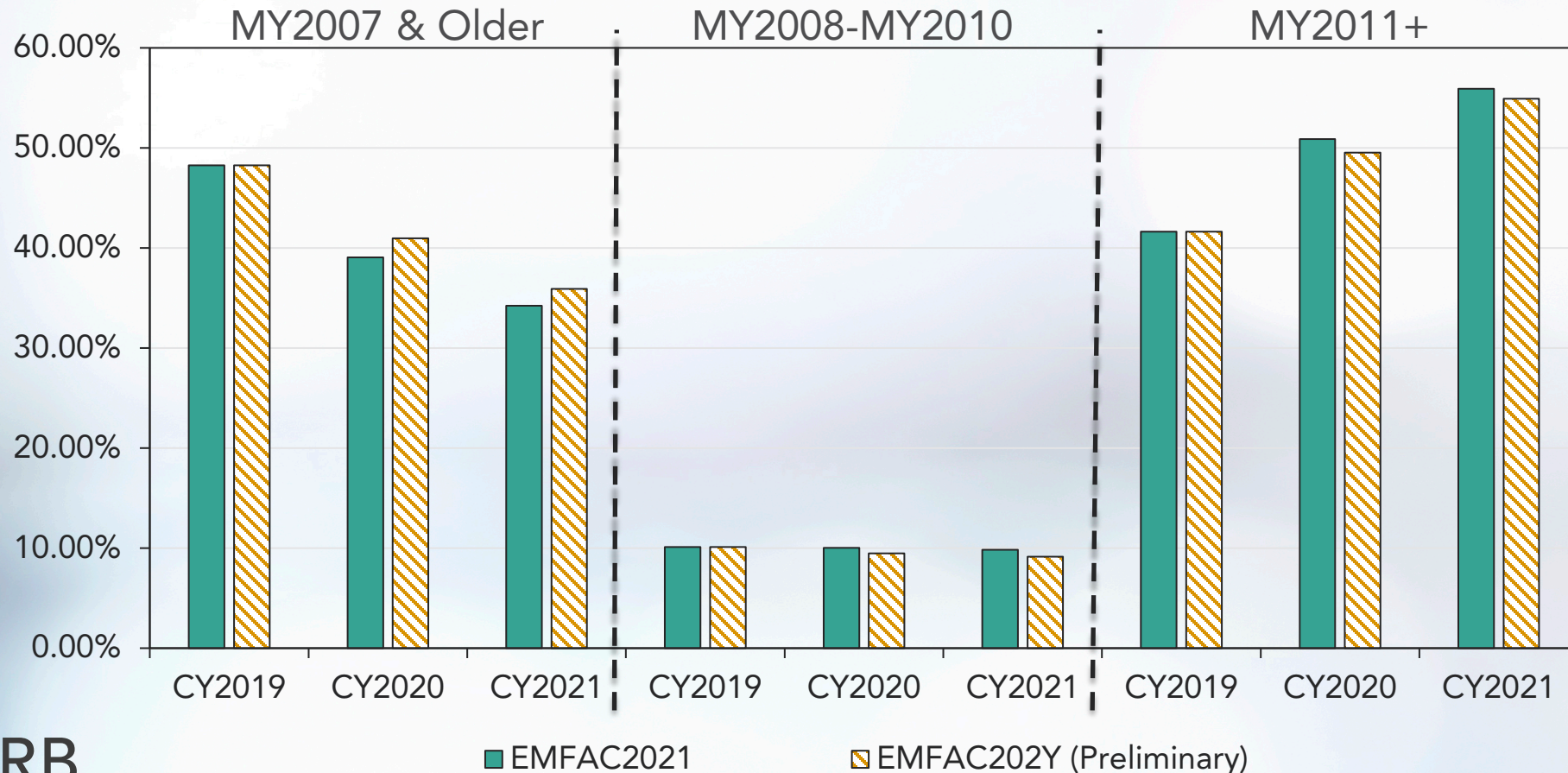
California Registered Medium Heavy Duty
(*GVWR 14,001 – 33,000 lbs.*)

- CA registered medium heavy truck counts were slightly lower in CY2020 and a bit higher in CY2021 than EMFAC2021 forecasts

Bar chart — Number of MHDs by Calendar Year, comparing EMFAC2021 and EMFAC202Y (Preliminary):

Calendar Year	EMFAC2021	EMFAC202Y (Preliminary)
CY2019	278,052	278,052
CY2020	273,913	269,761
CY2021	270,478	276,512
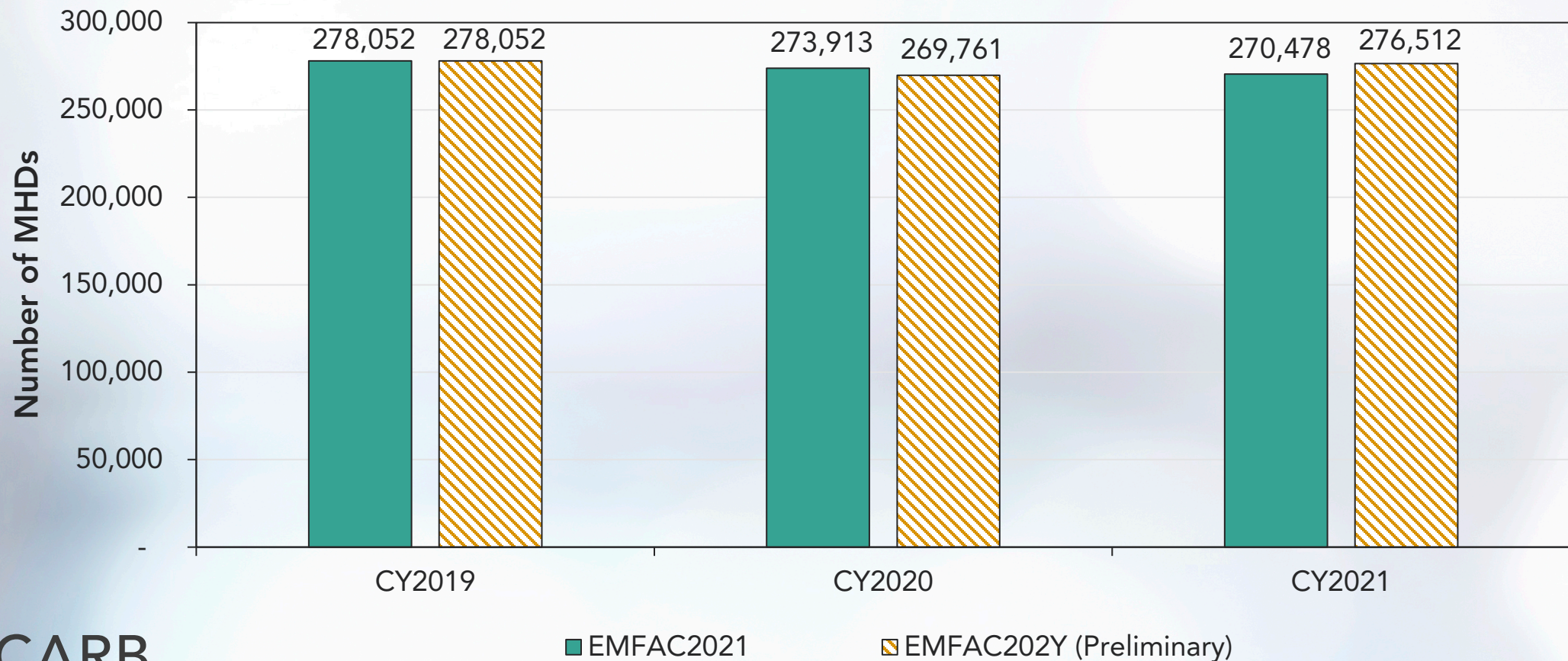
California Registered MHD - New Sales

- New sales in years 2020 and 2021 exceeded EMFAC2021 forecasts

Chart: New MHD Sales

Year	EMFAC2021	EMFAC202Y (Preliminary)
CY2019	17,313	17,313
CY2020	11,990	14,716
CY2021	4,382	13,818

Legend: ■ EMFAC2021   ▨ EMFAC202Y (Preliminary)

CARB
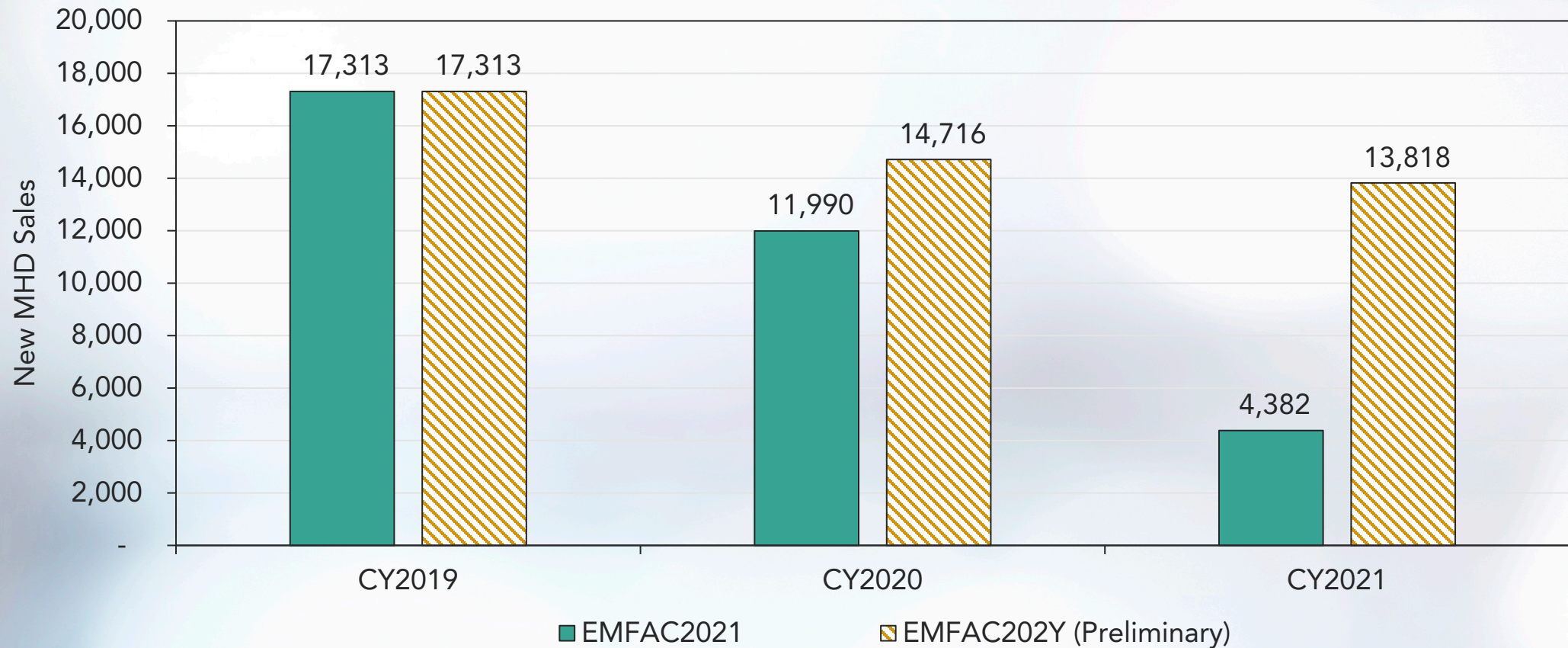
CY2021 California Registered MHD – Weight Classes

- Class 4 (GVWR 14,001-16,000 lbs.) — 14.1%
- Class 5 (GVWR 16,001-19,500 lbs.) — 30.2%
- Class 6 (GVWR 19,501-26,000 lbs.) — 33.4%
- Class 7 (GVWR 26,001-33,000 lbs.) — 22.4%

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California Registered MHD – Chassis MY Groups

- Fractions of MY 2007 & older vehicles are higher than predicted for CY 2020+
- Fractions of MY 2011+ vehicles are lower than predicted for CY 2020 and 2021
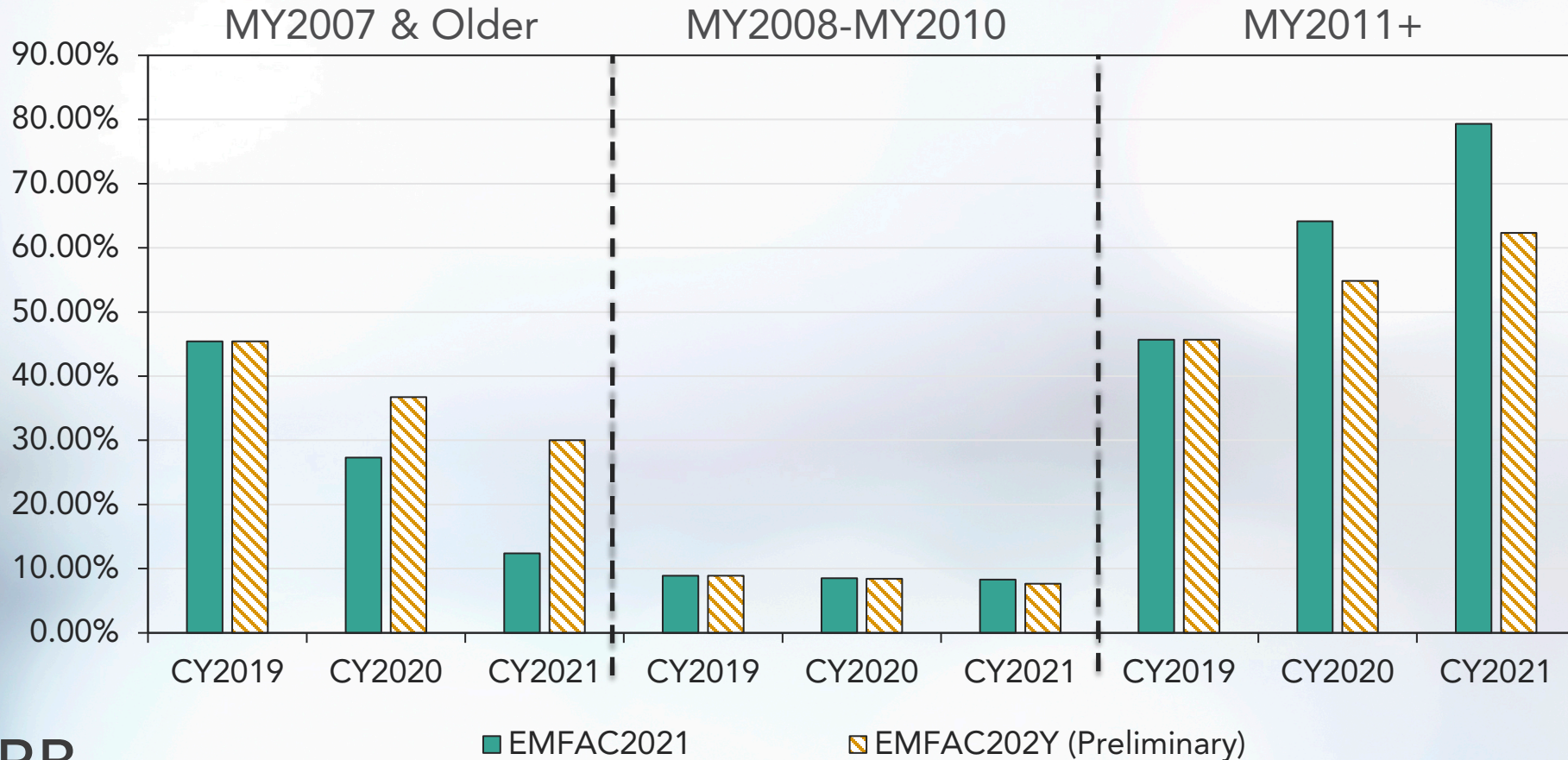
California Registered Heavy Heavy Duty (*GVWR >33,000 lbs.*)

- CA registered heavy heavy duty vehicle counts were higher in CY2020 and CY2021 than EMFAC2021 forecasts

Chart: Number of HHDs by calendar year, comparing EMFAC2021 and EMFAC202Y (Preliminary)

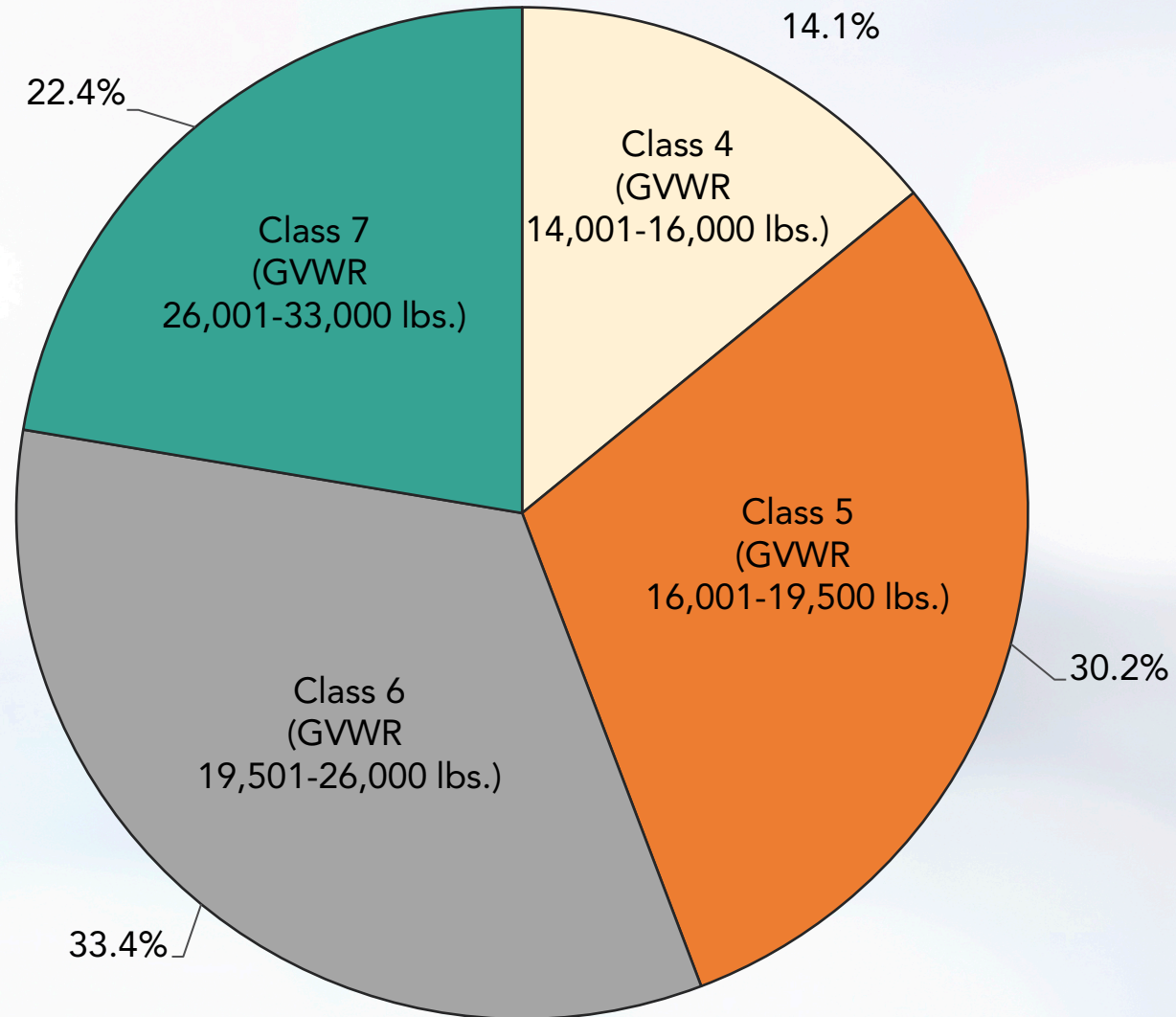|	EMFAC2021	EMFAC202Y (Preliminary)
CY2019	257,264	257,264
CY2020	262,351	265,298
CY2021	269,936	285,811

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California Registered HHD - New Sales

- New sales in years 2020 and 2021 exceeded EMFAC2021 forecasts
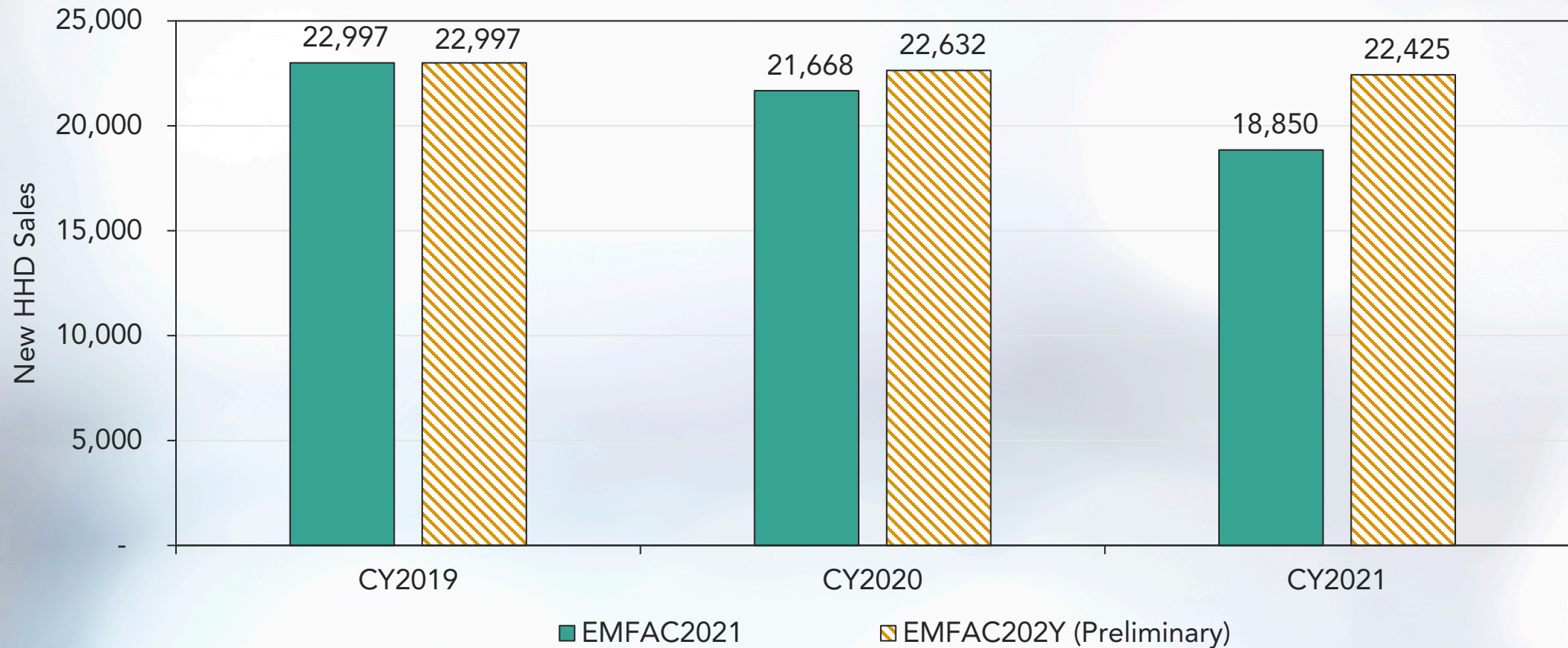
California Registered HHD – Chassis MY Groups
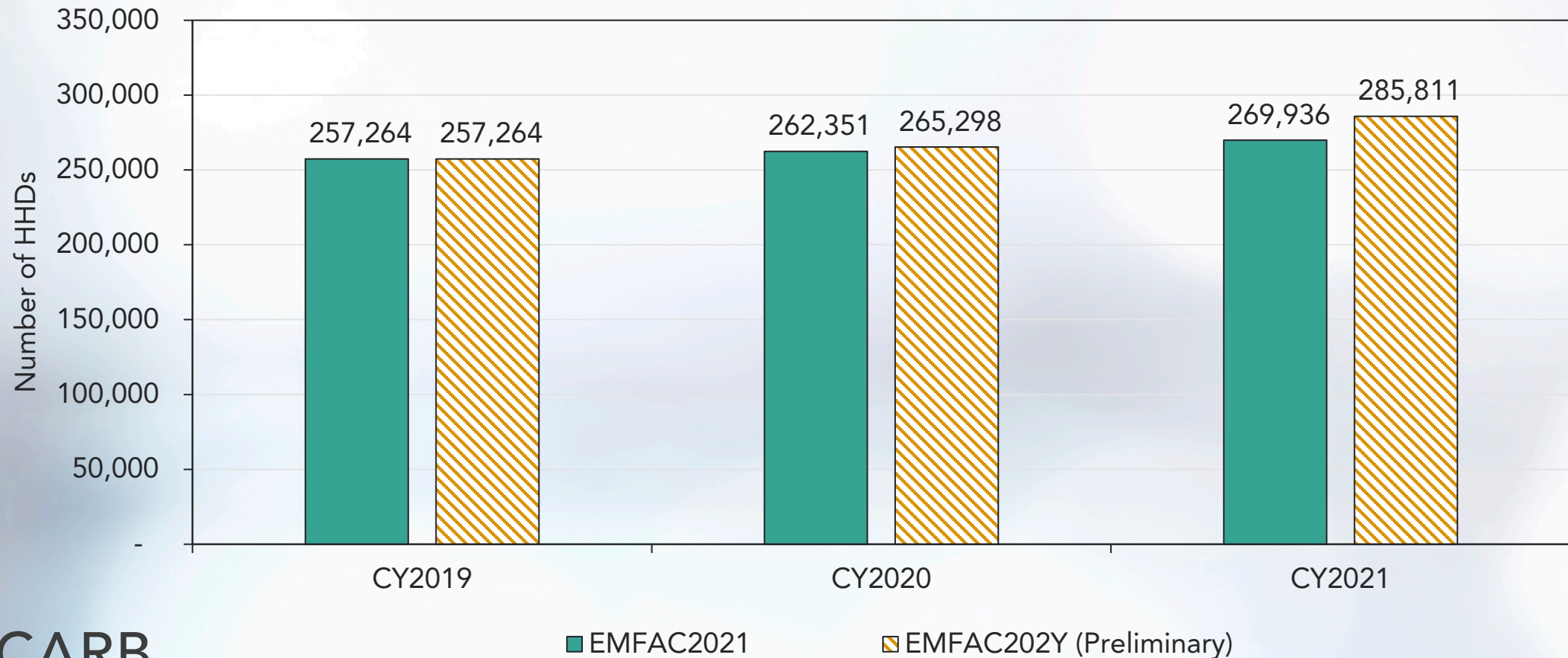
- EMFAC2021 overpredicted the phase-out of MY 2007 and older vehicles

- Actual registration in 2019, 2020, and 2021 suggest older vehicles are still being replaced with MY 2011 and newer models
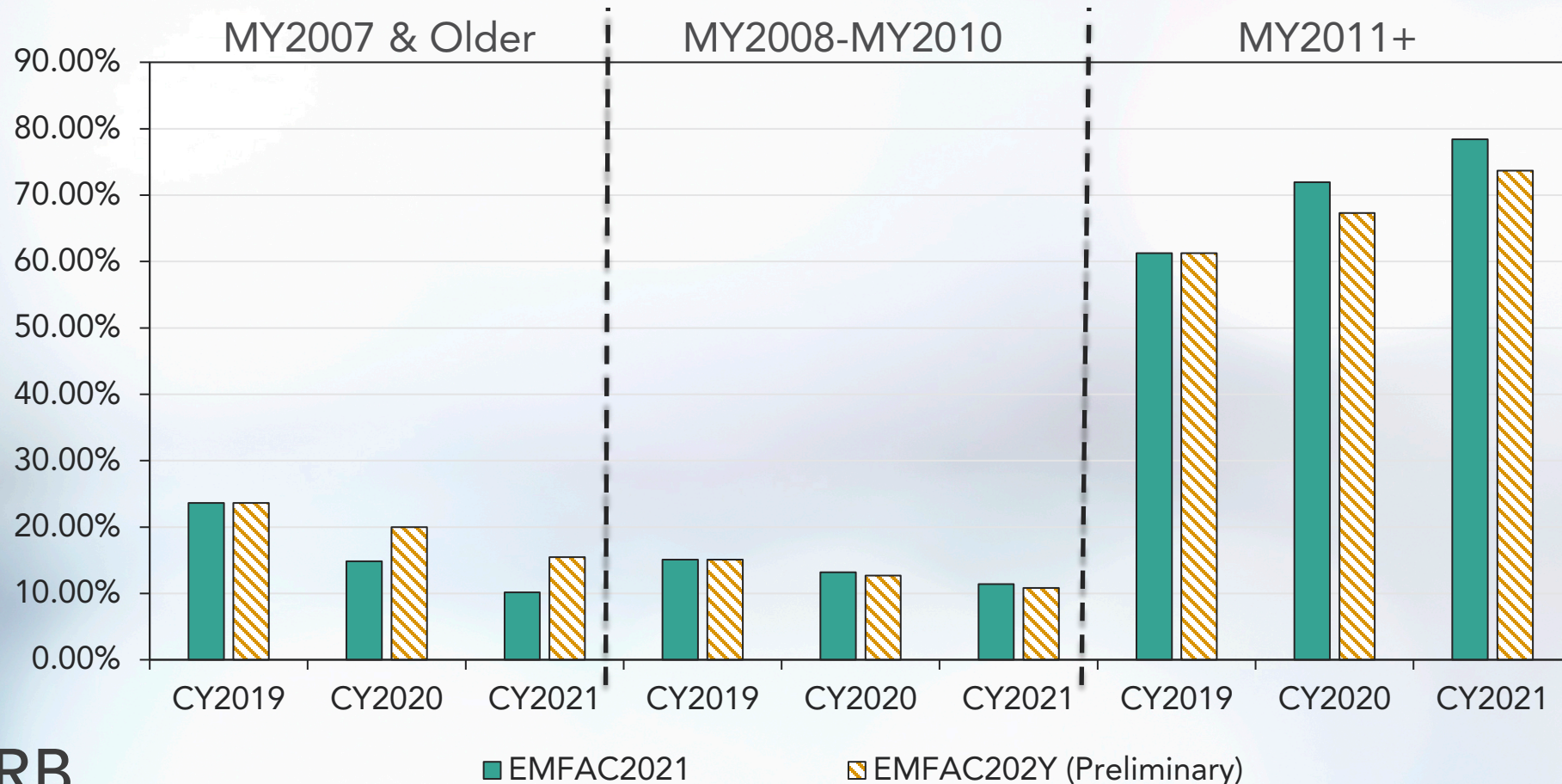
Truck and Bus Regulation Compliance Dates of Diesel T6 Class 4-6 (CA DMV as of Oct. 2021)
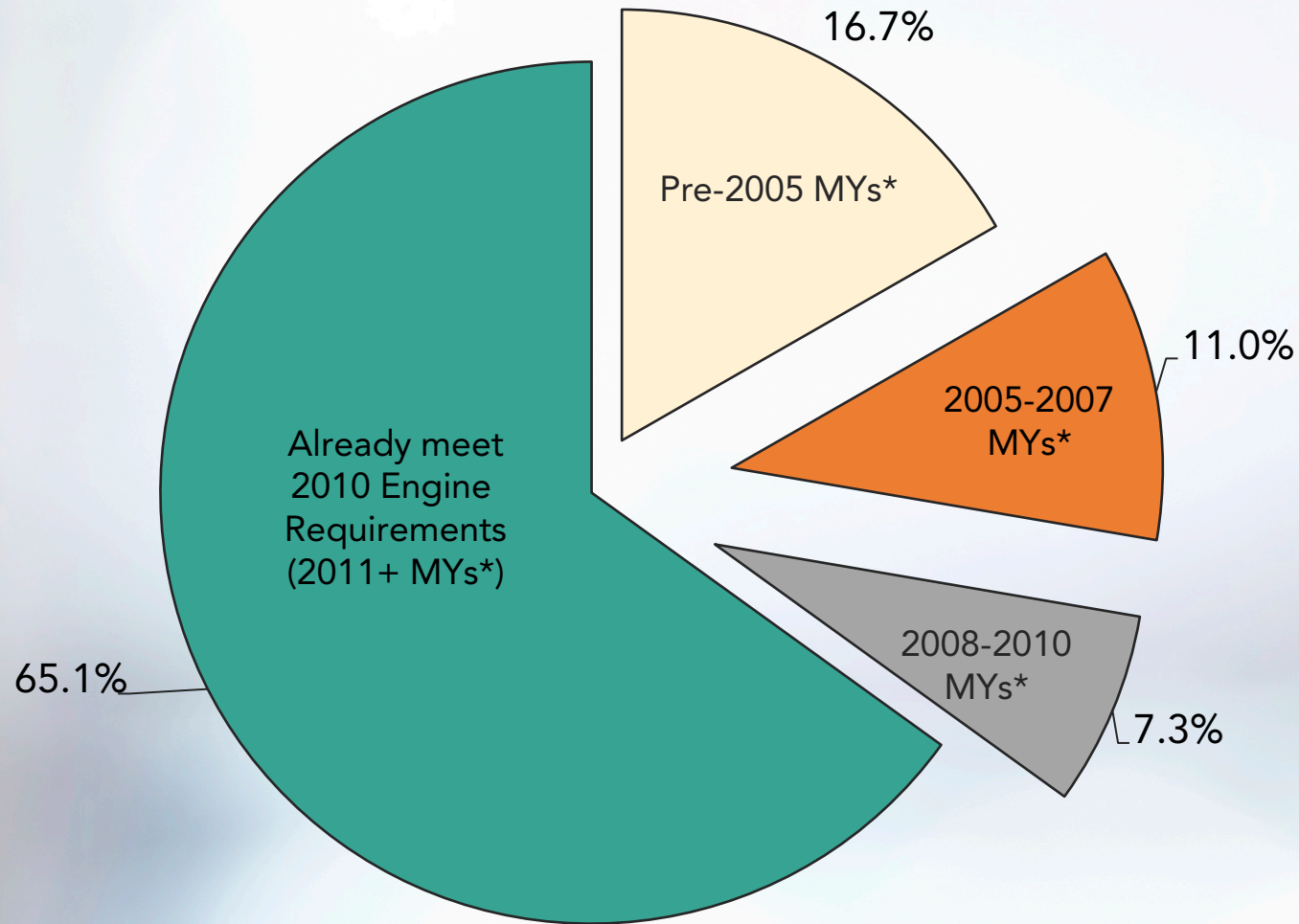
16.7% — Pre-2005 MYs*

11.0% — 2005-2007 MYs*

Already meet 2010 Engine Requirements (2011+ MYs*)

65.1%

2008-2010 MYs*

7.3%

*Diesel Vehicles Subject to Truck & Bus Rule were/are required to meet 2010 Engine Requirements by January 1st of these Calendar Years Unless they have an authorized exemption or are not subject to Rule***

- ▢ Prior to CY2021
- ▣ CY2021
- ▣ CY2023
- ▣ No Turnover Needed

**https://ww2.arb.ca.gov/sites/default/files/truckstop/tb/truckbus.html

*Chassis Model Years

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Truck and Bus Regulation Compliance Dates of Diesel T6 & T7 Class 7-8 (CA DMV as of Oct. 2021)
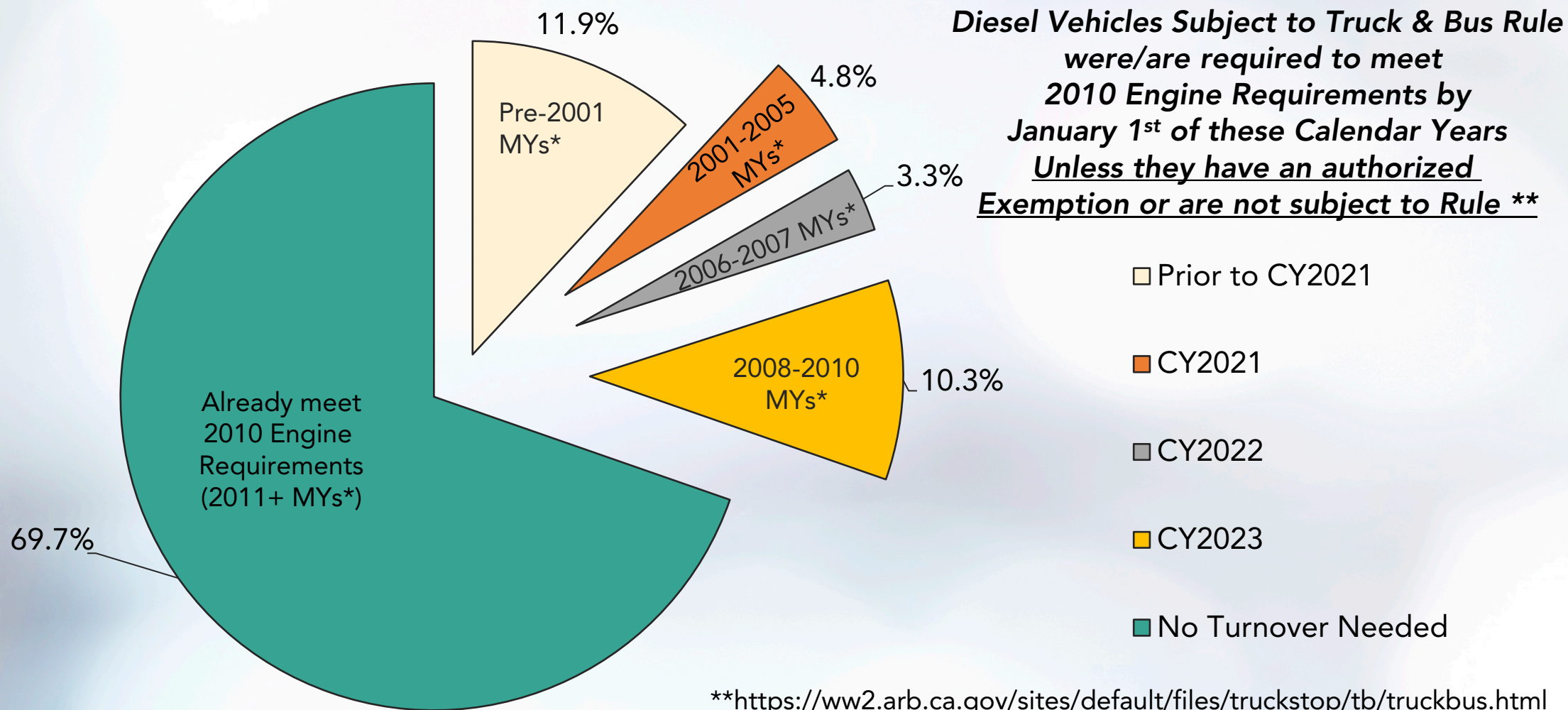
Proposed Changes to UBUS Population Methodology

Transit Bus Population (Based on CY 2020)
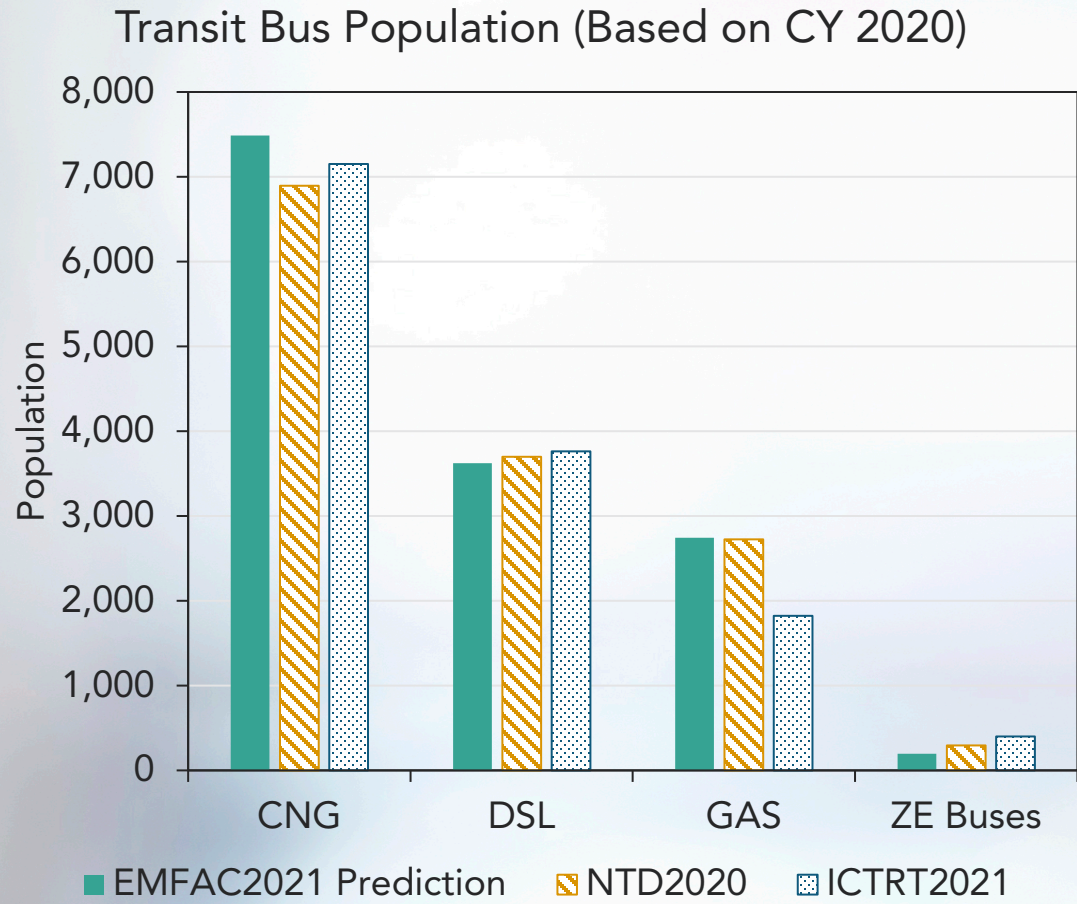
- EMFAC2021 relied on the National Transit Database (NTD) through CY2020 which covered only the agencies that received federal funding

- Proposing to use more comprehensive fleet data from Innovative Clean Transit Reporting Tool* (ICTRT)

  - Covers more agencies as every California transit agency must report into the ICTRT

*CARB, Innovative Clean Transit Reporting Tool & Data
https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit/reporting-tool-data

New Vehicle Category: T7 Rail Drayage Class 8

- Information provided by Union Pacific (UP) Railroad and Burlington Northern and Santa Fe (BNSF) Railway;

- Originally classified as T7 Tractor Class 8 (instate tractors) in EMFAC2021;

- Approximately 9,000 identified frequent visitors in CY2019.

Model Year Distribution in CY2019

CARB
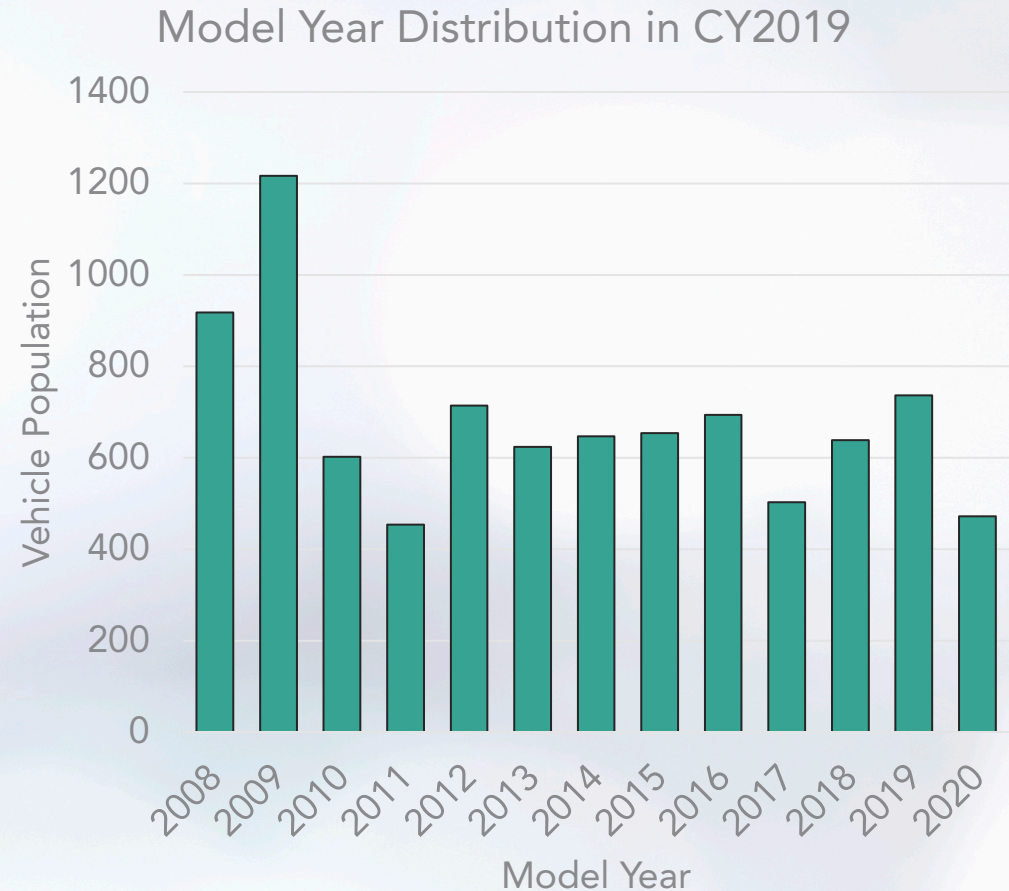
HD Fleet Characterization: Summary and Next Steps

- The updated historical inventory (population & VMT) for calendar years 2020-2022 will be finalized for use in EMFAC202Y;

- EMFAC202Y will forecast HDV inventory (population & VMT) for calendar years 2023+;

- Impacts of the updated inventory will be presented in a future EMFAC202Y workshop

CARB

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  - Background
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    - Heavy Duty Inspection and Maintenance
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- Question & Answer

- **Fleet Characterization**
  - Light-Duty (Population and New Sales)
  - **Heavy-Duty (Non-Gas Fueled)**
    - **Automated License Plate Reader (ALPR)**
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  - Heavy-Duty Activity and Forecasting
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- Question & Answer

CARB

Heavy-Duty Vehicles *(Non-Gas Fueled)*

Fleet Characterization: Automated License Plate Reader (ALPR)

CARB

Background on Out-of-State Fleet Characteristics

- Data sources on out-of-state fleets are limited

- Historically, EMFAC used mileage and all vehicles reported through IRP to calculate emissions from out-of-state vehicles in California

- Because IRP reports specify mileage, not number of vehicles, CARB has been unable to accurately identify which vehicles in IRP fleets operate in CA and their characteristics

- EMFAC assumes 100% compliance with Truck and Bus for out-of-state Class 7-8 vehicles.

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Information from ALPRs

- Collect Automated License Plate Reader (ALPR) data and link plates to out-of-state vehicles in IRP
  - Provides individual vehicle-level data
  - Corroborate previous inventory assumptions
- **Model Year (MY) Distribution:** Important for estimating deterioration of emissions controls systems and engine technology (e.g., 0.2 g/bhp-hr-certified)
- **Truck and Bus Regulation:** estimate compliance rates by determining the fraction of vehicles that meet model year requirements.

Near Blythe, CA

CARB

Automated License Plate Reader (ALPR) Data Collection

- CARB deployments of ALPR Systems*

- **Sample:** 60,000 *unique* heavy-duty out-of-state vehicles (300,000 out-of-state plates detected)

- **Period Considered here:** Jan – August 2022

- Data collected up to Fall 2023 will be considered for EMFAC202Y.

*Map labels: Mountain Pass, I-5**, SR-99**, Mojave National Preserve, SR-60**, Van Nuys, Blythe, SR-47**, I-710, SR-103, Calexico*
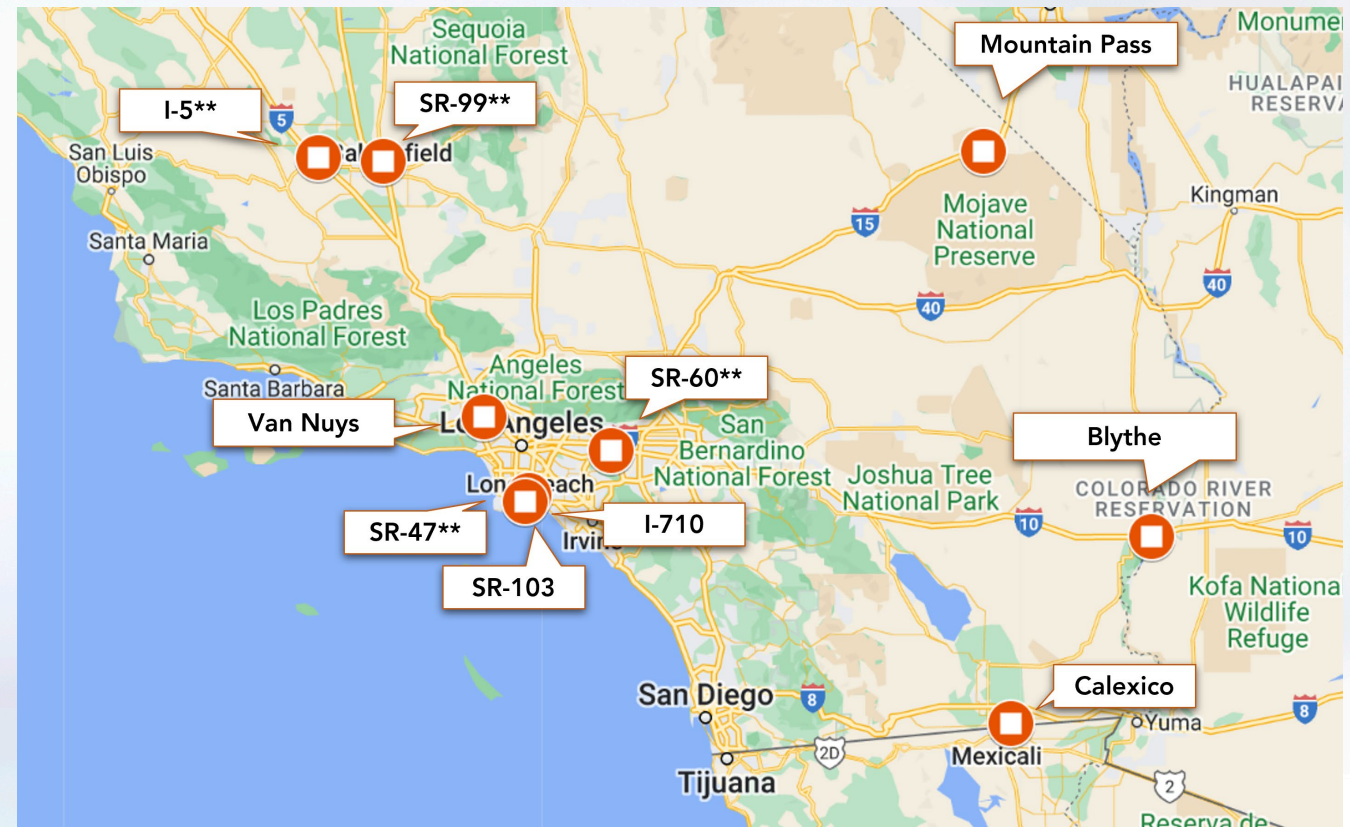
* ALPR Privacy and Usage Policy (2017)
https://ww2.arb.ca.gov/sites/default/files/2021-07/arb_alpr_privacy_usage_policy_050317.pdf
** Just installed; data analysis pending.

Preliminary Results: Out of State Vehicle Model Year Distribution

Neighboring Out-of-State (NOOS*) Class 8 (HHD) Vehicles

Larger fraction of age 0-3 vehicles

Small fraction of older pre-MY2000

- - - EMFAC2021 - CY2022
—— ALPR

Non-Neighboring Out-of-State (NNOOS) Class 8 (HHD) Vehicles

Slightly larger fraction of Age = 0 vehicles

Small fraction of older pre-MY2000

- - - EMFAC2021 - CY2022
—— ALPR
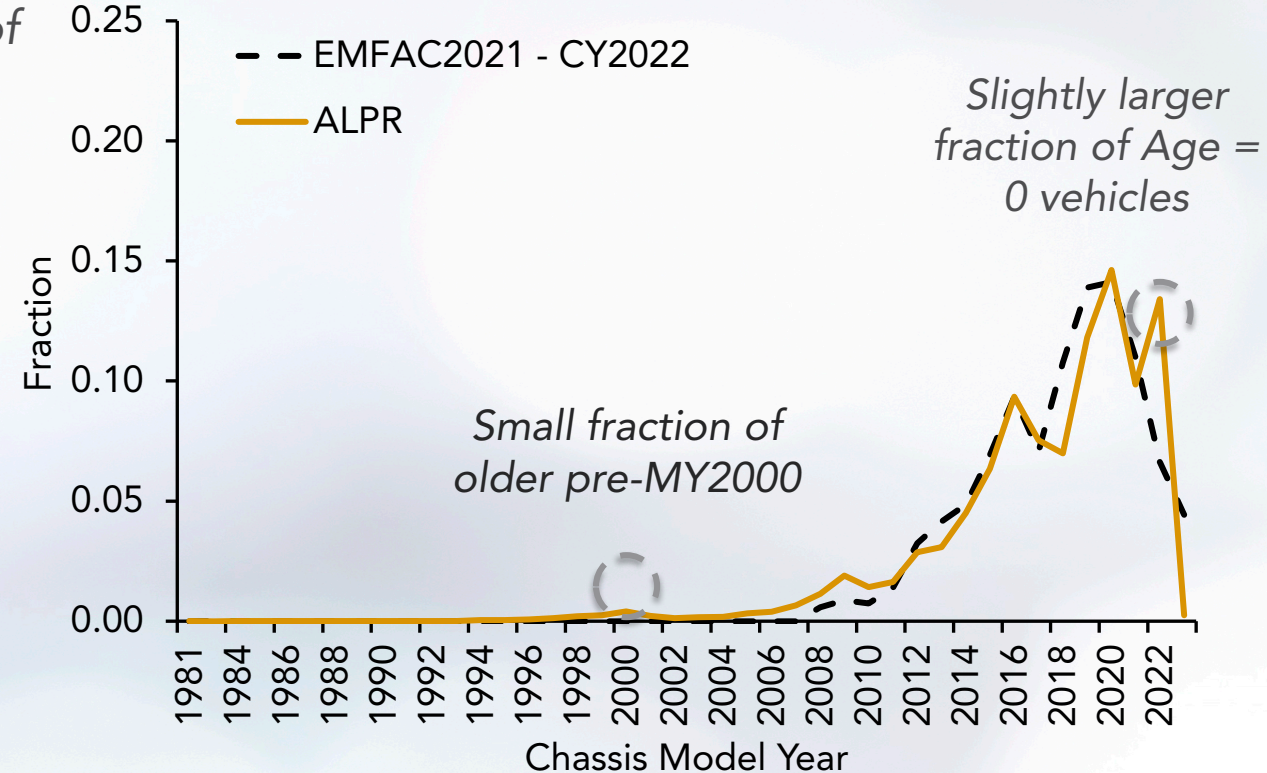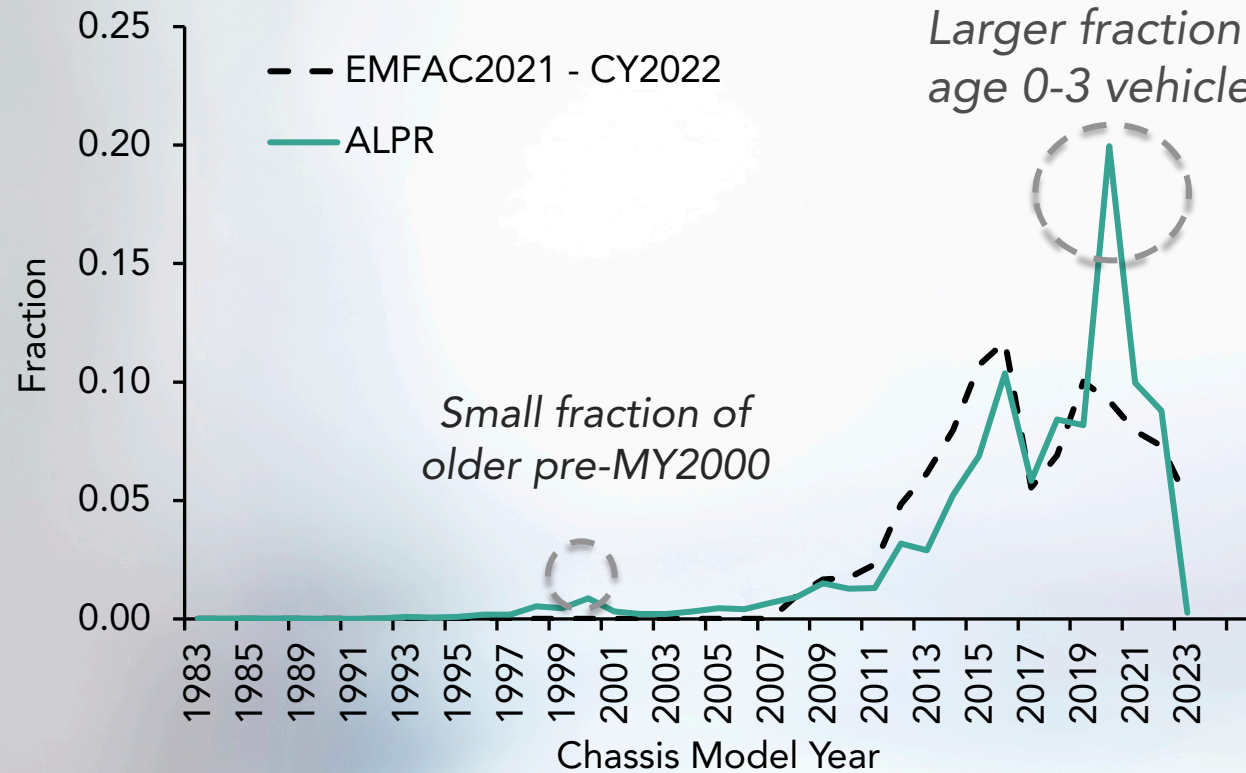
Overall, ALPR predicts a slightly newer fleet than EMFAC2021
→ Less deterioration of the emissions controls systems

* NOOS = NV, AZ, ID, OR, WA, BC

Truck and Bus Compliance Rates for Out-of-State Fleets (Class 7-8 Diesel Trucks) using ALPR
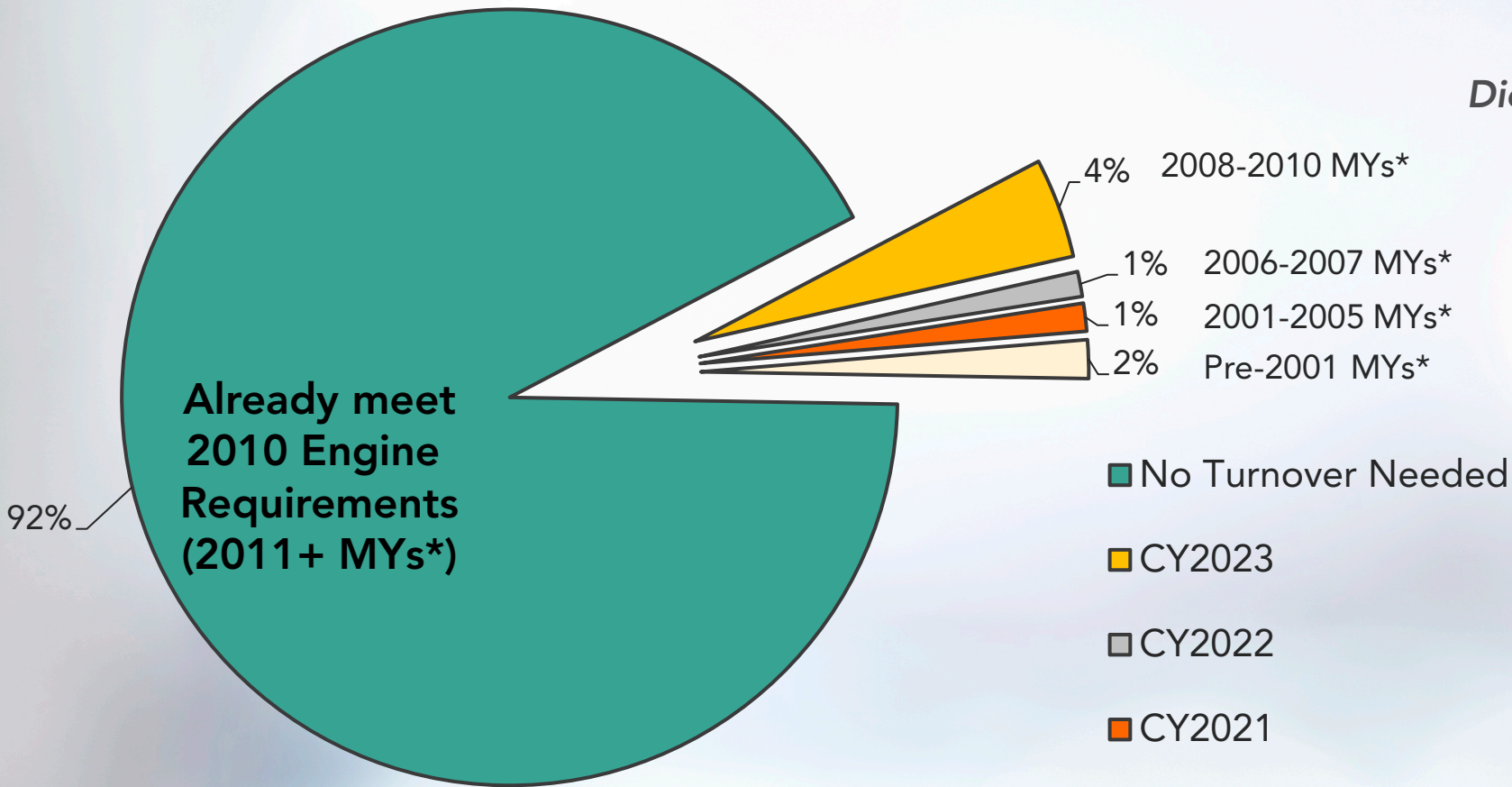
4% 2008-2010 MYs*

1% 2006-2007 MYs*

1% 2001-2005 MYs*

2% Pre-2001 MYs*

Diesel Vehicles Subject to Truck & Bus Rule were/are required to meet 2010 Engine Requirements by January 1st of these Calendar Years Unless they have an authorized exemption or are not subject to Rule.

Already meet 2010 Engine Requirements (2011+ MYs*)

92%

- No Turnover Needed
- CY2023
- CY2022
- CY2021
- Prior to CY2021

*Chassis Model Years

Overall Compliance Rate in 2022: 96% (considering exemptions)

ALPR Summary and Next Steps

- Current EMFAC assumptions for out-of-state model year distributions are consistent with observed ALPR data;

- Additional systems are now installed and analysis pending for SR-99 + I-5 (Kern County), SR-47 (Los Angeles County) and on SR-60 (San Bernardino County);

- Analyze ALPR data from CARB's Portable Emission Acquisition Systems (PEAQS), including those deployed in support of HD I/M;

- CARB staff will track out-of-state model year distributions through 2022 and update base year model year distributions;

- Staff is considering updates to Truck and Bus regulation compliance rates for out-of-state trucks based on ALPR and other data.

CARB

Agenda for AM Session

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  - Heavy-Duty
    - Heavy Duty Inspection and Maintenance
    - Advanced Clean Fleets
    - Federal Heavy-Duty Engine & Vehicle Standards
- Question & Answer

- Fleet Characterization
  - Light-Duty (Population and New Sales)
  - Heavy-Duty (Non-Gas Fueled)
    - Automated License Plate Reader (ALPR)
- **Vehicle Activity Profiles**
  - **Light-Duty Activity and Forecasting**
  - Heavy-Duty Activity and Forecasting
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- Question & Answer

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Light-Duty Vehicles
Vehicle Activity and Forecasting

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Statewide Light-Duty Vehicle Miles Traveled (VMT)

- EMFAC matches historical light-duty gasoline VMT with gasoline consumption in California (subtracting off-road uses)
- Data sources used in EMFAC2021
  - Gasoline consumption: California Department of Tax and Fee Administration (CDTFA) Motor Vehicle Fuel Tax data reports
  - Fuel economy: EPA (FuelEconomy.gov)
- For EMFAC202Y, staff is exploring data sources for calibrating historical statewide electric VMT

www.fueleconomy.gov
the official U.S. government source for fuel economy information

CARB

CDTFA
CALIFORNIA DEPARTMENT OF
TAX AND FEE ADMINISTRATION

Regional VMT Allocation

- EMFAC2017/2021: Used California Vehicle Activity Database (CalVAD) to allocate light-duty VMT to 69 Geographical Area Indexes (GAI) in California

- EMFAC202Y: Consider using Streetlight Data for VMT allocation in different GAIs

CARB

STREETLIGHT

Light-Duty VMT Forecasting in EMFAC2021

- Developed a multivariate regression model for forecasting statewide VMT growth
  - Performed Ordinary Least Squares (OLS) multivariate regression analysis on numerous combinations of economic variables
  - Investigated reasonableness of each combination and picked the best model
- Data sources for economic variables

Variable	Source
Human population and gross domestic product	Department of Finance, Jan 2020
Unemployment rate, housing starts, disposable income	UCLA Anderson Report, 2020
Gasoline price	California Energy Commission Fuel Prices Forecasts, 2019
Federal Rates	Federal Reserve Bank of St. Louis, 2019

Light-Duty VMT Forecasting Plan

- We are exploring different methodologies
    - Develop a multivariate regression model for statewide VMT forecasting (similar to EMFAC2021) with latest data available
    - Explore ways to reflect recent changes in travel behaviors
    - Explore the possibility of using forecasting data from Metropolitan Planning Organizations (MPOs) to estimate regional VMT growth rate

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Statewide Vehicle Population Forecasting

- In EMFAC2021 - new sales and retention rates of existing vehicles in fleet are standalone projections, while new and old vehicle markets interact in the real world
  - New sales are forecasted based on macro-economic variables
  - Retention rates are based on historical DMV data & static for future years
- For EMFAC202Y - dynamic vehicle population forecast model (UCSD contract #21AQP018)
  - Simulate interactions between new sales and retention rates
  - Consider the impact of vehicle price and regulations
  - Match the macro-economic forecast of VMT
- CARB staff will evaluate contract deliverables before incorporating the forecast results into EMFAC202Y

CARB

ZEV and PHEV Market Share Forecasting

CARB staff plans to forecast statewide ZEV* and PHEV market share based on the new-sales-based compliance scenario of automakers under ACC II

ACC II ZEV Requirement for Light-Duty Vehicles
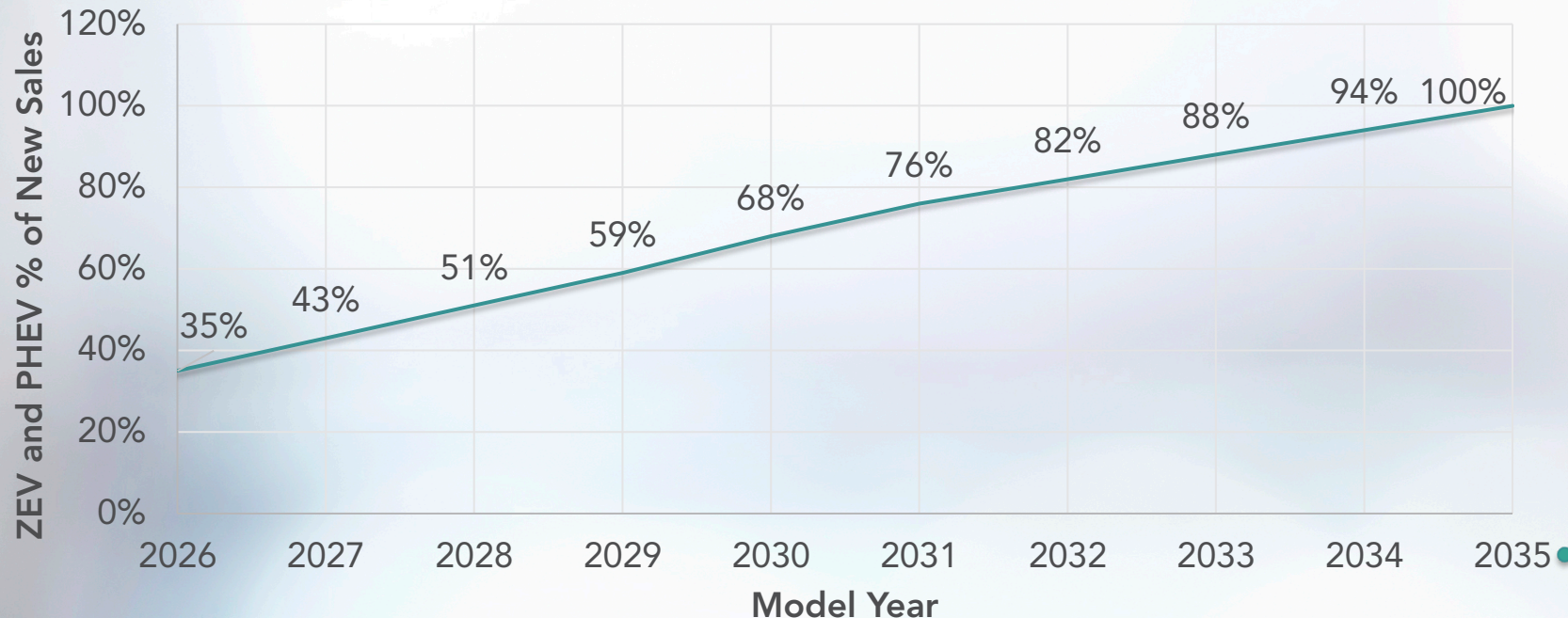
*ZEV includes Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV)

CARB

ZEV and PHEV Market Share Forecasting

- Statewide ZEV and PHEV market share

Interpolation between 2022 base year and 2026 ACC II scenario	ACC II Compliance Scenario (35% in 2026)	The market share of ZEV and PHEV stays 100%
2023–2025	**2026–2035**	**2035–2050**

- Regional ZEV and PHEV market share forecasting: CARB anticipates developing a contract to forecast regional variation in ZEV adoption

CARB

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    - Advanced Clean Cars II
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  - Heavy-Duty
    - Heavy Duty Inspection and Maintenance
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Heavy-Duty Vehicles
Vehicle Activity and Forecasting

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Background on EMFAC2021 HD Activity

- EMFAC2021 updated annual mileage accrual rates that represents average miles driven using Caltrans 2018 Survey and Geotab Telematics data*;

- EMFAC2021 also updated odometer schedules that represent the average cumulative vehicle mileage accrued by a given age based on Caltrans 2018 Survey data;

- Historical taxable diesel fuel sales** were used to normalize statewide VMT such that modeled fuel usage matched historical fuel sales for 2000-2019;

- EMFAC2021 used Portable Activity Measurement System (PAMS) to update idle hours, soak time and speed distributions.

*Heavy-Duty Vehicle Accrual Rates, Eastern Research Group, Inc. June 2019
https://ww2.arb.ca.gov/sites/default/files/2021-03/erg_finalreport_hdv_accruals_20190614_ada.pdf
**California Department of Tax and Fee Administration (CDTFA)
https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts.htm

CARB

HD Activity Forecasting in EMFAC2021

- EMFAC2021 adopted the same method to project HD new sales growth from EMFAC2017 with updated data;

- VMT forecasting was done using the California Statewide Travel Demand/Freight Forecasting Model (CSTDM/CSFFM) and other sources:

Forecasting Data	Source
New Vehicle Sales	Annual Energy Outlook (AEO) from the U.S. Energy Information Administration (EIA)
Generic HD VMT Forecasting	California Statewide Travel Demand/Freight Forecasting Model (CSTDM/CSFFM)
Drayage VMT Forecasting	Mercator International Forecast, 2016; Tioga Report*, 2020
Construction and Motor Coach Buses	UCLA Anderson Report, 2020

*The Tioga Group, 2019-2050 Bay Area Seaport Forecast, Prepared for SF Bay Conservation and Development Commission
https://www.bcdc.ca.gov/seaport/2019-2050-Bay-Area-Seaport-Forecast-Draft.pdf

CARB

Plan to Update EMFAC202Y HD Activity

- For EMFAC202Y, CARB staff plans to examine
  - Updated VMT and forecasting methods based on most recent data (e.g., fuel sales, fleet turnover);
  - Improved spatial resolution of truck activity;
  - The impact of COVID-19 on freight movement.

Monthly Twenty-foot Equivalent Units at the San Pedro Bay Ports (SPBP)

28%
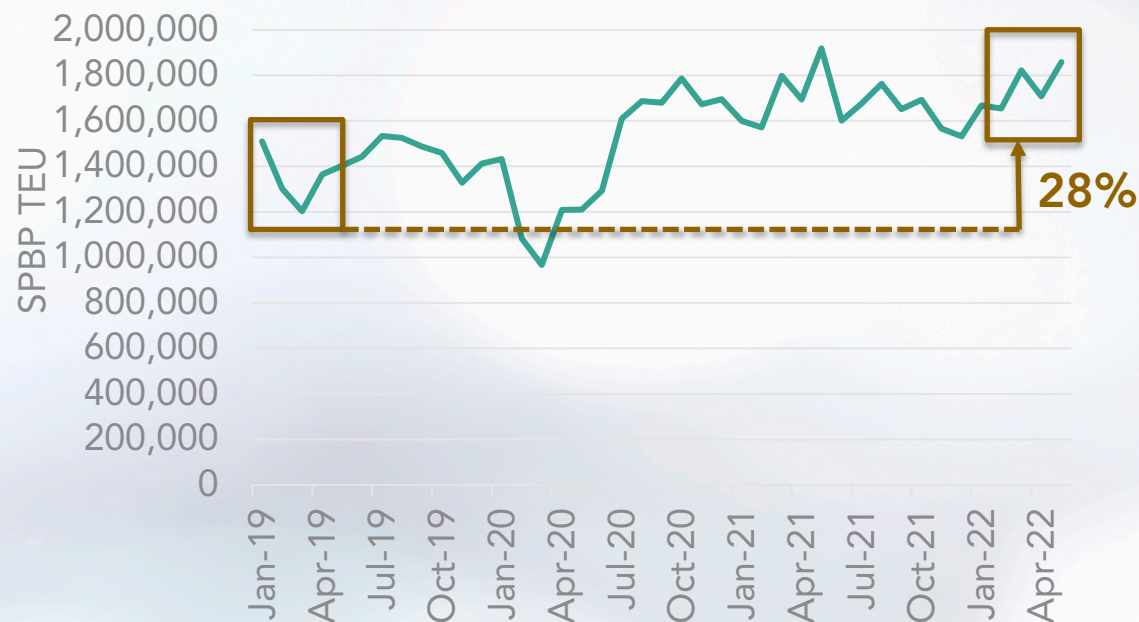
CARB, Emissions Impacts of Freight Movement Increases and Congestion near Ports of Los Angeles and Long Beach: June 2022
https://ww2.arb.ca.gov/sites/default/files/2022-06/SPBP_Freight_Congestion_Emissions_30JUN2022.pdf
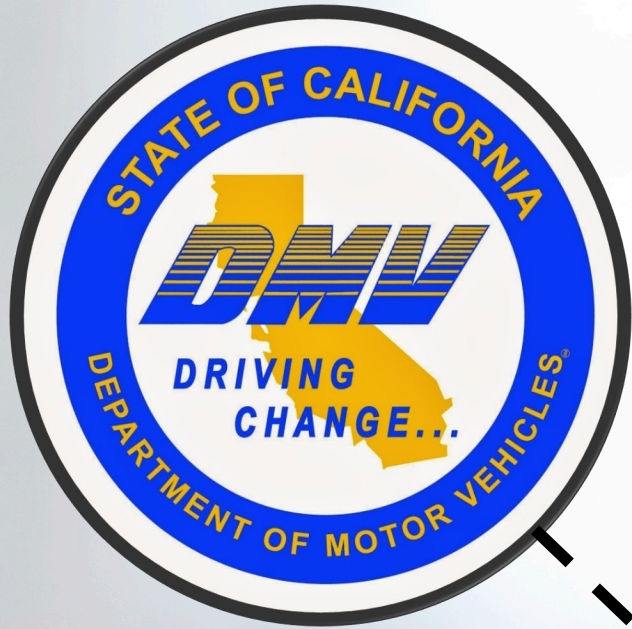
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Vehicle Activity from "Big Data" Platform

Location-Based Services Data Location
Circle radii vary: they accurately reflect the spatial precision of each unique data point

Navigation-GPS Data Location
Circle enlarged for visibility

Real-world vehicle operations, activities, and characteristics with desired temporal and geographic resolution.

Streetlight InSight: Our Methodology and Data Sources, Oct 2018
https://www.streetlightdata.com/wp-content/uploads/StreetLight-Data_Methodology-and-Data-Sources_181008.pdf

- Activity data from CY2019 to CY2021:
  - Monthly County-Level VMT in California, breakdown by passenger vehicles, commercial light-duty trucks, commercial medium heavy-duty trucks and commercial heavy heavy-duty trucks;
  - Daily average routes and origin/destination matrices of commercial trucks.
- Update HD VMT allocation and interregional travel assumptions for EMFAC and community inventories.

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Fleet Turnover Considering Financial Factors

- Using DMV October snapshots of calendar years 2017-2019

- Evaluating HD trucks survival rates based on fleets financial metrics

- D&B provides fleet financial information based on registered name and address

- CARB staff is improving match quality by using similarity between DMV and D&B name/address

dun & bradstreet

VIN	...	Address	Business Name	Address	Business Name	...	Financial

Joint Database →

VIN	...	Address	Business Name	...	Financial

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HD Activity: Summary and Next Steps

- Analyze and compare activity data from Streetlight to other sources (CSTDM, MPOs)

- Acquire other high resolution activity data (e.g., General Transit Feed Specification, ALPR)

- Evaluate impact of Truck & Bus Rule on truck survival (in DMV);

- Analyze PAMS data collected through CARB Agreement 21RD007 (100 vehicles);

- Update fleet turnover rates based on fleet type while considering the impact of new regulations.
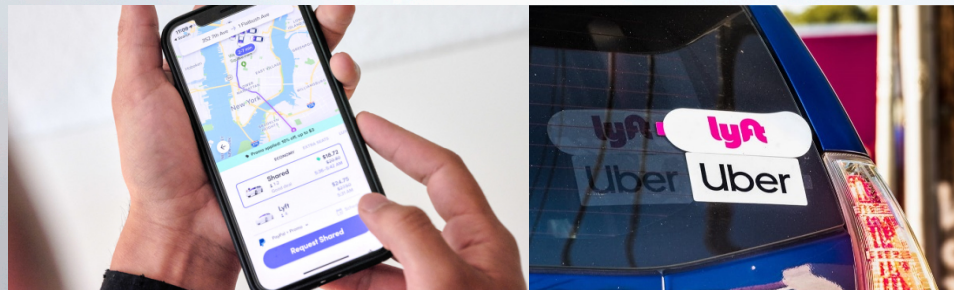
CARB

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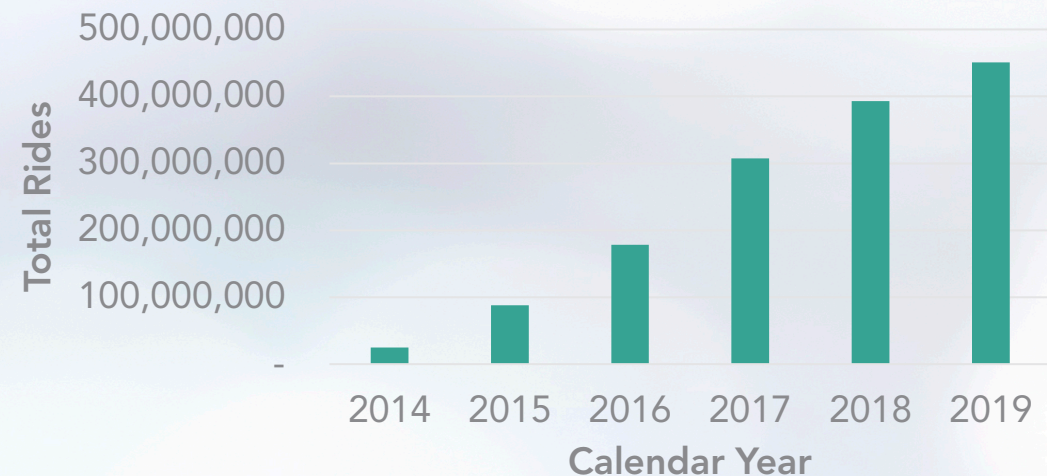- Question & Answer

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Light-Duty Vehicles
Transportation Network Company (TNC) Fleet

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Transportation Network Company (TNC)

- TNCs are defined by the California Public Utilities Commission (CPUC) as companies or organizations that provide transportation services using an online-enabled platform to connect passengers with drivers using their personal vehicles

- Fleet population and number of rides steadily grew from 2014 through 2019

- TNCs are a new mobility option for Californians

TNC Number of Rides

Total Rides axis: 500,000,000 / 400,000,000 / 300,000,000 / 200,000,000 / 100,000,000 / -

Calendar Year: 2014 2015 2016 2017 2018 2019

Source: CPUC

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Clean Miles Standard (CMS) Regulation

- Require TNCs to reduce greenhouse gas emissions and increase percentage of eVMT
- Adopted in May 2021
- Effective beginning in January 2023

CO2 Emissions per Passenger Mile Traveled (PMT) Targets

Electrification Targets

Plan for TNC in EMFAC202Y

- CARB staff plans to incorporate TNC vehicles as a dedicated vehicle category

- Historical population and VMT will be based on annual data reports from CPUC

- Future activity forecasts will consider historical trends

- Electric VMT forecasts will reflect the adoption of CMS

CARB

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Question & Answer

- Please raise your hand if you would like to ask a question
  - Include slide numbers, if possible
  - In Zoom: Use "Raise Hand" feature
  - On phone:
    - #2 to "Raise Hand"
    - *6 to Unmute/Mute
- Additional questions may be submitted after today to: emfac@arb.ca.gov

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Lunch Break
Afternoon session starts at 1:00 PM

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Agenda for PM Session

- **Emission Rates**
  - **Light-Duty Vehicles**
    - **Light-Duty Vehicles and On-Road Motorcycles**
    - Temperature, Humidity and Air Conditioning (AC) Correction Factors
    - Evaluation of Reid Vapor Pressure (RVP) Input
  - Light Heavy-Duty Vehicles
  - Medium/Heavy Heavy-Duty Vehicles
    - Speed Correction Factors
- Energy Consumption
- Closing Remarks
  - Timeline and Next Steps
- Question & Answer

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Light-Duty Vehicles
Emission Rates

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Light-Duty Vehicle Emission Rates

EMFAC Exhaust Emission Rates

- Chassis dynamometer data is cumulatively collected from vehicles tested in previous LD Vehicle Surveillance Programs (VSP), adding new model years with each program
- Additional emissions test data will update EMFAC202Y estimates for MY 2017+ vehicles

EMFAC Evaporative Emission Rates

- EMFAC2017 and earlier
  - Based on certification processes of Diurnal and Resting Loss, Running Loss and Hot Soak
- EMFAC2021 adopted USEPA MOVES 2014b method
  - Uses CA-specific activity and meteorological data
  - Models three physical processes: tank vapor venting, permeation and liquid leak
  - More data to be collected for EMFAC202Y

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Update Light-Duty Vehicle Emission Rates

Current Surveillance Data Available

- Data not included in EMFAC2021
- 32 LD passenger cars and trucks
- MY 2017-2019 includes tech groups ULEV125, ULEV70, ULEV50 and SULEV30

Upcoming LD Vehicle Surveillance Program

- Target is 60 LD vehicles
- Passenger cars and trucks up to 8,500 lbs GVWR
  - 2 pre-MY 2000, 2 post-MY 2000 models
  - 56 vehicles MY 2017+
- Chassis dynamometer tests
- On-road real-world PEMS testing

| Exhaust Tests	Special Testing

• Baseline Unified Cycle (UC) Test with NH3, PM and N2O;
• Baseline Federal Test Procedure (FTP);
• Starts Emissions tests after varying periods of soak time;
• Arterial and Freeway driving cycles
  • Represent speed bins
	40 Vehicles
	• Speciated emissions
	• Evaporative emissions
	  • Hot Soak
	  • Diurnal
	  • Running Loss

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LD PEMS Driving Routes
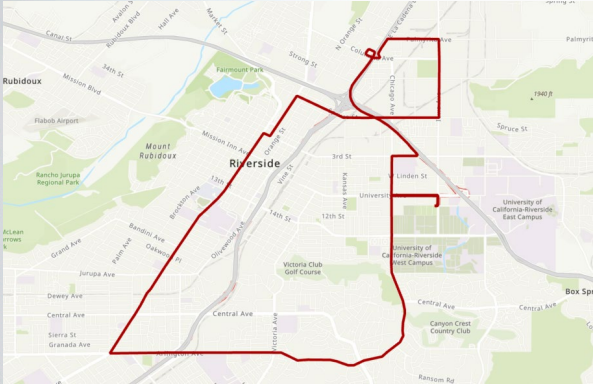
- **City Route (16 mi, 24 mph avg)**
  - Downtown Riverside area
  - Round trip from CARB laboratory
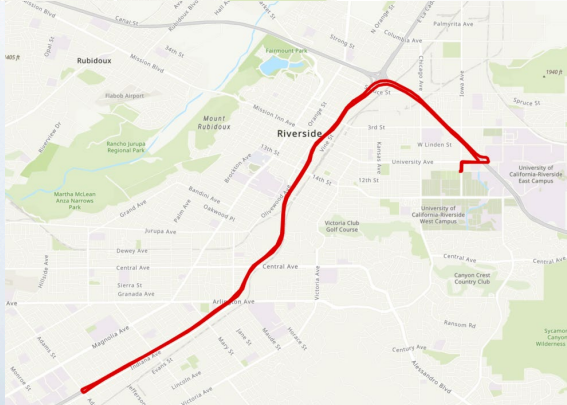
- **Freeway Route (17 mi, 48 mph avg)**
  - 60 and 91 freeways
  - Round trip from CARB laboratory
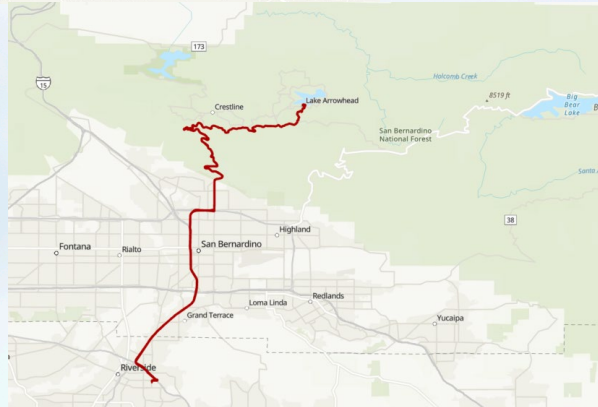
- **Mountain Route (71 mi, 40 mph avg)**
  - Round trip from CARB to Lake Arrowhead
  - Altitude gain of about 4150 ft

CARB

Light Duty Vehicles On-Road Motorcycles
Emission Rates

On-Road Motorcycles Background

- EMFAC2021 Emission Rates
  - Prior to EMFAC2021, emission factors have not been updated since 2000
  - Data from MY1978-80 exhaust FTP tests and 1998 UC tests (MY1998 and older)
    - Applied to MY2007 and older
  - Recent MCY project updated EMFAC2021 weighted emission rates
    - UC test data from 13 MY2008-2020 on-road motorcycles
      - 2 state-owned MCY in tampered and non-tampered condition
    - By odometer/mileage
    - Applied Non-tampered and tampered emission rates
    - Emission rate (grams per mile) =

        (Tamper emission)x(Tamper Rate) + (Non-Tamper emission)x(1 - Tamper Rate)

CARB

Update Motorcycle Emission Rates
Using Data from Upcoming Surveillance Project

- CARB intends to conduct extensive exhaust and evaporative testing
  - 3-year study beginning in 2023
- 25 On-road Motorcycles to be tested
  - MY 2018 and older data already collected
  - Target 2018 and newer from the CA in-use fleet
  - Class III (displacement > 280 cc)
    - About 90% CA DMV registration
  - Representative models by highest populations
  - Tampered testing
    - Online 2016-2020 MCY sales study on tampered parts
    - ~15% MCY tampers at age 1, increasing as vehicles age
    - EMFAC2021 includes tamper rates by age/mileage
   - More data will be collected

CARB

Motorcycle Emissions: Laboratory Testing

- **Exhaust Tests**
  - UC – results to be used to update motorcycle emission rates for EMFAC (Tech group MY2008+, Fuel Injected, Catalyst Equipped, gasoline)

  - FTP – data and test verification

  - World Motorcycle Test Cycle (WMTC) – collect research data to compare with upcoming regulation to harmonize with European Union (EU) standards

- **Evaporative SHED Tests**
  - 1-hour Hot Soak Test
  - Multi-day Diurnal Test
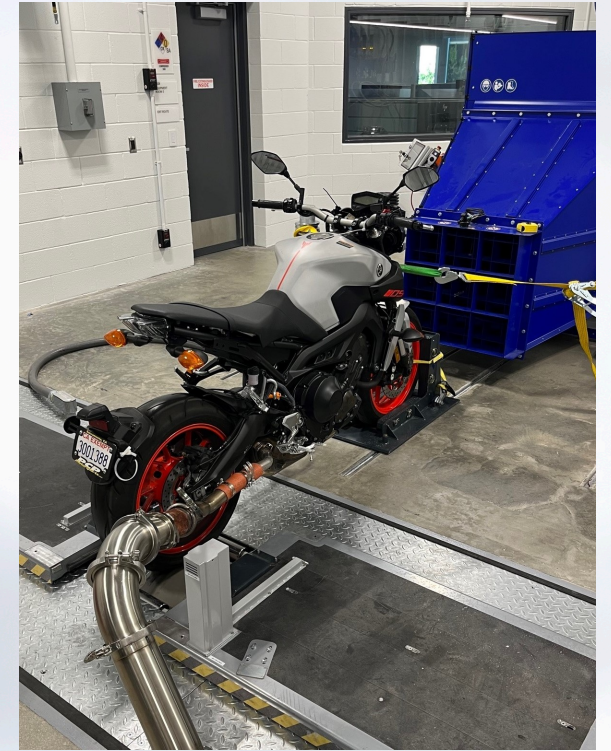
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Agenda for PM Session

- **Emission Rates**
  - **Light-Duty Vehicles**
    - Light-Duty Vehicles and On-Road Motorcycles
    - **Temperature, Humidity and Air Conditioning (AC) Correction Factors**
    - Evaluation of Reid Vapor Pressure (RVP) Input
  - Light Heavy-Duty Vehicles
  - Medium/Heavy Heavy-Duty Vehicles
    - Speed Correction Factors
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- Question & Answer

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Light-Duty Vehicles

Emission Rates: Temperature, Humidity and Air Conditioning (AC) Correction Factors

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EMFAC Default

- For catalyst equipped gasoline light-duty vehicles, all criteria pollutants except PM, temperature correction factor (TCF) is calculated as:

$$TCF = 1 + A \times (Temp - 75) + B \times [(Temp - 75)]^2 + C \times [(Temp - 75)]\text{^3}$$

- For all other vehicles and all criteria pollutants except PM, if temperature ≤ 75 °F:
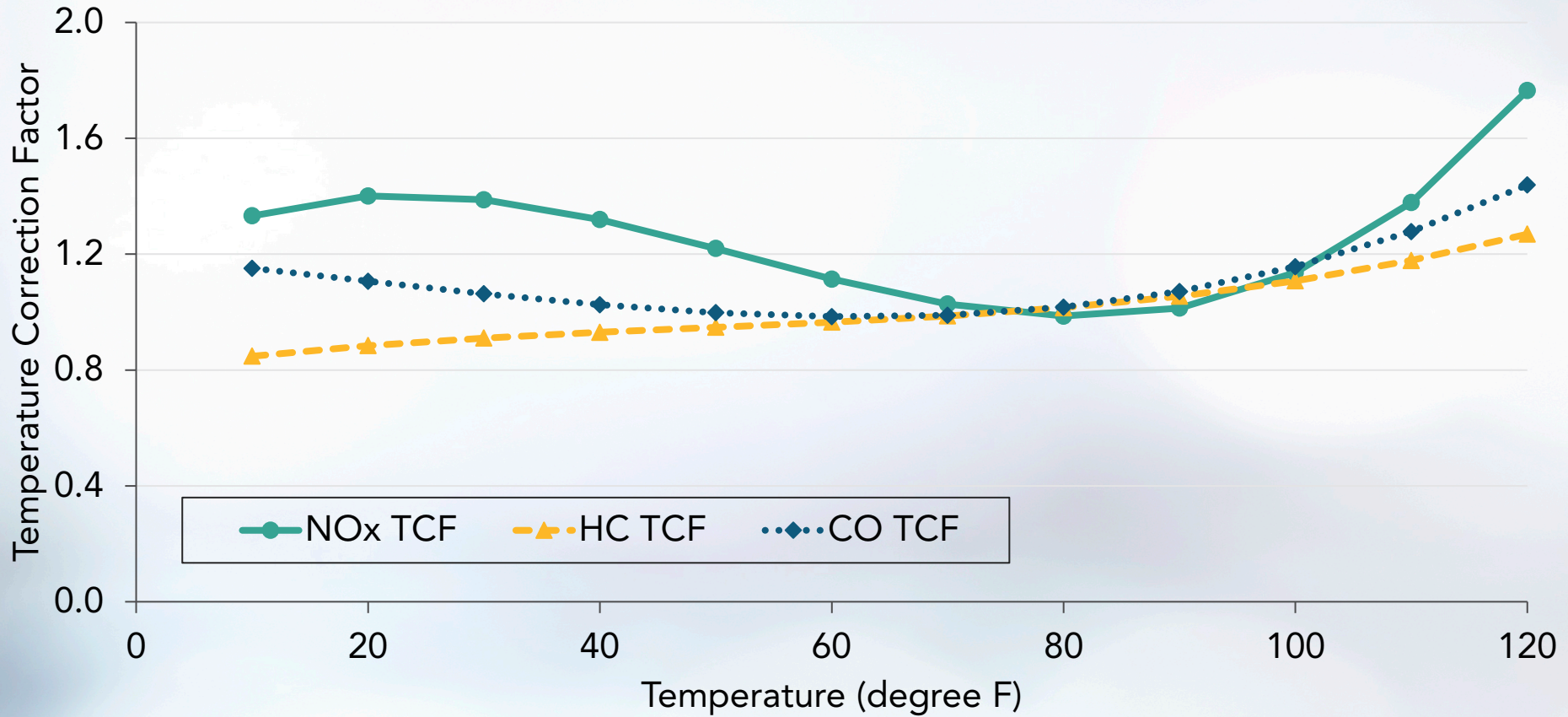
$$TCF = EXP[A \times (Temp - 75)]$$

- For all other vehicles and all criteria pollutants except PM, if temperature ≥ 75 °F:

$$TCF = EXP[B \times (Temp - 75)]$$

- The coefficients are dependent on technology groups, mode and pollutant

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Example EMFAC Default Temperature Correction Curves for SULEV30

Comparison with MOVES3 Model

- U.S. EPA found no evidence of a temperature effect for THC, CO, and NOx running exhaust between 5 and 95°F from test data of hundreds of vehicles with model year range of 1987-2010

- MOVES3 sets temperature adjustments for THC, CO and NOx running exhaust for all gasoline vehicles equal to 1, regardless of actual temperature and vehicle class

CARB

Changes to EMFAC Emissions

- Staff proposes to update temperature corrections in EMFAC202Y on gasoline HC, CO, and NOx running emissions

- Consistent with EPA MOVES model:

  - TCF for PM running exhaust = 1 in EMFAC2021

  - No change to start temperature corrections in EMFAC202Y

- Light-duty gasoline running exhaust emissions change relative to default EMFAC2021:

HC	CO	NOx
2.1%	0.2%	−8.3%

- Next step:
  - Validate running exhaust TCF in new test plan

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Temperature, Humidity and AC Correction Tests

- Subset of 5 LD vehicles to be tested as part of VSP

- Test Cell set at 4 Temperatures
  - 50-, 75-, 95- and 105-degrees F
  - Staff will investigate emissions impact at each temperature, at different relative humidity settings
  - Update and validate EMFAC Temperature and Humidity Correction Factors

- UC Tests with AC on and off
  - At simulated outside ambient temperatures
  - Analyze the impact of AC usage on emissions
  - Update and validate EMFAC AC Adjustment Factors
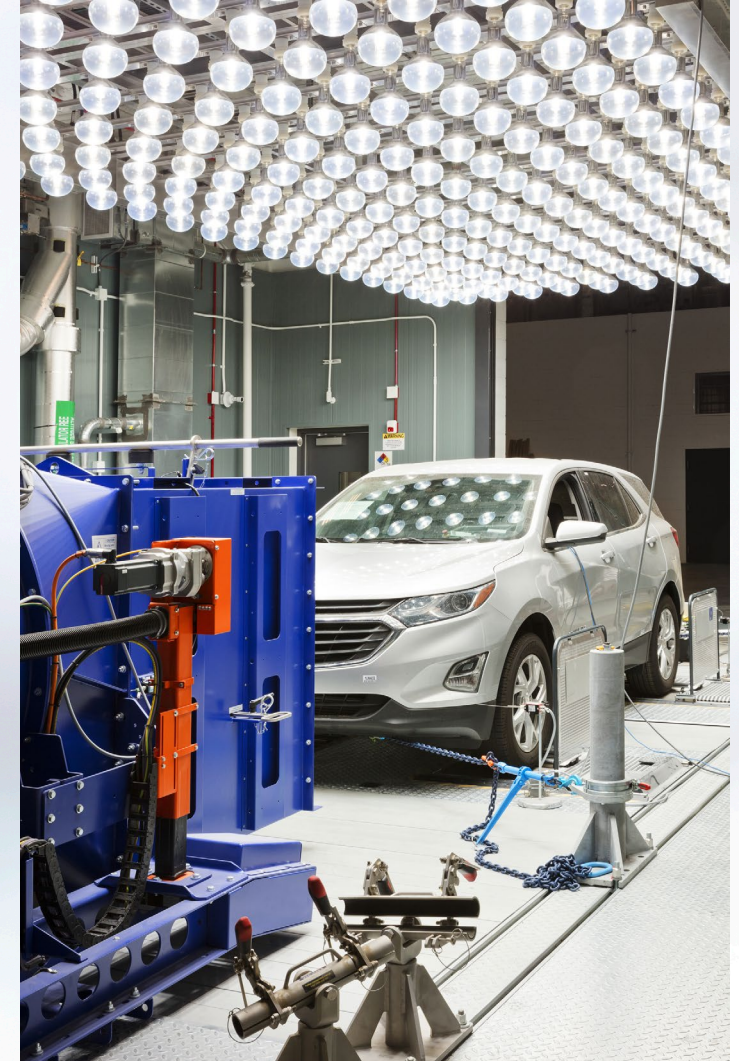
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Light-Duty Vehicles

Emission Rates: Evaluation of Reid Vapor Pressure (RVP) Input

Evaluation of RVP Input

- RVP: A common measure of and generic term for gasoline volatility

- Beginning in 1996, State regulation* requires that gasoline meets lower-volatility (less than 7.0 RVP) requirements in the summer ozone months

- EMFAC RVP input varies by month and air basin; was last updated in EMFAC2002.

- RVP influences evaporative, not exhaust, emissions rates

- For EMFAC202Y, staff plans to evaluate whether RVP input tables need updating based on more recent field samples

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* Title 13, California Code of Regulations §2262.4

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Light Heavy-Duty Vehicles
Emission Rates

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Light Heavy-Duty Vehicles (LHD)

- Class 2b – 3 vehicles with GVWR 8,501 to 14,000 lbs

- Either chassis or engine certified; > 95% chassis certified

- Further divided into two groups

  - LHD1: 8,501-10,000 lbs (MDV4 under LEV regulations)

  - LHD2: 10,001-14,000 lbs (MDV5 under LEV regulations)

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Heavy-Duty Truck Emissions Modeling

$$ER(g/mi) = (ZMR + DR^* \times Odometer) \times SCF$$

- **ZMR** (Zero-mile Emission Rate) – Fleet average UDDS emission rates for new trucks
- **DR** (Deterioration Rate) – Increase in emissions of in-use fleet over time
- **SCF** (Speed Correction Factor) – For determining emission rates at different driving speeds

* MHD and HHD NOx deterioration for engine model year 2013+ are represented by a power function

CARB

Review of EMFAC2021 LHD Emission Rates

- Updated emission rates using dynamometer data
- Updated ZMR & DR and SCFs using dynamometer data of multiple test cycles with different average speeds

Vehicle	Model Year	Fuel	Weight Class	Emission Standard
Vehicle 1	2015	Diesel	LHD1	LEV3 ULEV340
Vehicle 2	2017	Diesel	LHD1	LEV2 ULEV
Vehicles 3 – 4	2015	Diesel	LHD1	LEV2 ULEV
Vehicles 5 – 6	2015, 2017	Diesel	LHD2	LEV2 ULEV
Vehicle 7	2015	Diesel	LHD2	LEV3 ULEV570
Vehicles 8 – 9	2015	Gasoline	LHD1	LEV3 LEV395
Vehicle 10	2015	Diesel	LHD2	LEV2 ULEV
Vehicles 11- 12	2006	Diesel	LHD1	ULEV

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# Planned Revisions to LHD Emission Rates in EMFAC202Y

- Revise start emissions using PEMS data

- Revise ZMR & DR using dynamometer and PEMS data

- Revise speed correction factors using dynamometer and PEMS data

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# CARB LHD Emissions Testing Since Release of EMFAC2021

- To date, (2) 2019 MY LHD1 gasoline, (6) 2017+ MY LHD1 diesel, (1) 2019 MY LHD2 gasoline, and (1) 2019 MY LHD2 diesel vehicles tested on dynamometer over 3 test cycles: FTP, US06, and Hot 1435 UC

- All vehicles also tested with PEMS on 3 routes

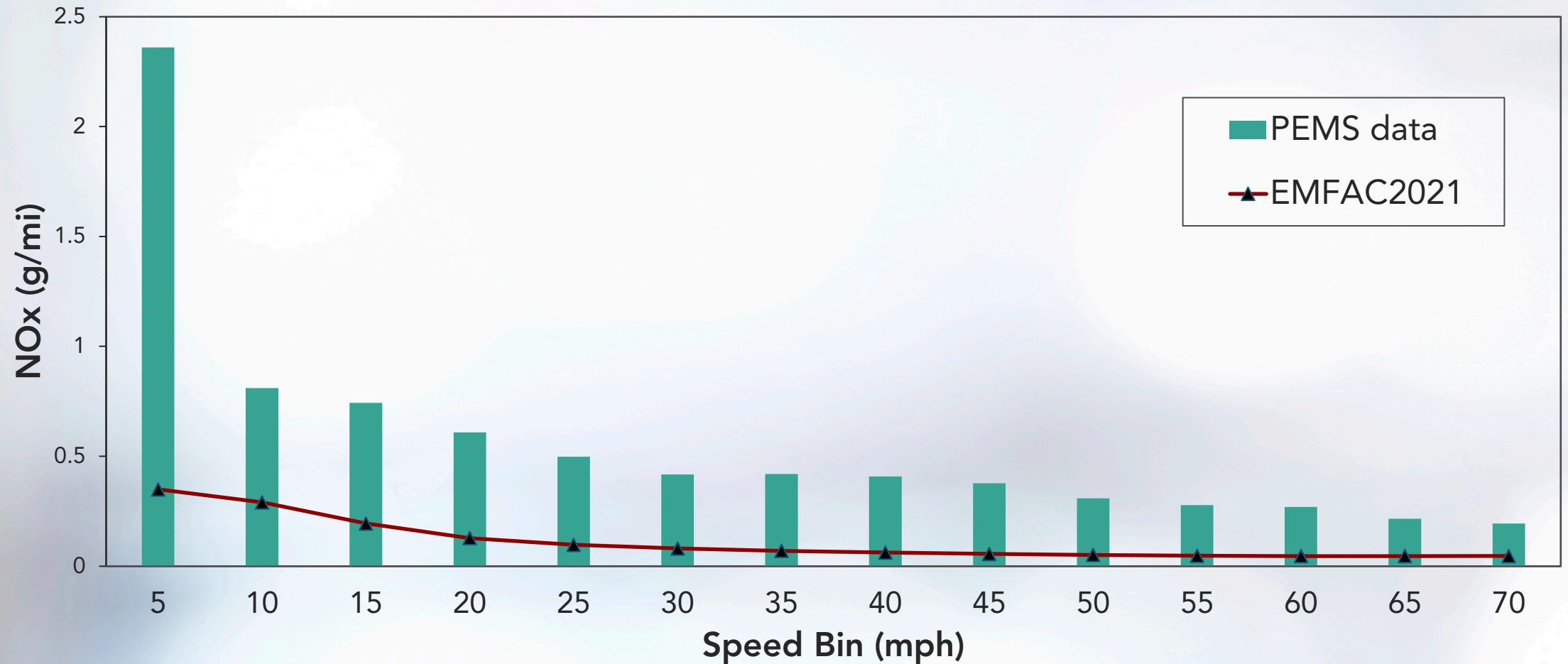| PEMS Route	Driving Type
Downtown LA	Urban
Oxnard	Freeway
Mt Baldy	Uphill / Downhill

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Preliminary Results: MY 2017 and Newer LHD NMOG+NOx (FTP Cycle)
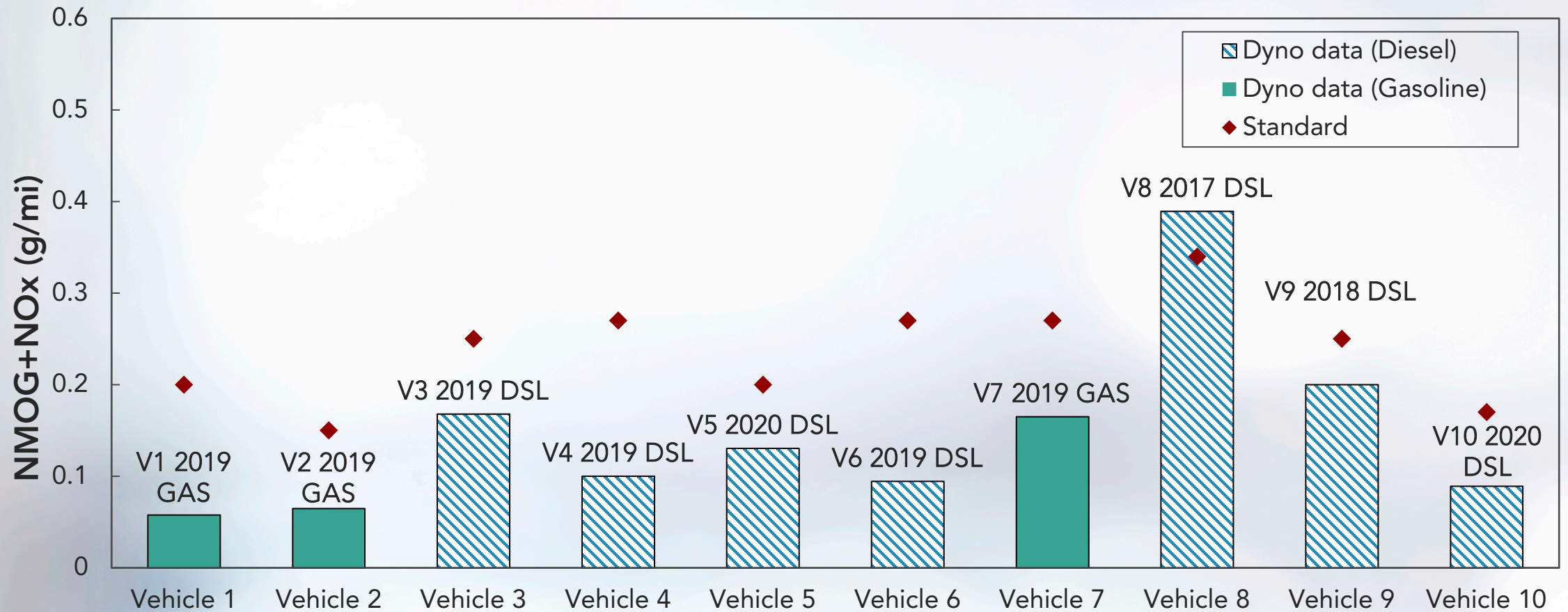
Preliminary Results: MY 2017 and Newer LHD PM (FTP Cycle)
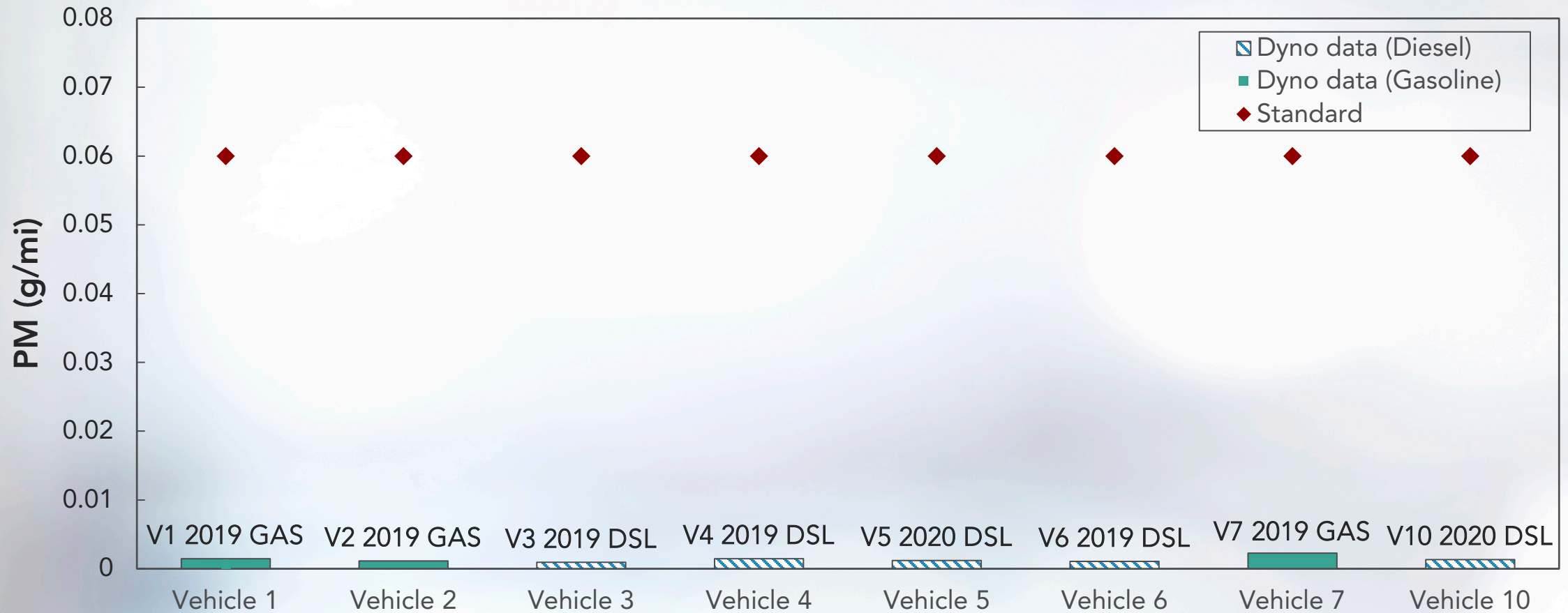
2017+ MY LHD1 Diesel PEMS NOx (Preliminary)

Next Steps: LHD Vehicle Surveillance Project

Exhaust Testing

- FTP with PM, NH3
- UC with PM, NH3
- Highway Fuel Economy Test Cycle
- Arterial and Freeway Driving Cycles
- 10 LHDs with MY2017+
  - 5 LHD1 vehicles, 4 DSL, 1 GAS
  - 5 LHD2 vehicles, 4 DSL, 1 GAS
- 4 MY2008- MY 2014 vehicles: High-mileage emissions study

PEMS Testing

- 14 vehicles
- Trailer Towing (4 vehicles):
  - LHD1, 1 DSL & 1 GAS
  - LHD2, 1 DSL & 1 GAS
- Impact of towing on emissions to be considered for modeling if significant

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Next Steps for LHD Emissions

- Ongoing LHD vehicle testing program at CARB
  - Additional data expected before EMFAC update cutoff date (Fall 2023)
- Explore new methodology for revising speed correction factors using PEMS data
- Explore new methodology for revising ZMR and DR based on dyno and PEMS data
- Determine whether correction for trailer/towing emissions should be incorporated

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Medium & Heavy Heavy-Duty Vehicles
Emission Rates

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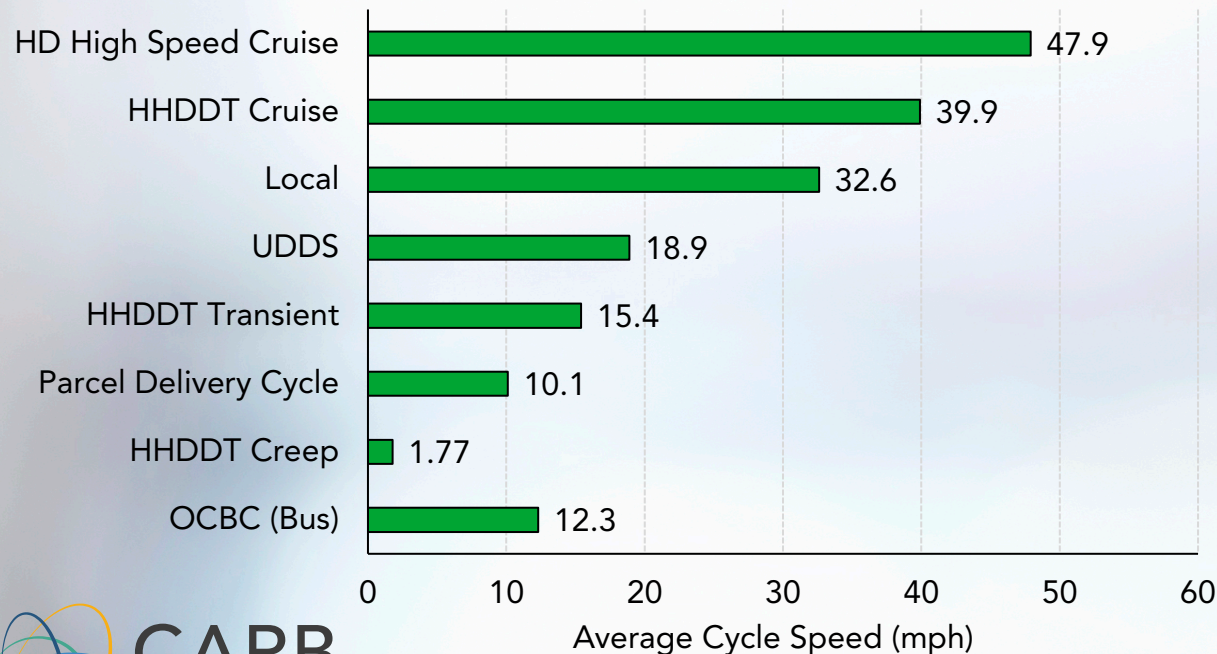# Medium Heavy-Duty (MHD) and Heavy Heavy-Duty (HHD) Vehicles

- Vehicles with GVWR from greater than 14,000 lbs
  - MHD: 14,001-33,000 lbs (Weight Class 4-7)
  - HHD: 33,001 lbs & over (Weight Class 8)
- Engines in MHD and HHD vehicles are certified outside of the vehicle, and then subsequently integrated into a chassis
  - Engine MY 2010+ (Chassis MY 2011+) : 0.2 g/bhp-hr NOx limit
  - Engine MY 2024+ (Chassis MY 2025+): Heavy-Duty Low NOx Omnibus Regulation for CA-certified engines
- MHD and HHD Use HD emissions modeling method

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Review of EMFAC2021 HD Emission Rates

- HHD Diesel (MY 2013+)
  - Updated running emissions from **26** trucks (chassis dynamometer test data of CARB TBSP)
  - Updated start emissions from **11** trucks (CARB PEMS test data)
- MHD Diesel (MY 2013+)
  - Updated running emissions from **8** trucks (chassis dynamometer test data of CARB TBSP)
- Natural Gas
  - Updated emissions from **47** vehicles (PEMS test data) from CEC-SCAQMD project

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CARB Surveillance Program for Class 4-6 Vehicles

- To date, **(5)** 2015+ MY trucks tested on dynamometer using multiple test cycles

- Most trucks are being tested with PEMS on 2 routes

Bar chart of Average Cycle Speed (mph):
- HD High Speed Cruise: 47.9
- HHDDT Cruise: 39.9
- Local: 32.6
- UDDS: 18.9
- HHDDT Transient: 15.4
- Parcel Delivery Cycle: 10.1
- HHDDT Creep: 1.77
- OCBC (Bus): 12.3

PEMS Route	Driving Type
Downtown LA	Urban
Oxnard	Freeway

2015+ MY MHD UDDS NOx (Preliminary)
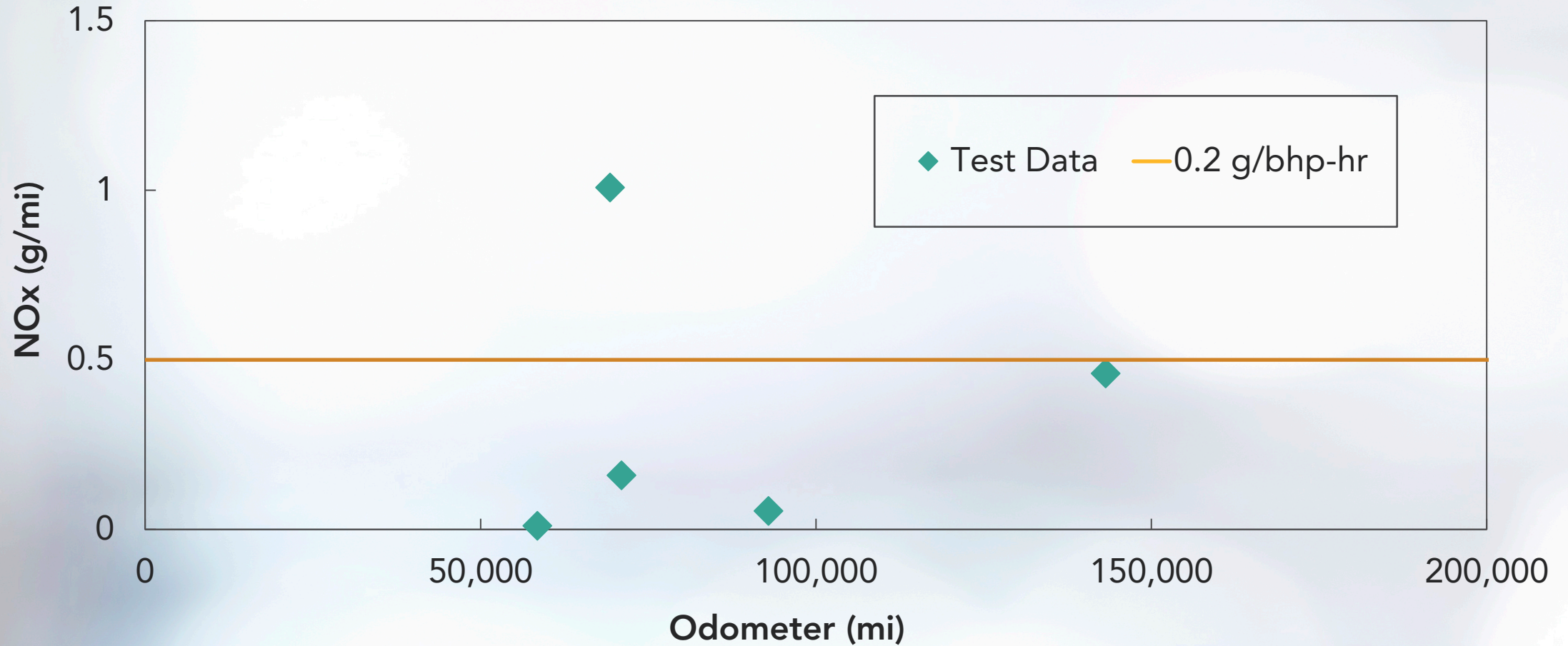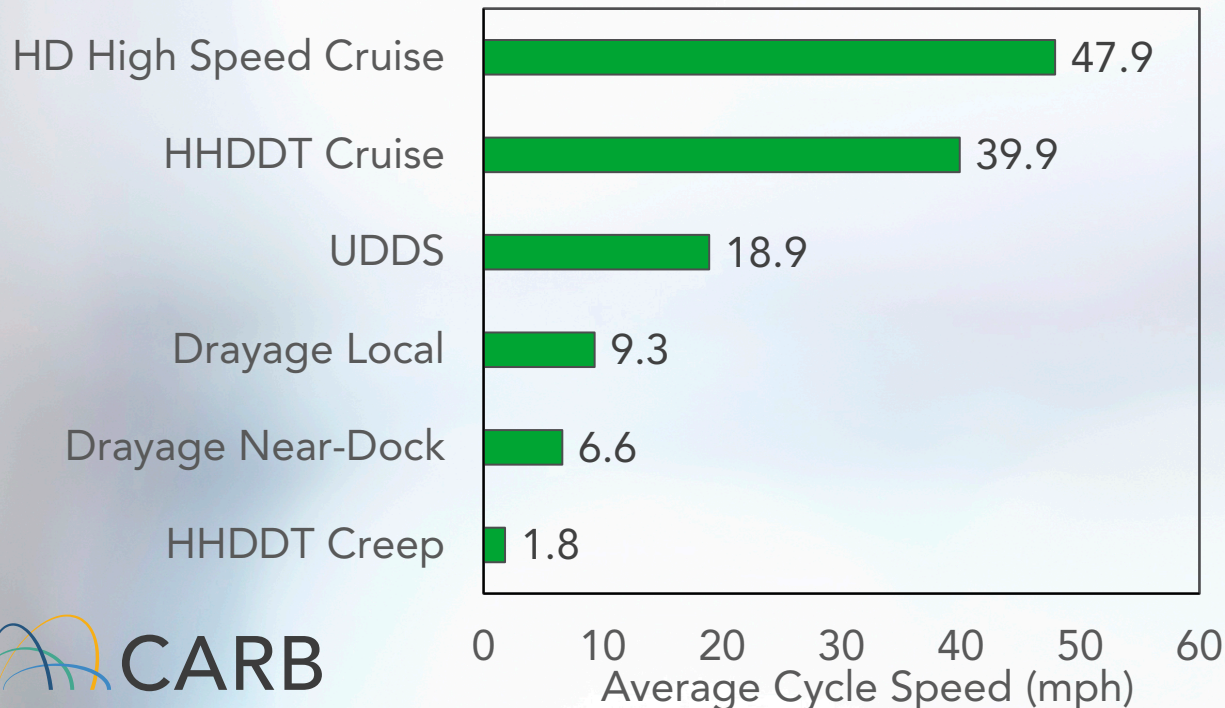
CARB Truck and Bus Surveillance Program (TBSP) for Class 7-8 Vehicles

- A maximum of **(40)** additional 2014+ MY trucks will be on dynamometer multiple test cycles

- Each truck may be tested with PEMS on 4 routes

- Data collected up to Fall 2023 will be considered for EMFAC202Y

HD High Speed Cruise	47.9
HHDDT Cruise	39.9
UDDS	18.9
Drayage Local	9.3
Drayage Near-Dock	6.6
HHDDT Creep	1.8

Average Cycle Speed (mph)

| PEMS Route	Driving Type
DP-WSAC-ART	Arterial
DP-WSAC-ART	Arterial / Freeway
DP-WSAC-INDEXT	Low Load / Low Speed
DP-PLAC	Uphill / Downhill

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Agenda for PM Session

- **Emission Rates**
  - Light-Duty Vehicles
    - Light-Duty Vehicles and On-Road Motorcycles
    - Temperature, Humidity and Air Conditioning (AC) Correction Factors
    - Evaluation of Reid Vapor Pressure (RVP) Input
  - Light Heavy-Duty Vehicles
  - **Medium/Heavy Heavy-Duty Vehicles**
    - **Speed Correction Factors**
- Energy Consumption
- Closing Remarks
  - Timeline and Next Steps
- Question & Answer

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Medium & Heavy Heavy-Duty Vehicles
Emission Rates: Speed Correction Factors

Background on Speed Correction Factors (SCFs) for MHD/HHD vehicles

UDDS Test Cycle Average Speed

NOx Speed Correction Factor vs *Speed (mph)*
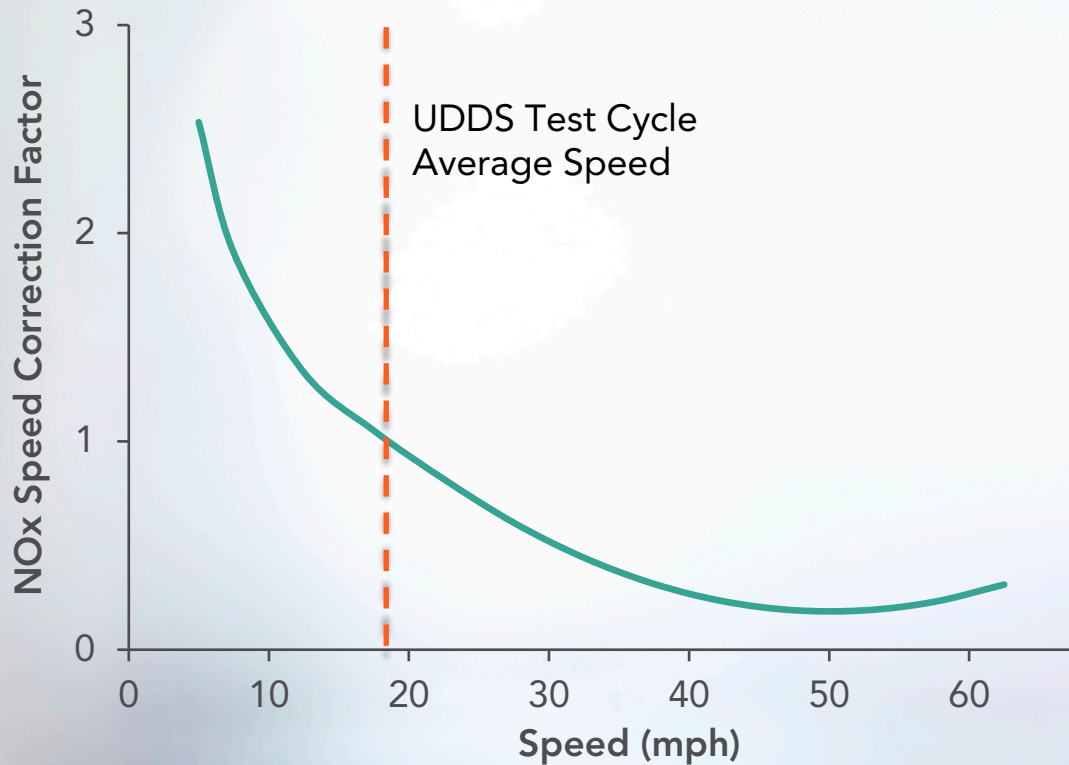
Speed correction factors account for variation of emissions for SCR*-equipped vehicles under different operating conditions (e.g. low load)

- EMFAC2021
  - Used mostly lab dyno testing data for HD emission rates and SCFs
  - Only had one set of SCFs for T6/T7

- Potential EMFAC202Y Improvements
  - More detailed SCFs by vocation and MY group
  - One step forward to transition emission data analysis from lab dyno testing toward PEMS based approaches

*SCR=Selective catalytic reduction

Heavy-Duty In-Use Testing Program (HDIUT)

- In June 2005, the U.S. EPA adopted a manufacturer-run in-use testing program, titled 'In-Use Testing Program for Heavy-Duty Diesel Engines and Vehicles (HDIUT)'.

- HDIUT "requires engine manufacturers to measure and report in-use exhaust emissions from heavy-duty vehicles using onboard PEMS during typical over-the-road operation."

- Provides a larger dataset to evaluate in-use behavior and refine SCFs
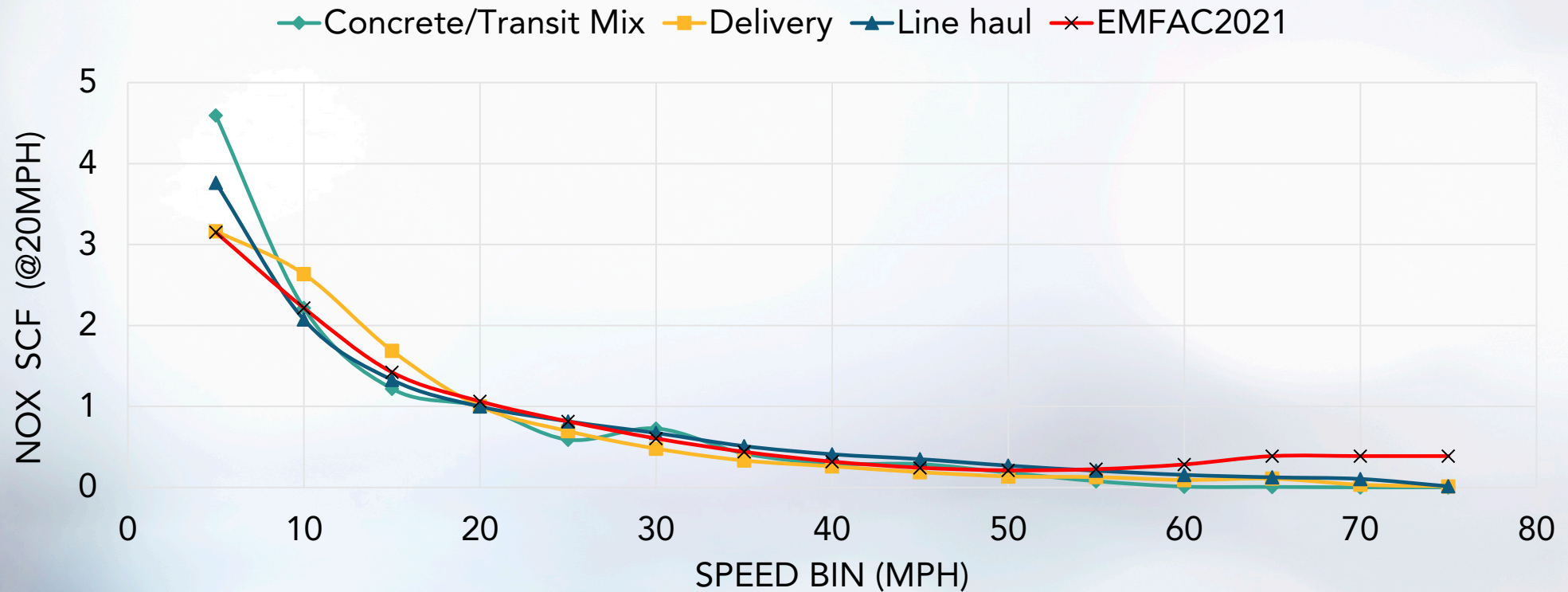
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Data Source: HDIUT PEMS (MHD and HHD)

- 469 vehicles from 19 manufacturers were used for analysis, after filtering for either ambiguous vehicle info or missing data
- Testing date range: 2006 – 2021
- Engine model year range: 2003 – 2017
- Data type: 1Hz
- Data processing
  - total NOx emissions, total VMT by speed
  - Subgroup by:
    - **Weight class** (T6/MHD and T7/HHD)
    - **Engine MY** (pre2010, 2010-2012, 2013+)
    - **Vocation**

CARB
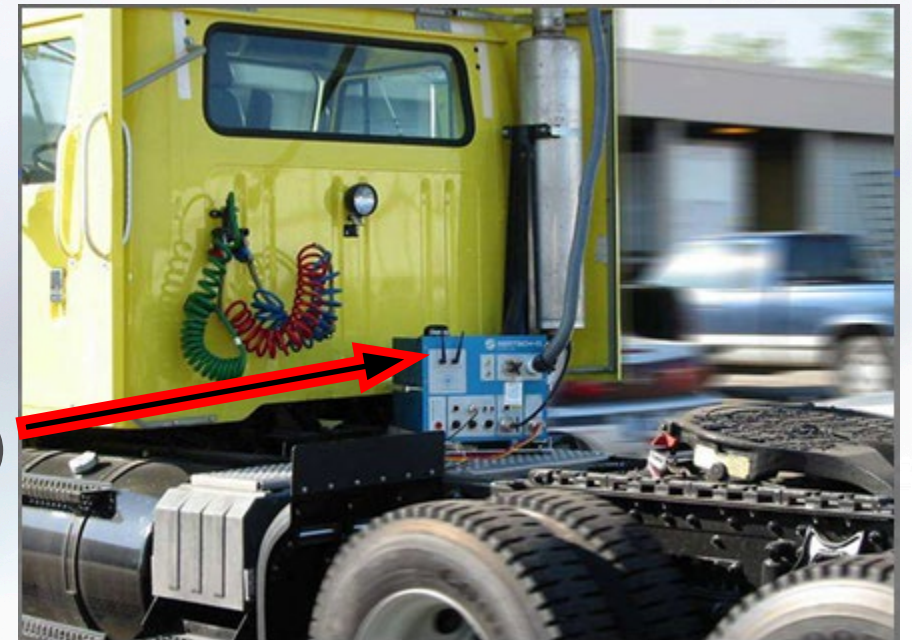
SCF of HHD MY 2013 and Newer Engines

HHD MY2013+ ENGINES

Legend: Concrete/Transit Mix — Delivery — Line haul — EMFAC2021
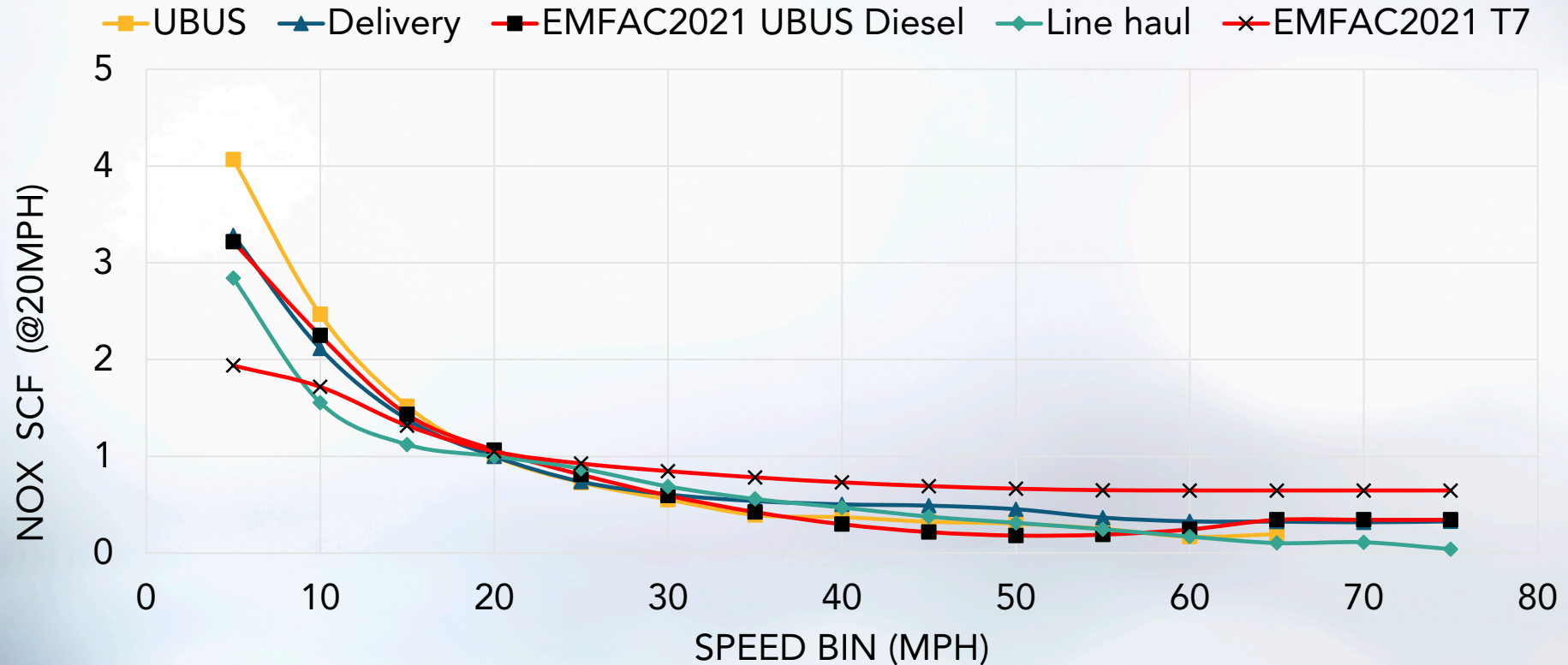
NOX SCF (@20MPH) vs SPEED BIN (MPH)

Sample size:
- **Concrete/Transit Mix: 1**
- **Delivery: 7**
- **Line haul: 63**

SCF of HHD MY 2010-2012 Engines

HHD MY2010-2012 ENGINES

Legend: UBUS, Delivery, EMFAC2021 UBUS Diesel, Line haul, EMFAC2021 T7
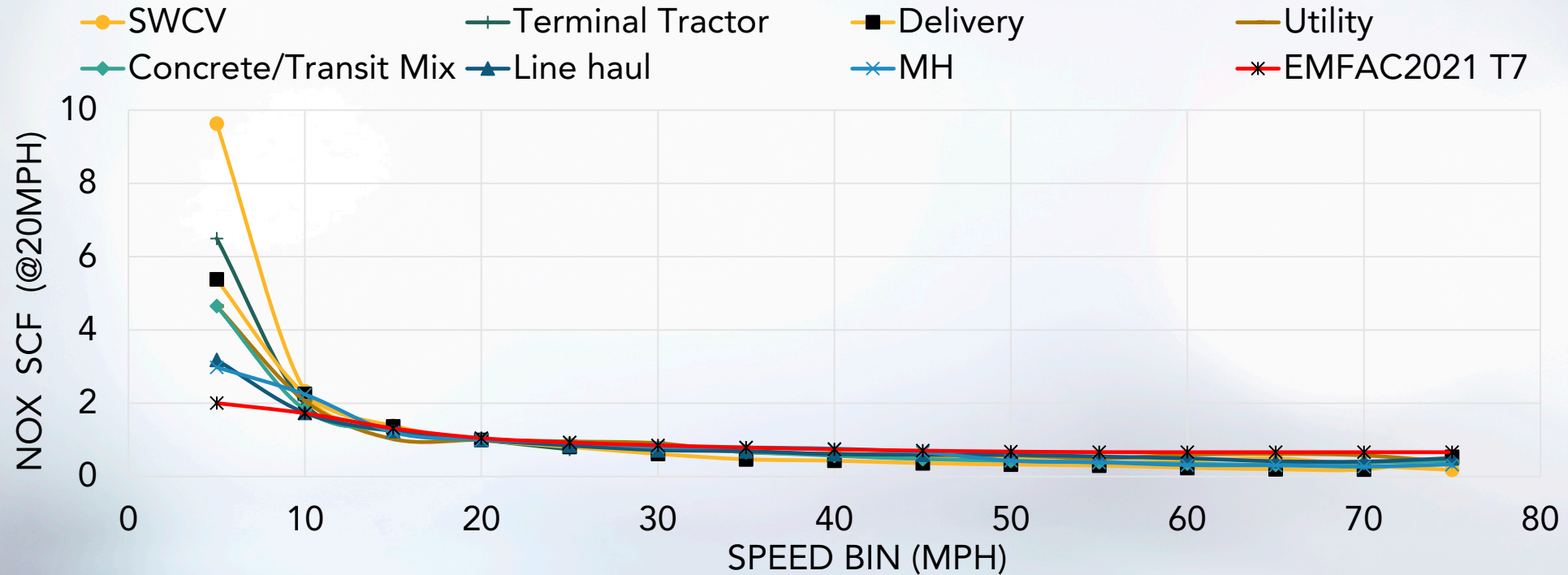
X-axis: SPEED BIN (MPH)
Y-axis: NOX SCF (@20MPH)

Sample size:
- UBUS: 7
- Delivery: 19
- Line haul: 84

SCF of HHD MY 2009 and Earlier Engines

HHD MY2009 AND EARLIER ENGINES

Legend: SWCV, Terminal Tractor, Delivery, Utility, Concrete/Transit Mix, Line haul, MH, EMFAC2021 T7

Y-axis: NOX SCF (@20MPH), range 0 to 10
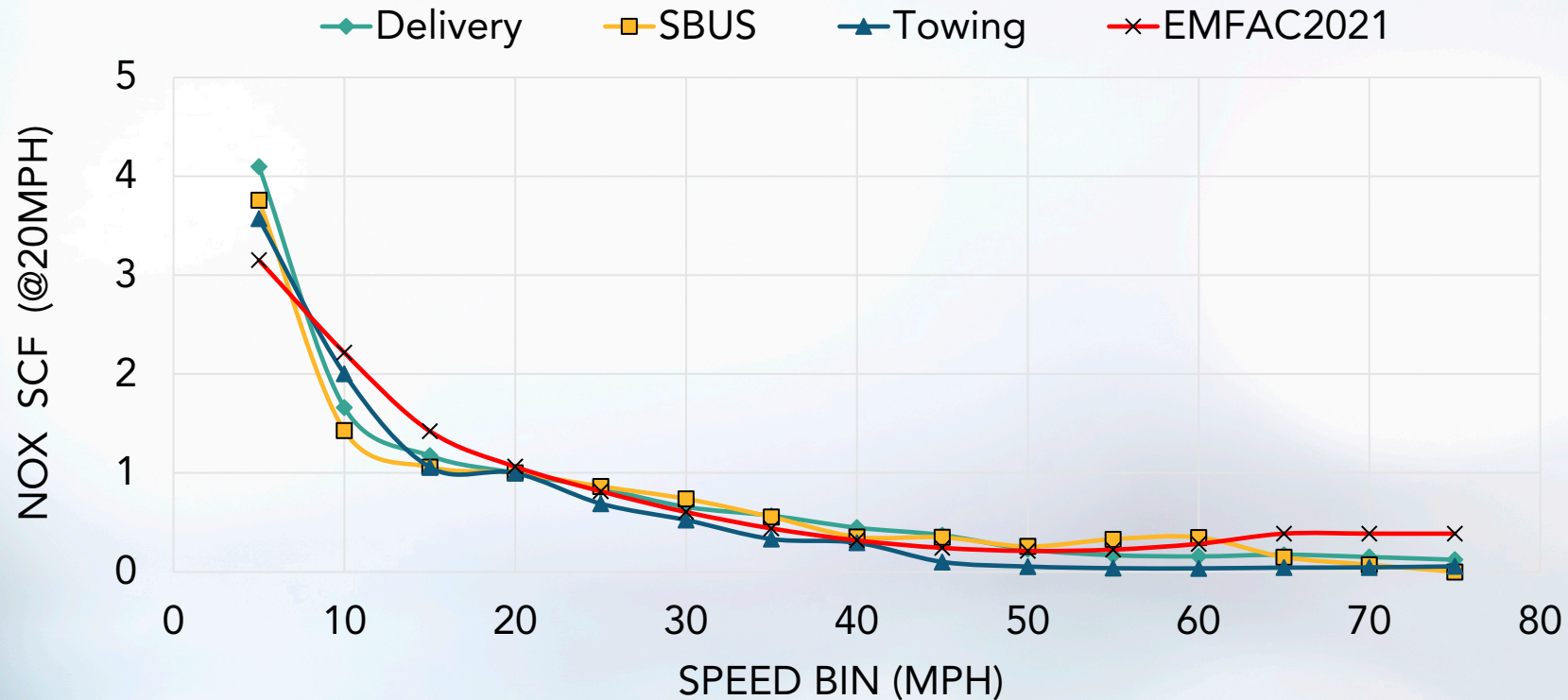X-axis: SPEED BIN (MPH), range 0 to 80

Sample size:
- Concrete/Transit Mix: 5
- Delivery: 13
- Line haul: 72
- Utility: 2
- MH: 5
- SWCV: 9
- Terminal Tractor: 2

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SCF of MHD MY 2013 and Newer Engines

MHD MY2013+ ENGINES

Legend: Delivery, SBUS, Towing, EMFAC2021
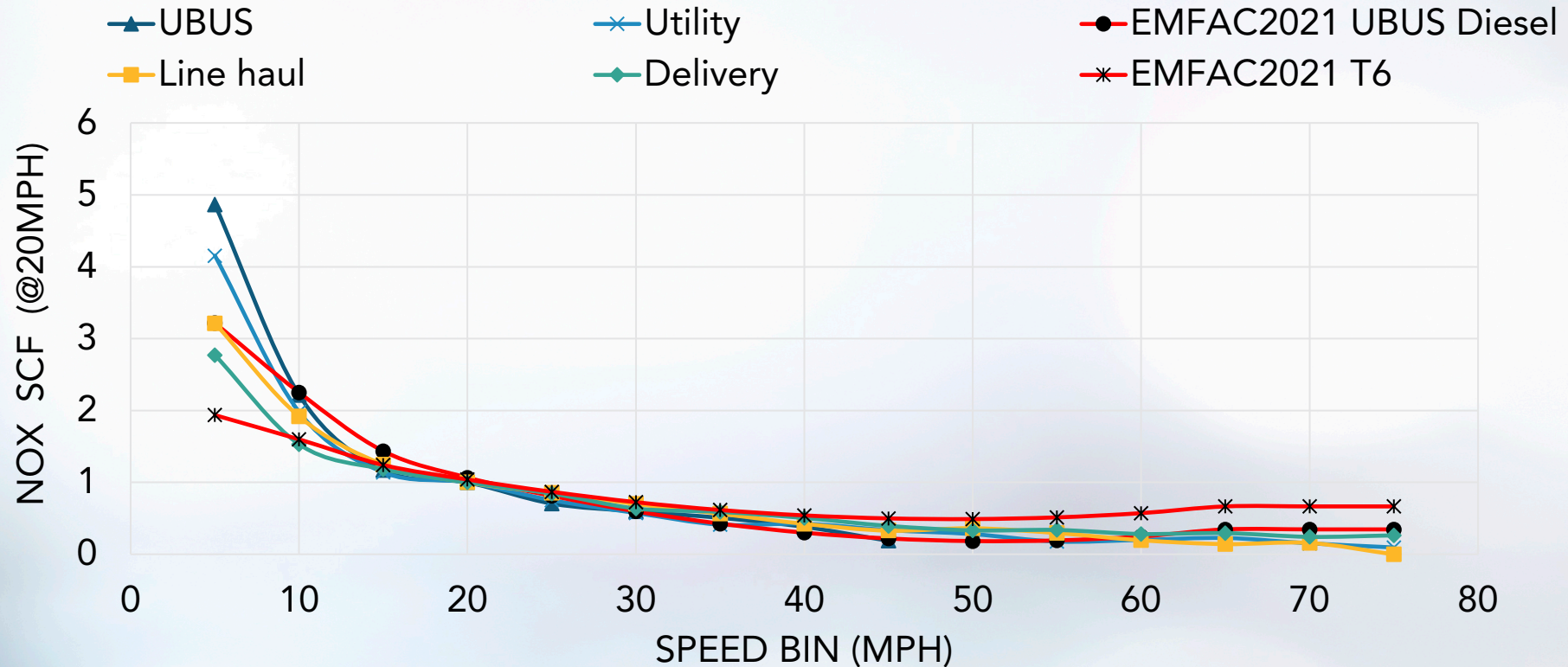
Y-axis: NOX SCF (@20MPH)
X-axis: SPEED BIN (MPH)

Sample size:
- Delivery: 47
- SBUS: 3
- Towing: 11

SCF of MHD MY 2010-2012 Engines

MHD MY2010-2012 ENGINES

Legend:
- UBUS
- Line haul
- Utility
- Delivery
- EMFAC2021 UBUS Diesel
- EMFAC2021 T6

Y-axis: NOX SCF (@20MPH)
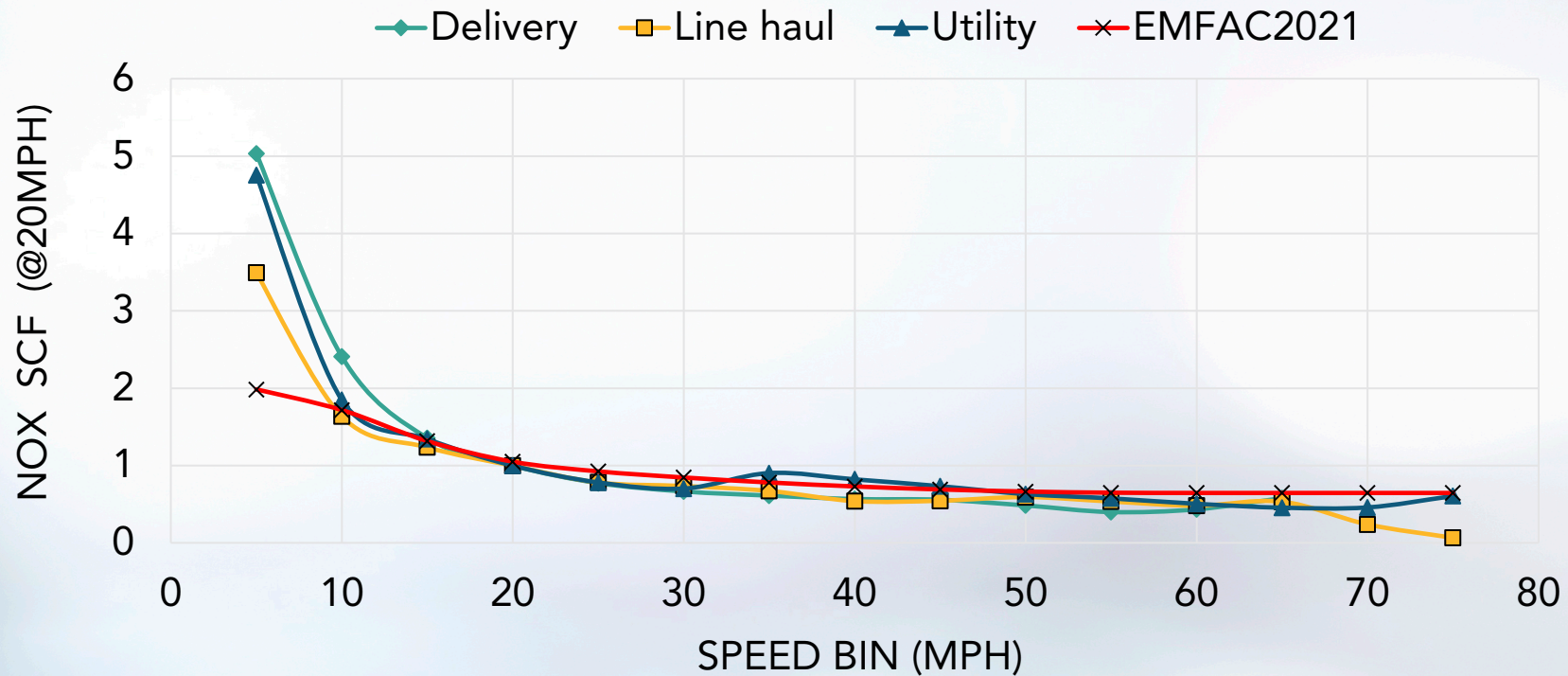X-axis: SPEED BIN (MPH)

Sample size:
- Delivery: 59   Line haul: 6
- UBUS: 4
- Utility: 6

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SCF of MHD MY 2009 and Earlier Engines

MHD MY2009 AND EARLIER ENGINES

Sample size:
- Delivery: 19
- Line haul: 13
- Utility: 6

Summary for SCFs

- MY group:
    - 2013+: SCFs derived from HDIUT PEMS data generally match with EMFAC2021
    - Pre2010 and 2010-2012: HDIUT data suggest larger SCFs at low speeds and smaller SCFs at high speeds, compared to EMFAC2021
- Vocation:
    - In general, at low speeds: line-haul < delivery < other vocations
    - At high speeds, differences are small
- Additional PEMS data will be included to update SCFs as they become available

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Next Steps for MHD and HHD Emissions Rates and SCFs

- Surveillance programs at CARB for HD vehicle testing ongoing
  - Additional dyno and PEMS data expected before EMFAC update cutoff date
- Additional PEMS and on-board sensing and reporting (OSAR) data will be acquired through extramural contracts 21RD018 and 21RD007
- Data from the 200-vehicle study will continue to be analyzed for EMFAC202Y
  - 73 additional natural gas vehicles (28 w/ dyno and 10 w/ PEMS)
  - 81 diesel vehicles (16 w/ dyno and 34 w/ PEMS)

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Agenda for PM Session

- **Emission Rates**
  - Light-Duty Vehicles
    - Light-Duty Vehicles and On-Road Motorcycles
    - Temperature, Humidity and Air Conditioning (AC) Correction Factors
    - Evaluation of Reid Vapor Pressure (RVP) Input
  - Light Heavy-Duty Vehicles
  - Medium/Heavy Heavy-Duty Vehicles
    - Speed Correction Factors
- **Energy Consumption**
- Closing Remarks
  - Timeline and Next Steps
- Question & Answer

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EMFAC202Y
Energy Module

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Background on the Energy Module

- EMFAC2021 included estimates of energy consumption from light and heavy-duty ZEVs

- As of October 2021, there were 732,623 light-duty BEVs and PHEVs registered in CA. Many more expected after the implementation of Advanced Clean Cars II.

- HD ZEV fleet growth through Advanced Clean Trucks, Innovative Clean Transit, and Advanced Clean Fleets

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Potential Applications of Energy Consumption Estimates

- Inform economic evaluation for regulations and incentives by estimating electricity consumed from charging battery electric vehicles

- Hydrogen demand assessments for heavy-duty vehicles to support state planning efforts, e.g., SB 643*

- Collaboration with sister agencies on demand projections to support transportation electrification

*SB-643 Fuel cell electric vehicle fueling infrastructure and fuel production: statewide assessment
https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB643

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On-Going Efforts to Quantify Vehicle Energy Demand and Efficiency

- Energy consumption estimates were added to EMFAC2021. Improve assumptions in EMFAC202Y by incorporating more data

- Sector-specific work performed by CARB regulatory teams as part of economic and cost analyses

- Energy Economy Ratios (EER) in CARB's Low Carbon Fuel Standard

- CEC's (California Energy Commission) energy demand forecast

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EMFAC202Y Improvements to the Energy Module

EMFAC2021

Light-Duty BEVs and PHEVS
- **Trip-by-trip data** submitted by OEMS
- **Model Years:** 2011-2016
- 6 PHEV models and 3 BEV models
- No info on Level 1 vs Level 2 charging time.

Heavy-Duty Vehicles
- Energy consumption for all heavy-duty zero emission vehicles based on battery electric transit bus data

EMFAC202Y

Light-Duty BEVs and PHEVS
- **Second-by-second data** from extramural contracts + in-house efforts
- Includes additional makes and models, e.g., Tesla Model S
- **Model Years:** 2012-2018
- Info on Level 1, Level 2, and Level 3 charging time – refine estimates for charging losses.*

Heavy-Duty Vehicles
- Additional vocations
  - School buses, drayage trucks, delivery trucks
- Hydrogen consumption from fuel cell electric vehicles

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* EMFAC2021 assumed a 20% loss for all vehicles based on Idaho National Laboratory test data. Estimated as a simple average of Level 1/Level 2 losses.

Battery Electric and Plug-In Hybrid Electric Vehicles

BEVs
- Vehicles operate using an electric motor only
- Battery can be recharged by plugging into a power source

PHEVs
- Vehicle with both an electric motor and a gasoline engine
- Battery can be recharged by plugging into a power source

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Data Sources for EMFAC202Y Updates

- CARB collected second-by second BEVs and PHEV data through in-house and extramural data collection projects (12-319, 16RD009, and 17AQP005) from 2015 to 2020

Make and Model	BEV or PHEV	# of Vehicles	# of Trips
Nissan Leaf	BEV	57	453,282
Tesla Model S	**BEV**	**48**	**482,406**
Chevy Bolt	**BEV**	**58**	**243,636**
Toyota Prius Prime	PHEV	27	223,201
Toyota Prius Plug-In	PHEV	22	271,779
Ford C-Max Energi	PHEV	33	386,652
Ford Fusion Energi	PHEV	27	386,089
Chevy Volt	PHEV	84	980,021

Make + models new in EMFAC202Y

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Methods

- Estimated energy consumption and electric vehicle miles traveled (eVMT) using second-by-second ECU data

- Grouped data from each trip into speed bins (5 mph, 10 mph, etc.)

- Excluded data with charging events

- Considered electric-only operation for PHEVs in which the engine **did not** turn on, i.e., rpm = 0
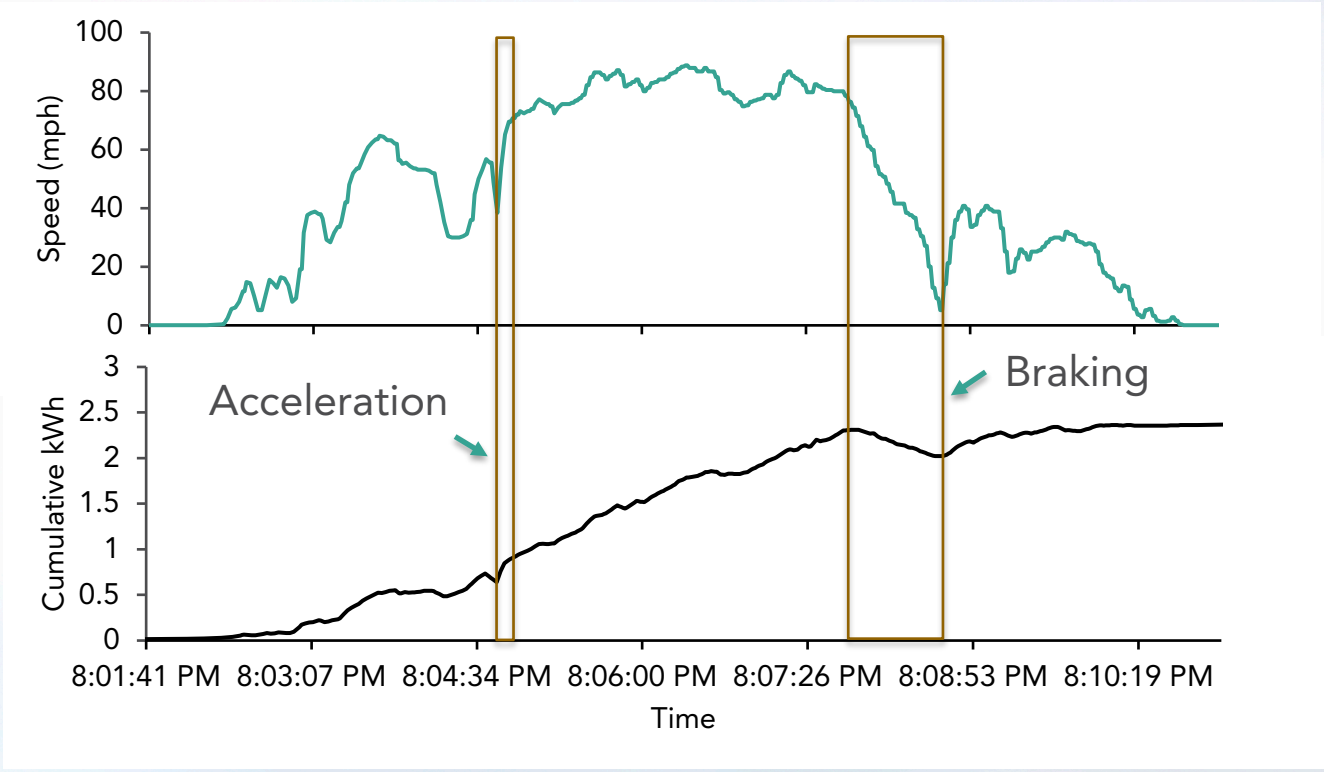
$$\textbf{Energy Consumption (kWh)} = \frac{\text{volts} \times \text{amps} \times \Delta\text{seconds}}{-1000 \times 3600} \qquad \textbf{eVMT} = \frac{\frac{\text{km}}{\text{s}}\,(\text{based on ECU}) \times \Delta\text{seconds}}{1.609 \times 3600}$$

$$\textbf{Energy consumption rate}\left(\frac{\textbf{kWh}}{\textbf{mile}}\right) = \frac{\text{Energy Consumption (kWh)}}{\text{Electric vehicle miles travelled(eVMT)}}$$
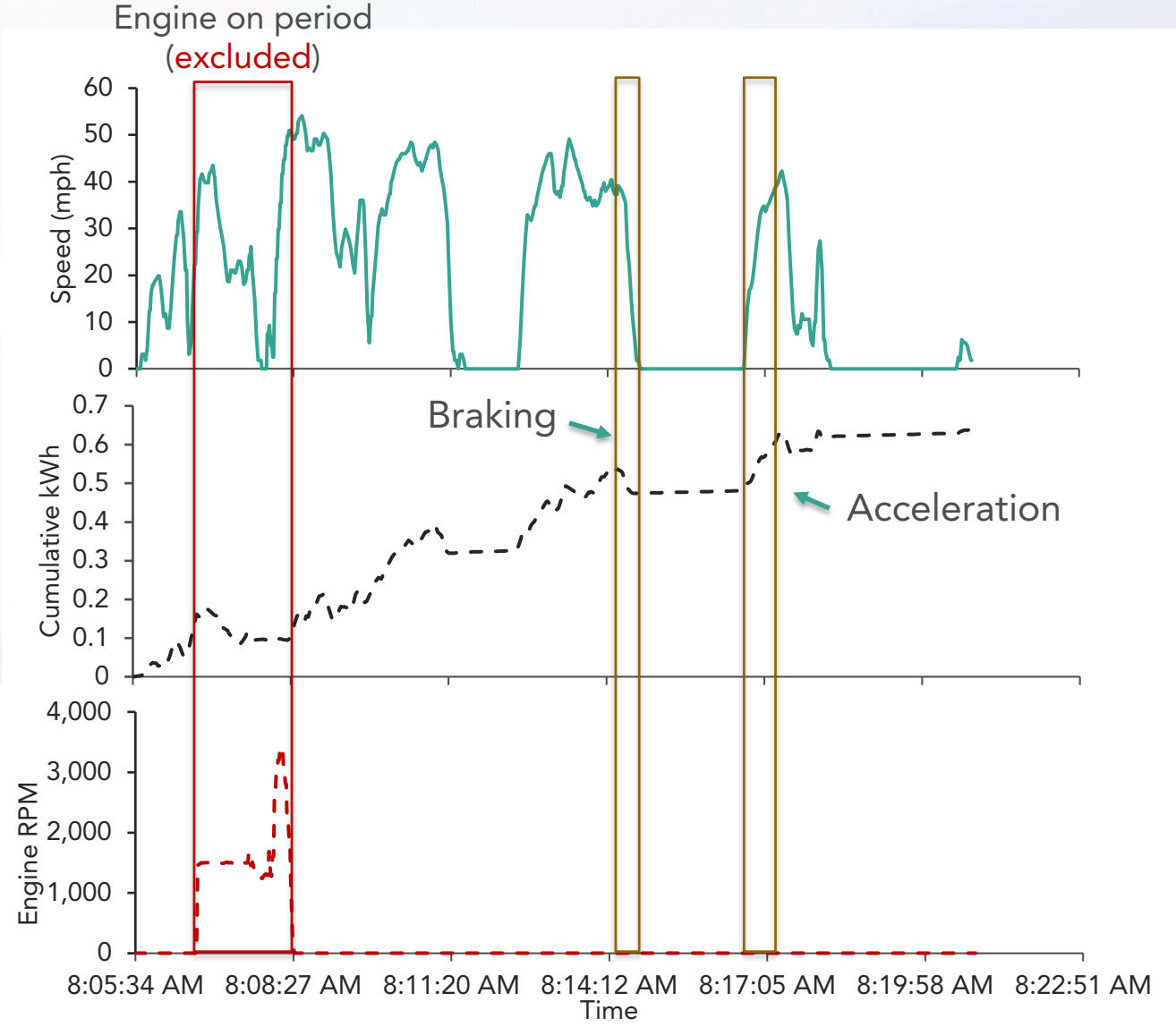
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Example 1 – Tesla Model S (BEV)

Example 2 – Prius Plug-In (PHEV)
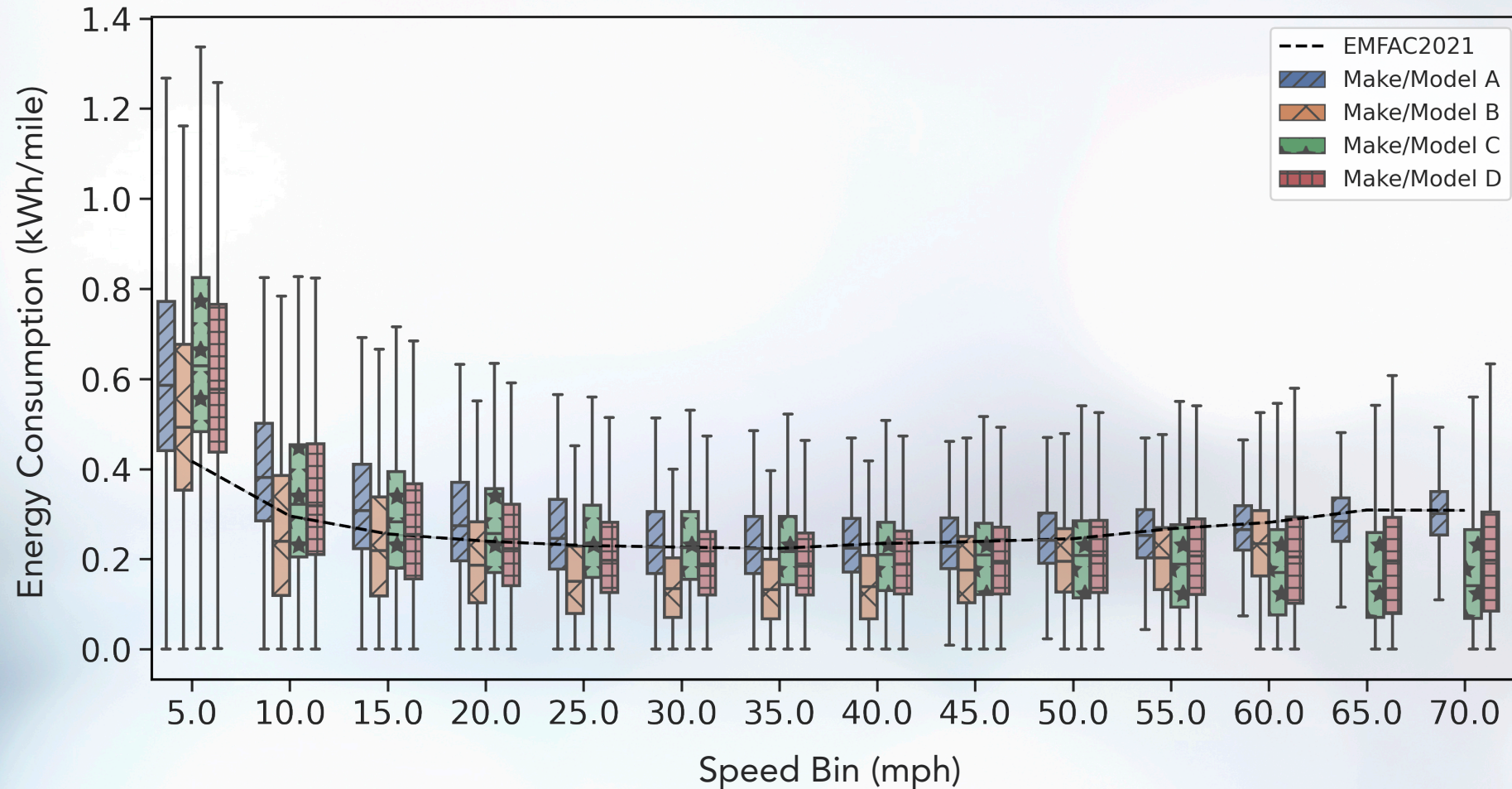
Preliminary BEV Energy Consumption Rates*
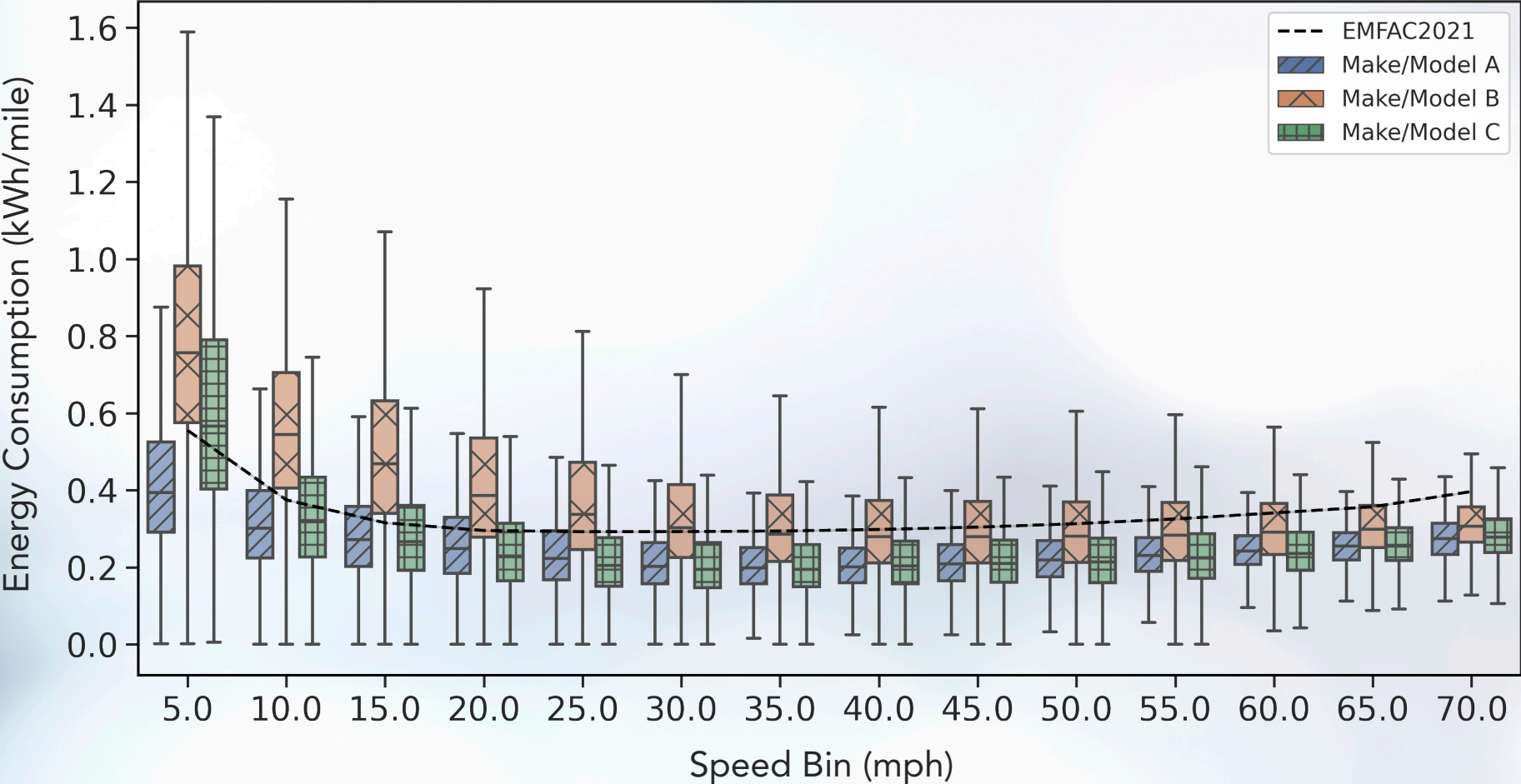
* Not corrected for charging losses

Preliminary PHEV Energy Consumption Rates*

Not corrected for charging losses

Next Steps for Light-Duty Energy Module

- Compare results to data previously used in EMFAC2021 and make necessary updates

- Add new data not previously in EMFAC

- Update BEV and PHEV electric energy consumption inputs by speed using a sales-weighted average for each make and model

- Explore effects of model year, air conditioner/heater usage, etc.

- Refine charging loss correction based on Level 1, 2 and 3 charging time distribution.

- Continue and expand interagency coordination

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Real-Time Heavy-Duty Activity Data

- CARB has collected vehicle activity information using data loggers through Low Carbon Transportation Heavy-Duty Pilot and Demonstration Projects**

- New data available for EMFAC202Y

| Vehicle Types	Battery Electric or Fuel Cell Electric	Number of Vehicles
Class 8 transit buses*	Battery Electric	25
School buses	Battery Electric	6
Class 8 drayage trucks	Battery Electric	8
Class 6 delivery trucks	Battery Electric	6
Class 8 transit buses	Fuel Cell Electric	5

Vocational categories new in EMFAC202Y

* Same dataset used in EMFAC2021 but re-analyzed to filter out idle events.
** https://ww2.arb.ca.gov/advanced-technology-demo-projects

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Data Analysis Methods
Battery Electric Vehicles

- Energy consumption (kWh) calculated from second-by-second voltage and current

- Speed bins identified through wheel-based activity data

- Energy consumption rates = aggregated energy consumption/aggregated VMT within various speed bins

- Identified and removed charging events

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# Preliminary Results: Battery Electric Vehicles
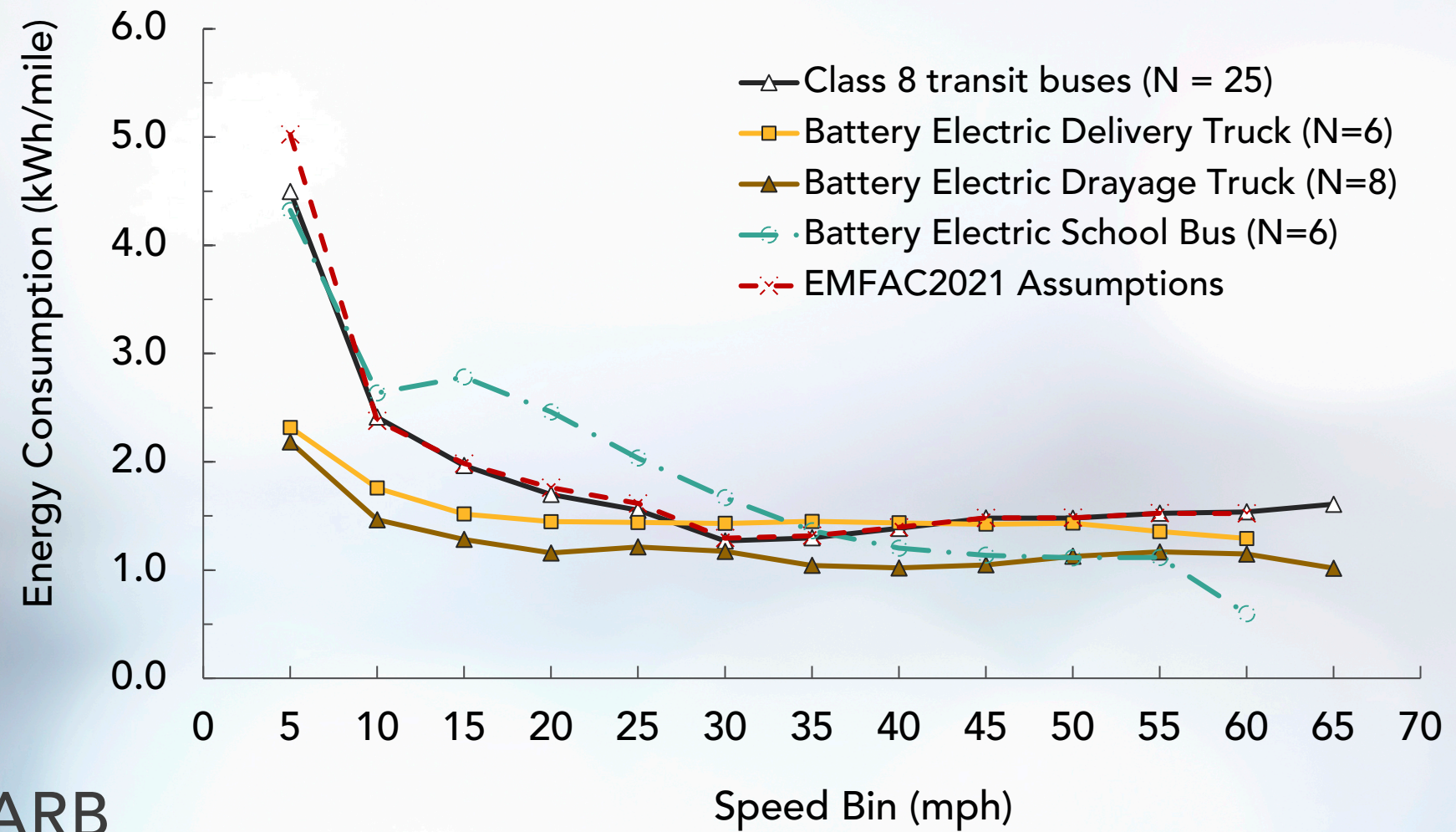
Data Analysis Methods
Hydrogen Fuel Cell Electric

- H_2 fuel consumption (kg) calculated from second-by-second H_2 consumption data logger

- Speed bins identified through wheel-based activity data

- H_2 fuel consumption rates = aggregated H_2 fuel consumption/aggregated VMT at a given speed bin

- Validated by H_2 fueling data

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Preliminary Results: Hydrogen Fuel Cell
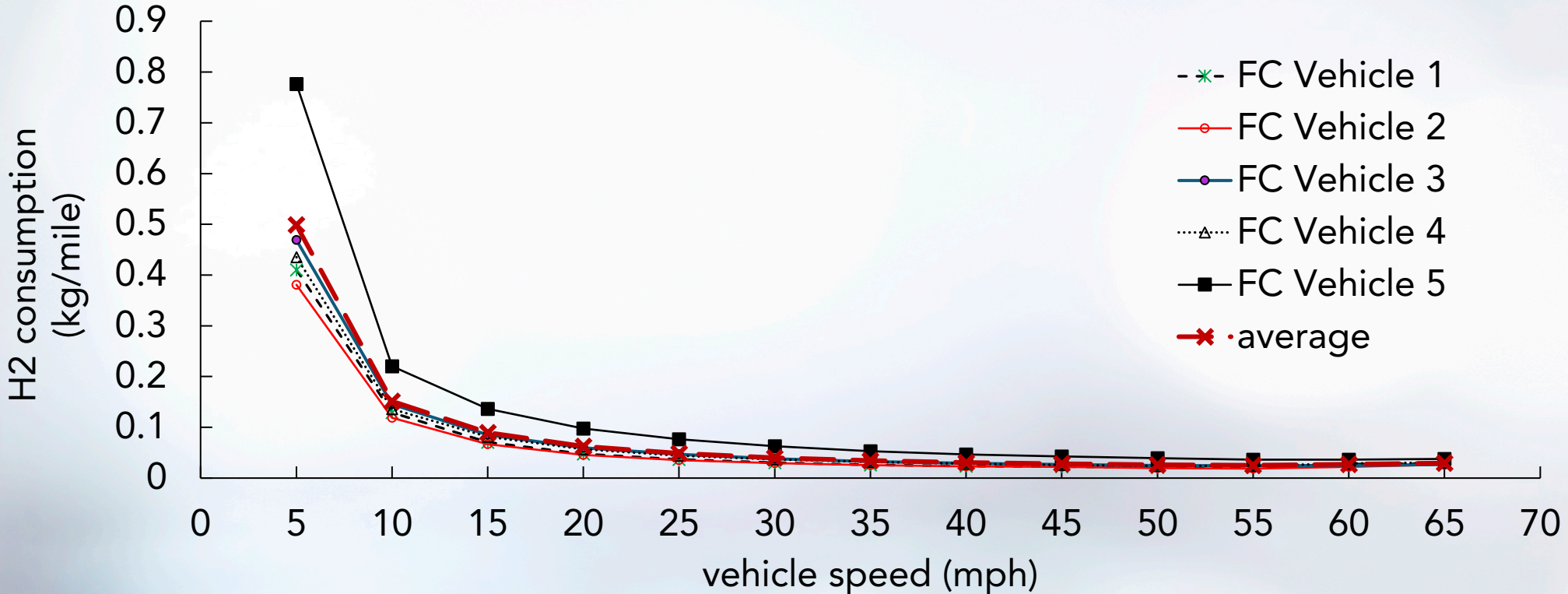
Next Steps for Heavy-Duty Energy Module

- Analyze more data collected through extramural contracts

- Examine other factors driving energy consumption besides speed

- Update energy consumption rates for battery electric drayage trucks, delivery trucks, and school buses

- Continue and expand interagency coordination

- Estimate hydrogen consumption rates for fuel cell vehicles and add as an EMFAC output

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Fuel Cell vs. Battery Electric

- Staff plans to separate Battery Electric (BEV) and Fuel Cell Electric Vehicles (FCEV) in EMFAC202Y;

- Fractions of BEV to FCEV will stay consistent with assumptions from ACC II and ACF, and vary by model year and weight class:

  - LD FCEV: 1% - 4% of total ZEV population[*]

  - HD FCEV: 10% - 50% of total ZEV population[**]

[*] CARB, Advanced Clean Cars II (ACC II), Aug 2022, https://ww2.arb.ca.gov/rulemaking/2022/advanced-clean-cars-ii
[**] CARB, Advanced Clean Fleets (ACF), Aug 2022, https://ww2.arb.ca.gov/rulemaking/2022/acf2022

Agenda for PM Session

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    - Light-Duty Vehicles and On-Road Motorcycles
    - Temperature, Humidity and Air Conditioning (AC) Correction Factors
    - Evaluation of Reid Vapor Pressure (RVP) Input
  - Light Heavy-Duty Vehicles
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  - **Timeline and Next Steps**
- Question & Answer

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EMFAC202Y
Timeline and Next Steps

Tentative Timeline for EMFAC202Y

- CARB staff requests your comments and feedback by **November 18, 2022,** for any new concept to be adequately considered for EMFAC202Y

- Alpha Release Testing:

  A preliminary version of the model will be released to CARB designated testers

- Public Beta Release Testing:

  A revised version of the model reflecting feedback will be released

User Survey
Summer 2021

1st Public Workshop
Oct 2022

2nd Public Workshop
Summer 2023

Alpha Release
Fall 2023

Public Beta Release
Winter 2023

3rd Public Workshop
2024

Final Release
2024/2025

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Next Steps for EMFAC202Y Development

- Update the progress of EMFAC2021 EPA approval
    - Grace period will be granted once EMFAC2021 is approved;
    - Users will have an option to choose between EMFAC2017 and EMFAC2021;
- Continue data collection and analysis;
- Improve spatial resolution of EMFAC using big data and road-side monitors;
- Engage community members and stakeholders most impacted by vehicular emissions and air pollution;
- Coordinate with other agencies on vehicle activity, growth forecasting, and emission updates.

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Questions and Comments

For questions and comments please contact us at:
EMFAC@arb.ca.gov

You can also visit our website at:
EMFAC Web Platform
https://arb.ca.gov/emfac/
Mobile Source Emissions Inventory
https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory

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Question & Answer

- Please raise your hand if you would like to ask a question
  - Include slide numbers, if possible
  - In Zoom: Use "Raise Hand" feature
  - On phone:
    - #2 to "Raise Hand"
    - *6 to Unmute/Mute
- Additional questions may be submitted after today to: emfac@arb.ca.gov

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