



CALIFORNIA
AIR RESOURCES BOARD

**EMFAC202Y:
An Update to California On-Road
Mobile Source Emissions Inventory**

Mobile Source Analysis Branch

Air Quality Planning and Science Division

2nd Public Workshop

January 17, 2024

Workshop Instructions

- Telephone Call-In: (888) 363-4734
- Access Code: 350021
- Workshop is being recorded
- Slides and recording will be available on our website:
 - [CARB's On-Road Conferences and Workshops](https://ww2.arb.ca.gov/our-work/programs/msei/conferences-and-workshops-onroad-emfac)

Public Process So Far



Items for future workshops:

- 1) Overall emissions impacts in tons per day/year from all module updates
- 2) Final module-specific impacts until we finalize data cutoff
- 3) Comparisons of model estimates between EMFAC202Y and EMFAC2021

Workshop Agenda

AM Session (9AM)

- EMFAC Overview
- New Major Updates in EMFAC202Y
- Fleet Characterization
- Vehicle Activity Forecasting

PM Session (Starts no earlier than 1PM)

- Updates to Emission Rates
- Light-Duty (LD) Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps

AM Session Agenda

- **EMFAC Overview**
- New Major Updates in EMFAC202Y
- Fleet Characterization
 - LD Vehicle Population
 - LD Age 45+ Vehicles Survey and Results
 - Heavy Duty (HD) Vehicle Population
 - Urban or Transit Buses (UBUS)
- Question & Answer
- Vehicle Activity Forecasting
 - LD New Vehicle Sales Forecasting
 - LD VMT Forecasting
 - HD Activity Forecasting
 - Advanced Clean Fleets Module
 - Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV) Splits
- Question & Answer

Workshop Questions

- We will pause for questions approximately every 60 to 90 minutes
- 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 Mute/Unmute
- Additional questions may be submitted after the workshop to:
emfac@arb.ca.gov

EMFAC Overview

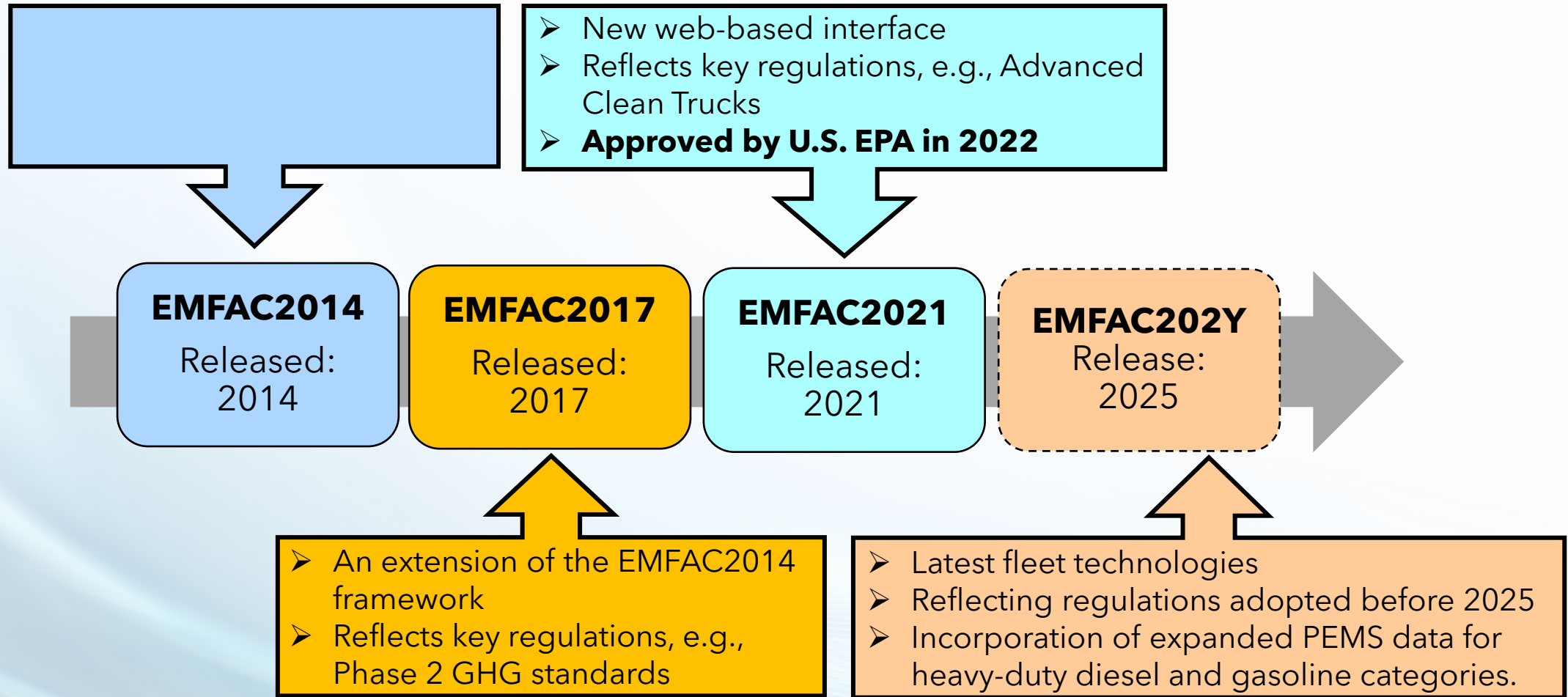
Background of EMFAC



Background of EMFAC (cont.)

- U.S. Environmental Protection Agency (EPA) approves California specific 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

EMFAC Updates



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Major Updates in EMFAC202Y

Updated LD Emission Rates with In-Use Data



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



Federal In-Use
Verification
Program (IUVP)



Motorcycle dyno test data

Updated HD Emission Rates with In-Use Data



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



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



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

Population and Fleet Characterization



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

Fleet Characterization and Activity Profiles



New to EMFAC202Y: A new category for vehicles used by Transportation Network Companies (TNC)

Activity data will be based on CPUC annual reports

GEO TAB®



REPLICA



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

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

Population and Activity Forecasting



dun & bradstreet

New to EMFAC202Y: Industrial and financial information about businesses

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



UC San Diego



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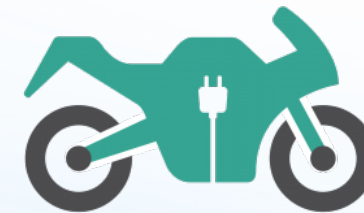
New to EMFAC202Y: Improve understanding of LD sales, retention, and VMT forecasting.

Achieved through intramural contracts and in-house efforts.

Recently-Adopted and Upcoming Light-Duty Regulations

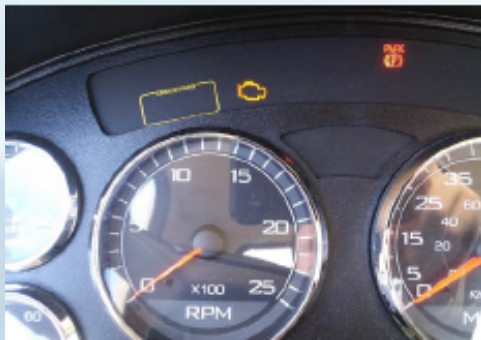


Advanced Clean Cars II
(ACC II)



On-Road Motorcycle
(ONMC) Regulation

Recently-Adopted Medium and Heavy-Duty Regulations



Clean Truck Check, previously Heavy-Duty Inspection and Maintenance (HD I/M)



Advanced Clean Fleets (ACF)



Control of Air Pollution from New Motor Vehicles: HD Engine and Vehicle Standards

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Fleet Characterization

LD Vehicle Population

Major Data Sources

- California Department of Motor Vehicles (DMV) Registration Data (2000 - 2022) - 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)

Latest Vehicle Registration Data

- CARB receives a snapshot of vehicle registration data every quarter (January, April, July, and October) from DMV
- EMFAC uses the count of vehicles from the October snapshot
- From the October DMV data,
 - Vehicles are considered to be registered for the status codes C (currently registered) and E (evidence of use)
 - A subset of status code S (pending) is included if the status code becomes C or E in the following April DMV data
- EMFAC202Y will utilize DMV registration data at least from years 2000 through 2022

Selected Vehicle Classes Modeled in EMFAC202Y

Heavy-Heavy Duty Trucks



Medium Heavy Duty Trucks



Pickups / Vans



Motorcycles



Passenger Vehicles



School Buses Transit Buses Motorhomes



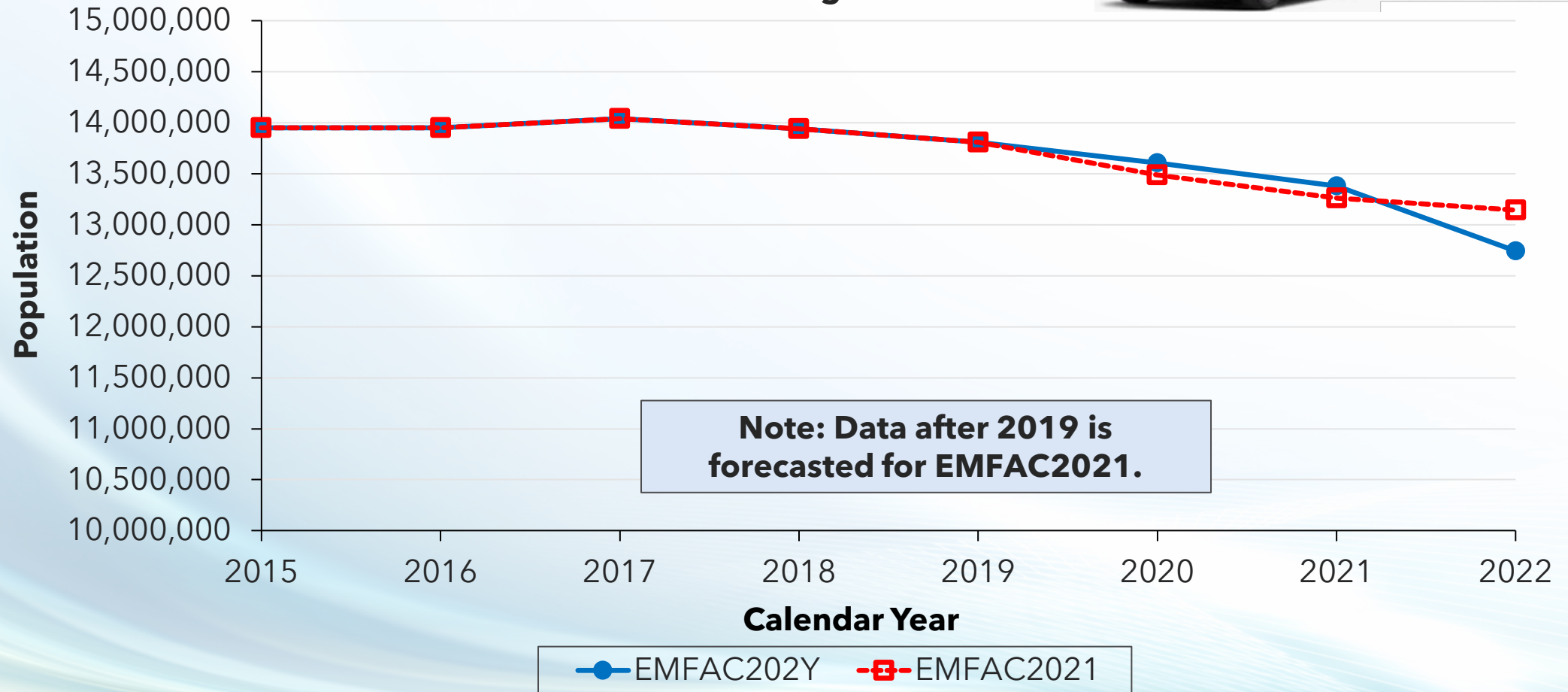
In the next slides you will hear about...

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

EMFAC202Y vs EMFAC2021 Population Gasoline



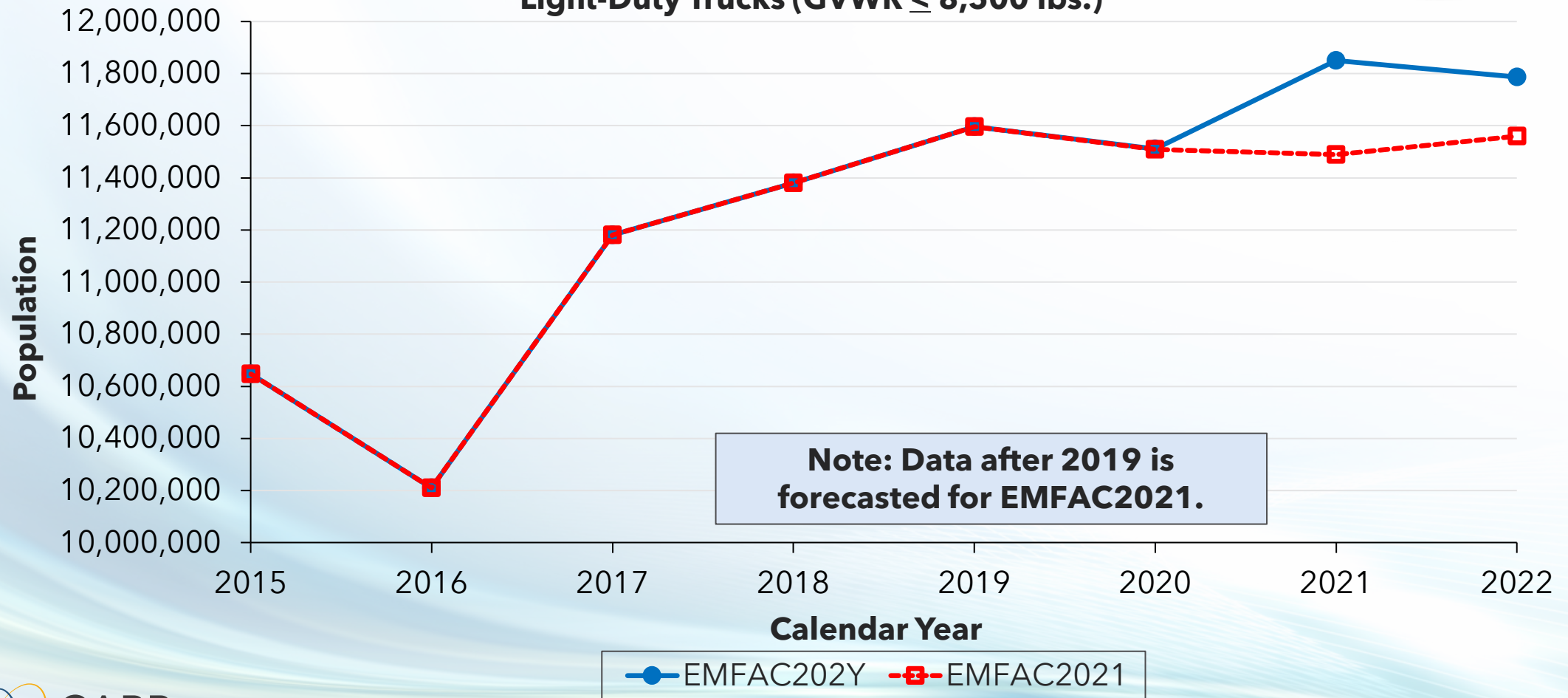
Passenger Cars



EMFAC202Y vs EMFAC2021 Population Gasoline



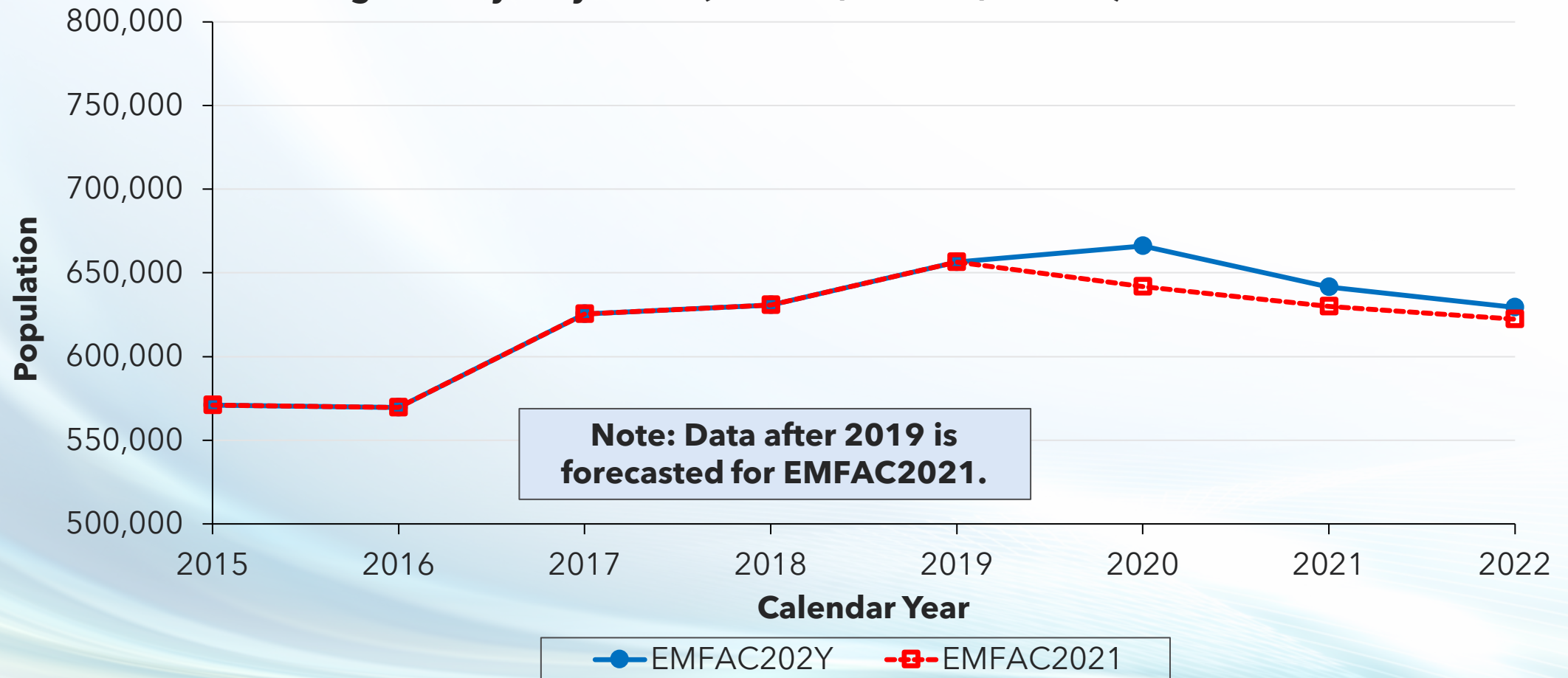
Light-Duty Trucks (GVWR \leq 8,500 lbs.)



EMFAC202Y vs EMFAC2021 Population Gasoline



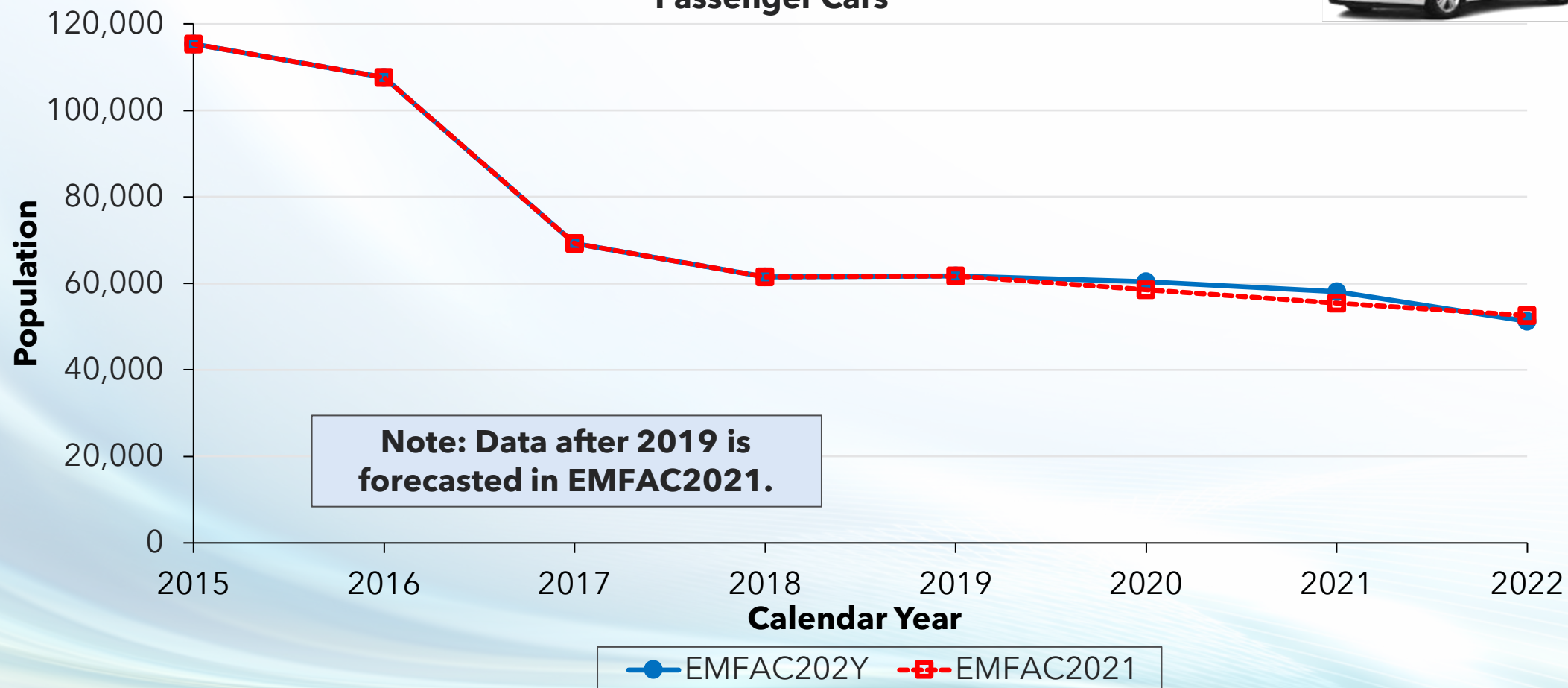
Light-Heavy Duty Trucks (GVWR 8,501 - 14,000 lbs.)



EMFAC202Y vs EMFAC2021 Population Diesel



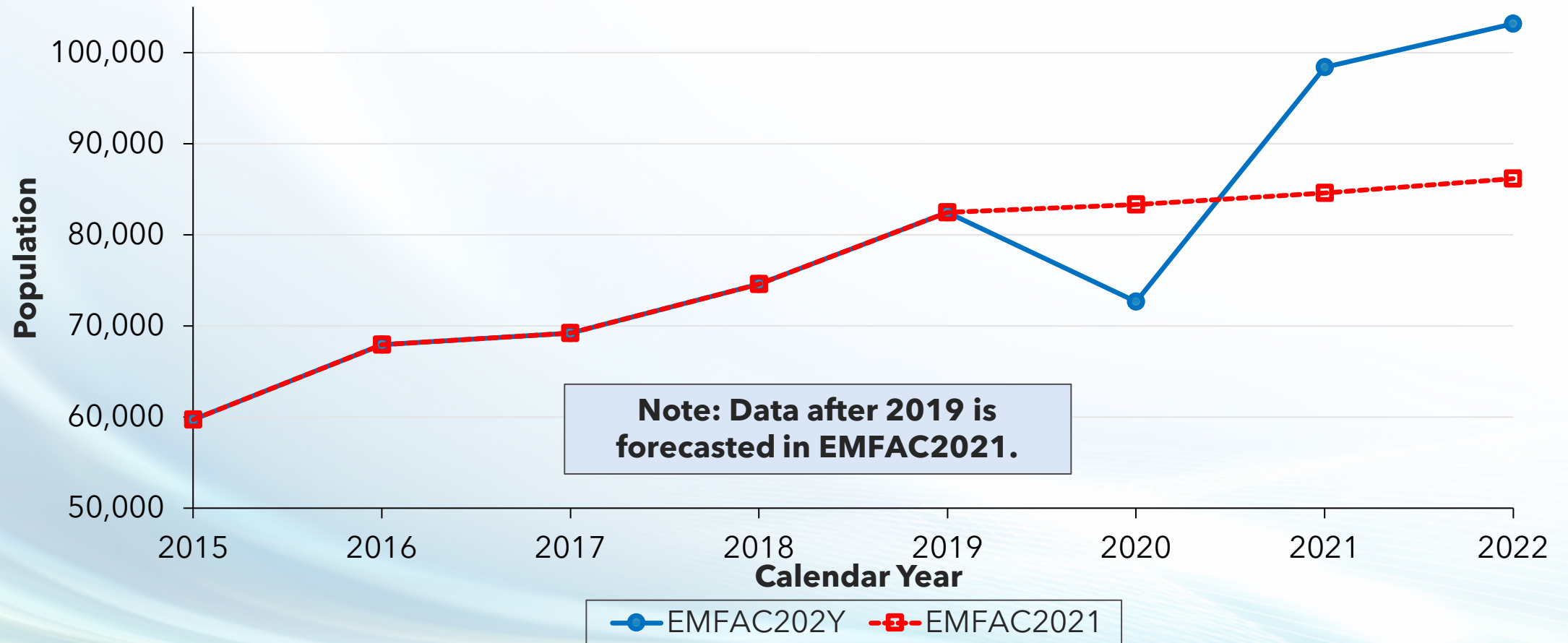
Passenger Cars



EMFAC202Y vs EMFAC2021 Population Diesel



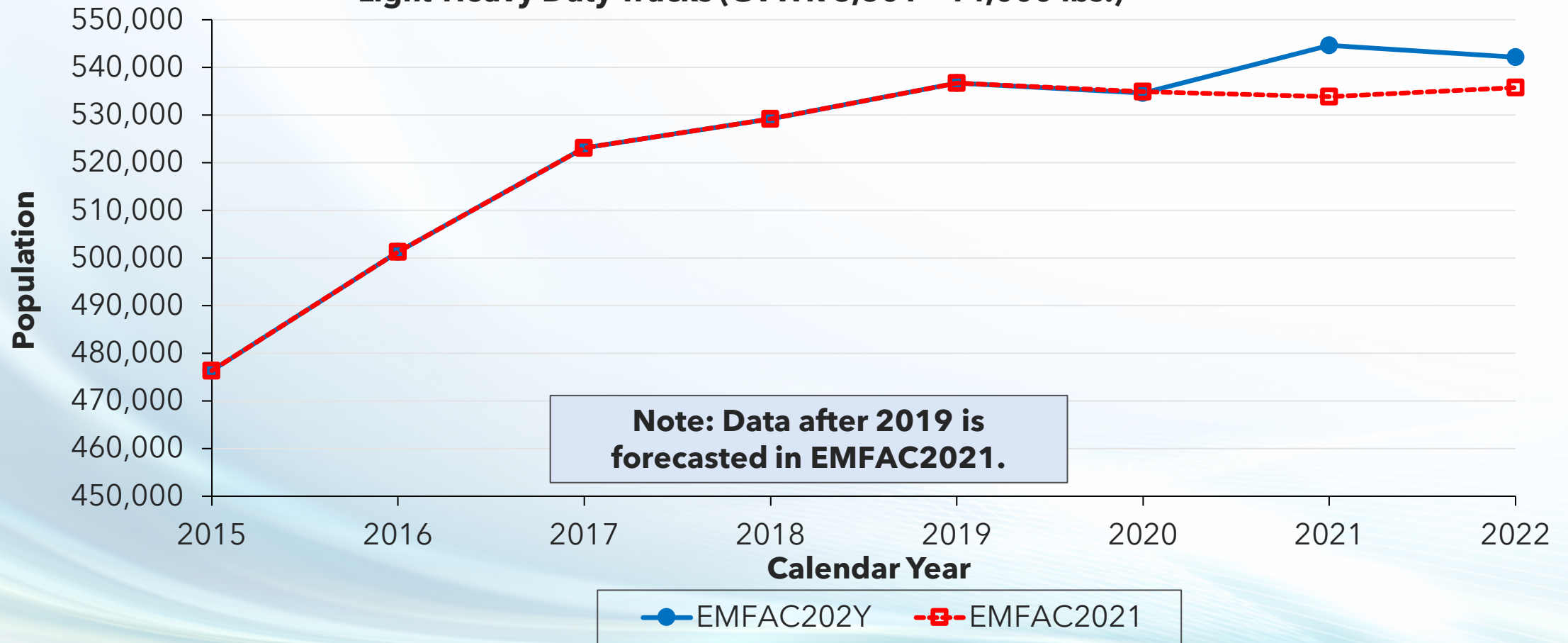
Light-Duty Trucks (GVWR \leq 8,500 lbs.)



EMFAC202Y vs EMFAC2021 Population Diesel

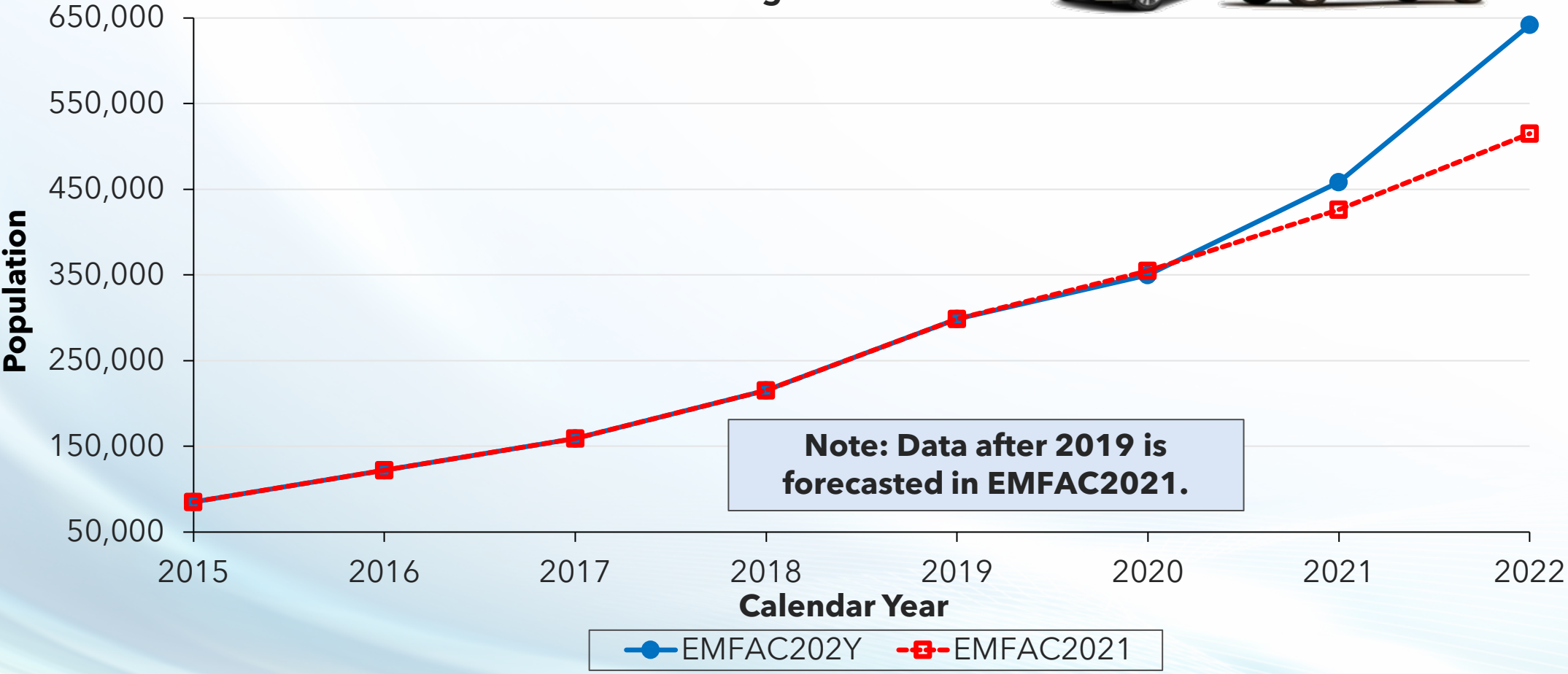


Light-Heavy Duty Trucks (GVWR 8,501 - 14,000 lbs.)



EMFAC202Y vs EMFAC2021 Population Electric*

Passenger Cars

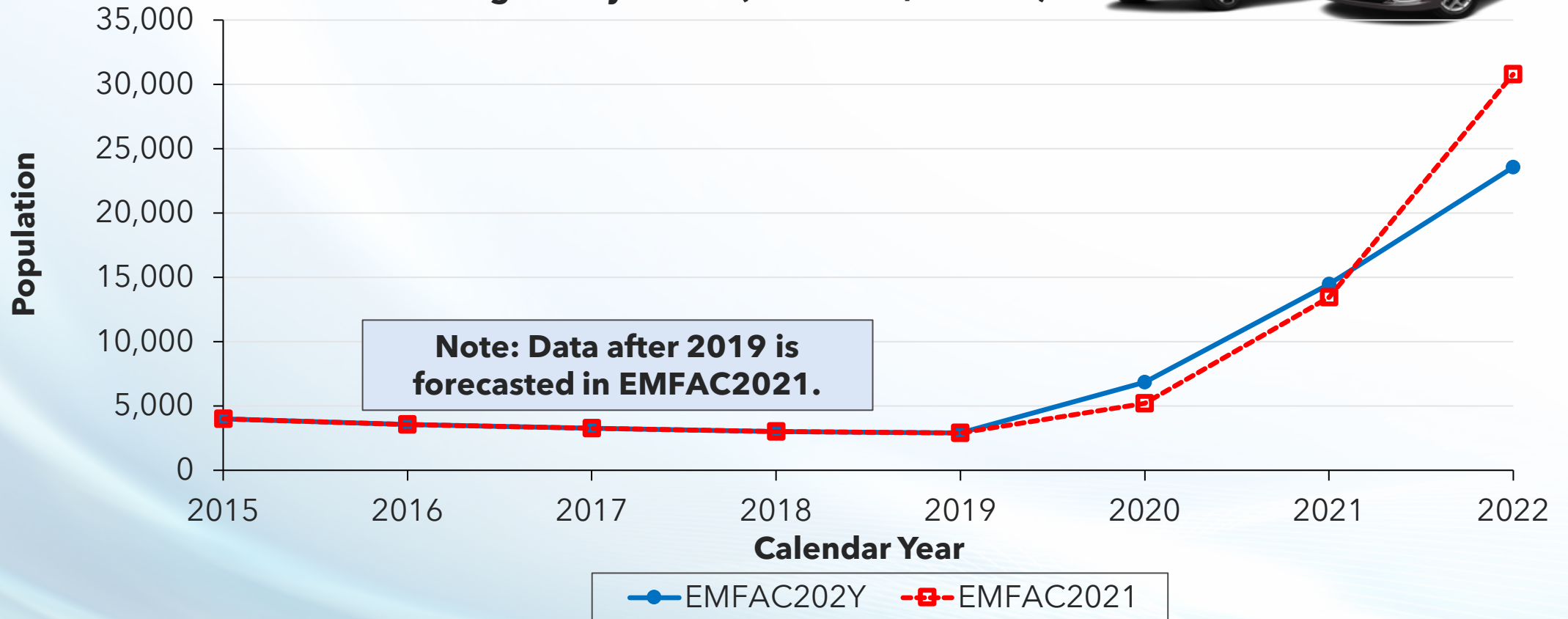


*Electric is defined by "motive power" by DMV, which excludes PHEVs that have a combustion engine.

EMFAC202Y vs EMFAC2021 Population Electric*



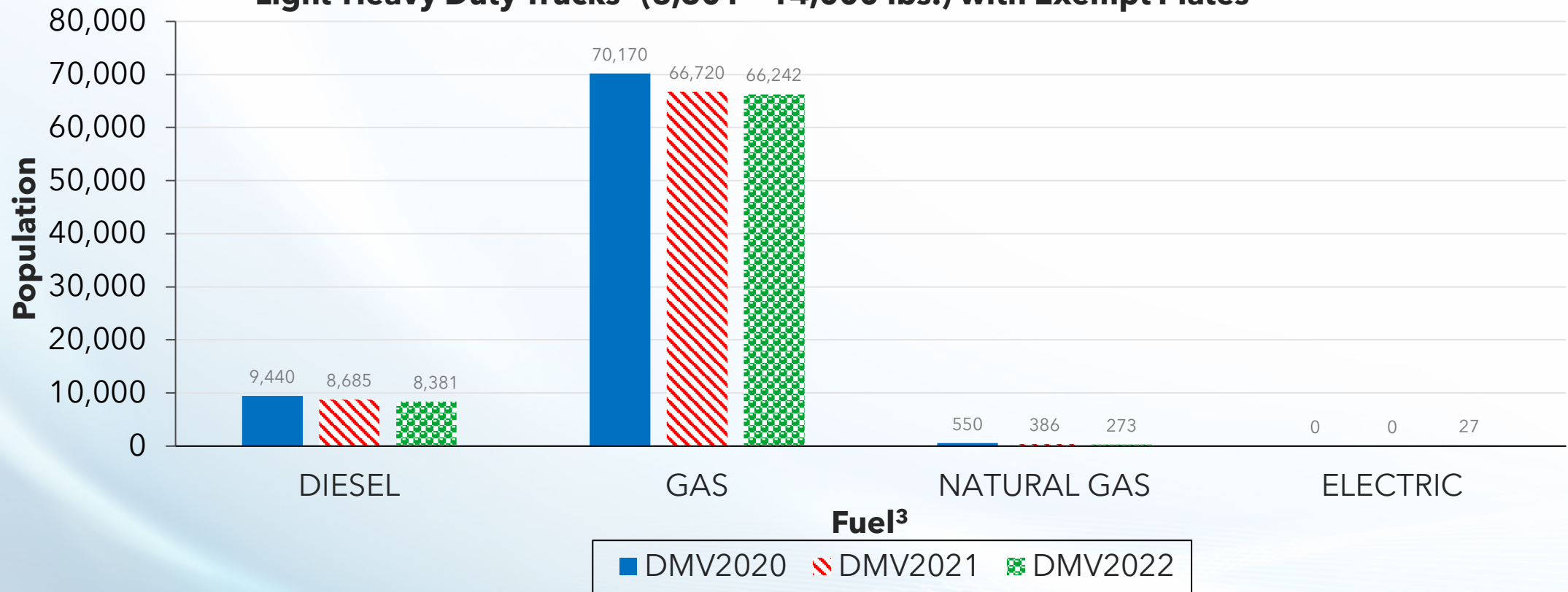
Light-Duty Trucks (GVWR ≤ 8,500 lbs.)



*Electric is defined by "motive power" by DMV, which excludes PHEVs that have a combustion engine.

New Vehicle Category: Public Fleet¹ LHD1 & LHD2

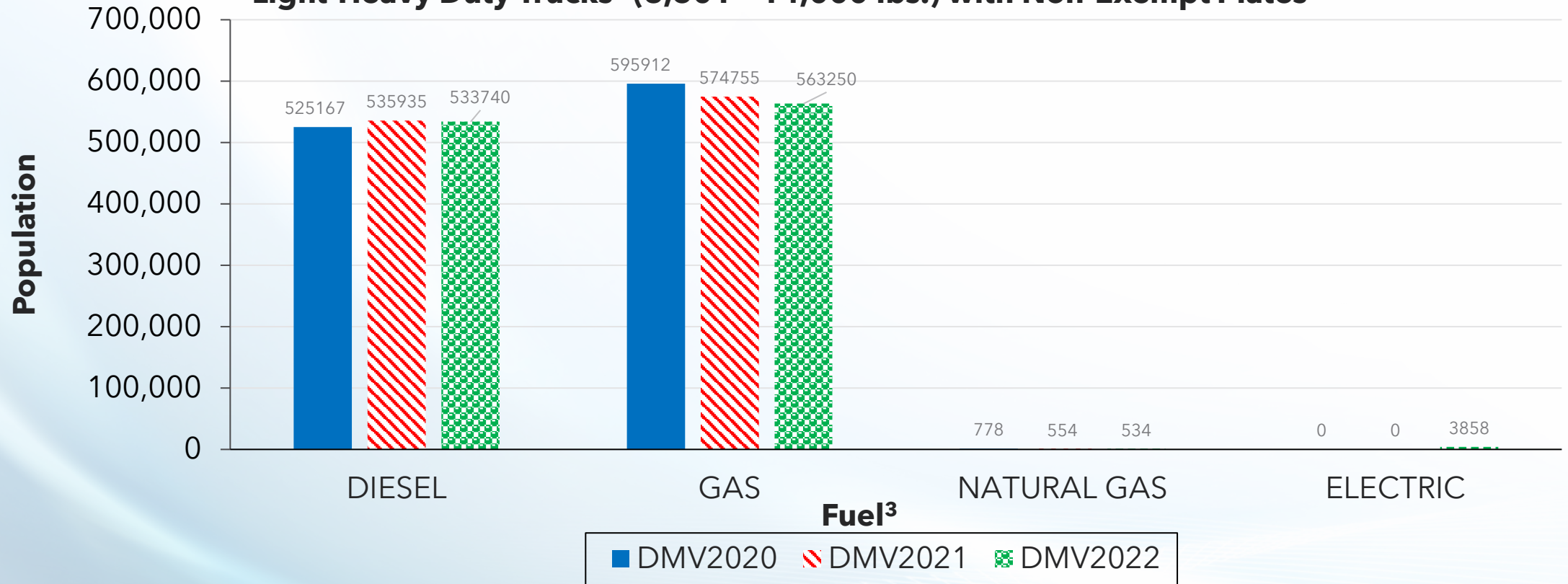
Light-Heavy Duty Trucks² (8,501 - 14,000 lbs.) with Exempt Plates



1. Public fleets comprise of permanent exempt vehicles indicated by DMV with an expiration date of 12/31/2099.
2. These totals are a subset of the diesel and gasoline populations from the earlier slides for this category.
3. Electric trucks in this category will increase in population for future DMV years.

Non-Public Fleet¹ LHD1 & LHD2

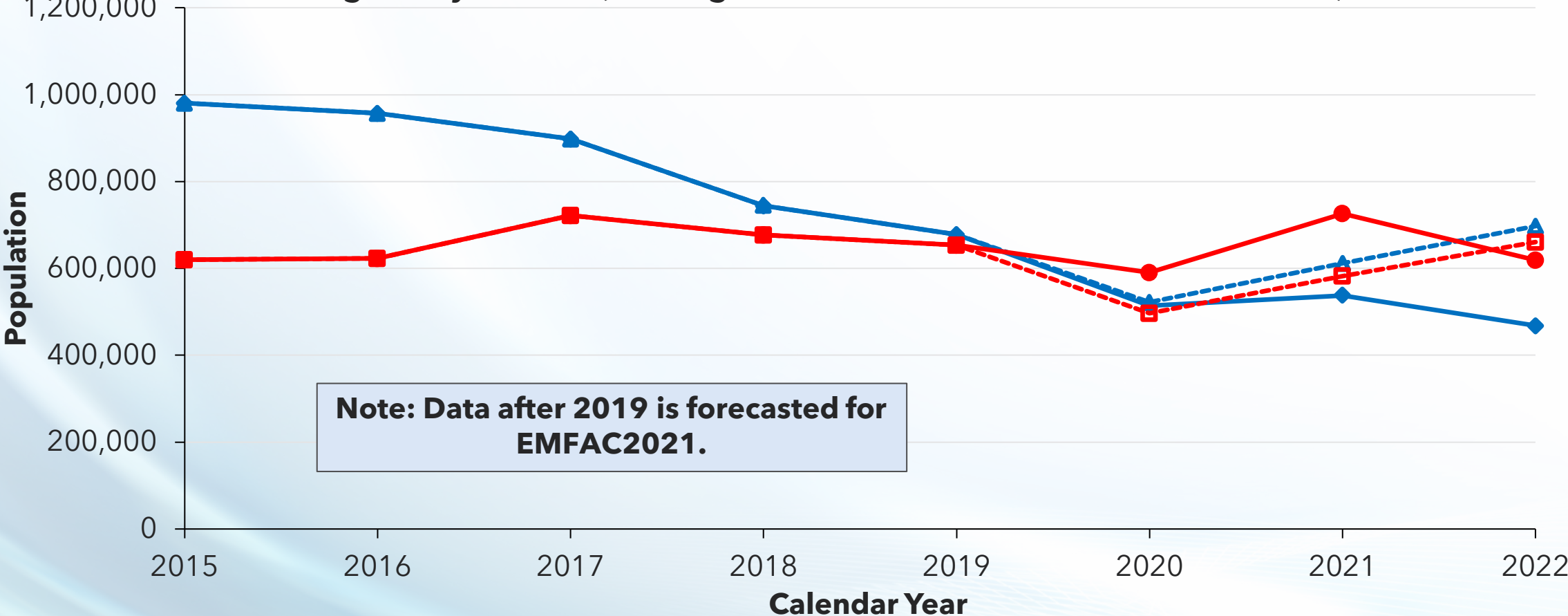
Light-Heavy Duty Trucks² (8,501 - 14,000 lbs.) with Non-Exempt Plates



1. Public fleet are permanent exempt vehicles that are usually assigned with an expiration date of 12/31/2099.
2. These totals are a subset of the diesel and gasoline populations from the earlier slides for this category.
3. Electric trucks in this category will increase in population for future DMV years.

New Sales - Gasoline Vehicles

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

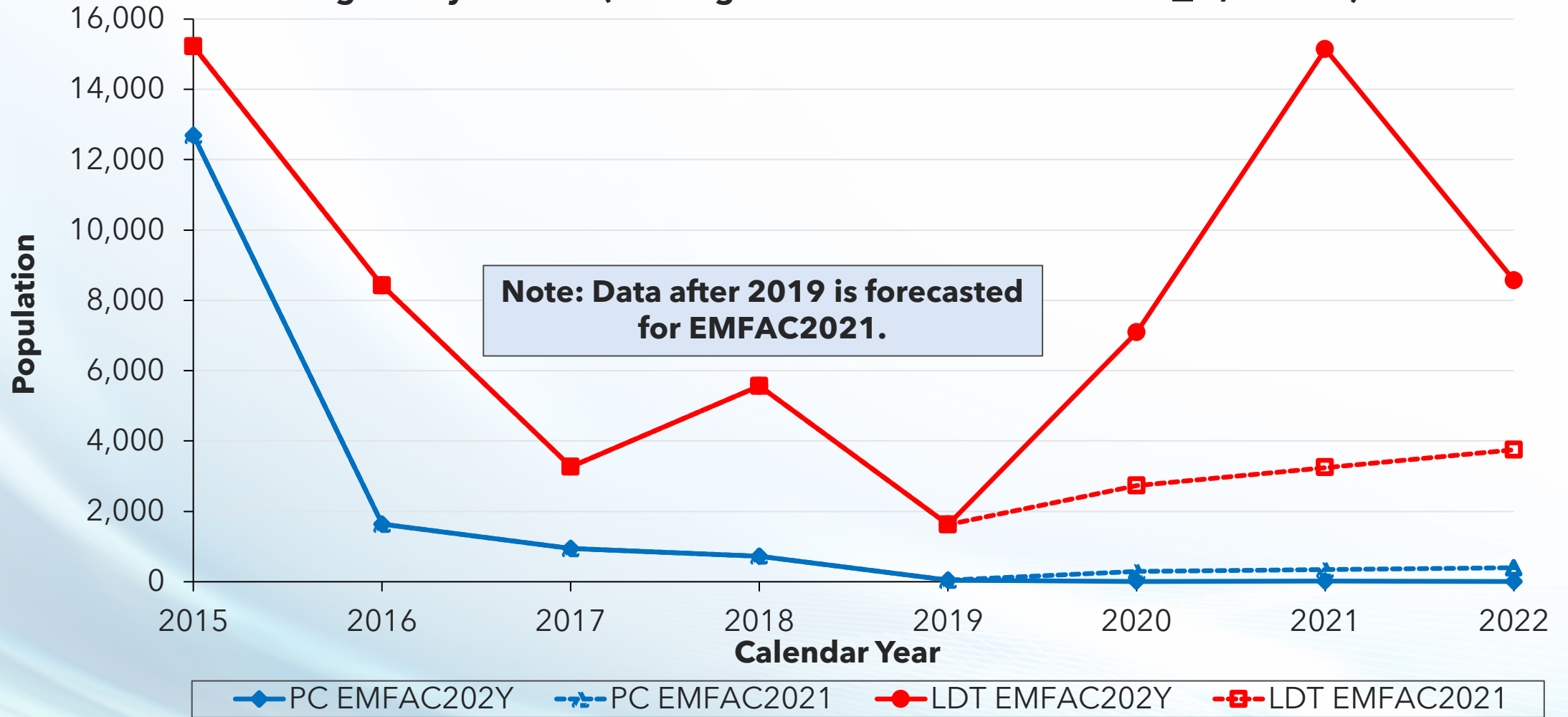


Note: Data after 2019 is forecasted for EMFAC2021.

PC EMFAC202Y PC EMFAC2021 LDT EMFAC202Y LDT EMFAC2021

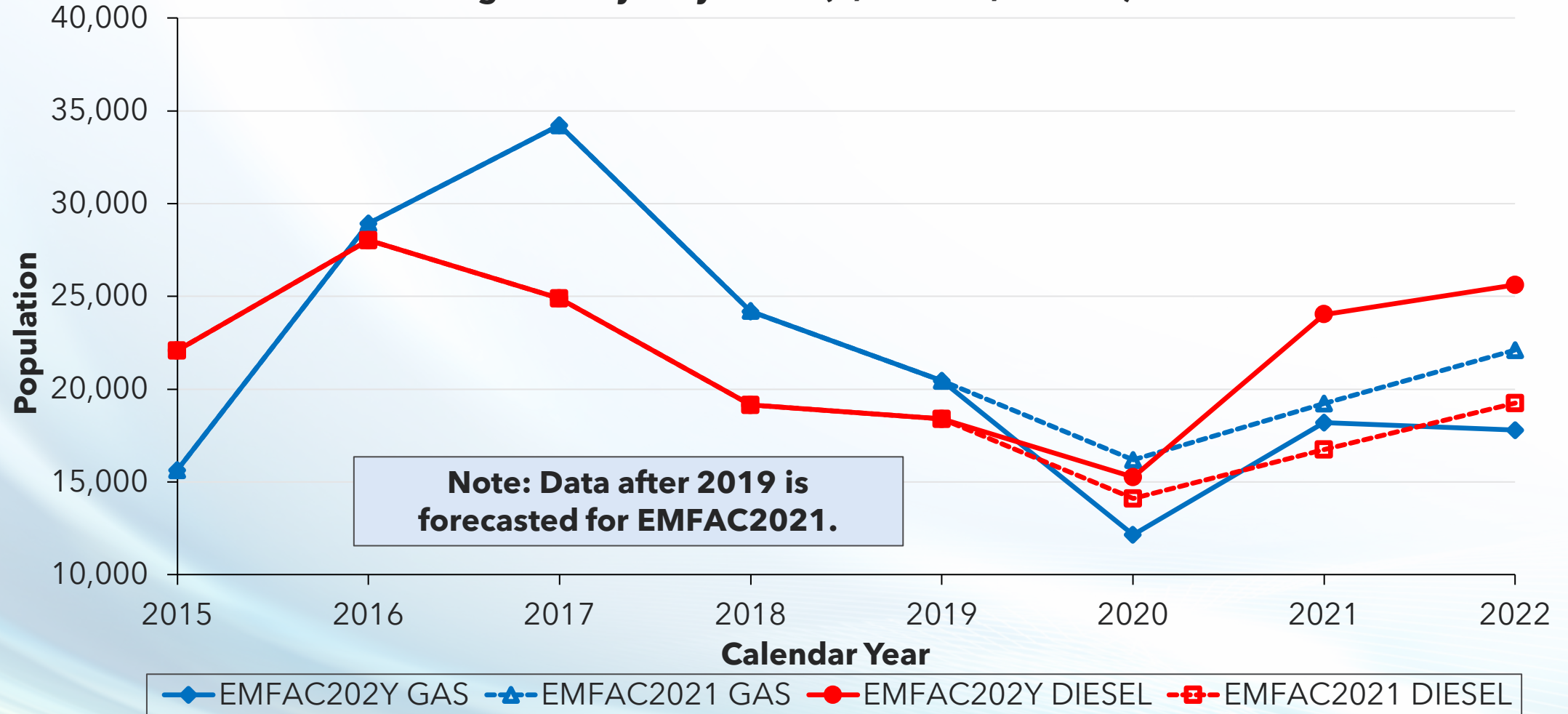
New Sales - Diesel Vehicles

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



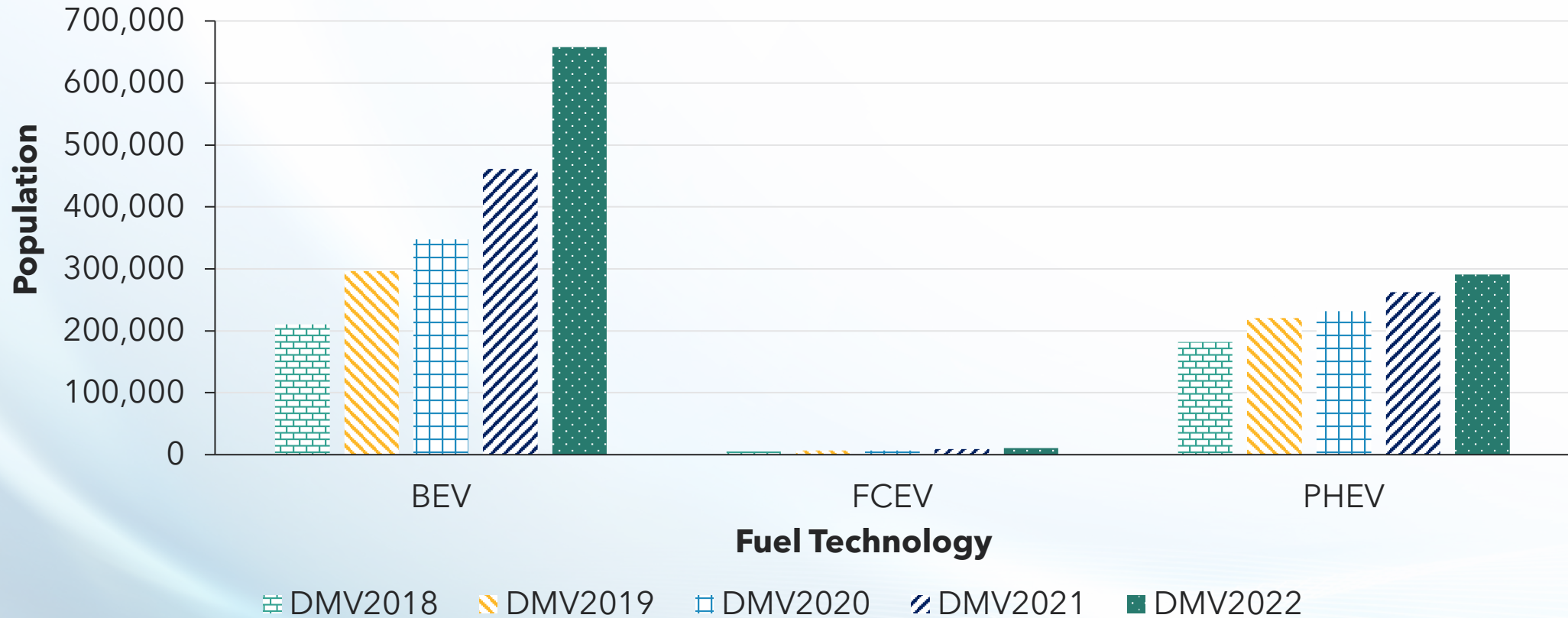
New Sales - Gasoline and Diesel

Light-Heavy Duty Trucks (8,501 - 10,000 lbs.)



On-Road Light-Duty Zero-Emission Vehicles

Zero-Emission Vehicle Populations up to 14,000 lbs.



Please note this is the population of vehicles in all weight classes with “currently” registered status code in CA DMV data and is not equivalent to cumulative sales. DMV2022 counts also include MY 2023 vehicles that were sold before October 2022.

Population Counts for CA Registered Vehicles (includes all ages)

Vehicle Category	Gross Vehicle Weight Rating	2018	2019	2020	2021	2022
Passenger Cars	N/A	14.5M	14.5M	14M	13.9M	13.4M
Light-Duty Trucks	GVWR < 6000 lbs.	7.1M	7.3M	7.3M	7.5M	7.5M
	6,001 - 8,500 lbs.	4.3M	4.2M	4.3M	4.4M	4.4M
Light-Heavy Duty Trucks	8,501-10,000 lbs.	918,000	939,000	987,000	947,000	925,000
	10,001-14,000 lbs.	201,000	212,000	216,000	240,000	251,000
Medium-Heavy Duty Trucks	14,001-16,000 lbs.	303,000	315,000	294,000	277,000	285,000
	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	254,000
Buses	ALL	85,000	86,000	81,000	84,000	85,000
Total¹		27.6M	27.8M	27.4M	27.6M	27.2M

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

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

- Passenger car populations declined by 1 million vehicles since 2018. In addition, the share of electric vehicles has tripled.
- Light-duty truck populations substantially grew especially for diesel and electric vehicles between 2020 and 2022.
- BEV population is increasing rapidly; in 2022, counts surpassed CEC consumer choice model prediction (EMFAC2021) by over 100,000 vehicles
- Total on-road population registration counts remain relatively constant since 2018 in the range of ~27 million vehicles

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Fleet Characterization

LD Age 45+ Vehicles Survey and Results

Background

- EMFAC2021 light-duty vehicle population range is age 0 to 44 years
- About 500,000 vehicles age 45 years and older are registered with DMV (~2% of total light-duty population)
- Lack of accrual rate (annual mileage) for vehicles age 45 and older:
 - California's Smog Check Program informs accrual rates in EMFAC, but only includes vehicles MY 1976 and newer
 - Southern California American Automobile Association (AAA) provided accrual rates to CARB, but only for insurance subscribers in Southern California
- Vehicles 45 years and older may be "classic collector" cars with different usage, retention, and storage trends than newer vehicles

Age 45+ Vehicle Survey

- CARB performed a mailout survey to inform activity assumptions for age 45+ vehicles
- Study Design
 - 25,000 (5% of MY 1978 and older population) mailouts
 - Random stratified sampling by county and age group from DMV2022
 - Online survey consists of 7 short questions and 2 open ended comment questions
- Survey Timeframe
 - Planning: April - July 2023
 - Mailouts: end of July 2023
 - Data collection: August - September 2023

Age 45+ Vehicle Survey Results - Summary

- Overall response rate:
 - Received 2,960 online responses within 60 days
 - 2,889 responses that met quality assurance/quality control (QA/QC) requirements
 - ~11.6% response rate out of total 25,000 mailouts

• Age distribution:

Decade	DMV Database	Survey Responded
1890s	0.001%	NA
1900s	0.018%	NA
1910s	0.1%	0.1%
1920s	1.3%	1.8%
1930s	4.2%	5.6%
1940s	3.8%	4.5%
1950s	13.8%	15.3%
1960s	42.0%	41.4%
1970s	34.8%	31.4%
Total	100%	100%

Age 45+ Vehicle Survey Results - Primary Vehicle Operating County

- The primary vehicle operating county distribution is relatively consistent with the vehicle registration distribution in the DMV database

County	DMV Database	Survey Responded
Los Angeles	21%	17%
San Diego	8%	8%
Orange	7%	7%
Riverside	5%	5%
Sacramento	5%	5%
San Bernardino	5%	4%
Santa Clara	4%	4%
Alameda	3%	3%

- Top 5 responses: Los Angeles (17%), San Diego (8%), Orange (7%), Riverside (5%), Sacramento (5%)

Age 45+ Vehicle Survey Results - Current Odometer Reading

- Asked for total mileage since the car was new
- Summary:

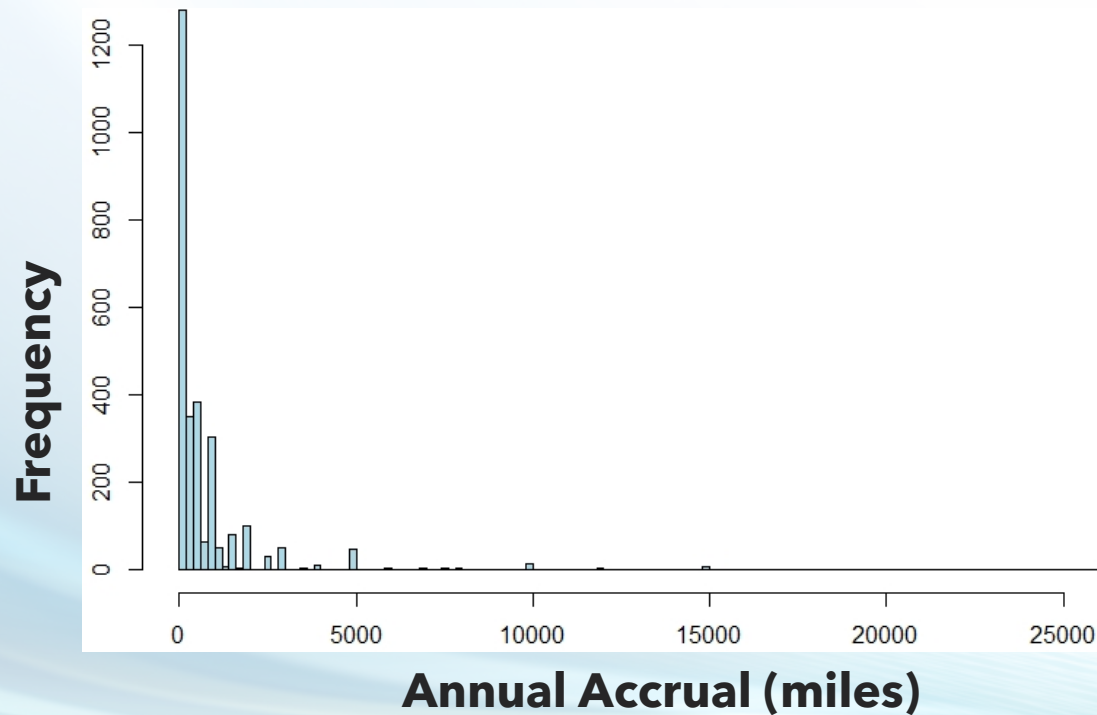
Counts	Minimum	1 st Quartile	Median	Mean	3 rd Quartile	Maximum
2424	50	42,964	79,774	97,888	122,000	999,999

- Classic car might have odometer roll-over issue with a max of five-digit display
- Many vehicle owners have purchased a second-hand car so they cannot provide the exact lifetime total mileage
- The answers collected might be the current display odometer, or reflect the vehicle owner's best estimate

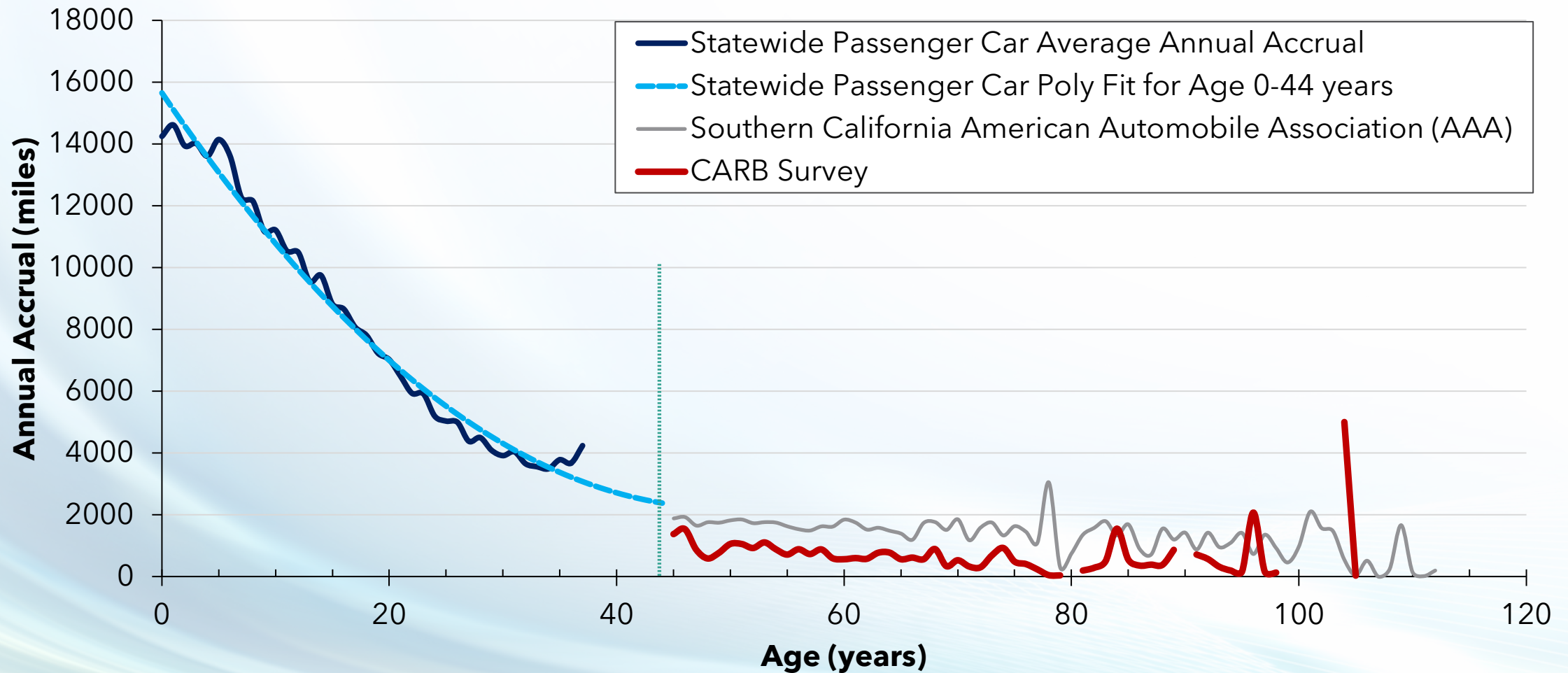
Age 45+ Vehicle Survey Results - Annual Mileage Accrual (Miles Driven Per Year)

- Summary:

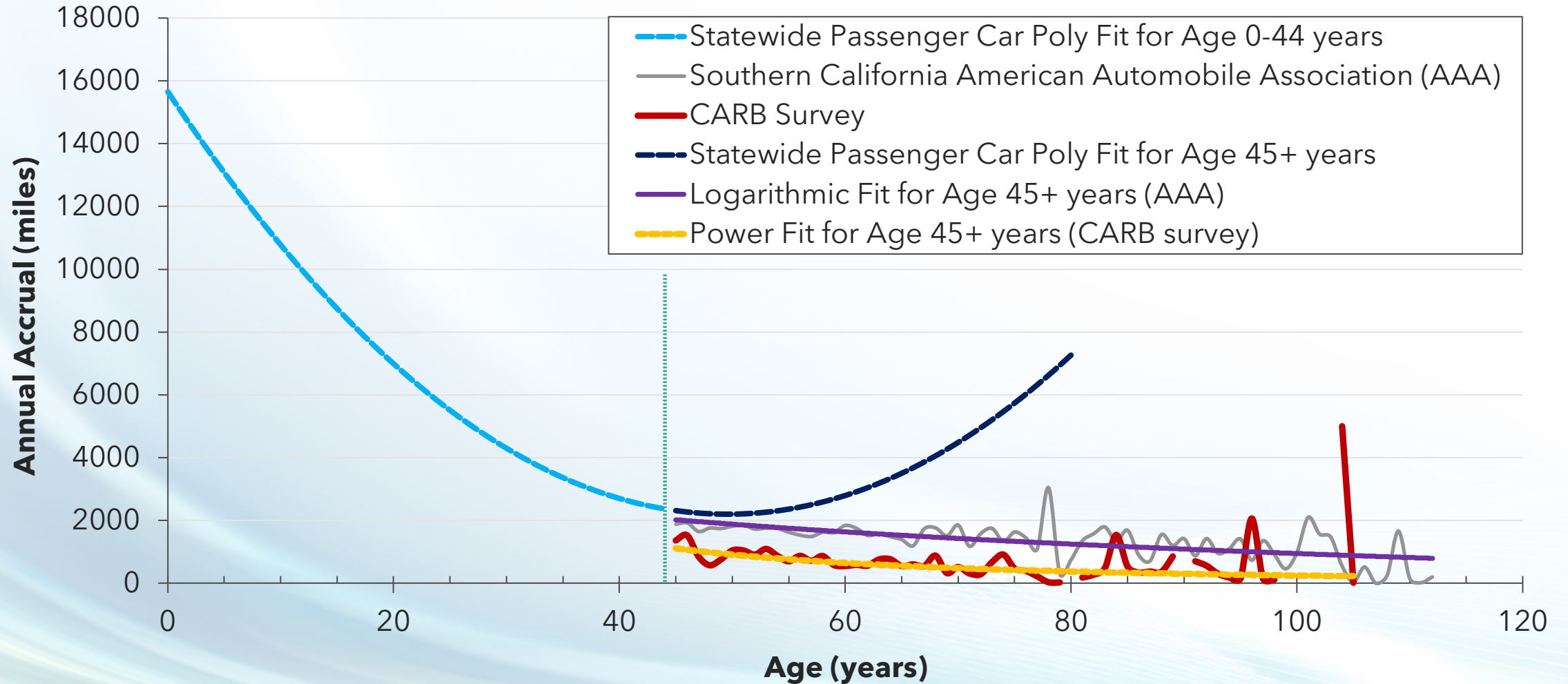
Counts	Minimum	1 st Quartile	Median	Mean	3 rd Quartile	Maximum
2824	0	100	300	803	1000	26,000



Age 45+ Vehicle Survey Results - Annual Mileage Accrual

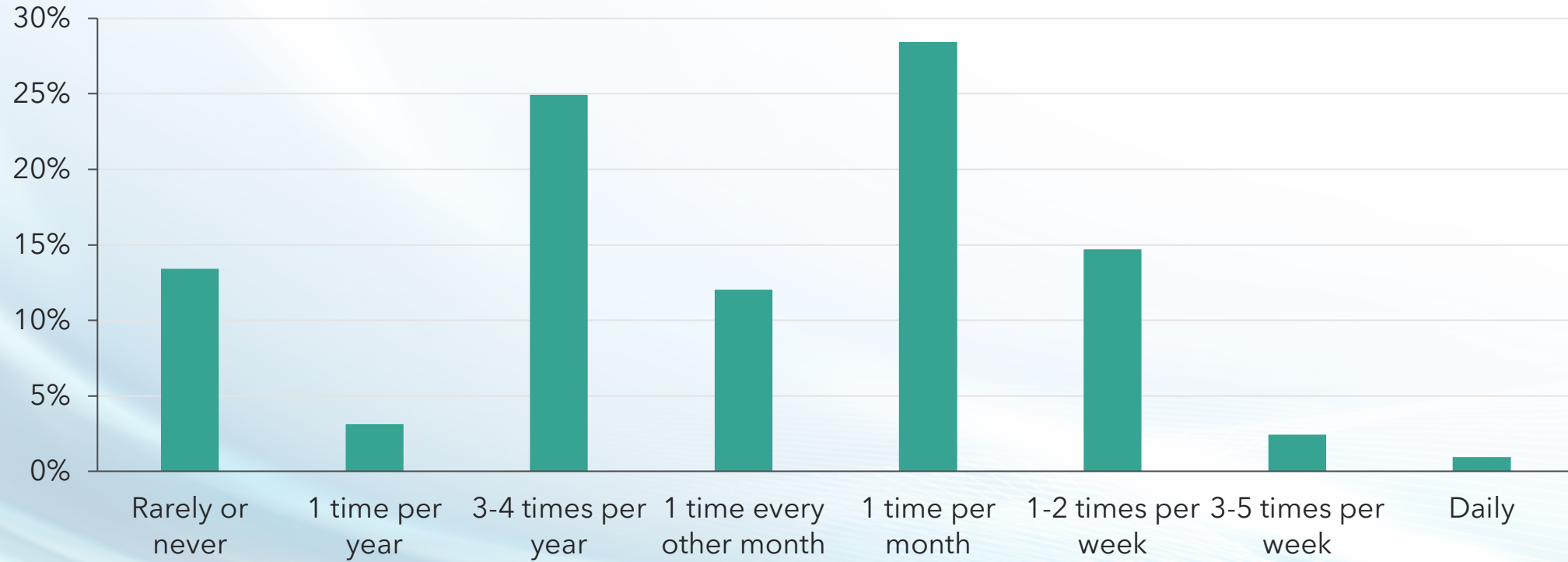


Age 45+ Vehicle Survey Results - Annual Mileage Accrual



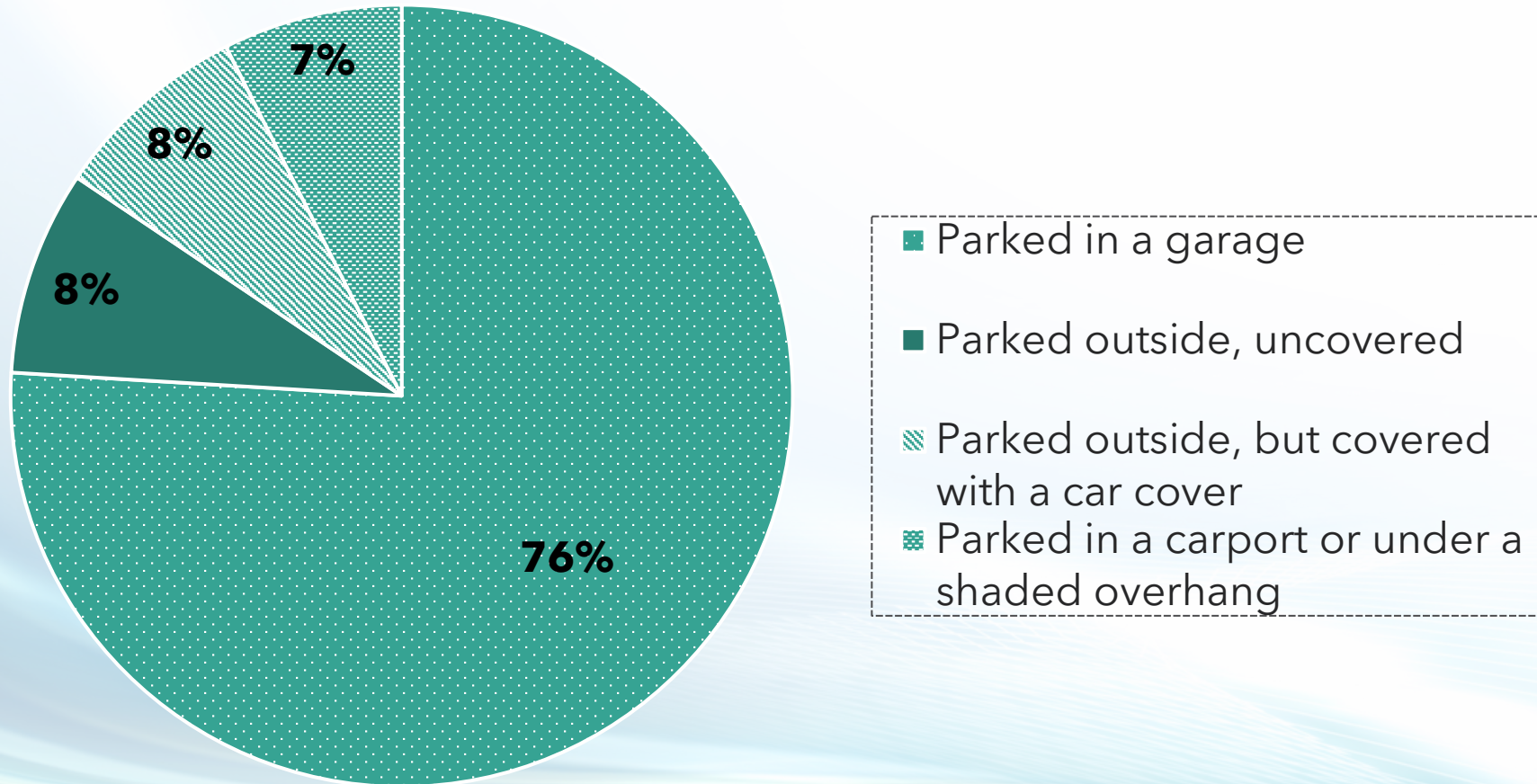
Age 45+ Vehicle Survey Results - Driven Frequency

- Top 3 answers: 1 time per month (28%), 3-4 times per year (25%), 1-2 times per week (15%)

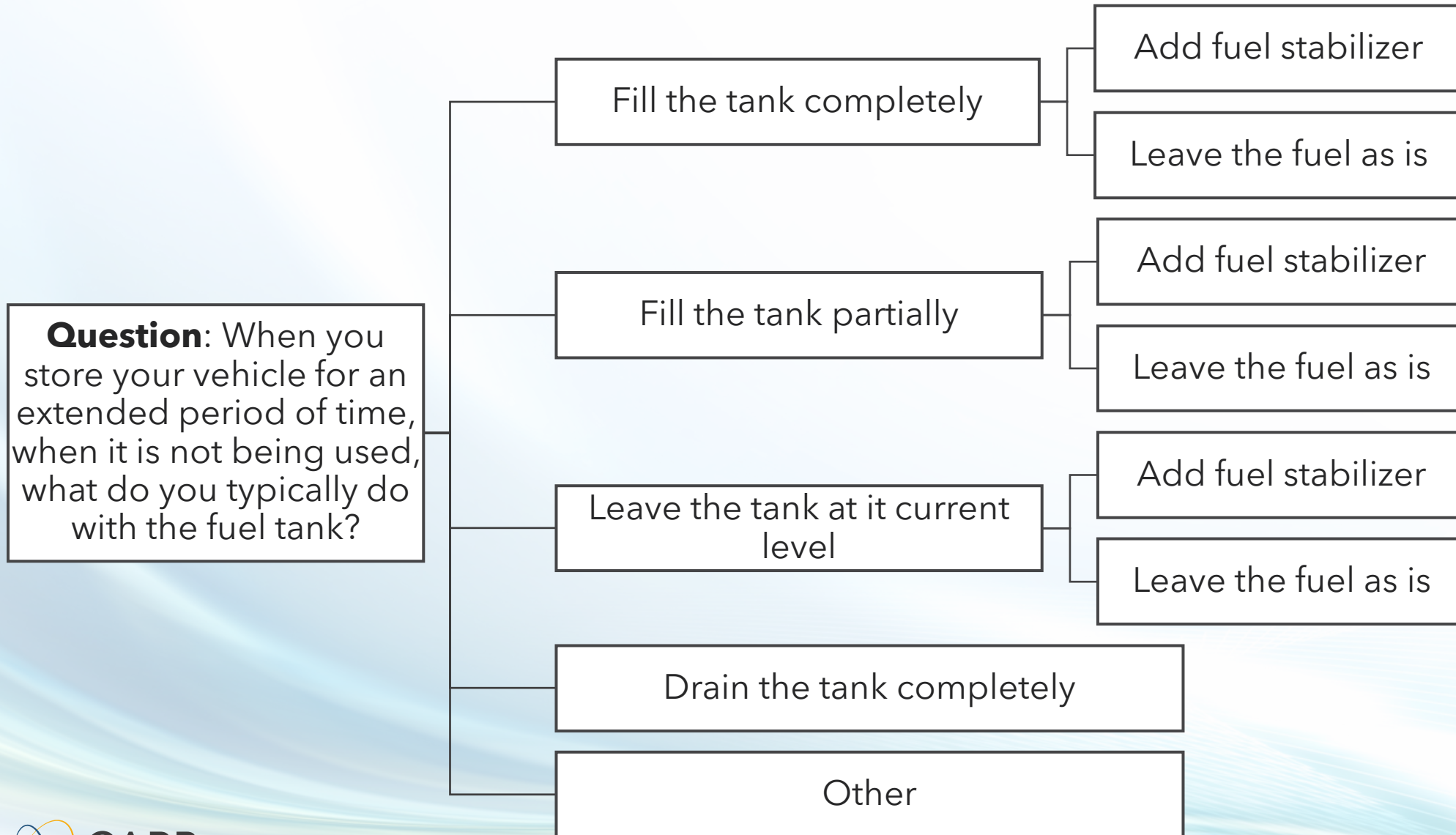


Age 45+ Vehicle Survey Results - Storage Condition

- 76% of vehicle owners park their car in a garage

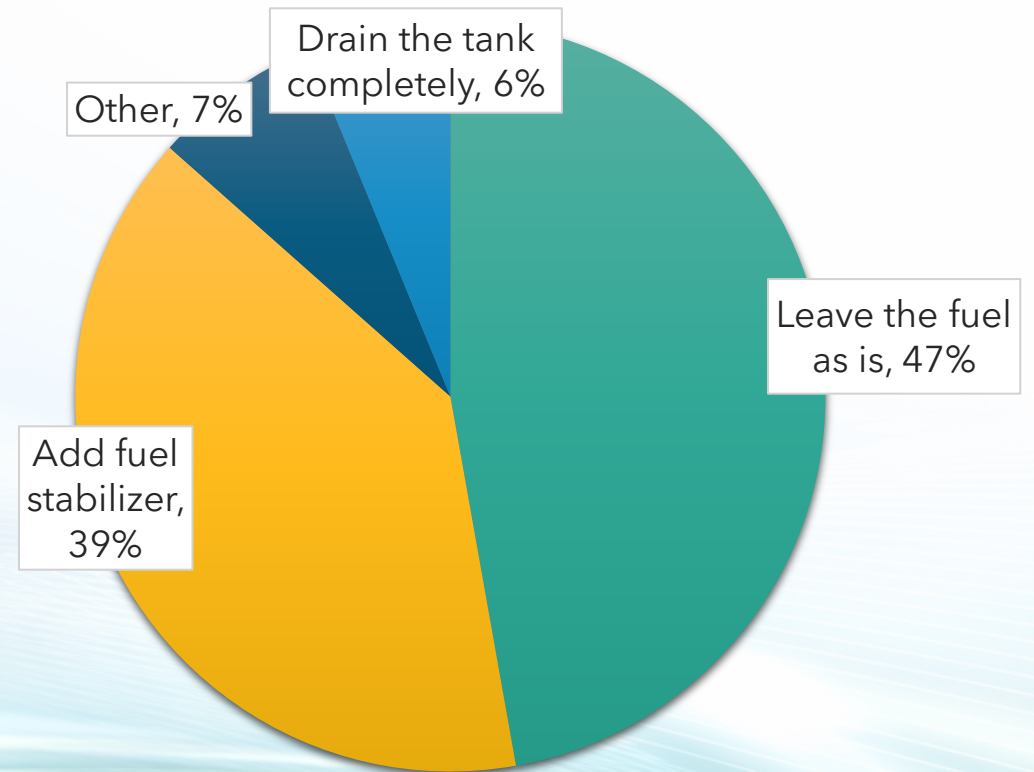
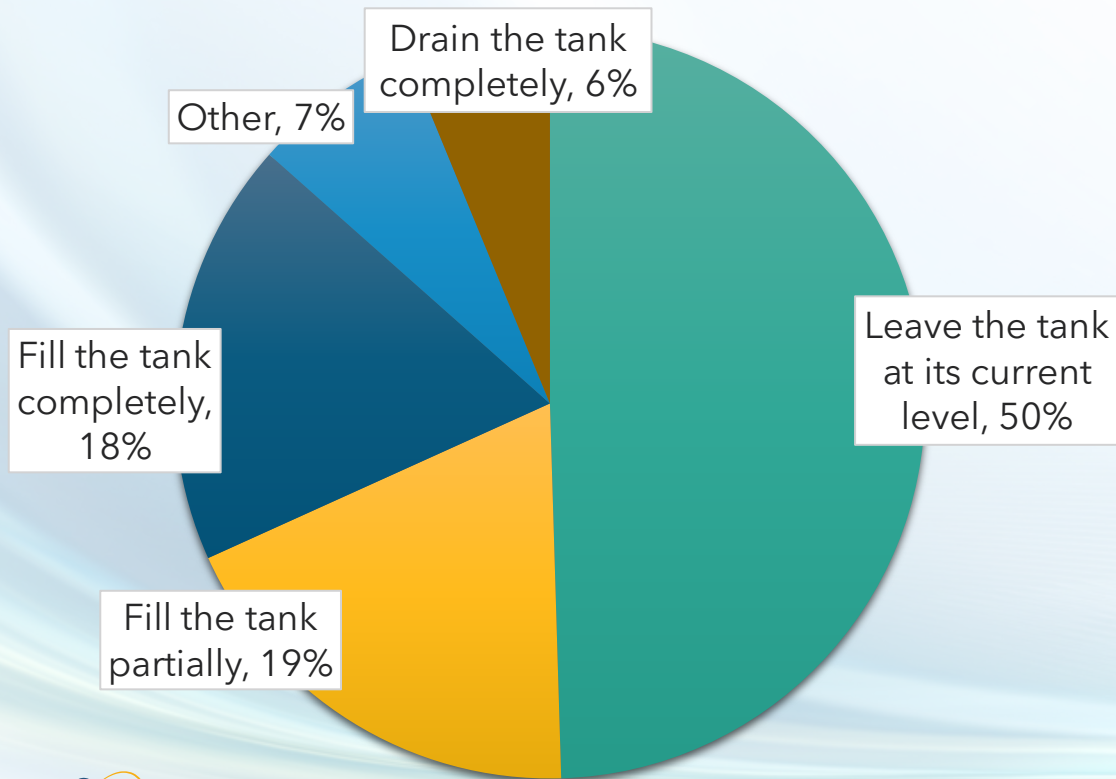


Age 45+ Vehicle Survey Results - Fuel Tank Condition

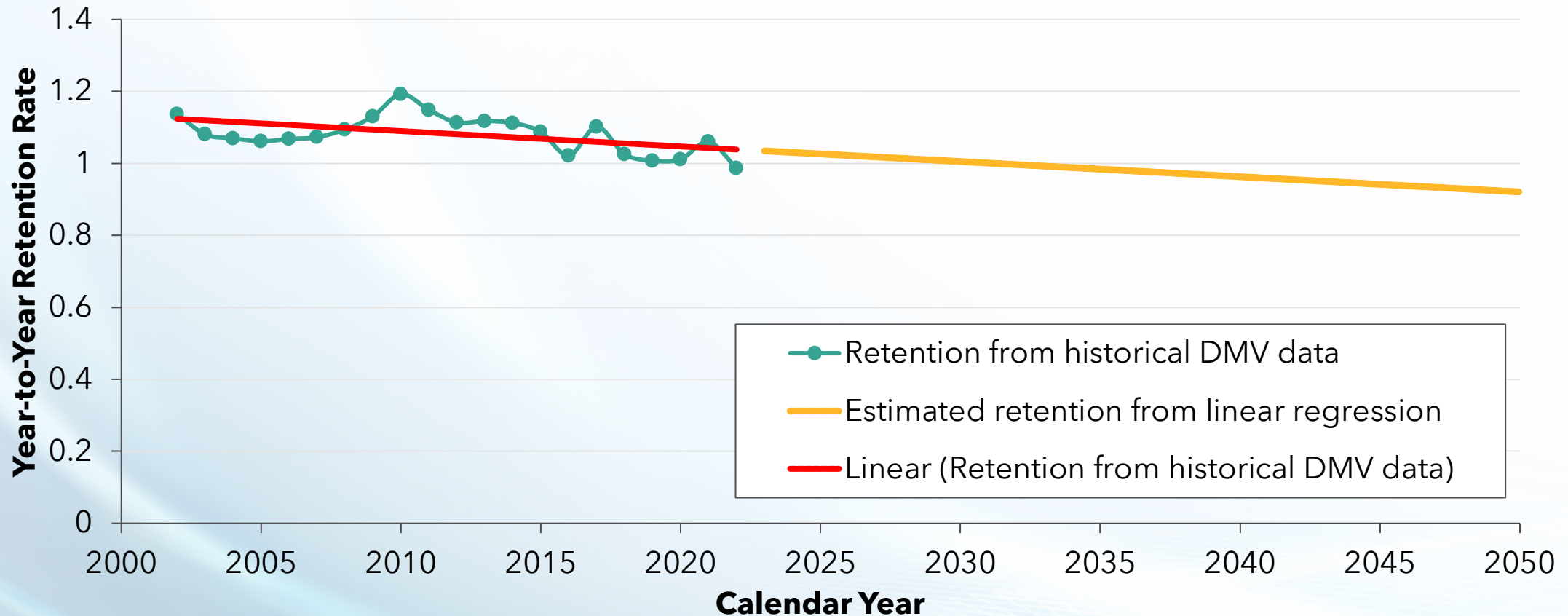


Age 45+ Vehicle Survey Results - Fuel Tank Condition

- Top 3 answers: Leave the tank at its current level, leave the fuel as is (34%); Leave the tank at its current level, add fuel stabilizer (16%); Fill the tank completely, add fuel stabilizer (13%)

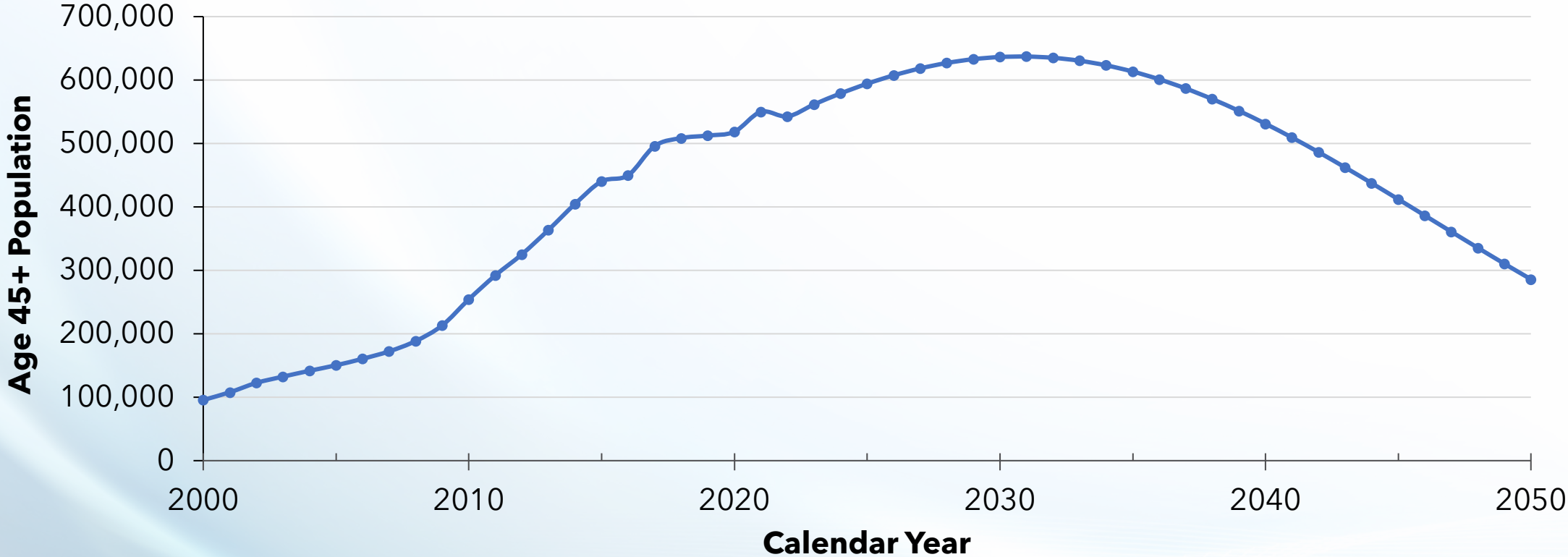


EMFAC Implementation - Age 45+ Vehicles Year-to-Year Retention Rate



- Fit a linear regression to the retention rates of age 45+ vehicles from DMV2001-2022 data
- Extend the line to develop the estimated retention rates for age 45+ vehicles in 2023-2050

EMFAC Implementation - Age 45+ Vehicle Population

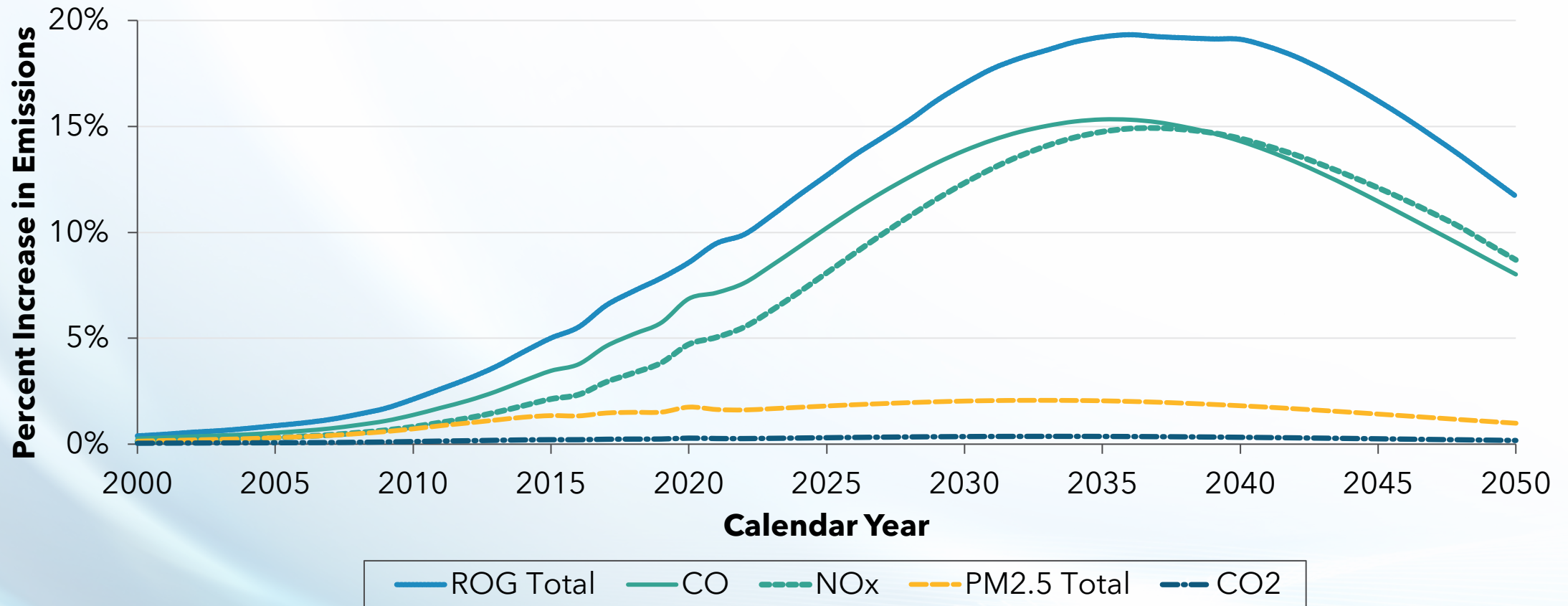


- Population in CY 2001 to 2022 are based on DMV database
- Population in remaining years are based on estimated year-to-year retention rates in previous slide
- Assume all age 45+ vehicles are gasoline

EMFAC Implementation - Methodology

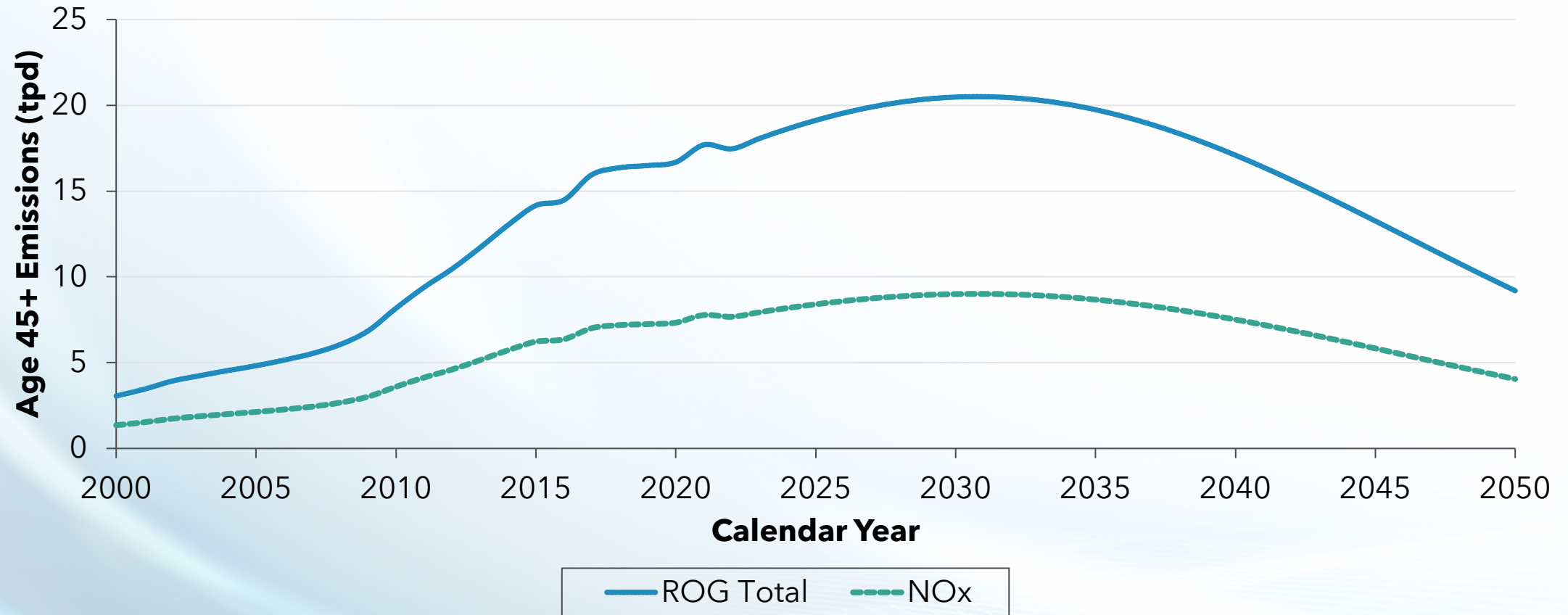
- Treat all age 45+ vehicles as one age group
- Use annual accrual of 803 miles for age 45+ vehicles
- Based on age 45+ vehicles age distributions (50% between age 45-55), use age 55 emission rates in each CY to represent age 45+ emission rates
 - CY 2000-2018, age 55 is MY 1946-1964 (oldest emission rate MY is 1965 in EMFAC, use MY 1965 rates instead)
 - In CY 2030, age 55 is MY 1976
 - In CY 2050, age 55 is MY 1996

EMFAC Implementation - Estimated Emissions Impacts



- With 0.5-2.6% added population, the total light-duty emissions increased 0.05-19% by pollutant and CY (estimated using emission rates from EMFAC2021)

EMFAC Implementation - Statewide Estimated ROG/NOx Emissions



- ~20 tpd total ROG and 9 tpd NOx emissions from age 45+ vehicles in 2030

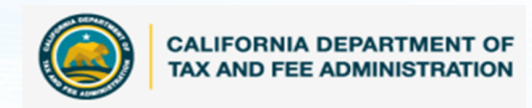
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On-Road Vehicle Population Primary Sources

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 state¹) and NNOOS (non-neighboring out of state) Inventory based on the annual miles in CA per jurisdiction



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

On-Road Vehicle Population Other Sources

Other 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
- TRUCRS¹/EDVR² 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 from Advanced Clean Trucks (ACT) regulation



1. Truck Regulation Upload, Compliance and Reporting System (TRUCRS)
2. Excluded Diesel Vehicle Reporting (EDVR)

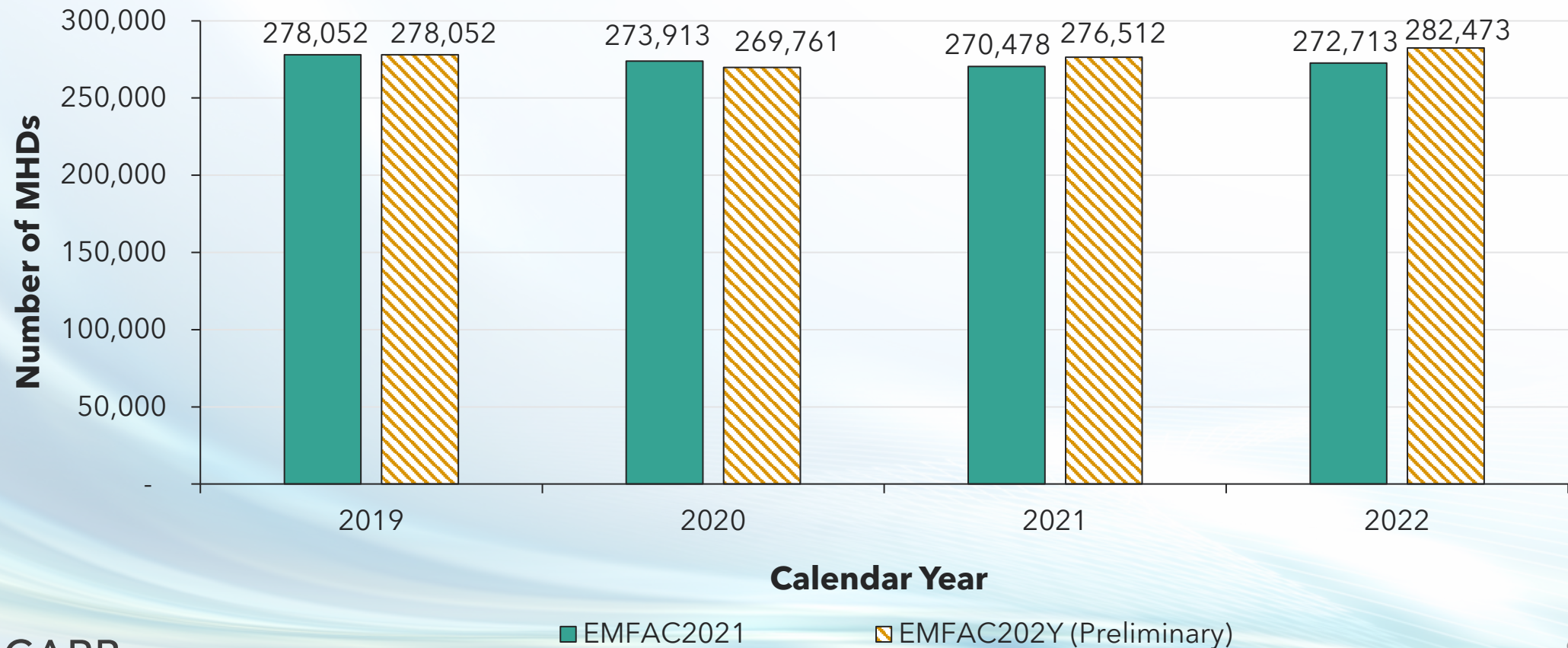
Priority Sequencing for Assigning Fleet Categories

- 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)

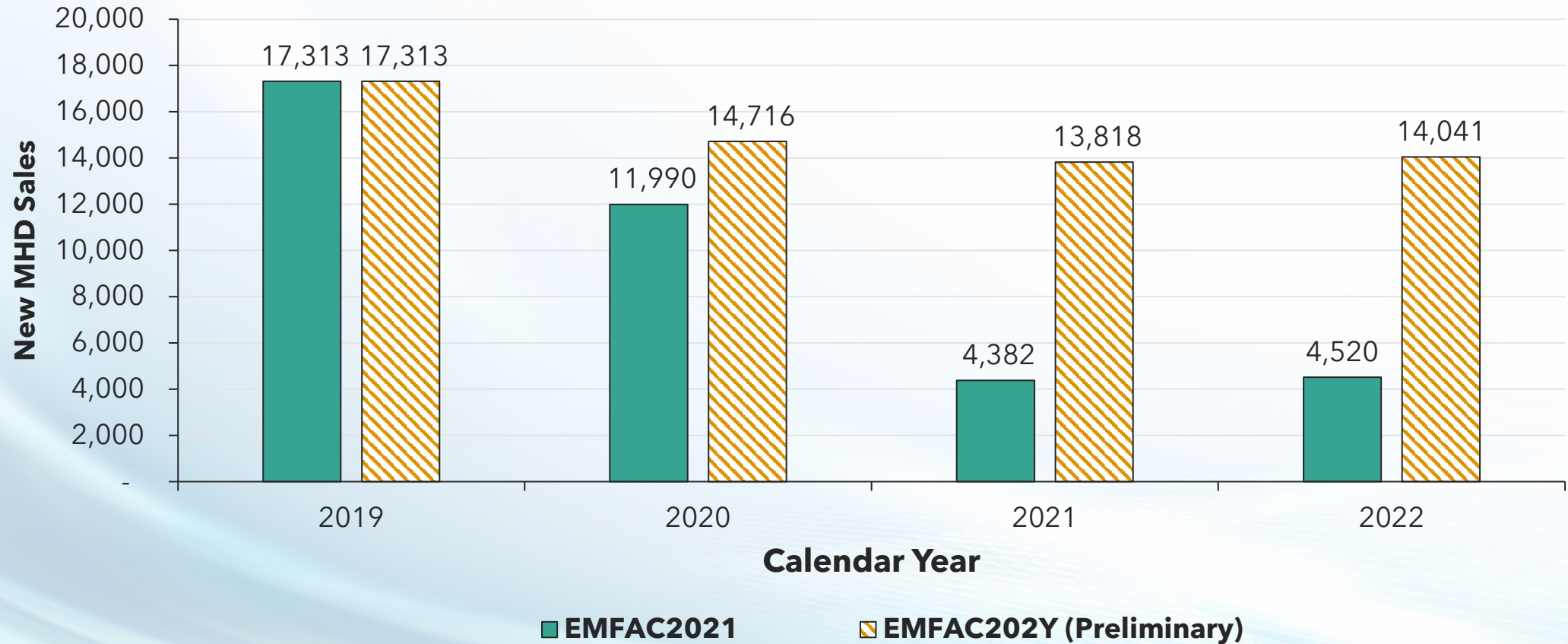
California Registered MHD (GVWR 14,001 - 33,000 lbs.)

- CA registered MHD truck counts were slightly lower in CY 2020 and a bit higher in CY 2021 - 2022 than EMFAC2021 forecasts

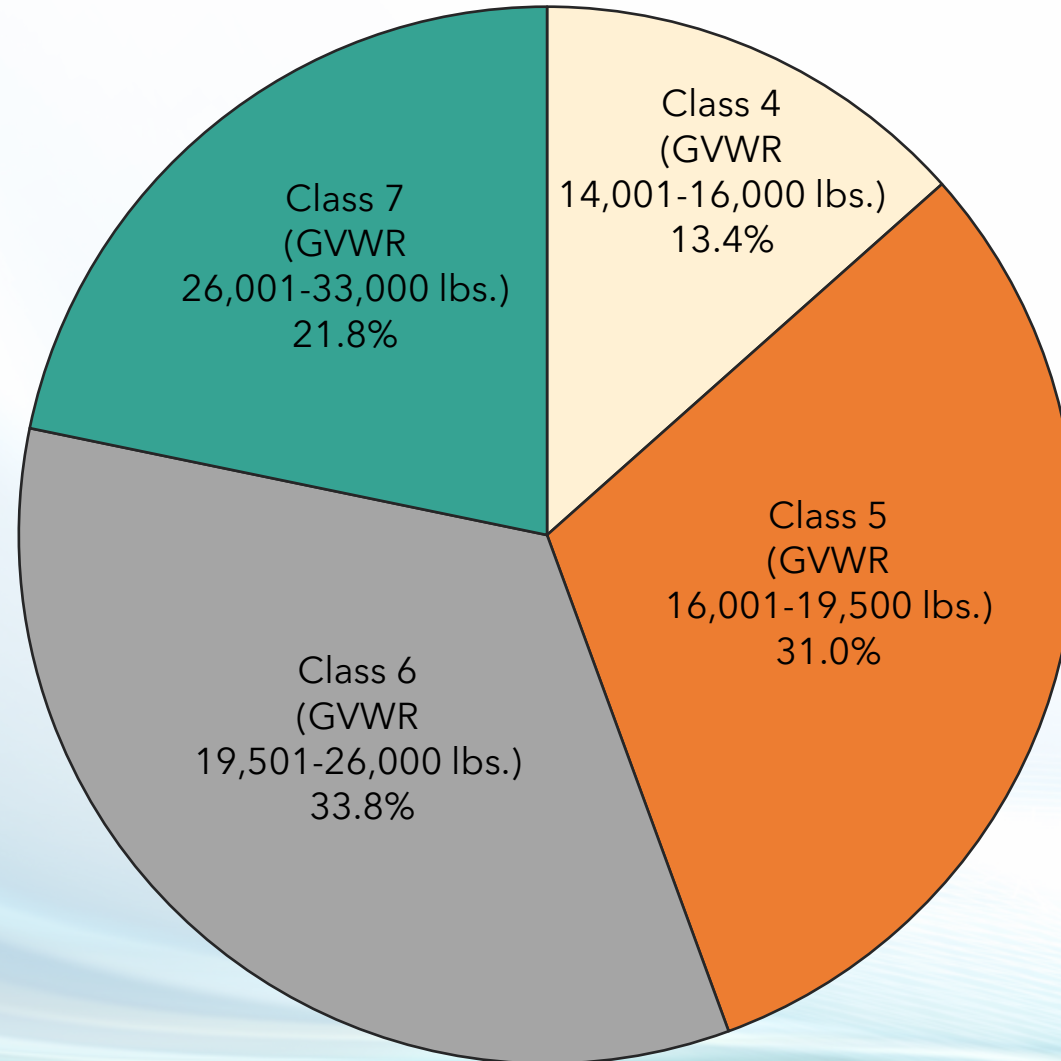


California Registered MHD - New Sales

- New sales in years 2020 - 2022 exceeded EMFAC2021 forecasts

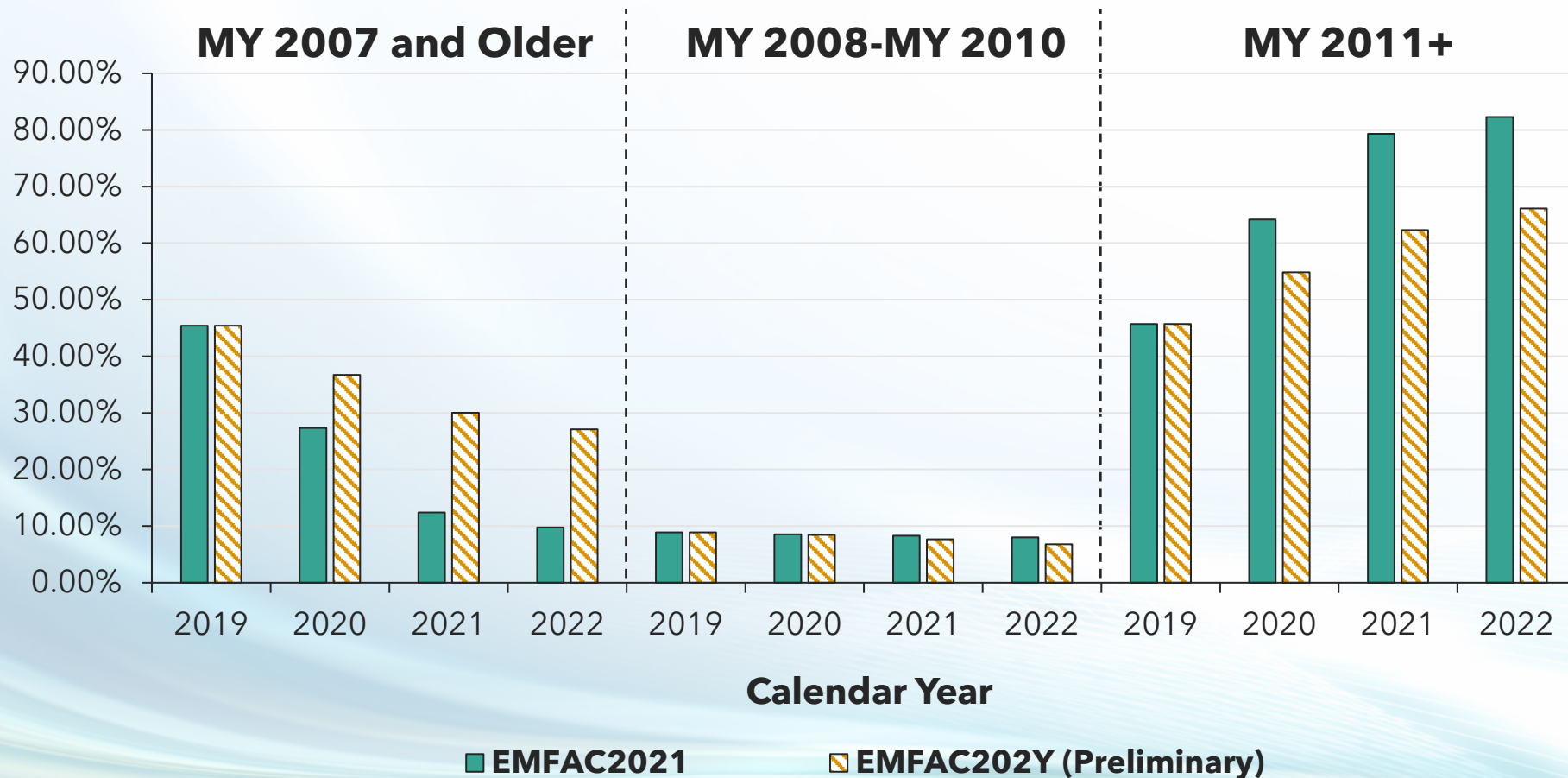


CY 2022 California Registered MHD - Weight Classes



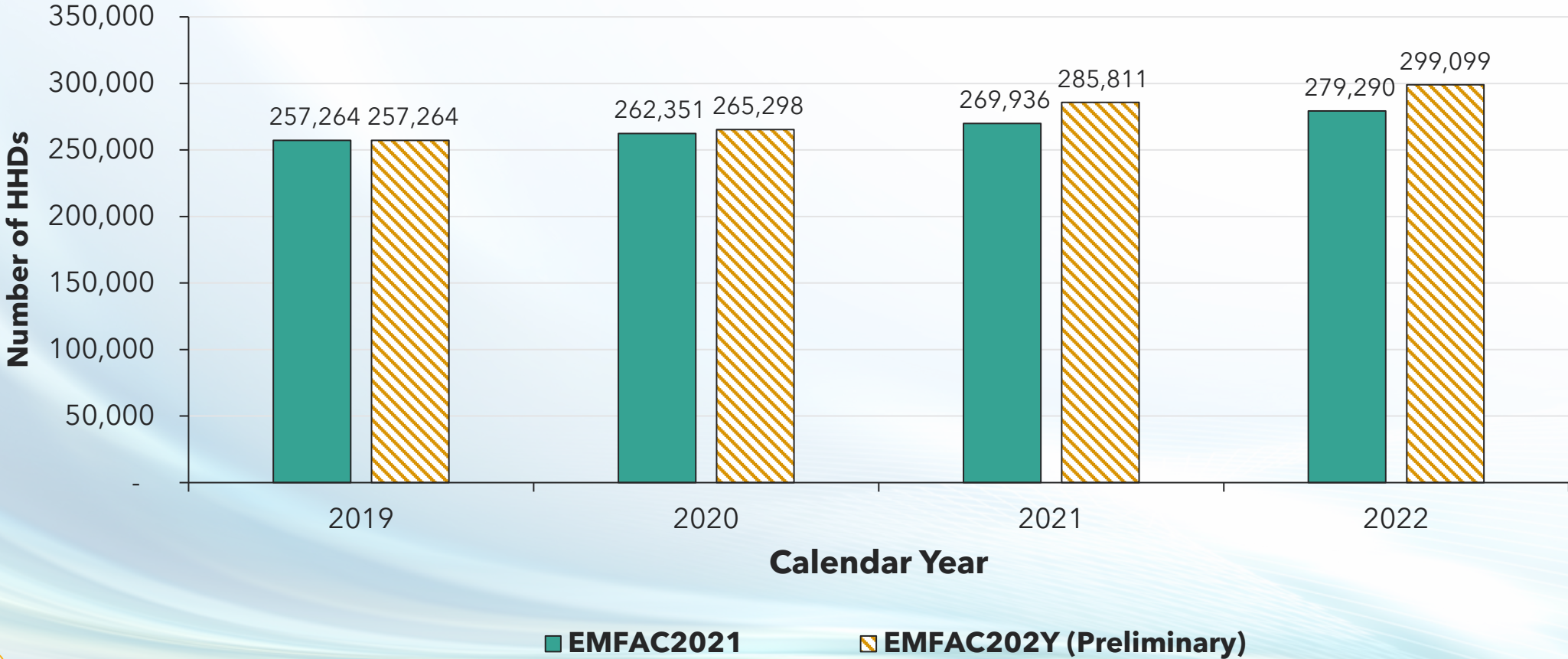
California Registered MHD - Chassis MY Groups

- Fractions of MY 2007 & older vehicles are higher than predicted for CY 2020+
- Fractions of MY 2011+ vehicles are lower than predicted for CY 2020-22



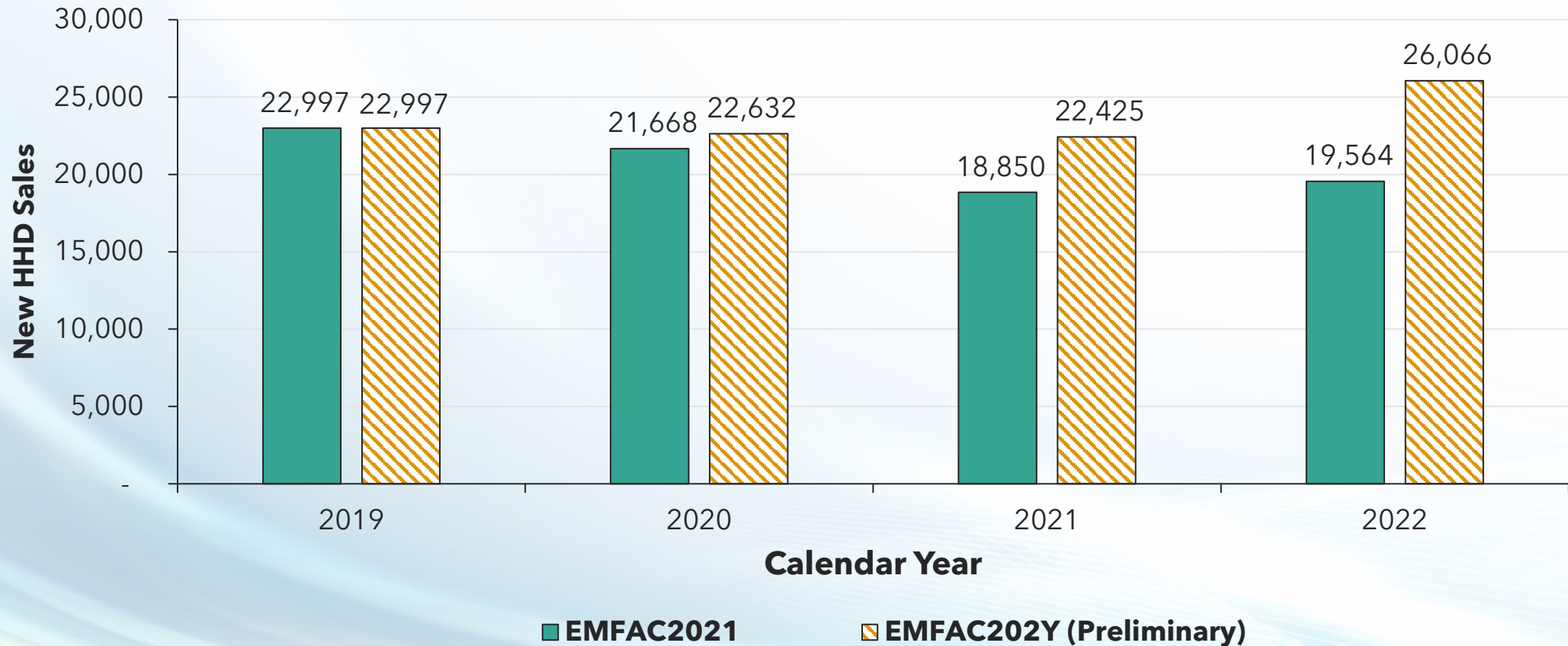
California Registered Heavy-Heavy Duty (HHD) (GVWR >33,000 lbs.)

- CA registered HHD vehicle counts were higher in CY 2020-2022 than EMFAC2021 forecasts



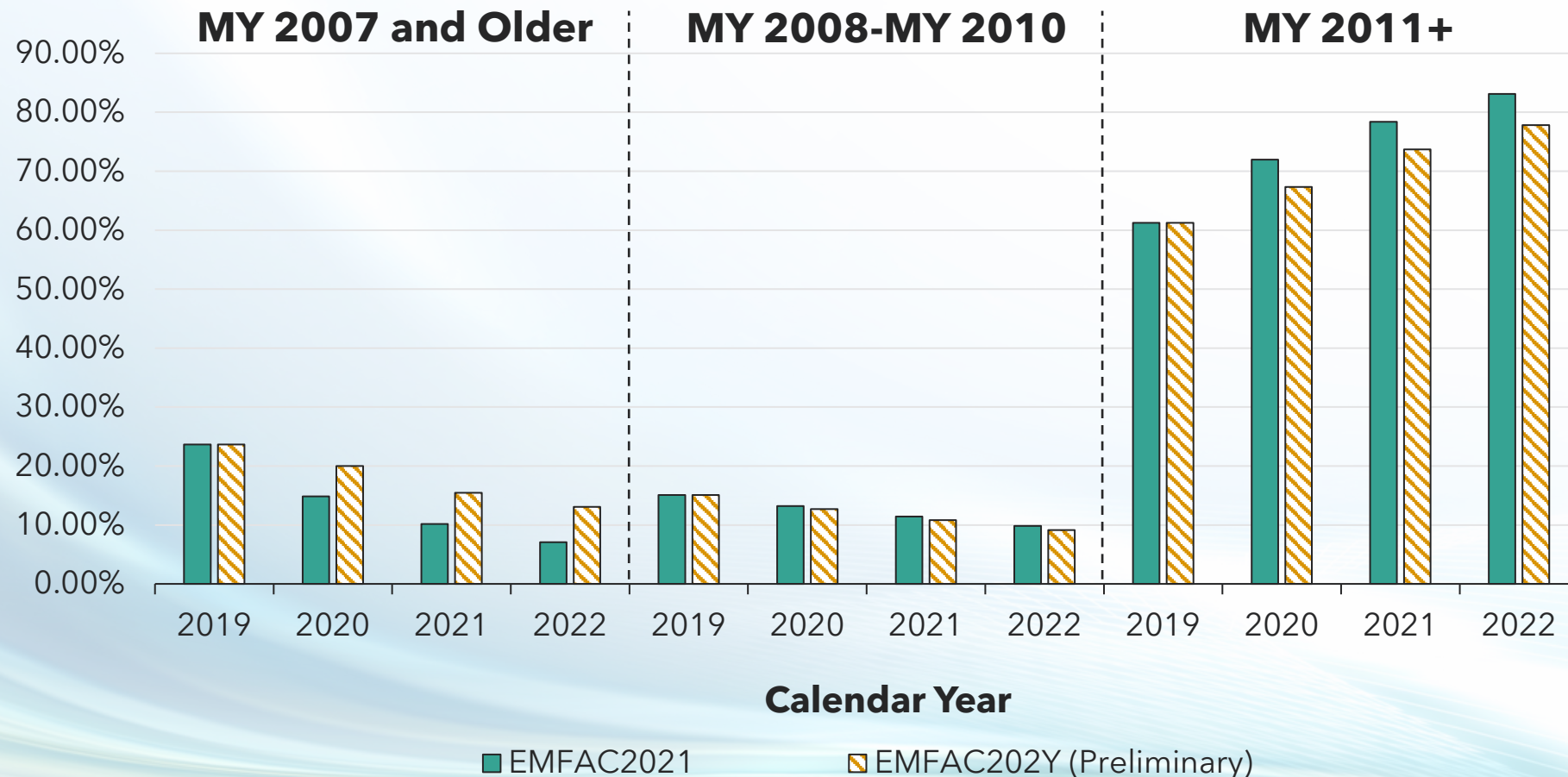
California Registered HHD - New Sales

- New sales in years 2020 - 2022 exceeded EMFAC2021 forecasts



California Registered HHD - Chassis MY Groups

- EMFAC202Y updates show MY 2007 and older proportions were higher and MY 2011+ proportions were lower than predicted by EMFAC2021 forecasts for CY 2020 - 2022
- Overall trends in EMFAC202Y updates from CY 2019 - 2022 are in the expected direction (fewer older and more newer vehicles counts)



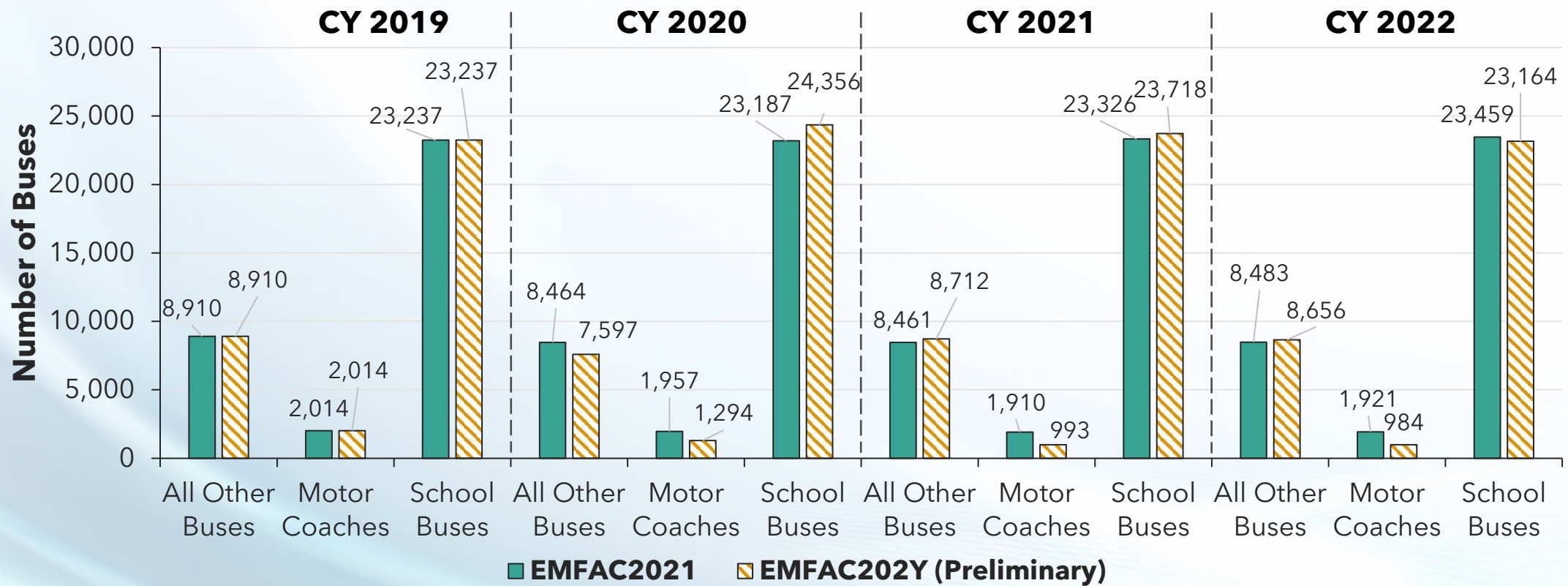
HDV Bus Categories

- Transit/UBUS = Urban Buses (not privately owned)
- School Buses = Buses used for transport to/from schools (subject to CHP inspections)
- Motor Coaches = Large Travel Buses with Interstate CA Registration
- All Other Buses = All sizes of buses not included in above categories



California Registered Buses (Excludes Transit/UBUS)*

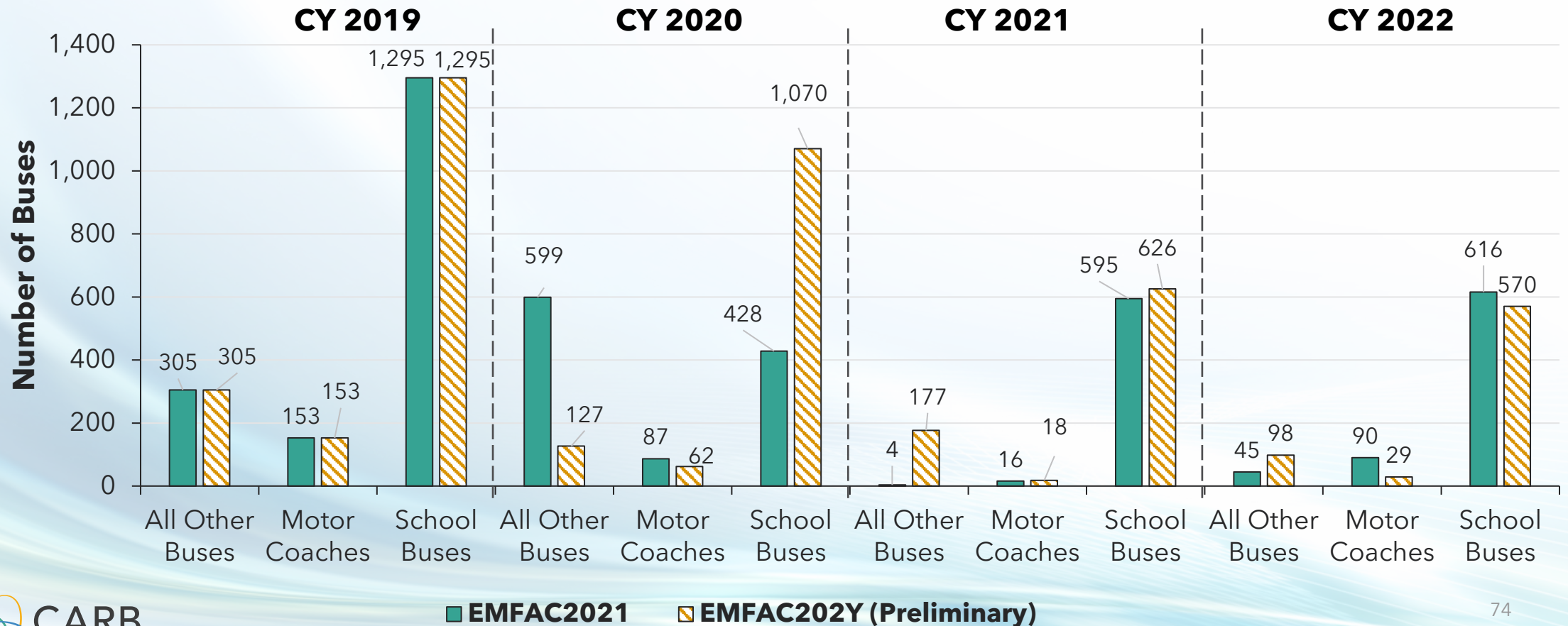
- CA registered bus counts in years 2020 - 2022 were very close to EMFAC2021 forecasts except for Motor Coach counts, which dropped likely due to COVID impacts on leisure activities



*Transit buses (UBUS category) are not required to renew their registration. Therefore, DMV does not have up-to-date data. Instead, EMFAC uses other data sources for the transit/UBUS inventory.

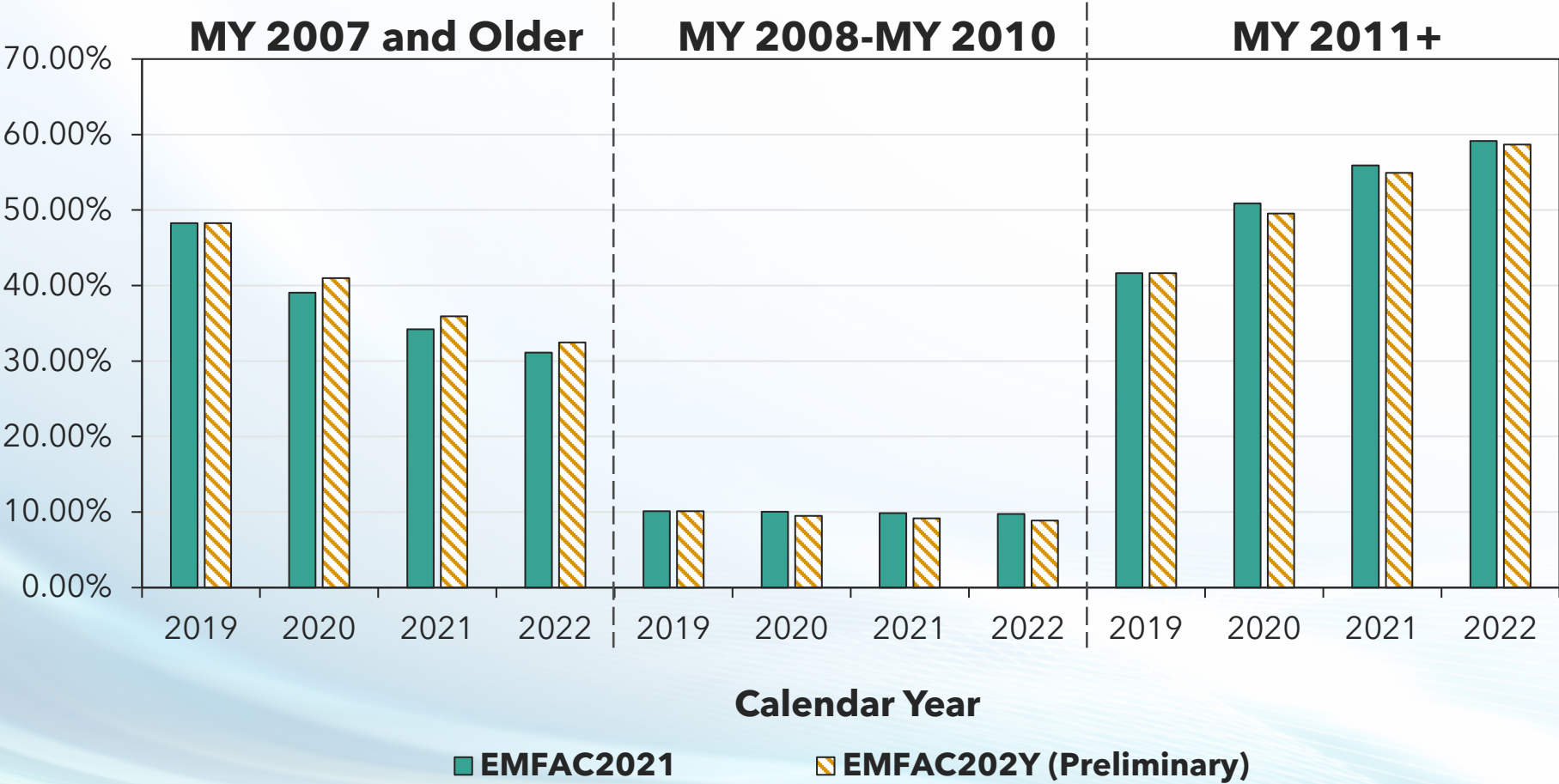
California Registered Buses - New Sales (Excludes Transit/UBUS)

- New sales in 2020 exceeded EMFAC2021 forecasts for School Buses but All Other Buses and Motor Coaches had lower new sales than forecasted
- New Sales exceeded EMFAC2021 forecasts in 2021



CA Registered Buses - Chassis MY Groups (Excludes Transit/UBUS)

- EMFAC2021 forecasts were close to the updated values for EMFAC202Y



HD Fleet Characterization: Summary and Next Steps

- The updated historical inventory (population & VMT) for CY 2020-2022 will be finalized for use in EMFAC202Y
- EMFAC202Y will forecast HDV inventory (population & VMT) for CY 2023+
- Impacts of the updated inventory will be presented in a future EMFAC202Y workshop

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Fleet Characterization

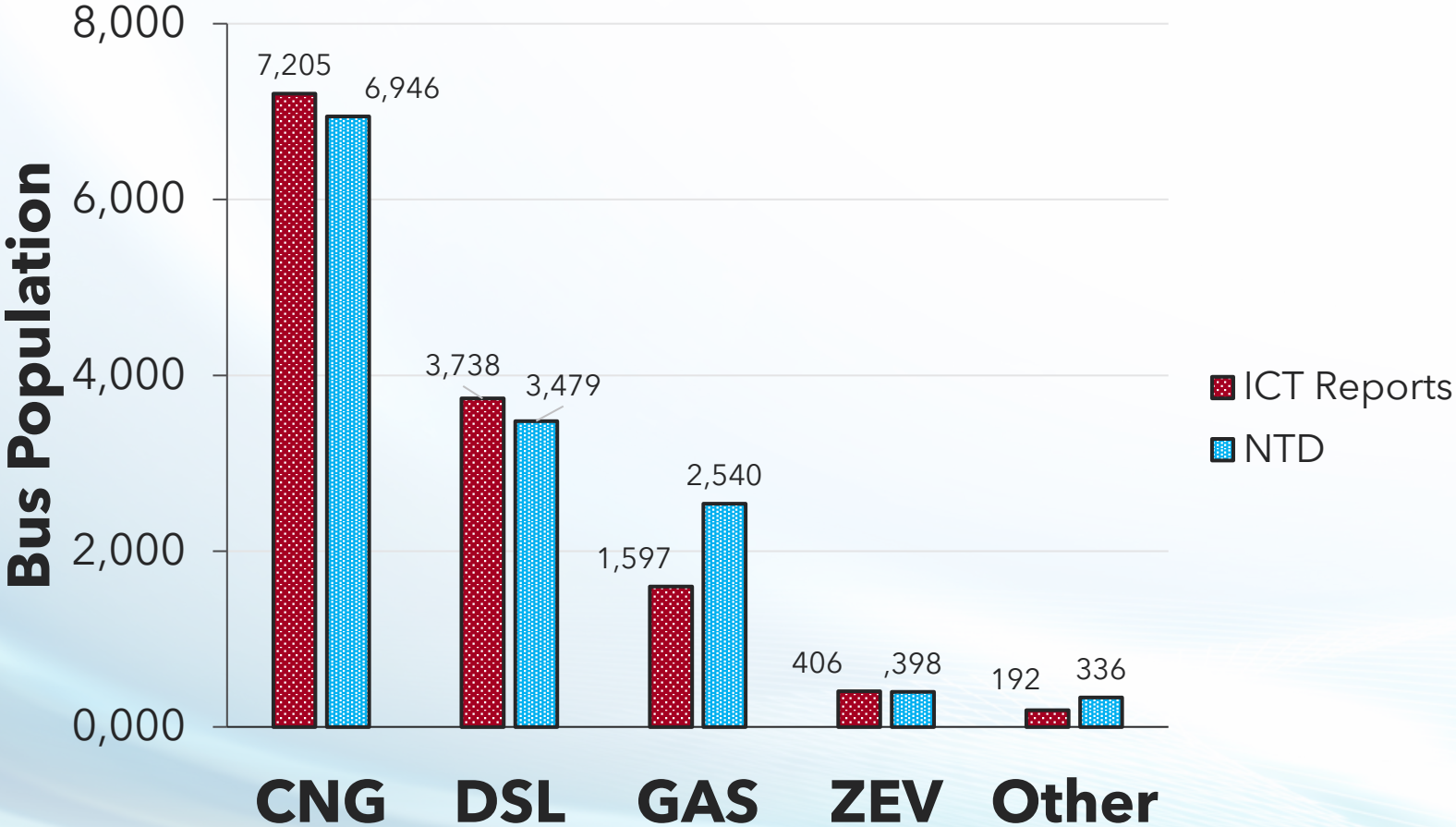
UBUS

Transit Bus Population Estimation

- The National Transit Database (NTD) was used for transit bus (UBUS) population and VMT in EMFAC2021 and prior versions
- Starting in 2021, all California transit agencies are required to submit annual reports to comply with the Innovative Clean Transit (ICT) regulation
 - The reports contain VIN-level information, but do not provide VMT
- Staff plans to use ICT reports and NTD data to obtain transit bus population and estimate VMT, respectively
- Projection of fuel mix reflects requirements of ICT Regulation

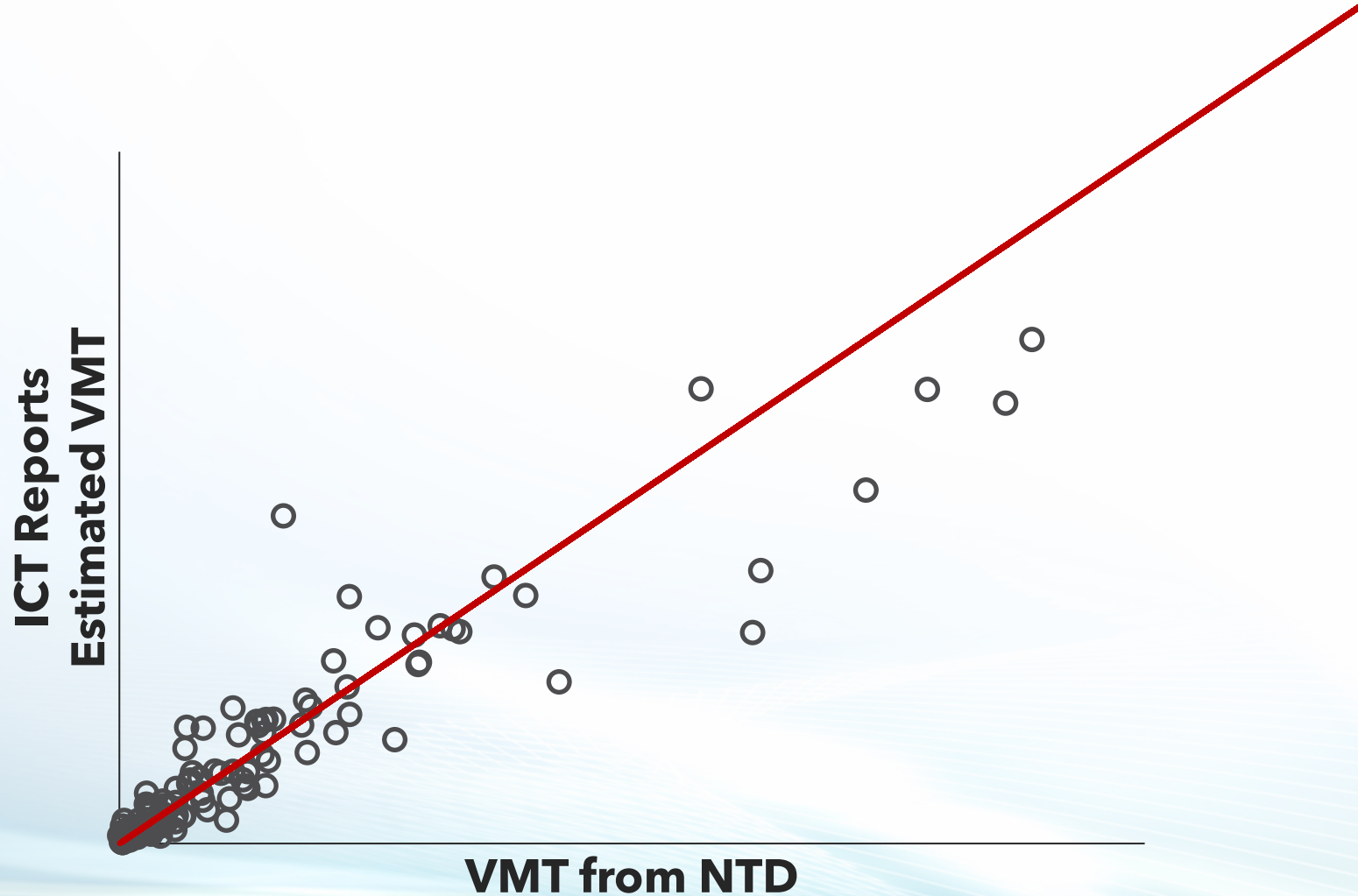
NTD vs ICT Reports

Transit Bus Population in 2021



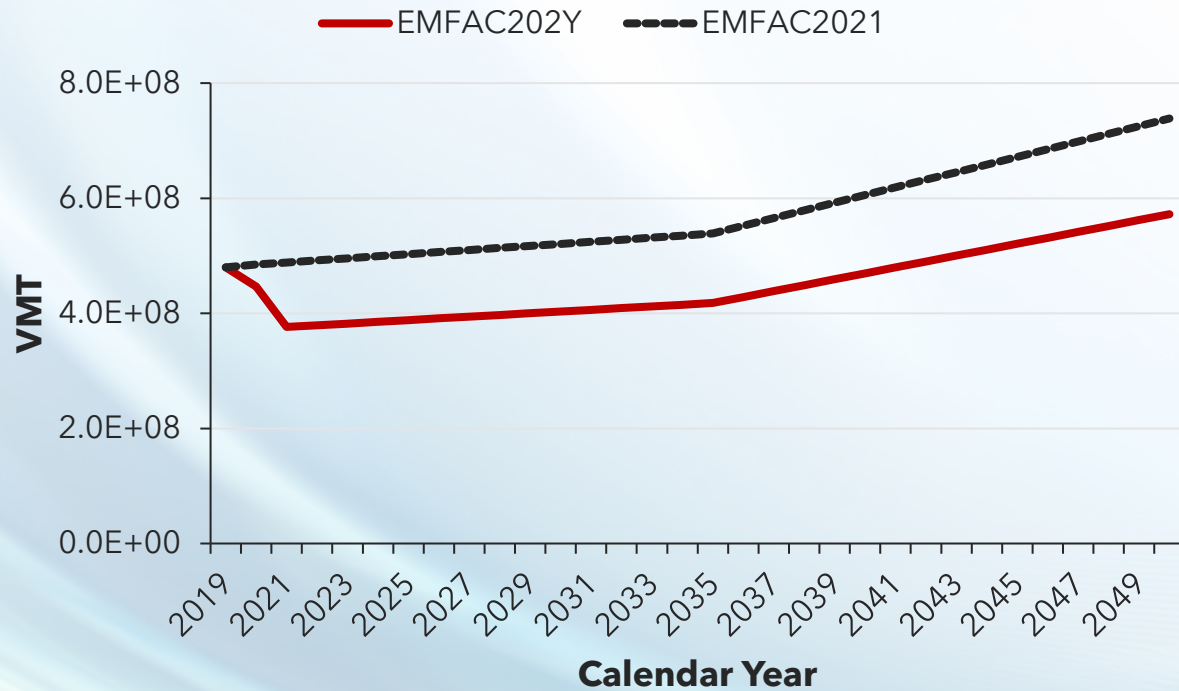
VMT Estimation

- Calculate accrual rates at agency level based on NTD
- Estimate accrual rates for agencies appearing in ICT reports but not in NTD, based on GAI, fuel type, etc. using K-nearest neighbors algorithm
- Calculate VMT based on accrual rates

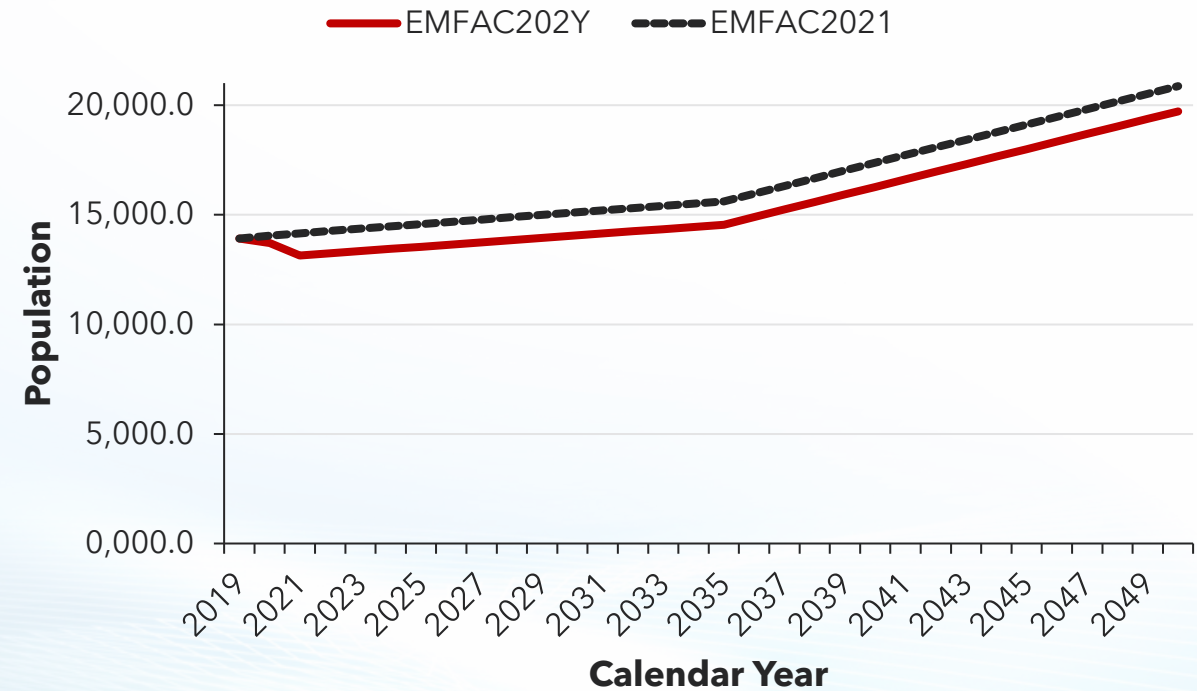


EMFAC2021 vs EMFAC202Y

VMT EMFAC202Y



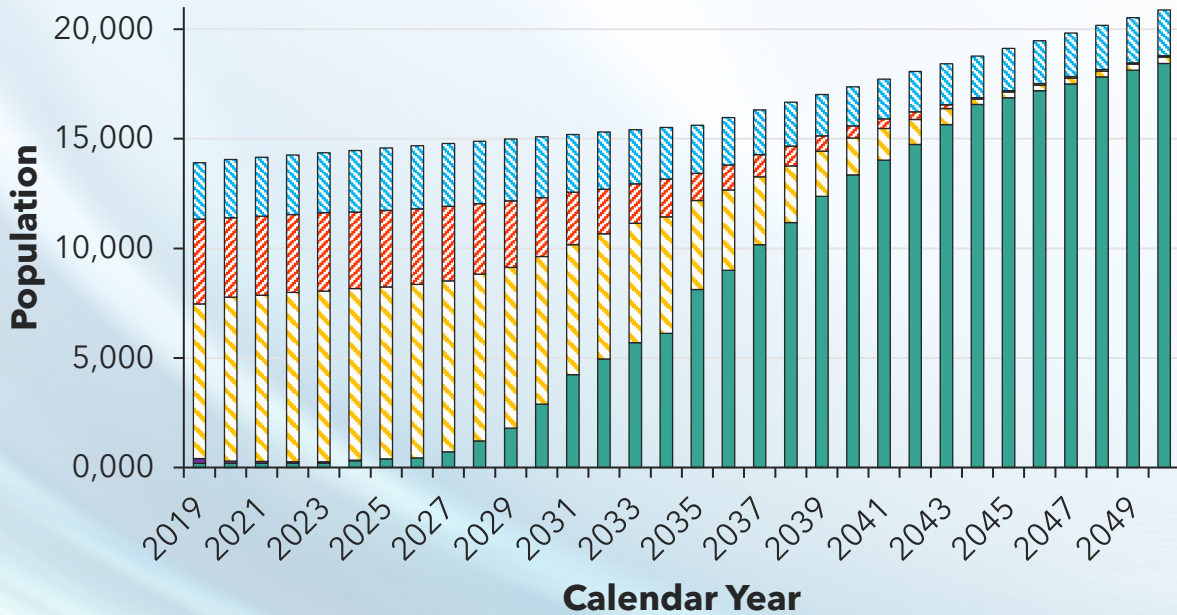
Population EMFAC202Y



Bus Population by Fuel

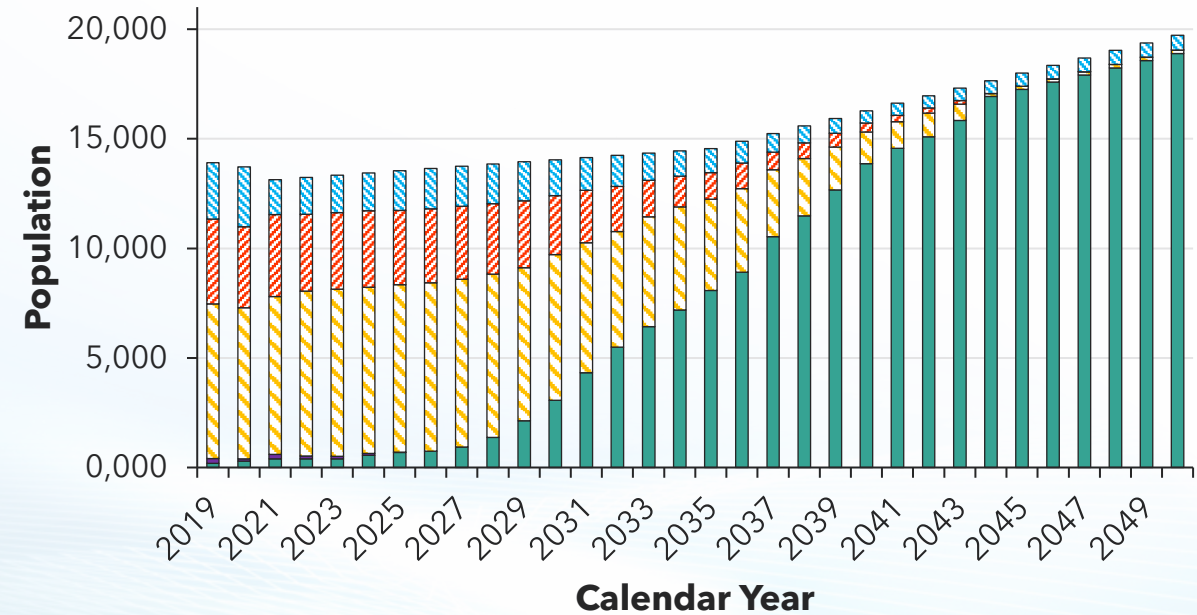
Population EMFAC2021

ZEB Alt. CNG DSL GAS



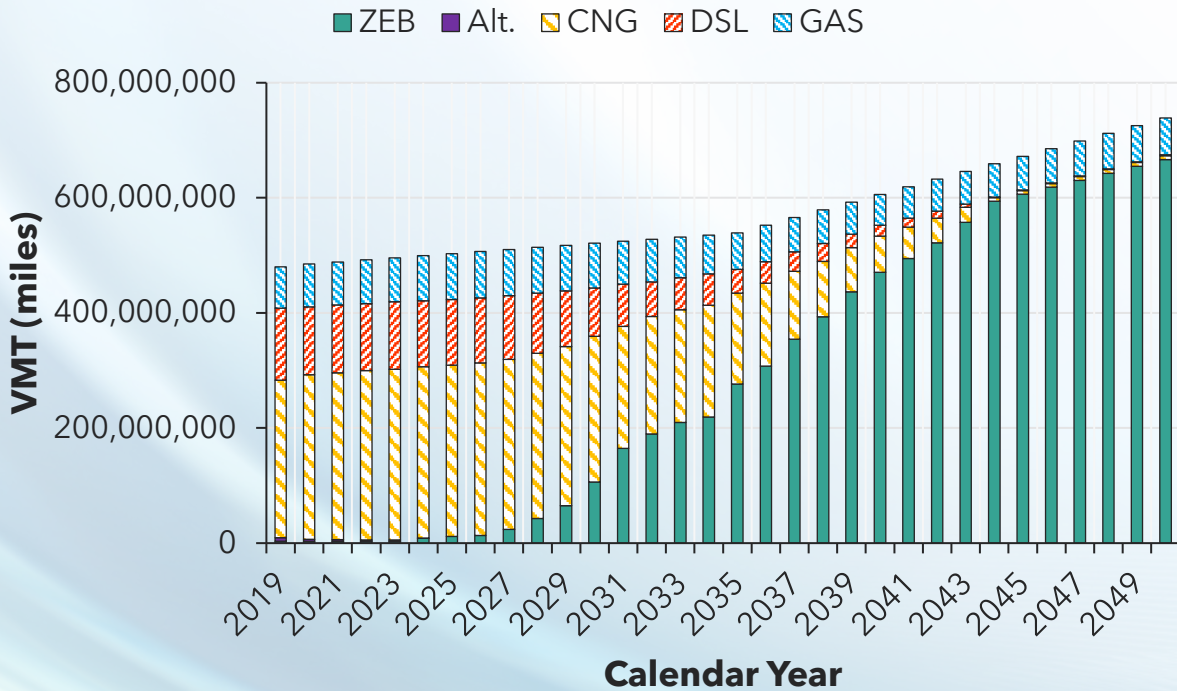
Population EMFAC202Y

ZEB Alt. CNG DSL GAS

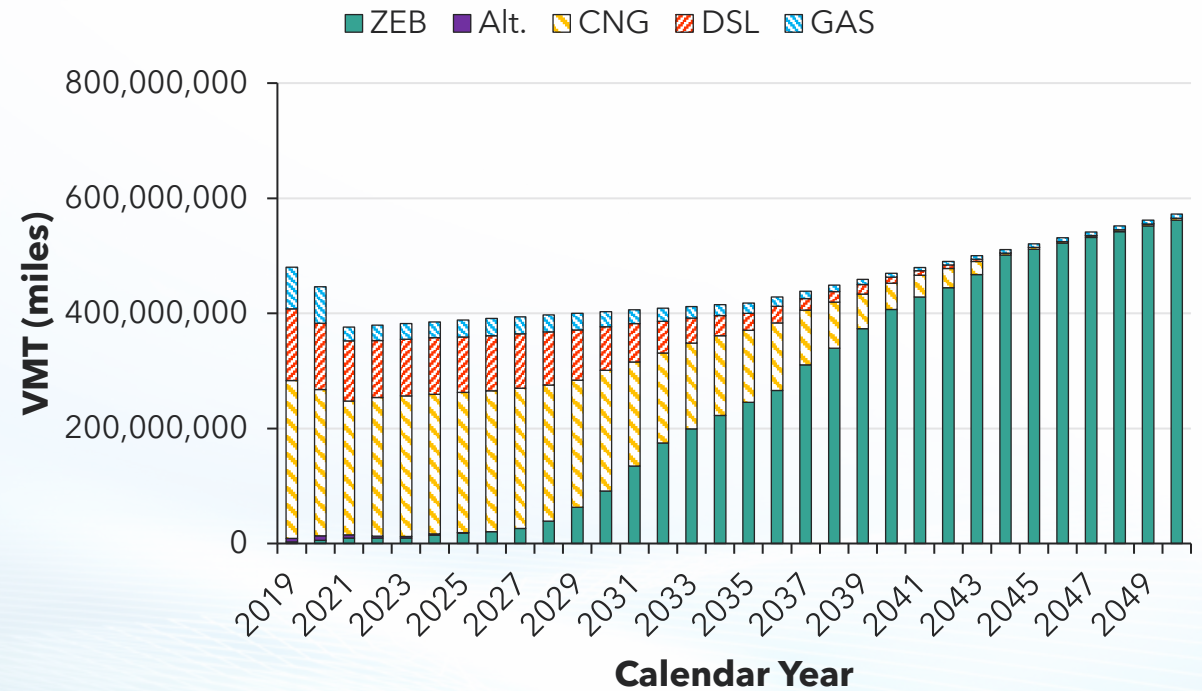


Bus VMT by Fuel

VMT EMFAC2021



VMT EMFAC202Y



Next Steps

- Process ICT reporting and NTD data for 2022, which was just released in November 2023.
- Finalize updated forecasting for EMFAC202Y using 2022 rather than 2021 as the base year

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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 Mute/Unmute
- Additional questions may be submitted after today to:
emfac@arb.ca.gov

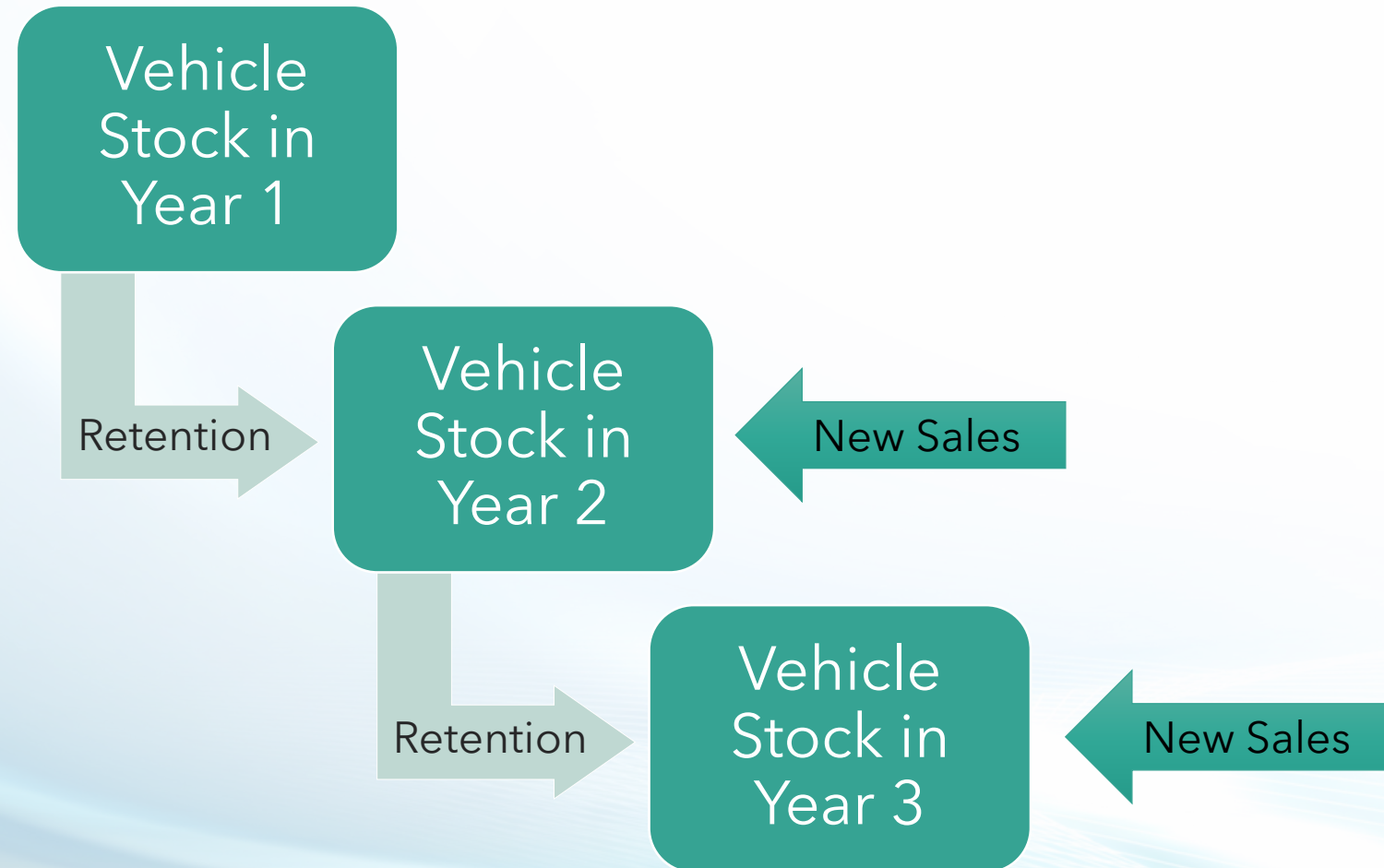
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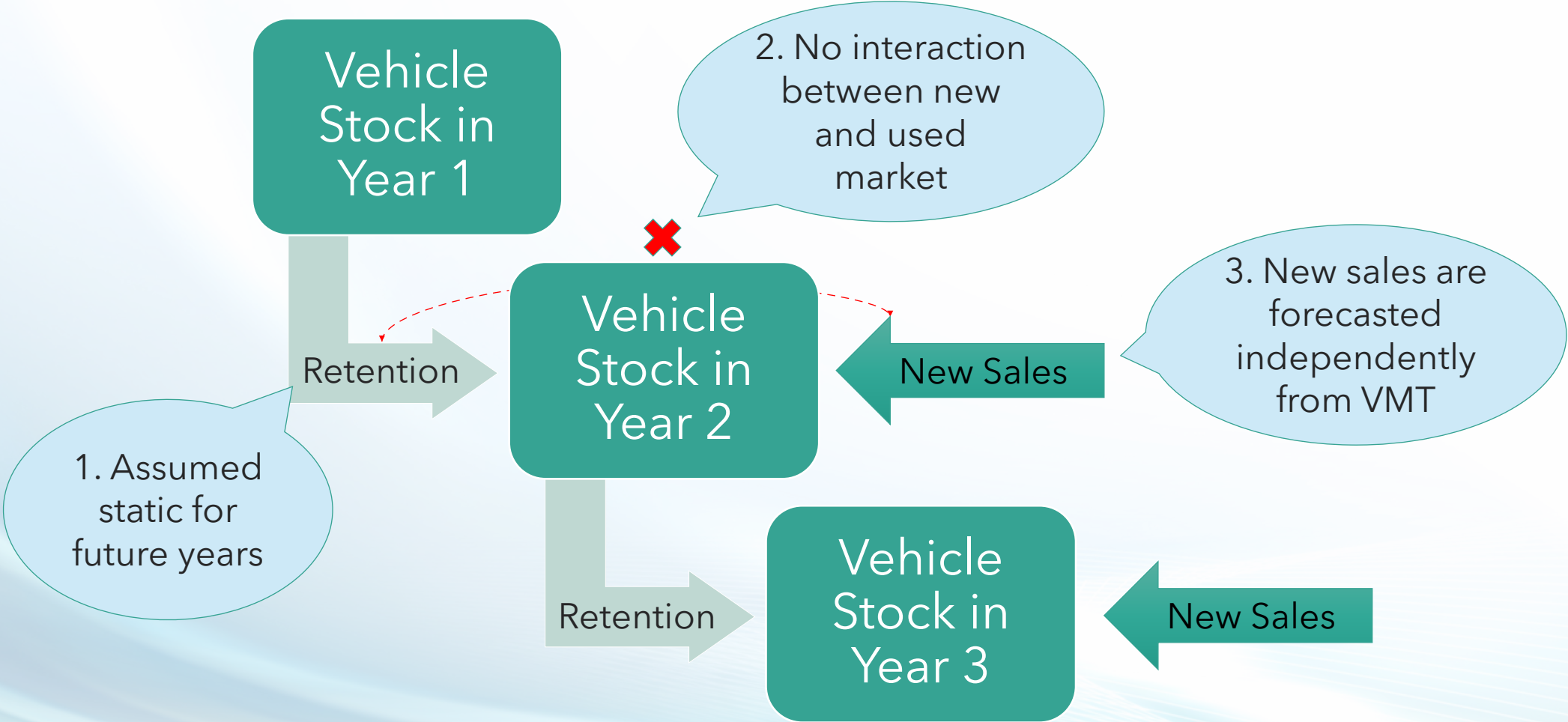
Vehicle Activity Forecasting

LD New Vehicle Sales Forecasting

LDV Population Forecasting Framework in EMFAC2021



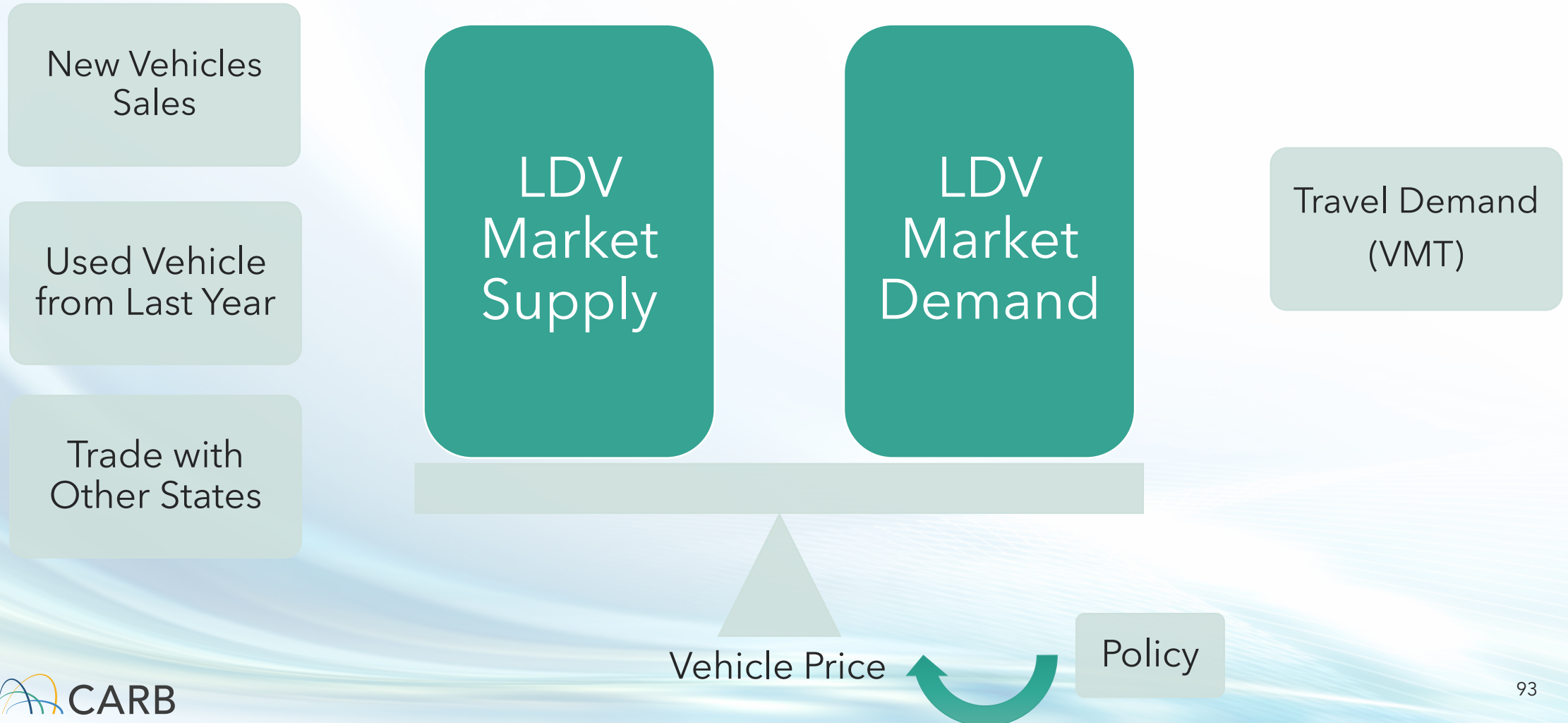
Limitation of LDV Population Forecasting in EMFAC2021



A New LDV Population Forecasting Framework in EMFAC202Y

- Dynamic vehicle population forecast model
 - Contract #21AQP018 with Prof. Mark Jacobsen at UCSD
- Project Goals:
 - Simulate interactions between new sales and retention rates
 - Consider the impact of vehicle price and regulations
 - Match the macro-economic forecast of VMT

Statewide LDV Population Forecasting Model



LDV Population Forecasting Flowchart

Key Inputs

- Travel demand forecast (VMT forecast)
- Effect of regulation on new vehicles

Parameters and Data

- Historical retention patterns
- Demand elasticities (new and used)
- Scrap elasticity
- Trade elasticity

Equilibrium Model

Solves for a dynamic sequence of used vehicle prices

Output

- Retention rates
 - Scrap rates
 - Trade flows
- New sales

Limitations

- Current model assumes the vehicle market in year zero to be in a stable state, which may not always be the case:
 - 2020-2021 COVID, 2022 chip shortage
- The model does not differentiate fuel types
 - ZEV vs. Gasoline LDV

Next Steps

- Use the LDV population forecasting model with latest available data to generate new sales and retention rates for EMFAC202Y
- Incorporate the results of the LDV population forecasting model into EMFAC202Y

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Vehicle Activity Forecasting

LD VMT Forecast

Short-Term (5-year) LD VMT Forecasting Methodology

Light-Duty = All gasoline, plug-in hybrid and electric vehicles in all vehicle classes

Socioeconomic Variables



Gasoline Prices

Housing Starts

UCLA

Disposable Income

Unemployment Rate



GDP



Federal Interest Rates

Population

Multivariate linear regression

- Developed numerous models using combinations of these variables
- Chose the best model based on statistical quantities and reasonableness of the combinations

Vehicle Miles Traveled

Light Duty VMT Forecast in EMFAC2021

VMT (billion miles per year) = -381.5
years 2020-2024

-13.75 x **GAS PRICE**

+ 18.9 x **POPULATION**

+ 0.0249 x **L1 HOUSING STARTS**

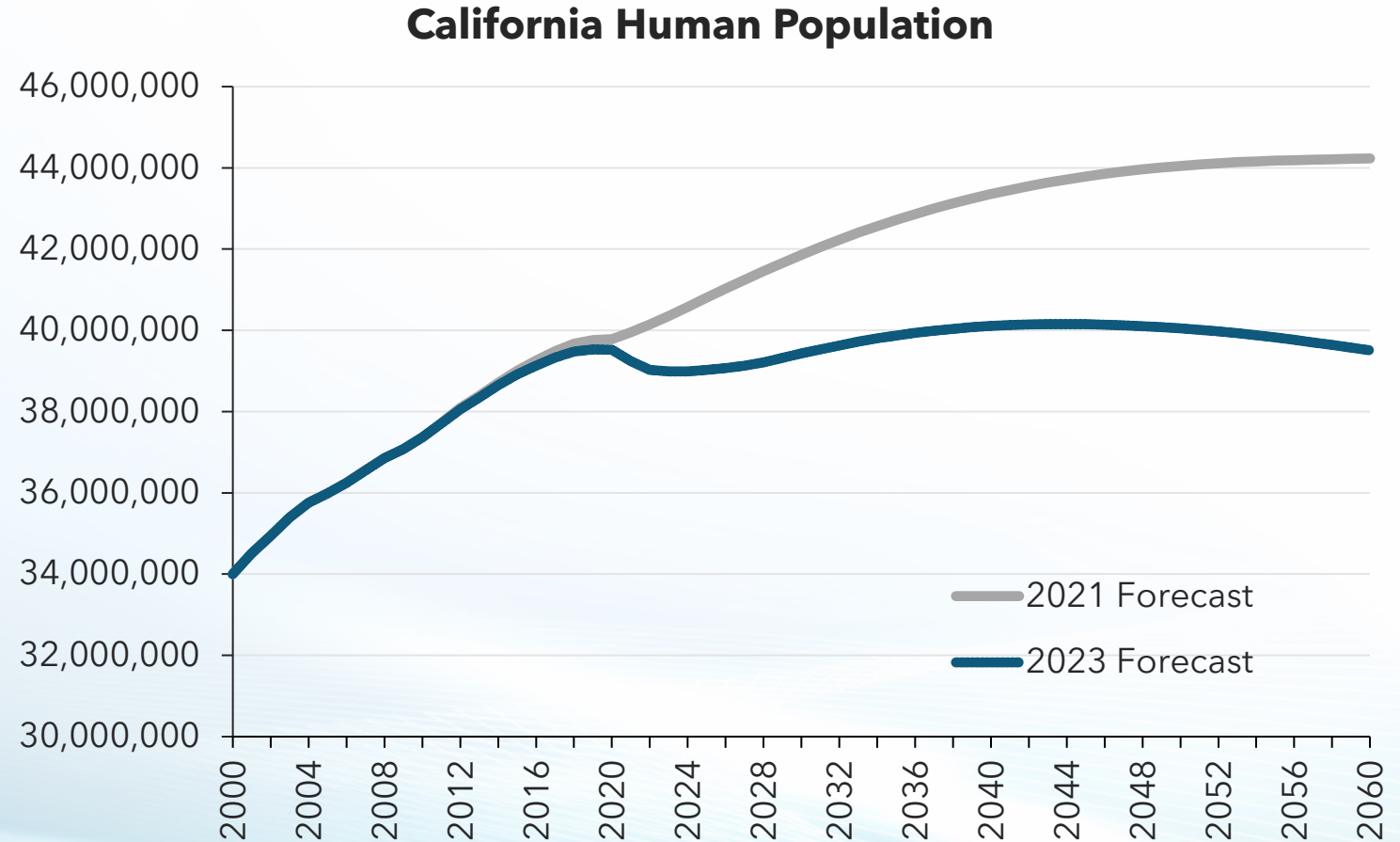
p-value				R ²
Intercept	GAS PRICE	POPULATION	L1 HOUSE STARTS	
2.7×10 ⁻⁸	1.1×10 ⁻⁵	~0.0	9.3×10 ⁻⁷	0.98

Updates in EMFAC202Y Forecast

- Used the latest socioeconomic data (2003-2022)
- Excluded the year 2020 from regressions because of the COVID-19 pandemic
- Modeled **VMT per capita** instead of absolute VMT

Why VMT Per Capita?

- Population is the strongest predictor of VMT
- California's population forecasts have shifted drastically
- A per capita metric allows us to isolate the impacts of economic trends on driver behavior
- We still multiply by population at the end to estimate absolute VMT

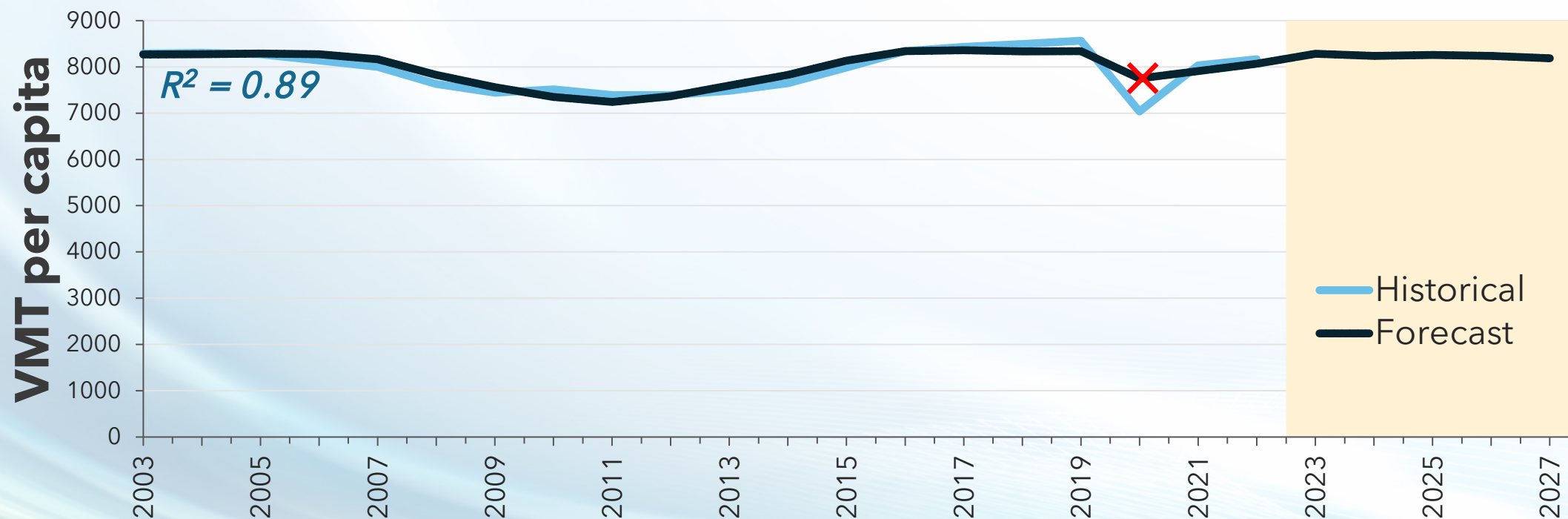


Data source: California Department of Finance Total Population Projections

EMFAC202Y Forecasting Equation

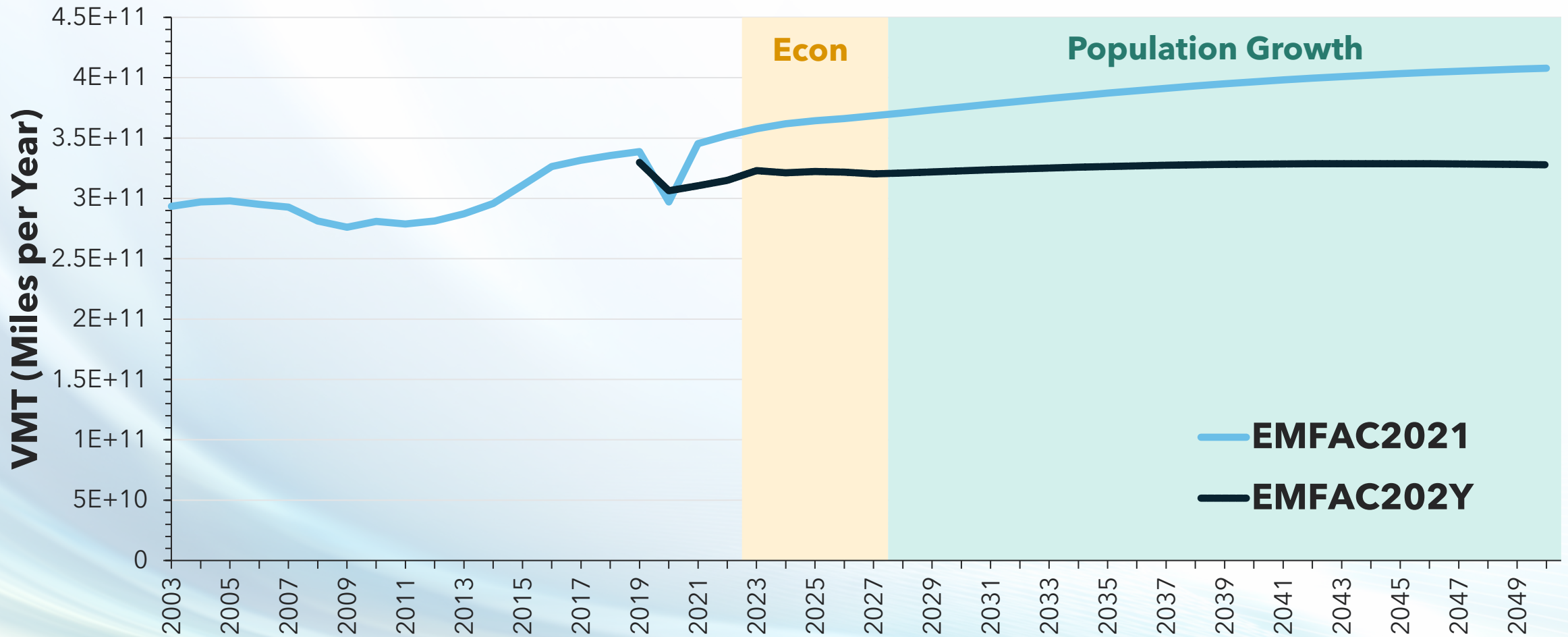
$$\frac{\text{VMT}}{\text{Population}} = 9685 - 118.7 \times \text{UNEMPLOYMENT RATE} - 206.5 \times \text{GAS PRICE}$$

$pval = 1.8 \times 10^{-18}$
 $pval = 7.3 \times 10^{-8}$
 $pval = 7.9 \times 10^{-4}$



Please note that CY 2020 was excluded during the model fitting process and thus is not represented by this equation.

New Projections Show a Significant Flattening of Future LD VMT Trends



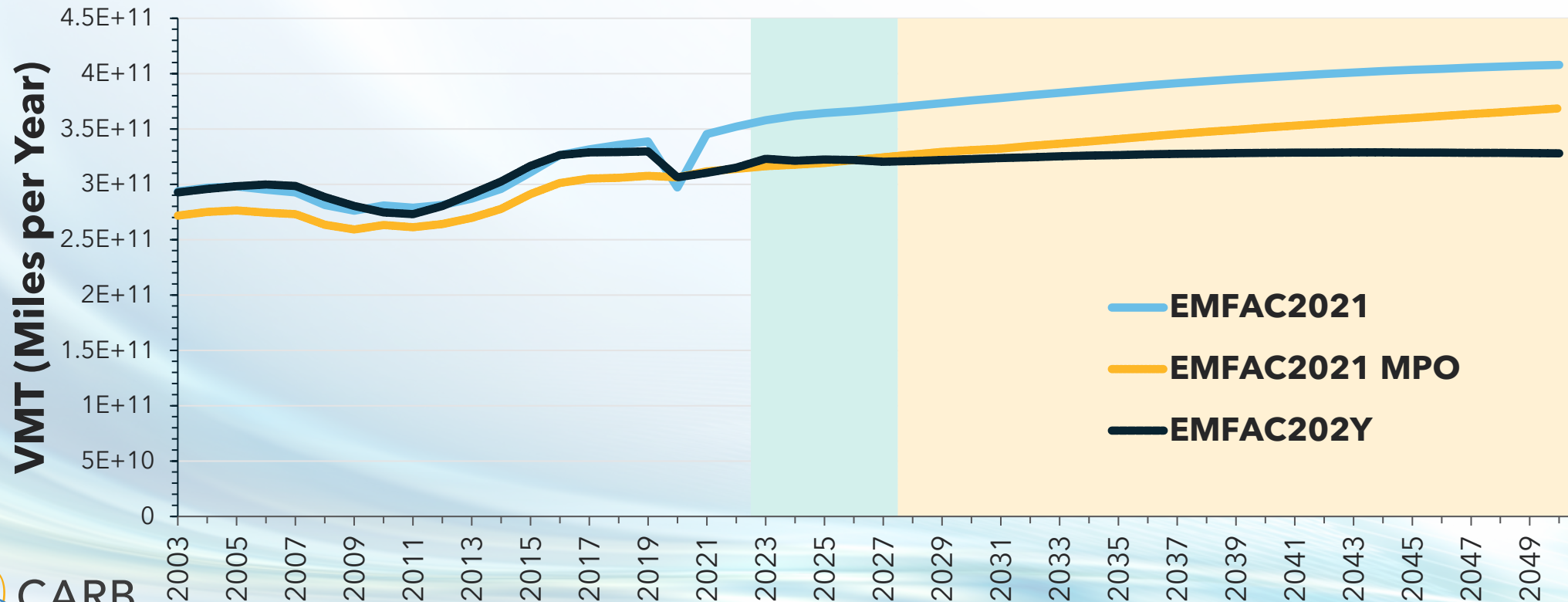
Top Reasons for Lower VMT Forecast in EMFAC202Y

- Lower human population growth rate than previously estimated
- Higher gasoline prices over last few years and forecasts

After accounting for human population and gas prices in 2022 versus 2019, there is **no evidence to suggest total VMT is lower due to telework** or other post-pandemic travel behavior changes

Ongoing and Future Work for LD VMT Forecasting in EMFAC2022Z

- Further explore effects of telework on VMT trends (Contract 19STC006 titled "Barriers to Reducing the Carbon Footprint of Transportation")
- Explore the possibility of using forecast data from Metropolitan Planning Organizations (MPOs) to estimate regional VMT growth rates



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Vehicle Activity Forecasting

HD Activity Forecasting

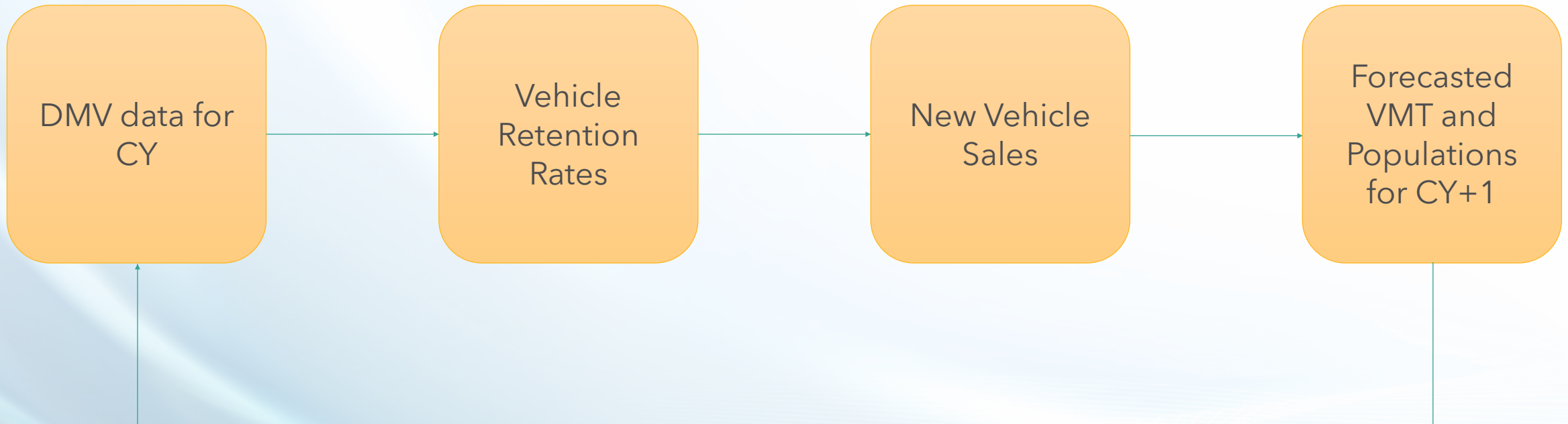
HD Activity Forecasting in EMFAC202Y

- For HD vehicles >14,000 lbs. (excluding transit buses, urban buses (UBUS) & gasoline vehicles), EMFAC202Y adopted the same method to project HD new sales and VMT growth from EMFAC2017 with updated data:

Forecasting Data	Source
New Vehicle Sales	Annual Energy Outlook (AEO) from the U.S. Energy Information Administration (EIA)
HD VMT Forecasting	California Statewide Travel Demand/Freight Forecasting Model (CSTDM/CSFFM)
Drayage VMT Forecasting	Mercator International Forecast, 2016; Tioga Report ¹ , 2020
Construction and Motor Coach Buses	UCLA Anderson Report, 2023

[1. The Tioga Group, 2019-2050 Bay Area Seaport Forecast, Prepared for SF Bay Conservation and Development Commission](#)

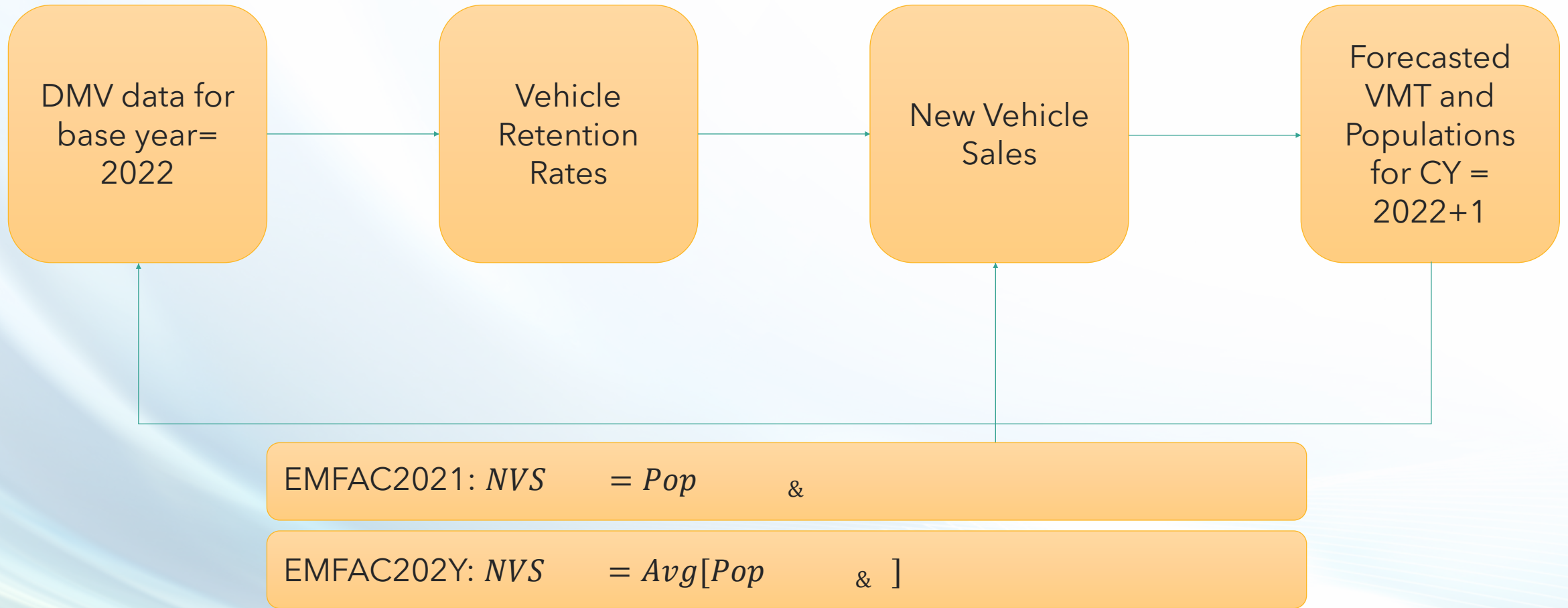
EMFAC202Y HD Activity Forecasting



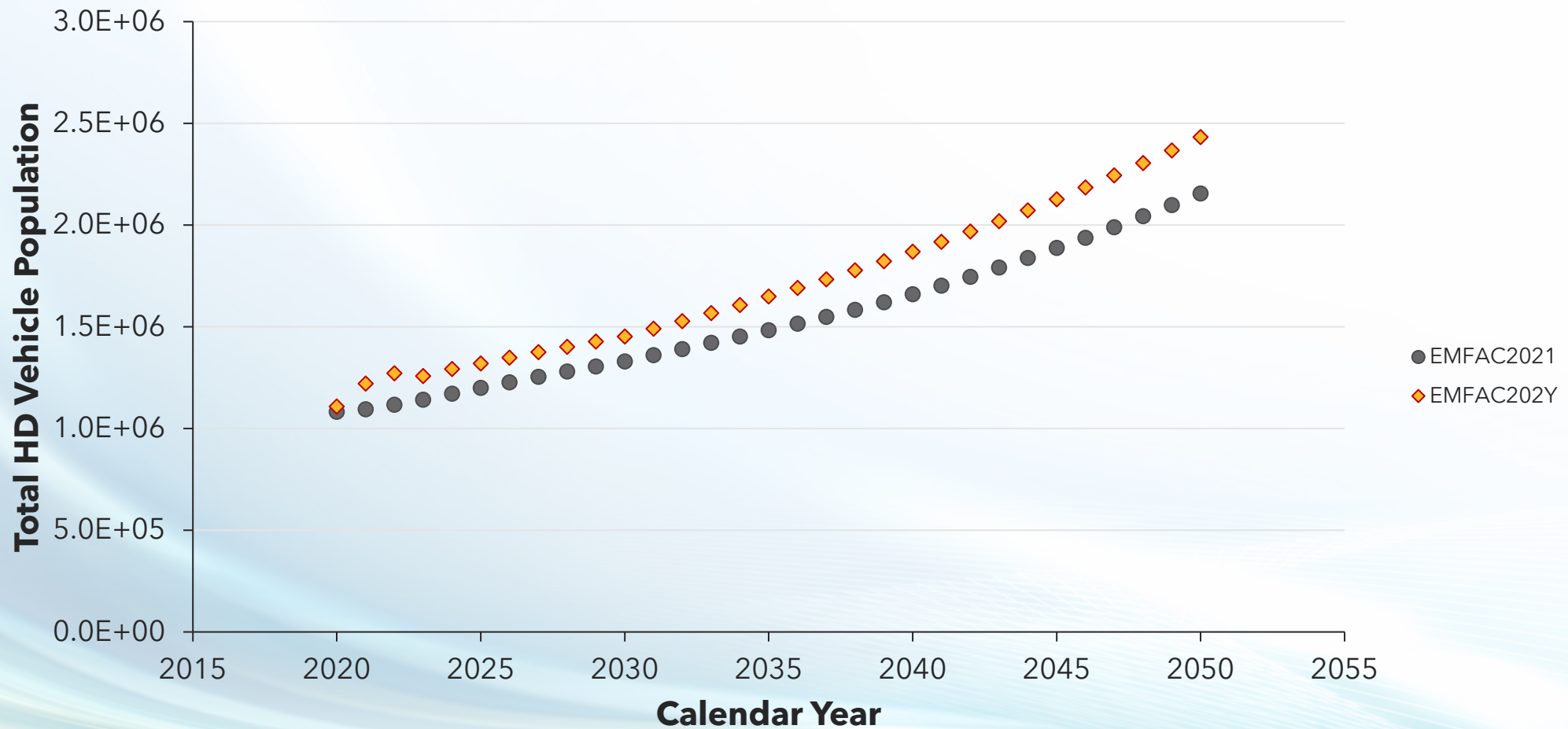
New Vehicle Sales Averaged over 3 Calendar Years

EMFAC202Y HD Forecasting updated to base year = 2022

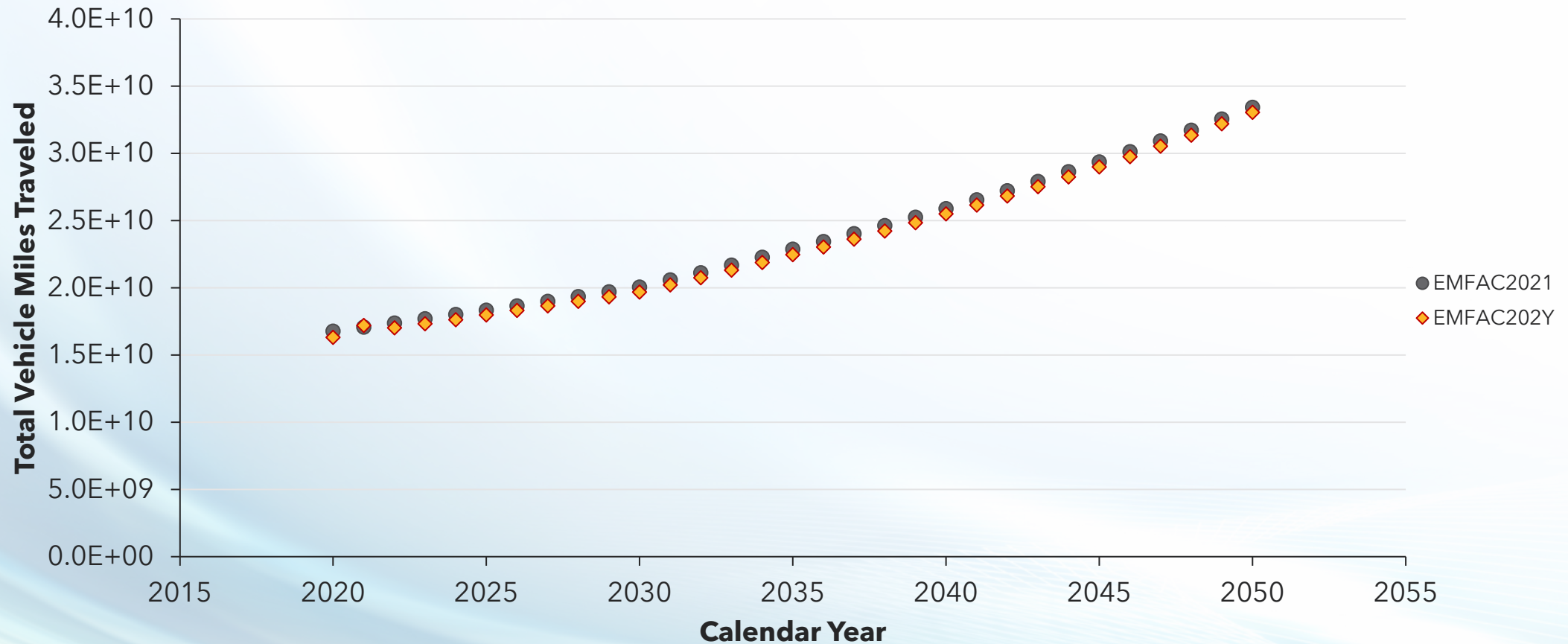
EMFAC202Y HD Activity Forecasting



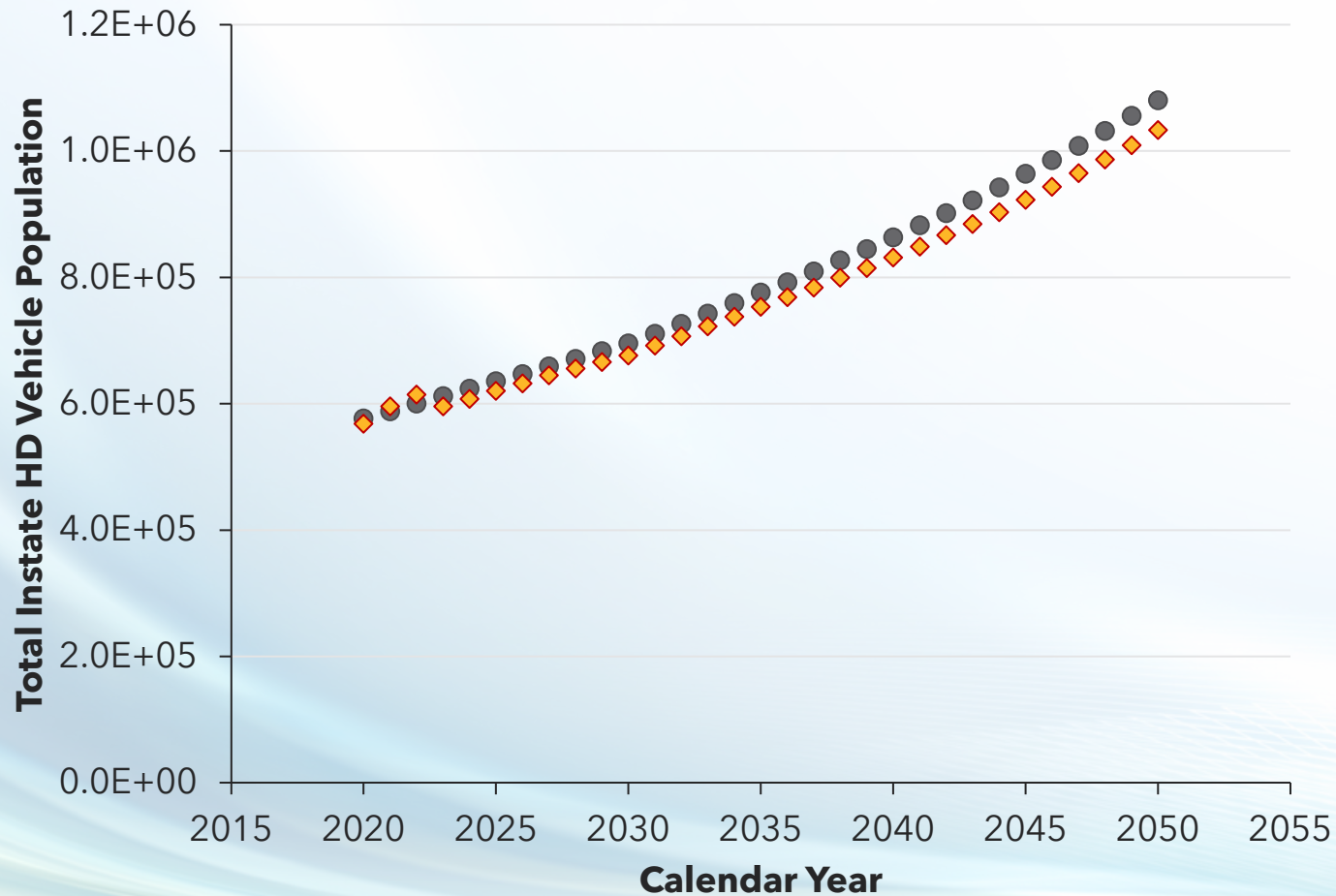
EMFAC202Y Shows an Increase in Projected HD Vehicle Populations Compared to EMFAC2021



EMFAC202Y Shows Similar Trends in Projected HD VMT Compared to EMFAC2021

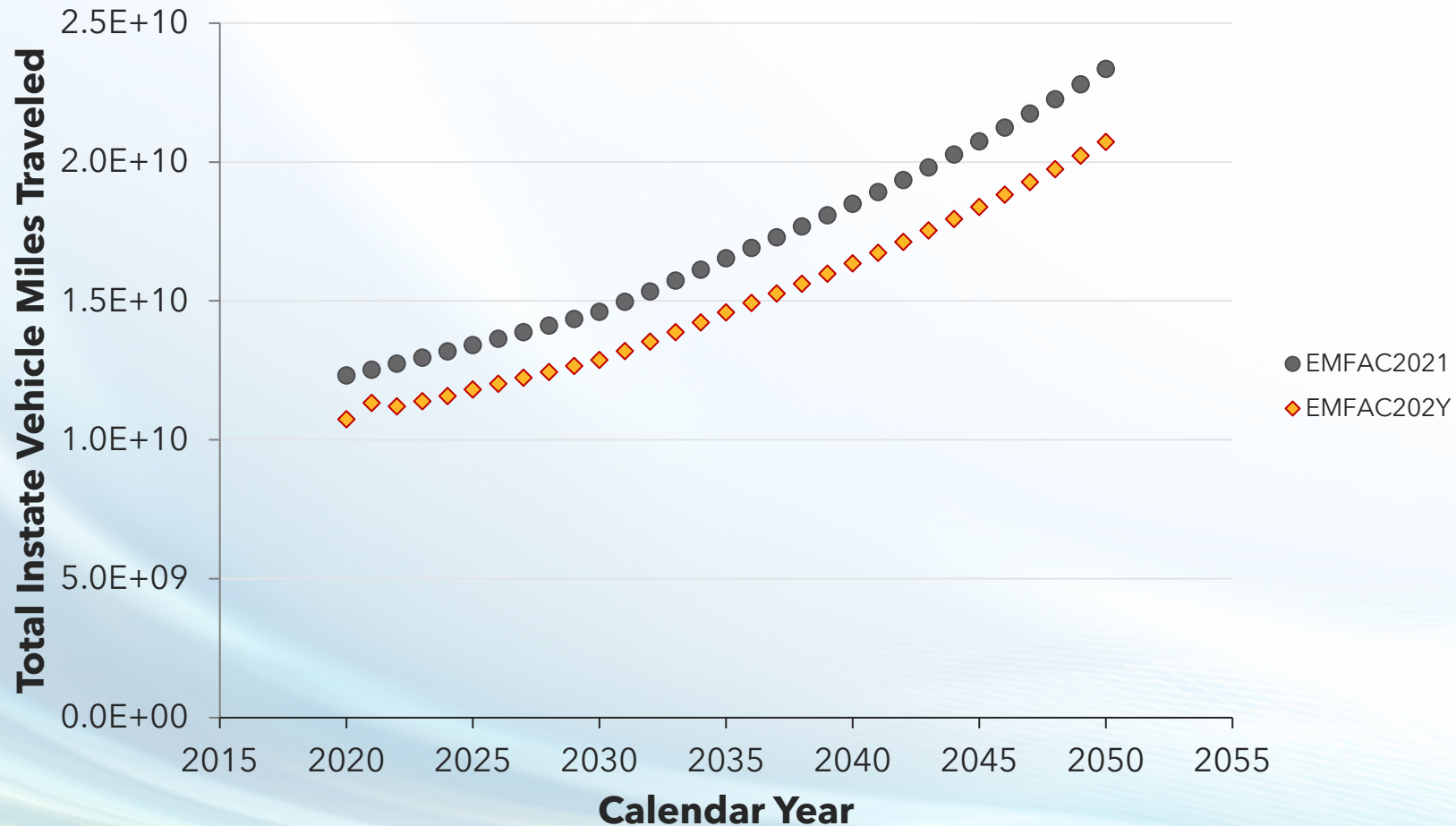


Vehicle Population Forecasts Are Lower for In-State* Vehicle Populations



*In-State refers to all HD vehicle classes except the Out of State (OOS), Neighboring Out of State (NOOS), and non-neighboring out of state (NNOOS)

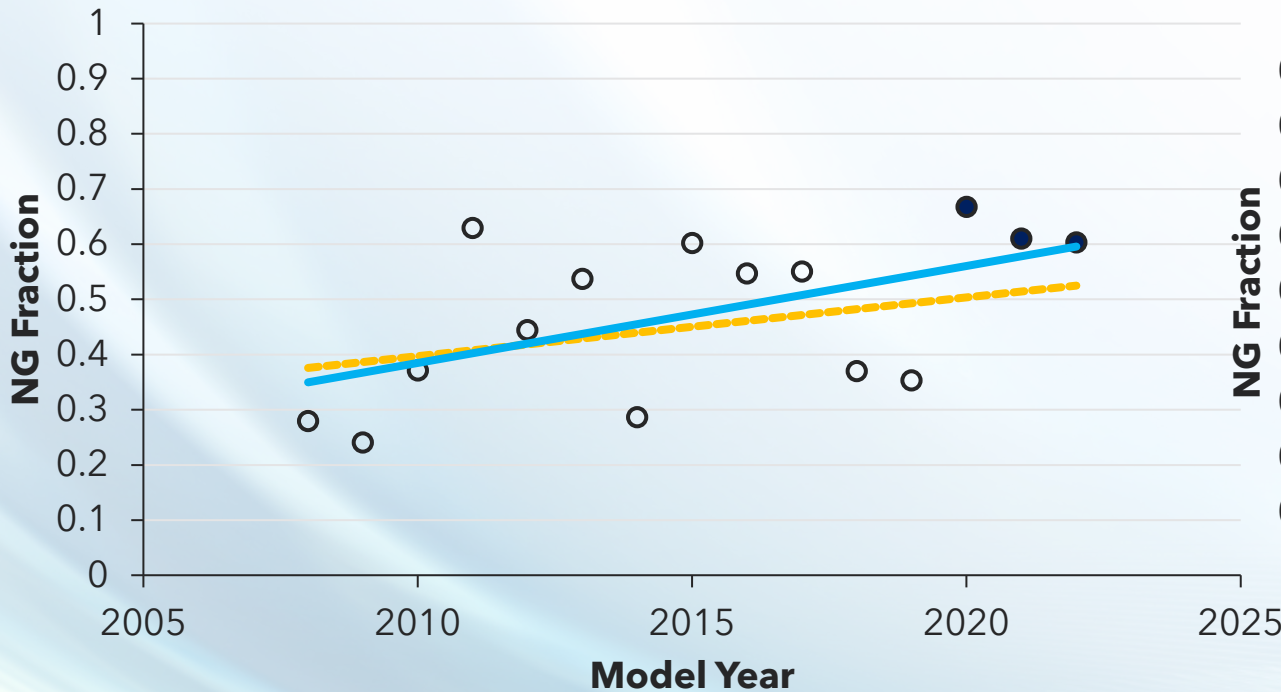
VMT is Lower for In-State* Vehicle Populations Compared to EMFAC2021



* In-State refers to all HD vehicle classes except, the Out of State (OOS), Neighboring Out of State (NOOS), and non-neighboring out of state (NNOOS)

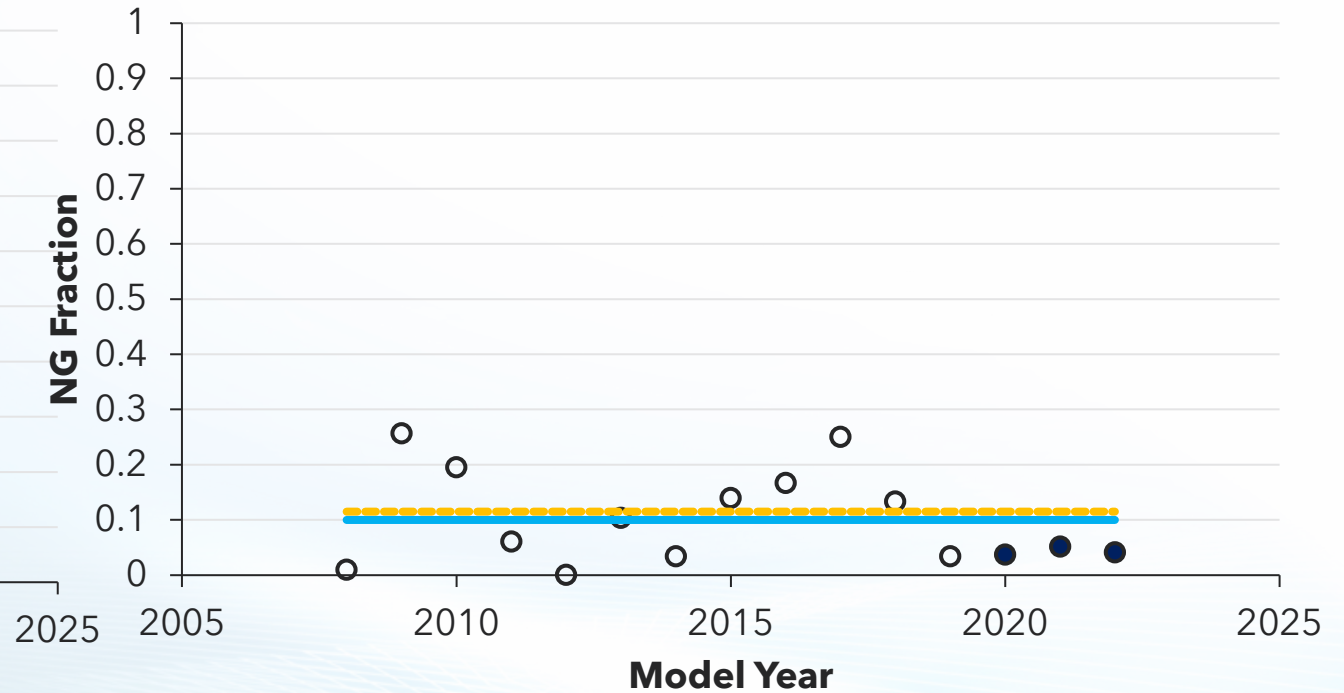
Natural Gas (NG) Predictions Have Been Updated With Data Through 2022

T7 Public, SC



○ DMV Data - - - EMFAC2021 — EMFAC2022

T7 Public, SJV



○ DMV Data - - - EMFAC2021 — EMFAC2022

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Vehicle Activity Forecasting

Advanced Clean Fleets Module

Advanced Clean Fleets Regulation (ACF) Overview

Target Fleet

- Any vehicle with a manufacturer's gross vehicle weight rating (GVWR) above 8,500 lbs
- Off-road yard tractors (will be incorporated separately as part of the appropriate off-road models)
- Light-duty package delivery vehicles (will be incorporated separately)

Regulated Fleet Groups

- State and Local Government Fleets
- Drayage Fleets
- High Priority and Federal Fleets

Sales Target

- 100% ZEV sales by 2036

Adopted in April 2023. Implementation begins in 2024.

Examples of Affected Vehicles



Data Sources to Identify High Priority Fleets

- Identified trucks by entities that:
 - Own or dispatch 50 or more vehicles under common ownership or control, using DMV & IRP Registration database as well as Dun & Bradstreet database.
 - Earned >\$50 million gross annual revenue with at least 1 vehicle, using Dun & Bradstreet database.
- Subhauler population were estimated using ACT Large Entity Reporting.



High Priority and Federal Fleets Requirements

ACF Regulation

- **Option 1 (Model Year Schedule):** Must purchase only ZEVs beginning 2024 and, starting 2025, remove internal combustion engine vehicles at the end of their useful life.
- **Option 2 (ZEV Milestones Option):** Fleets may elect to meet ZEV targets as a percentage of the total fleet starting with vehicle types that are most suitable for electrification (Table below).

Group #	Percentage of vehicles that must be zero emission	10%	25%	50%	75%	100%
1	Box trucks, vans, two-axle buses, yard trucks	2025	2028	2031	2033	≥2035
2	Work trucks, day cab tractors, three-axle buses	2027	2030	2033	2036	≥2039
3	Sleeper cab tractors and specialty vehicles	2030	2033	2036	2039	≥2042

Assumption:

- 50% of Group 1 and 25% of Group 2 follows Model Year Schedule.
- The remainder (50% of Group 1, 75% of Group 2 and 100% of Group 3) follows ZEV Milestones.

High Priority and Federal Fleets Requirements

Internal Combustion Engine Purchase Requirements for ZEV Milestone Option

- Priority fleets can no longer buy used non-omnibus diesel trucks
- Every new purchase must be either zero-emission or comply with MY 2024+ CA-Omnibus standards

Drayage Fleets - Data Sources and Regulatory Requirements

Data Sources

- Obtained list of VINs for trucks visiting Port of Los Angeles/Long Beach (POLA) and the Port of Oakland (POAK), frequently.

ACF Regulation

- All legacy drayage trucks must report in the CARB Drayage Truck Registry - TRUCRS by December 31, 2023.
- Starting January 1, 2024, only ZEVs may be added to CARB Drayage Truck Registry - TRUCRS.
- Legacy drayage service ends when engine model is 13 years old or 800,000 miles, whichever comes last (no more than 18 years).
- By 2035, all drayage trucks must be zero-emission.



Public Fleets

Data Sources and Regulatory Requirements

Input

- Identified public vehicles owned by state and local agencies from the California DMV vehicle registration database.

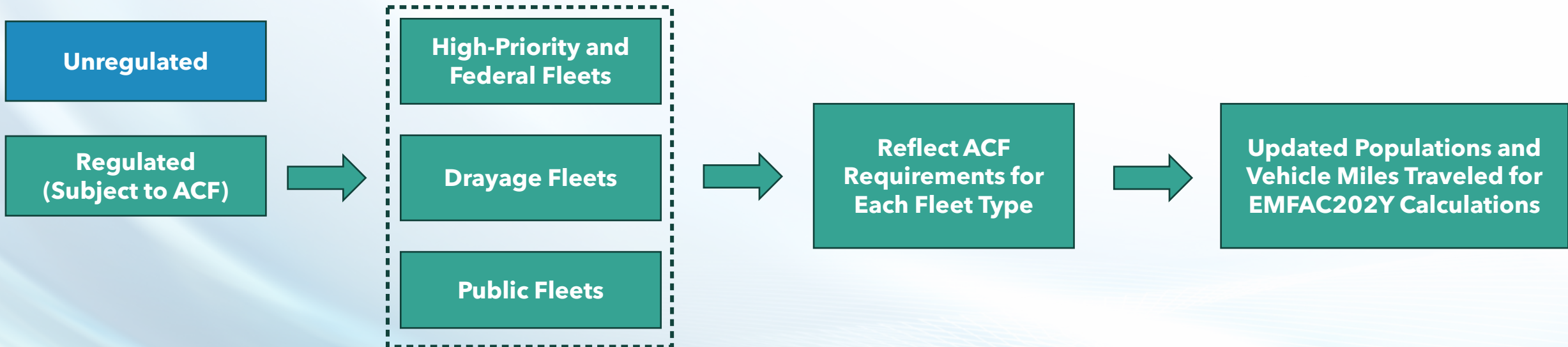
ACF Regulation

- Must purchase ZEVs when adding vehicles to the fleet
 - 50% of purchases for 2024-2026 model year
 - 100% of purchases for 2027 and newer model years
- Until 2035, may purchase NZEV¹ if no ZEV is available

1. Near Zero Emission Vehicle (NZEV): NZEVs are plug-in hybrids with some all-electric range

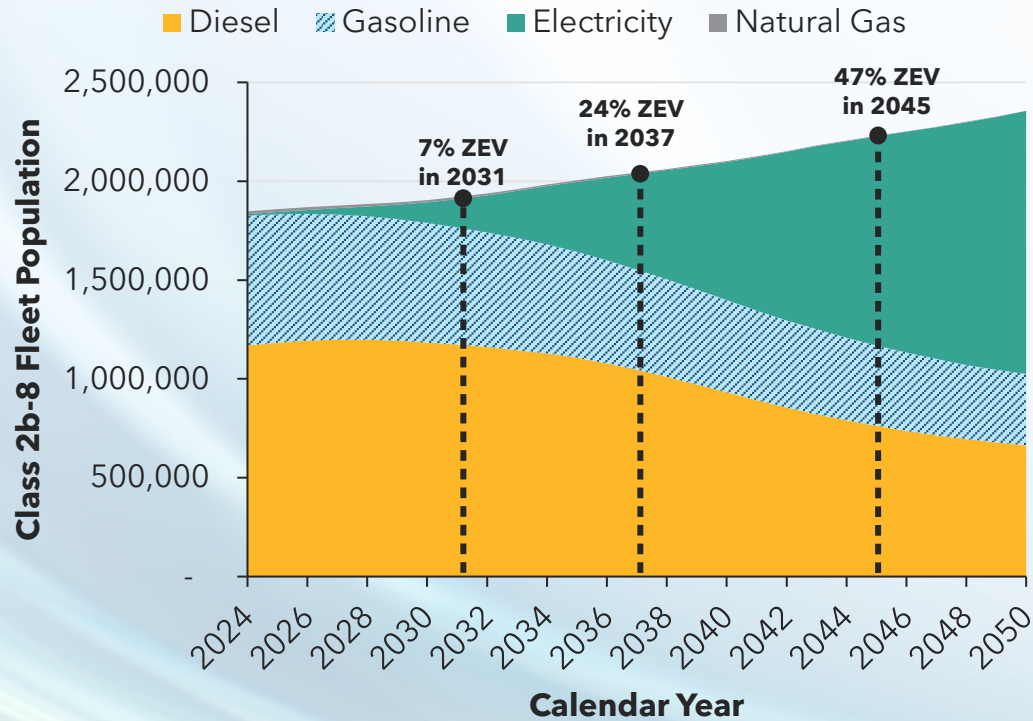
Advanced Clean Fleets Module

Populations and Vehicle Miles Traveled Output from Activity Forecasting Module.

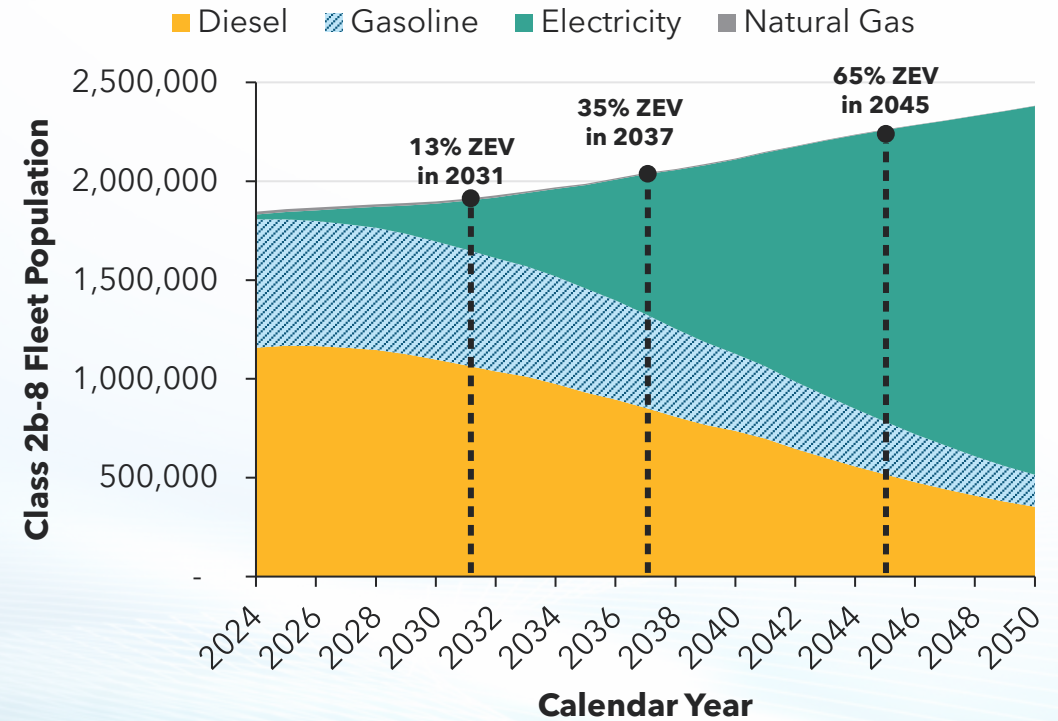


Preliminary Populations by Fuel Type Results (Includes Regulated and Unregulated Fleets)

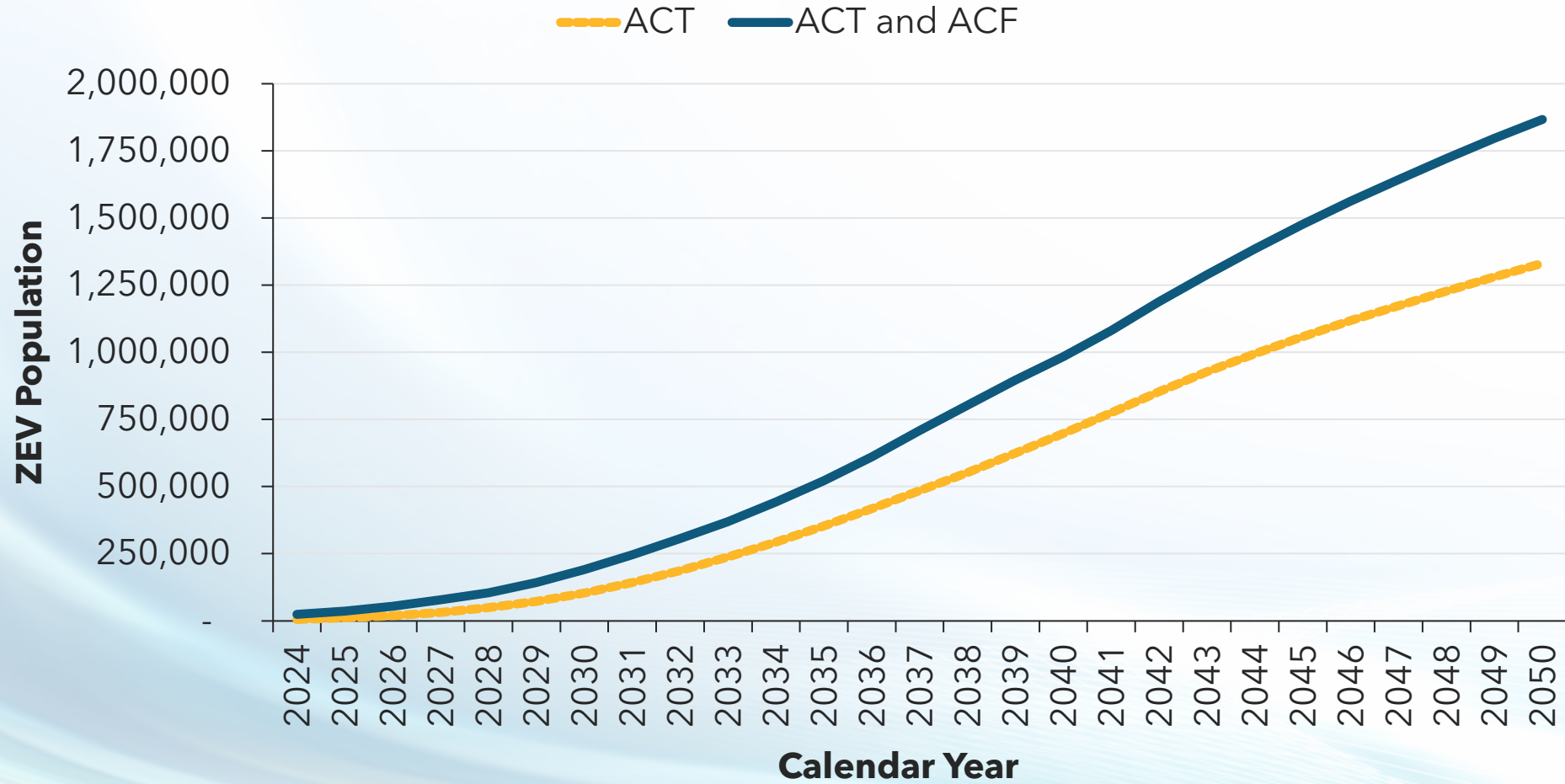
Under ACT Regulation



Under ACT and ACF Regulations



ZEV Population Class 2b-8 Vehicles



Next Steps

- Incorporate HD activity forecasting updates into ACF module
- Implement into EMFAC202Y model

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Vehicle Activity Forecasting

Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV) Splits

Background

- In EMFAC2021, heavy-duty ZEV was assumed to be entirely battery electric vehicles (BEV)
- In EMFAC202Y, ZEV population will be split into BEV and fuel cell electric vehicles (FCEV) to support hydrogen demand assessment (e.g., SB 643)
- Electricity (kWh) and hydrogen (kg) demands will be output of EMFAC202Y Energy Module

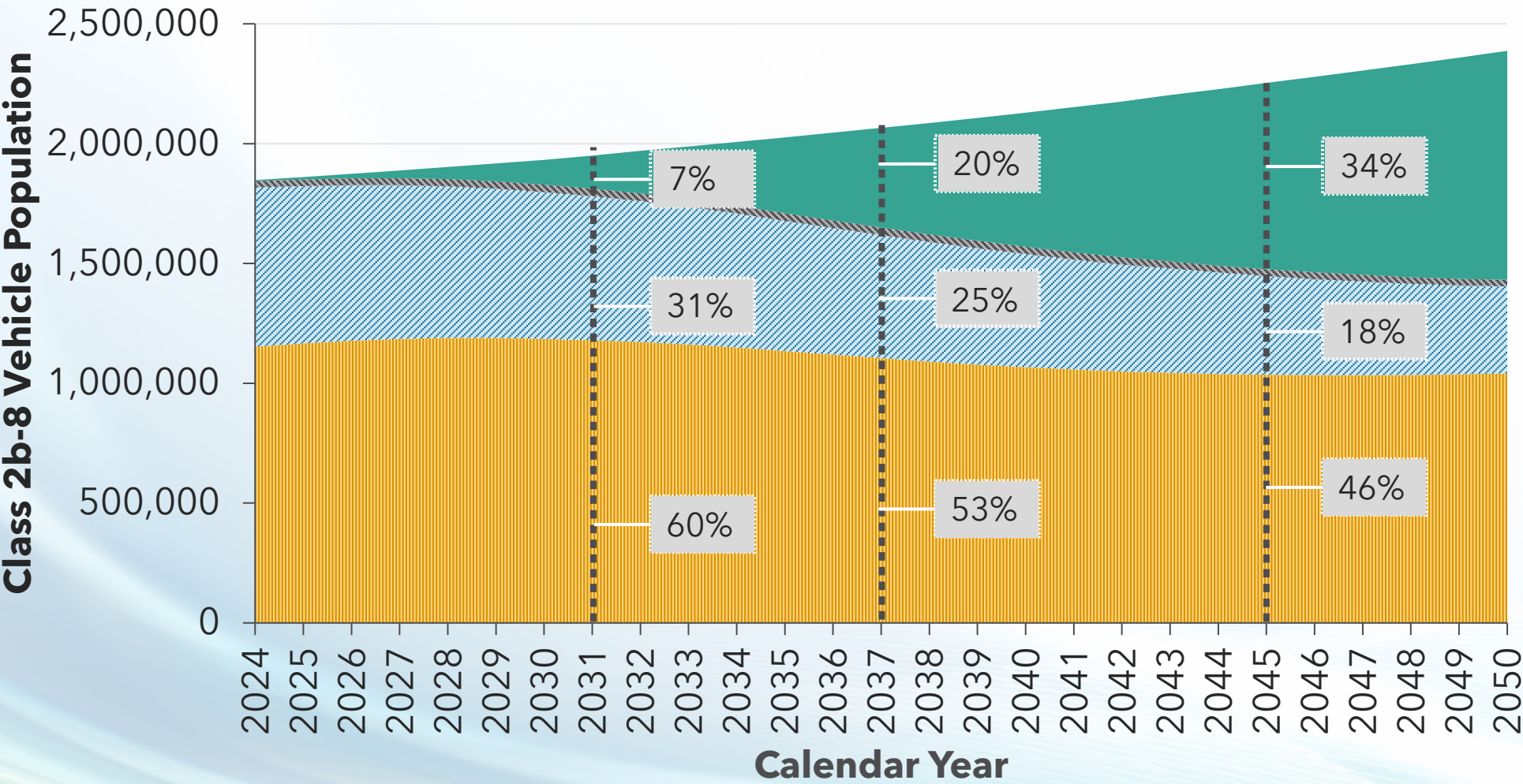
[1. CARB, Advanced Clean Cars II \(ACC II\), Aug 2022](#)

[2. CARB, Advanced Clean Fleets \(ACF\), Aug 2022](#)

Technology Mix Projections

- Based on expected manufacturer product availability and vehicle suitability analyses, ZEVs are assumed to comply with proposed ACC II¹ and ACF² regulations with a combination of BEVs and FCEVs.
 - FCEVs commonly have shorter refueling times and are expected to have less sensitivity to weight concerns in heavy-duty long-range applications relative to BEVs. In contrast, BEVs offer greater fuel cost-savings, especially for overnight charging.
- Assumed fractions of BEV and FCEV are 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. Larger percentages are assumed for heavy-duty long-haul applications.

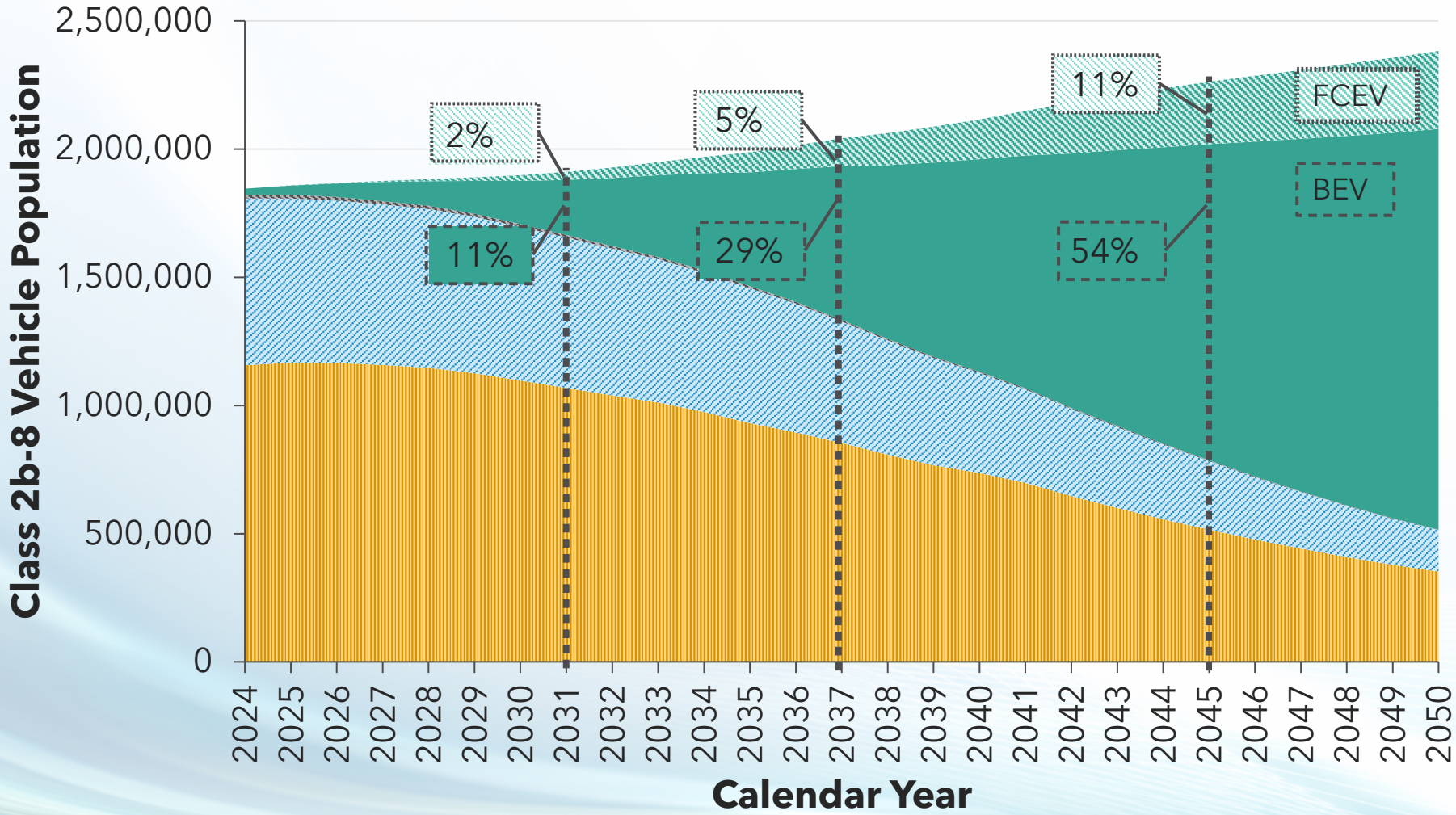
Projected MD and HD Vehicle Population by Fuel Type (EMFAC2021: 'ZEV → BEV' & ACT)



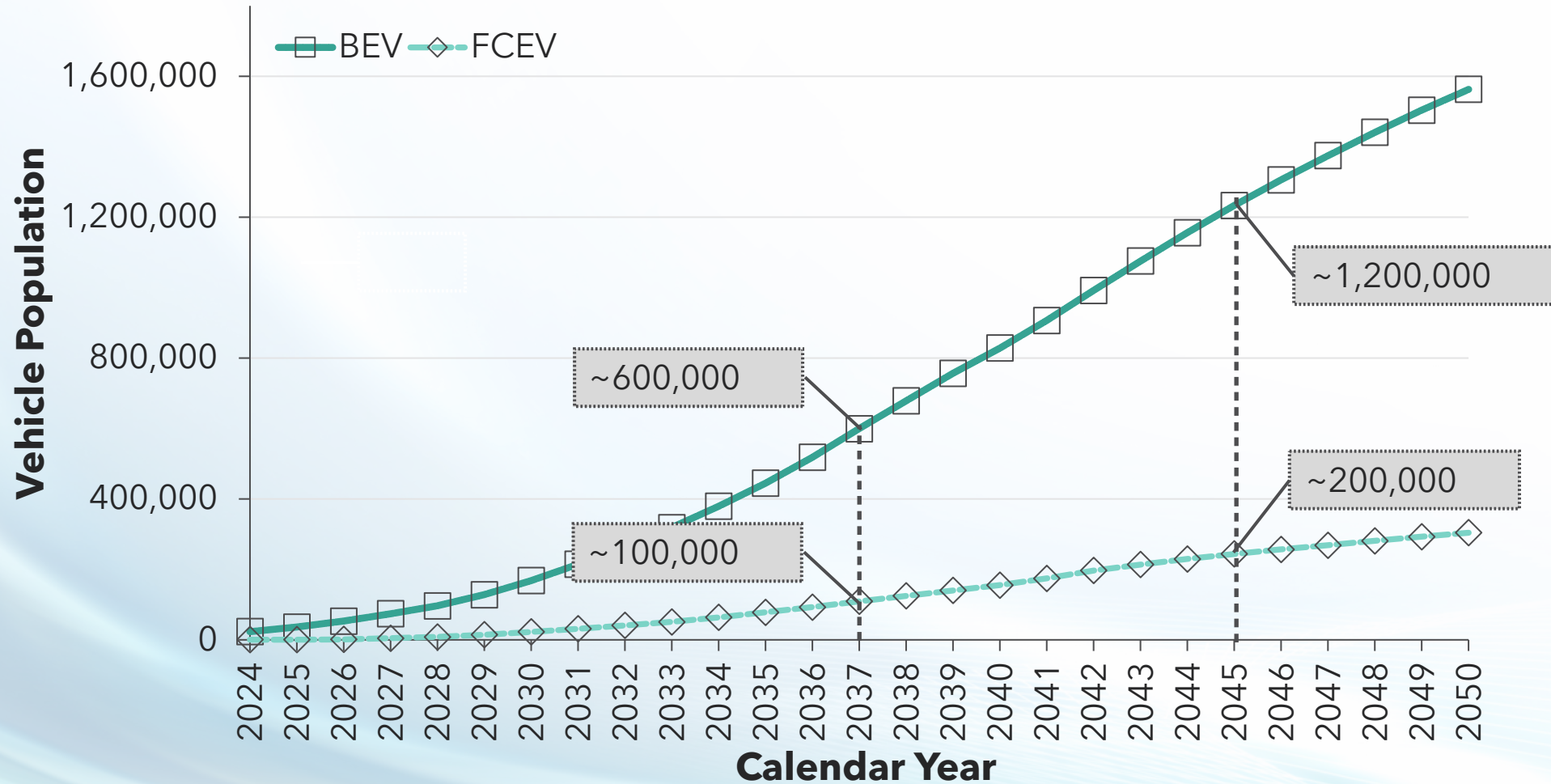
Notes:

- Natural gas: <2% throughout
- Percentages are rounded to nearest integers; may not add up to 100%

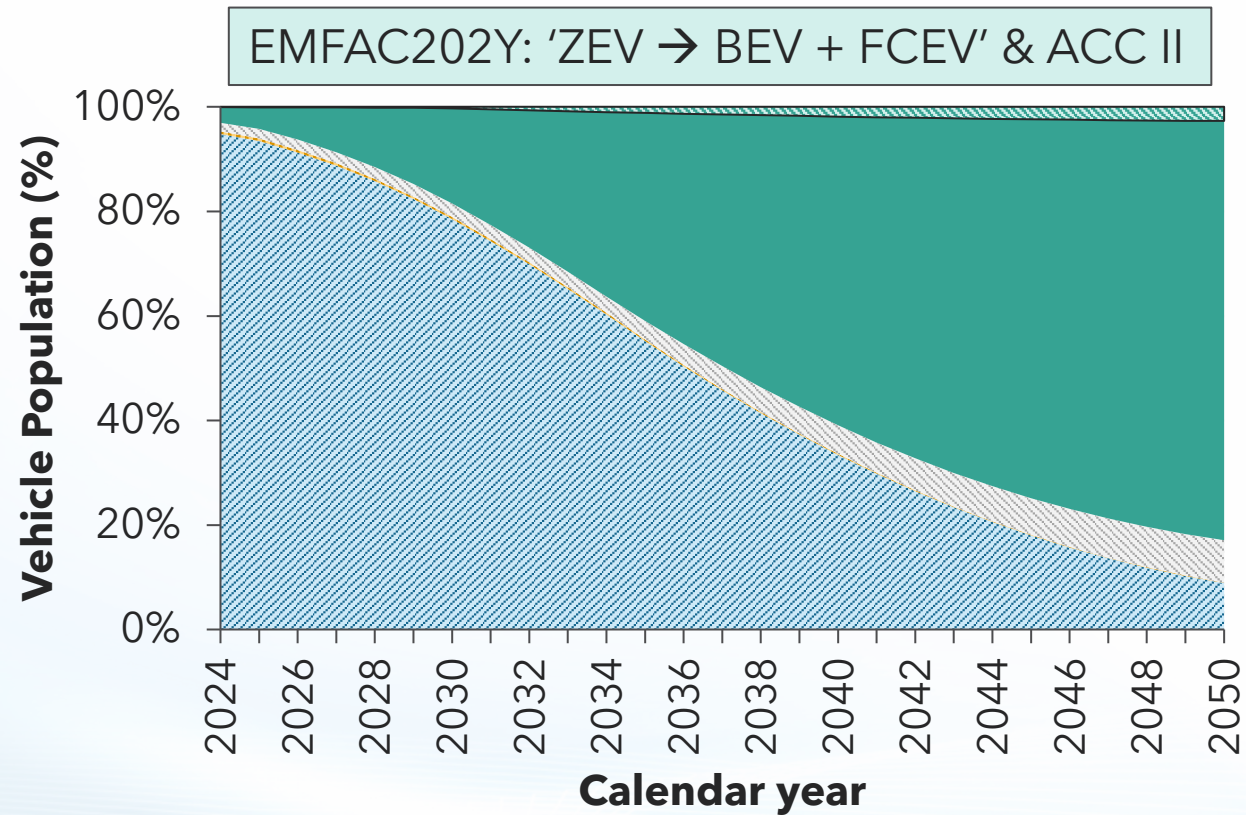
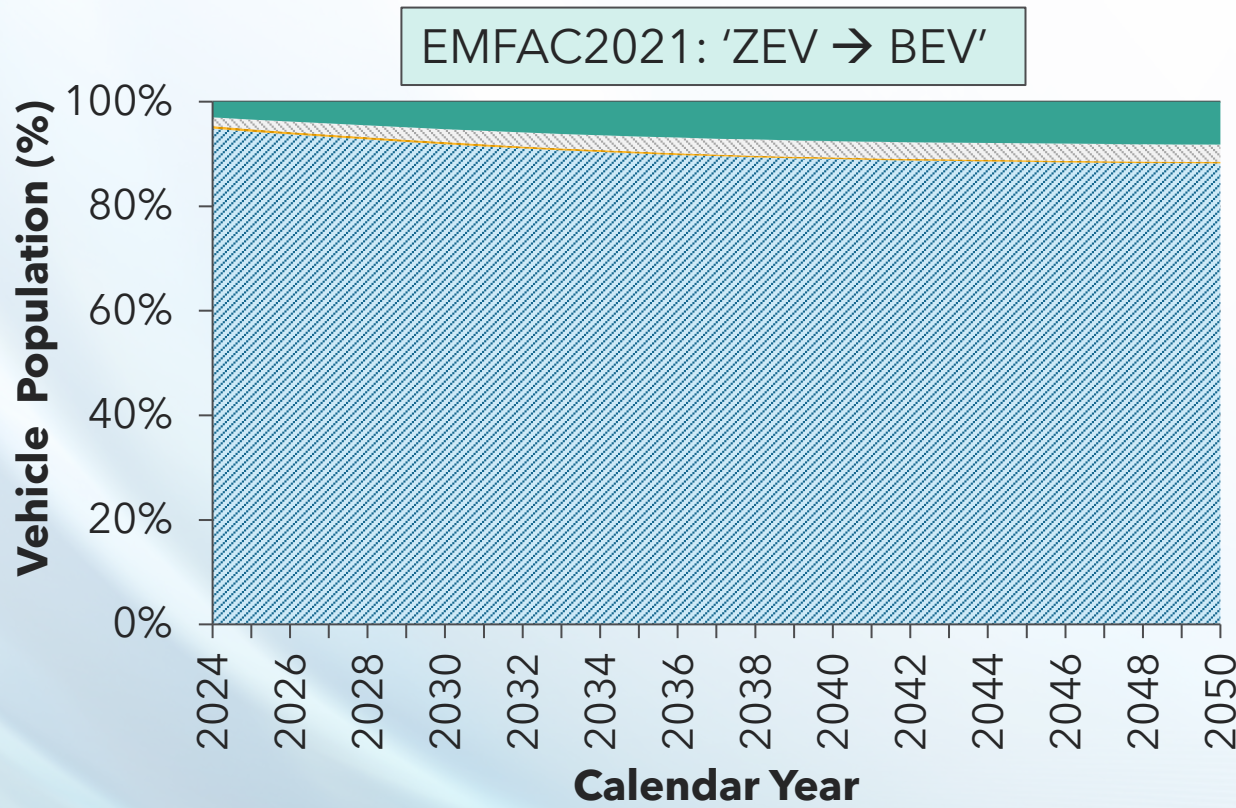
Projected MD and HD Vehicle Population by Fuel Type (EMFAC202Y: 'ZEV → BEV + FCEV' & ACF)



Projected BEV and FCEV Populations (EMFAC202Y: 'ZEV → BEV + FCEV' & ACF)



Projected¹ LD² Vehicle Population (%) by Fuel Type



Gasoline Diesel Plug-in Hybrid ZEV

Gasoline Diesel Plug-in Hybrid BEV FCEV

1. EMFAC202Y Forecasted LD Populations under development
2. LD: LDA + LDT1 + LDT2 + MDV

Next Steps

- Refine estimates for LD based on light-duty forecasting updates
- Implement BEV and FCEV population splits for EMFAC202Y

AM Session Agenda

- EMFAC Overview
- New Major Updates in EMFAC202Y
- Fleet Characterization
 - LD Vehicle Population
 - LD Age 45+ Vehicles Survey and Results
 - Heavy Duty (HD) Vehicle Population
 - Urban or Transit Buses (UBUS)
- Question & Answer
- Vehicle Activity Forecasting
 - LD New Vehicle Sales Forecasting
 - LD VMT Forecasting
 - HD Activity Forecasting
 - Advanced Clean Fleets Module
 - Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV) Splits
- **Question & Answer**

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 Mute/Unmute
- Additional questions may be submitted after today to:
emfac@arb.ca.gov

PM Session Agenda

- **Updates to Emission Rates**

- **Test Plans**

- **LD, LHD, MCY Surveillance Test Plans and Status**

- LD High-Speed Test Plan

- Fuel Reid Vapor Pressure (RVP)

- Sulfur Content

- Emission Rates

- LHD

- Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method

- Question & Answer

- LD Zero Emissions Vehicle (ZEV) Energy Consumption

- Schedule/Next Steps

- Question & Answer

Updates to Emission Rates

LD, LHD, MCY Surveillance Test Plans and Status

New LD, LHD, MCY Data Sources Planned for EMFAC202Y

- Test data collected at CARB's Haagen-Smit Laboratory (El Monte, CA) after EMFAC2021 freeze date (summer 2019) through April 2023 when operations ended
- Any potential upcoming testing at CARB's new Riverside Lab through July 2024:
 - LD Vehicle Surveillance Program 21 (LDVSP21)
 - LHD Vehicle Surveillance
 - On-Road Motorcycle Surveillance
 - High-Speed Driving Project

Light-Duty: Vehicle Surveillance Program Series 20 (LDVSP20)

- 39 total vehicles tested on chassis dyno (baseline FTP, UC, start emissions tests)
 - Data from first 7 vehicles used in EMFAC2021
 - 32 additional vehicles tested for use in EMFAC202Y
- 21 of 39 vehicles also tested on-road using PEMS
 - None used in EMFAC2021
 - Analysis of on-road PEMS emission rates by speed bin is ongoing
 - CARB staff has yet to determine how and whether PEMS data will be used to augment existing chassis dyno data for LD vehicle category

Planned Future LD Testing

- **Current CARB LD Vehicle Surveillance Project (LDVSP21)**

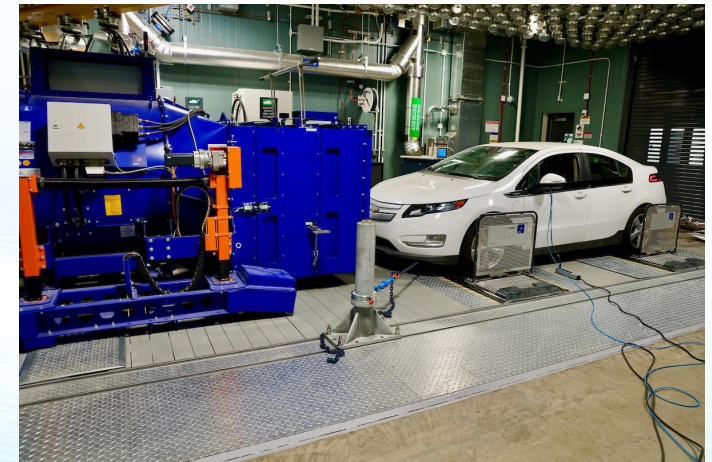
- 60 passenger cars and trucks up to 8,500 lbs. GVWR
- MY 1998 to 2025 vehicles from the current in-use fleet

- **Dynamometer Tests**

- Baseline Unified Cycle (UC) Test
 - HC, CO, NO_x, CO₂ with NH₃, PM and N₂O
- Baseline Federal Test Procedure (FTP)
- Starts Emissions tests after varying periods of soak time
- Arterial and Freeway driving cycles

- **Special Testing (40 vehicles)**

- Speciated emissions
- Evaporative emissions
 - Hot Soak
 - Diurnal
 - Running Loss



Temperature and Air Conditioning (AC) Correction Tests

- **Subset of 5 LD vehicles to be tested**
- **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
- **Test Cell set at 4 Temperatures**
 - 50-, 75-, 95- and 105-degrees F
 - Set humidity level
 - Monitor vehicle air intake temperature
 - Update and validate EMFAC Temperature Correction Factors



Planned Future LHD Testing

Current CARB LHD Trucks Surveillance Project

- **10 MY 2017 and newer**
 - 5 LHD1 vehicles 8,501-10,000 lbs. GVWR, 2 diesel, 3 gasoline
 - 5 LHD2 vehicles 10,001-14,000 lbs. GVWR, 3 diesel, 2 gasoline
- **Dynamometer Exhaust Tests**
 - FTP
 - UC
 - Arterial and Freeway Driving Cycles
 - All tests to collect HC, CO, NO_x, and CO₂
 - With PM, N₂O and NH₃



Future On-Road Testing - LD and LHD

Portable Emissions Monitoring System (PEMS) Data Collection

- 60 LD passenger cars and trucks
- 5 LHD1 vehicles 8,501-10,000 lbs. GVWR
 - 2 diesel, 3 gasoline
 - Trailer Towing: 1 diesel vehicle
- 5 LHD2 vehicles 10,001-14,000 lbs. GVWR
 - 3 diesel, 2 gasoline
 - Trailer Towing: 1 diesel vehicle
- City, Freeway and Mountain routes



Planned Future Motorcycle Testing

Current CARB On-Road Motorcycle Surveillance Project

- CARB intends to conduct extensive exhaust and evaporative testing to better understand in-use motorcycle emissions
- 25 On-road Motorcycles to be tested
 - MY 2018 and newer from the CA in-use fleet
 - Class III (displacement > 280 cc)
 - About 90% CA DMV registration
 - Representative models by highest sales
- Tamper Testing of 2 state-owned bikes
 - MY 2018 and 2019



Motorcycle Emissions Testing

- **Exhaust Tests**

- **UC** - results to be used to develop proposed motorcycle emission rates for EMFAC (MY 2018+, Fuel Injected, Catalyst Equipped, gasoline)
- **FTP** - data and test verification
- **World Motorcycle Test Cycle (WMTC)** - results to compare with upcoming CARB regulation to harmonize with European Union (EU) standards



- **Evaporative SHED Tests**

- 1-hour Hot Soak Test
- 3-day Diurnal Test

Project Timeline

LD and LHD Status

- November 2023 - LD and LHD Vehicle Selection
- December 2023 and January 2024 - Vehicle Procurement
- January 2024 to August 2026 - LD and LHD testing

MCY Status

- January 2024 - MCY Selection
- February 2024 to August 2026 - MCY Procurement and Testing

LD, LHD, and MCY Data for EMFAC202Y

- Any data collected through June 2024 will be incorporated in EMFAC202Y

PM Session Agenda

- **Updates to Emission Rates**

- **Test Plans**

- LD, LHD, MCY Surveillance Test Plans and Status

- **LD High-Speed Test Plan**

- Fuel Reid Vapor Pressure (RVP)
 - Sulfur Content
 - Emission Rates
 - LHD
 - Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method

- Question & Answer

- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps
- Question & Answer

Updates to Emission Rates

LD High-Speed Driving Test Plan

Background

- **CARB Surveillance Test Plans**

- The previous light-duty Surveillance test plans included freeway driving cycles where the highest speed cycle Freeway Cycle 7 (FC7) averaged 73 mph
 - FC7 emissions data was previously insufficient (criteria pollutants) for EMFAC
 - The data from speeds above 65 mph will be used to update EMFAC and the emissions inventory

- **Driving Behavior (UC Berkeley Survey)¹**

- 73% of CA drivers drove 10 mph over the freeway speed limit and 23% drove 20 mph over the limit
- In 2019 about 58% of drivers used freeways 6-7 times a week, increasing from 50% in 2015

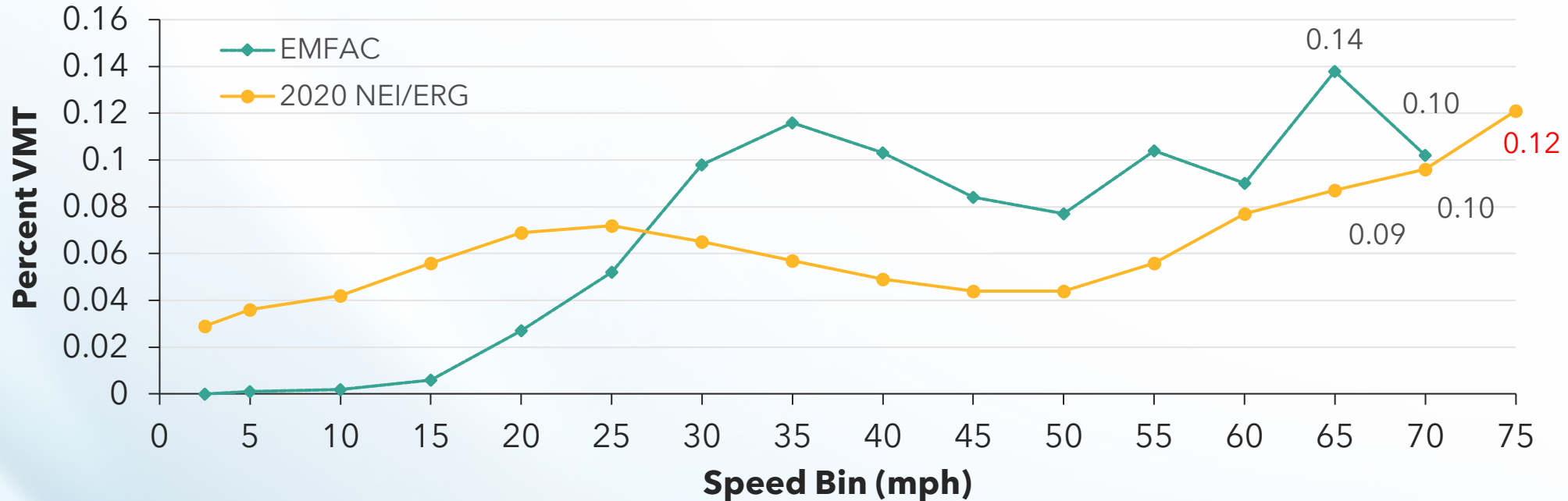
- **2018 Drivemode Study²**

- 10% of driving time over 70 mph

1. CA Speeding and Aggressive Driving Study August 2019 Data Analysis, CHP and Safe Transportation Research and Education Center - UC Berkeley (SafeTREC)
2. Data Report: States Most Frequently Driving At Dangerously High Speeds, May 2018, Drivemode

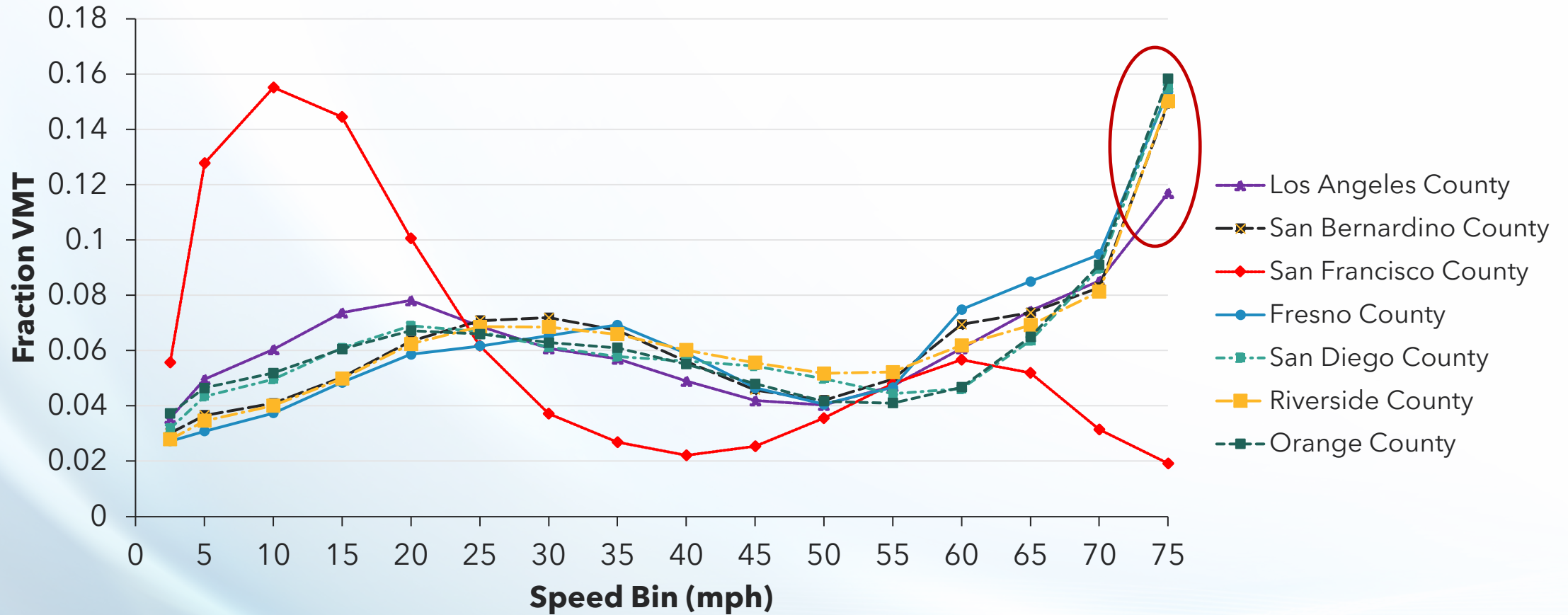
Background Cont.

Speed Distribution Comparison



- EMFAC2021 vehicle miles traveled (VMT) by speed distribution (Metropolitan Planning Organization) data only goes up to 70 mph whereas the 2020 NEI/ERG (National Emissions Inventory/Eastern Research Group) data extends to the 75 mph and above speed bin
- EMFAC speed correction factor of 65 mph is applied to VMT distribution of 65 and 70 mph
- EMFAC VMT may be underestimating high speed distributions (65+ mph), and more data is needed to confirm VMT above 65 mph

Background Cont.



- 2020 NEI data speed distribution for several CA counties
- San Francisco has the lowest VMT fraction at 75+ speed bin

Test Plan Objectives

- **Propose testing in Riverside Laboratory**
 - Include light-duty vehicles (up to 10,000 lbs. GVWR) for high-speed testing
 - Newly proposed freeway driving cycles will include testing aimed at 80 mph, 90 mph, and 100 mph
- **Collect High Speed Emissions to improve EMFAC**
 - Update speed correction factors (SCFs)
 - FTP and UC will be performed for baseline
 - FC 5, 6, and 7 will be performed for reference data
 - Introduce three new high speed dynamometer driving cycles
 - Freeway Cycle 8 (Average speed of 83 mph)
 - Freeway Cycle 9 (Average speed of 93 mph)
 - Freeway Cycle 10 (Average speed of 103 mph)

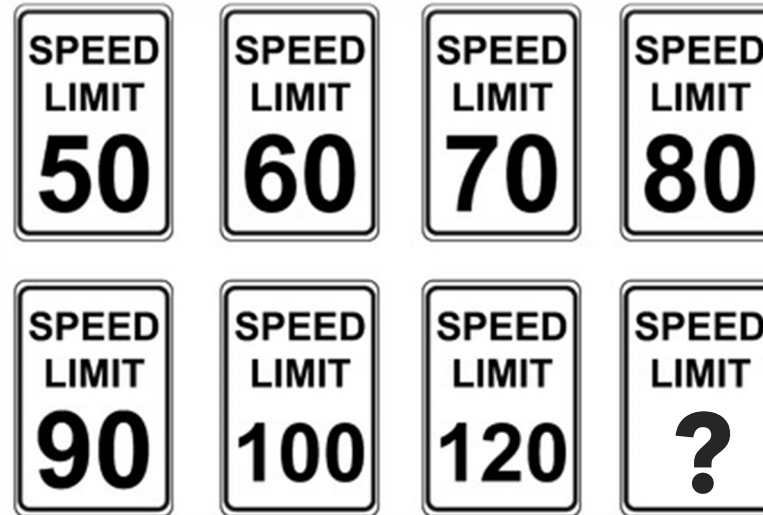
Proposed Testing Program

- **Procure and test a total of 5 vehicles**
 - Mix of mid-sized passenger cars, SUVs and trucks
 - Model Year ranging from 2018-2022
 - Mix of manufacturers
 - Dynamometer safety clearance
 - Tires in new or very good condition (check tire depth)
 - 2 SULEV 30
 - 2 ULEV 50
 - 1 Light Heavy-Duty Truck



Test Sequence

- **Baseline FTP (cold) with Particulate Mass (PM)**
- **Baseline UC (cold) with PM**
- **Freeway Cycles (estimated average speed) with PM**
 - FC5 (56 mph)
 - FC6 (65 mph)
 - FC7 (73 mph)
 - FC8 (83 mph)
 - FC9 (93 mph)
 - FC10 (103 mph)



Project Timeline

- **Project Status**

- June to September 2023 - Test Plan review and edits
- November - December 2023 - Vehicle selection
- January 2024 - Vehicle procurement
- January 2024 to July 2024 - Testing, data collection and analysis

- **Inventory Timeline**

- Data collected will be used for next inventory model version EMFAC202Y

PM Session Agenda

- **Updates to Emission Rates**

- Test Plans
 - LD, LHD, MCY Surveillance Test Plans and Status
 - LD High-Speed Test Plan

- **Fuel Reid Vapor Pressure (RVP)**

- Sulfur Content
- Emission Rates
 - LHD
 - Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method

- Question & Answer

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- Schedule/Next Steps
- Question & Answer

Updates to Emission Rates

Fuel RVP

Background and Goals

- Reid Vapor Pressure (RVP) is a measure of gasoline volatility
- Beginning in 1996, California gasoline must have an RVP no higher than 7 psi during summer months¹
- RVP varies by month and air basin and values were last updated in EMFAC2002
- RVP influences only evaporative, not exhaust emissions rates
- For EMFAC202Y, RVP input tables will be updated based on recent field samples

RVP by Control Regions

- Current data in EMFAC incorporates regulations for summer fuel blends.
- California is divided into five control regions A, B, C, D and E.
- Each control region is a group of air basins or a group of Geographical Area Indices (GAI) that share fuel blend transition dates from summer to winter, and vice versa.

CALIFORNIA RVP CONTROL PERIODS BY AIR BASIN AT RETAIL STATION



Link to Source: [California diesel retail prices by region - California energy commission.](#)

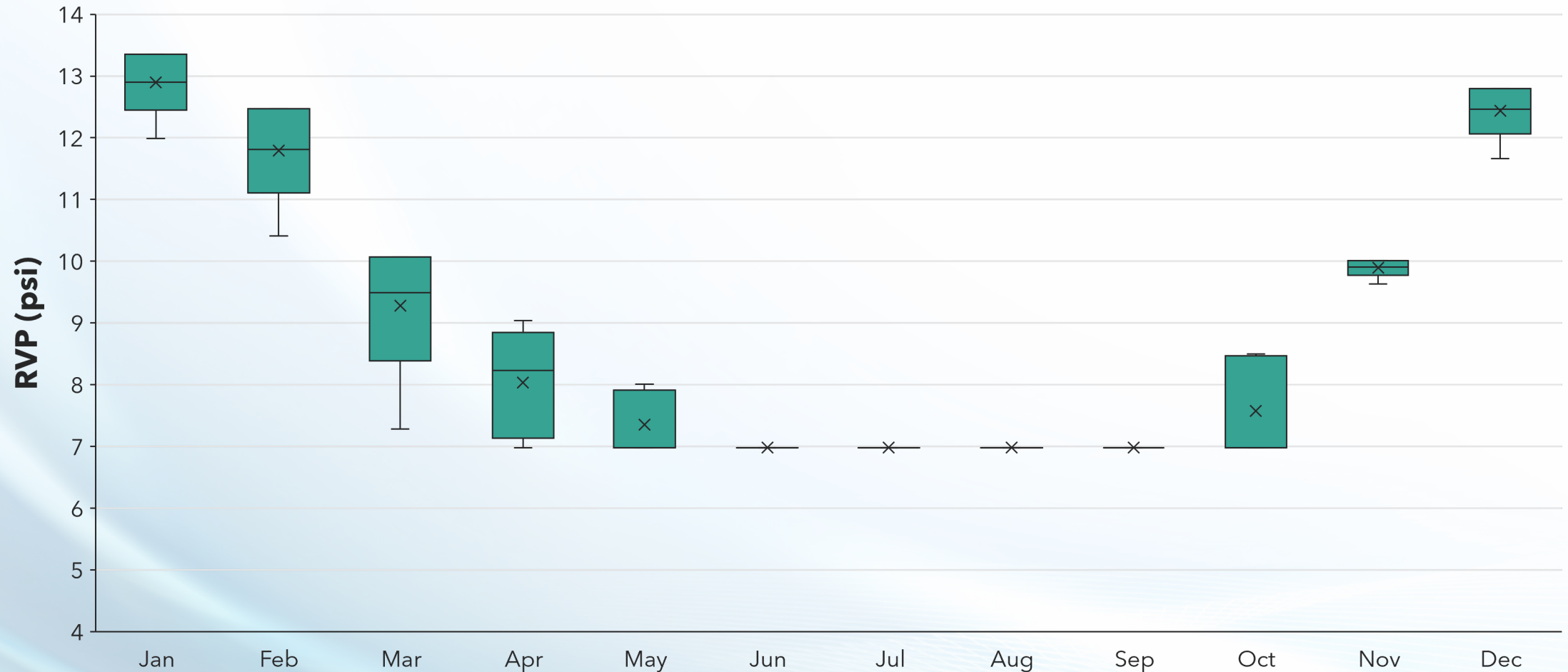
Data Sources

- CARB's Enforcement Division (ED) collected RVP and sulfur data from different source types between years 2008 to 2022.
- This data will be utilized to update RVP and sulfur in the EMFAC202Y model.
- Only RVP and sulfur values measured from Service Stations (SS) were included in the update.

Data Collection Source Types

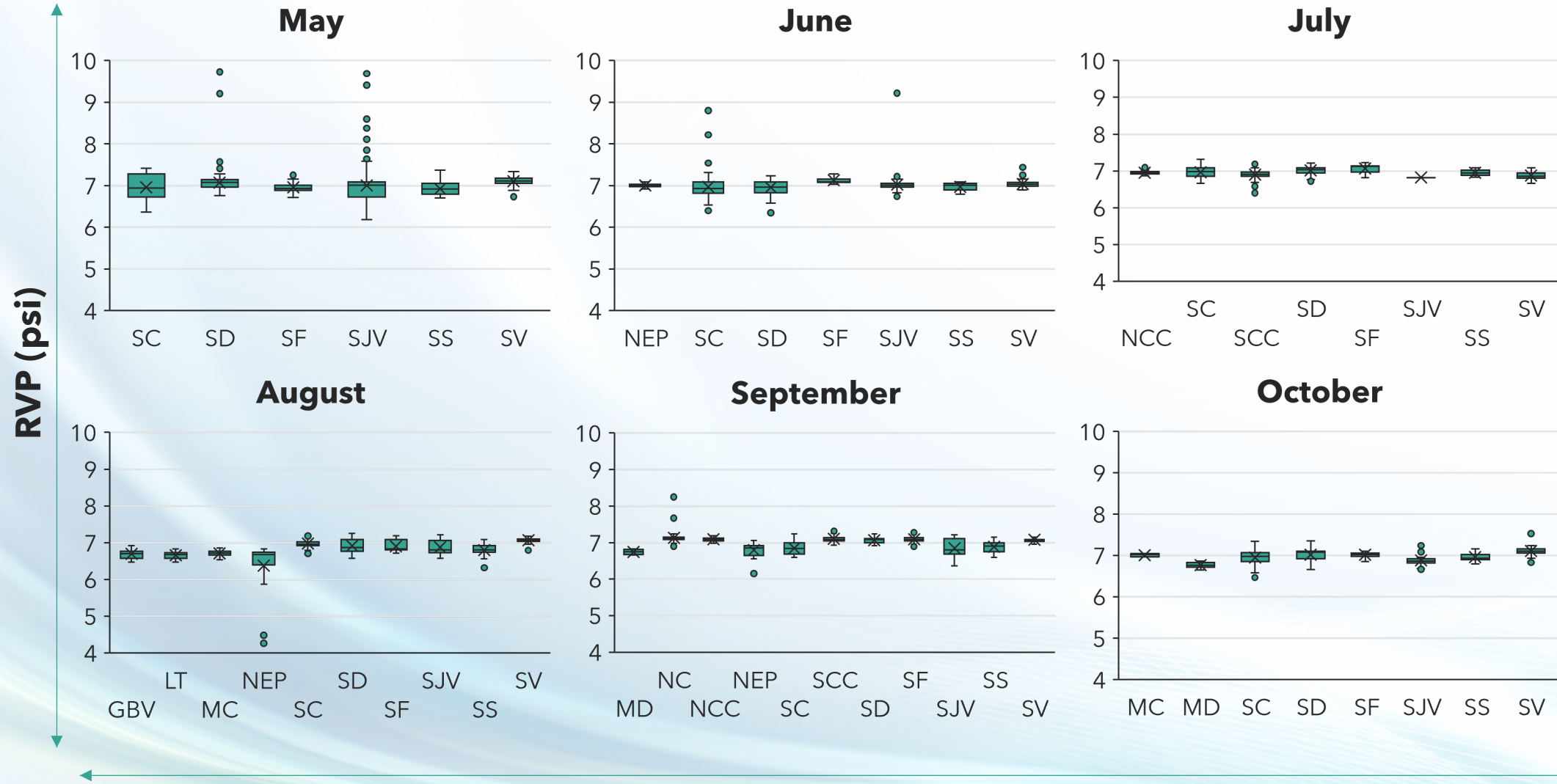
RP	Refinery production sample
RD	Refinery downstream sample
TP	Terminal production sample
TD	Terminal downstream sample
SS	Service Station
VI	Vessel import sample
XI	Railcar import sample
HI	Shore import sample

Fuel Sample RVP by Month



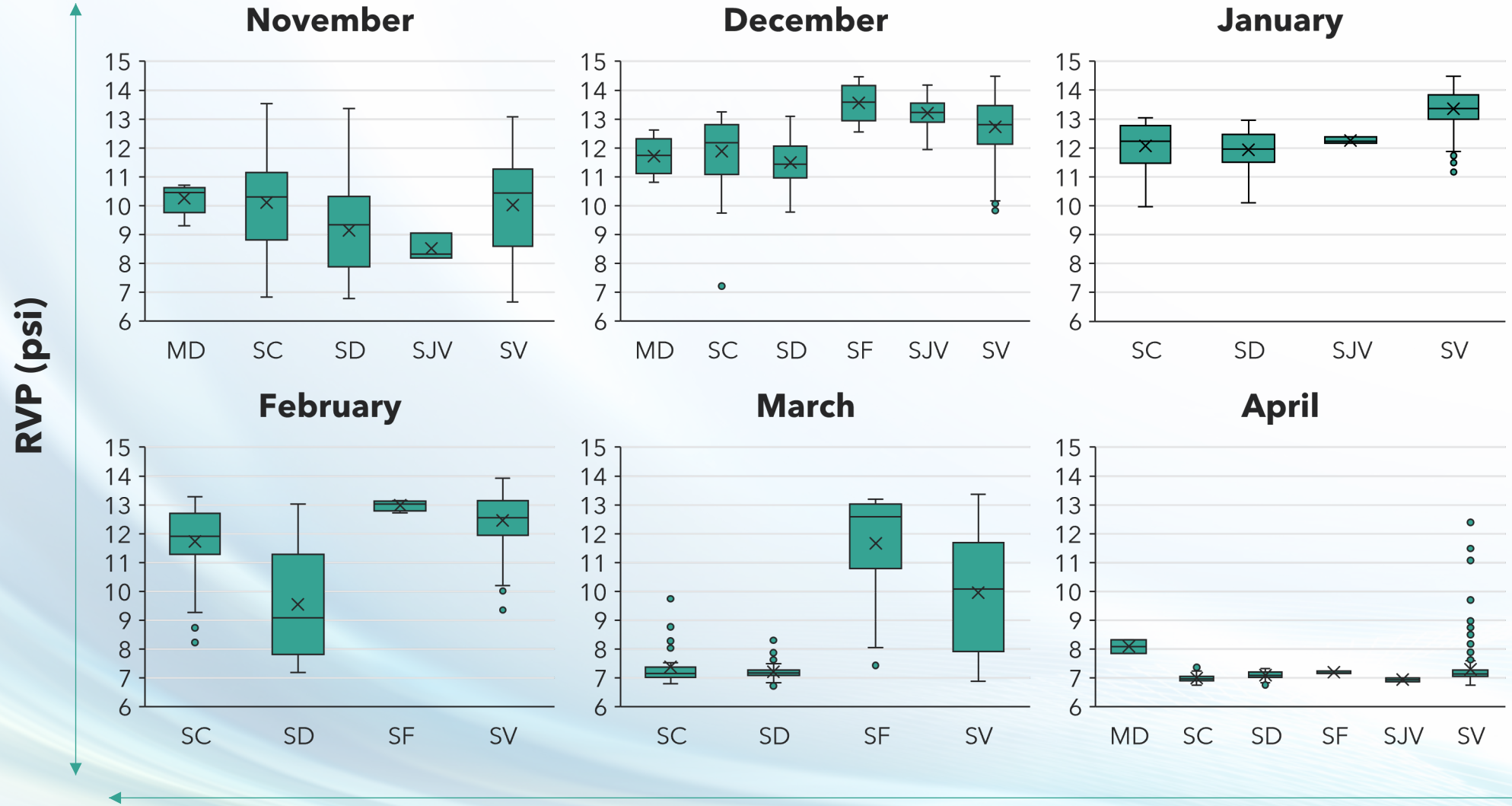
Summer (May - October) fuel blends RVP are observed in the range of 6.40 to 7.20 psi whereas winter (November - April) fuel blends are typically in the 8 psi and above range.

Summer RVP by Air Basin



GBV	Great Basin Valleys
LT	Lake Tahoe
MC	Mountain Counties
MD	Mojave Desert
NC	North Coast
NCC	North Central Coast
NEP	Northeast Plateau
SC	South Coast
SCC	South Central Coast
SD	San Diego
	San Francisco Bay Area
SF	Area
SJV	San Joaquin Valley
SS	Salton Sea
SV	Sacramento Valley

Winter RVP by Air Basin



MD	Mojave Desert
SC	South Coast
SD	San Diego
SF	San Francisco Bay Area
SJV	San Joaquin Valley
SV	Sacramento Valley

Data Processing

- RVP values were obtained by averaging data points by month for each area (A,B,C,D, & E)

Area D	Month	RVP
1	Jan	13.35
2	Feb	12.47
3	Mar	10.07
4	Apr	
5	May	
6	Jun	6.95
7	Jul	6.95
8	Aug	6.95
9	Sep	6.95
10	Oct	
11	Nov	10.01
12	Dec	12.80



Interpolation if 2 consecutive data points are missing



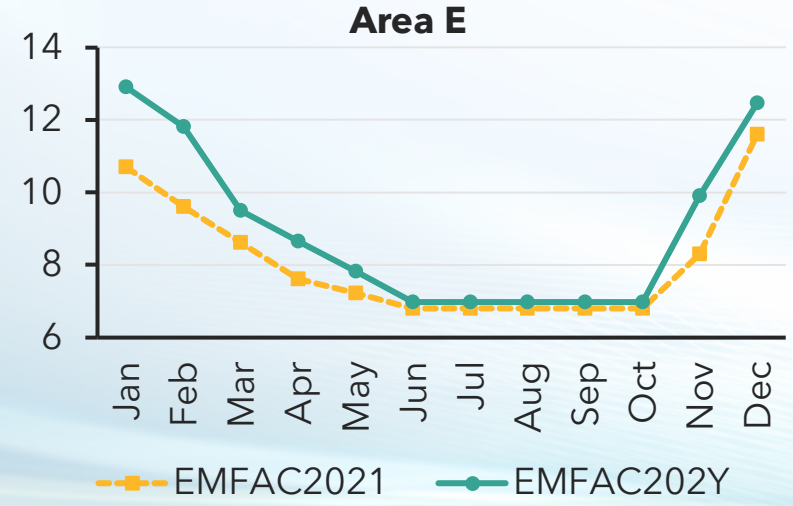
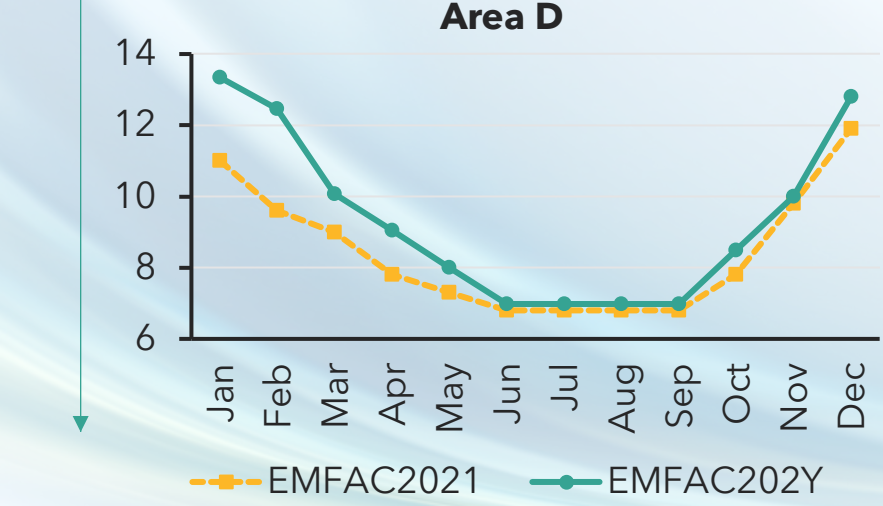
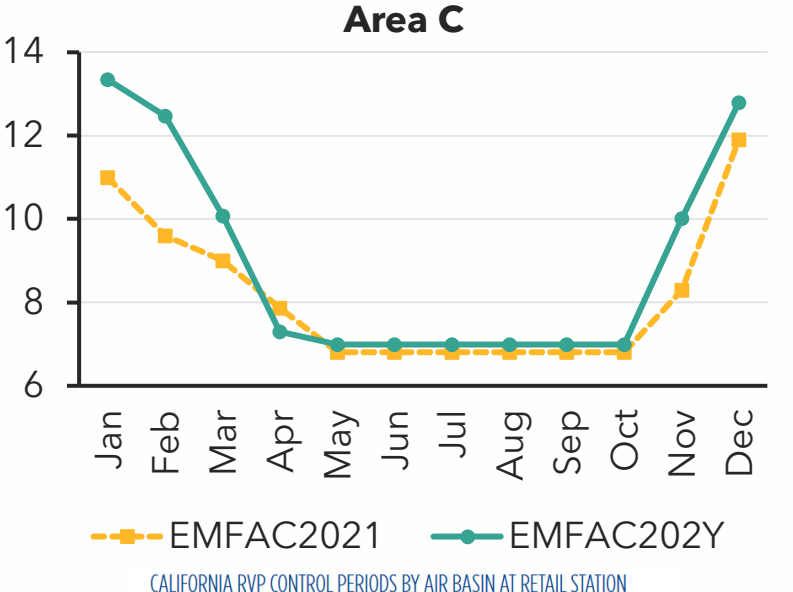
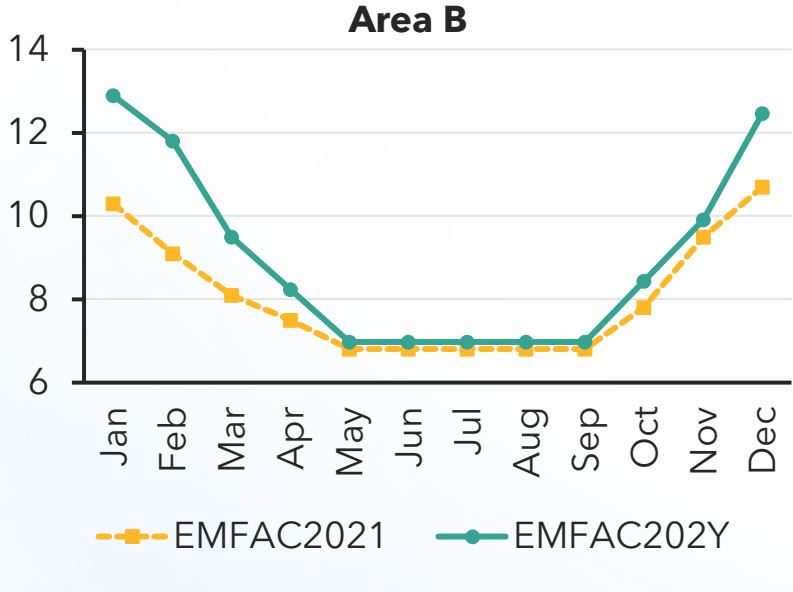
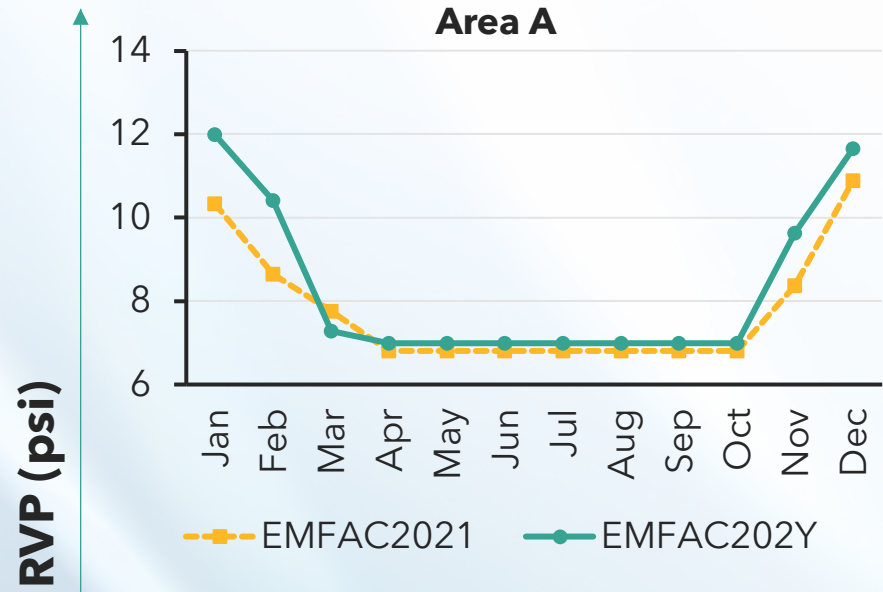
Average of surrounding areas by month if a single data point is missing



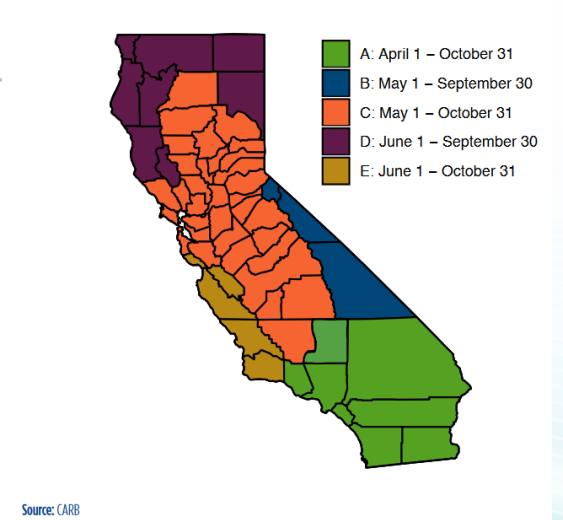
Area D	Month	RVP
1	Jan	13.35
2	Feb	12.47
3	Mar	10.07
4	Apr	9.04
5	May	8.01
6	Jun	6.95
7	Jul	6.95
8	Aug	6.95
9	Sep	6.95
10	Oct	8.92
11	Nov	10.01
12	Dec	12.80

- Derived RVP tables were updated in EMFAC202Y

EMFAC2021 vs. Updated RVP



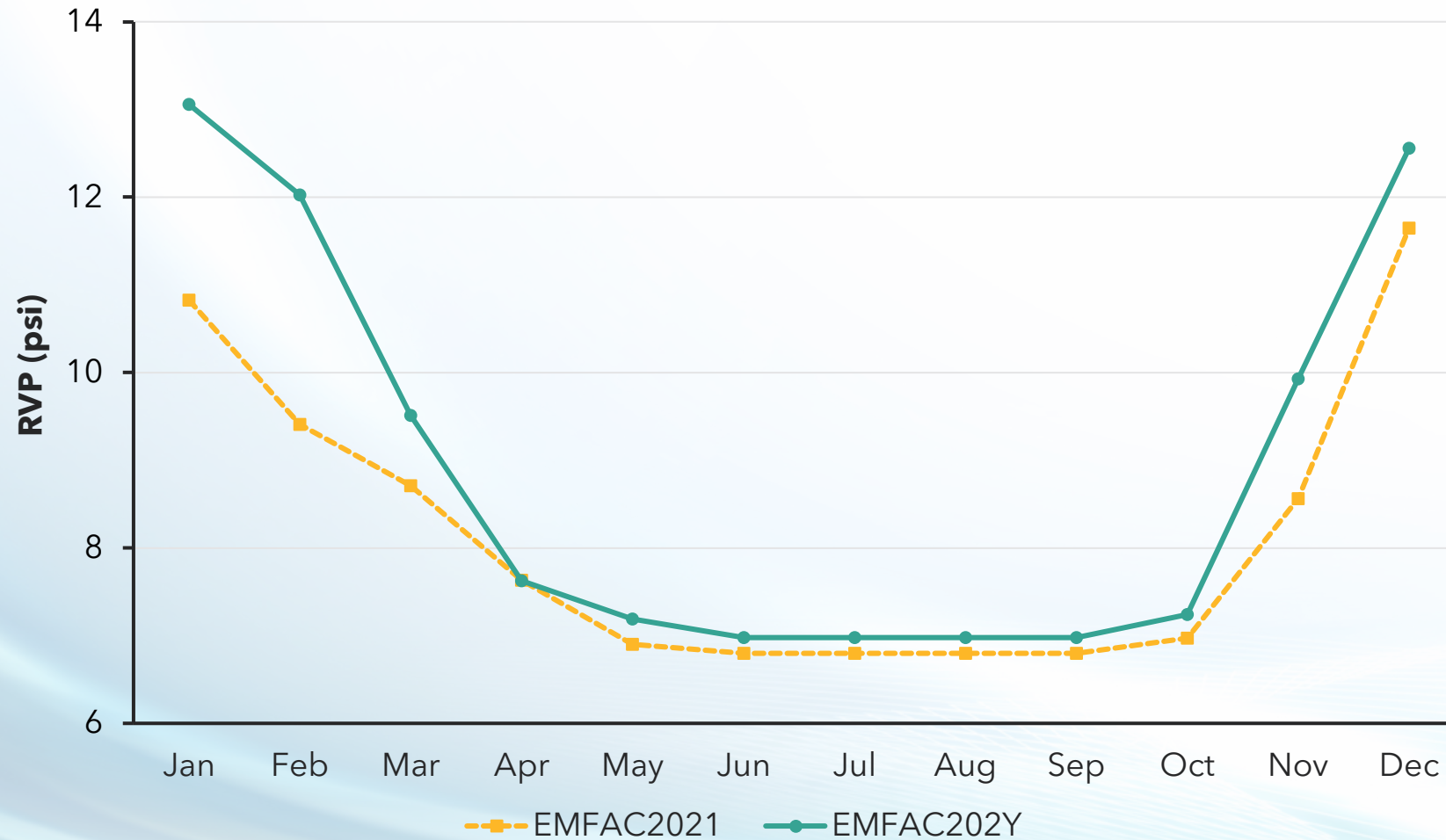
CALIFORNIA RVP CONTROL PERIODS BY AIR BASIN AT RETAIL STATION



Source: CARB

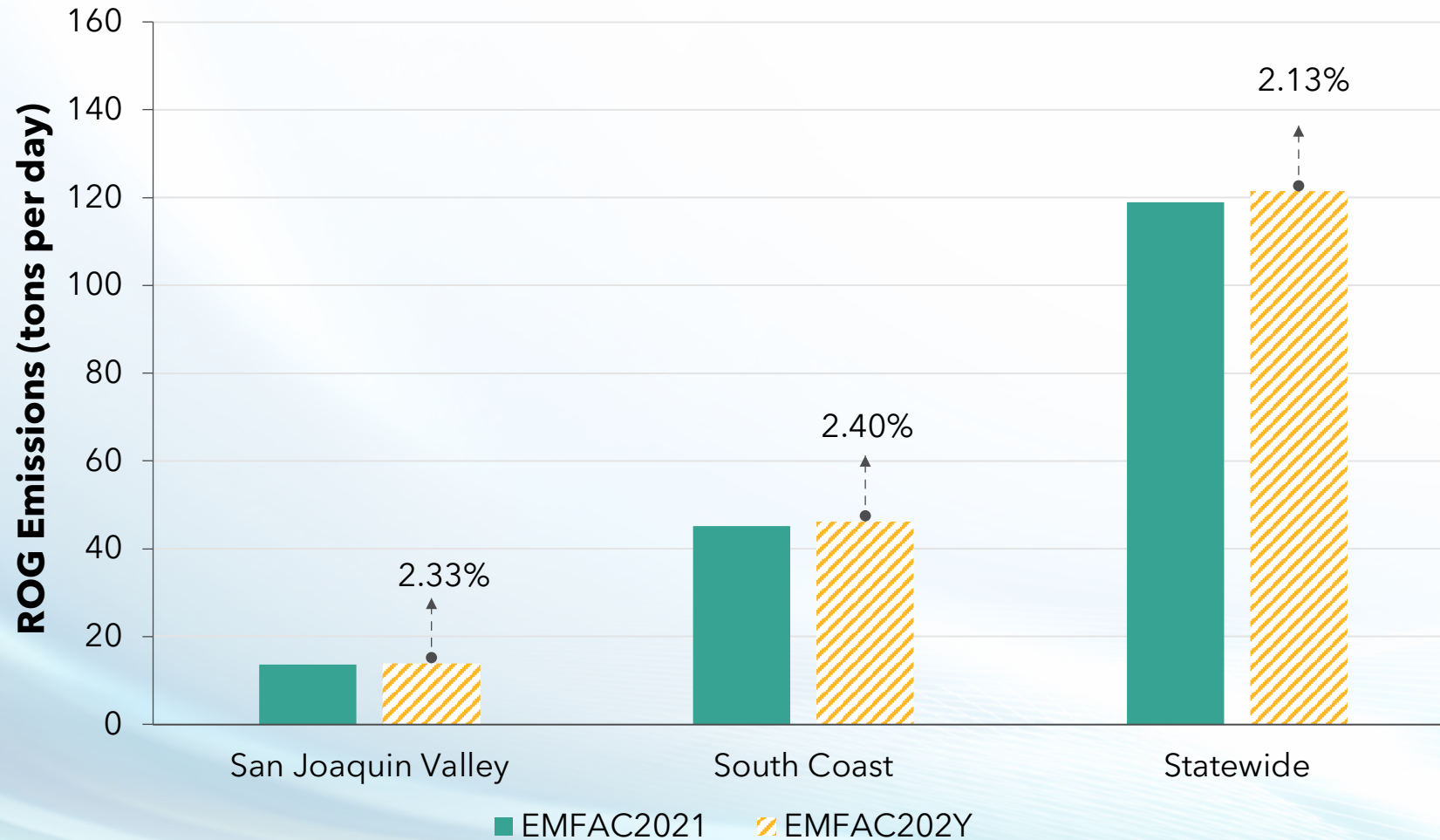
EMFAC2021 vs. Updated RVP

California



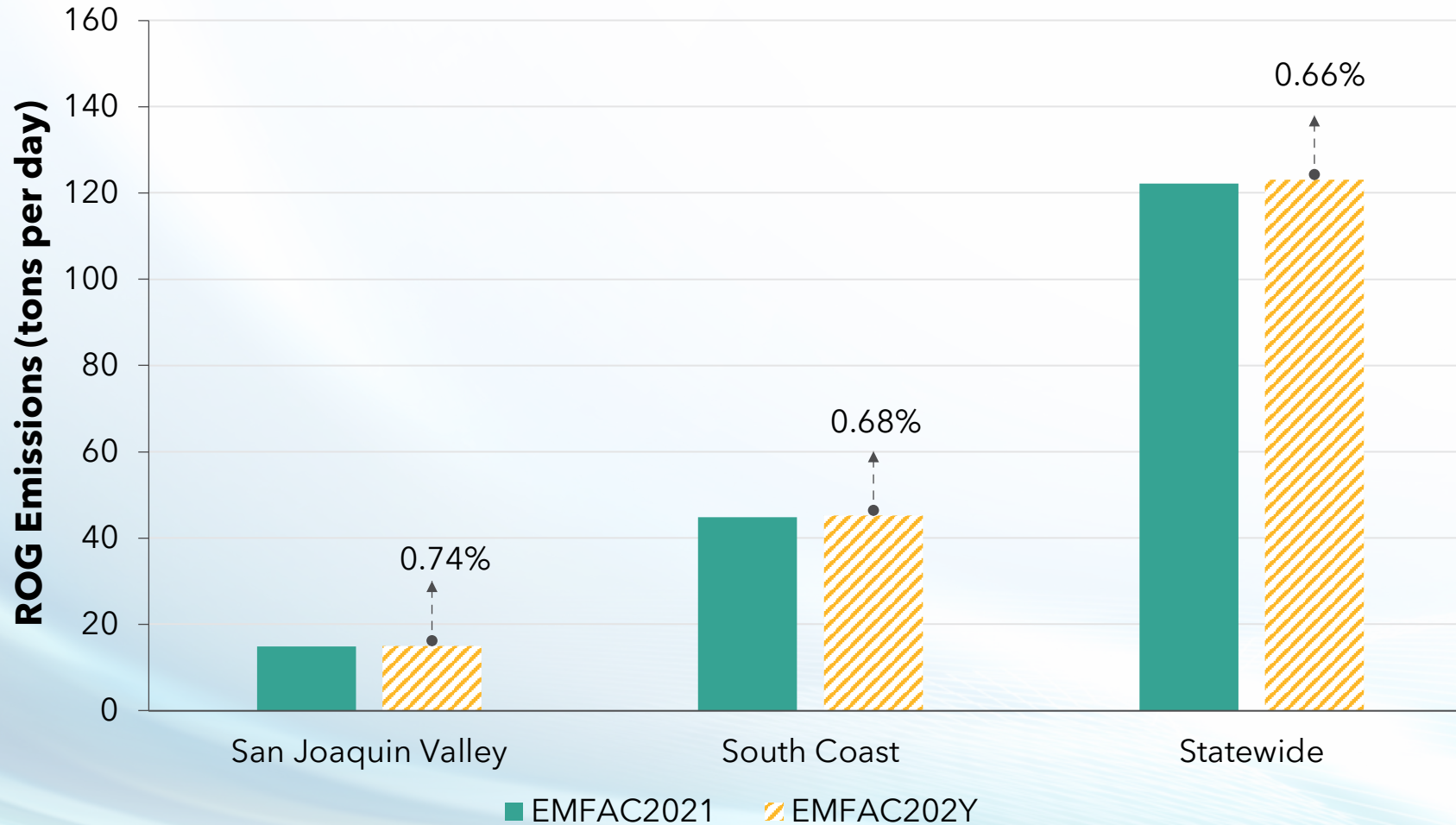
Emission Impacts of RVP Updates

SJC/SC/Statewide Winter ROG Evaporative Emission



Emission Impacts of RVP Updates

SJC/SC/Statewide Annual ROG Evaporative Emission



PM Session Agenda

- **Updates to Emission Rates**

- Test Plans
 - LD, LHD, MCY Surveillance Test Plans and Status
 - LD High-Speed Test Plan
- Fuel Reid Vapor Pressure (RVP)

- **Sulfur Content**

- Emission Rates
 - LHD
 - Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method

- Question & Answer

- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps
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Updates to Emission Rates

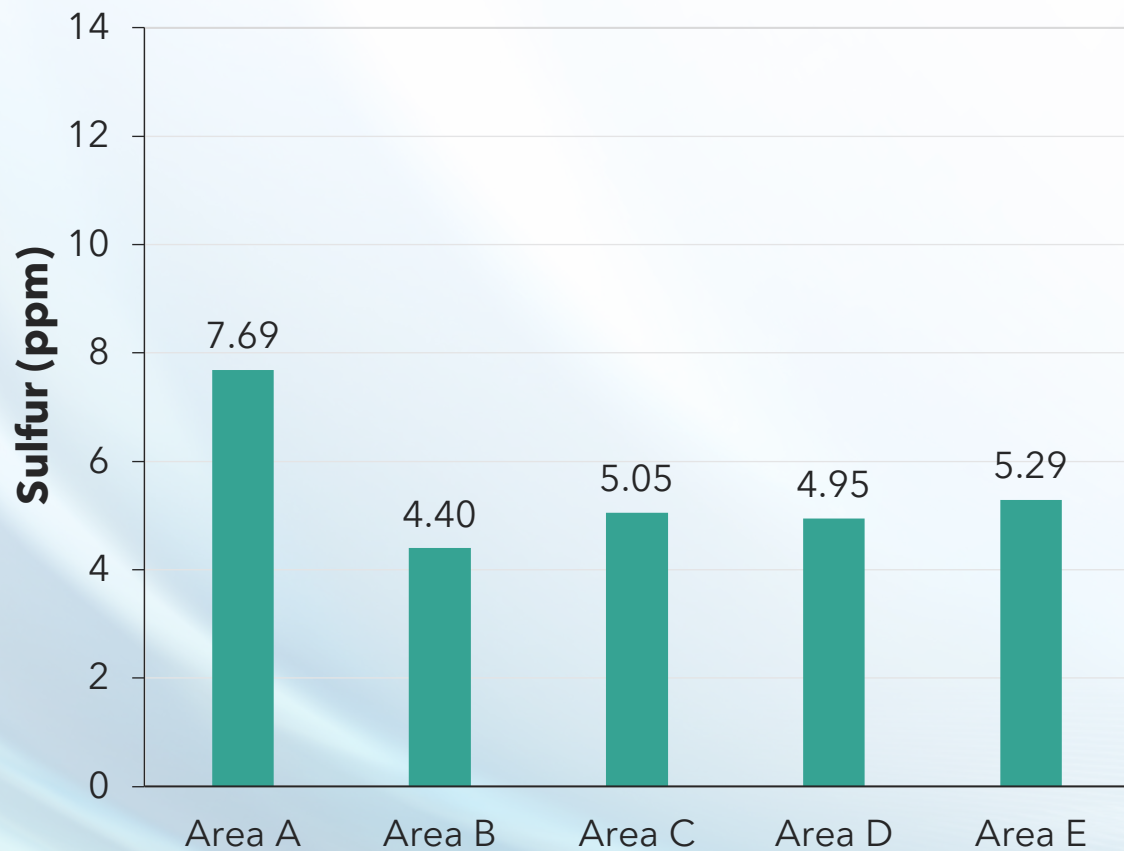
Sulfur Content

Background and Data Collection

- Sulfur content in EMFAC2021: 15 ppm for CYs 2003+ gasoline and CYs 2007+ diesel.
- Sulfur values were collected from the same data sources as RVP.
- Sulfur updates calculated as annual averages of the data points.
 - Updated gasoline sulfur content: 6.5ppm
 - Updated diesel sulfur content: 5.2ppm

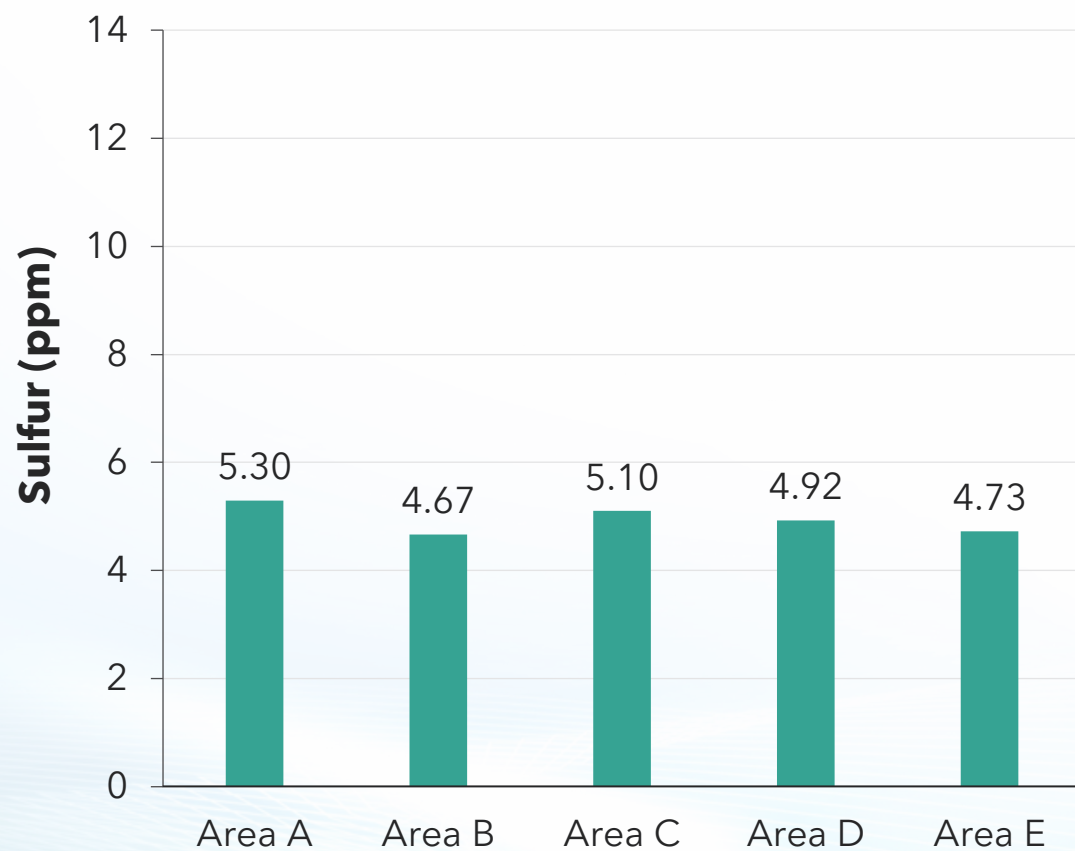
Sulfur - Annual Averages

Gasoline



Weighted Area Averages = 6.5 ppm

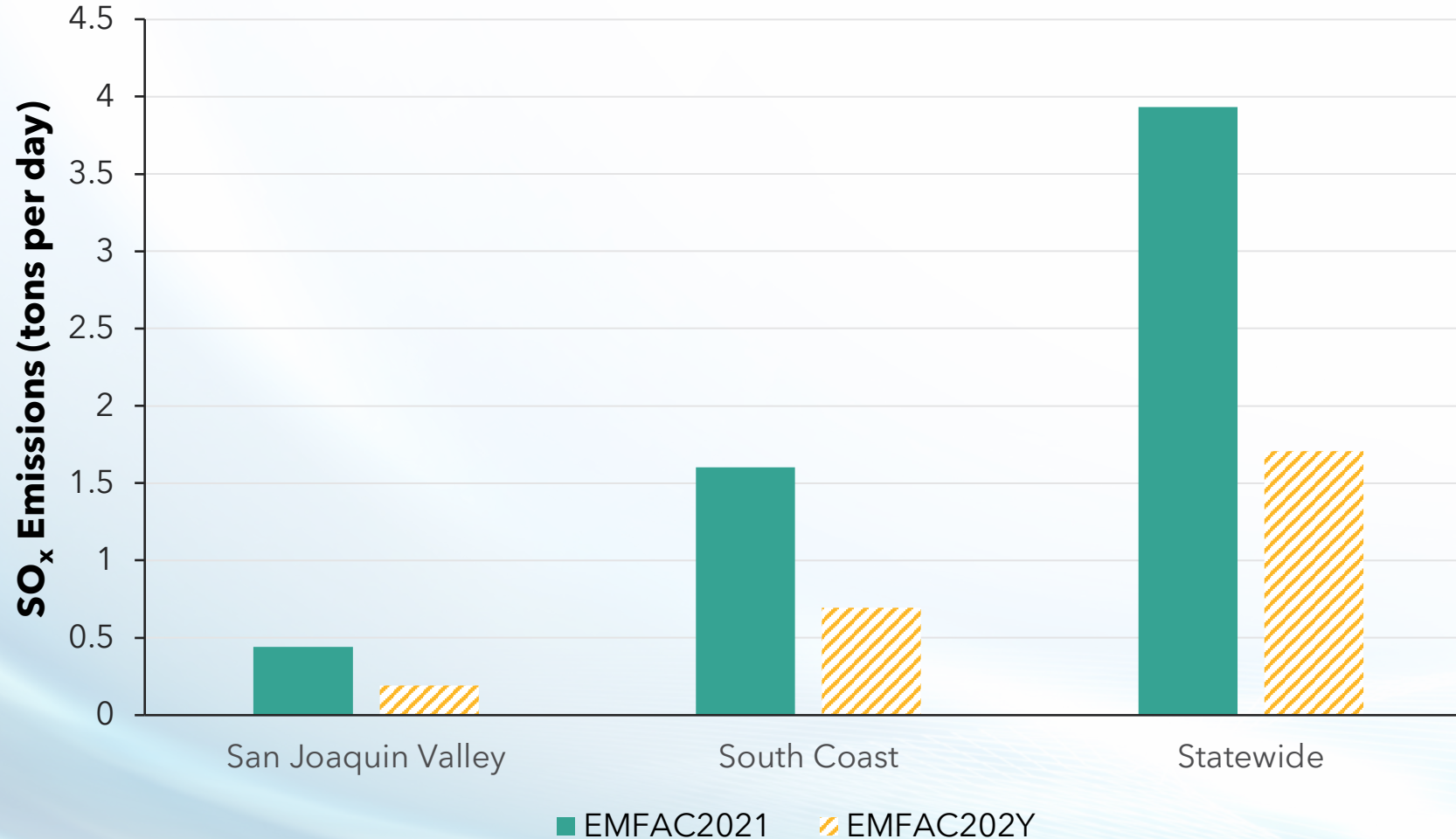
Diesel



Weighted Area Averages = 5.2 ppm

Emission Impacts of Sulfur Updates

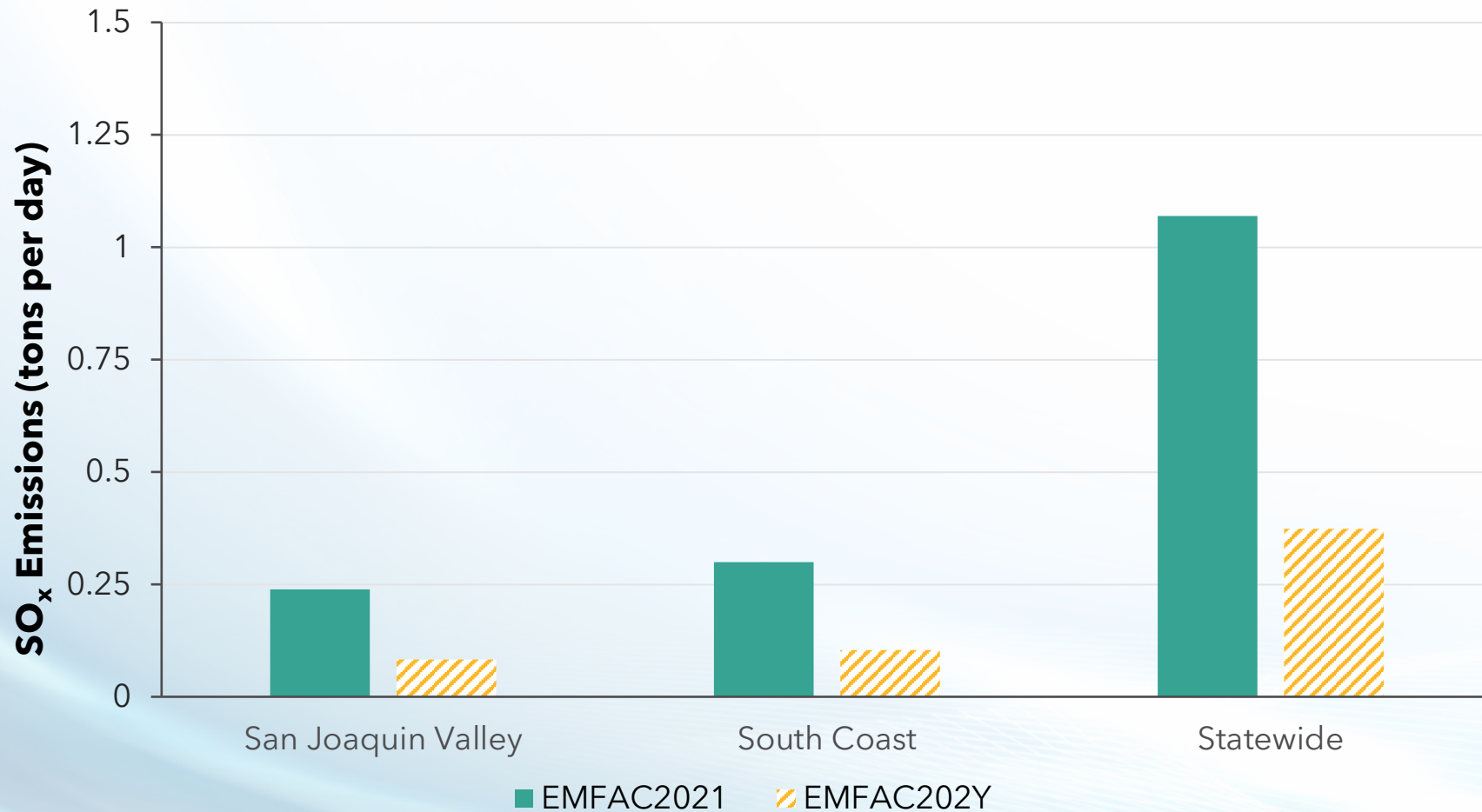
Gasoline



SO_x emission reduction ~ 56%

Emission Impacts of Sulfur Updates

Diesel



SO_x emission reduction ~ 65%

PM Session Agenda

- **Updates to Emission Rates**

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- **Emission Rates**
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- Question & Answer

- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps
- Question & Answer

Updates to Emission Rates

LHD Emission Rates

LHD Vehicles

- 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)

Review of EMFAC2021 LHD Emission Rates

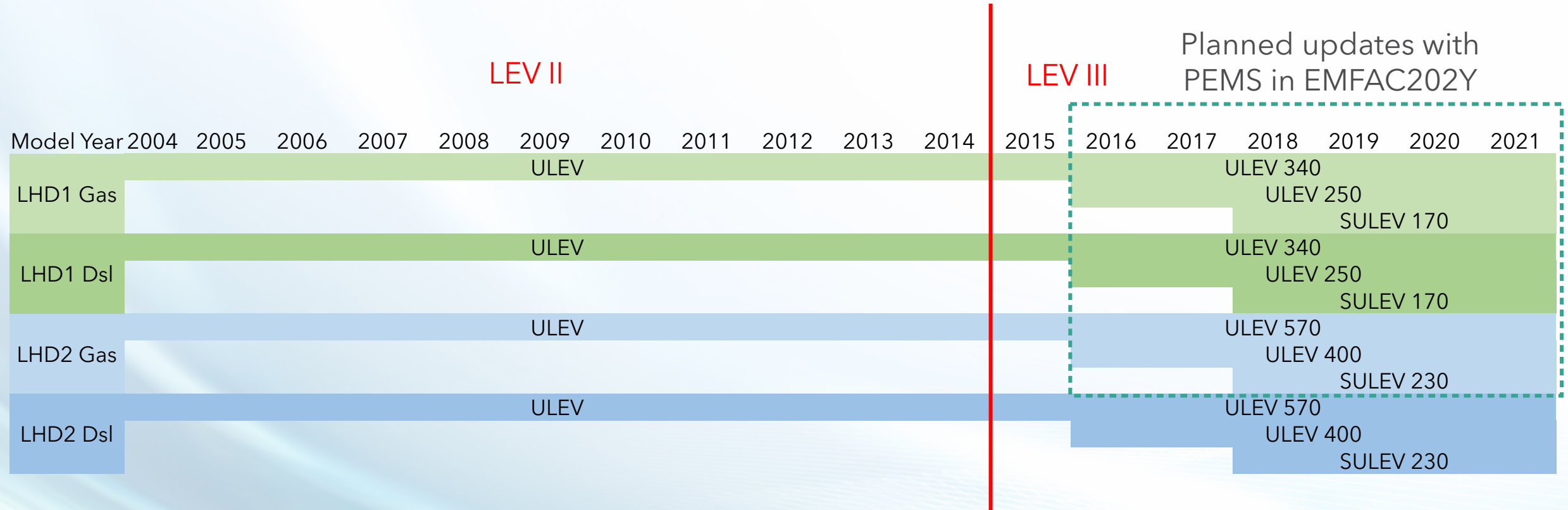
- MY 2004 and newer vehicles were exclusively based on chassis dynamometer data from 12 vehicles listed below.
- Data informed Zero-Mile Rates, Deterioration Rates (DR) and Speed Correction Factors (SCFs)

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

CARB LHD Emissions Testing for EMFAC202Y

Vehicle	Model Year	Fuel	Weight Class	Emission Standard	Test Data
Vehicle 1	2019	Gasoline	LHD1	ULEV200	PEMS & Dyno
Vehicle 2	2019	Gasoline	LHD1	SULEV150	PEMS & Dyno
Vehicle 3	2020	Gasoline	LHD1	ULEV200	PEMS & Dyno
Vehicle 4	2020	Diesel	LHD1	SULEV170	PEMS & Dyno
Vehicle 5	2019	Gasoline	LHD2	ULEV270	PEMS & Dyno
Vehicle 6	2021	Gasoline	LHD2	ULEV270	PEMS & Dyno

LHD Data Sources and Planned Updates



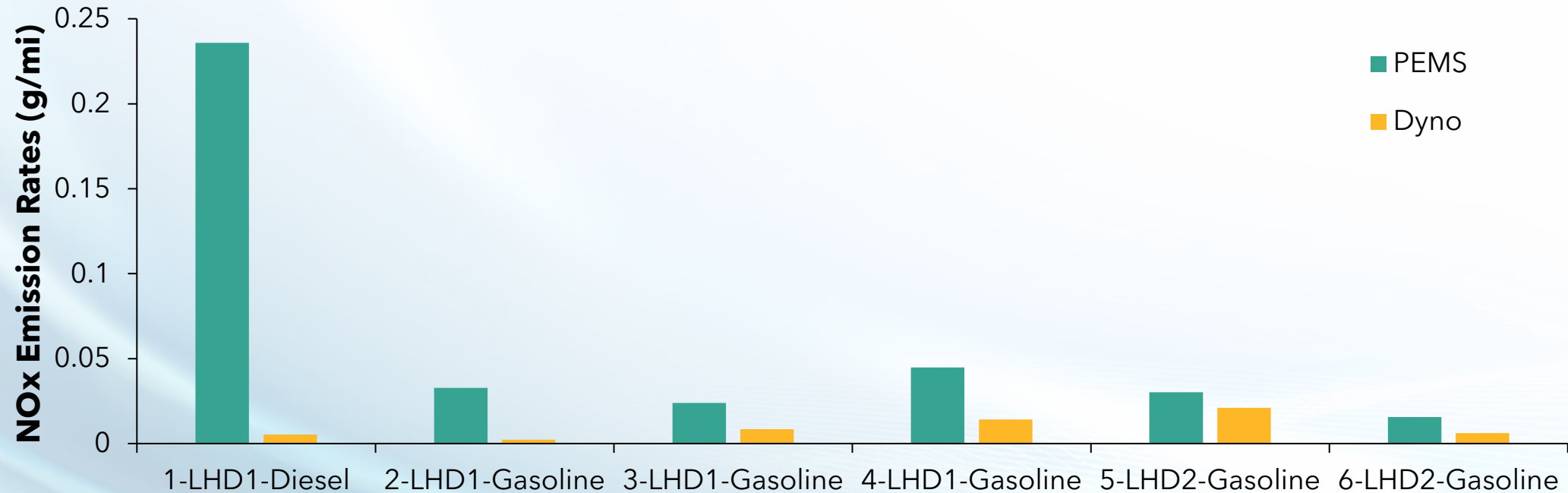
CARB LHD Emissions Testing for EMFAC202Y

- All vehicles tested on dynamometer over 3 test cycles: FTP, US06, and Hot 1435 UC
- All vehicles also tested with PEMS on 3 routes. CARB staff **plans to use PEMS data only for LHD updates in EMFAC202Y.**
- Pollutants: NO_x, CO, and HC

PEMS Route	Driving Type	Runs per Vehicle	Average Trip Speed	Average Travel Distance
Downtown LA	Urban	1 - 3	20 mph	40 miles
Oxnard / Escondido	Freeway	1 - 5	35 mph	130 miles
Mt Baldy / Arrowhead	Uphill / Downhill	1 - 3	45 mph	75 miles

Preliminary Results: Dynamometer vs. PEMS for NO_x at 20 MPH

- PEMS data shows that NO_x emission rates are larger under real-world driving conditions.

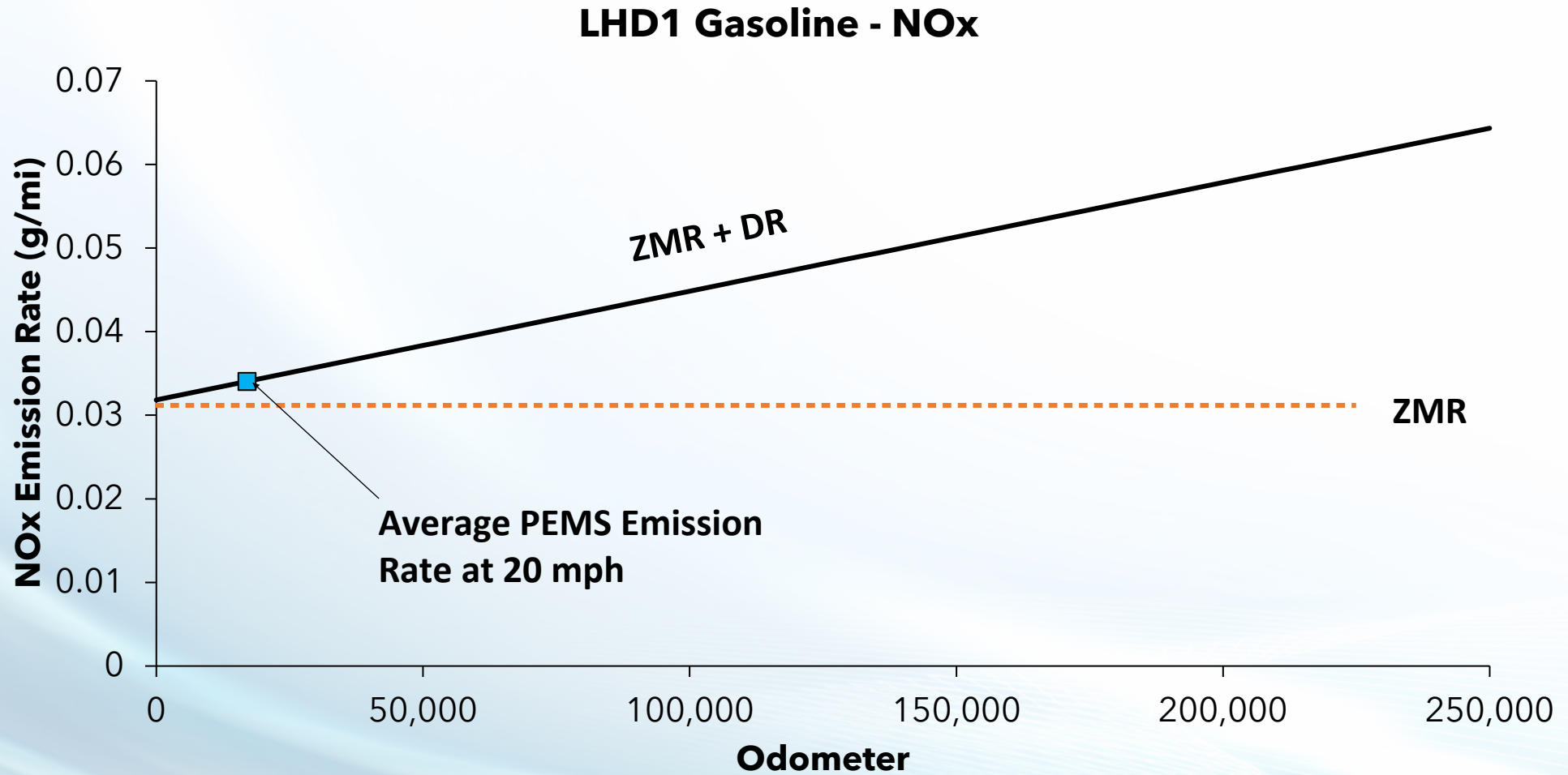


Base Emission Rate Equation for LHD in EMFAC202Y

$$ER \left(\frac{g}{mile} \right) = (ZMR + DR \times Odometer) \times SCF$$

- Zero-mile emission rate (**ZMR**)
- In-Use Emission Deterioration Rate (**DR**) – adapted from light-duty deterioration assumptions
- Speed Correction Factors (**SCF**)

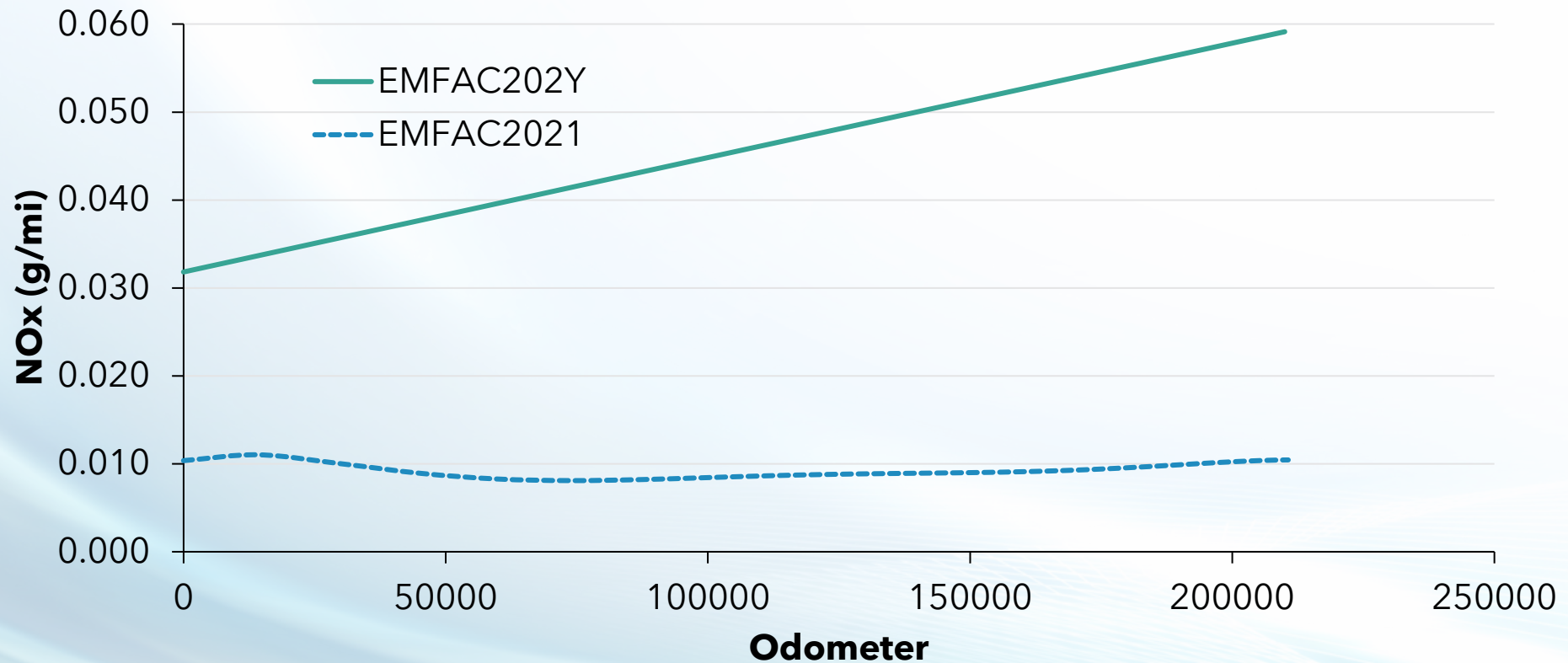
Example: ZMR and DR at 20 mph



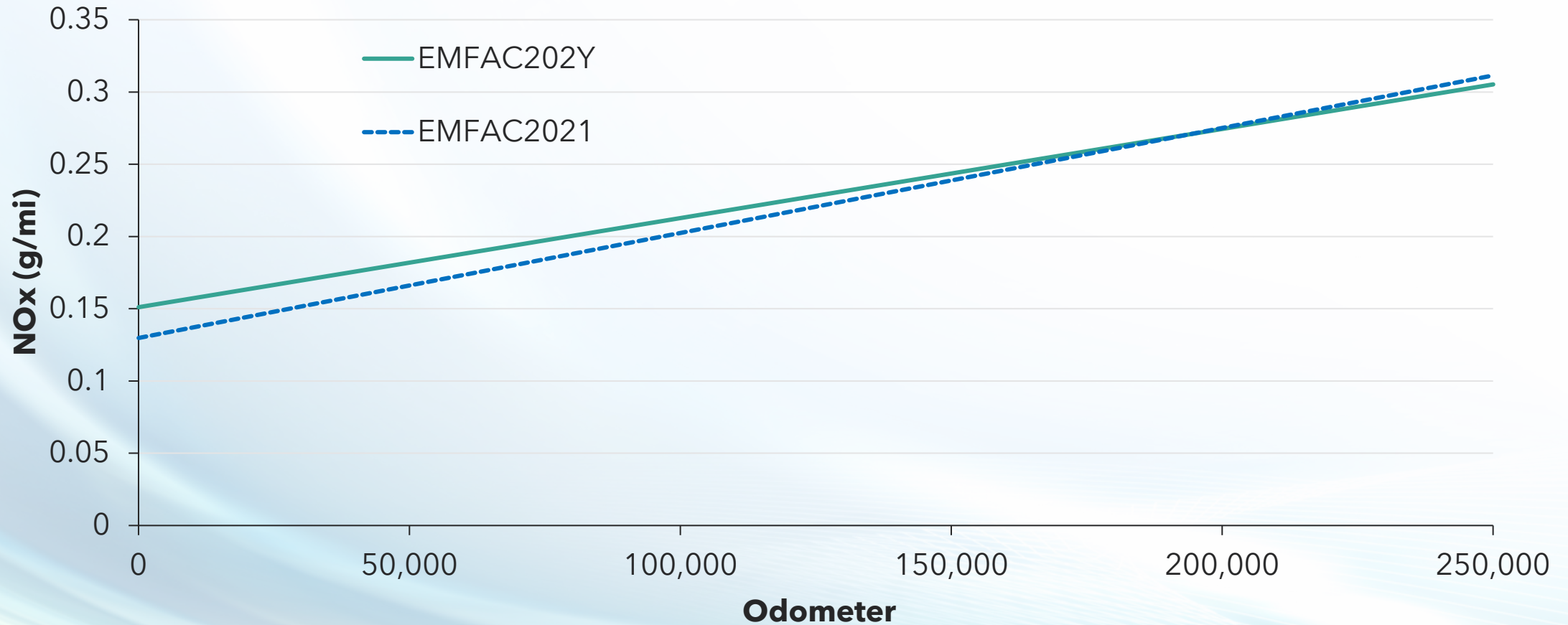
Preliminary MY 2010+ LHD Running Exhaust Updates Based on PEMS Tests

Vehicle Class	Fuel Type	Pollutant	ZMR (g/mi) @ 20 mph	DR (g/mi/10k mi)
LHD1	Gasoline	HC	0.0076	0.000039
LHD1	Gasoline	CO	0.49	0.011
LHD1	Gasoline	NO _x	0.032	0.0013
LHD1	Diesel	HC	0.046	0.00024
LHD1	Diesel	CO	0.76	0.016
LHD1	Diesel	NO _x	0.15	0.0062
LHD2	Gasoline	HC	0.0037	0.000019
LHD2	Gasoline	CO	0.30	0.0064
LHD2	Gasoline	NO _x	0.019	0.00079

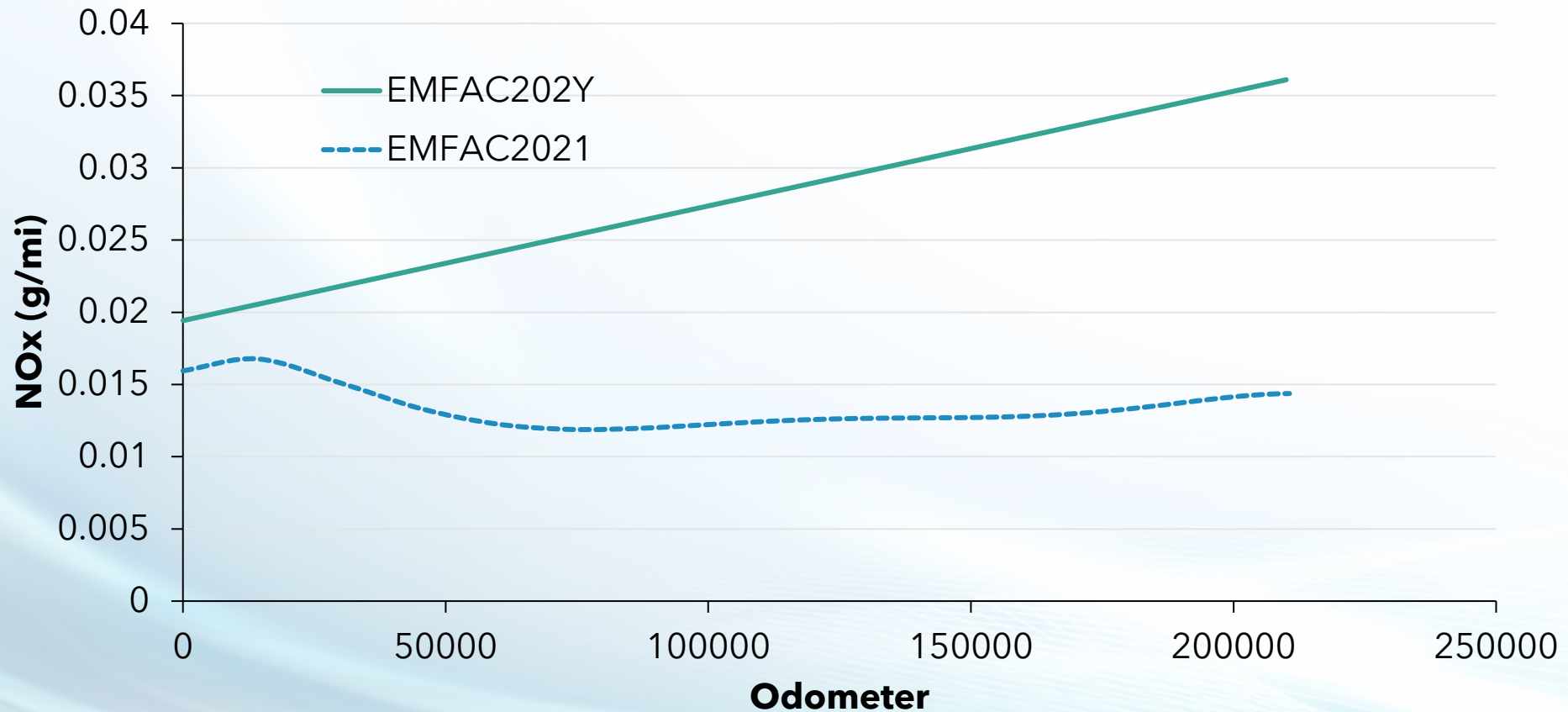
Example of NO_x Running Exhaust Emission Rate Update for LHD1 Gasoline (MY 2023)



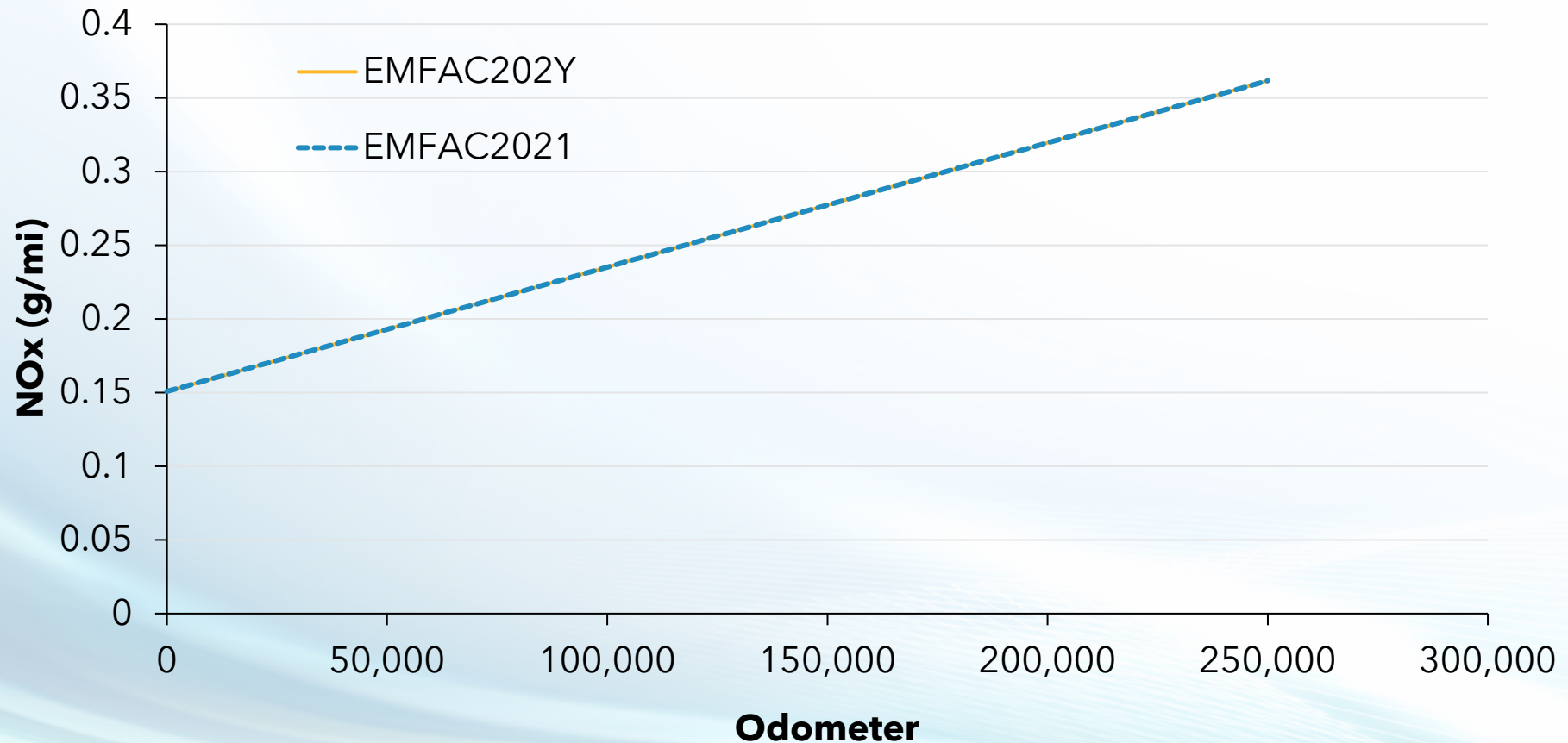
Example of NO_x Running Exhaust Emission Rate Update for LHD1 Diesel (MY 2023)



Example of NO_x Running Exhaust Emission Rate Update for LHD2 Gasoline (MY 2023)



No Updates for LHD2 Diesel (MY 2016+)



Preliminary LHD Updates Summary Based on PEMS

<p>LHD1 Gasoline</p> <p>EMFAC2021 ZMR: 0.01 g/mi DR: 6th order polynomial (approximately flat)</p> <p>EMFAC202Y ZMR: 0.032 g/mi DR: 0.0013 g/mi/10k mi</p>	<p>LHD1 Diesel</p> <p>EMFAC2021 ZMR: 0.13 g/mi DR: 0.0069 g/mi/10k mi</p> <p>EMFAC202Y ZMR: 0.15 DR: 0.0062 g/mi/10k mi</p>
<p>LHD2 Gasoline</p> <p>EMFAC2021 ZMR: 0.016 g/mi DR: 6th order polynomial (approximately flat)</p> <p>EMFAC202Y ZMR: 0.019 g/mi DR: 0.00079 g/mi/10k mi</p>	<p>LHD2 Diesel</p> <p>EMFAC2021 ZMR: 0.15 DR: 0.0084</p> <p>EMFAC202Y No Update.</p>

Next Steps: Update Emission Rates Based on LHD Surveillance Project

Dynamometer Testing

- FTP with PM, NH₃
- UC with PM, NH₃
- Highway Fuel Economy Test Cycle
- Arterial and Freeway Driving Cycles
- 10 LHDs with MY 2017+
 - 5 LHD1 vehicles, 2 DSL, 3 GAS
 - 5 LHD2 vehicles, 3 DSL, 2 GAS

PEMS Testing

- 10 vehicles
- Trailer Towing (2 vehicles):
 - LHD1, 1 DSL
 - LHD2, 1 DSL
- Impact of towing on emissions to be considered for modeling if significant



Test data from up to 4 vehicles expected by EMFAC202Y cut-off on July 31st, 2024

Conclusions

- PEMS data, which reflects real-world driving conditions, show higher running exhaust emission rates than emission rates determined by chassis dynamometer tests for gasoline and diesel LHD vehicles.
- Based on preliminary results, LHD1 and LHD2 gasoline emission rates will be larger in the next version of EMFAC202Y, pending results from future LHD Surveillance Project data.
- Update LHD NO_x, HC, and CO ZMR and DR values in EMFAC202Y

PM Session Agenda

- **Updates to Emission Rates**

- Test Plans
 - LD, LHD, MCY Surveillance Test Plans and Status
 - LD High-Speed Test Plan
- Fuel Reid Vapor Pressure (RVP)
- Sulfur Content
- **Emission Rates**
 - LHD
 - **Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method**

- Question & Answer

- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps
- Question & Answer

Updates to Emission Rates

MHD/HHD New PEMS Analysis Method

Heavy-Duty Vehicles (HDV) Emissions Testing Data in EMFAC2021



Heavy Heavy-Duty Diesel

- + Running exhaust emission rates from **27** MY 2013+ vehicles tested on chassis dyno (TBSP)
- Start emission rates from **11** MY 2013+ vehicles based on PEMS data (TBSP)

Medium Heavy-Duty Diesel

- + Running exhaust emission rates from **8** MY 2013+ MY vehicles from Class 4-6 Surveillance Test Program

Compressed Natural Gas (CNG)

- + Running exhaust emission rates from **46** MY 2008-2017 MHD or HHD vehicles from a multi-agency 200-vehicle testing project

Acronyms

MY: Model Year

PEMS: Portable Emission Measurement Systems

Dyno: Dynamometer

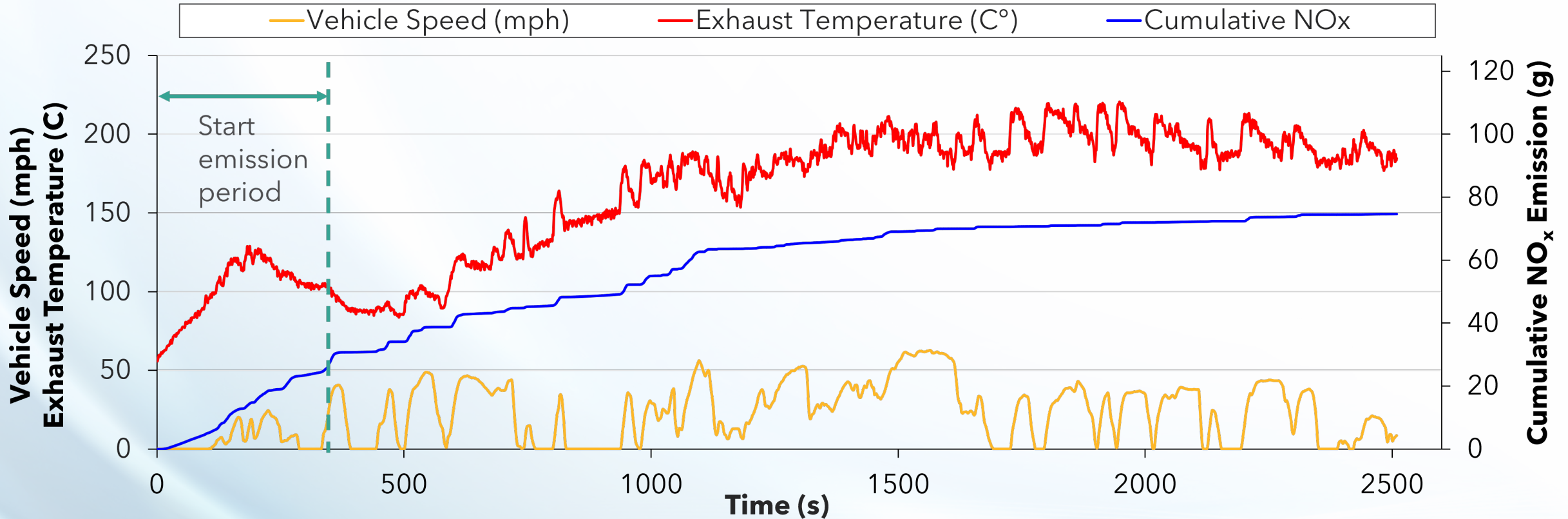
TBSP: Truck and Bus Surveillance Program

HDV Start Emission Rates Modeling in EMFAC2021

- EMFAC2021 HDV Start Emission Rates
 - Updated 2013+ MY diesel HD trucks based on PEMS data of 11 trucks from CARB TBSP
 - Start emissions PEMS testing were conducted with controlled soak time: 20 min, 2 h, 4 h, 8 h, overnight
- Method Limitations
 - Manually review the data and identify start emission
- Proposed New Method
 - Re-analyzing the same test data, use standardized criteria to identify start emission period

Start Emissions Method in EMFAC2021

VEH1-3 - NO_x vs. Temperature & Vehicle Speed (2 Hour soak)

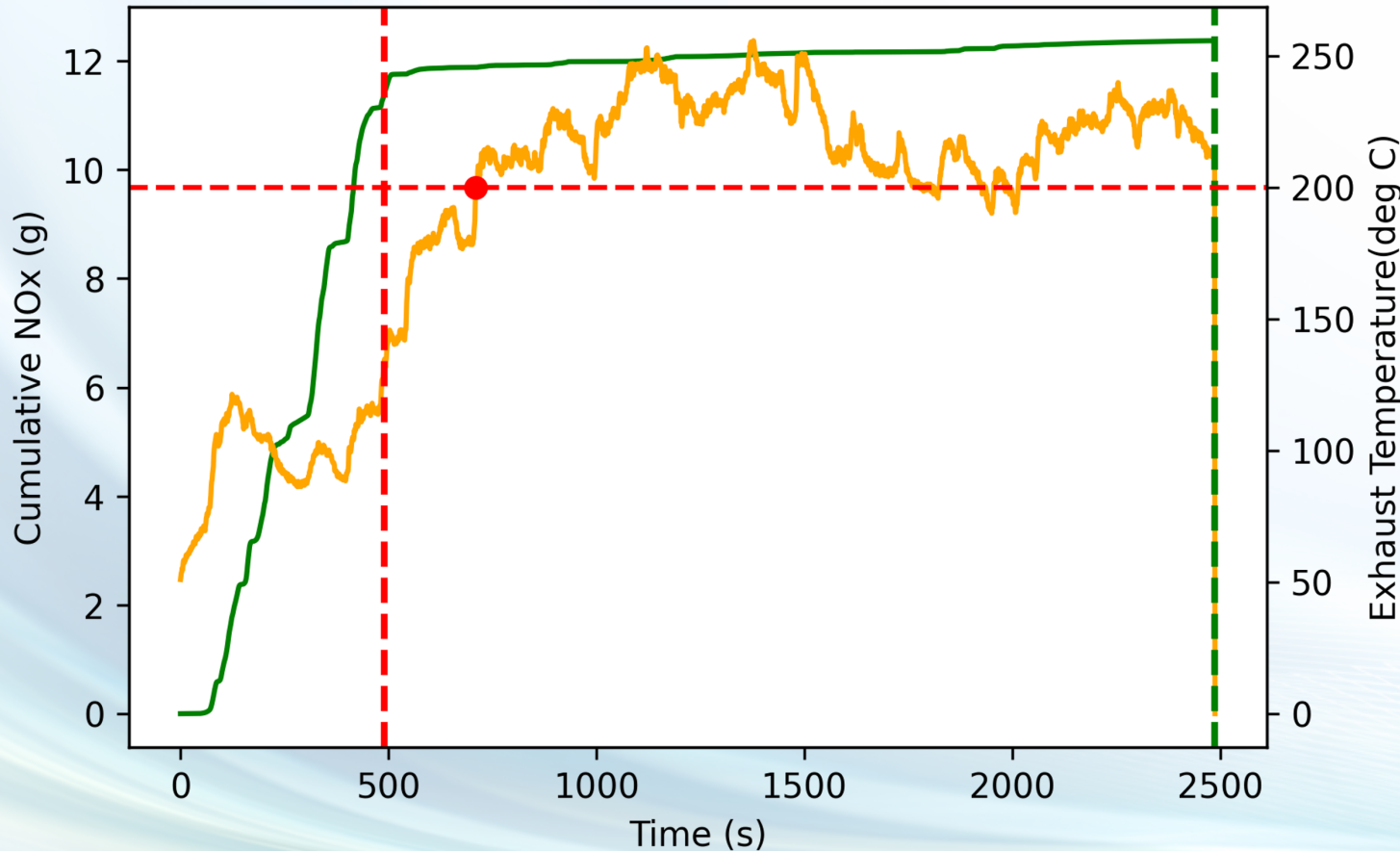


	time	Cumulative NO _x (g)	Exhaust T (deg C)
Point 1	354	28.89	97
Point 2	1000	54.99	169.2

$$\begin{aligned}
 \text{Start Emissions} &= (ER_{total} - ER_{running}) \times \text{start period time} \\
 &= \left(\frac{NOx(t_1)}{t_1} - \frac{NOx(t_2) - NOx(t_1)}{t_2 - t_1} \right) \times t_1
 \end{aligned}$$

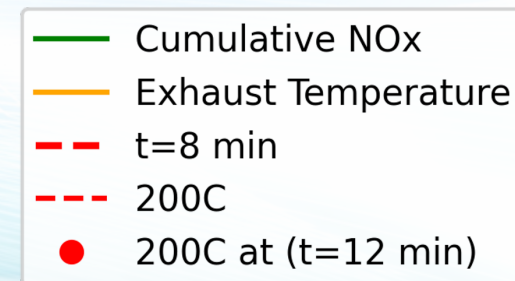
Proposed New Method to Delineate Start from Running Emissions

Veh10-1
Soak Time = 120min

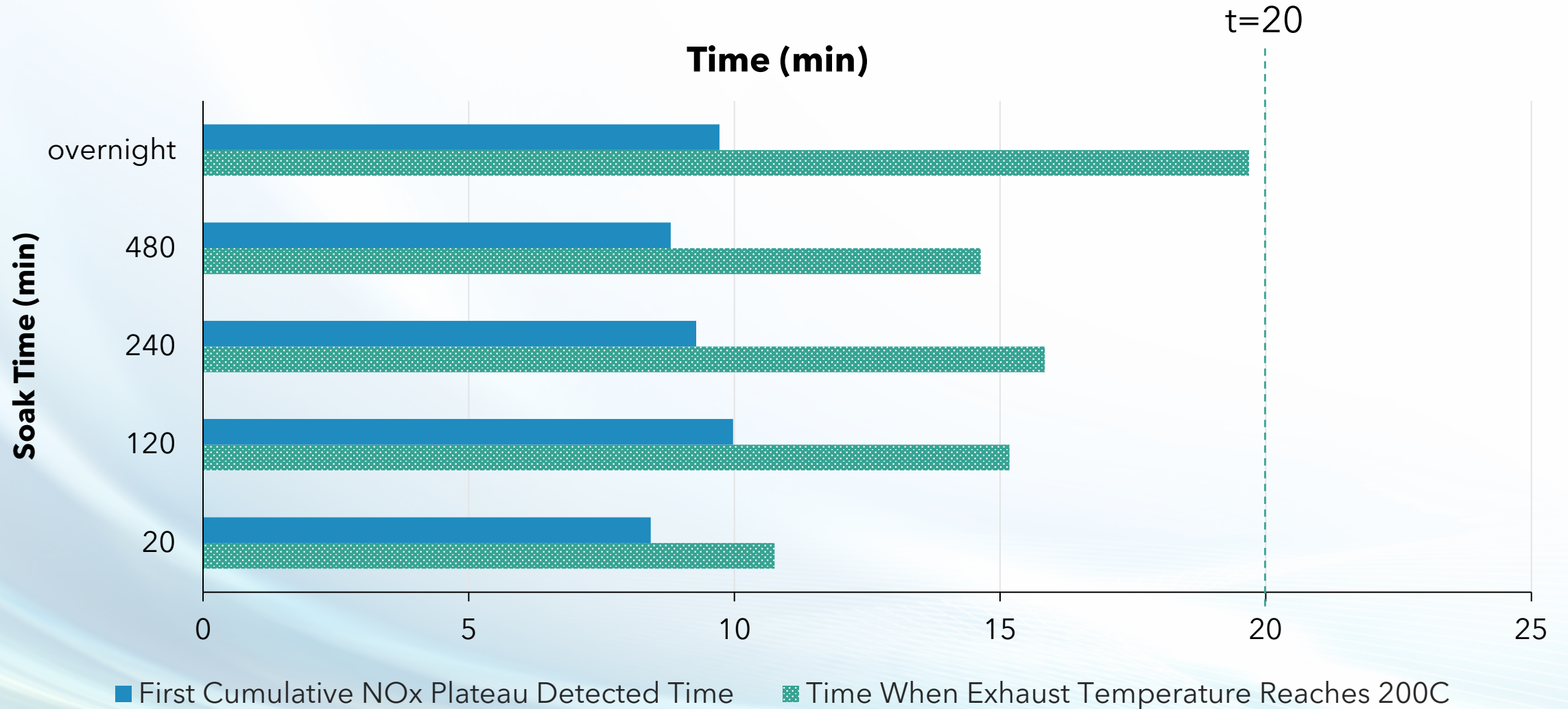


The following criteria are used to detect the end of start emission period, whichever comes first:

1. The start time of first detected cumulative NOx "plateau" (cumulative NOx change smaller than 0.03 g for at least 100 seconds)
2. Time when exhaust temperature reaches 200 °C
3. No emissions will be counted as Start Emissions after 20 min (based on testing data)

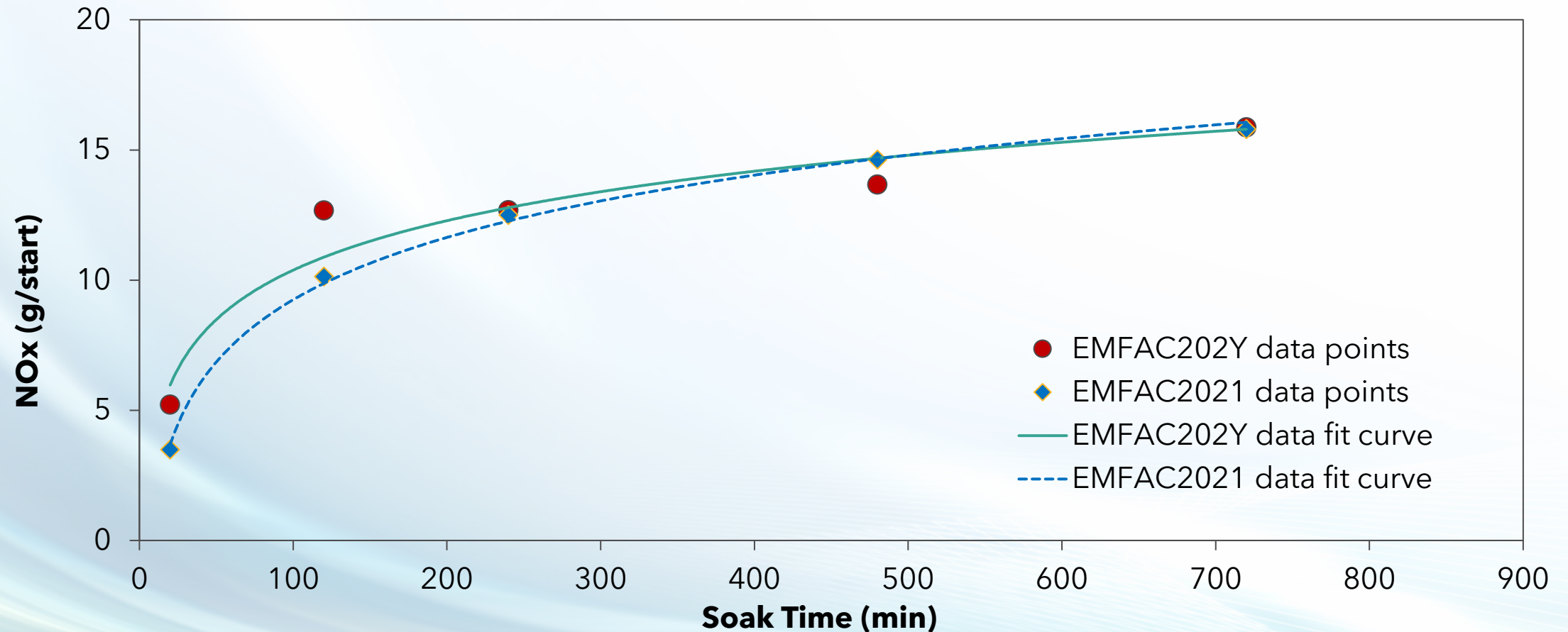


Different Cut Criteria Comparison



HDV Start Emission Rates

Re-analyzing EMFAC2021 Data for EMFAC202Y

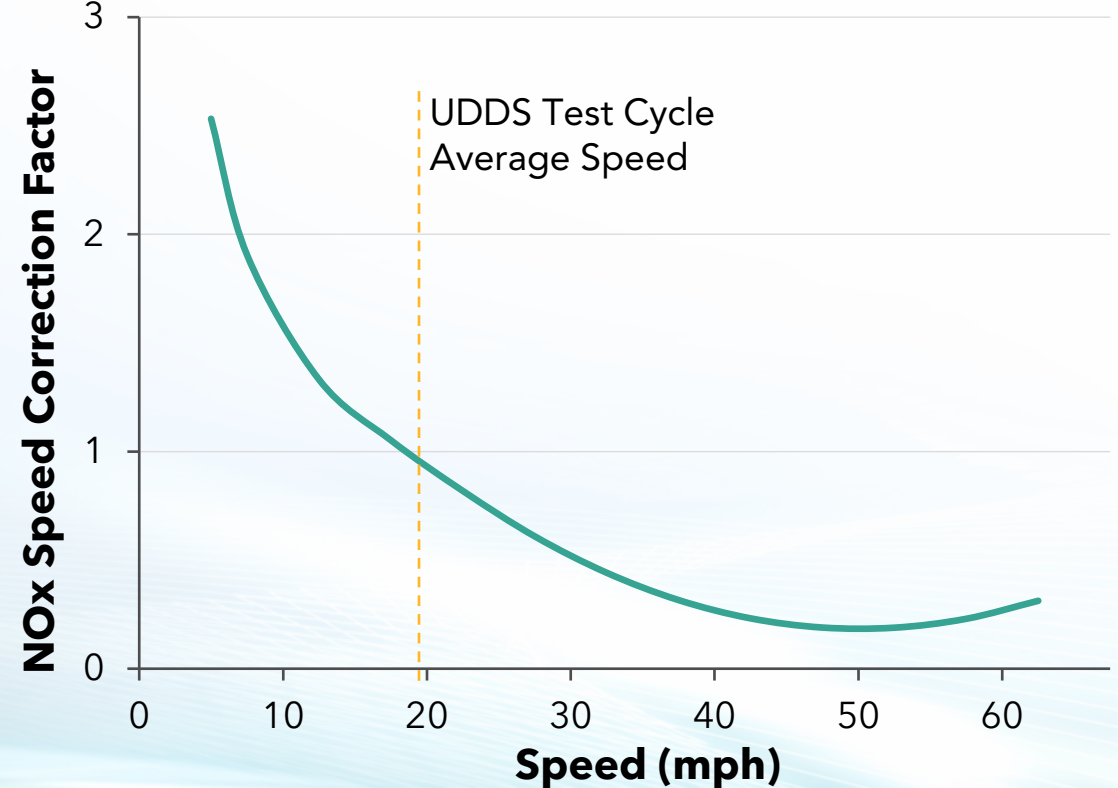


HDV Running Exhaust Emission Rates Modeling in EMFAC2021

$$\text{Emission Rate} \left(\frac{g}{\text{mile}} \right) = \text{BER} \times \text{SCF}$$

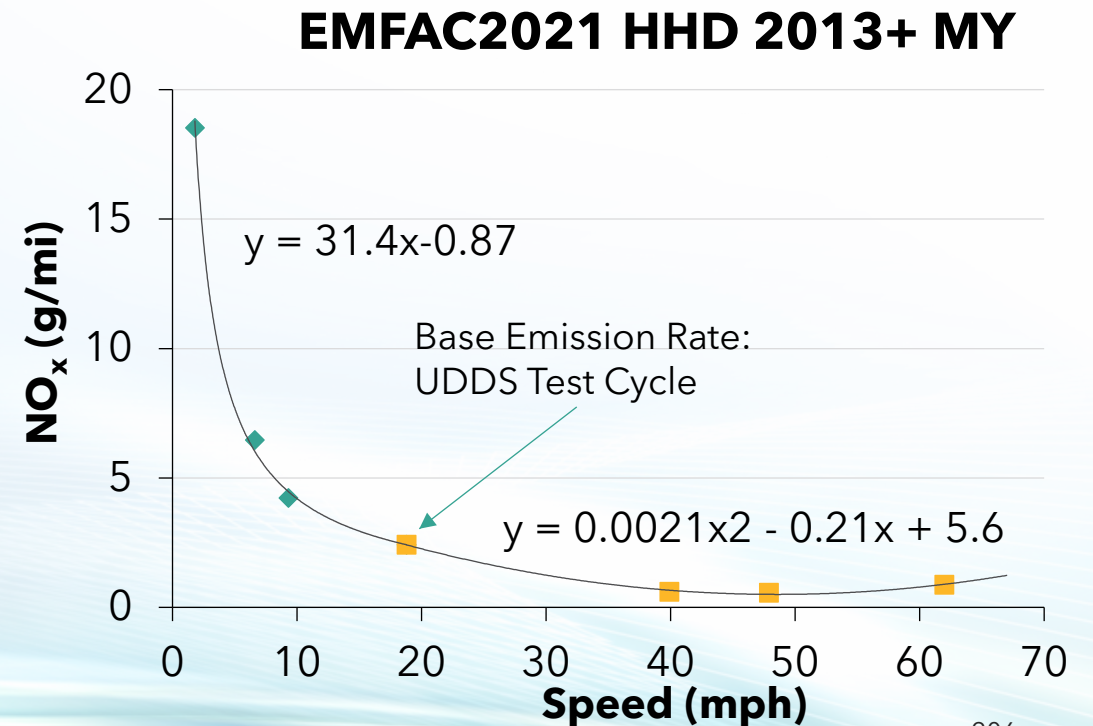
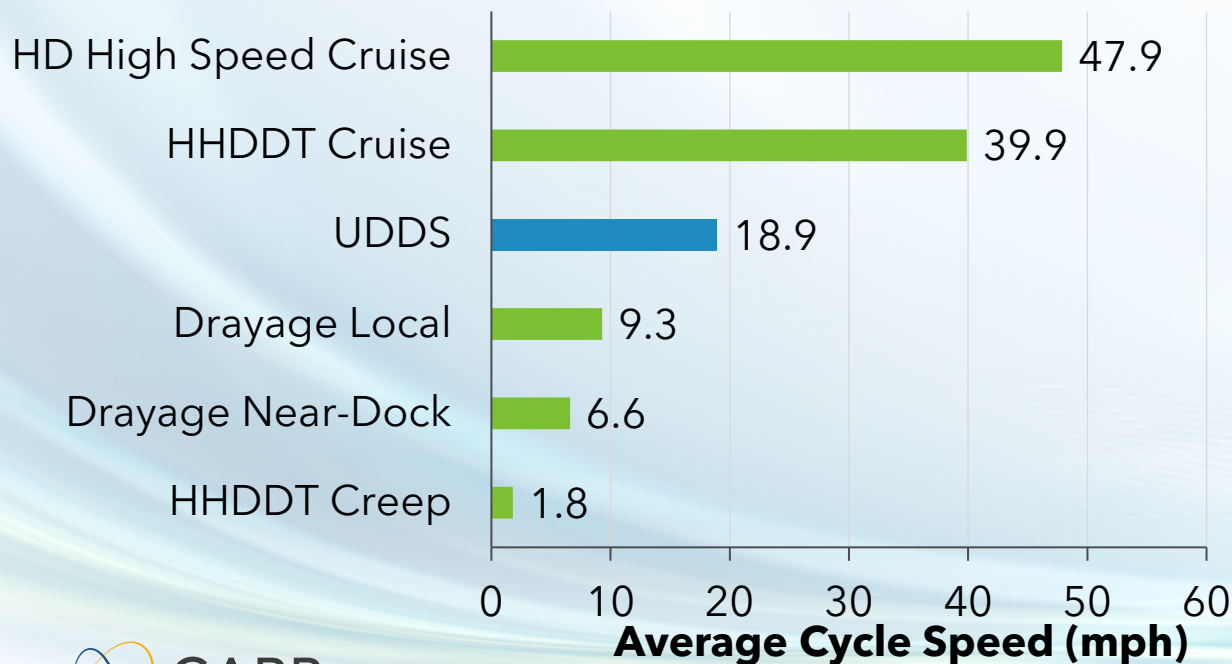
- Base Emission Rate (BER) is developed for each Model Year group and weight class group (MHD/HDD).
- Speed correction factors (SCFs) account for variation of emissions under different vehicle speed.

Typical SCFs of SCR*-equipped HD Vehicles



HDV Base Emission Rates and SCFs

- In EMFAC2021, chassis dyno testing cycles from CARB's Truck and Bus Surveillance Program (TBSP) are used to develop emission rates under different driving speeds.
- Urban Dynamometer Driving Schedule (UDDS) cycle is used to inform the HDV base emission rates for Class 4-8 vehicles.



Heavy-Duty PEMS Testing



Heavy-Duty PEMS Testing



Goal: explore how PEMS can be used to inform EMFAC HD emission rates



Base Emission Rate Data Sources

Data from EMFAC2021 after recalled vehicles taken out

Data from existing vehicles in EMFAC2021 that were not analyzed

Test Program	Fuel Type	Weight Class	Engine MY Range	Test Type and Sample Size	
CARB TBSP	Diesel	Class 8	2013-2019	Chassis Dyno 15	PEMS 10
		Class 6-7	2013-2017	Chassis Dyno 8	PEMS 1
200-Vehicle Study	Diesel	Class 7-8	2010-2018	Chassis Dyno 11	PEMS 15

New vehicles that are not included in EMFAC2021 (excluding recalled vehicles)

PEMS Data Sources

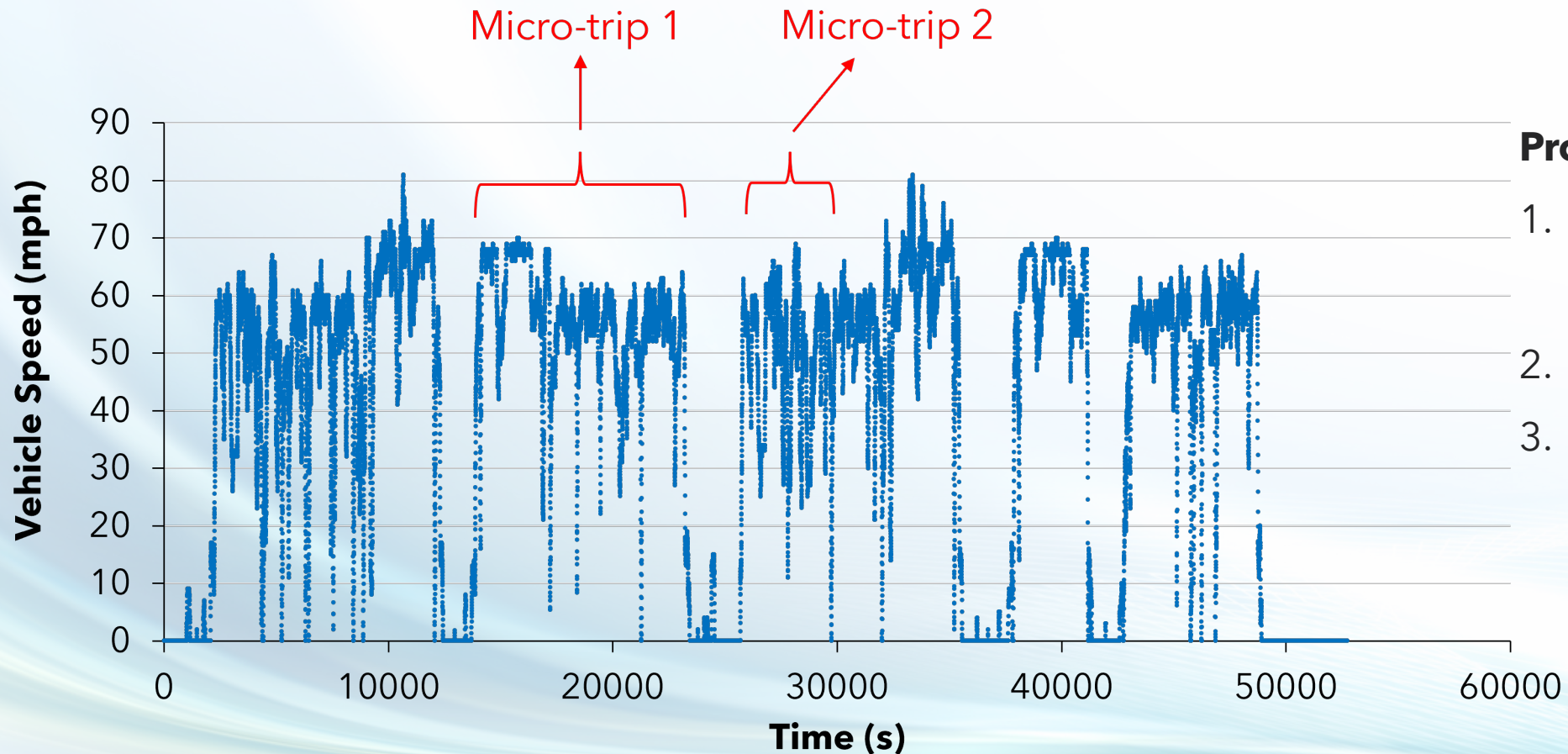
- TBSP
 - 18 Class 7-8 vehicles from TBSP that have both Chassis Dyno and PEMS testing data (10 used after removing recalled vehicles)
 - In PEMS testing, each vehicle was tested 10-20 times under different conditions: AM/PM, City/Highway, Origin/Destination (in-bound/out-bound)
 - Each PEMS test lasts 1-2 hours
- 200-Vehicle Project
 - 20 Class 7-8 vehicles (15 used after removing recalled vehicles)
 - One test per vehicle, each PEMS test lasts for 1 day
 - Tested during their business-as-usual operation

PEMS Data Analysis Method

- Exclude start emissions from the PEMS data
- Running exhaust emissions were analyzed for each vehicle
- Steps
 1. Aggregate second-by-second PEMS data points into micro-trips
 2. Aggregate micro-trip level data into speed bins of 5 mph
 3. Develop a function of emission rate based on speed
 4. Determine the base emission rate at 18.8 mph
- Compare NO_x emission rates (g/mile) of PEMS vs Chassis dyno

Identifying Micro Trips in PEMS Data

Micro-trips are defined as "from start to stop"

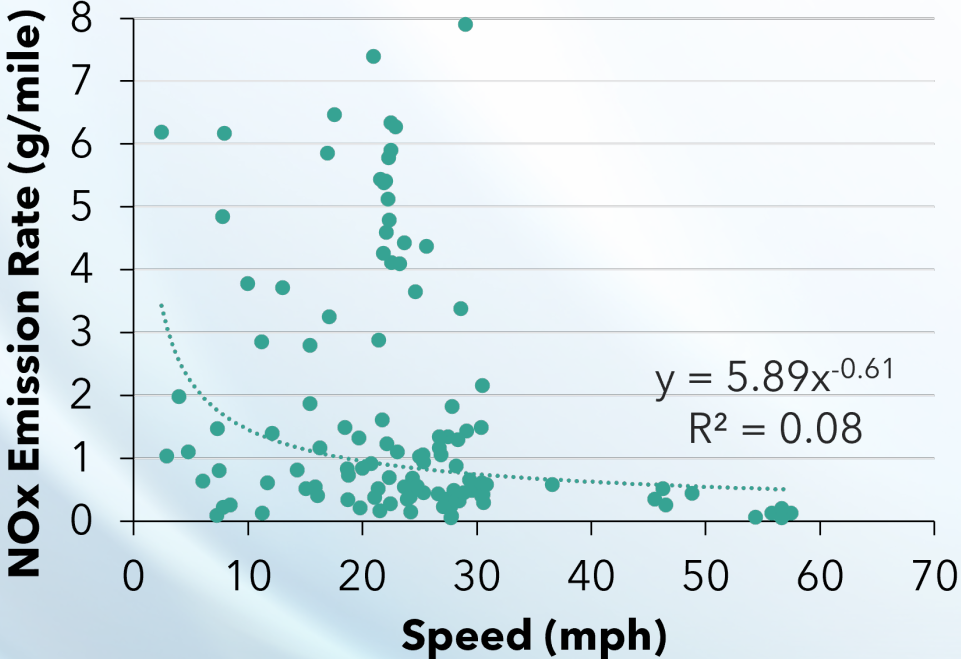


Processing micro trips:

1. Exclude extended idling events
2. Merge trips <0.25 mile
3. Split trips >3 miles

Summarize Micro-Trip Data Points into Speed Bins

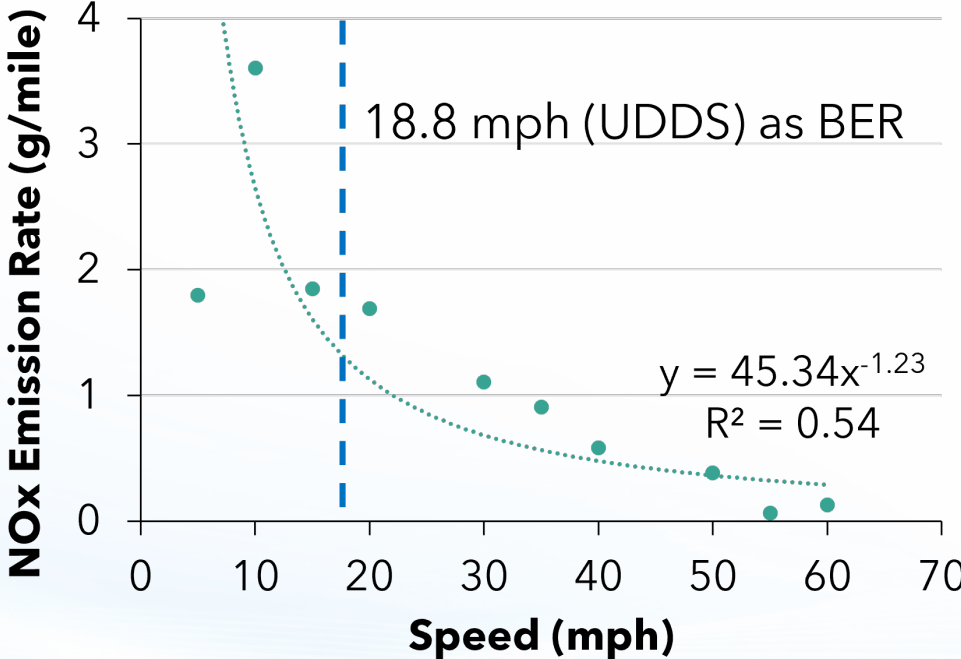
Veh2-1 Microtrip Level Data



Summarize into 5 mph speed bins

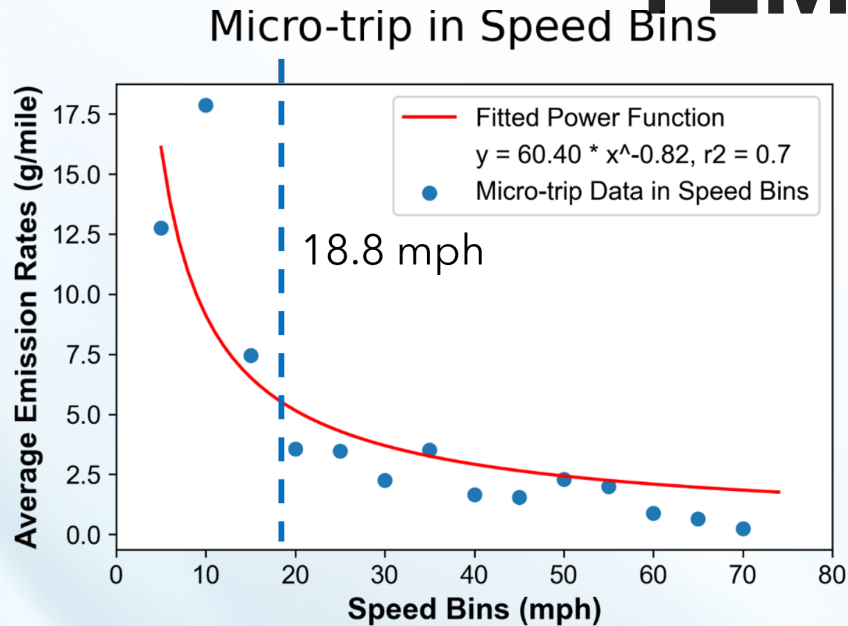


Veh2-1 Microtrip in Speed Bins

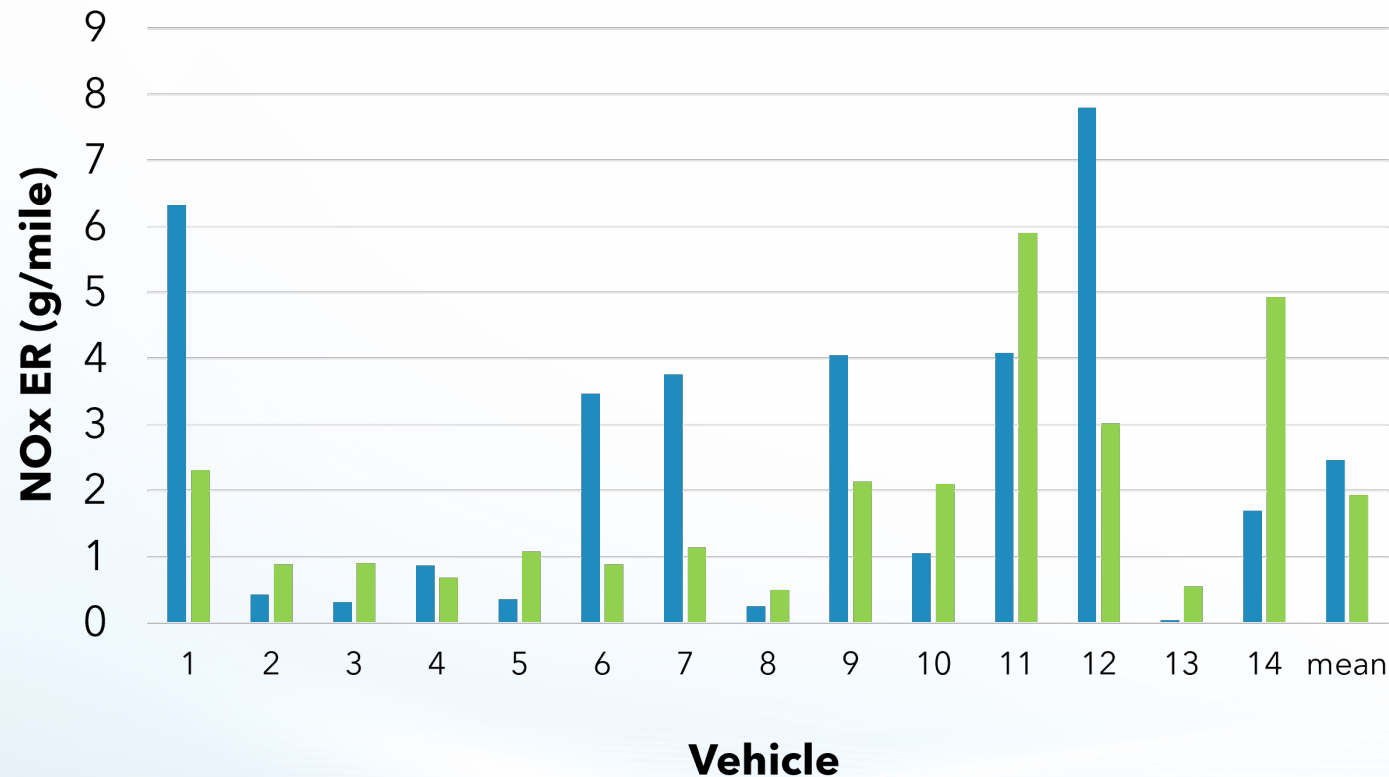


NOx Emission Rates Comparison

PEMS vs Chassis Dyno



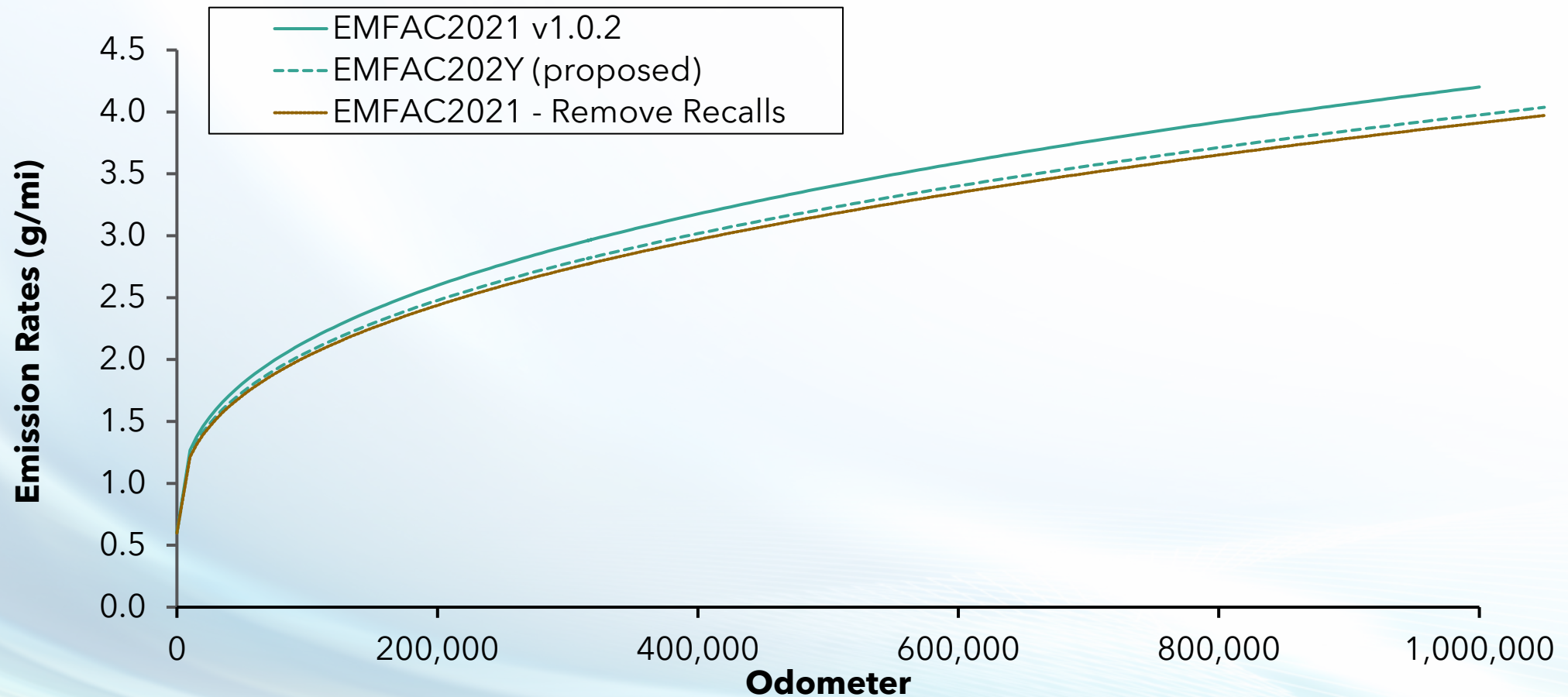
NOx ER @ 18.8 mph



NOx ER @ 18.8mph	PEMS	Chassis dyno
Fleet average	2.1	1.9

■ Chassis Dyno UDDS ■ PEMS @ 18.8 mph

Zero-Mile Rate and Deterioration Rate Update for HHD 2013+



HDV Speed Correction Factors in EMFAC2021

- Speed correction factors (SCFs): account for variation of emissions under different vehicle speed.
- EMFAC2021
 - Used lab dynamometer testing data for HD emission rates
 - Two SCFs, one for all T6, another for all T7 vehicles
- Potential EMFAC202Y Improvements
 - Use PEMS data for closer-to-real-world SCFs
 - Increase sample size for more detailed SCFs by vocation and MY group

Speed Correction Factor Data Sources

Test Program	Fuel Type	Weight Class	Engine MY Range	Test Type and Sample Size
Heavy-Duty In-Use Testing (HDIUT)	Diesel	Class 4-8	2003-2017	PEMS: 566
CARB TBSP	Diesel	Class 6-8	2013-2018	PEMS: 10
200-Vehicle Study	Diesel	Class 7-8	2010-2018	PEMS: 20

Data Source of HDIUT PEMS

- 776 vehicles from 19 manufacturers
 - 566 were used for analysis, the rest were filtered out for either ambiguous vehicle info or missing data
- Testing date range: 2006 - 2021
- Engine model year range: 2003 - 2017
- Data type: 1Hz
 - NO_x (and other pollutants) emissions
 - Vehicle speed
 - Temperature (ambient, tailpipe)
 - Engine status (RPM, torque)
- Data length: Typically 1-2 days

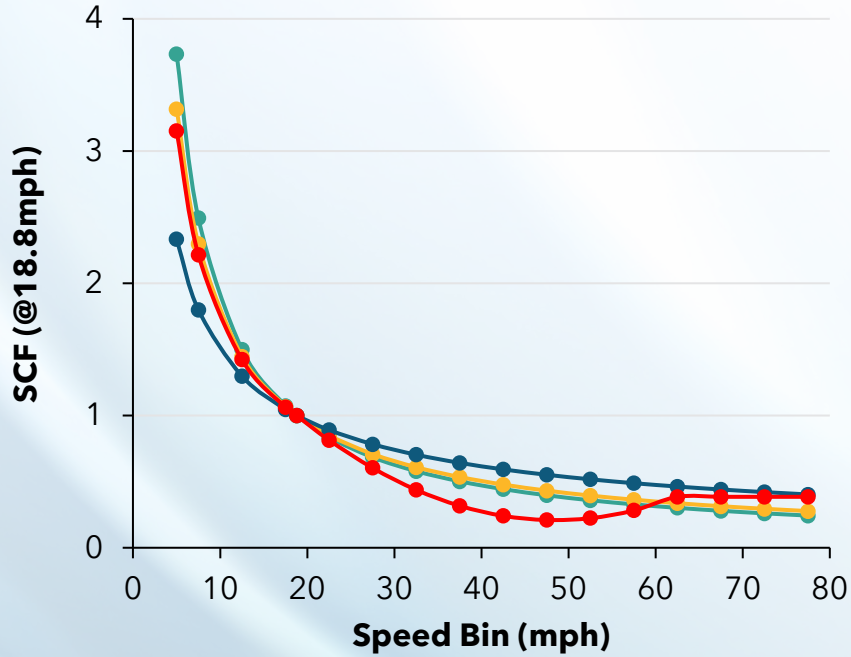


Data Processing of PEMS Data

- Data cleaning
 - Null/negative/non-continuous data points
 - Unrealistic vehicle operation status parameters (engine RPM, engine power, torque, exhaust flow, CO₂ or O₂ flow)
 - Exclude start emissions
- Data processing
 - Same mirco-trip method used for calculating base emission rates
 - Calculate total NOx emissions, total VMT by speed bins
 - Subgroup by:
 - **Weight class** (T6 or T7, based on VINdecoder)
 - **Engine MY** (pre2010, 2010-2012, 2013+)
 - **Vocation** (provided by manufacturers, validated by DMV datasets and some manual speed profile check)

SCFs for Heavy HDV (Class 8)

Engine Model Year 2013+

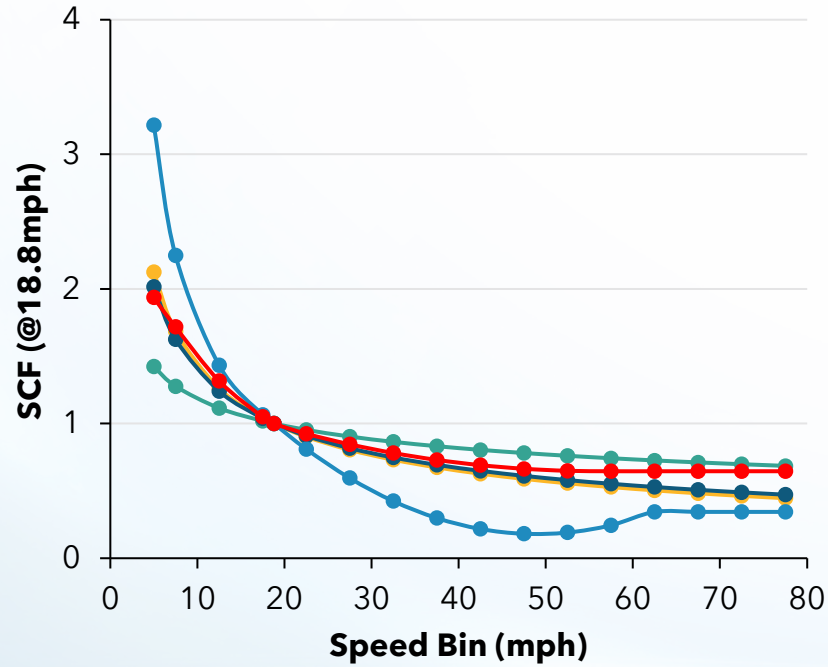


● Concrete/Transit Mix ● Delivery
● Line haul ● EMFAC2021

Sample size:

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

Engine Model Year 2010-2012

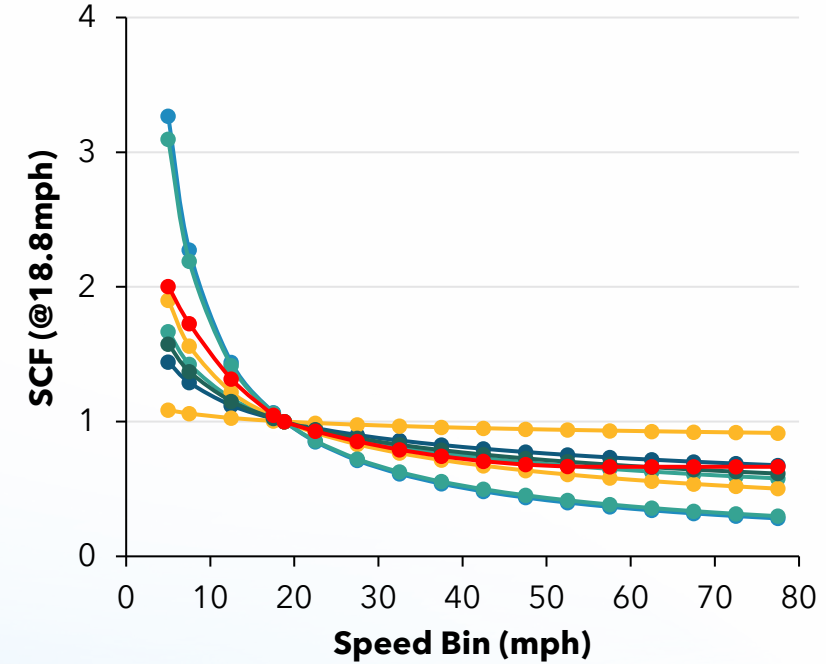


● Delivery
● Line haul
● UBUS
● EMFAC2021 UBUS Diesel
● EMFAC2021 T7

Sample size:

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

Engine Model Year pre2010



● Concrete/Transit Mix ● Delivery
● Line haul ● SWCV
● Terminal Tractor ● Utility
● MH ● EMFAC2021

Sample size:

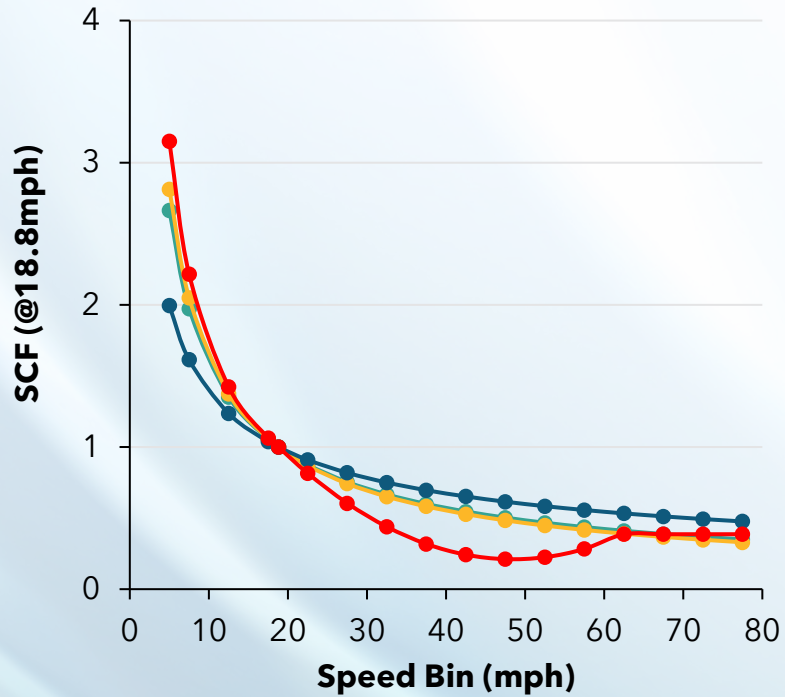
- Concrete/Transit Mix: 5
- Delivery: 13
- Line haul: 72
- Utility: 2
- MH: 5
- SWCV: 9
- Terminal Tractor: 2

SCFs for Medium HDV (Class 4-7)

Engine Model Year 2013+

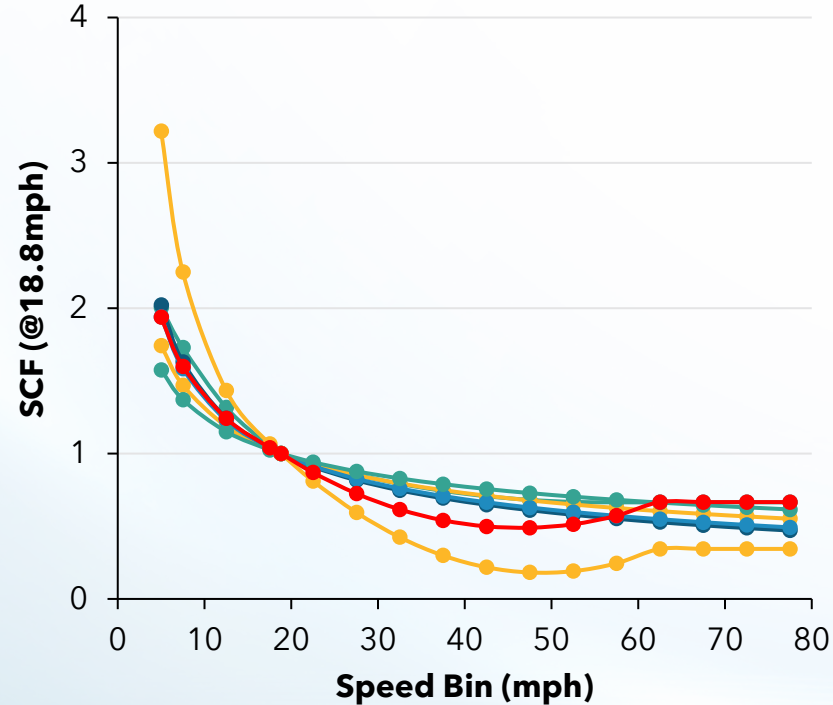
Engine Model Year 2010-2012

Engine Model Year pre2010



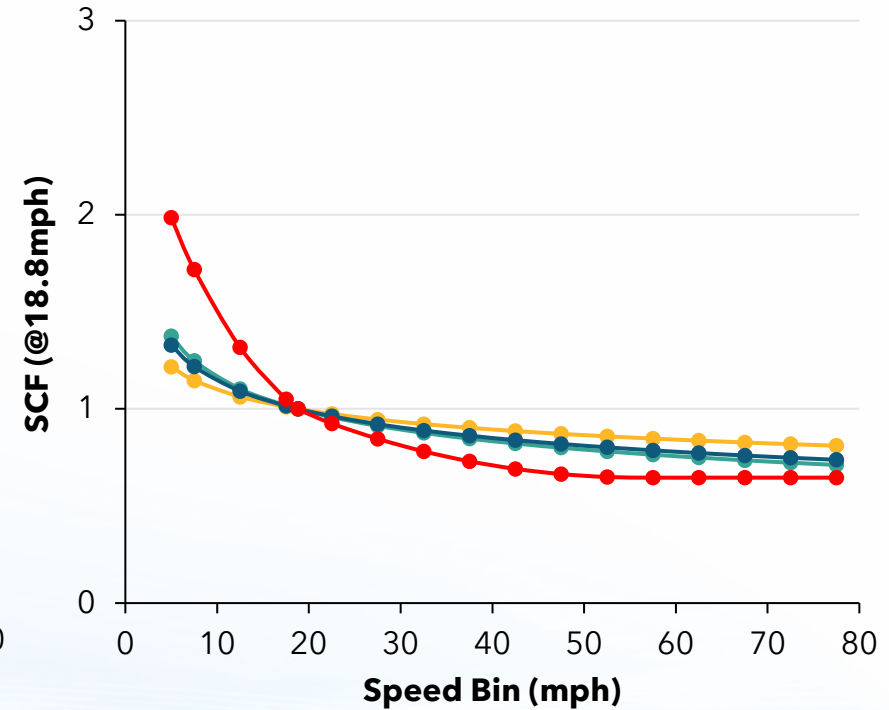
- Delivery
- SBUS
- Towing
- EMFAC2021

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



- EMFAC2021
- Line haul
- Utility
- Delivery
- EMFAC2021 T6
- UBUS
- EMFAC2021 UBUS

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



- Delivery
- Utility
- Line haul
- EMFAC2021

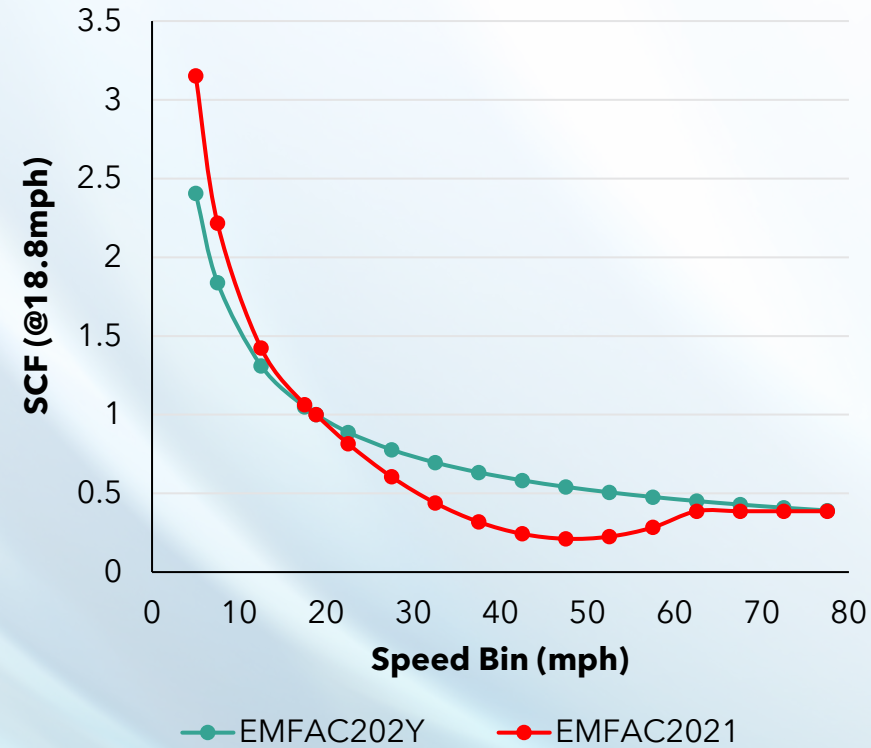
- Sample size:
- Delivery: 19
 - Line haul: 12
 - Utility: 6

Proposed SCFs for Heavy HDV (Class 8) in EMFAC202Y

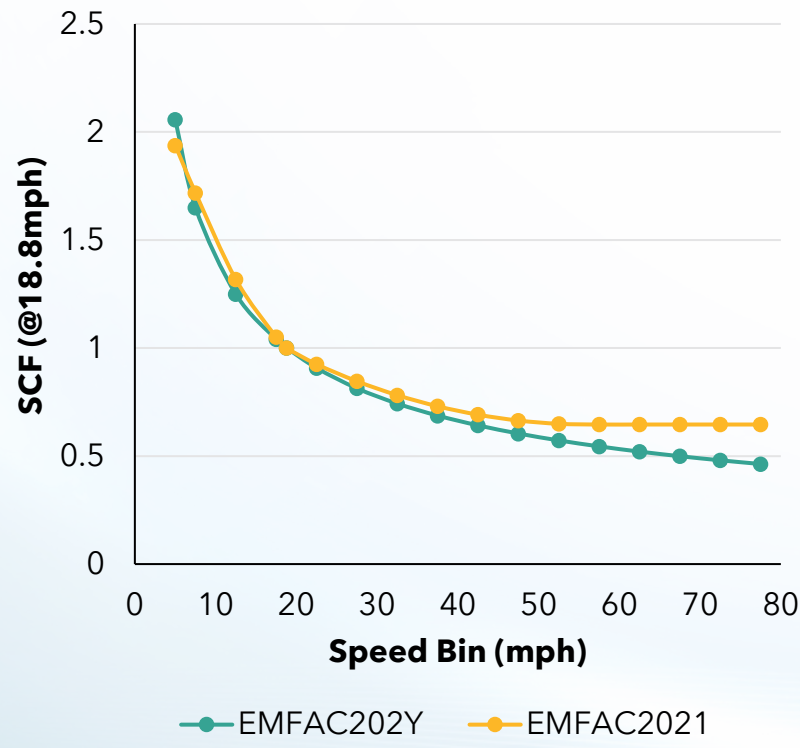
Engine Model Year 2013+

Engine Model Year 2010-2012

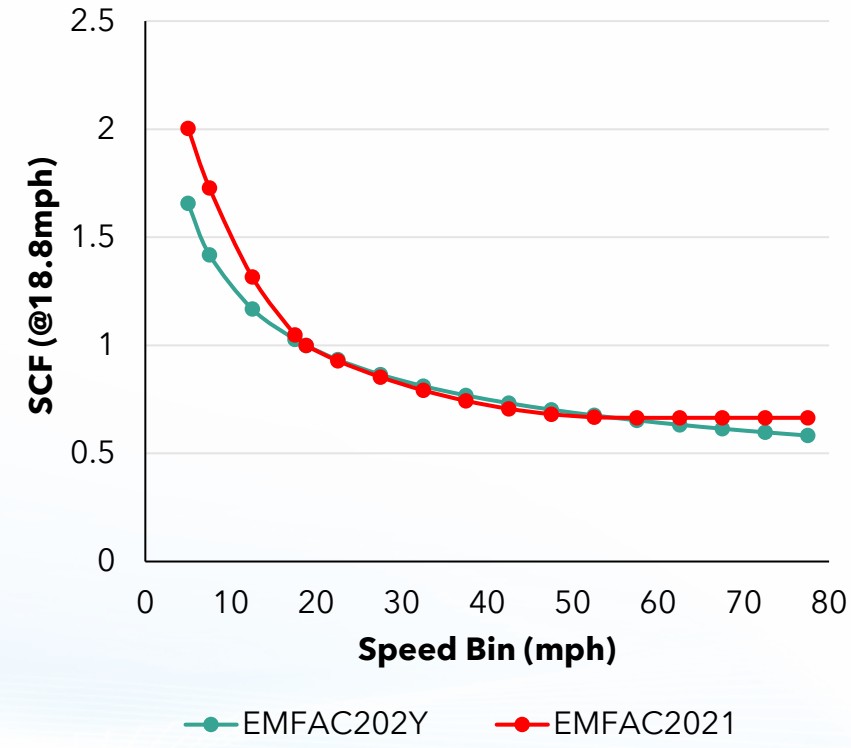
Engine Model Year pre2010



Sample size: 73



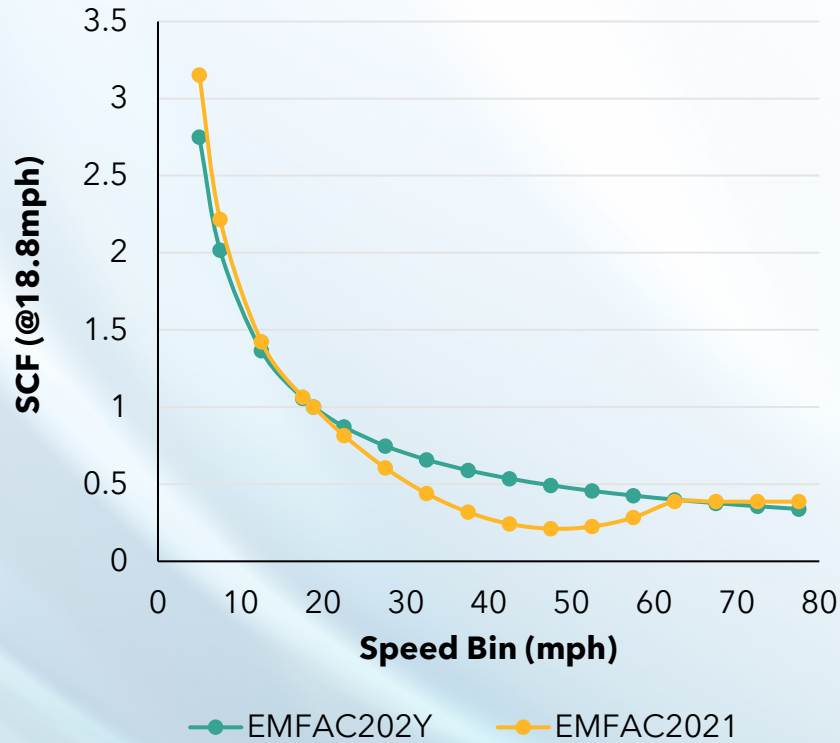
Sample size: 113



Sample size: 125

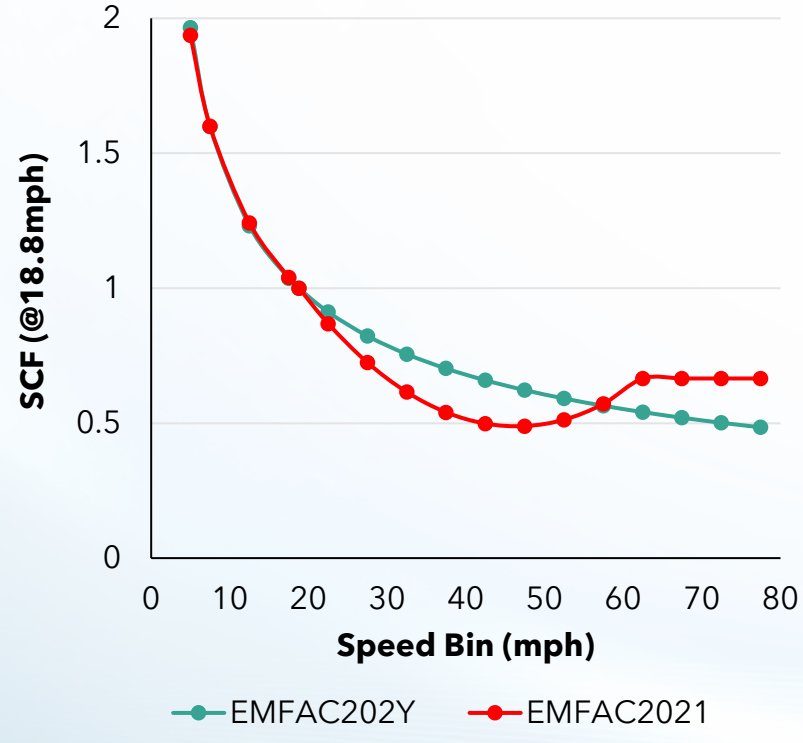
Proposed SCFs for Medium HDV (Class 4-7) in EMFAC202Y

Engine Model Year 2013+



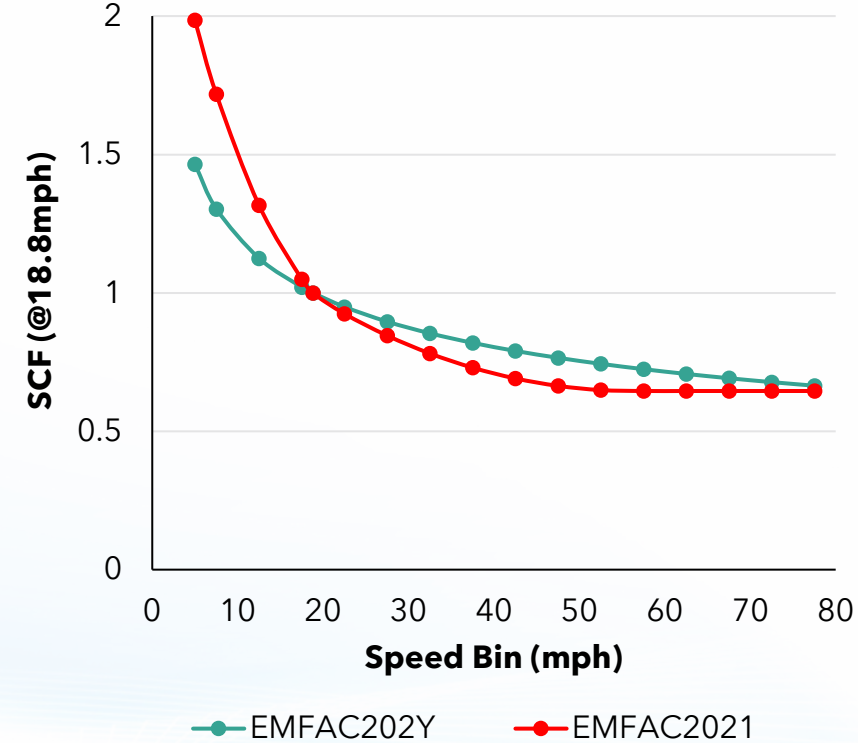
Sample size: 61

Engine Model Year 2010-2012



Sample size: 86

Engine Model Year pre2010

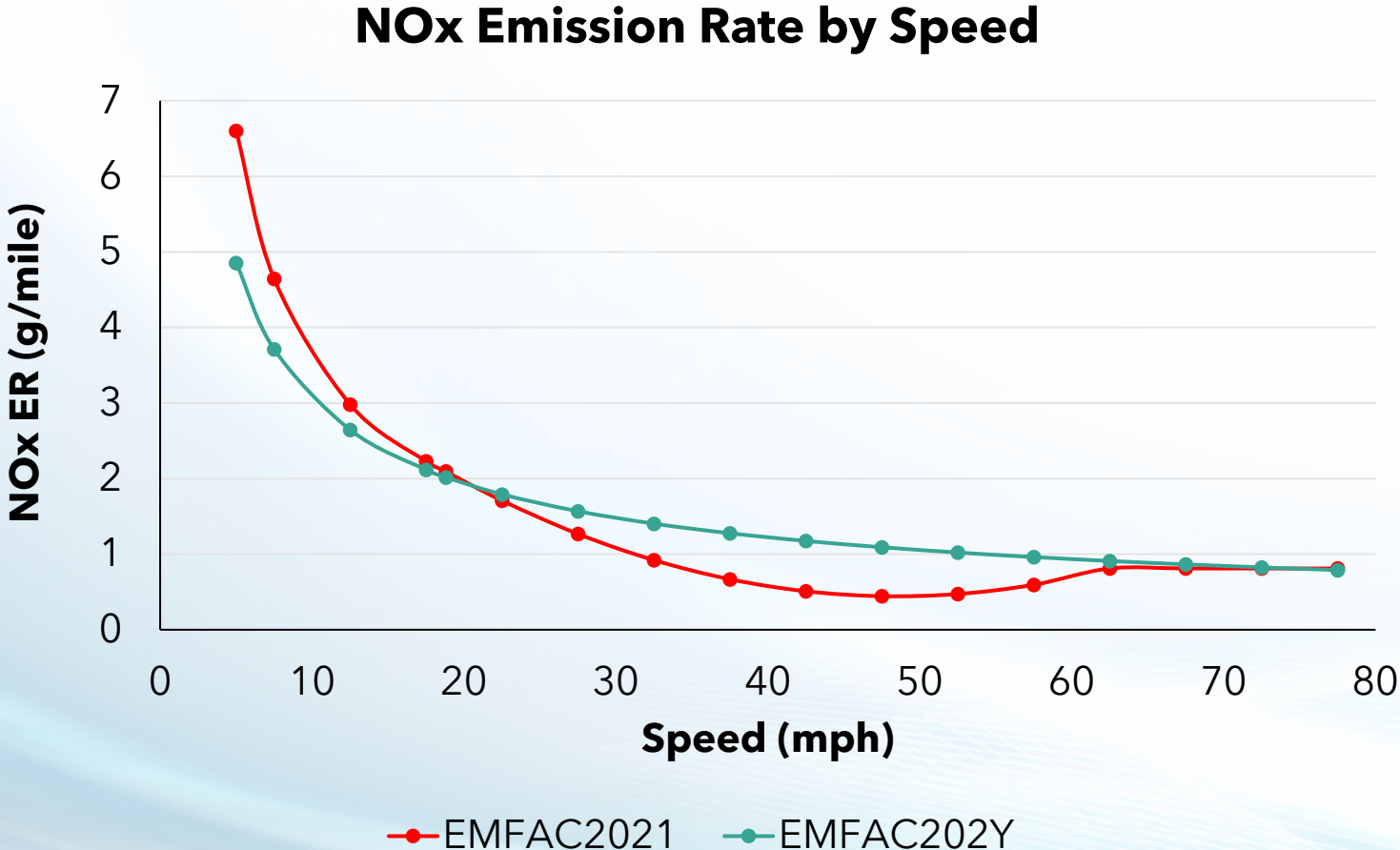


Sample size: 50

Summary

- Adding new test vehicles and PEMS data points, base emission rates of HHD 2013+ vehicles slightly decrease.
- Speed Correction Factors:
 - By weight class: in general, HHD vehicles show larger variance in SCFs than MHD vehicles.
 - By Engine Model Year group: In general, 2013+ vehicles show larger variance in SCFs than 2010-2012 and pre2010 vehicles, likely due to equipping SCR.
 - By vocation: No noticeable difference across vocations
 - CARB staff plans to update SCFs by weight class and engine model year group in EMFAC202Y

Emission Rate by Speed Update for HHD 2013+ EMFAC202Y vs EMFAC2021



PM Session Agenda

- Updates to Emission Rates
 - Test Plans
 - LD, LHD, MCY Surveillance Test Plans and Status
 - LD High-Speed Test Plan
 - Fuel Reid Vapor Pressure (RVP) and Sulfur Content
 - Emission Rates
 - LHD
 - MHD/HHD PEMS Analysis
- **Question & Answer**
- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps
- Question & Answer

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 Mute/Unmute
- Additional questions may be submitted after today to:
emfac@arb.ca.gov

PM Session Agenda

- Updates to Emission Rates
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 - LD High-Speed Test Plan
 - Fuel Reid Vapor Pressure (RVP)
 - Sulfur Content
 - Emission Rates
 - LHD
 - Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method
- Question & Answer
- **LD Zero Emissions Vehicle (ZEV) Energy Consumption**
- Schedule/Next Steps
- Question & Answer

LD Zero Emissions Vehicle (ZEV) Energy Consumption

Background

- EMFAC2021 included estimates of energy consumption from light and heavy-duty ZEVs.
- As of October 2022, there were 948,882 light-duty BEVs and PHEVs registered in CA. Many more are expected after the implementation of Advanced Clean Cars II.

Applications of Energy Module

- Inform economic evaluation for regulations and incentives by estimating electricity consumed from charging battery electric vehicles.
- Collaboration with sister agencies (e.g. California Energy Commission, CEC) and other energy stakeholders on demand projections to support transportation electrification.

PEVs, BEVs, PHEVs

Plug-in Electric Vehicle (**PEV**)

Battery Electric Vehicle (**BEV**)
Powered only by *electric motor*

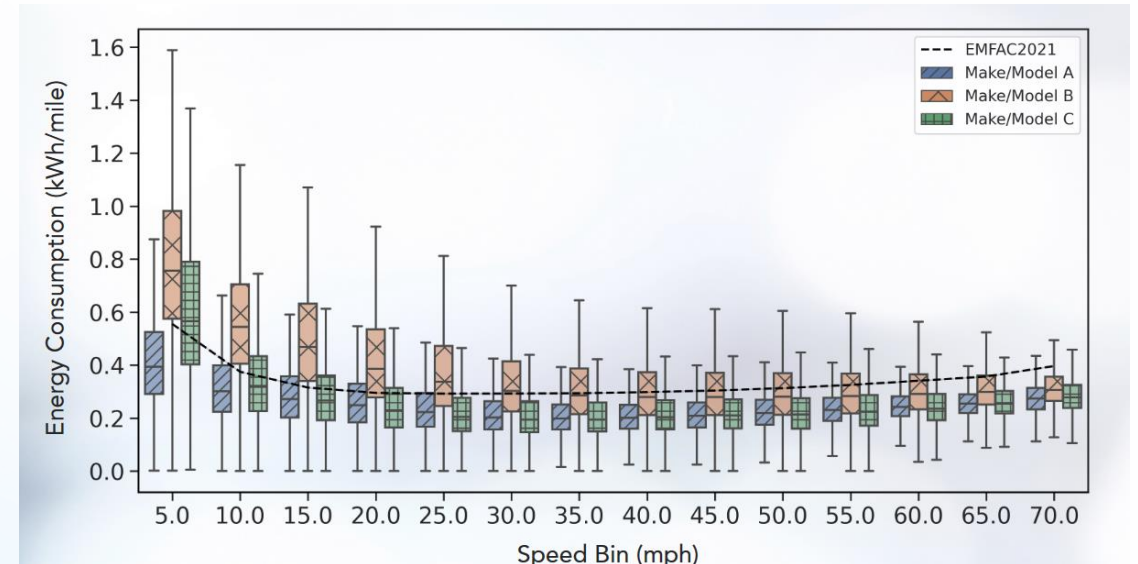


Plug-in Hybrid Vehicle (**PHEV**)
Powered by *electric motor and combustion engine*



October 2022 Workshop Recap

- In previous workshop, we analyzed data from CARB Contract 12-319¹ here referred to as “UC Davis” dataset
- Generated energy consumption curves for select make and model PEVs



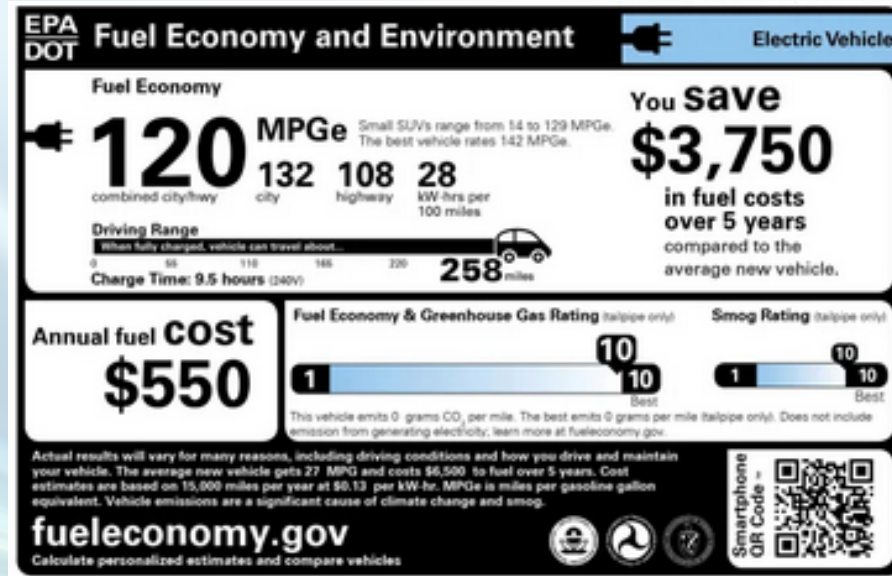
- **Update:** By combining UC Davis data with FuelEconomy.gov data and DMV inventory, we improve energy consumption curves for EMFAC202Y to more comprehensively represent the real-world fleet

1. Titled: Advanced Plug-in Electric Vehicle Travel and Charging Behavior

Data Sources

FuelEconomy.gov

- Website that compiles “window sticker” information for all make and model cars.
- Includes ratings for energy efficiency, GHG and smog production for all cars sold.
 - Comprehensive list of all BEVs and PHEVs
 - Values do now reflect real-world driving



UC Davis Dataset

- Dataset used the analysis shown in previous workshop
- 250 PEVs equipped with dataloggers and driven for one year
- Select make and models included
 - BEVs: Tesla Model S, Nissan Leaf, etc.
 - PHEVs: Toyota Prius, Chevy Volt, etc.
 - Model year range: 2012- 2018
- Gives energy consumption values at various speeds, that represent real-world driving behavior.

Planned Process

DMV Inventory

LDA LDT1 LDT2 MDV

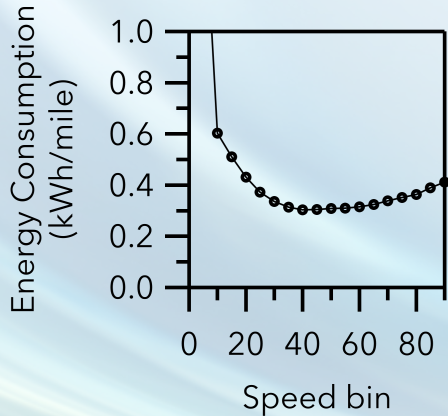
FuelEconomy.gov

Energy consumptions avg. (kWh/mile)

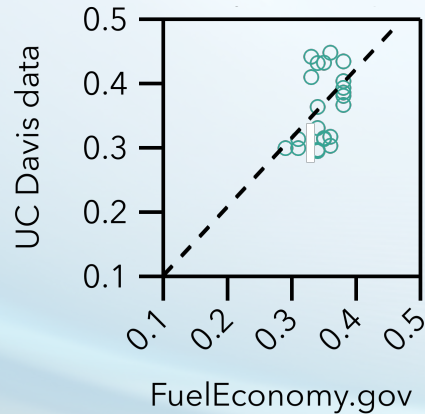
LDA	LDT1	LDT2	MDV
0.30	0.33	0.37	0.44

UC Davis dataset

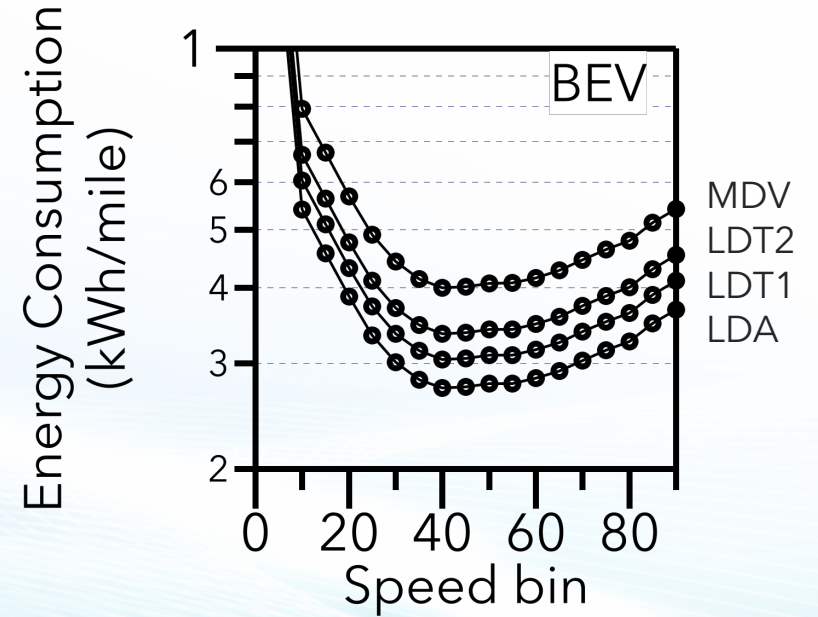
Speed distribution



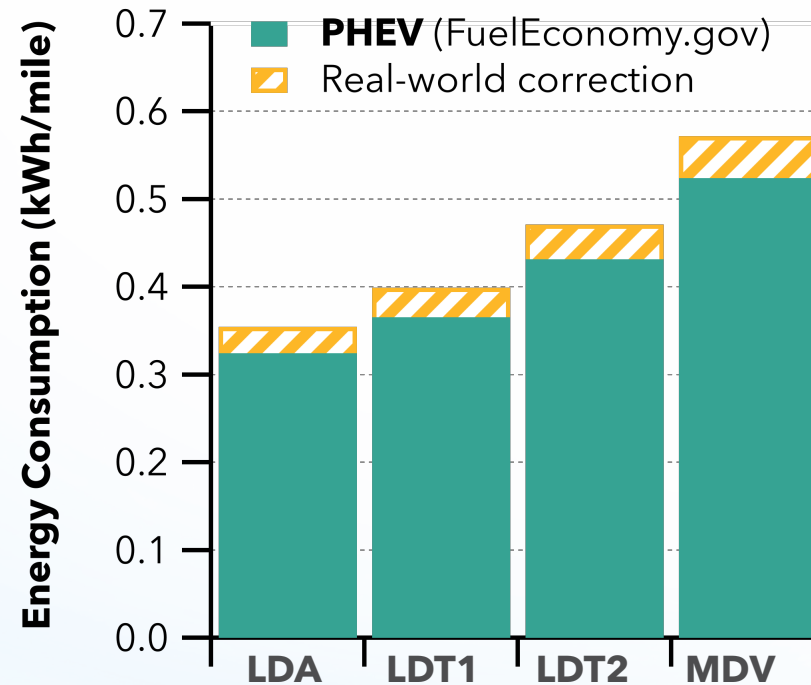
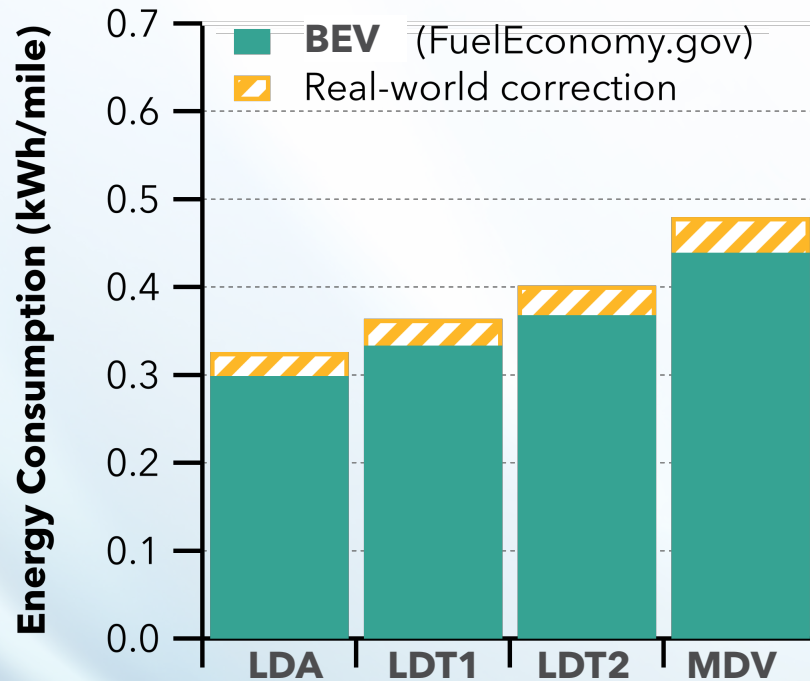
Real-world correction



Final Result

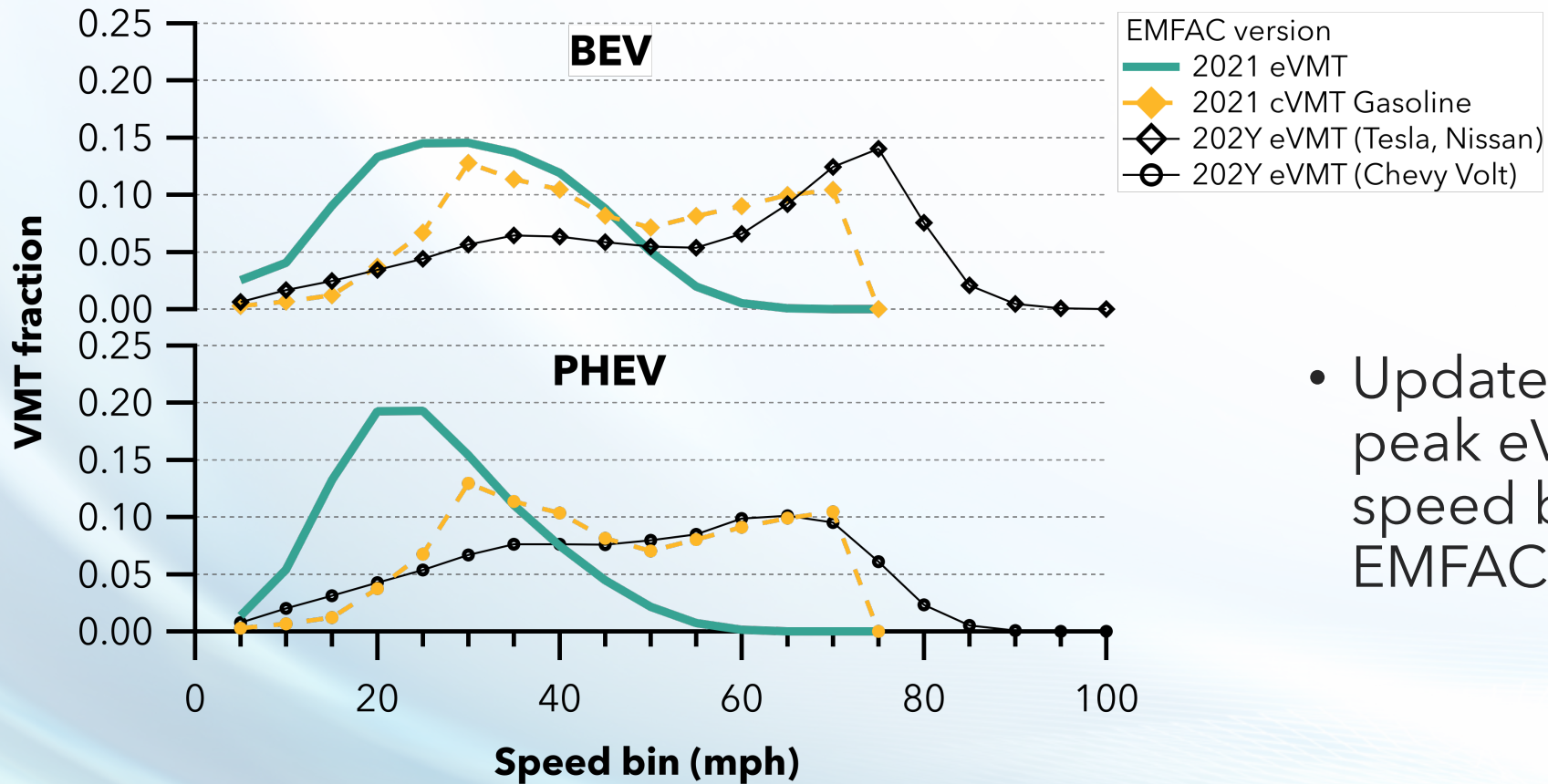


Preliminary Results: Energy Consumption Averages



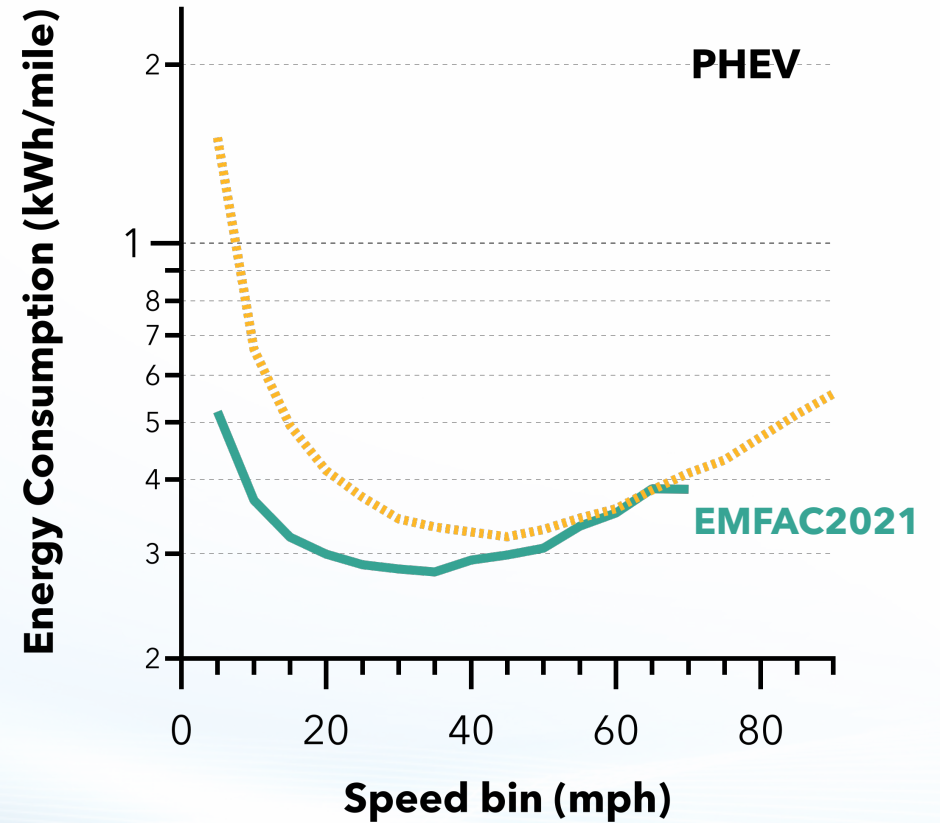
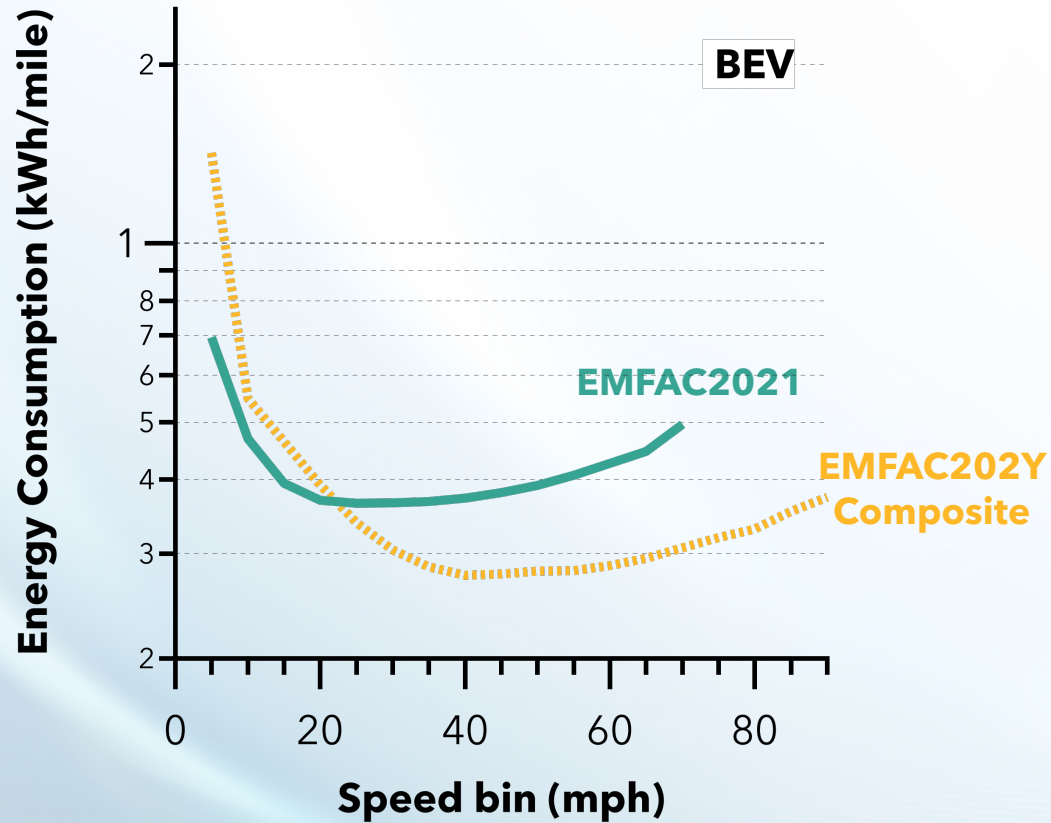
- Based on analysis of UC Davis data, FuelEconomy.gov values are increased by 9% to account for real-world driving behavior
 - Includes a 14.3% correction for charging losses applied to all make and models.

Preliminary Results: eVMT by Speed Bin



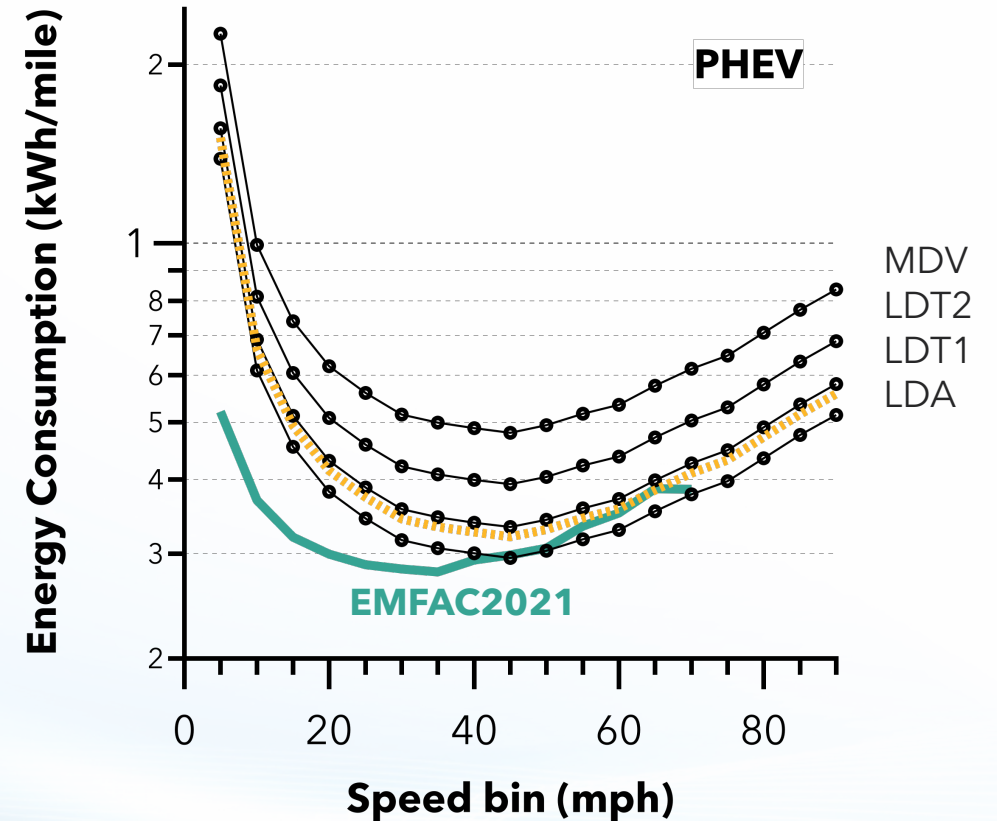
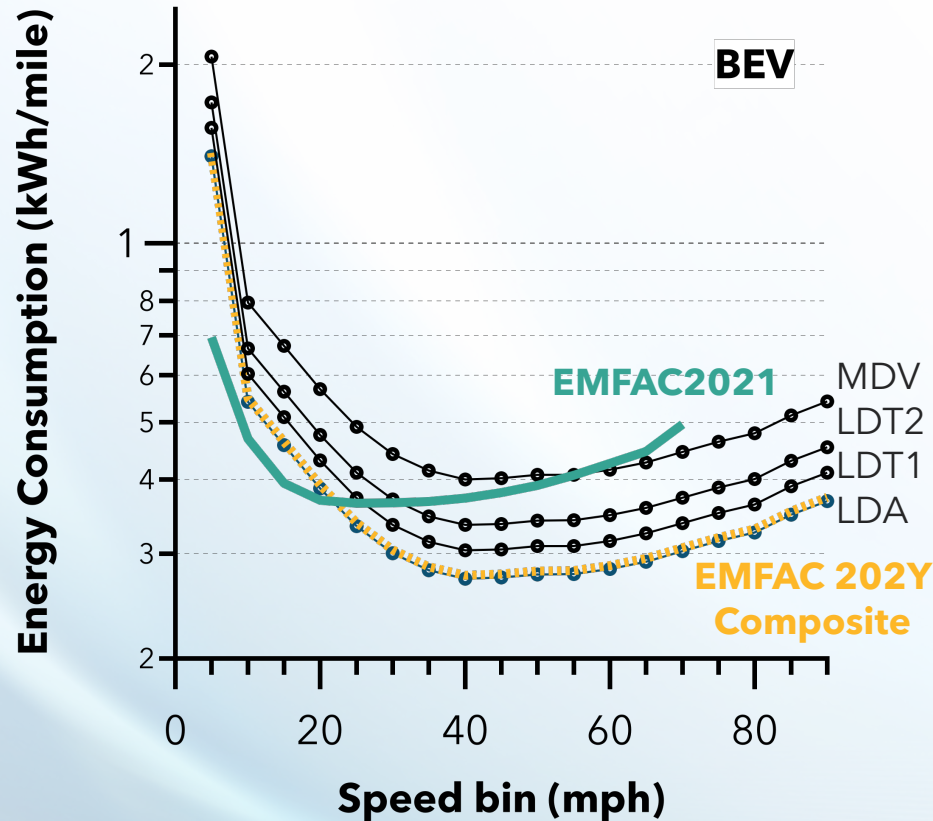
- Updated distributions show peak eVMT at much higher speed bins than previous EMFAC version.

Preliminary Results: Energy Consumption Curves



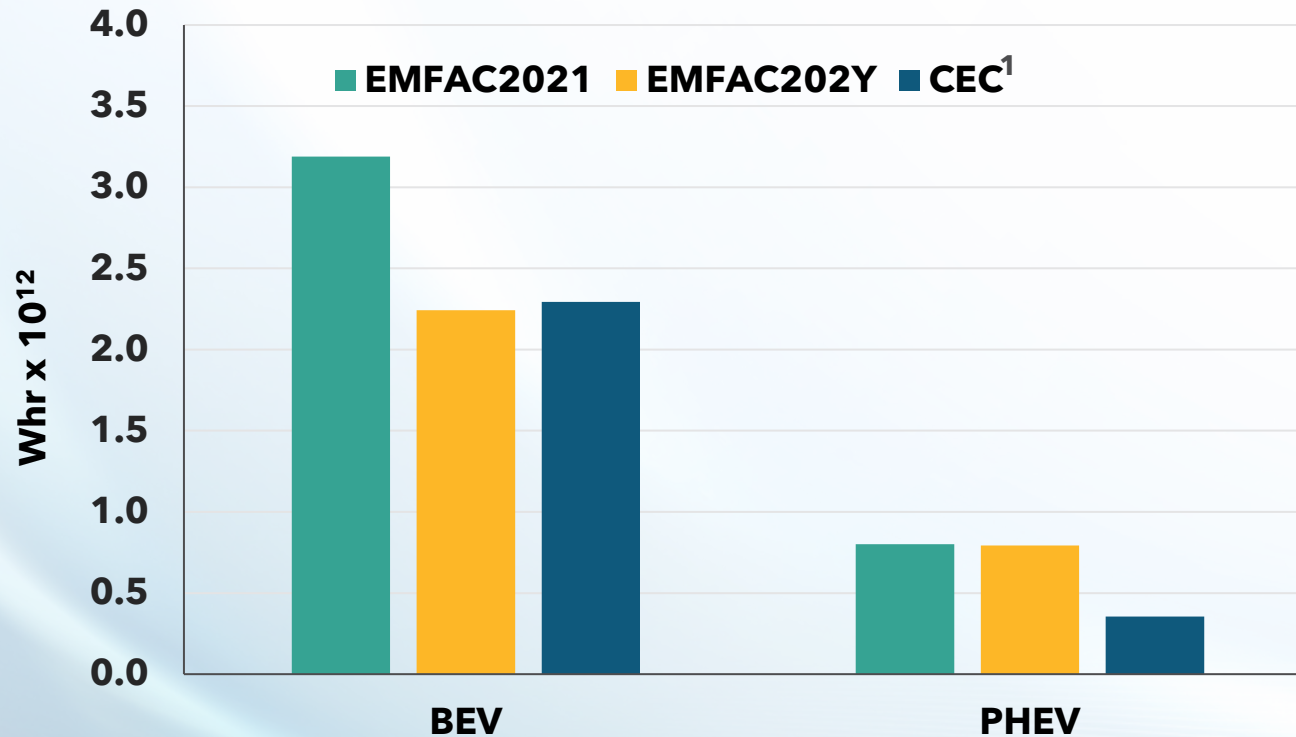
- BEV curve shape based on Tesla Model S/Nissan Leaf data, and PHEV on Chevy Volt.
- EMFAC202Y composite energy consumption rates will be applied out to CY 2050 in model, but in future model releases, CARB staff expects curve to change as ZEV technology rolls out.

Preliminary Results: Energy Consumption Curves



Energy consumption curves for EMFAC202Y are now split into 4 weight classes, and better represent real-world driving conditions.

Preliminary Results: CY 2022 Annual Energy Consumption Estimates



- EMFAC202Y predicts less energy use for BEVs, but a similar energy use for PHEVs, relative to EMFAC2021.
- Note: eVMT used for PHEVs in EMFAC202Y is still under development

Next steps

- Refine estimates based on external stakeholder feedback.
- Coordinate with sister agencies, such as CEC, to develop best estimates of future energy demand from PEVs.
- Preliminary results will be implemented into EMFAC202Y
 - Energy consumption rates by speed
 - Updated eVMT speed distributions

PM Session Agenda

- Updates to Emission Rates
 - Test Plans
 - LD, LHD, MCY Surveillance Test Plans and Status
 - LD High-Speed Test Plan
 - Fuel Reid Vapor Pressure (RVP)
 - Sulfur Content
 - Emission Rates
 - LHD
 - Medium Heavy-Duty/Heavy Heavy-Duty (MHD/HHD) New PEMS Analysis Method
- Question & Answer
- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- **Schedule/Next Steps**
- Question & Answer

Schedule/Next Steps

Tentative Timeline for EMFAC202Y

- Alpha Release (Summer 2024):
A preliminary version of the model will be released to CARB designated testers
- Public Beta Release (Fall 2024):
A revised version of the model reflecting feedback will be released



Next Steps for EMFAC202Y Development

- Continue analysis of emissions or other data provided to CARB through July 31, 2024
- Engage stakeholders most impacted by vehicular emissions and air pollution
- Coordinate with other agencies on vehicle activity, growth forecasting, and emission updates
- CARB staff requests comments on material presented today by **February 16, 2024** to ensure feedback is considered for EMFAC202Y release

Workshops #3 and #4 Tentative Agenda

- 3rd Workshop (Fall 2024)
 - Final updates to emission rates
 - Regional ZEV forecasting
 - Fuel economy and CO2 updates
 - Light-duty activity forecasts
 - Transportation Network Company (TNC) module
- 4th Final Workshop (Spring 2025)
 - Aggregate and total emissions, activity, and energy consumption impacts of EMFAC202Y model updates

PM Session Agenda

- Updates to Emission Rates
 - Test Plans
 - LD, LHD, MCY Surveillance Test Plans and Status
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- Question & Answer
- LD Zero Emissions Vehicle (ZEV) Energy Consumption
- Schedule/Next Steps
- **Question & Answer**

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 Mute/Unmute
- Additional questions may be submitted after today to:
emfac@arb.ca.gov