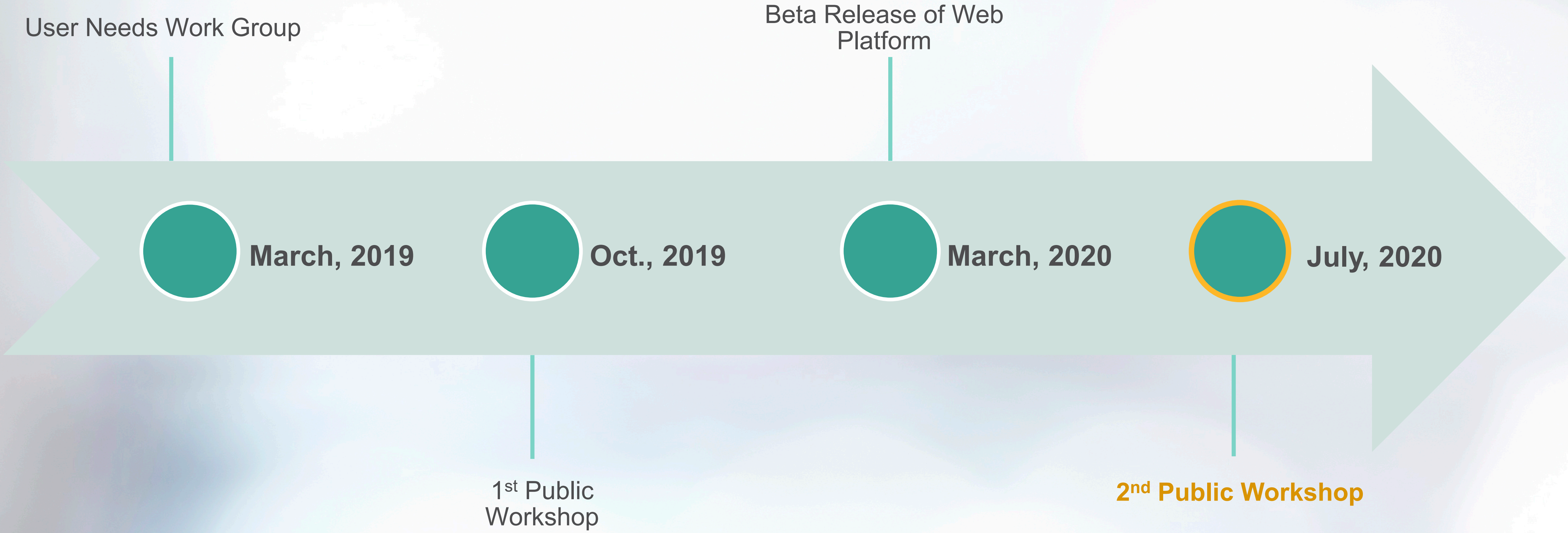
EMFAC202x Updates

Mobile Source Analysis Branch
Air Quality Planning and Science Division
California Air Resources Board

July 30, 2020

Public Process So Far



Agenda for Today's Workshop

AM Session

i. Background and Major Updates
ii. Web Platform (Demo)
iii. Activity and Forecasting

PM Session

v. Emission Rates
vi. Motorcycle Activity & Emission
vii. Latest Regulations

Overview

Background and Major Updates

Background of EMFAC

- California specific with USEPA approval
- More than three decades of data collection and methodology refinement
- Advanced Data Mining and Analysis
- Real World Emission Testing
- Use of Big Data (e.g., Telematics)
- Integrated modeling

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A Decade of EMFAC Updates

2011

EMFAC2011

- ✓ Integrating In-Use Diesel Regulations
- ✓ Modular approach

2014

EMFAC2014

- ✓ Single Package
- ✓ Reflecting Advanced Clean Cars, 2014 Amendments to Truck and Bus Rule, and Heavy-Duty Green House Gas (GHG) Regulations

2017

EMFAC2017

- ✓ An extension of the EMFAC2014 framework
- ✓ Reflecting measures adopted before 2018

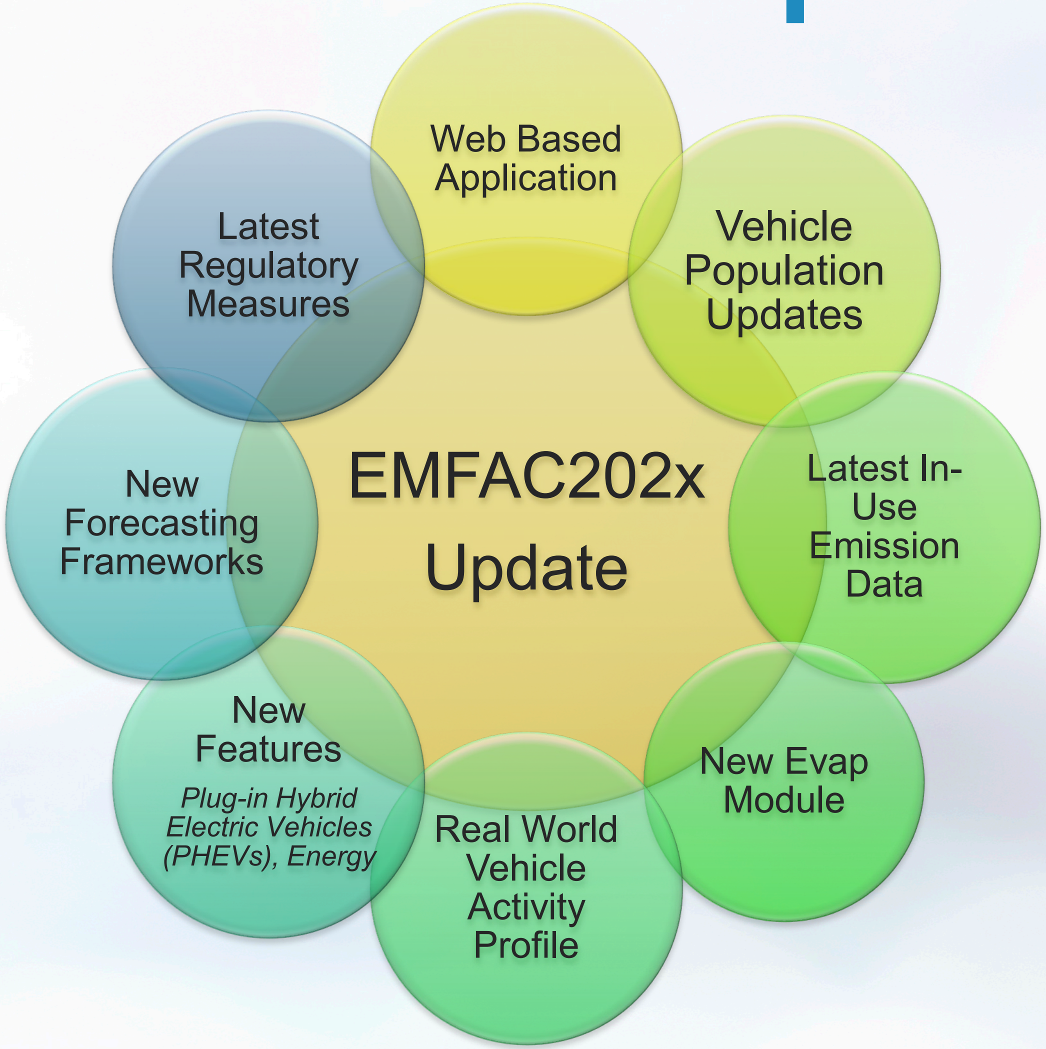
2020/2021

EMFAC202x

What's coming next?

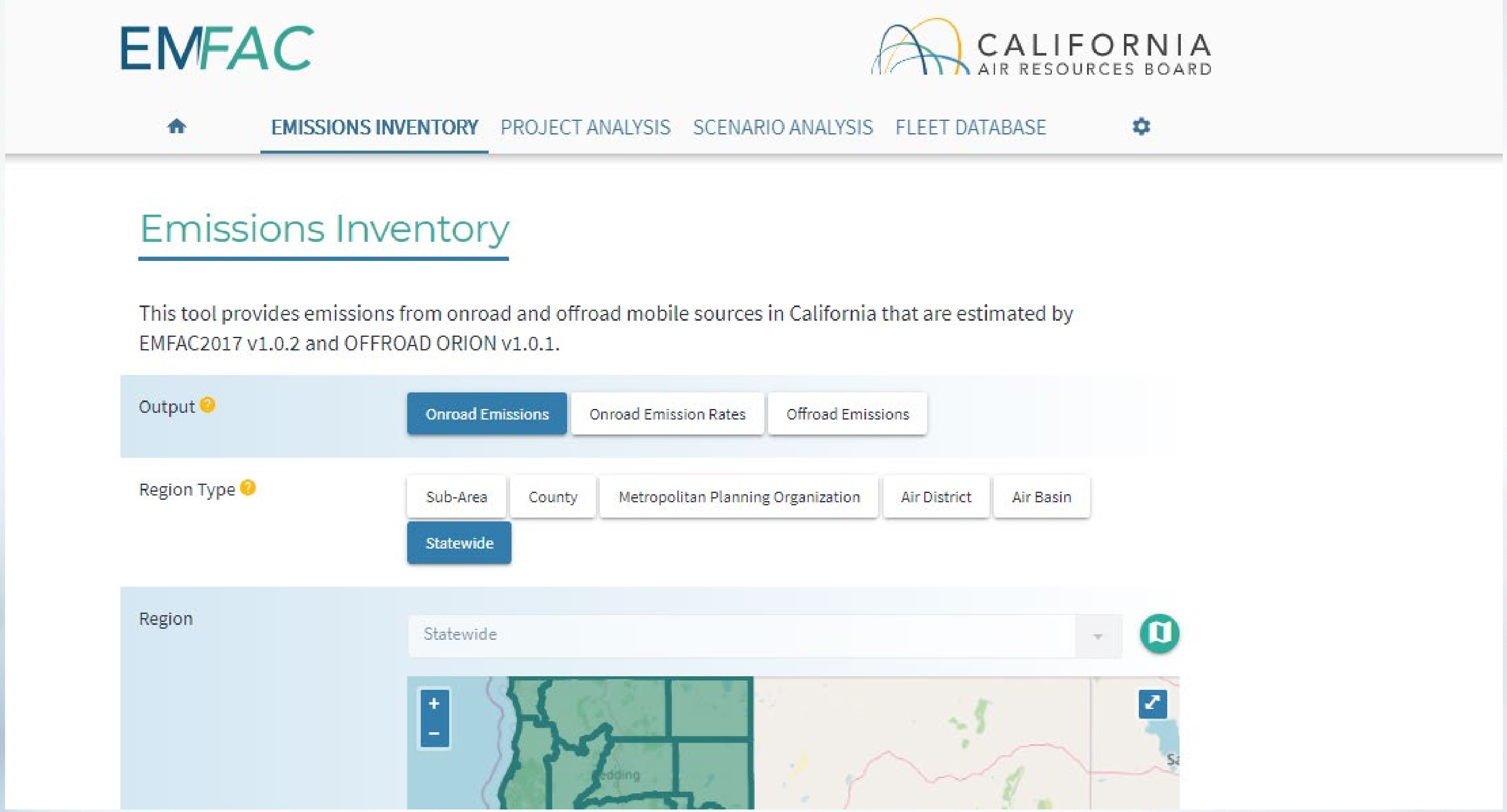
EMFAC

EMFAC202x Updates



New Web Platform

Quick & Easy Access to Emissions Inventories



Vehicle Population Updates

State of California
Department of Motor Vehicles

IHS Markit™

INTERNATIONAL REGISTRATION PLAN, INC.

Vehicle
Population
Updates

CDTFA
CALIFORNIA DEPARTMENT OF
TAX AND FEE ADMINISTRATION

Federal Transit Administration

CALIFORNIA
HIGHWAY PATROL

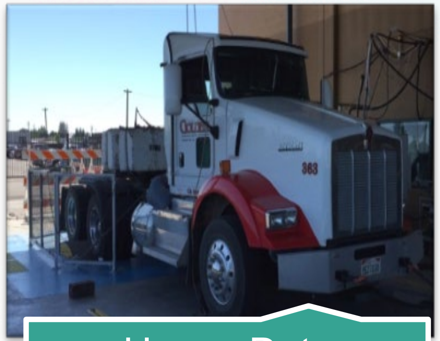
THE PORT OF LOS ANGELES

Port of
LONG BEACH
The Green Port

PORT OF OAKLAND

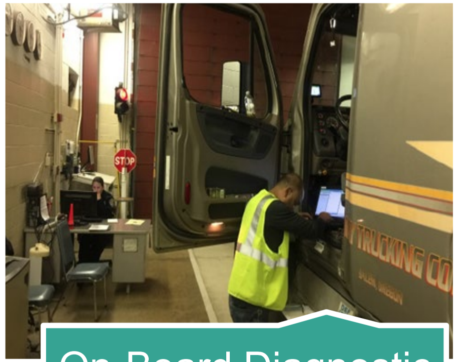
Latest In-Use Emissions Data

Light-Duty



Heavy-Duty (Diesel and CNG)

Motorcycle



On-Board Diagnostic (OBD)

PHEV

Brake-Wear

Real World Vehicle Activity Profile

California Vehicle Inventory and Use Survey (VIUS)

Replaces the Federal VIUS (discontinued)

Data collected using a combination of surveys & instrumented vehicles

Collection of truck activity data through Telematics service providers

Information on:

- Vehicles miles traveled
- Idling/hoteling
- Drive cycles

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New Features




Vocational Truck Categories

Three Level Categorization:

1. Gross Vehicle Weight Rating (GVWR)
2. In-State/International Registration Plan (IRP) Out-of-State (OOS)
3. Body Type

PHEV Module to separately categorize plug-in hybrids

Models high power start emissions

Accounts for electric vehicle miles travelled (VMT) and charging behavior

Energy Module

Estimates energy consumption by plug-in electric vehicles (PEVs)

Data from more than 50k vehicles are analyzed

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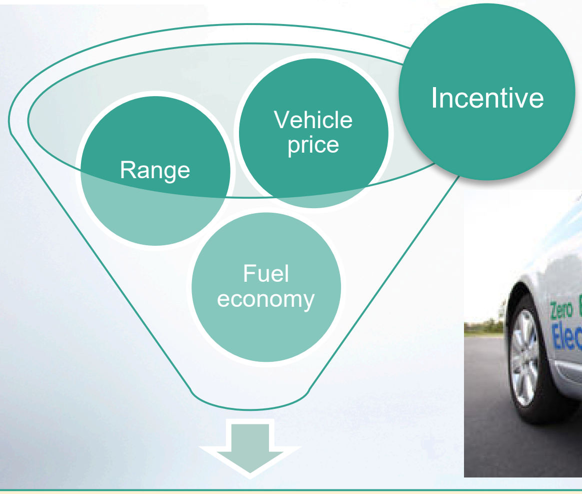
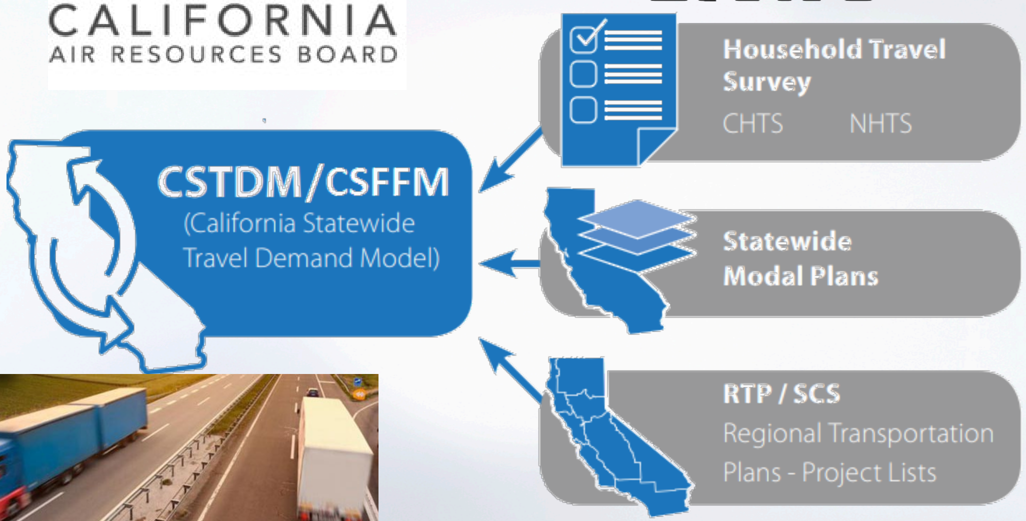
New Forecasting Frameworks



Utilizing vehicle choice models from California Energy Commission (CEC) to forecast Light-Duty (LD) zero-emission vehicle (ZEV) sales

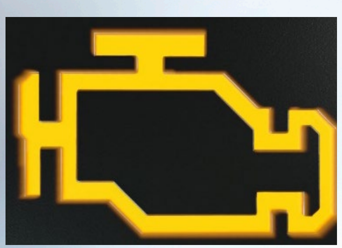


Utilizing statewide travel demand models from Caltrans to forecast Heavy-Duty (HD) Vehicle Miles Travelled (VMT)

Latest Regulatory Measures

HD Vehicle Inspection Program (HDVIP)/ Periodic Smoke Inspection Program (PSIP)

HD Warranty



Innovative Clean Transit (ICT)

Zero Emission (ZE) Airport Shuttle Bus

SAFE Part One & Final Rule

Advanced Clean Trucks (ACT)

Low NOx Omnibus

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EMFAC202x Next Steps

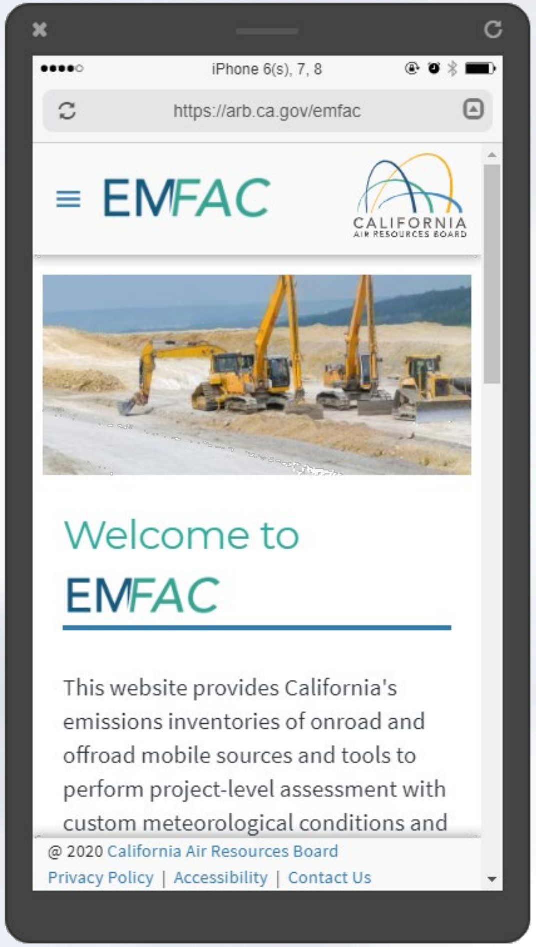
- **July, 2020** — **2nd Workshop**
- **August, 2020** — Alpha Release and Testing
- **Fall, 2020** — Beta Release and Testing
- **Winter, 2020** — 3rd Workshop
- **Late 2020/ Early 2021** — Official Public Release

New Interface

EMFAC Web Platform

New EMFAC Web Platform:
Quick & Easy Access to Emissions Inventories

- All the features of EMFAC on the web, including "Project Level" and "Custom Activity" modes
- Fast as it runs with preprocessed output
- Better user interface with a modern web and mobile-device friendly web design
- Provides *Fleet Database*, a database to access vehicle population at very detailed spatial resolution (e.g., census block group)
- Provides access to off-road mobile source emissions inventories



Mobile device friendly!

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Demo of EMFAC Web Platform

https://arb.ca.gov/emfac

Light-Duty Vehicles (LD)

Fleet Characterization

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Latest Vehicle Registration Data

- CARB receives a snapshot of California vehicle registration data every quarter (January, April, July, and October)
- EMFAC uses the counts of vehicle from the October snapshot
- CARB staff have made significant improvement in processing the registration data for use in EMFAC
- EMFAC202x will utilize Department of Motor Vehicle (DMV) registration data from years <u>2000 through 2019</u>

Major Data Sources

- California DMV Registration Data (2000 – 2019)
- Polk/IHS VINtelligence Web Service
- CARB Certification Executive Orders (EO)
- VIN stems to identify fuel technologies
  - Plug-in Hybrid Electric Vehicle (PHEV)
  - Battery Electric Vehicle (BEV or BEVx*)

    *essentially all electric but with a range extender (REx)
  - Fuel Cell Vehicle (FCV)

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Vehicle Classes Modeled in EMFAC202x

In the next few slides you will hear about…

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

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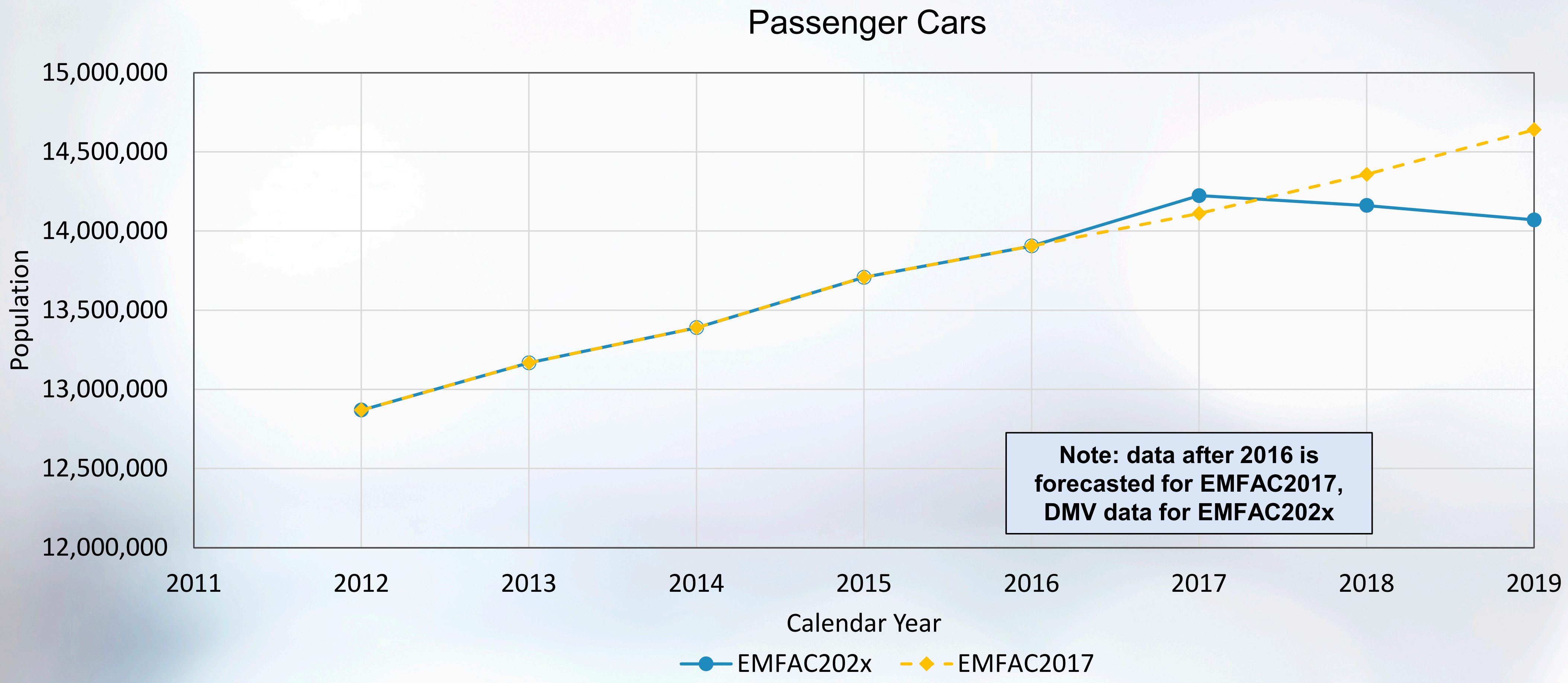
EMFAC202x vs EMFAC2017 Population Gasoline



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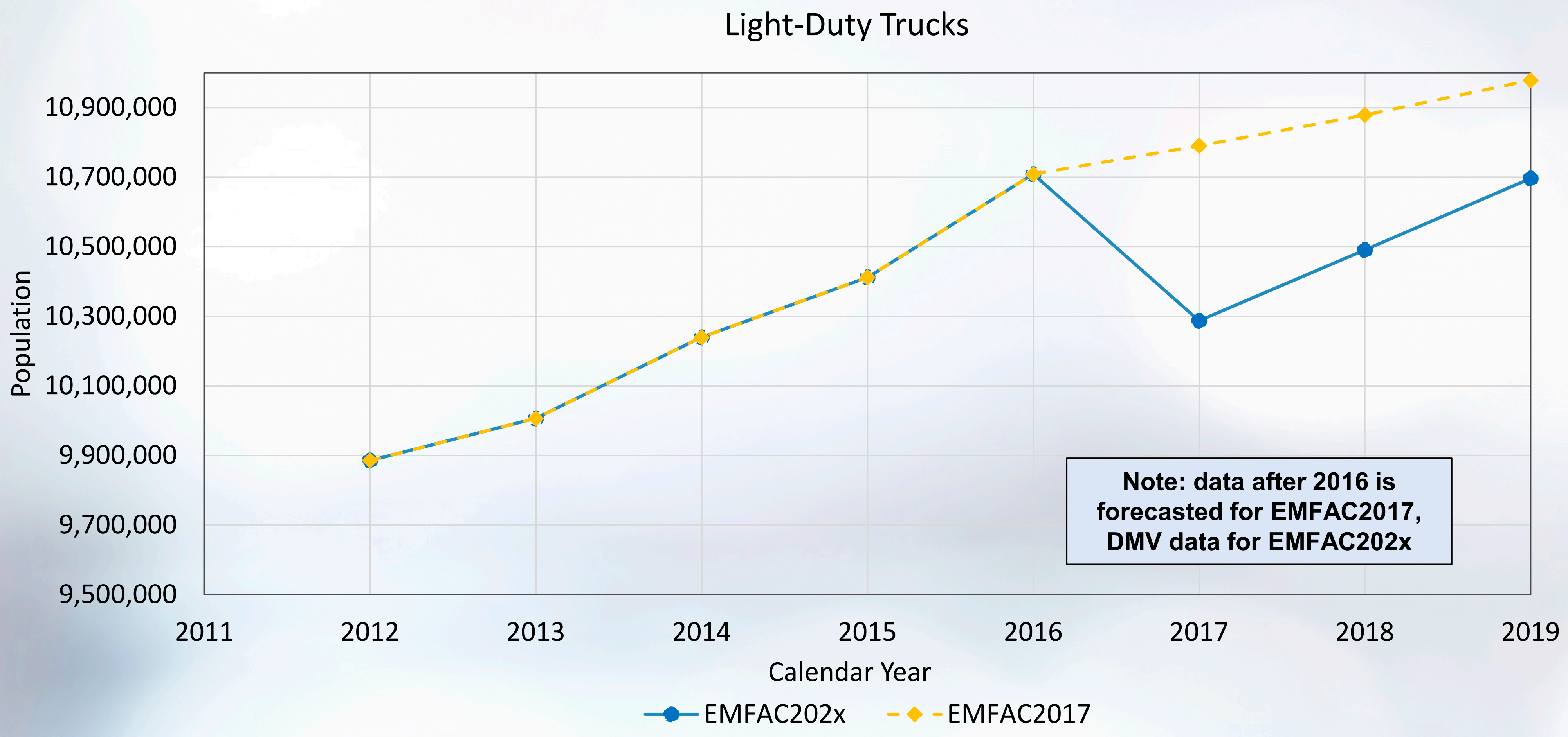
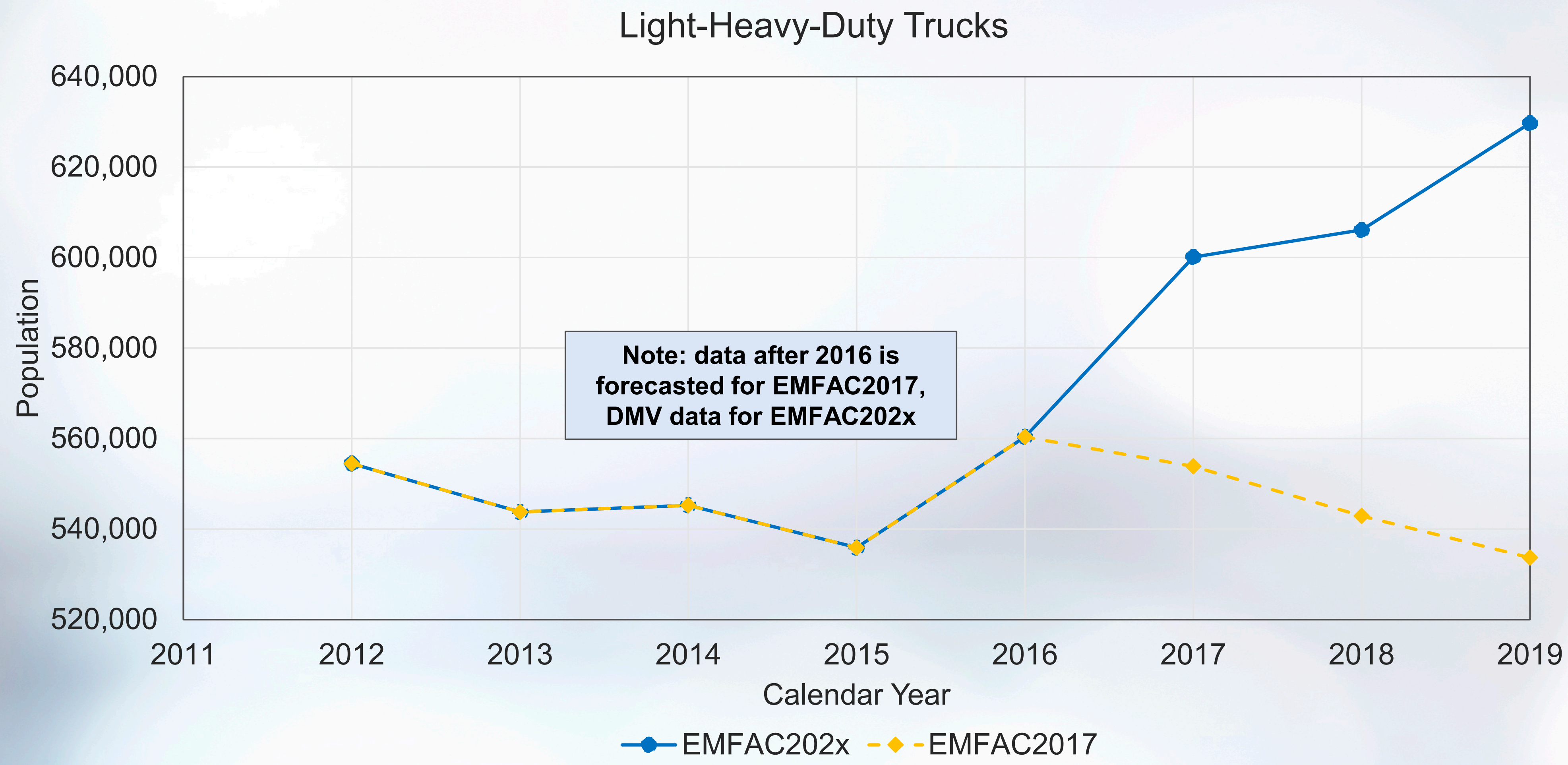
EMFAC202x vs EMFAC2017 Population Gasoline



EMFAC202x vs EMFAC2017 Population Gasoline



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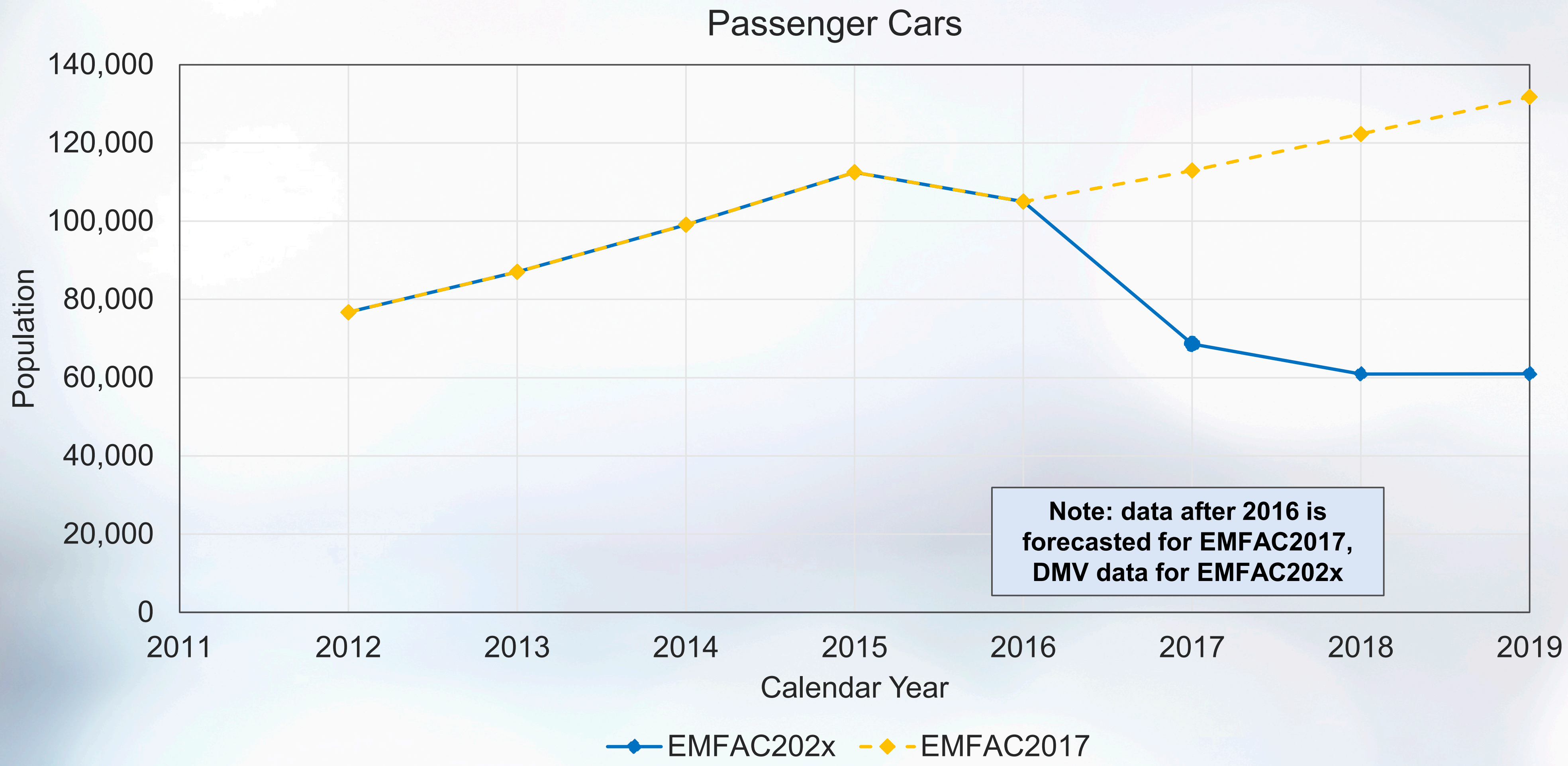
EMFAC202x vs EMFAC2017 Population Diesel



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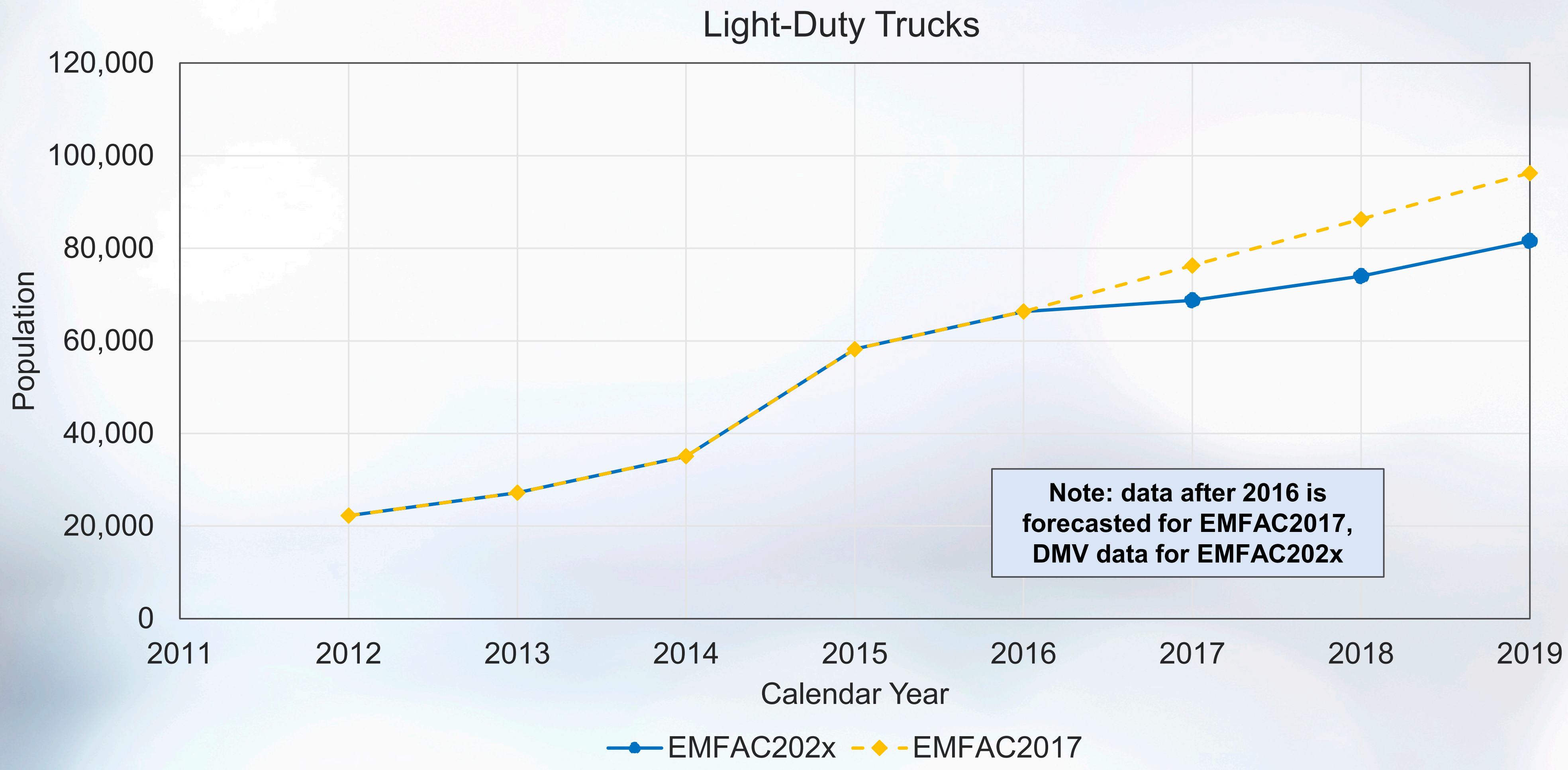
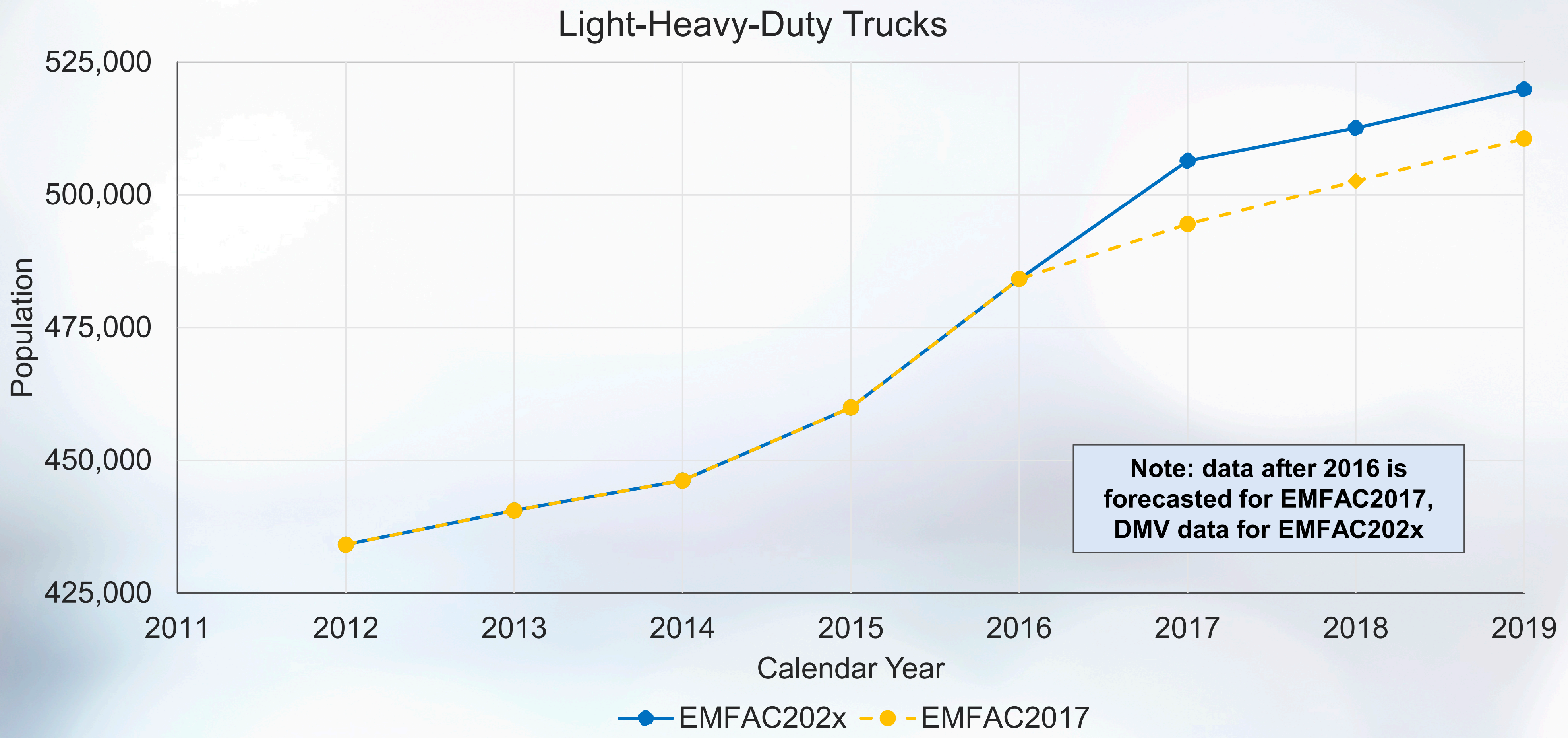
EMFAC202x vs EMFAC2017 Population Diesel

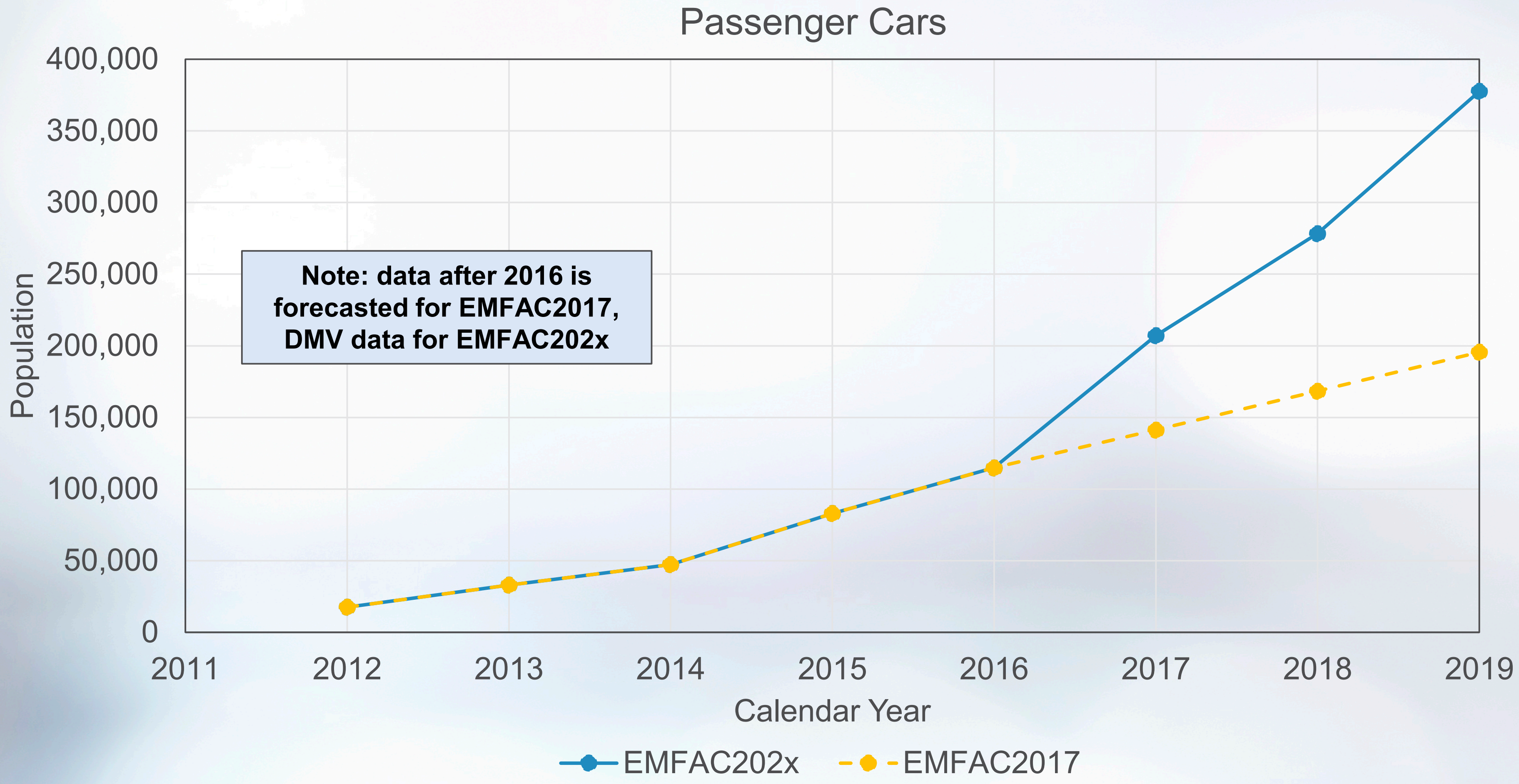


*LDT: Light-Duty Trucks with GVWR ≤ 8,500 lbs.

EMFAC202x vs EMFAC2017 Population Diesel



EMFAC202x vs EMFAC2017 Population Electric*



* Electric equivalent vehicles: Vehicles with motive power of electric in DMV data and electric fraction of PHEVs

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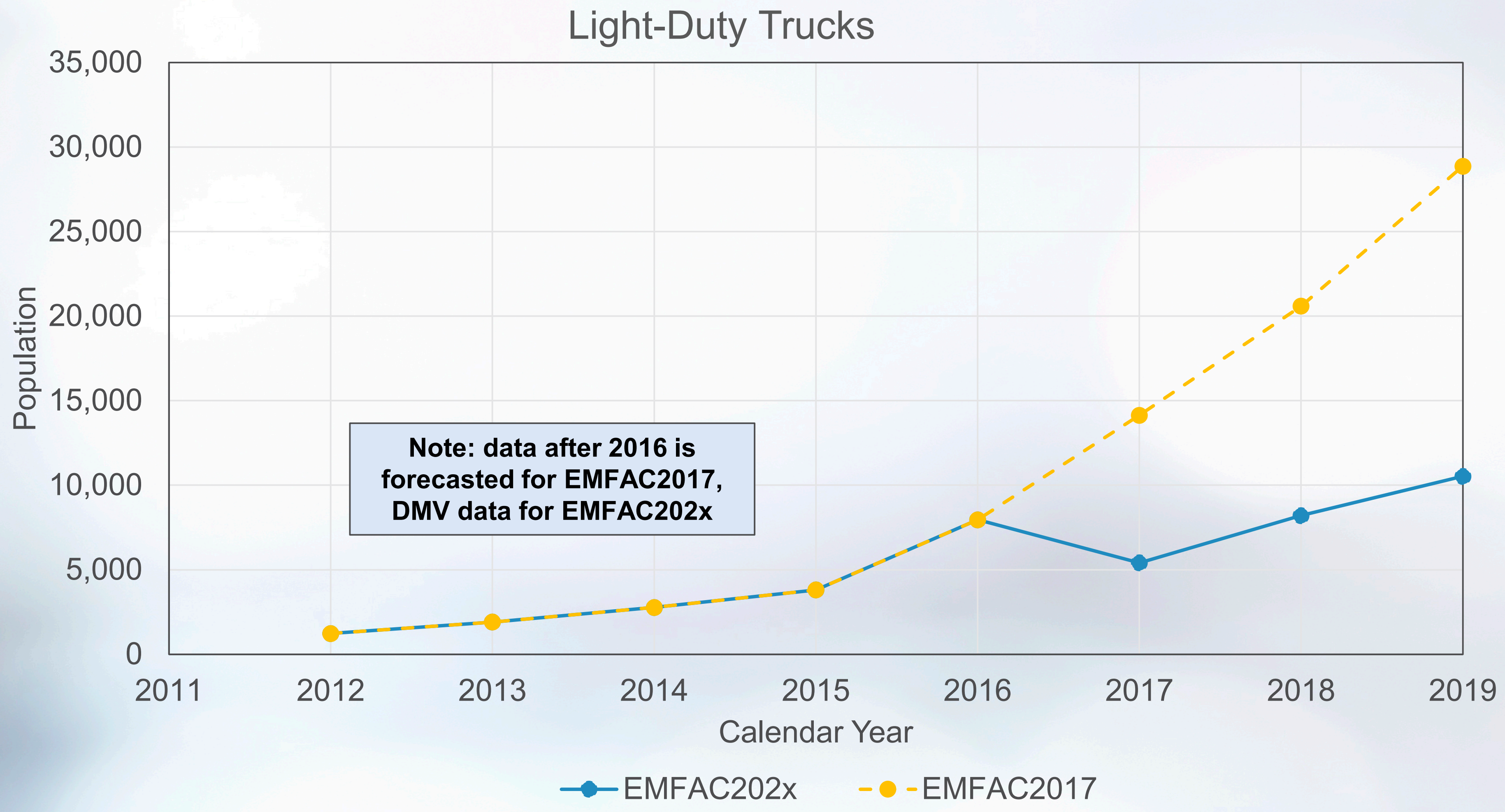
EMFAC202x vs EMFAC2017 Population Electric*



* Electric equivalent vehicles: Vehicles with motive power of electric in DMV data and electric fraction of PHEVs

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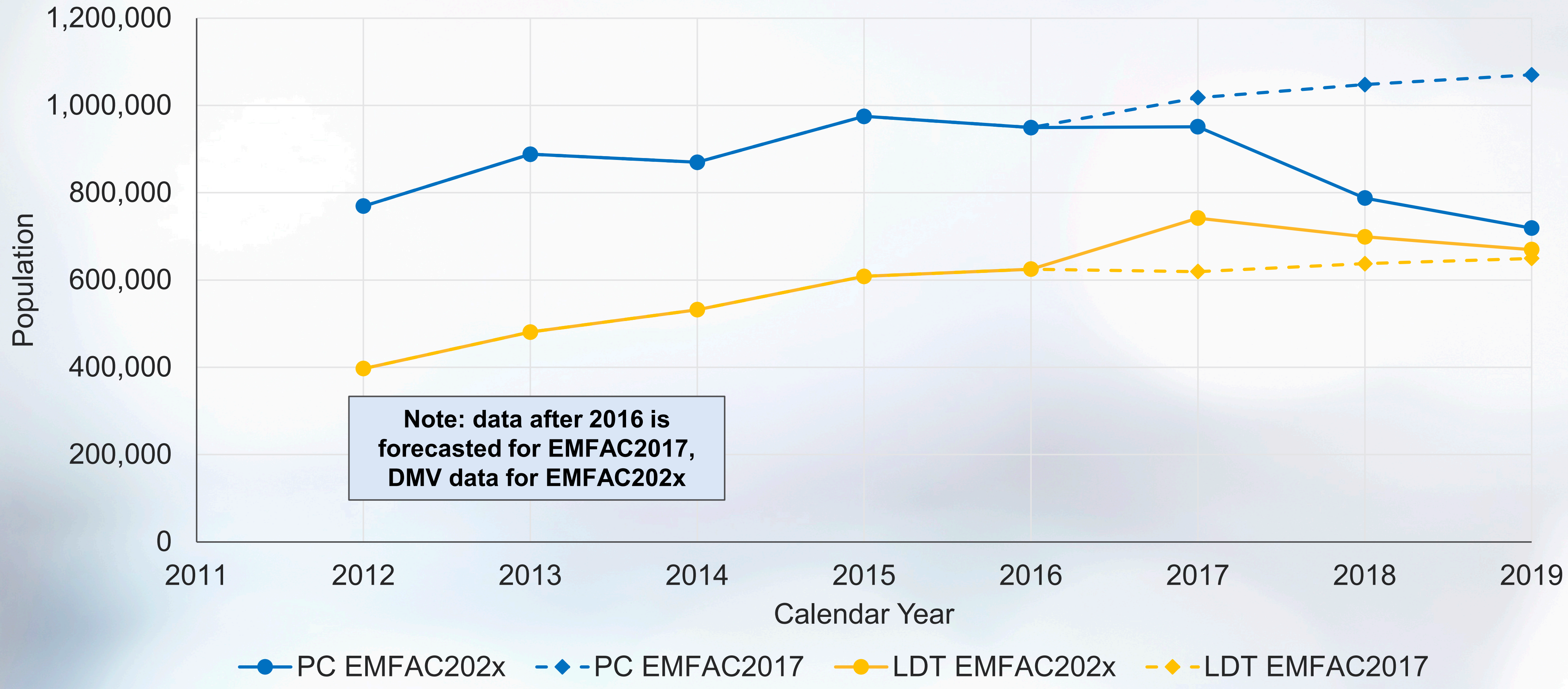
New Sales – Light-Duty Vehicles Gasoline



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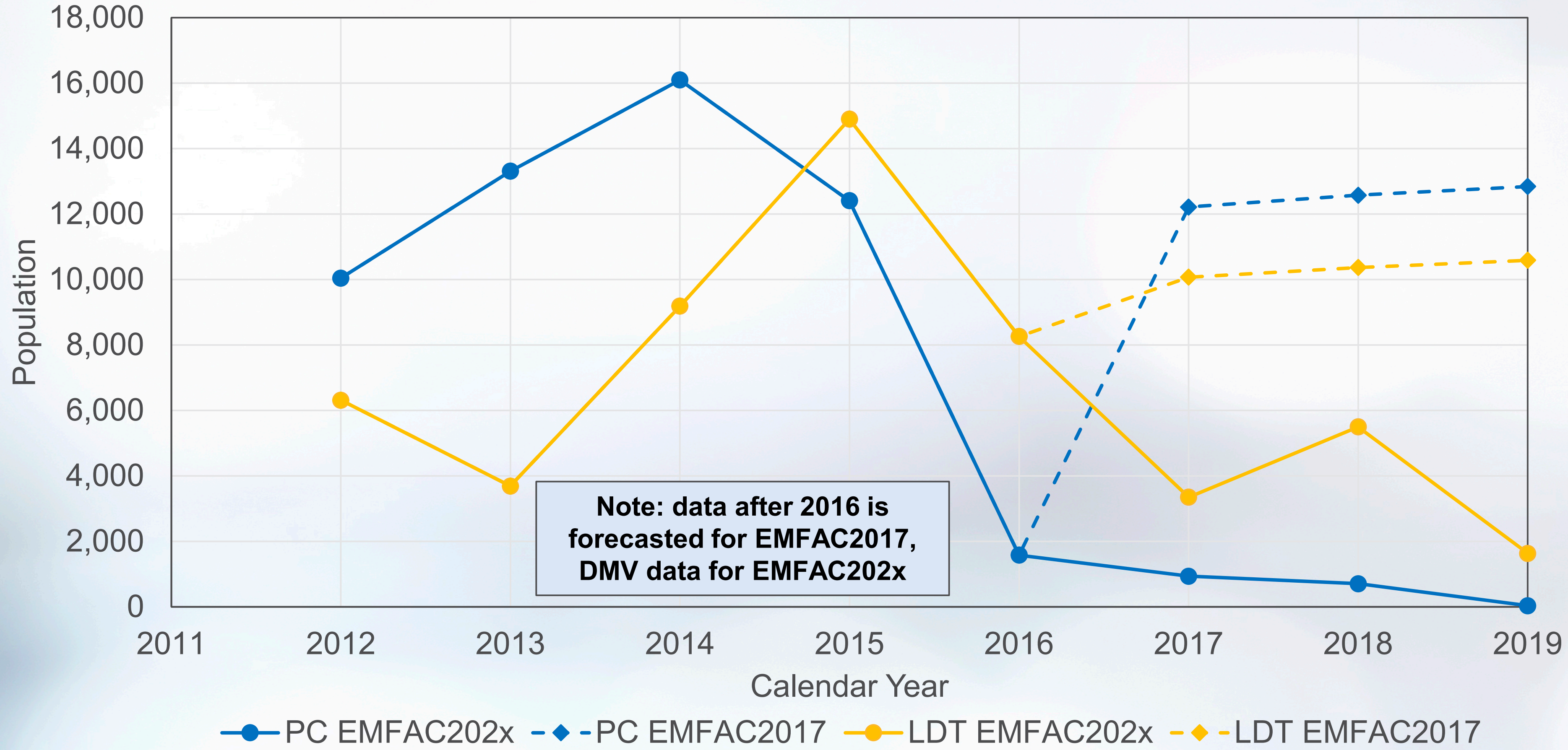
New Sales – Light-Duty Vehicles Diesel



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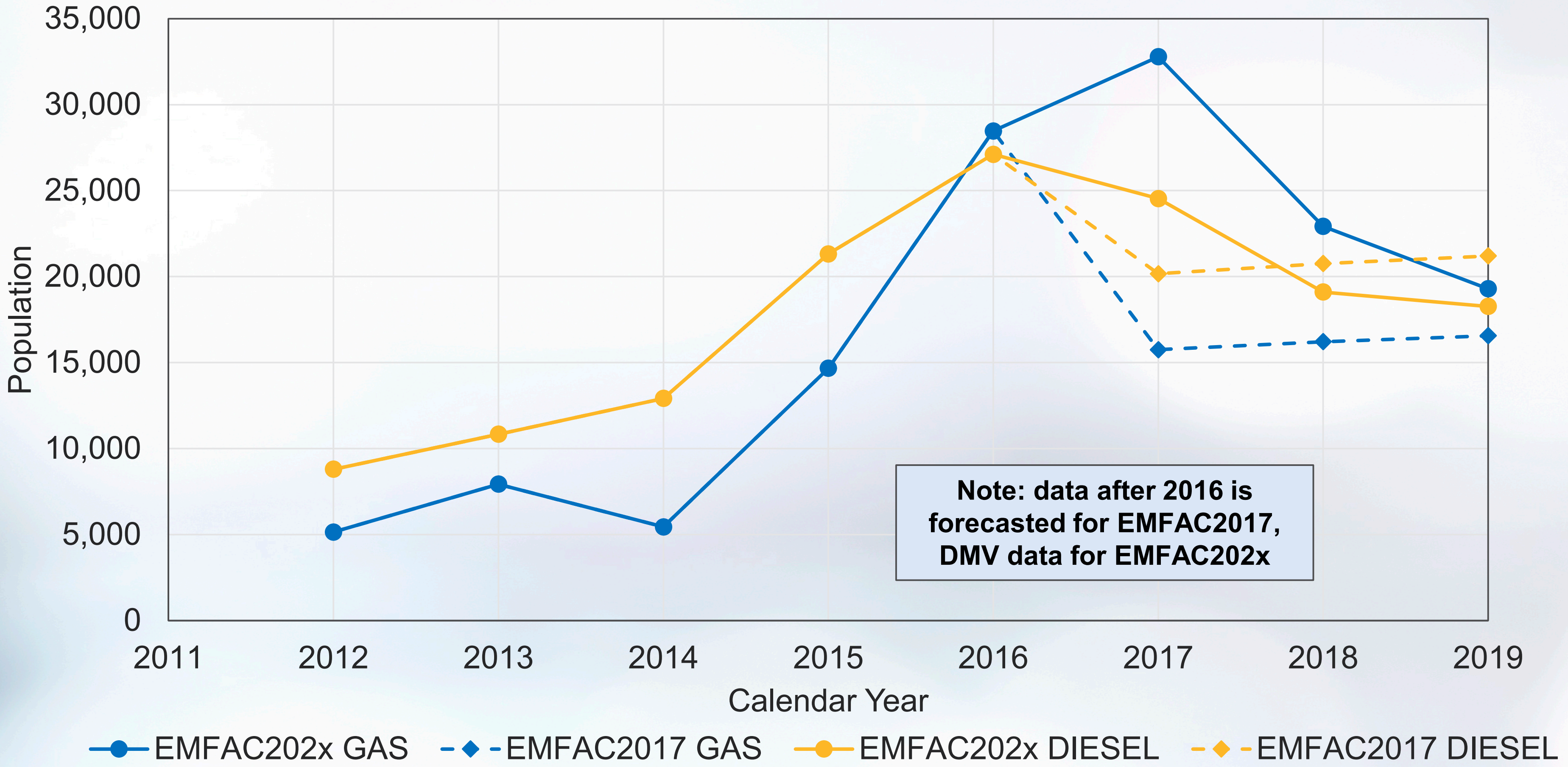
New Sales – Light-Heavy-Duty Trucks Diesel and Gasoline



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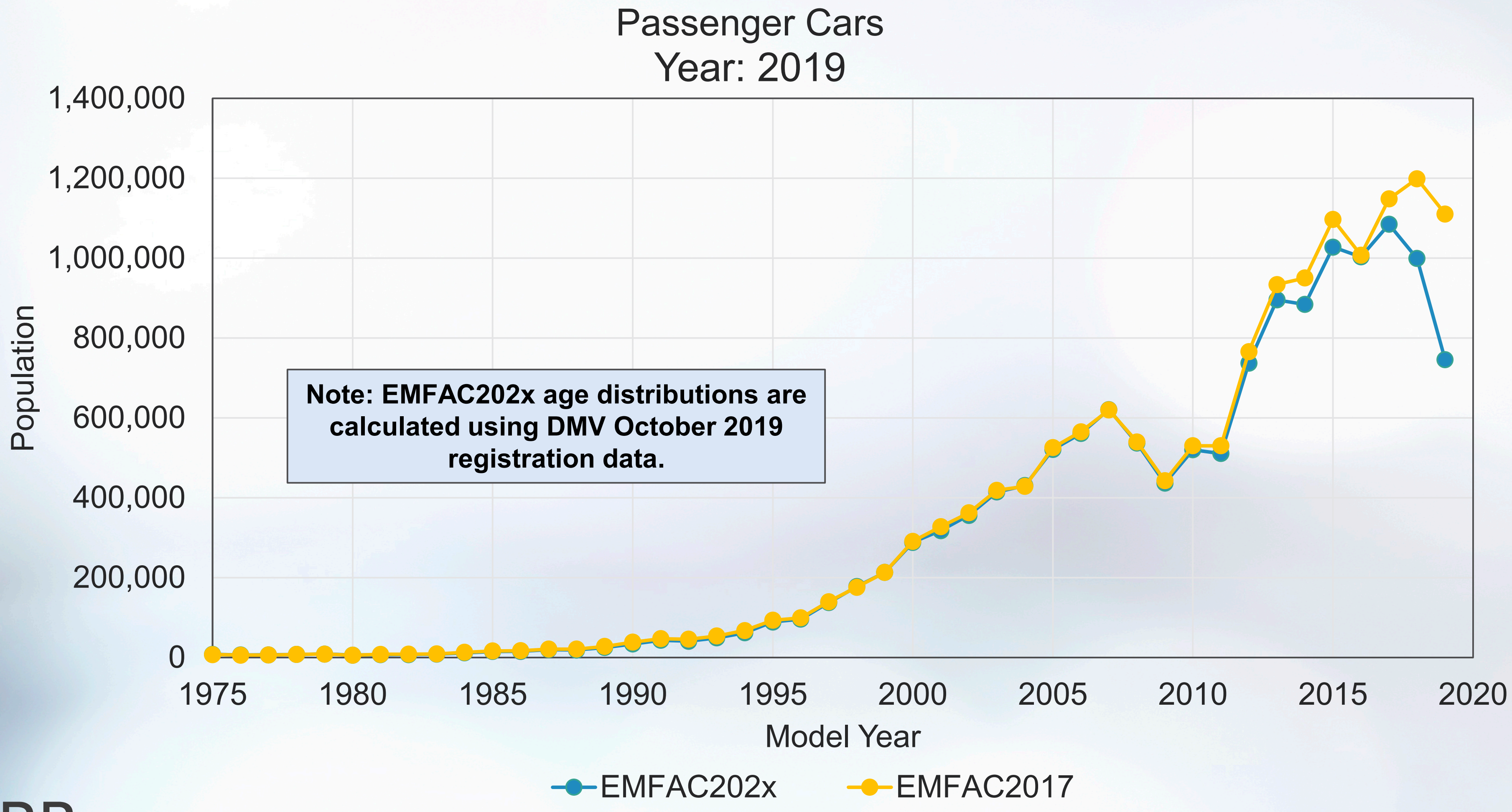
EMFAC202x Model Year Distribution
All Fuel Types



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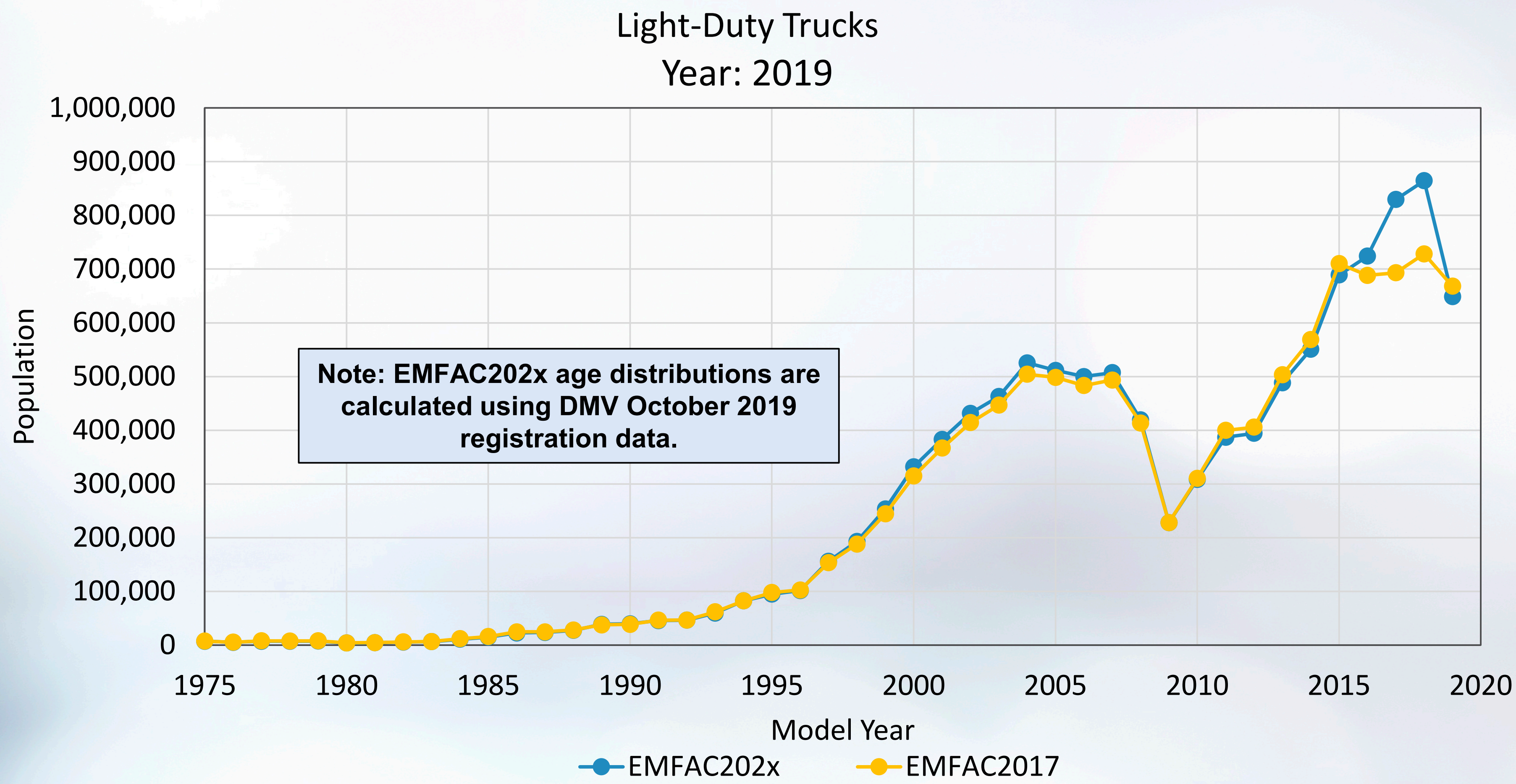
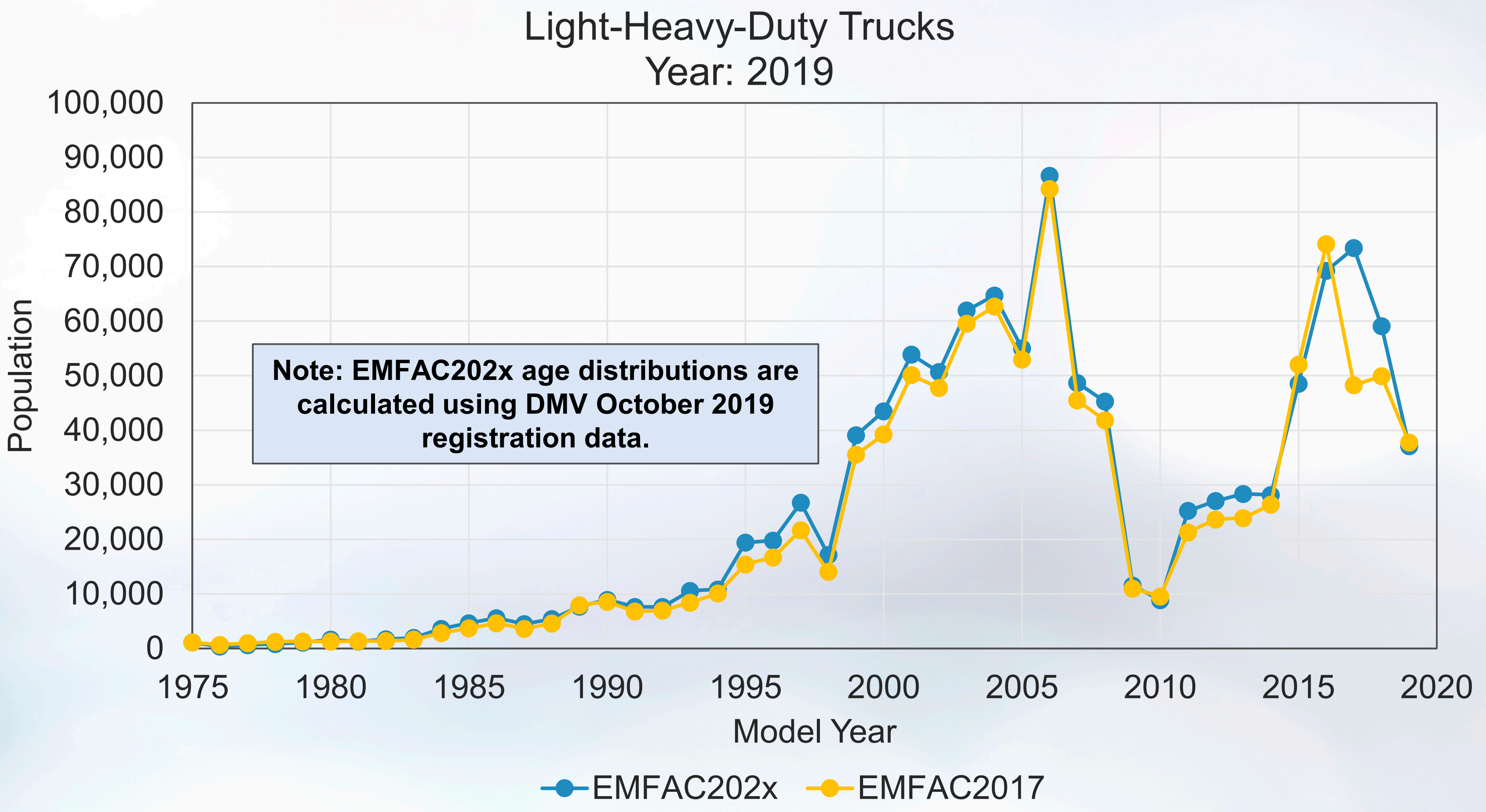
EMFAC202x Model Year Distribution All Fuel Types



EMFAC202x Model Year Distribution All Fuel Types



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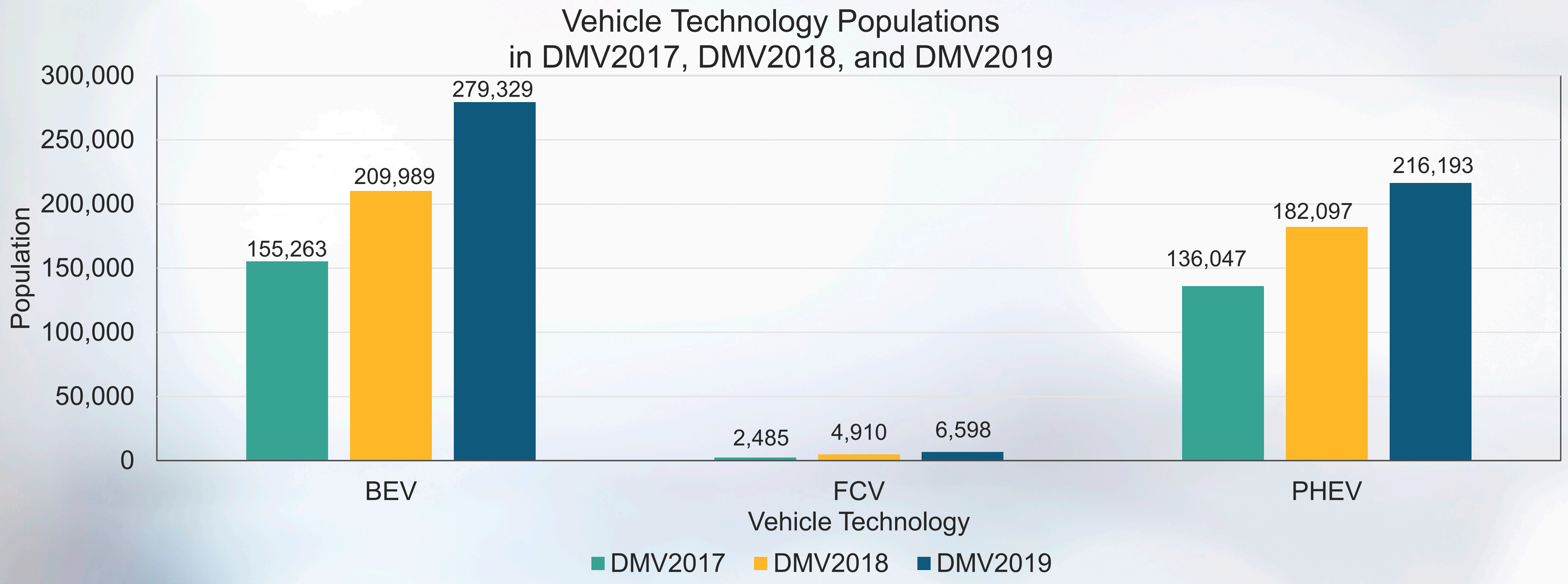
On-road Population Growth for Advanced Technology Vehicle Groups



This the population of “currently” registered in CA DMV data and is not equivalent to cumulative sales. Registration status codes that are counted include C (currently registered), E (evidence of use), and S (pending status, included if the same vehicles become C or E in the following April DMV data cut).

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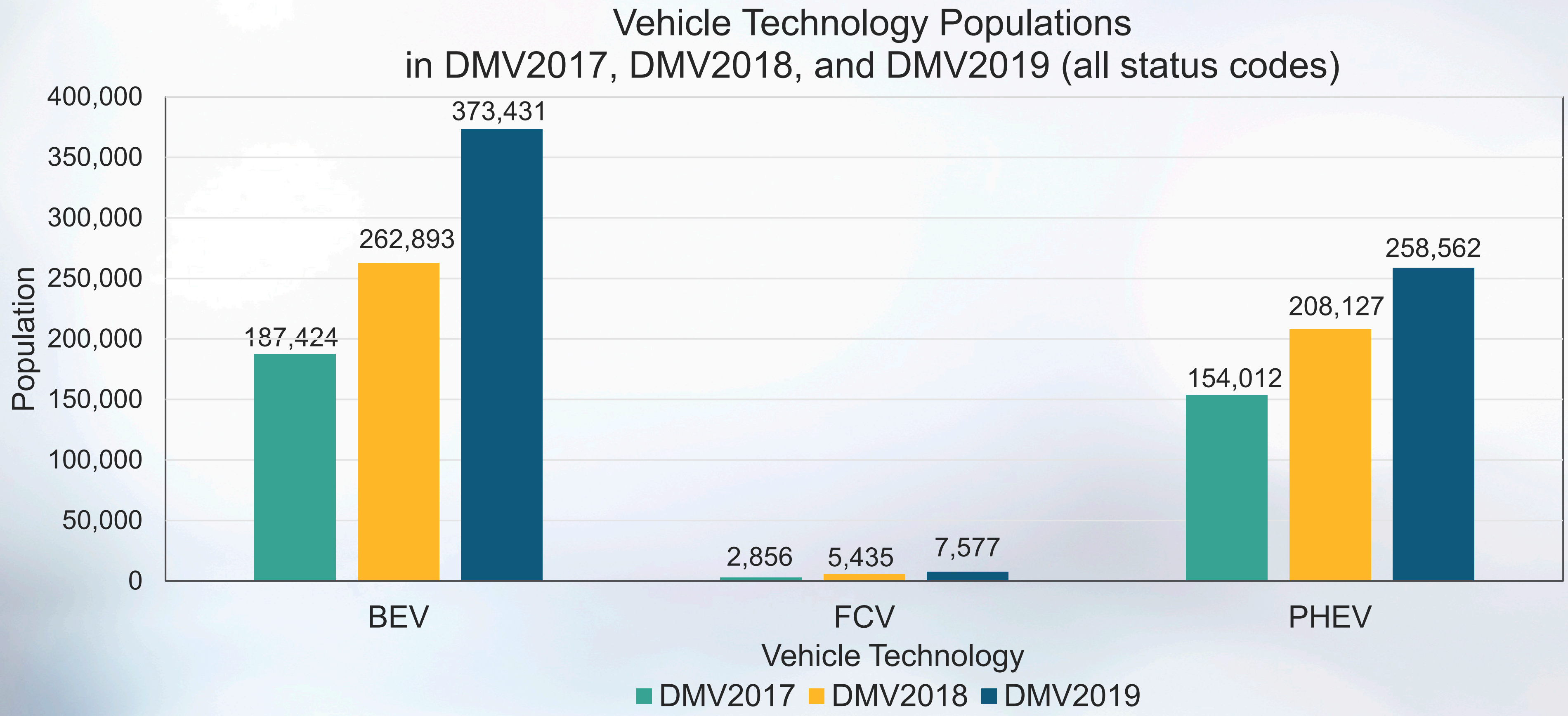
On-road Population Growth for Advanced Technology Vehicle Groups (all status codes)



DMV registration status codes include C (currently registered), E (evidence of use), N (not currently registered), P (planned non-operational), R (prior history), and S (pending status).

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Population of CA Registered On-Road Vehicles

Vehicle Category	Gross Vehicle Weight Rating	2016	2017	2018	2019
Passenger Cars	N/A	14.6M	14.5M	14.5M	14.5M
Light-Duty Trucks	GVWR < 6000 lbs.	6.8M	6.9M	7.1M	7.3M
	6,001 - 8,500 lbs.	5.2M	5.3M	5.5M	5.8M
Light-Heavy-Duty Trucks	8,501 - 10,000 lbs.	872,000	911,000	918,000	939,000
	10,001 - 14,000 lbs.	185,000	197,000	201,000	212,000
Medium-Heavy-Duty Trucks**	14,001 - 16,000 lbs. 16,001 - 19,500 lbs. 19,501 - 26,000 lbs. 26,001 - 33,000 lbs.	295,000	303,000	303,000	315,000
Heavy-Heavy-Duty Trucks**	GVWR > 33,000 lbs.	222,000	225,000	227,000	205,000
Buses	ALL	79,000	86,000	85,000	86,000
Total*		**27.2M**	**27.1M**	**27.3M**	**27.8M**

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

** The population is only reflective of CA registered trucks and does not account for out of state trucks driving on California roadways

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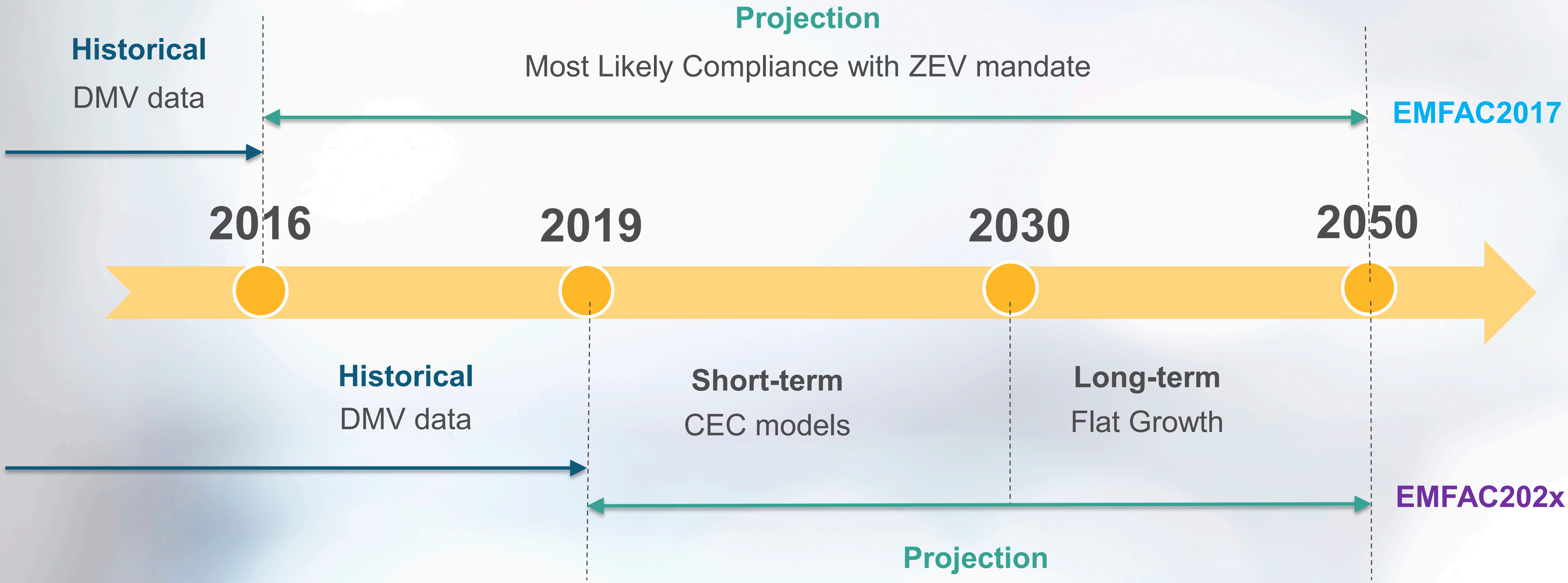
Major Findings

- Gasoline passenger cars and light-duty truck populations are lower than those forecasted by EMFAC2017 for calendar years 2017-2019
- New sales for gasoline passenger cars and diesel light-duty vehicles have declined after 2016
- Electric passenger cars are continuing to increase but electric trucks are lower than that predicted by EMFAC2017
- No significant change in the counts of light-duty vehicles by model year is observed (small increase after 2015)

Light-Duty Vehicles

ZEV Market Share Projection

ZEV Sales Modeling in EMFAC



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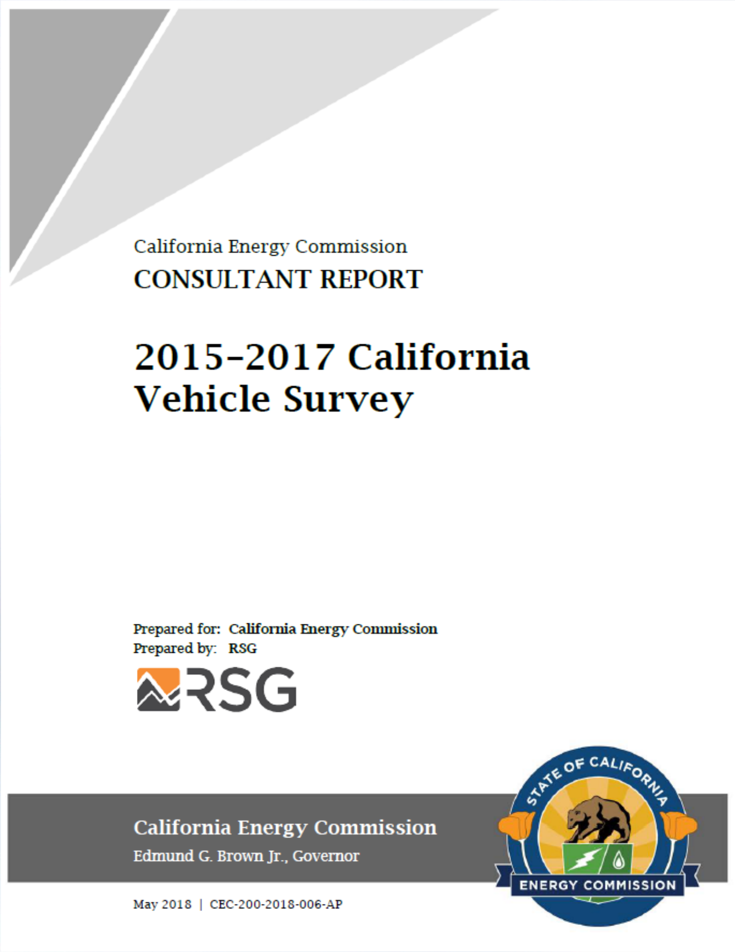
Projections of ZEV Sales in CEC Models

- **Personal vehicle choice (PVC) & Commercial vehicle choice (CVC) models**
  - Long history of development since 1983
  - Important components used for policymaking in CA:
    - predicting demand for alternative fuel vehicles
    - forecasting future transportation energy consumption
    - performing analysis under a variety of scenarios
- **Projections for rental and governmental sectors in 2019 Integrated Energy Policy Report (IEPR)**

California Specific Data in CEC Models

- Model coefficients were estimated based on the California Vehicle Survey
- The survey represents geographic distribution of households and businesses across CA
- The survey collected 3,614 residential responses (including 315 PEV owner surveys) and 1,712 commercial responses (including 285 PEV owners)



CEC PVC model

Current year stock
(fuel type, vintage, vehicle class)

Next year stock
(fuel type, vintage, vehicle class)

…… 2030

Vehicle attributes

Socioeconomic variables

Incentives

Fuel price

Personal Vehicle Choice Model

Change in # of households that have 0, 1, 2, 3+ vehicles

Probability of a household replacing vehicles

Probability of purchasing/dropping vehicles of a particular class, age, and fuel type

Statewide vehicle stock (sales)

Update ZEV Input Attributes for EMFAC Purposes

- **Vehicle attributes**
  - Vehicle price
  - Fuel economy
  - Range
- **Incentives**
  - Clean Vehicle Rebate Project (CVRP)
  - HOV lane policy

Major Data Sources

- **ZEV vehicle attributes:**
  - Vehicle price: WARDS Intelligence
  - Fuel economy and range from DOE/EPA: https://fueleconomy.gov/
  - New Sales: IHS/POLK
  - Projections: ICCT White Paper (2018)
- **Incentives:**
  - CVRP Rebate: CARB's Annual Funding Plan
  - HOV Lane: California Vehicle Code (CVC) §§5205.5 and 21655.9

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Update Projections for Vehicle Attributes for PHEV and BEV

Step 1: Calculate base-year (2018) sales-averaged attributes

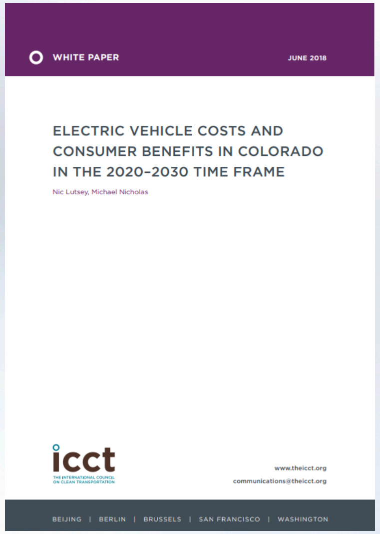
Data Driven

The base year will be updated to 2019

Step 2: Make assumptions for future trend

ICCT white paper

Regulatory teams at CARB


WHITE PAPER JUNE 2018

ELECTRIC VEHICLE COSTS AND CONSUMER BENEFITS IN COLORADO IN THE 2020–2030 TIME FRAME

Nic Lutsey, Michael Nicholas

icct

www.theicct.org
communications@theicct.org

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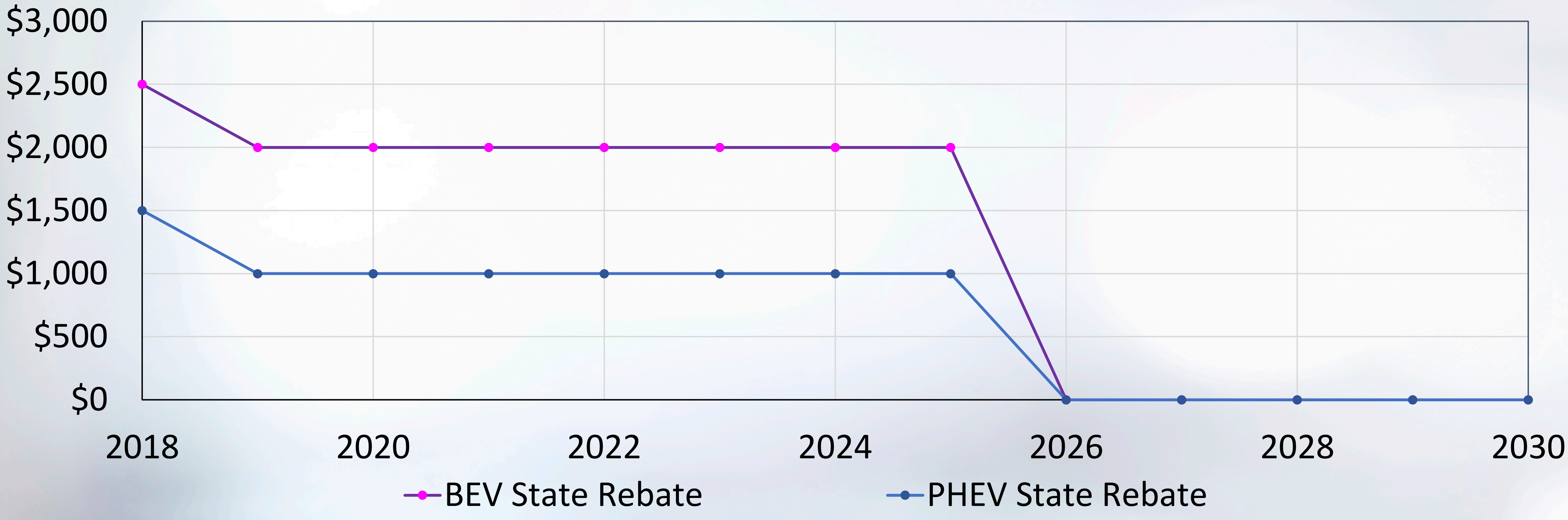
For vehicle classes that are not available in the base year, CARB would follow CEC projections for IEPR2019 Reference scenario.

Update Projections for Incentives



- HOV lane incentives will end in 2025

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Convert CEC Models Output to EMFAC Input

CEC PVC and CVC models output new sales by fuel type & CEC vehicle classes

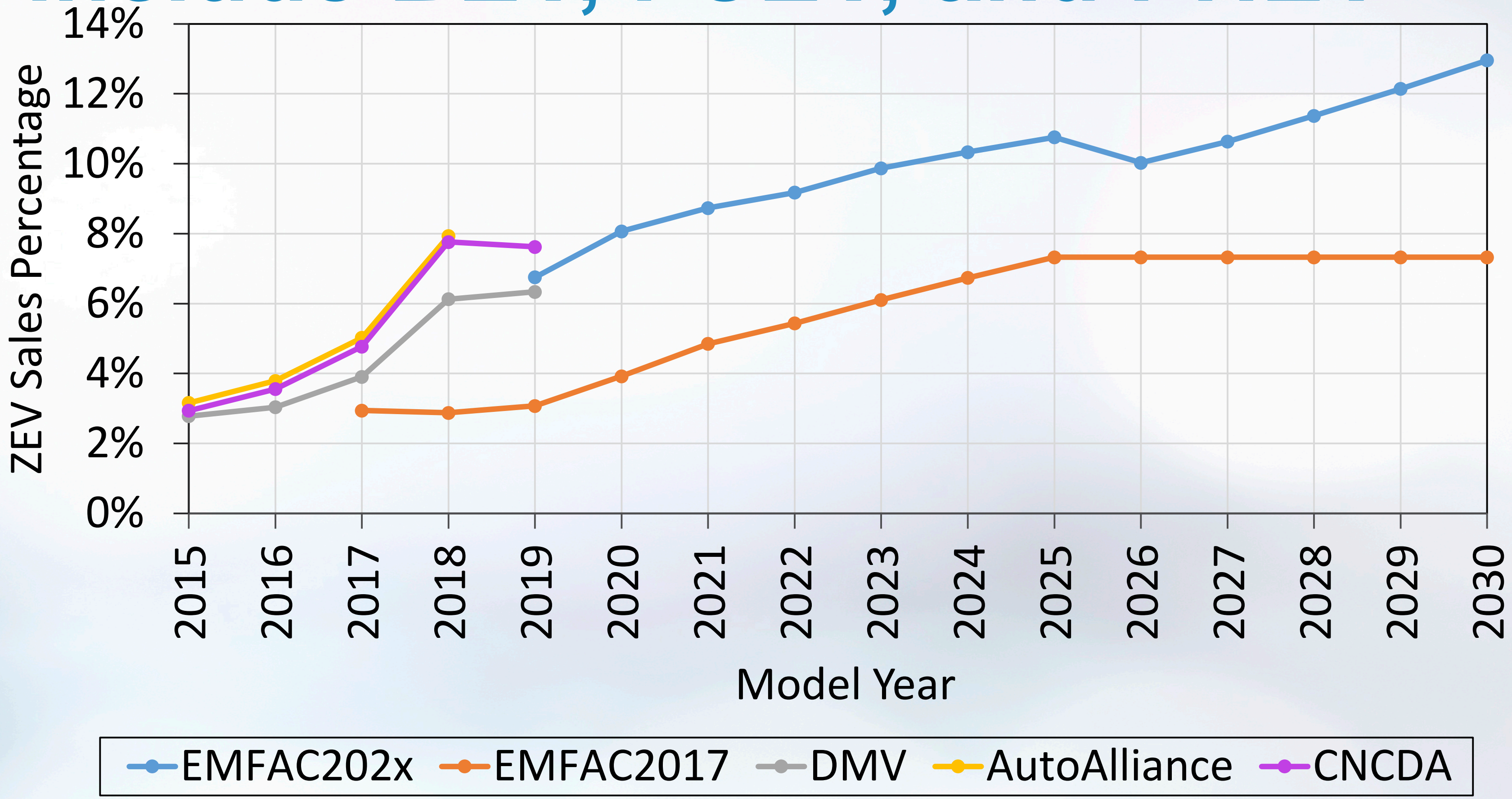
BEV, PHEV, FCEV sales	Vehicle sales of all fuel types

Calculate percentage of ZEV in new sales by EMFAC vehicle classes

PHEV % in new vehicle sales	BEV+FCEV % in new vehicle sales

Preliminary results

ZEV Market Share: Include BEV, FCEV, and PHEV



* AutoAlliance and CNCDA reported sales are for calendar years

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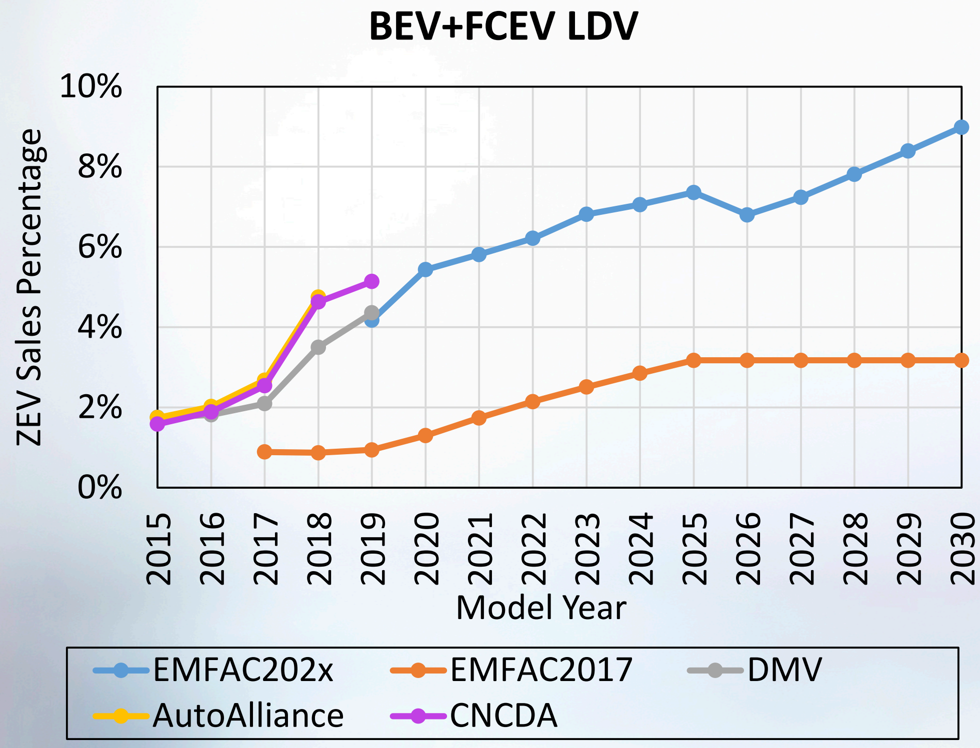
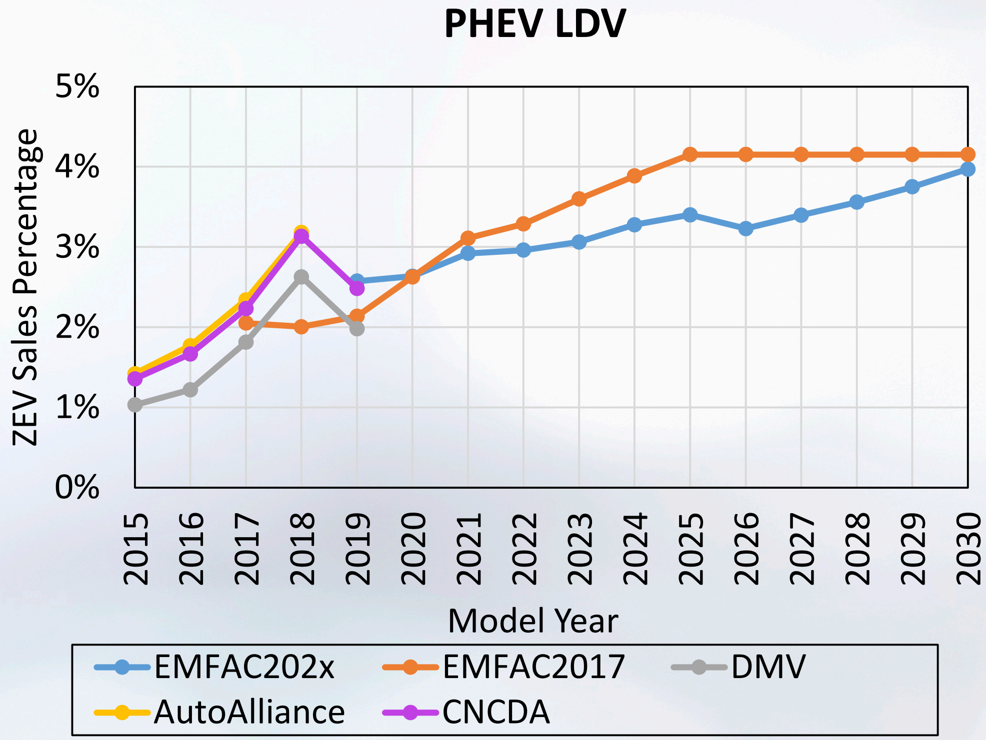
ZEV Market Share: Separate BEV+FCEV and PHEV





* AutoAlliance and CNCDA reported sales are for calendar years

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Next Steps

- Improve ZEV market share projections
  - Fine-tune ZEV input attributes to CEC models (price, fuel economy, and range)
  - Calibrate model results to ZEV sales of EMFAC vehicle classes in 2019 DMV data
- Spatially resolved ZEV sales projections (TBD)
  - Project GAI level sales based on statewide ZEV growth rate

  OR

  - Project ZEV sales based on regional socioeconomic factors

Light-Duty Vehicles

VMT and New Vehicle Sales Forecasting

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Outline

- Introduction
- Modeling approach and data sources
- Historical and projected input data
- Modeling results
- Conclusions

Introduction

- EMFAC2017 utilized a static multivariate regression analysis
- Latest available statewide historical socioeconomic data and an improved multivariate regression analysis are used to update California-specific econometric models in EMFAC202x
- New models are used to forecast future statewide new vehicle sales and VMT of light-duty vehicles (LDV)

Statistical Modeling Approach

- Econometric approach
- Performed Ordinary Least Squares (OLS) multivariate regression analysis on numerous parameter combinations:
    - Gross domestic product (GDP), unemployment rate, housing starts, gas price, and federal Interest rate, disposable income, 1 and 2-year lagged variables
- Historical socioeconomic data included years 2001 – 2019, and projected input data used for forecasting included data for years 2019 up to 2050

Statistical Modeling Approach Cont.

- Investigated reasonableness of each combination and picked the best model for new vehicle sales and VMT
- The reasonableness test included the following criteria
  - Parameters coherency
  - Sign validity for the coefficients
  - Meaningfulness of t-statistic value
  - Overall impact on the future trends up to 2050

Data Sources

Data sources included the following:

- UCLA Anderson Forecast 2018 and 2020 reports
- California Energy Commission (CEC)
- CA Department of Finance, 2020
- CA Department of Tax and Fee Administration (CDTFA), 2019 Motor Vehicle Fuel Tax (MVF)
- Federal Reserve Economic Data, Federal Reserve Bank of St. Louis, 2019

Updated New Vehicle Sales Equation

New vehicle sales per capita =

0.05744068 – 0.004672403 x UR + 0.00271036 x L1_UR

p-value			R^2
Intercept	**UR**	**L1 UR**	
2.35×10^{-13}	4.17×10^{-7}	2.29×10^{-4}	89%

Where:

UR is unemployment rate

L1 UR is the same as unemployment rate (UR) with one year lag

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Updated VMT Equation

VMT (miles per year) =

– 381.5 – 13.75 x GAS_PRICE + 18.9 x POP + 0.0249 x L1_HS_STRT

p-value				R^2
Intercept	GAS PRICE	POP	L1 HS STRT	
2.7×10^{-8}	1.1×10^{-5}	5.4×10^{-12}	9.3×10^{-7}	98%

Where:

GAS PRICE is gas price in dollars

POP is population in millions

L1 HS STRT is 1-year lagged housing starts in thousands

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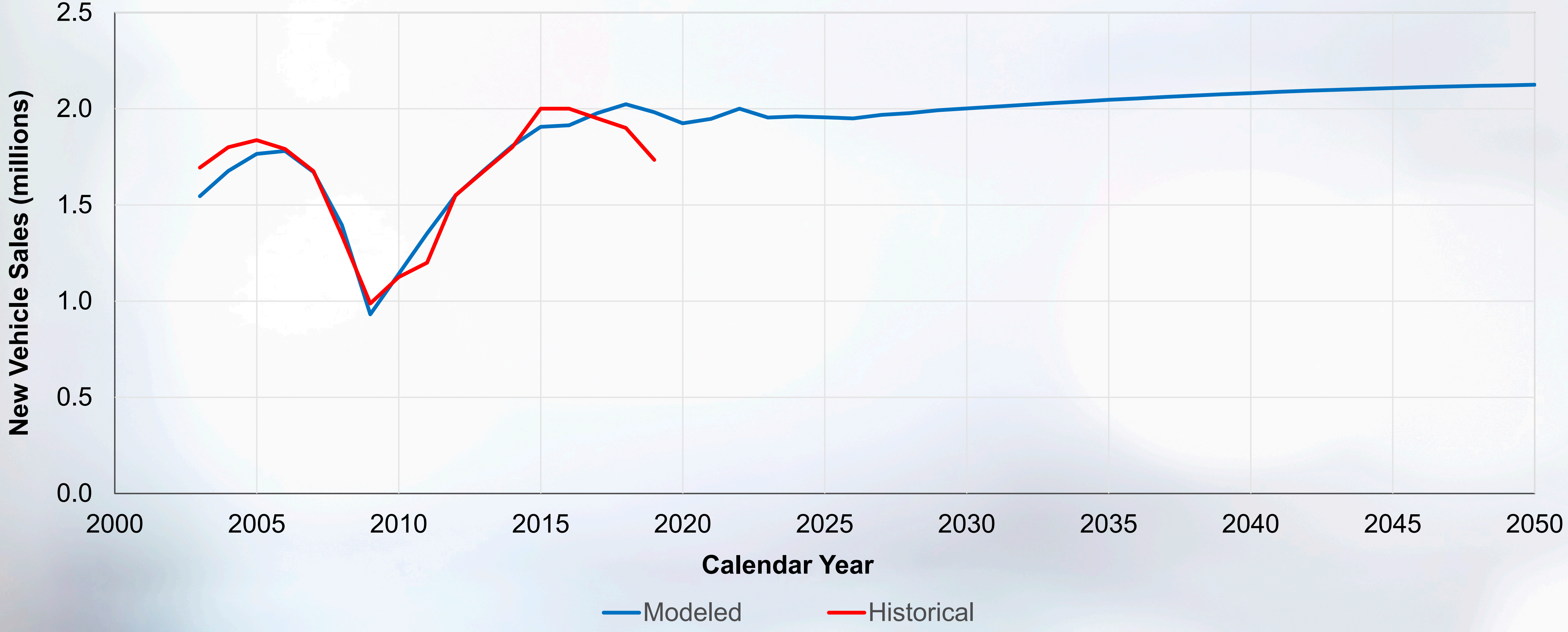
New Vehicle Sales Trend EMFAC202x



- Model predicts the drop in sales in 2009 resulting from the economic recession
- Slight drop starting in 2015 - econometric modeling unable to explain
- Based on UCLA Anderson Forecast reports; may differ compared to DMV October counts

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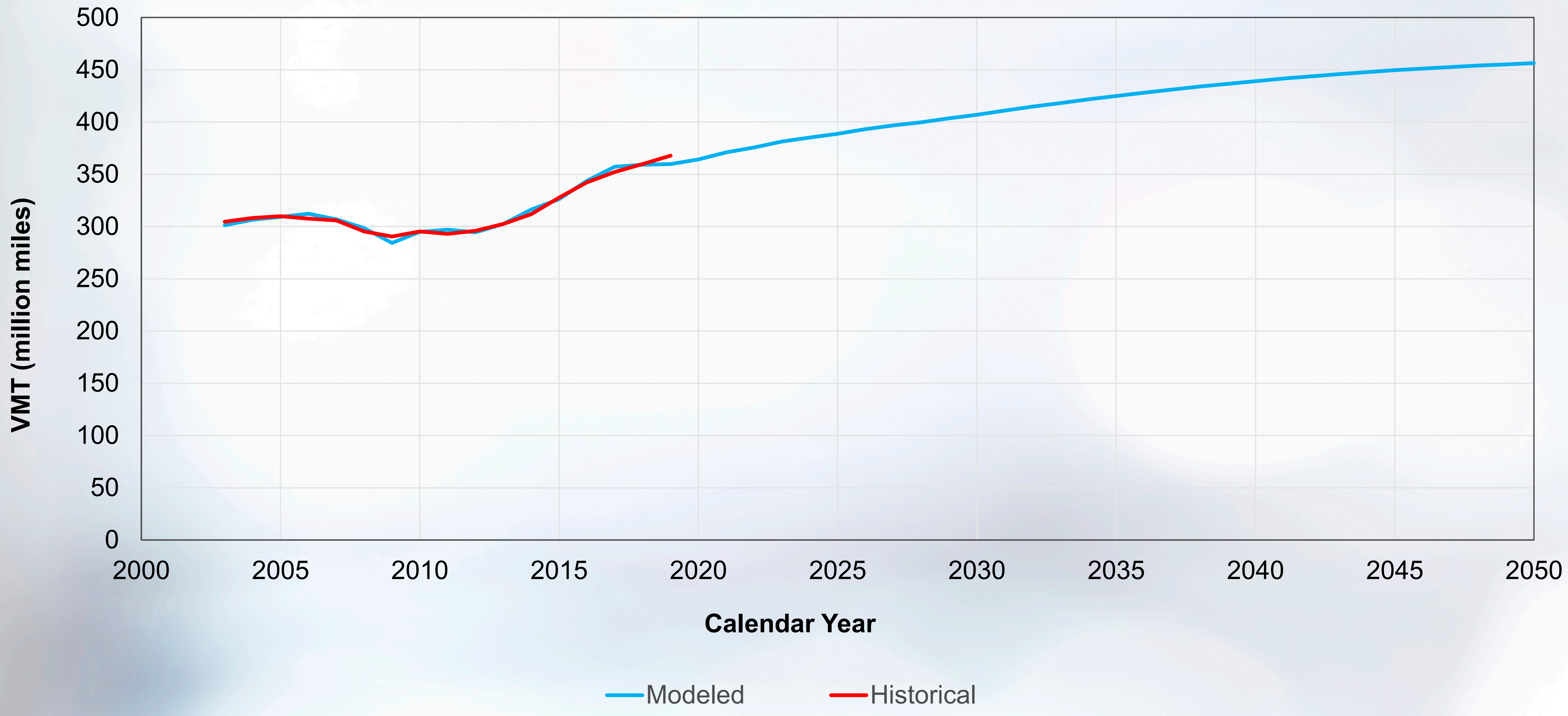
VMT Trend EMFAC202x



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Calculation of Historical VMT

- **Step 1:** Statewide fuel sales data obtained from California Department of Tax and Fee Administration (CDTFA)
- **Step 2:** EMFAC2017 run estimated statewide CO_2 emissions and VMT for historical years
- **Step 3:** Using a value of 8,480 g CO_2 per gallon of gasoline, an average statewide fuel economy was developed
- **Step 4:** The average statewide fuel economy from Step 3 was used to recalculate the statewide VMT using CDTFA fuel usage from Step 1

Conclusions

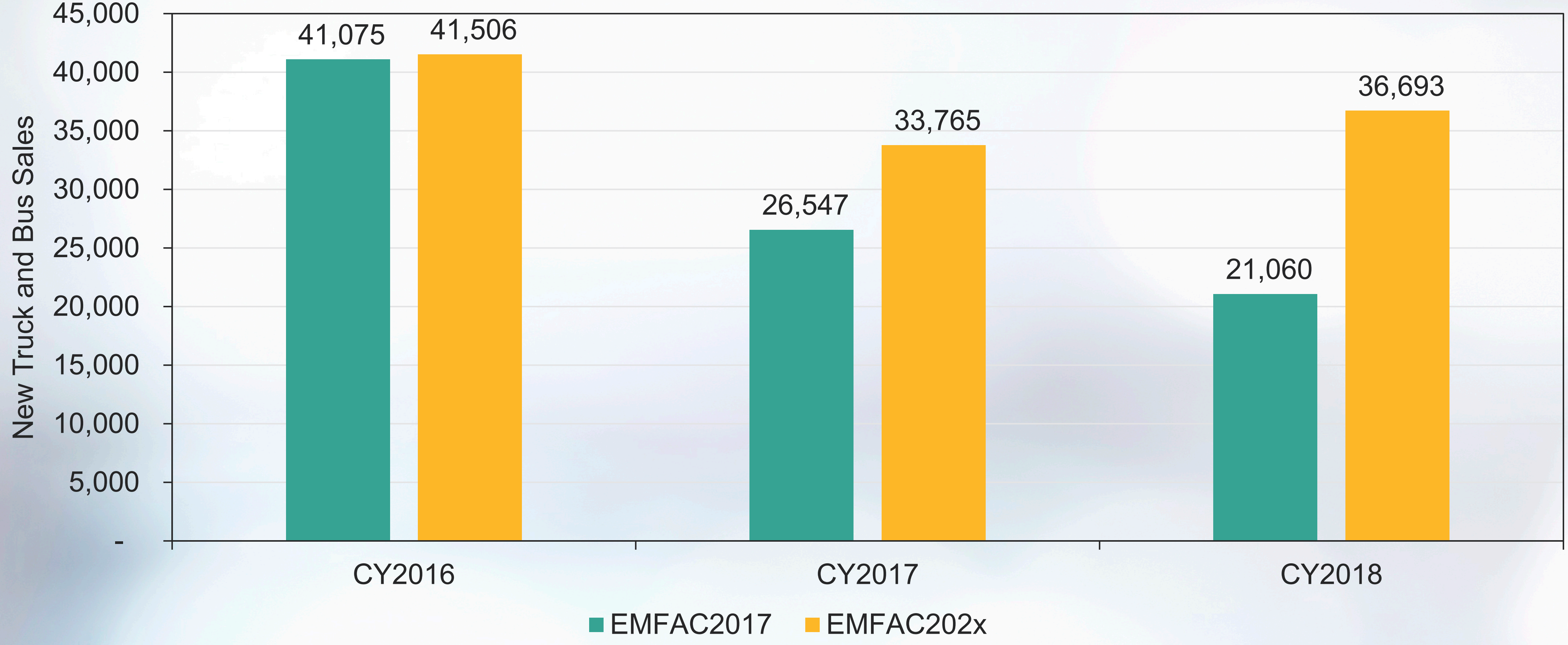
- New vehicle sales and VMT equations were updated with the latest data
- Models depending on historical data such as unemployment rate and population: Designed to represent business-as-usual conditions
- COVID-19 social and economic impacts: Uncertainty for both short- and long-term forecasting
- Projections will be revised based on future data

Heavy-Duty Vehicles (HDV)

Fleet Characterization

In-state Truck & Bus New Sales (Includes CA IRP, excludes Transit Buses)

- New sales in years 2017 and 2018 exceeded EMFAC2017 forecasts



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Diesel Truck and Bus Rule (Engine Replacement Requirement)

- Starting in January 2020, California Department of Motor Vehicles began withholding vehicle registrations in 2020 for vehicles not meeting CARB diesel rules

- Owners of Heavy vehicles (above 26,000 lbs.) of model year 2000 and older and light vehicles (14,001 – 26,000 lbs.) of model year 2004 and older will not be able to renew their registration unless they are exempt or are using a provision under the truck and bus rule

CA.GOV

State of California
Department of Motor Vehicles

Effective January 1, 2020, the Department of Motor Vehicles (DMV) will begin verifying with the California Air Resources Board (CARB) that your diesel vehicle(s) is compliant with, or exempt from, its Truck and Bus Regulation, related to emission standards.
https://www.dmv.ca.gov/portal/dmv/detail/mcs/dieselcomp

EMFAC displays Chassis Model Years

CARB

Fleet Categories and Weight Groups

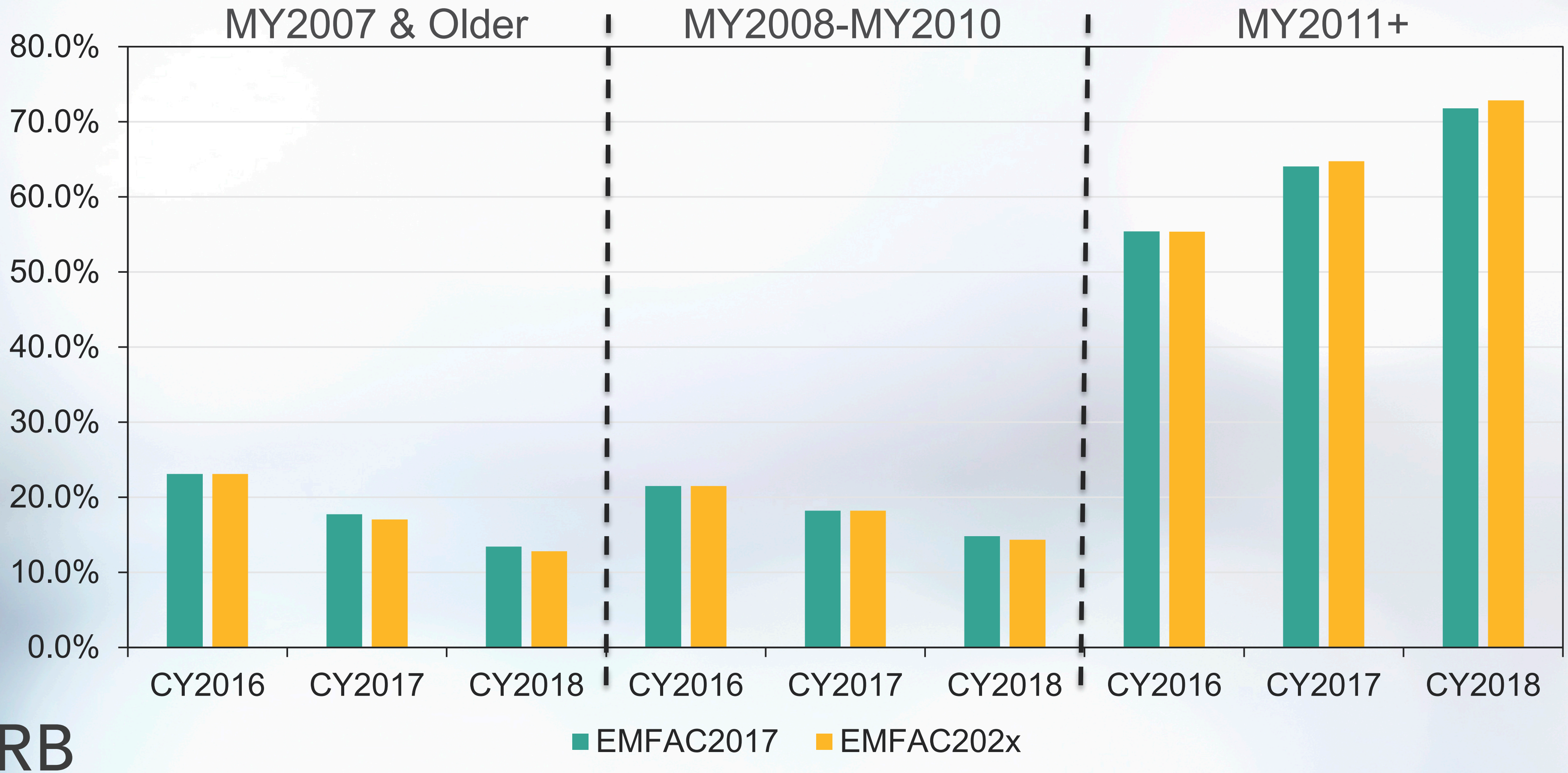
EMFAC Fleet Categories	Vehicle Weight Class Groups	Diesel Truck & Bus Rule
Medium Heavy-Duty (MHDT)	Class 4 (14,001-16,000 lbs. GVWR)	Lighter Vehicle (14,001-26,000 lbs. GVWR)
	Class 5 (16,001-19,500 lbs. GVWR)	
	Class 6 (19,501-26,000 lbs. GVWR)	
	Class 7 (26,001-33,000 lbs. GVWR)	Heavier Vehicle (>26,000 lbs. GVWR)
Heavy-Duty (HHDT)	Class 8 (>33,000 lbs. GVWR)	

GVWR = Gross Vehicle Weight Rating by Manufacturer

CARB

HHDT Interstate (IRP) Model Year (MY) Group Proportions

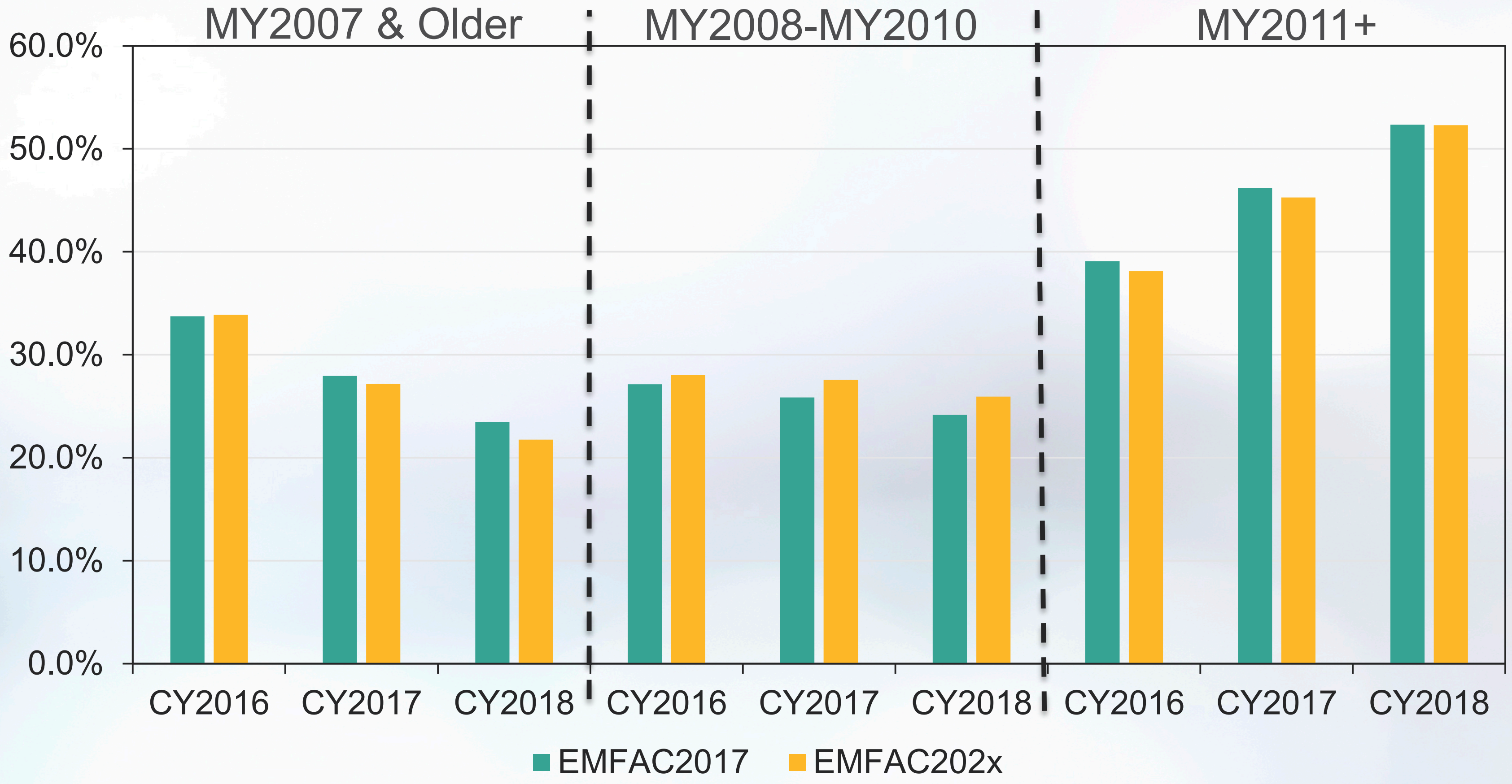
- In years 2017 and 2018, EMFAC2017 forecasts were close to the updated values for EMFAC202x



CARB

HHDT In-State Tractor MY Group Proportions

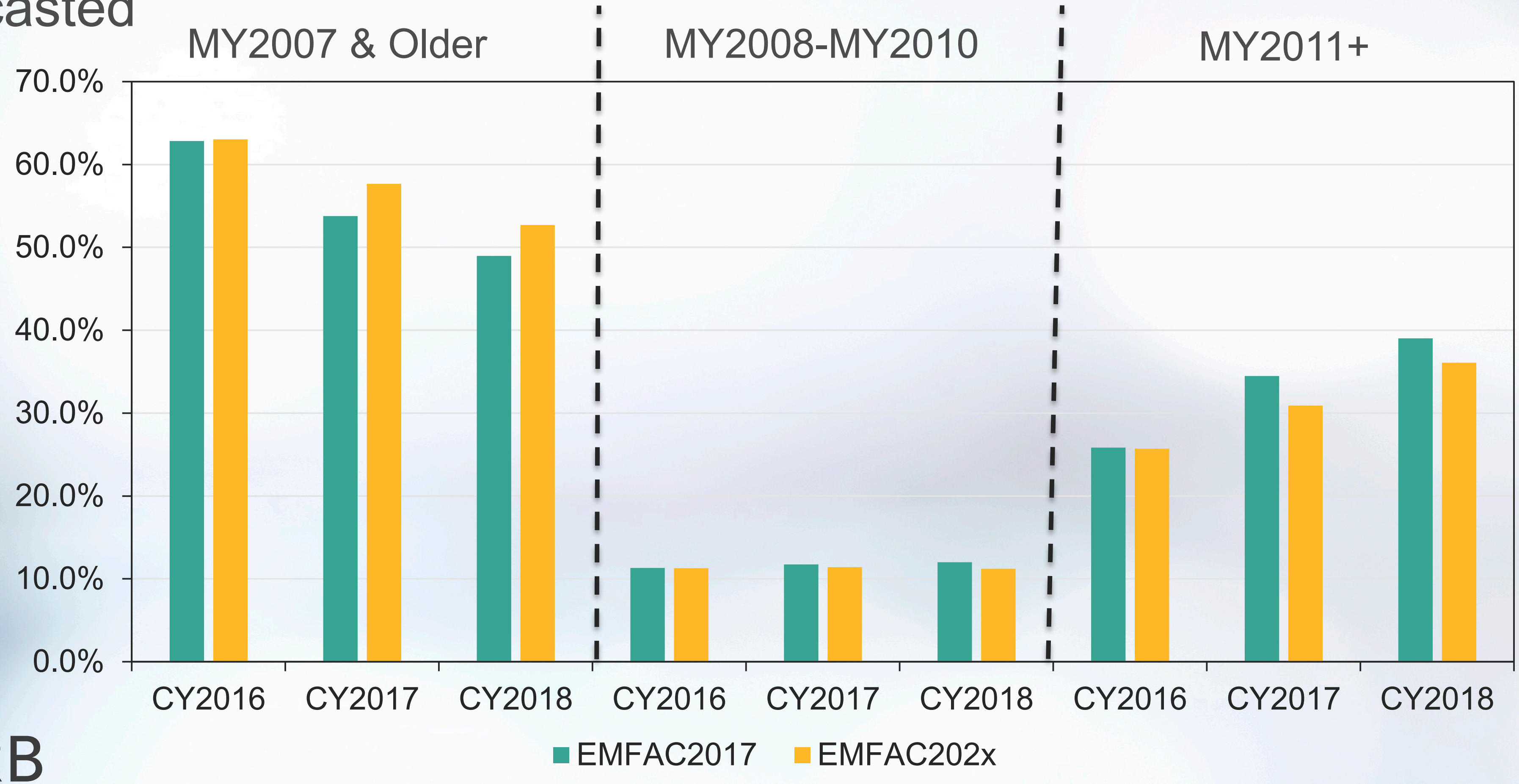
- In years 2017 and 2018, there were slightly lower percentages of MY2007 & Older and MY2011+ vehicles, and a higher percentage of MY2008-M2010 than EMFAC2017 forecasted



CARB

HHDT In-State Single MY Group Proportions

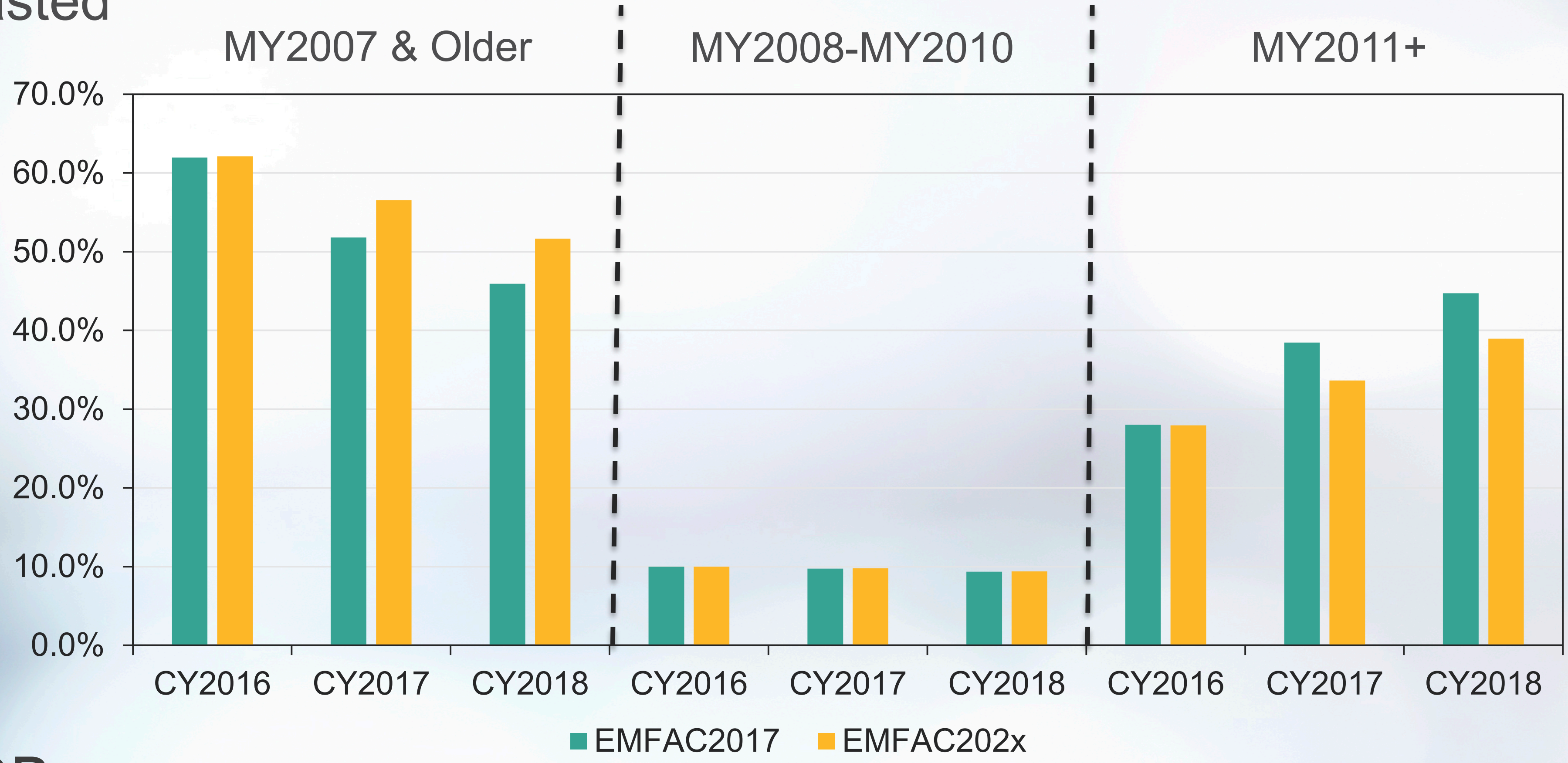
- In years 2017 and 2018, there were a higher percentage of MY2007 & Older & a lower percentage of MY2011+ vehicles than EMFAC2017 forecasted



CARB

MHDT In-State MY Group Proportions

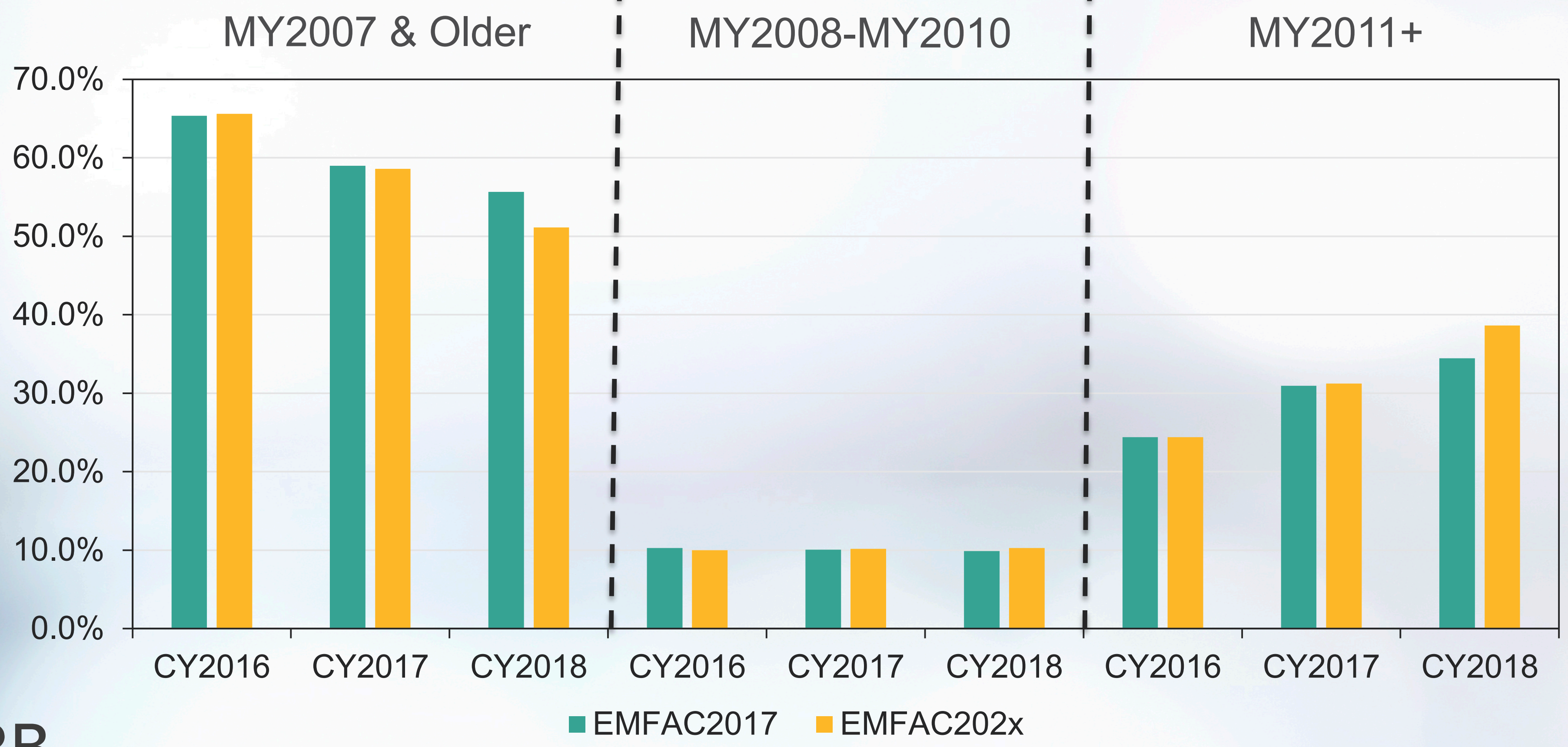
- In years 2017 and 2018, there were a higher percentage of MY2007 & Older & a lower percentage of MY2011+ vehicles than EMFAC2017 forecasted



CARB

Non-Transit Bus MY Group Proportions

- In years 2017 and 2018, EMFAC2017 forecasts were close to the updated values for EMFAC202x but with a lower percentage of MY2007 & Older and a higher percentage of MY2011+ Buses in CY2018



CARB

CARB Enforcement Efforts

- CARB increased enforcement efforts
  - ❑ Streamlined Truck Enforcement Program (STEP)*
    - ✓ Identified longest-standing non-compliant trucks
  - ❑ Nearly 24,000 vehicle registration holds were set at CA DMV by CARB on non-compliant vehicles by the end of 2019

*Refer to page 10 of the 2019 Enforcement Report at:
https://ww2.arb.ca.gov/resources/documents/enforcement-reports

CARB

Key Takeaways

- New trucks sales were higher than those estimated by EMFAC2017

- In-state fleets in 2018 were older than forecasted by EMFAC2017
- 2019 DMV registration data reflect actions taken by CARB's Enforcement Programs (e.g., STEPS)

- CA DMV registration holds started in CY2020 for vehicles not meeting CARB in-use diesel rules

Heavy-Duty Vehicles

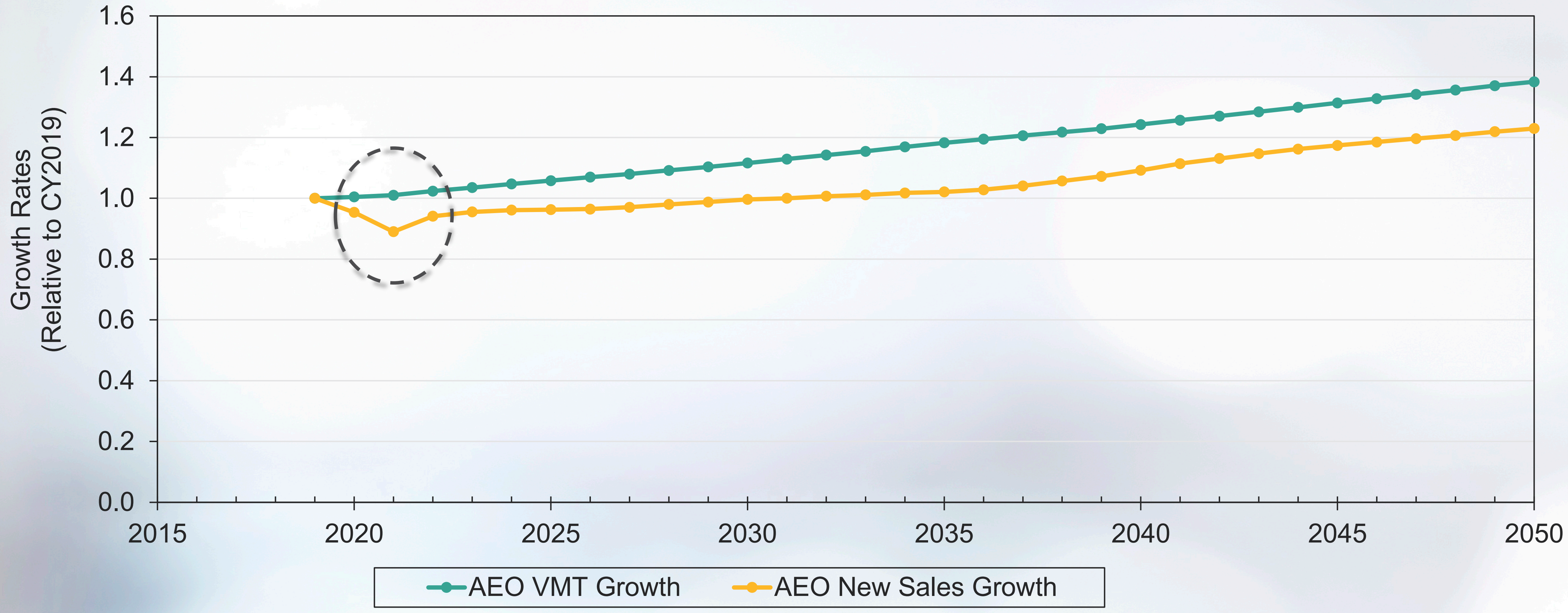
Activity Forecasting

CARB

Forecasting New Vehicle Sales

- In EMFAC2014 and EMFAC2017, CA's new HD sales growth rate used Annual Energy Outlook (AEO) national new HD sales growth, adjusted by AEO national vs. CA VMT growths
- EMFAC202x uses the same method with updated data:
  - Base year HD new sales
    - Sources: DMV and IRP for CY2019 (*new Base Sales*)
  - National new HD sales growth trend
    - Annual Energy Outlook 2020 (AEO2020) released in January 2020
  - California's HD VMT growth trend ratio
    - National (AEO2020) vs. California (will be discussed later)

AEO2020 National VMT & New Sales Growth



Note: In the AEO US model, the sales of new heavy and medium trucks are affected by investment in transportation equipment (and the relative price of gas).

CARB

Forecasting VMT

New data sources for VMT growth trends in EMFAC202x

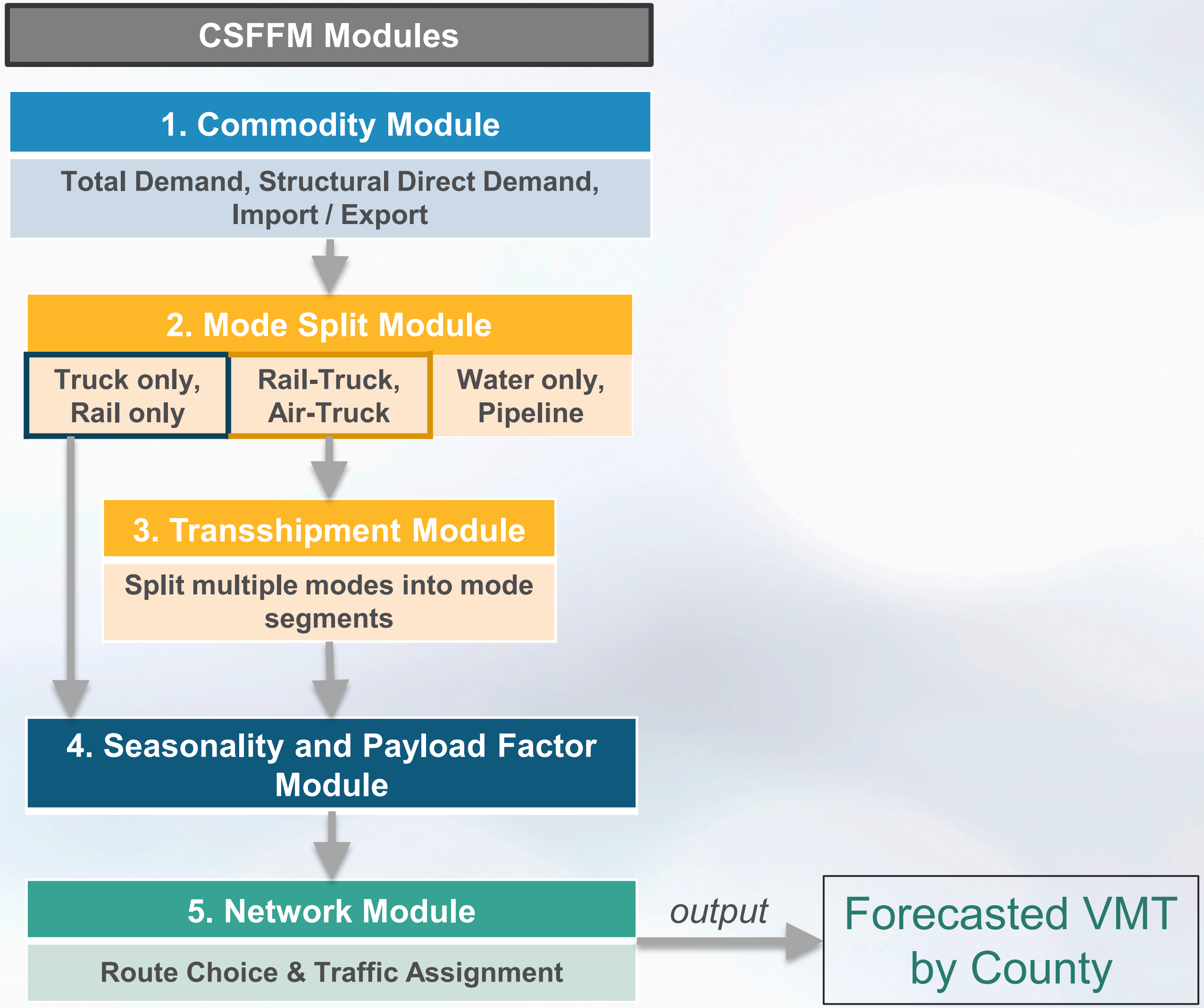
- **Drayage trucks:**
  - ❑ Forecasted cargo growth rates from Tioga (Port of Oakland) and Mercator (San Pedro Bay Ports) reports are used
  - ❑ Assuming no mode shift from truck to rail or vice versa
- **Most HD fleet categories:**
  - ❑ California Statewide Freight Forecasting Model (CSFFM)
- **Others:**
  - ❑ UCLA Anderson Annual Economic Forecasts

California Statewide Freight Forecasting Model (CSFFM)

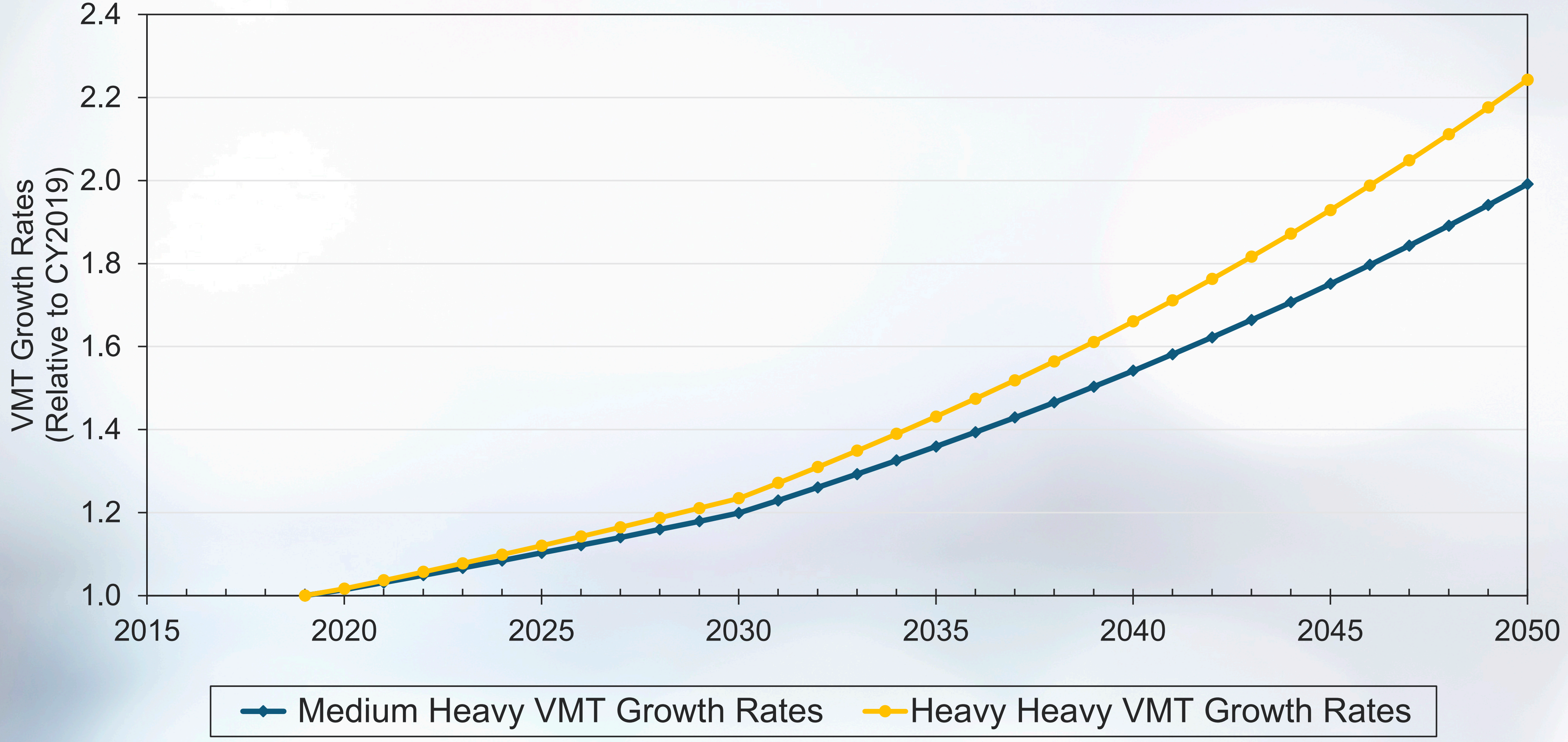
- Forecasts commercial vehicle and commodity flows within California
- Developed for the California Department of Transportation (Caltrans) in partnership with:
  - ❖ Other State Agencies
  - ❖ Metropolitan Planning Organizations (MPOs), and
  - ❖ Institute of Transportation Studies (ITS), UC Irvine
- Growth surrogates:
  - ❖ Import/export based on Freight Analysis Framework
  - ❖ Socioeconomic inputs consistent with Regional Transportation Plans (RTPs)

CSTDM/CSFFM
(California Statewide Travel Demand Model)

CSFFM Architecture



CSFFM VMT Growth Rates Statewide



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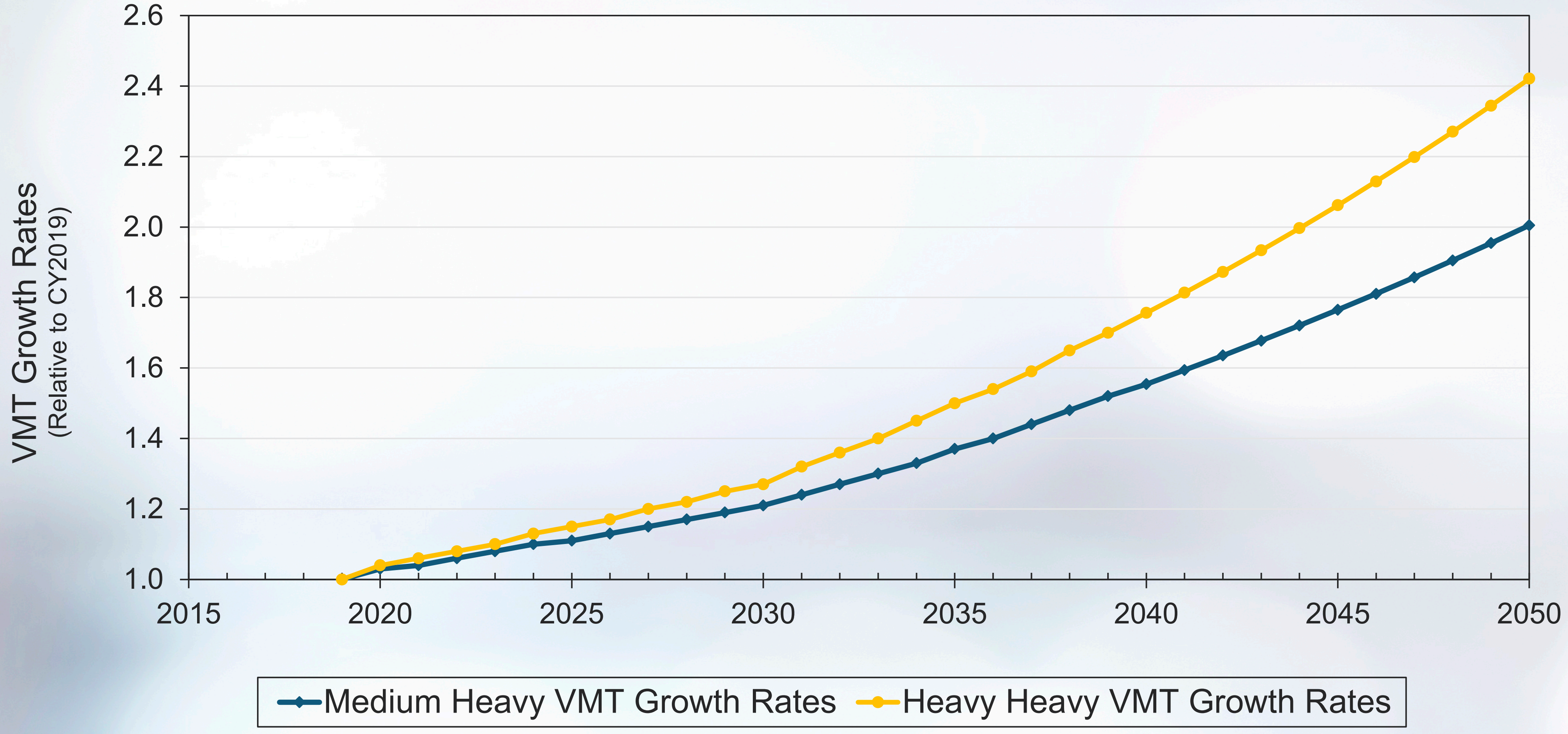
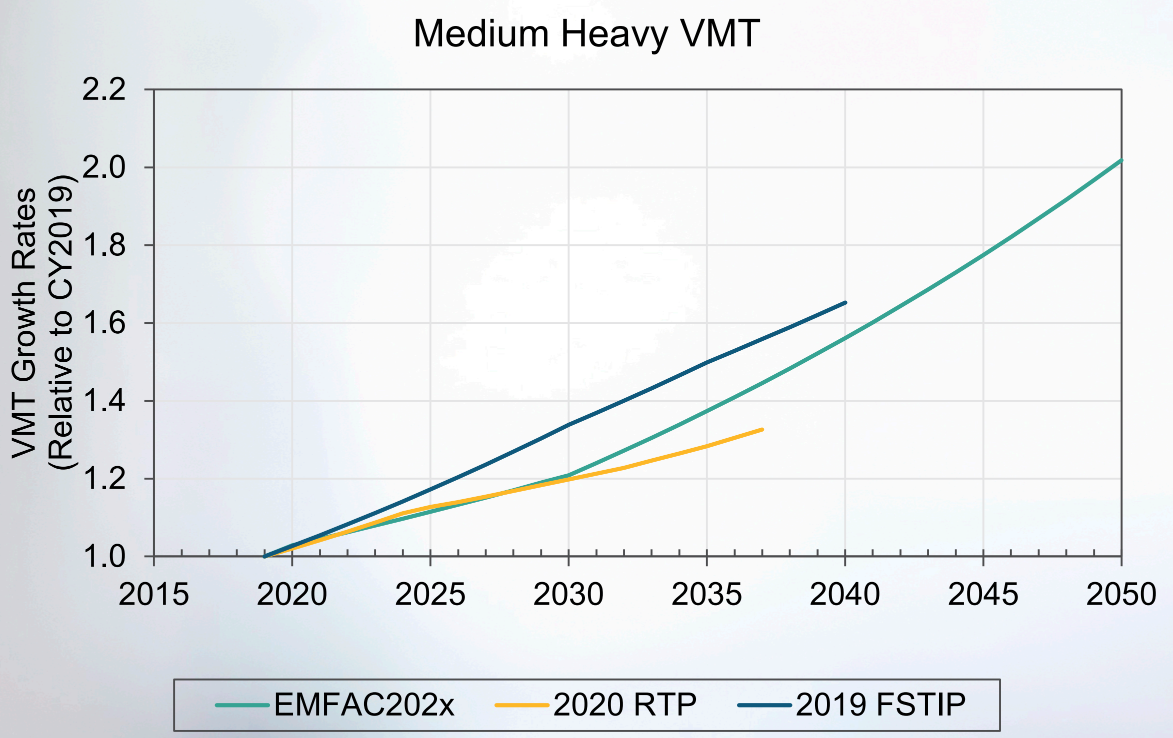
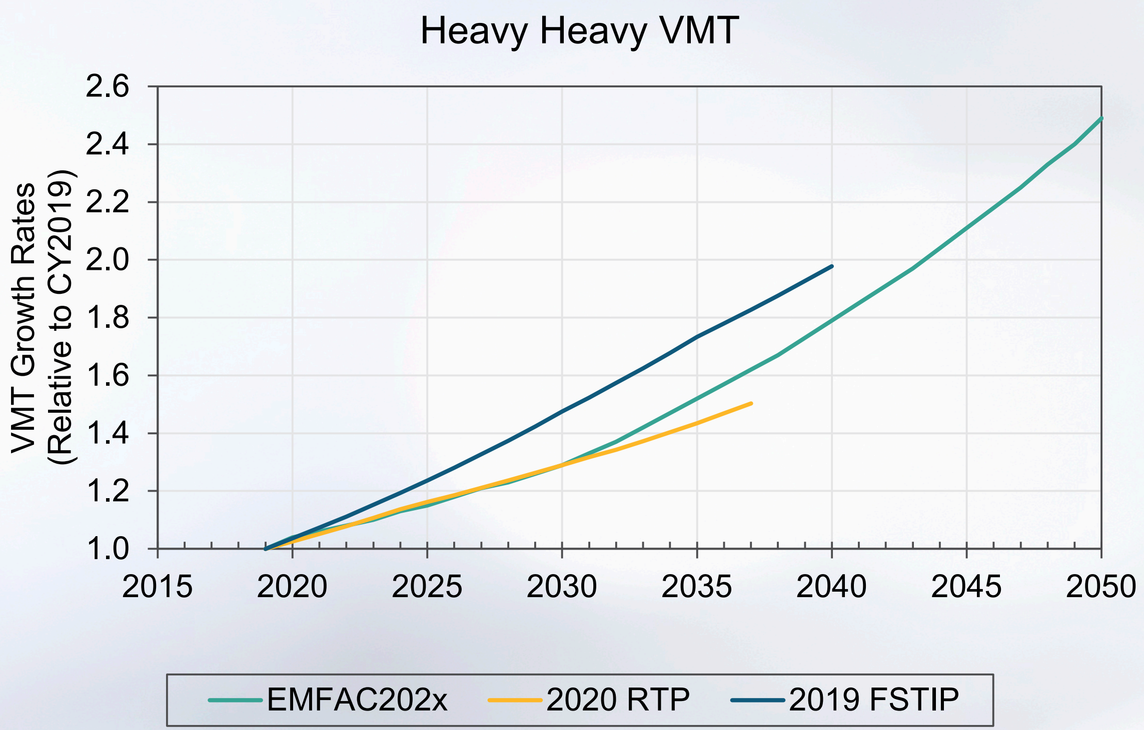
CSFFM VMT Growth Rates
South Coast Air Basin



South Coast Air Basin CSFFM includes the counties of Los Angeles, Orange, Riverside and San Bernardino

SCAG VMT Growth Rate Comparison





SCAG: Southern California Association of Governments

RTP: Regional Transportation Plan
(Adopted for federal transportation conformity purposes only)

FSTIP: Federal State Transportation Improvement Program

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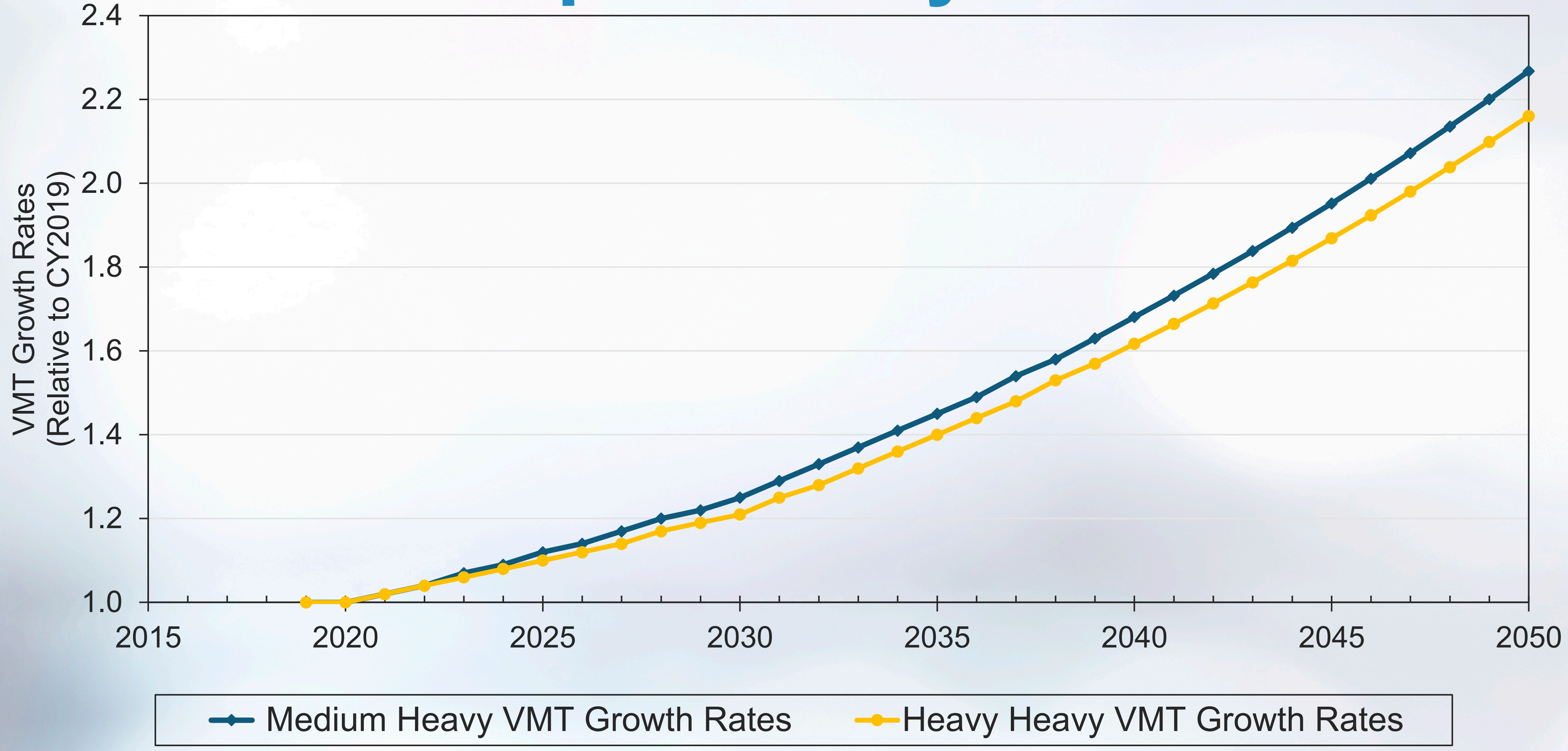
CSFFM VMT Growth Rates
San Joaquin Valley Air Basin



San Joaquin Valley Air Basin CSFFM includes the counties of Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare

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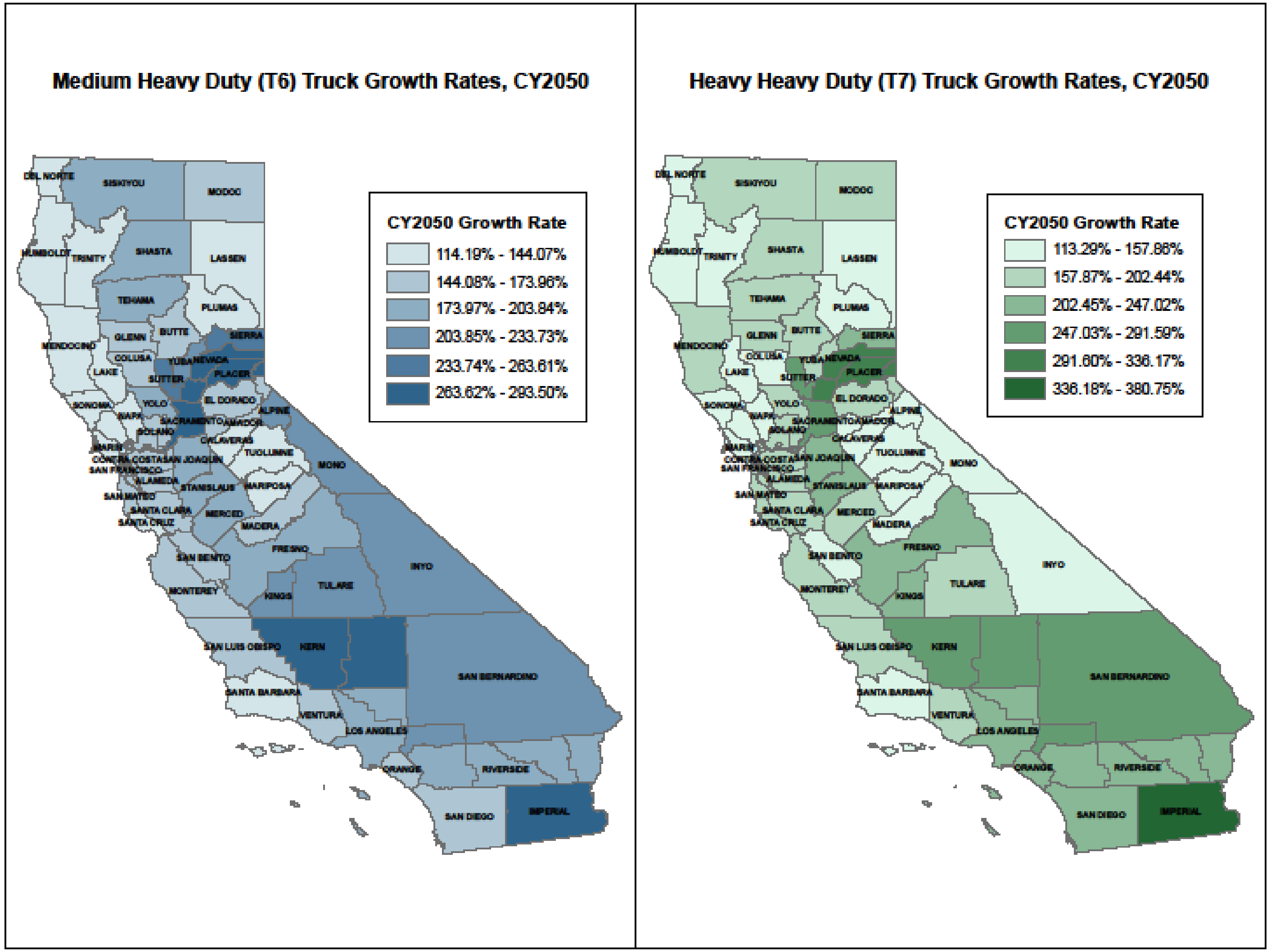
VMT Growth Rates by County in 2050

(Relative to CY2019)



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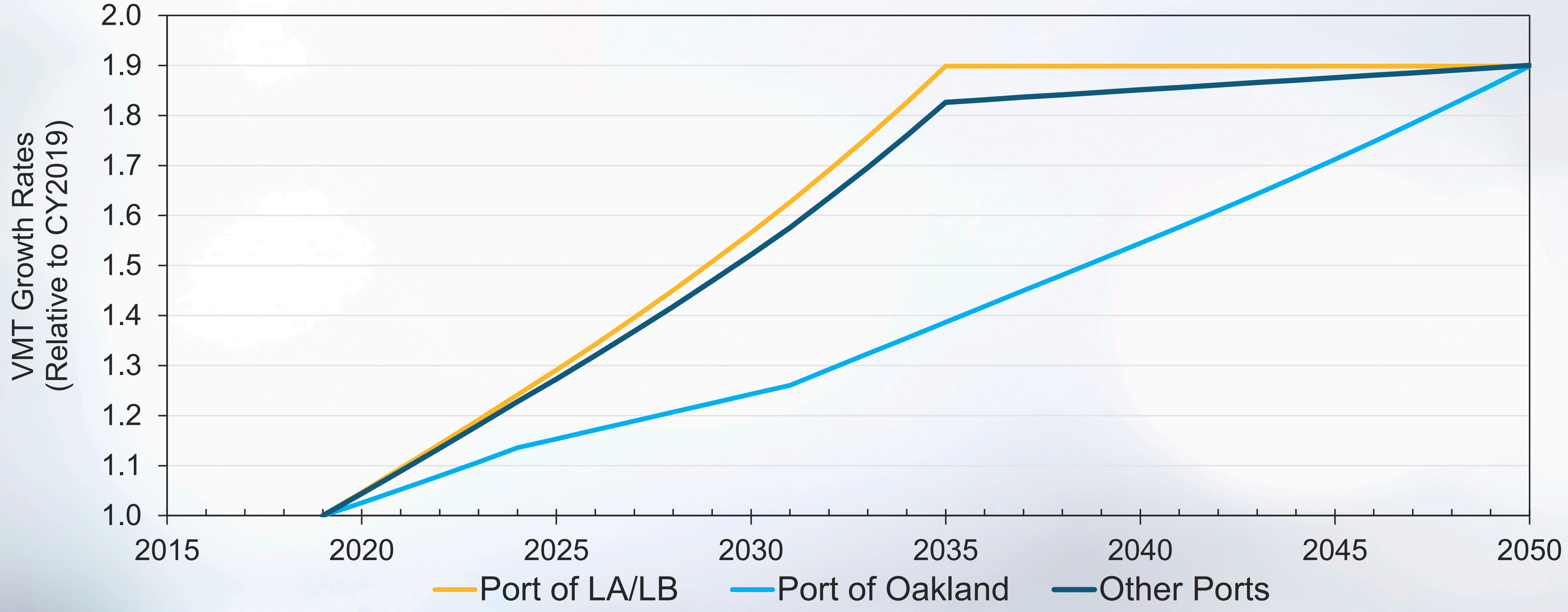
Drayage VMT Growth Rates



- Based on port specific forecasts of cargo growth rates
  - LA/LB: Mercator report (Feb. 2016)
  - Oakland: Tioga report (May 2020)
  - Other ports: weighted average of LA/LB (87.5%) and Oakland (12.5%)
- Does not account for mode shifts between truck and rail transport

CARB

Summary and Next Steps

- HDV inventory updated for DMV registration data for years 2017 and 2018
  - 2019 update is in process
- Updated growth rates will be used to forecast future new vehicle sales and VMT in EMFAC202x
  - *[NEW]* CSFFM county level VMT forecasts will be used to calculate VMT growth rates for most of the Heavy-Duty truck categories

Heavy-Duty Vehicles

Transit Bus Population

Transit Bus Module

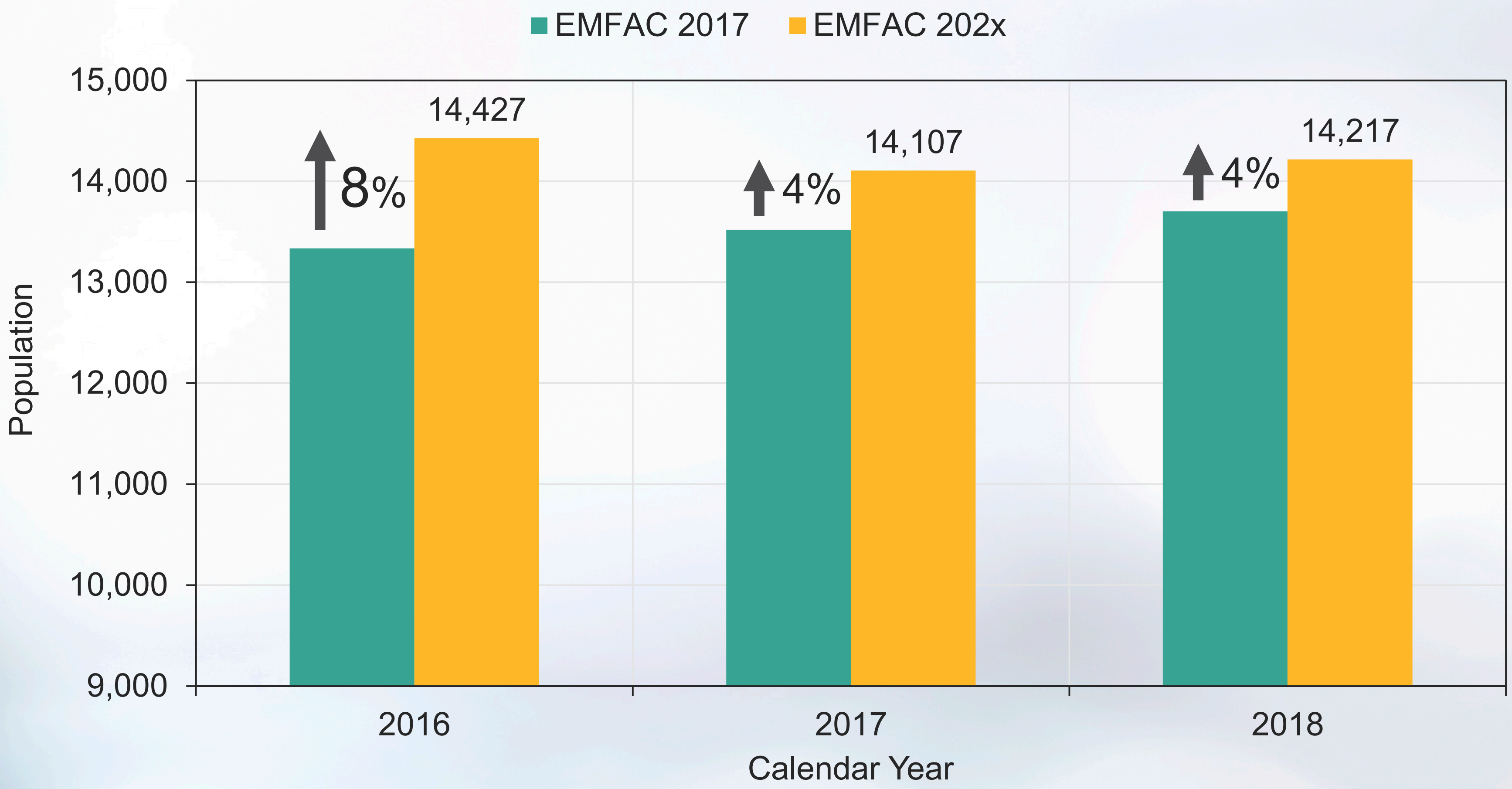
- Relatively new module (added during EMFAC 2017)
- Improve characterization of the urban transit fleets: fuel type, body type, and weight class, and the regional differences.
- Adopt new regulations: Innovative Clean Transit (ICT)

CARB

Summary of Data Sources

- Historical bus population and VMT:
  - National Transit Database (NTD)
  - Added 2016-2018 for EMFAC2020x
- Growth rates for population and VMT forecasting:
  - **MPO regions**: transit operation miles projections from Regional Transportation Plan (RTP)/Sustainable Communities Strategy (SCS)
  - **Non-MPO regions**: human population projections from Department of Finance (DOF)
  - Updated both based on the latest information for EMFAC202x
- Phase-in of Zero-Emission Buses (ZEBs):
  - Purchase requirements from Innovative Clean Transit (ICT) regulation, adopted by CARB in 2018.

Historical Bus Population



- EMFAC202x with updated NTD data shows 4%-8% higher bus population compared to EMFAC2017 forecasting
- There is a slight decrease in 2017 and 2018, relative to 2016

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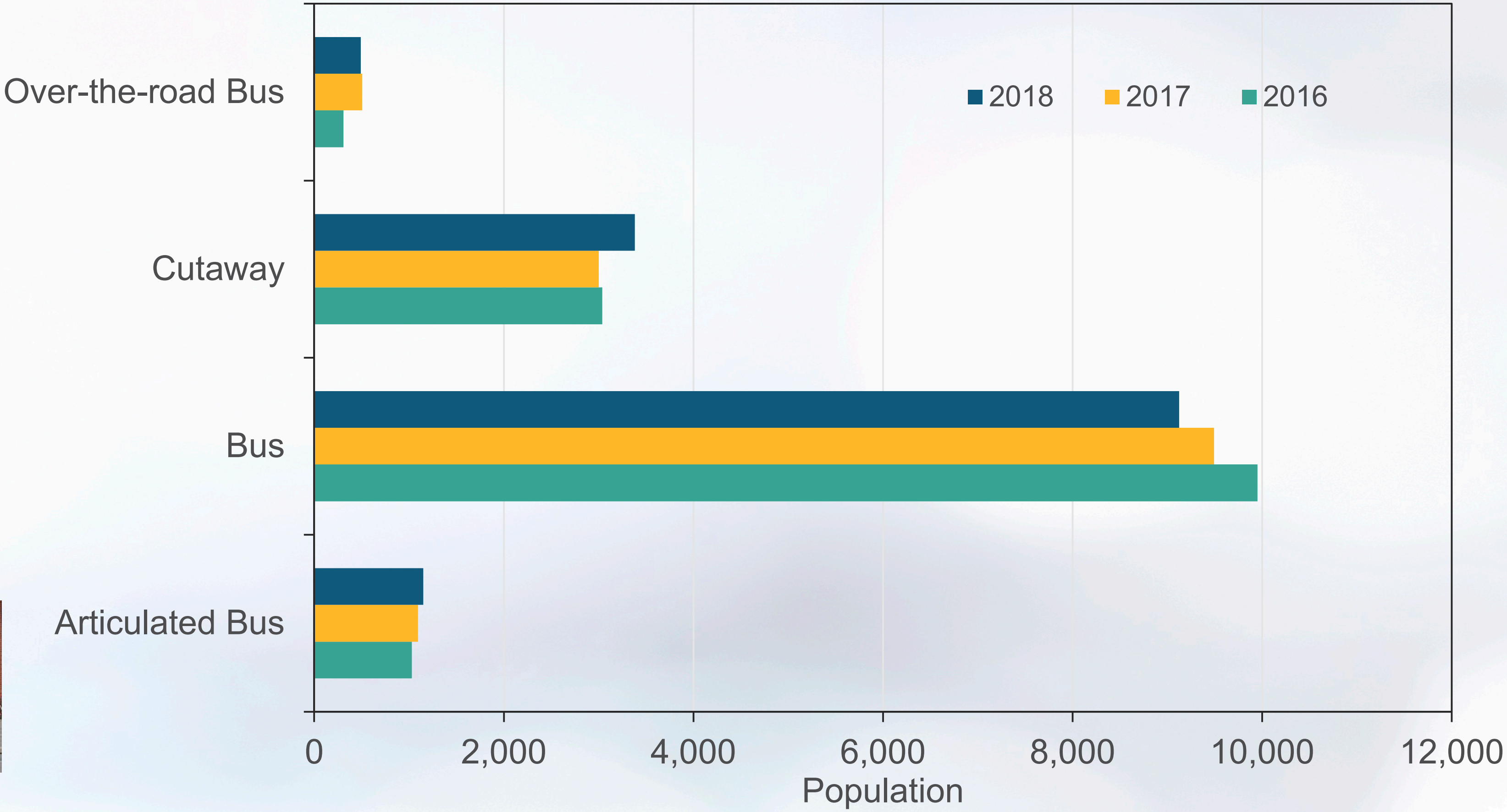
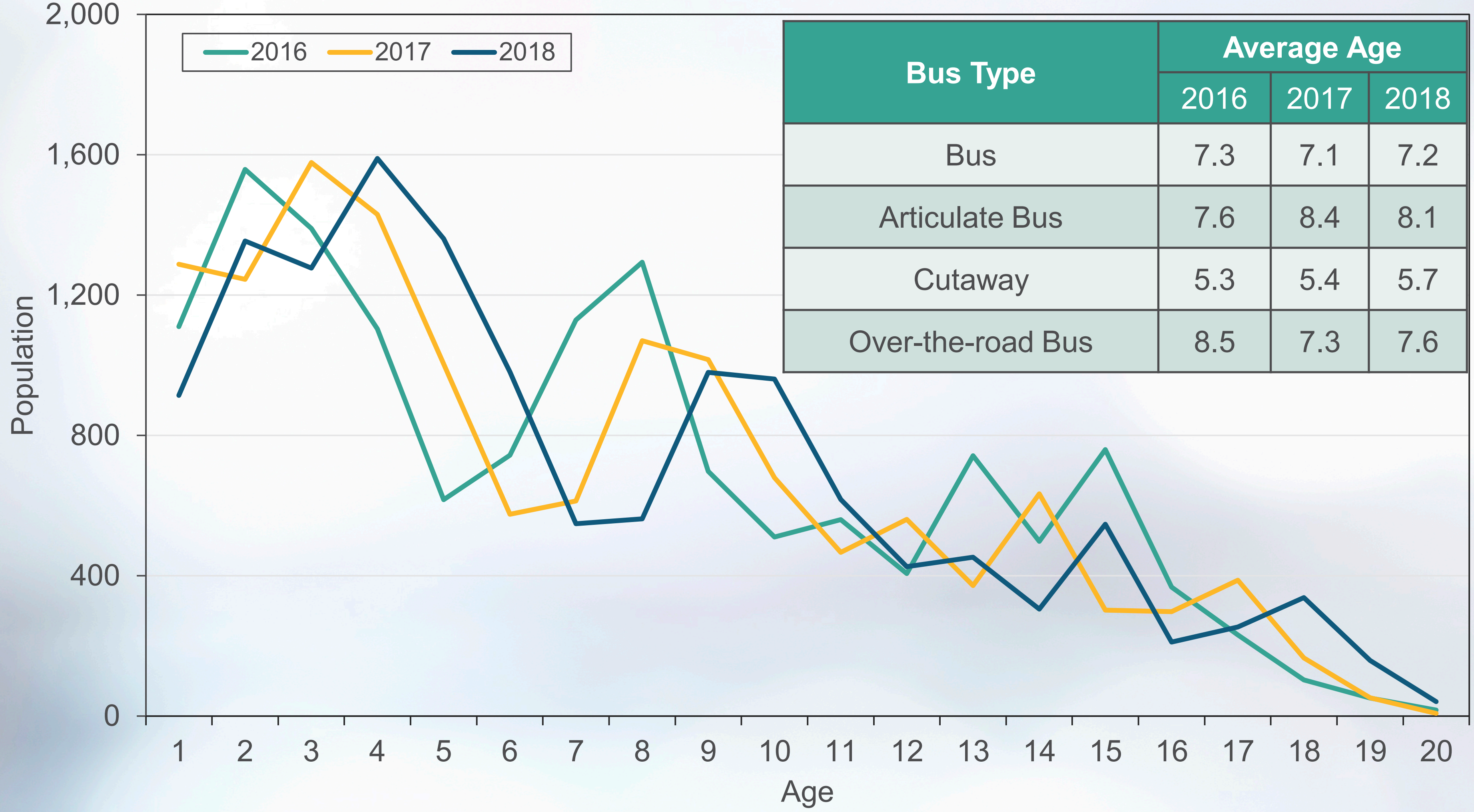
Population by Bus Type



- Bus (or standard bus) is the dominant type, contributing over 65% of the total, in spite of a decrease in the recent two years

Bus Age Distribution



Bus Type	Average Age		
	2016	2017	2018
Bus	7.3	7.1	7.2
Articulate Bus	7.6	8.4	8.1
Cutaway	5.3	5.4	5.7
Over-the-road Bus	8.5	7.3	7.6

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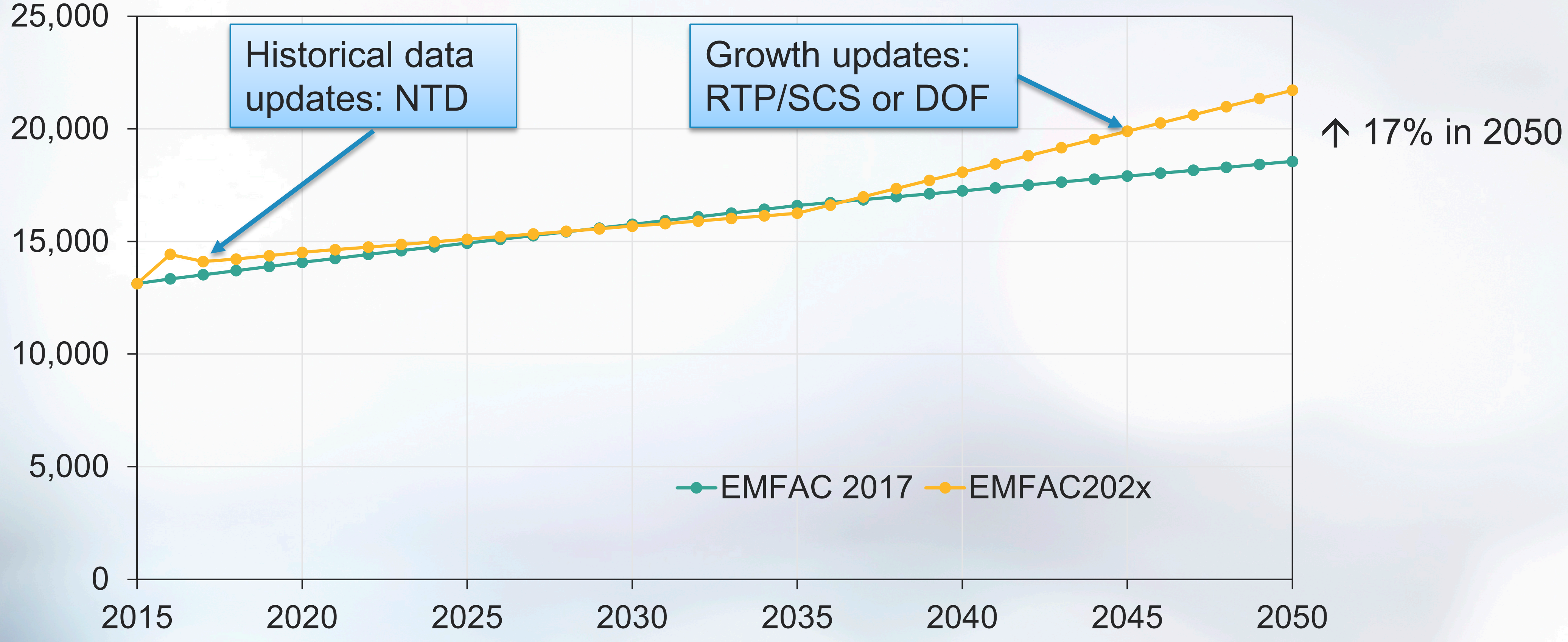
Forecasted Bus Population



- EMFAC202x has higher bus growth rates, mainly due to the higher growth in SCAG starting in 2035

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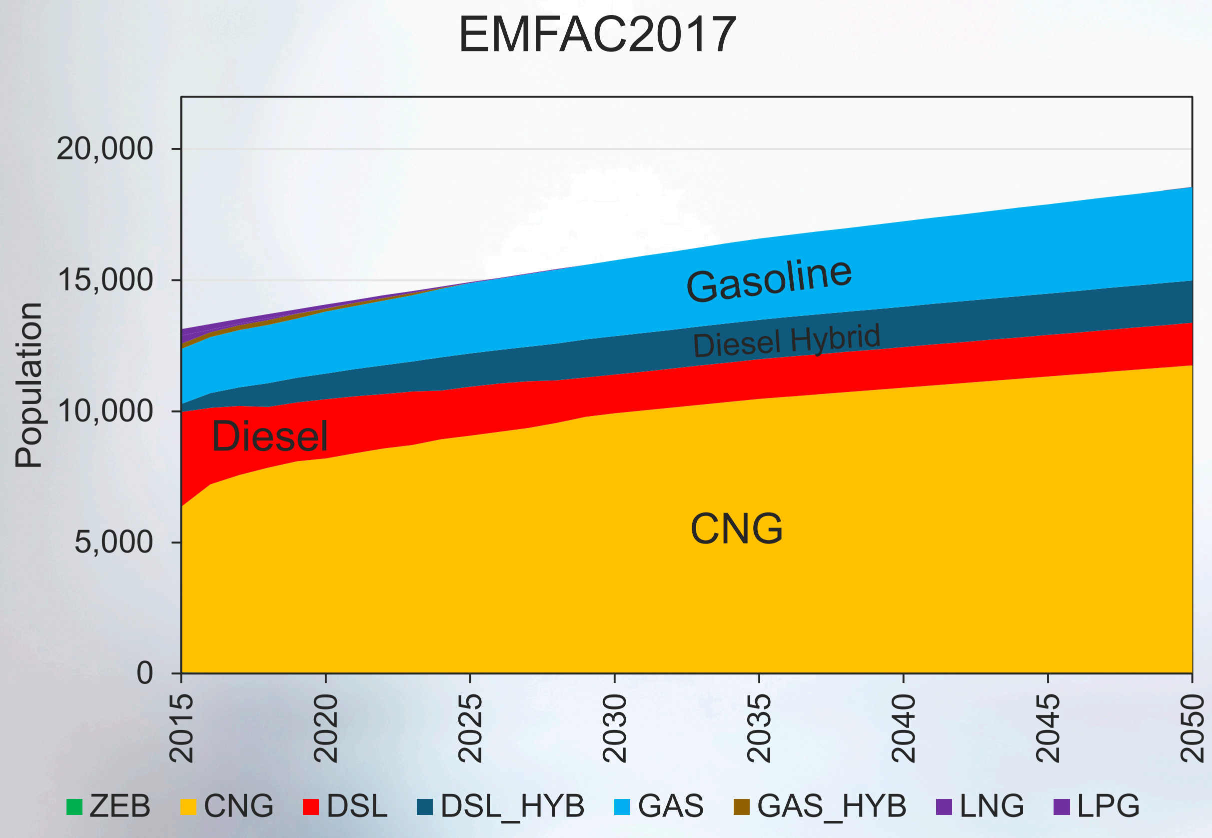
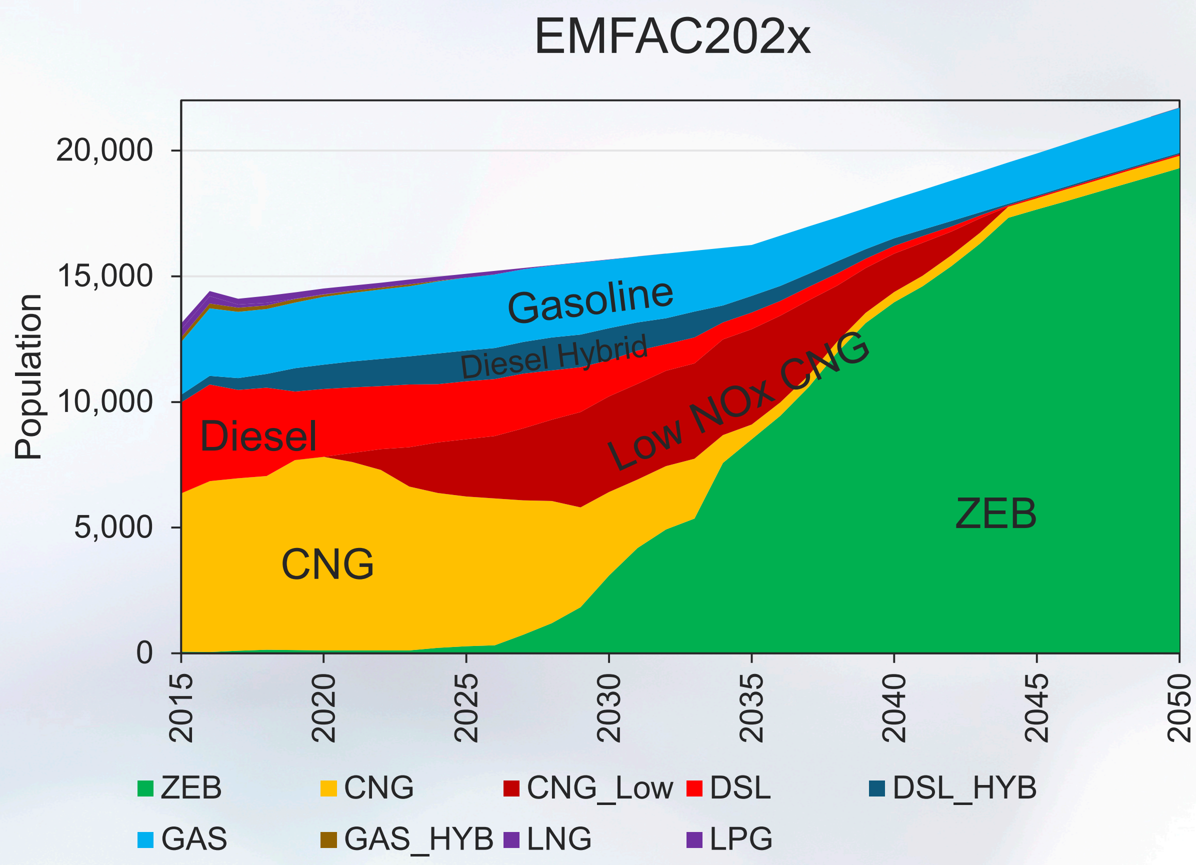
Bus population by Fuel and Technology





- With the ZEB purchase requirements by ICT from 2023, ZEBs gradually phase-in.

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Major Findings and Next Steps

- NTD shows 4%-8% higher bus population in 2016-2018 than that forecasted by the EMFAC2017
- Faster growth for SCAG starting in 2035 explains higher annual growth rates in EMFAC202x
- ZEBs gradually phase-in with the purchase requirements of ICT
- Next steps:
  - Update battery electric and fuel cell electric ratio based on Rollout Plan
  - Implement updated emission rates for CNG buses (0.2 g/bhp-hr and 0.02 g/bhp-hr) from 200 Vehicle In-Use Emissions Testing Project
  - Combination of BEB and FCEB will be updated based on Rollout Plan data.
  - Assess the impacts of both bus activity and emission rate updates on total emission from transit buses

Heavy-Duty Vehicle

Activity Profile

CARB

Background

- HD vehicle activity profiles have significant effects on emissions
- NOx emission rates of newer trucks equipped with Selective Catalytic Reduction (SCR) technology, is highly dependent on
  - Vehicle speed
  - Number of engine start
  - Length of extended idling
- EMFAC2017 incorporated the latest findings from University of California Riverside (UCR) CE-CERT HD activity data collection study
  - 90 vehicles by 19 vocational/regional groups
  - Global Positioning System (GPS) and electronic control unit (ECU) data loggers at 1Hz resolution

CARB

Updates in EMFAC202x

- **New data collection**
  - In-Use Emissions Testing and Fuel Usage Profile of On-Road Heavy-Duty Engines
    - Funded by South Coast Air Quality Management District (SCAQMD)/CEC/CARB/SoCalGas
    - Conducted by UC Riverside (UCR) and West Virginia University (WVU)
  - Portable Activity Measurement System (PAMS)
    - Telemetry loggers equipped with GPS and vehicle ECU connection
    - Tested ~200 vehicles by UCR and WVU
- **Similar data analysis method to EMFAC2017**
  - VMT distribution by speed and by hour
  - Number of starts by soak time and by hour
  - Extended idling by hours

PAMS Data by Fuel and Vocational Type

Data Source	Fuel Type	Delivery	Goods Movement	Refuse	School Bus	Transit Bus	Total
UCR	CNG	6	18	13	10	2	49
	Diesel	7	22		3		32
WVU	CNG	8	17	13	11	7	56
	Diesel	11	10	1	3		25
Total Used		**32**	**67**	**27**	**27**	**9**	**162**

Note:

- ✓ UCR tested 86 vehicles in total. 81 vehicles are used for this preliminary analysis and 5 are excluded due to missing/invalid data
- ✓ WVU tested 95 vehicles in total. 81 vehicles are used for this preliminary analysis, and 14 are excluded due to missing/invalid data

VMT by vocation type: Goods Movement (1)

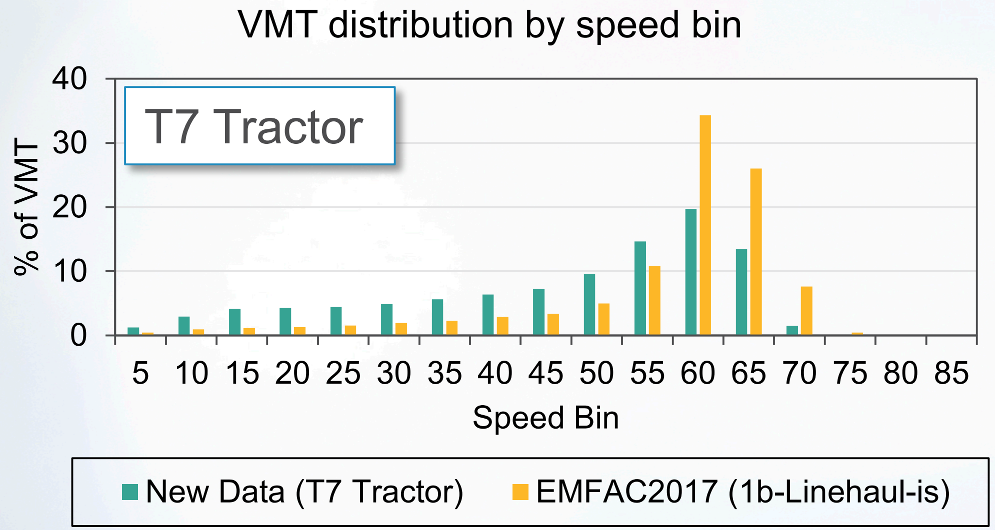
Hour of Day	Speed Bin 5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
0	0.03	0.08	0.11	0.12	0.12	0.13	0.15	0.17	0.20	0.32	0.51	0.65	0.73	0.18	0.01	0.00	0.00
1	0.03	0.07	0.10	0.10	0.11	0.12	0.14	0.16	0.19	0.29	0.53	0.95	0.77	0.09	0.01	0.00	0.00
2	0.02	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.14	0.21	0.38	0.86	0.85	0.07	0.00	0.00	0.00
3	0.01	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.07	0.11	0.28	0.63	0.63	0.05	0.00	0.00	0.00
4	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.10	0.22	0.58	0.69	0.03	0.00	0.00	0.00
5	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.08	0.09	0.18	0.34	0.51	0.47	0.05	0.00	0.00	0.00
6	0.03	0.06	0.08	0.10	0.11	0.13	0.15	0.16	0.18	0.28	0.54	0.76	0.50	0.03	0.00	0.00	0.00
7	0.05	0.13	0.18	0.19	0.20	0.21	0.24	0.26	0.26	0.35	0.56	0.69	0.33	0.03	0.00	0.00	0.00
8	0.06	0.14	0.20	0.23	0.24	0.26	0.28	0.30	0.34	0.42	0.57	0.74	0.37	0.03	0.00	0.00	0.00
9	0.06	0.14	0.21	0.24	0.25	0.28	0.31	0.36	0.43	0.53	0.80	0.96	0.65	0.04	0.00	0.00	0.00
10	0.07	0.14	0.19	0.20	0.21	0.24	0.26	0.34	0.41	0.61	1.02	1.24	0.82	0.04	0.00	0.00	0.00
11	0.06	0.12	0.17	0.19	0.21	0.23	0.26	0.31	0.36	0.53	0.97	1.25	0.72	0.03	0.00	0.00	0.00
12	0.06	0.12	0.16	0.18	0.20	0.24	0.27	0.32	0.38	0.55	0.94	1.24	0.77	0.05	0.00	0.00	0.00
13	0.07	0.14	0.18	0.19	0.21	0.24	0.27	0.32	0.35	0.51	0.90	1.20	0.73	0.02	0.00	0.00	0.00
14	0.07	0.15	0.22	0.25	0.27	0.29	0.32	0.34	0.37	0.46	0.81	1.16	0.81	0.02	0.00	0.00	0.00
15	0.07	0.15	0.20	0.23	0.24	0.25	0.27	0.29	0.32	0.42	0.73	0.84	0.64	0.01	0.00	0.00	0.00
16	0.06	0.14	0.19	0.21	0.23	0.24	0.26	0.28	0.31	0.39	0.56	0.75	0.73	0.02	0.00	0.00	0.00
17	0.05	0.13	0.16	0.16	0.17	0.18	0.18	0.20	0.22	0.31	0.49	0.75	0.70	0.03	0.00	0.00	0.00
18	0.05	0.11	0.16	0.18	0.18	0.18	0.19	0.20	0.23	0.34	0.58	0.75	0.76	0.04	0.00	0.00	0.00
19	0.05	0.13	0.19	0.20	0.20	0.23	0.24	0.26	0.32	0.50	0.90	1.25	0.98	0.08	0.00	0.00	0.00
20	0.04	0.10	0.13	0.15	0.17	0.19	0.21	0.24	0.31	0.52	1.14	1.39	0.66	0.05	0.00	0.00	0.00
21	0.04	0.09	0.12	0.13	0.14	0.14	0.15	0.19	0.25	0.45	1.07	1.52	0.72	0.06	0.00	0.00	0.00
22	0.03	0.08	0.10	0.11	0.11	0.12	0.14	0.16	0.18	0.30	0.70	1.08	0.50	0.04	0.00	0.00	0.00
23	0.03	0.08	0.10	0.10	0.10	0.11	0.13	0.14	0.19	0.35	0.65	0.87	0.7[illegible]	0.20	0.01	0.00	0.00
Grand Total	1.08	2.42	3.30	3.61	3.83	4.23	4.63	5.28	6.17	9.03	16.20	22.65	16.23	1.28	0.05	0.00	0.00

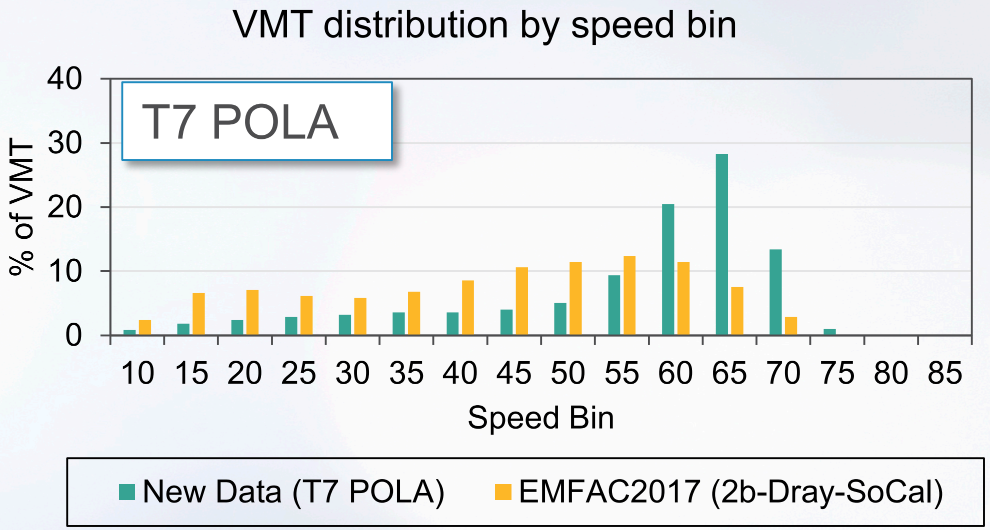
✓ Over 55% of VMT within speed bins of 55-65 mph

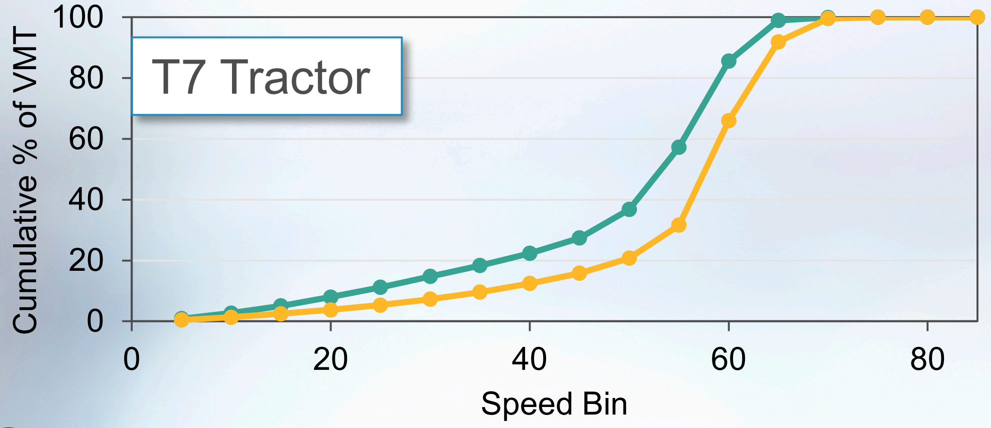
EMFAC Category	Counts
T7 Port of Los Angeles/Long Beach (T7 POLA)	34
T7 Tractor	25

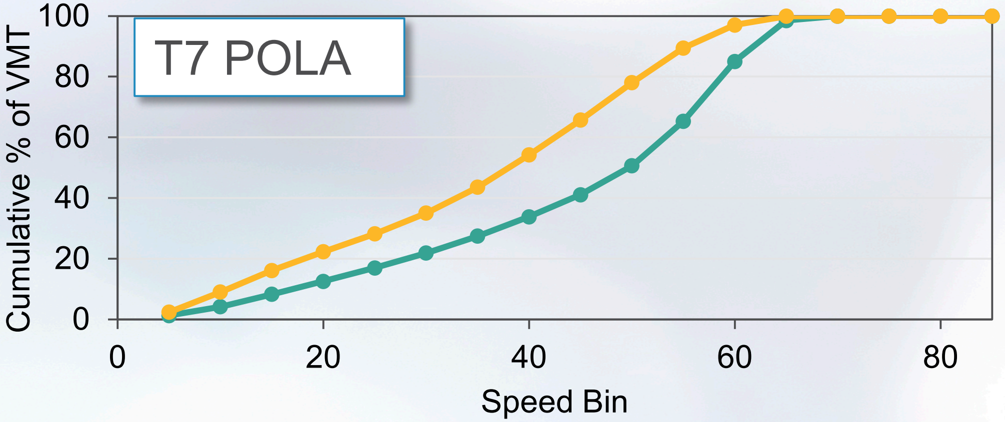
CARB

VMT by vocation type: Goods Movement (2)





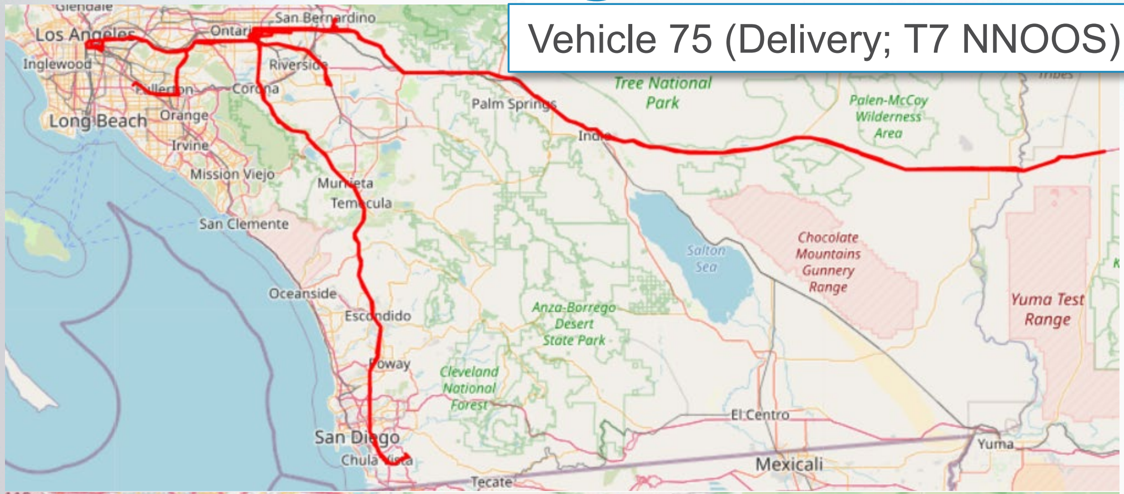




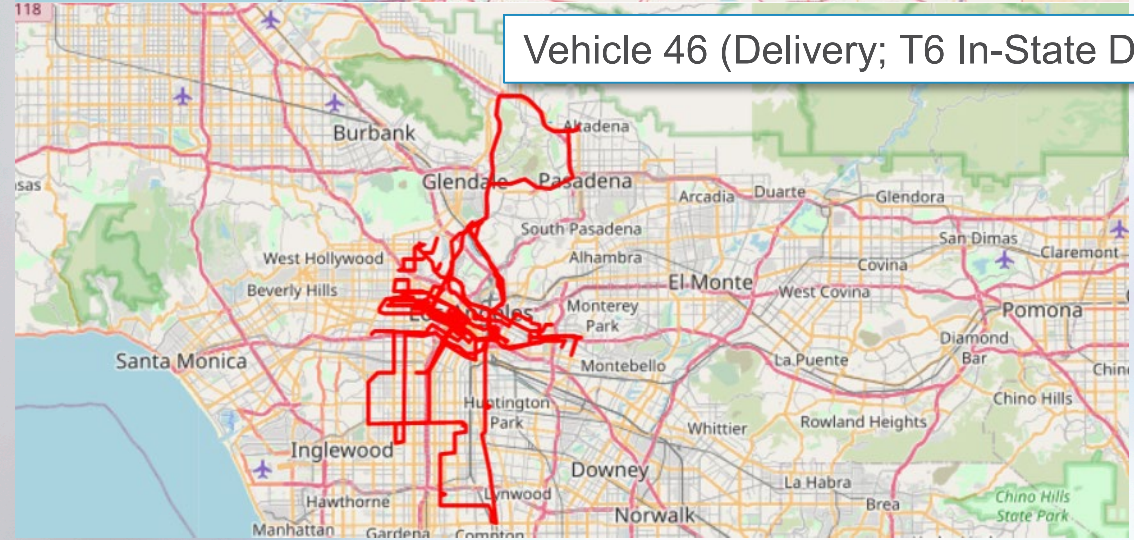
CARB

VMT by vocation type: Delivery(1)

Vehicle 75 (Delivery; T7 NNOOS)



Vehicle 46 (Delivery; T6 In-State Delivery)



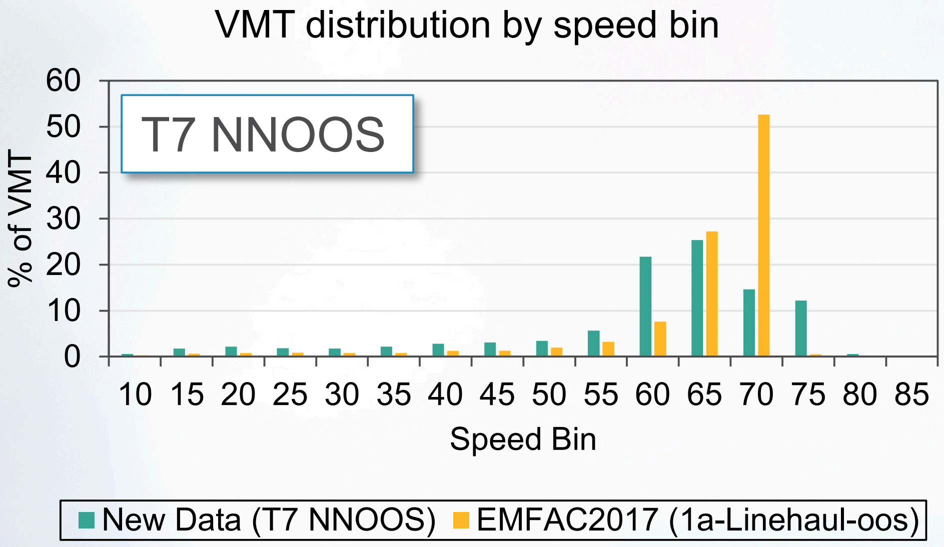
- Speed profile varies greatly by delivery truck type

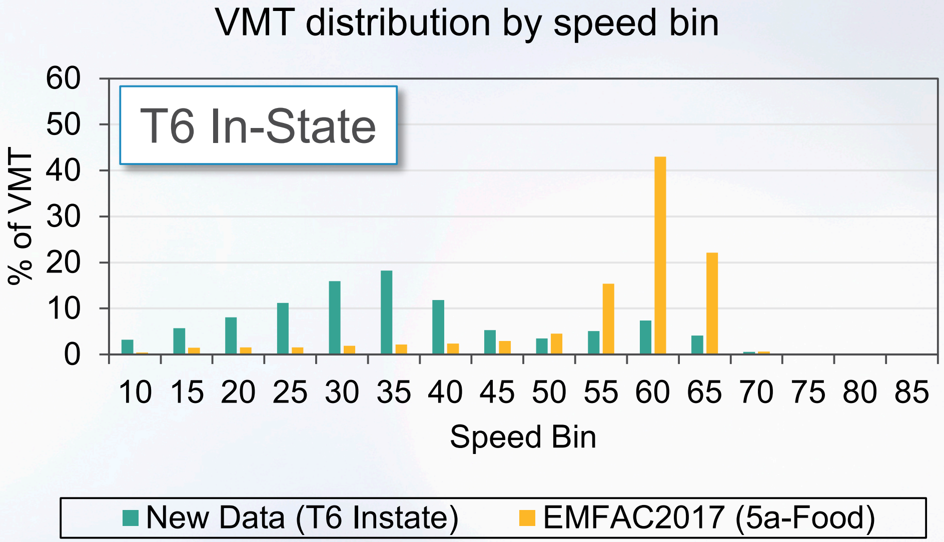
EMFAC Category	Counts
T7 Non-Neighboring Out of State (NNOOS)	17
T6 In-State Delivery	2
T6 In-State Other	1
T6 In-State Tractor	5
Others	7
Total	**32**

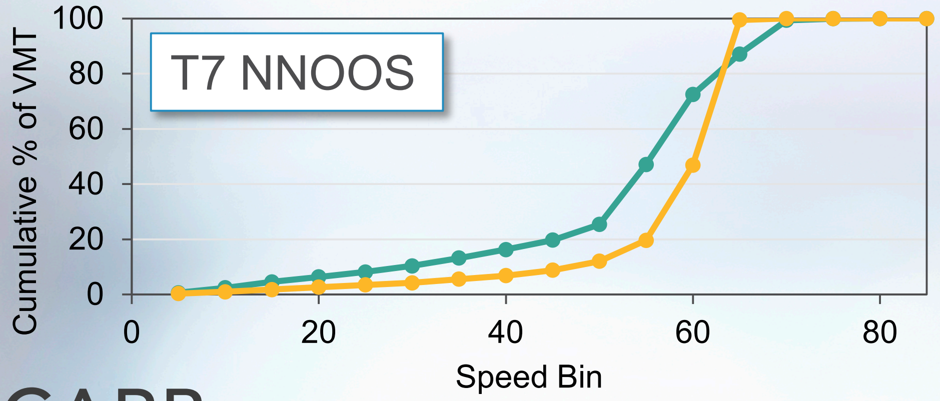
T6 In-State

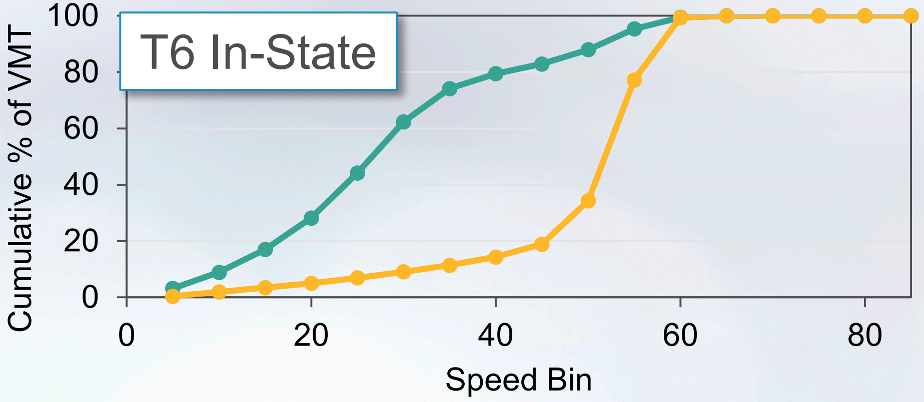
CARB

VMT by vocation type: Delivery (2)





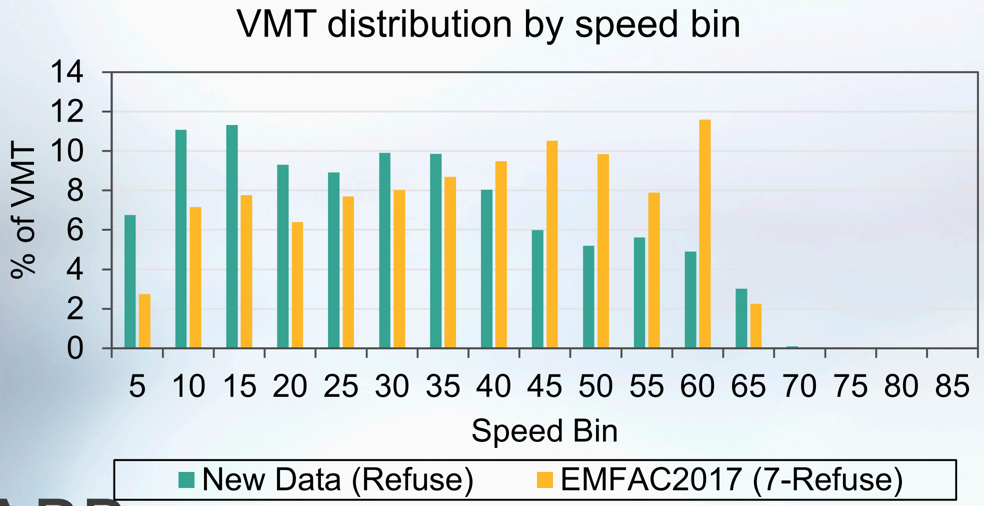


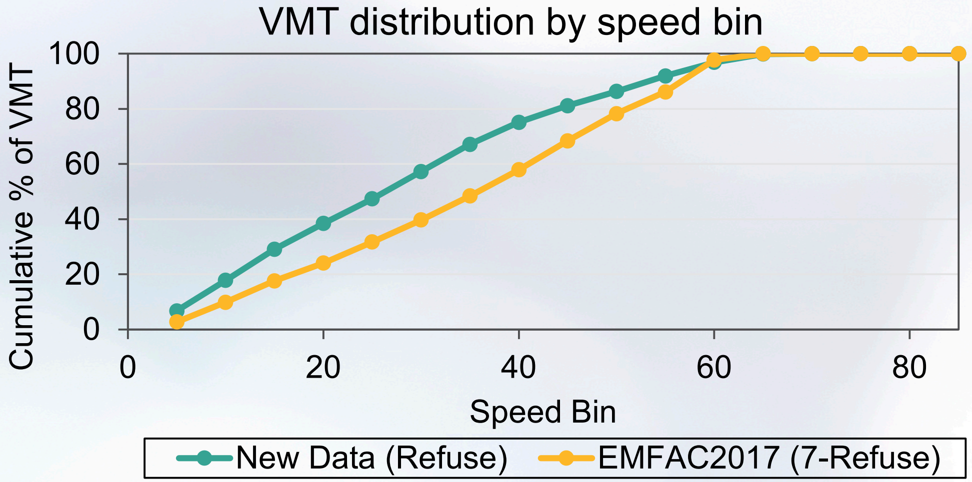


Preliminary Results

VMT by vocation type: Refuse

Hour of Day	Speed Bin 5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.02	0.04	0.05	0.07	0.15	0.19	0.14	0.10	0.13	0.18	0.29	0.17	0.01	0.00	0.00	0.00	0.00
5	0.12	0.19	0.25	0.27	0.27	0.27	0.26	0.29	0.39	0.48	0.71	0.74	0.34	0.01	0.00	0.00	0.00
6	0.42	0.72	0.77	0.63	0.52	0.61	0.70	0.59	0.52	0.60	0.58	0.35	0.30	0.01	0.00	0.00	0.00
7	0.72	1.23	1.12	0.75	0.56	0.56	0.59	0.42	0.26	0.17	0.08	0.07	0.06	0.01	0.00	0.00	0.00
8	0.73	1.29	1.26	0.86	0.68	0.70	0.77	0.66	0.45	0.22	0.16	0.13	0.17	0.01	0.00	0.00	0.00
9	0.69	1.21	1.27	1.03	0.83	0.81	0.81	0.62	0.41	0.29	0.30	0.29	0.25	0.00	0.00	0.00	0.00
10	0.71	1.10	1.14	0.90	0.77	0.80	0.77	0.63	0.46	0.41	0.70	0.55	0.18	0.01	0.00	0.00	0.00
11	0.62	0.90	0.98	0.79	0.77	0.85	0.80	0.66	0.45	0.52	0.54	0.58	0.43	0.01	0.00	0.00	0.00
12	0.58	0.95	0.94	0.81	0.81	0.93	0.90	0.71	0.46	0.27	0.27	0.31	0.28	0.01	0.00	0.00	0.00
13	0.58	0.96	0.91	0.70	0.70	0.85	0.82	0.63	0.53	0.50	0.54	0.60	0.34	0.00	0.00	0.00	0.00
14	0.55	0.89	0.84	0.63	0.62	0.70	0.75	0.64	0.39	0.33	0.34	0.39	0.32	0.00	0.00	0.00	0.00
15	0.44	0.72	0.78	0.72	0.72	0.81	0.79	0.59	0.37	0.30	0.29	0.26	0.16	0.00	0.00	0.00	0.00
16	0.34	0.54	0.62	0.68	0.78	0.89	0.94	0.77	0.57	0.47	0.54	0.26	0.12	0.00	0.00	0.00	0.00
17	0.19	0.27	0.34	0.42	0.64	0.80	0.69	0.57	0.48	0.31	0.19	0.18	0.05	0.02	0.00	0.00	0.00
18	0.03	0.03	0.03	0.04	0.08	0.11	0.13	0.13	0.12	0.10	0.07	0.02	0.00	0.00	0.00	0.00	0.00
19	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	6.76	11.07	11.32	9.31	8.91	9.91	9.86	8.03	5.99	5.19	5.62	4.91	3.02	0.10	0.00	0.00	0.00





CARB

Preliminary Results

of Starts by Soak Time (1): Examples

T7 Tractor

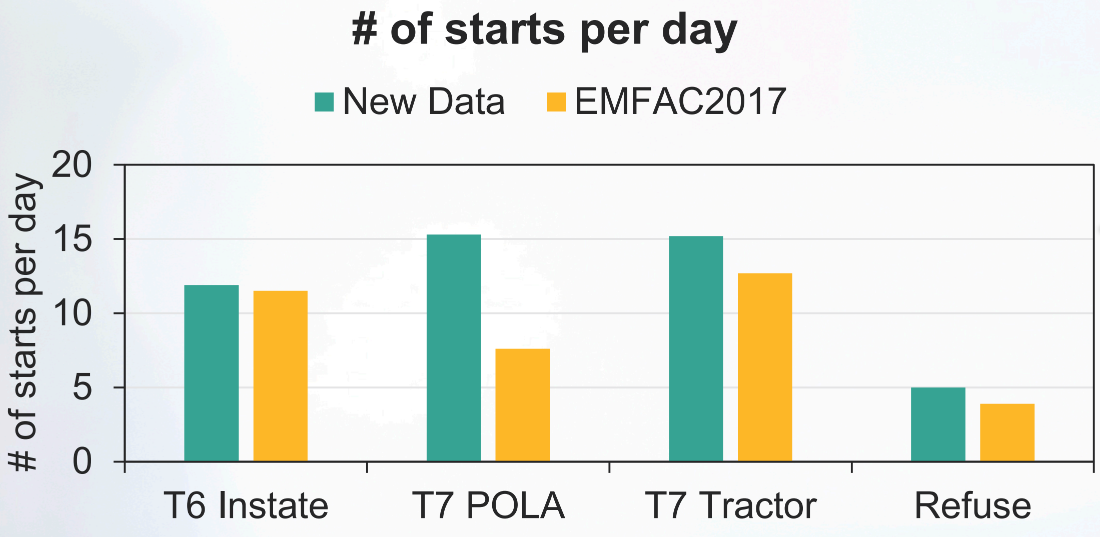
Hour of Day	Soak Time Bin 5	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600	660	720	721
0	1.18	0.75	0.97	0.39	0.23	0.17	0.14	0.39	0.08	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.33
1	1.55	0.50	0.85	0.39	0.08	0.08	0.08	0.12	0.08	0.00	0.02	0.00	0.04	0.02	0.02	0.00	0.00	0.00	0.12
2	1.39	0.73	0.87	0.31	0.17	0.04	0.10	0.21	0.06	0.00	0.04	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.06
3	1.12	0.68	0.70	0.33	0.02	0.10	0.02	0.19	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14
4	1.22	0.50	0.43	0.21	0.06	0.06	0.02	0.29	0.04	0.06	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.10
5	1.33	0.37	0.50	0.27	0.21	0.15	0.06	0.14	0.10	0.00	0.00	0.02	0.02	0.02	0.02	0.00	0.02	0.10	0.23
6	1.30	0.31	0.46	0.17	0.15	0.04	0.02	0.08	0.08	0.08	0.02	0.00	0.02	0.04	0.00	0.02	0.02	0.00	0.19
7	1.18	0.46	0.58	0.35	0.10	0.12	0.00	0.06	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.00	0.10
8	1.39	0.83	0.54	0.39	0.10	0.10	0.04	0.04	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.04
9	1.60	0.35	0.56	0.21	0.14	0.06	0.02	0.08	0.02	0.02	0.00	0.04	0.00	0.00	0.02	0.06	0.02	0.00	0.19
10	2.86	0.60	0.43	0.25	0.17	0.06	0.04	0.04	0.02	0.04	0.06	0.04	0.10	0.00	0.02	0.00	0.00	0.06	0.06
11	2.42	0.73	0.50	0.37	0.12	0.14	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.00	0.00	0.00
12	2.36	0.39	0.41	0.23	0.12	0.21	0.06	0.06	0.06	0.04	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.06
13	2.69	0.72	0.58	0.19	0.10	0.06	0.10	0.17	0.02	0.00	0.00	0.00	0.00	0.02	0.04	0.02	0.02	0.00	0.12
14	2.73	0.68	0.64	0.23	0.14	0.04	0.00	0.04	0.08	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.12
15	2.65	0.41	0.41	0.39	0.14	0.06	0.12	0.12	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.15
16	2.55	1.14	0.52	0.25	0.29	0.12	0.00	0.23	0.02	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.08
17	1.84	0.37	0.58	0.19	0.17	0.15	0.08	0.17	0.08	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
18	1.72	0.44	0.48	0.31	0.17	0.17	0.14	0.31	0.06	0.02	0.02	0.02	0.00	0.04	0.02	0.00	0.00	0.00	0.50
19	1.72	0.73	0.64	0.31	0.25	0.14	0.02	0.15	0.12	0.04	0.10	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.23
20	1.78	0.85	0.75	0.54	0.33	0.08	0.08	0.12	0.00	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
21	1.35	0.58	1.24	0.46	0.33	0.12	0.10	0.08	0.08	0.12	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.12
22	1.70	0.79	1.22	0.52	0.27	0.15	0.06	0.15	0.15	0.00	0.08	0.00	0.02	0.00	0.02	0.00	0.00	0.15	0.04
23	0.99	0.73	0.70	0.39	0.54	0.27	0.25	0.35	0.06	0.06	0.00	0.02	0.00	0.04	0.02	0.00	0.00	0.00	0.00
Grand Total	42.61	14.65	15.54	7.66	4.39	2.67	1.51	3.61	1.35	0.58	0.52	0.23	0.29	0.25	0.21	0.21	0.08	0.37	3.27

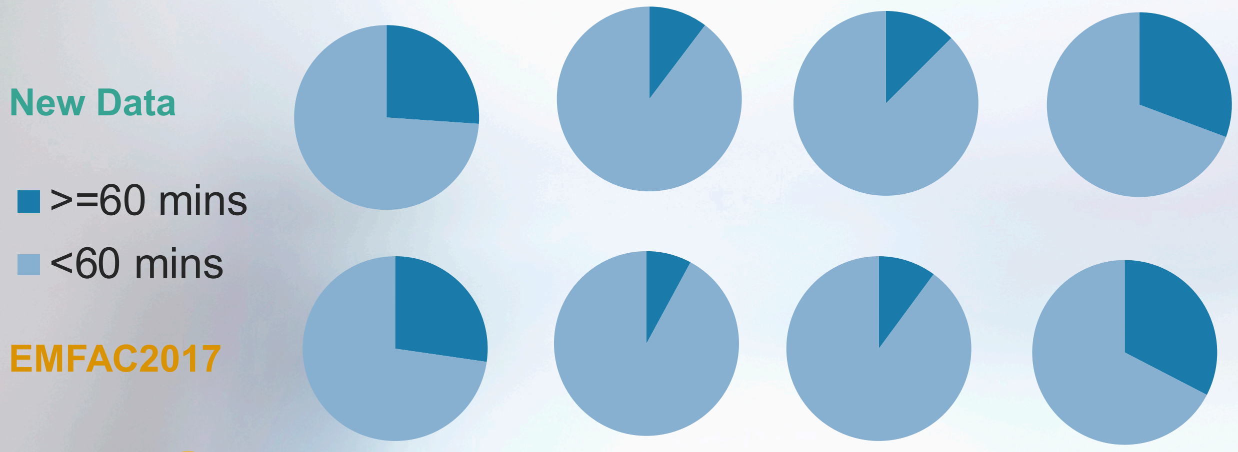
T6 In-State

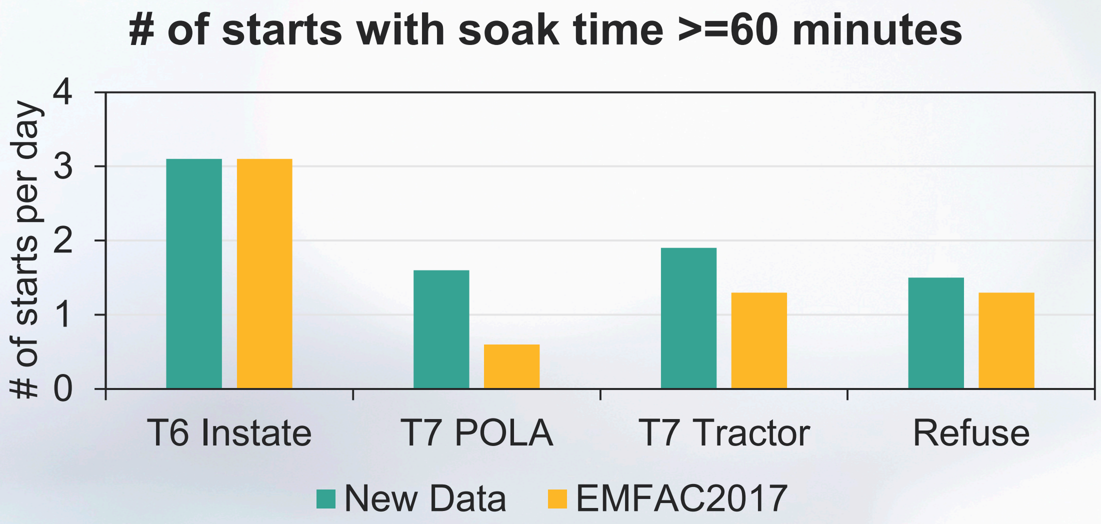
Hour of Day	Soak Time Bin 5	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600	660	720	721
0	0.58	0.08	0.17	0.00	0.00	0.00	0.08	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.17
1	0.25	0.08	0.00	0.00	0.08	0.00	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
2	0.17	0.00	0.00	0.00	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.08	0.00	0.08
4	0.00	0.08	0.08	0.17	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.08	0.00	0.00	0.08	0.00	0.00	0.00	0.17
5	0.50	0.25	0.25	0.00	0.17	0.00	0.00	0.00	0.08	0.00	0.33	0.08	0.00	0.08	0.00	0.08	0.08	0.00	0.33
6	1.33	0.91	0.66	0.50	0.08	0.08	0.08	0.25	0.00	0.08	0.00	0.17	0.08	0.08	0.08	0.17	0.17	0.08	0.50
7	1.16	0.50	0.83	0.66	0.33	0.50	0.17	0.08	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.08	0.00	0.08	0.50
8	0.75	0.83	0.83	0.91	0.50	0.25	0.25	0.42	0.00	0.08	0.08	0.17	0.00	0.08	0.00	0.00	0.00	0.00	0.58
9	0.66	0.25	1.08	0.75	0.83	0.25	0.25	0.91	0.08	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.66
10	1.16	0.25	0.83	0.75	0.91	0.66	0.58	0.75	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.25
11	1.33	0.42	1.00	0.83	1.33	0.50	0.33	0.42	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.50
12	1.66	0.83	1.66	0.75	0.75	0.66	0.33	0.42	0.42	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.25
13	1.41	0.66	1.66	0.83	1.33	0.66	0.25	0.83	0.08	0.08	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.42
14	1.16	0.50	1.16	1.50	0.75	0.50	0.50	0.75	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
15	0.83	0.33	1.25	0.75	0.91	0.42	0.33	0.66	0.17	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.08
16	0.91	0.91	1.25	0.42	0.75	0.50	0.33	0.66	0.08	0.17	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.17
17	1.00	0.58	1.50	0.83	0.50	0.17	0.25	0.42	0.08	0.08	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.08
18	0.66	0.83	0.91	0.50	0.25	0.33	0.08	0.58	0.25	0.00	0.00	0.17	0.00	0.08	0.00	0.00	0.00	0.00	0.00
19	0.33	0.66	1.08	0.33	0.33	0.42	0.33	0.42	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08
20	0.25	0.50	0.91	0.42	0.33	0.17	0.00	0.33	0.08	0.00	0.08	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.00
21	0.08	0.08	0.42	0.50	0.08	0.17	0.08	0.08	0.08	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
22	0.17	0.17	0.17	0.17	0.33	0.08	0.00	0.17	0.08	0.08	0.08	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00
23	0.83	0.33	0.08	0.17	0.00	0.25	0.00	0.17	0.00	0.00	0.08	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.00
Grand Total	17.19	10.05	17.77	11.71	10.55	6.64	4.24	8.80	1.91	1.08	1.00	1.00	0.25	0.66	0.58	0.33	0.42	0.58	5.23

CARB

of Starts by Soak Time (2): Comparisons



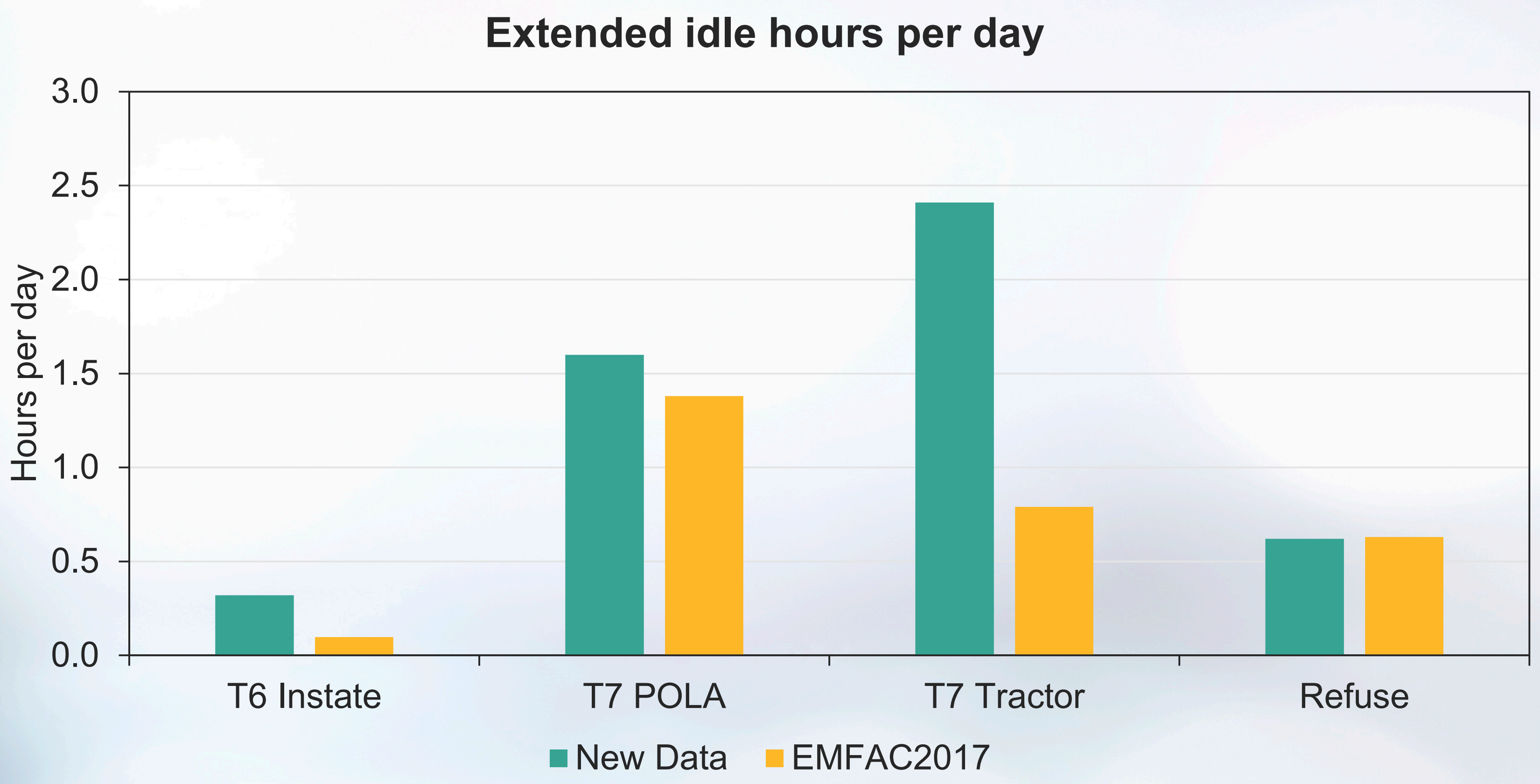




CARB

Preliminary Results

Extended Idle Hours Per Day



Key Takeaways

- ~200 vehicles are used for analysis
- Over 55% of VMT for goods movement trucks is within speed bins of 55-65 mph
- Compared with EMFAC2017, the new dataset shows
  - More VMT at lower speeds (except for T7 POLA)
  - Higher number of starts with soak time greater than 1-hr
  - Higher idling hours

Next Steps

- Fine-tune the data analysis with EMFAC categories
- Make similar analysis with school bus and transit bus
- Combine the data from CE-CERT 90 vehicle study for EMFAC2017
- Implement the results in EMFAC202x to assess the impact of updates on total emissions

Light-Duty Vehicles

Emission Rates

Background and Motivation

- As part of EMFAC202x
  - Light-Duty Base Emissions Rates (BER) will be updated using data from In-Use Verification Program (IUVP) and CARB Vehicle Surveillance Program (VSP) program
  - Details were presented in the October 2019 EMFAC202x workshop

- Ratio of Standards (ROS) were previously used to estimate emission rates for future technologies and certification levels, e.g., LEVIII certification levels such as ULEV50 and SULEV20
  - Update ROS based on latest information
  - Verify if the base selection is appropriate
  - Verify if applying the same ROS to different Unified Cycle (UC) bags is valid

ROS in EMFAC2017

Tech Group	Base	ROS
LEVIII ULEV70	LEVII ULEV	70/125 = 0.56
LEVIII ULEV50	LEVII ULEV	50/125 = 0.40
LEVIII SULEV20	LEVII SULEV	20/30 = 0.67

- ROS were derived from the ratio of emission standards between the LEVIII HC+NOx certification and its LEVII base
- Same ROS was applied to different phases of the Unified Cycle (UC)

ROS from Recent LEV III Test Results

Tech Group	Base	HC			NOX		
		Bag 1	Bag 2	Bag 3	Bag 1	Bag 2	Bag 3
ULEV70 (N=4)	SULEV30 (N=3)	2.25	2.39	2.49	1.40	1.84	1.99

- Most recent test results from CARB VSP
- Applying the same ROS to all test phases may not be appropriate

CARB

LEVIII Updates in EMFAC202x

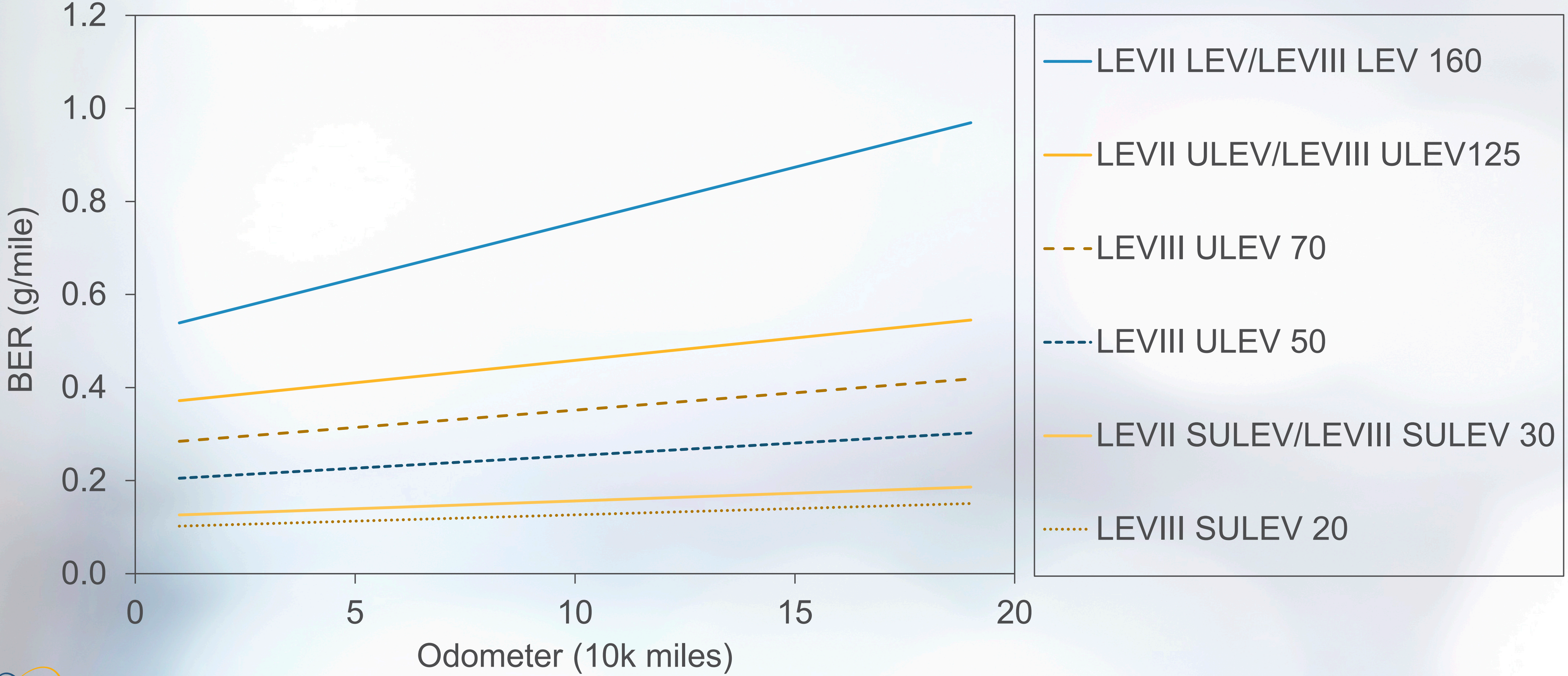
Tech Group	Updates
SULEV30	Shares the same base emission regressions with LEVII SULEV
ULEV70/ULEV50	Based on LEVIII SULEV30 instead of LEVII ULEV
ULEV70	ROS are based on latest VSP data
ULEV50	ROS are based on available EPA Fuel Economy data and engineering judgement
SULEV20	ROS are based on analysis of CARB Federal Test Procedure (FTP) test data and engineering judgement (higher reduction in Bag 1 cold start)

ROS in EMFAC202x

Tech Group	Base	EMFAC 2017	EMFAC202x					
			THC			NOX		
			Bag 1	Bag 2	Bag 3	Bag 1	Bag 2	Bag 3
LEVIII ULEV70	LEVIII SULEV30	2.33	2.25	2.39	2.00	1.40	1.20	1.40
LEVIII ULEV50	LEVIII SULEV30	1.67	1.63	1.70	1.50	1.20	1.10	1.20
LEVIII SULEV20	LEVIII SULEV30	0.67	0.58	0.90	0.90	0.42	0.90	0.90

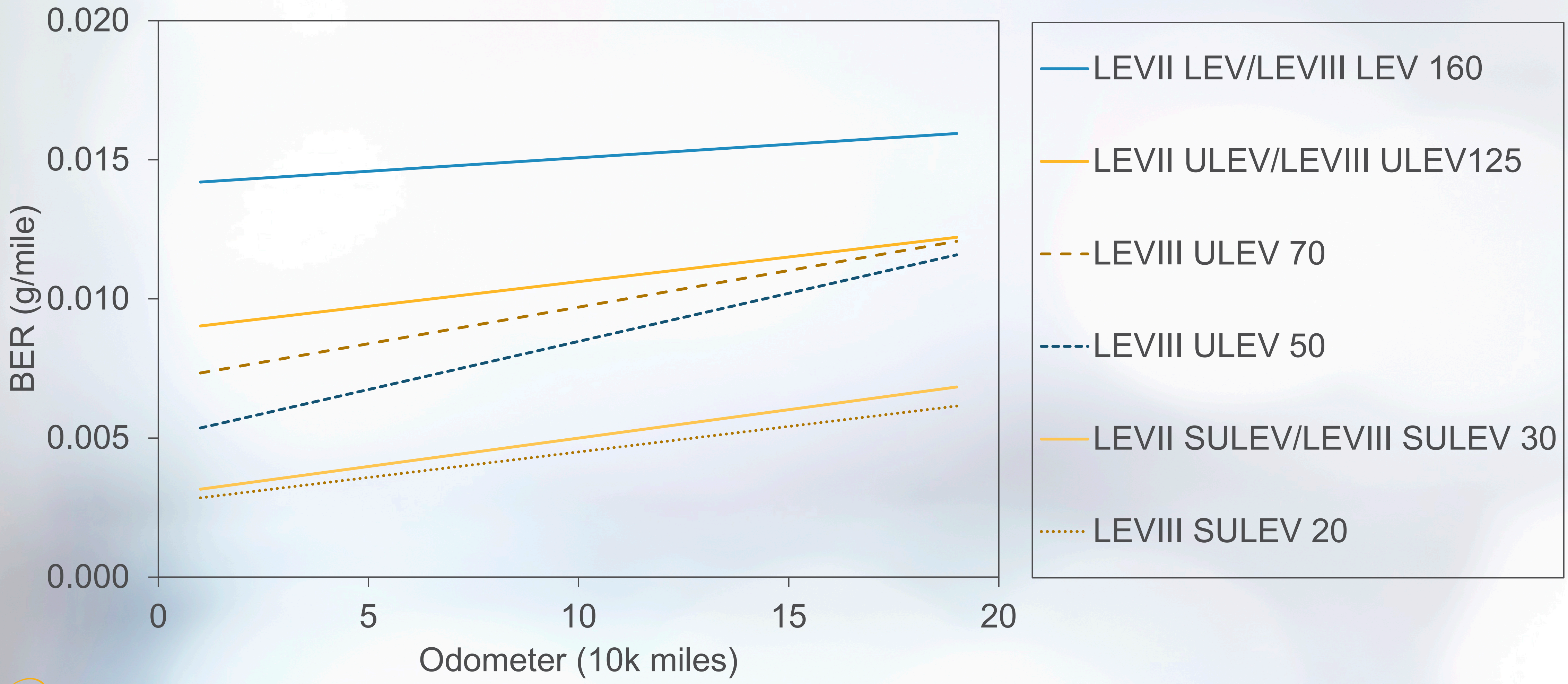
CARB

THC UC Bag 1: Cold Starts Base Emission Rate



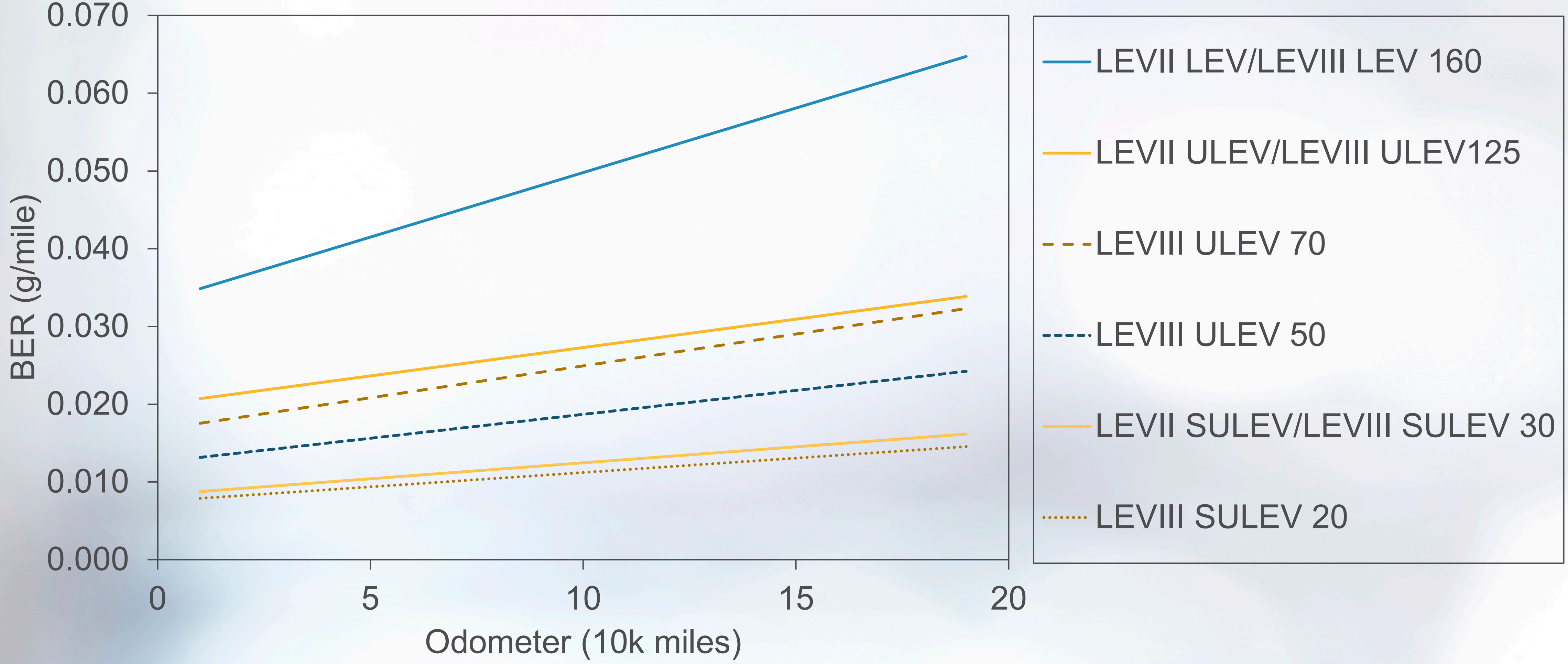
CARB

THC UC Bag 2: Running Exhausts Base Emission Rate



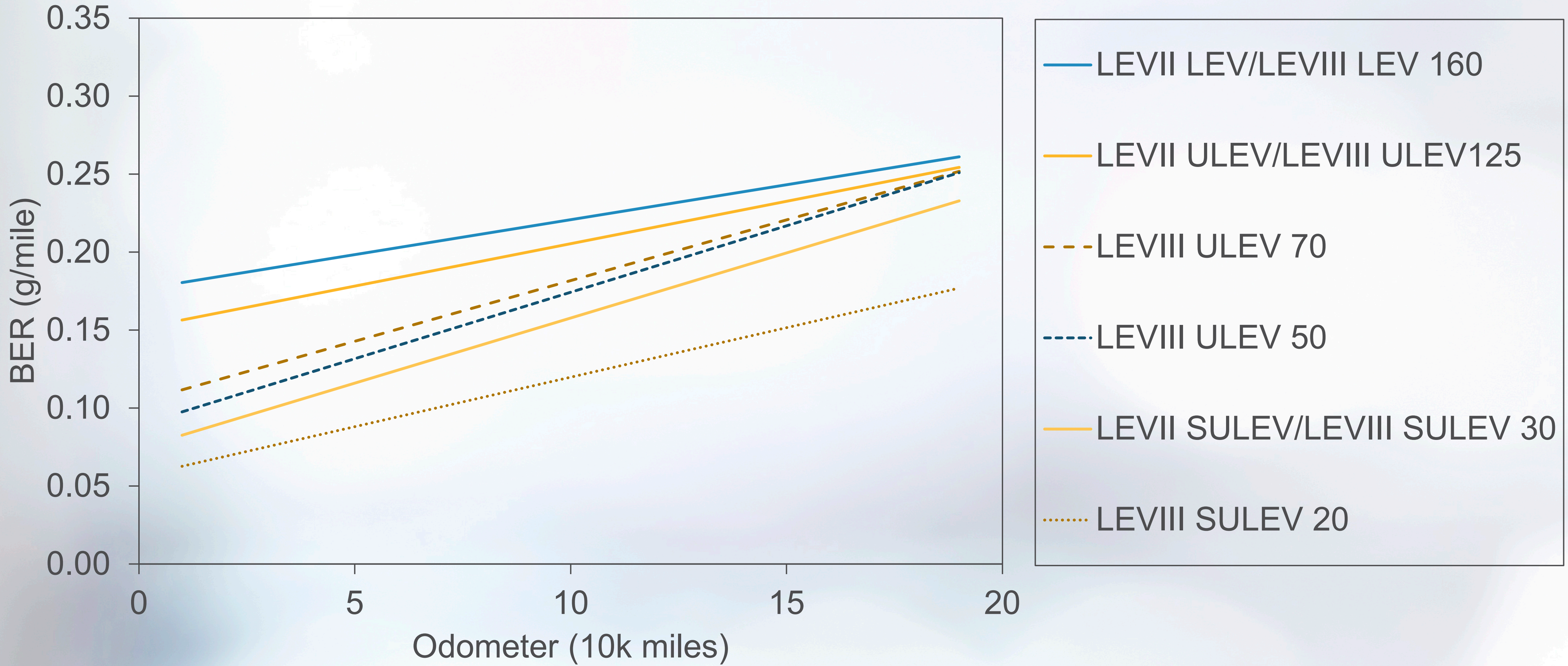
* Slope for ULEV70 was slightly adjusted so the line doesn't exceed ULEV125

THC UC Bag 3: Warm Starts Base Emission Rate



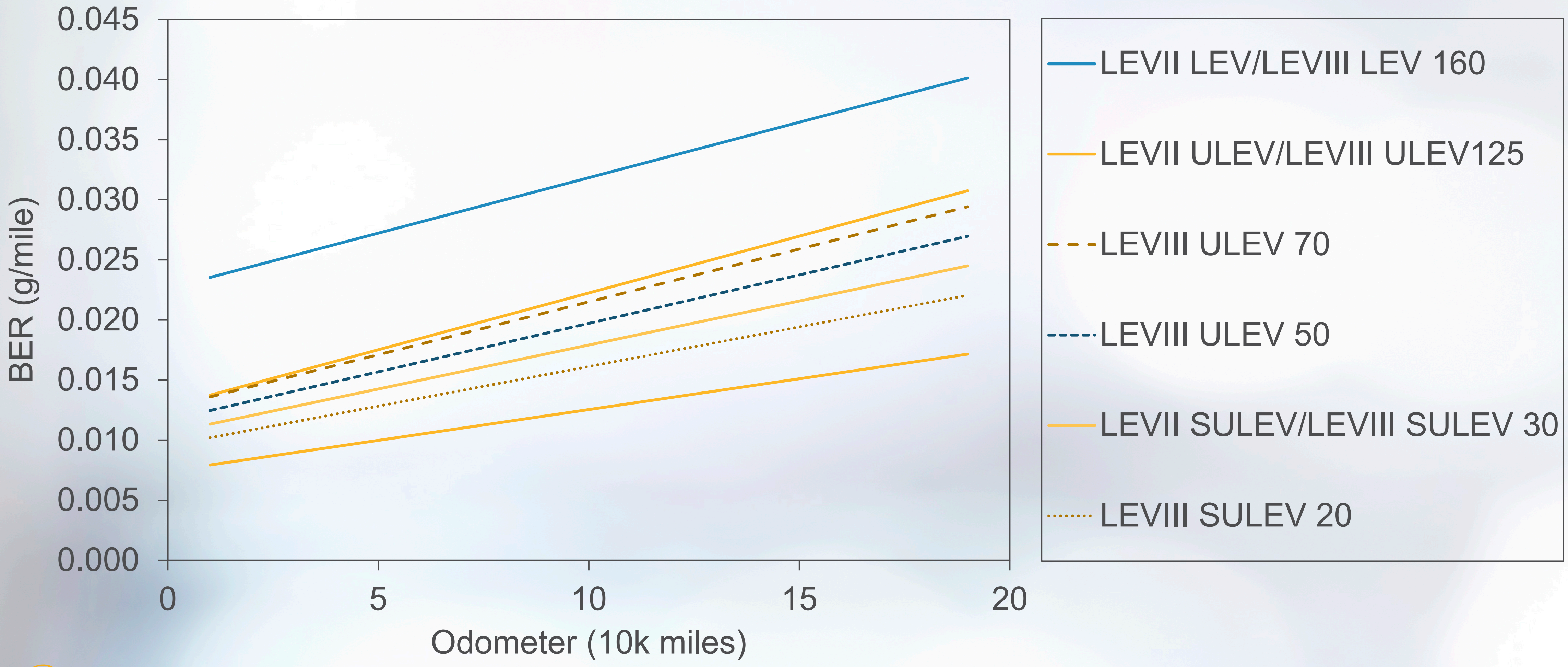
CARB

NOX UC Bag 1: Cold Starts Base Emission Rate



* Slopes for Phase 1 of ULEV70 and ULEV50 were slightly adjusted so the lines do not exceed ULEV125 and at the same time do not fall below SULEV30 emissions

NOX UC Bag 2: Running Exhausts Base Emission Rate



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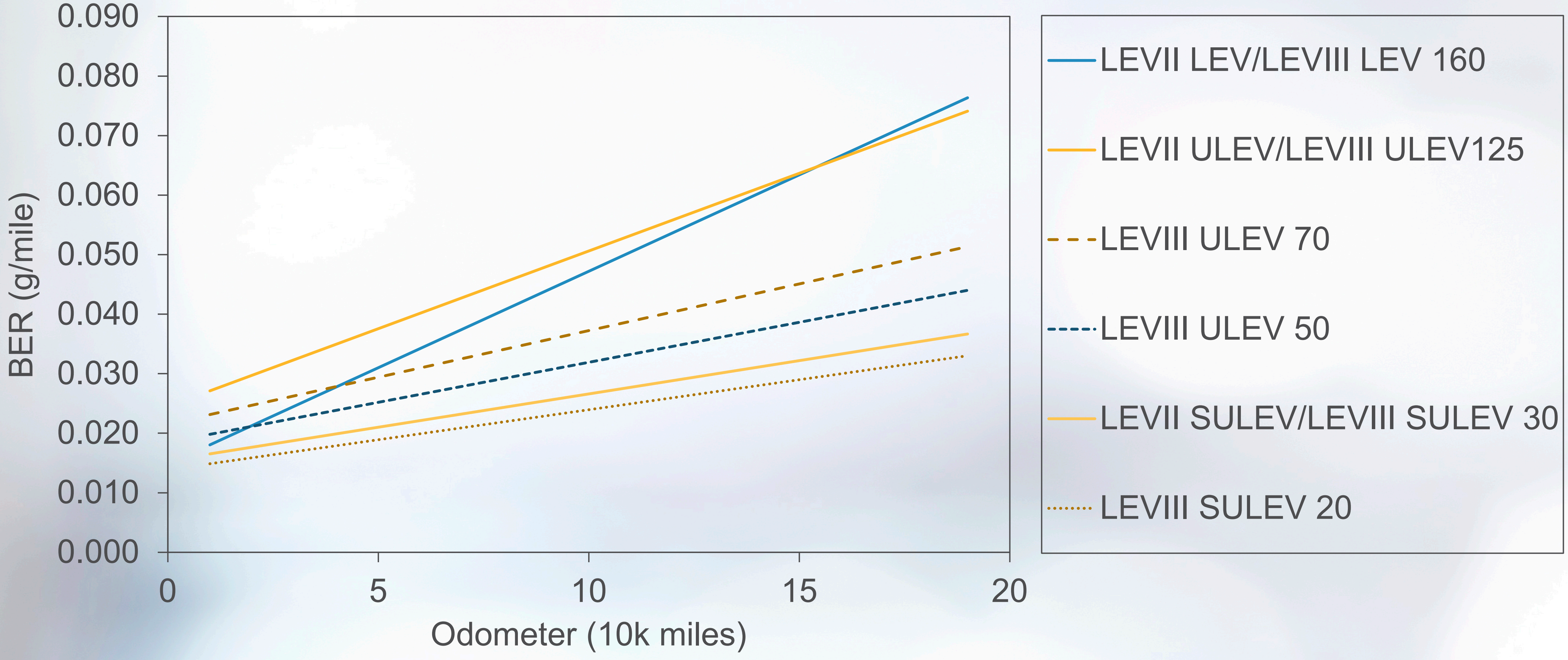
NOX UC Bag 3: Warm Starts Base Emission Rate



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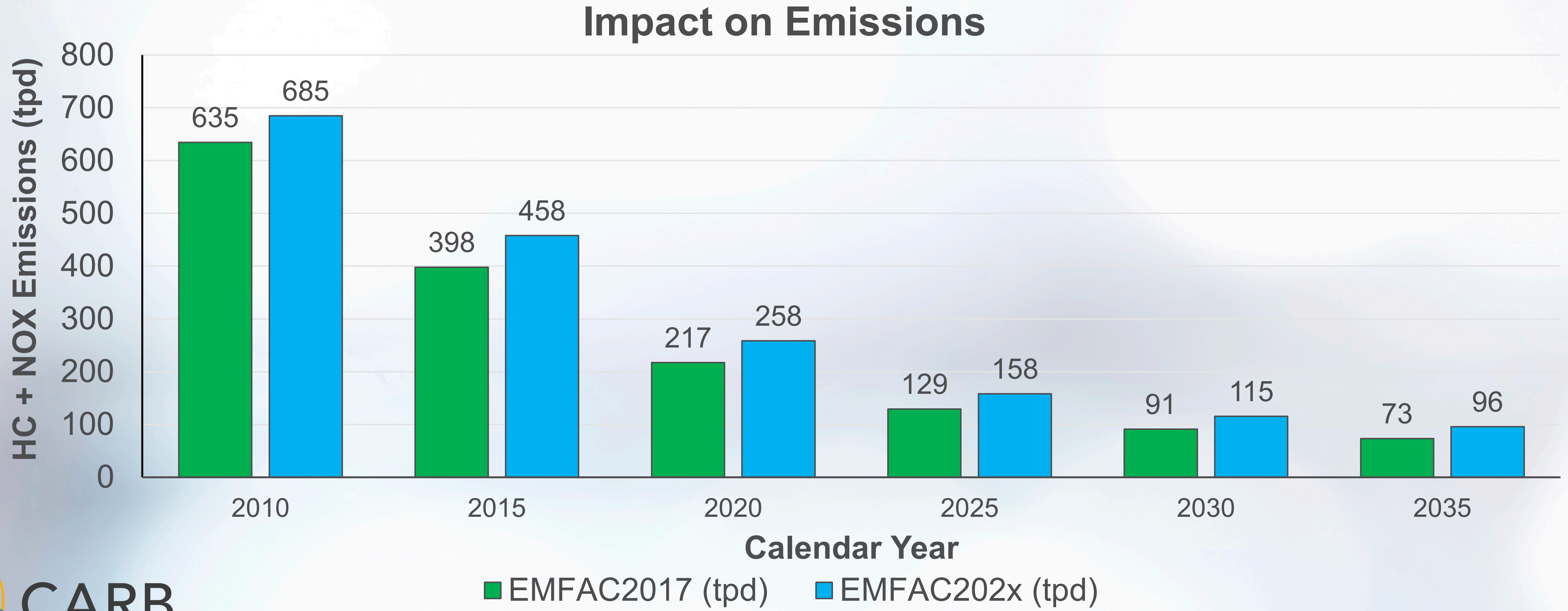
Impact on EMFAC Emissions

- Scenario: Start and Running, Light-Duty Vehicle, Gasoline, Annual Statewide
- EMFAC202x run includes updated LEVI and LEVII BERs (as described in October 2019 EMFAC202x workshop), as well as the updated LEVIII ROS



Future Work

- Utilize latest data from IUVP and VSP prior to EMFAC202x release
- Target LEVIII vehicles, especially ULEV50 and SULEV20 for the Surveillance Program to fill data gaps
- Develop UC BERs for LEVIII SULEV30 based on most recent data
- Update ROS based on future emissions test data

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Light-Duty Vehicles

PHEV Module

Background and Motivation

- PHEV (Plug-in Hybrid Electric Vehicle) module – new feature in EMFAC202x
- Previous EMFAC workshop (Oct 2019) – preliminary results from CARB's real-world emission testing of eight PHEVs
- PHEV activity analysis completed via extramural contract in early 2020
- The presentation will focus on:
    - Updated PHEV emission results
    - Updated activity profiles

List of Test PHEVs Included for Analysis

1. 2017 Toyota Prius Prime
(LEV III SULEV30)

2. 2017 Audi A3 E-Tron
(LEV III SULEV30)

3. 2012 Chevy Volt
(LEV II SULEV)

4. 2014 Ford Fusion
(LEV II SULEV)

5. 2016 Ford C-Max
(LEV II SULEV)

6. 2016 Hyundai Sonata
(LEV III SULEV30)

9. 2016 Mercedes C350e
(LEV III SULEV30)

10. 2014 Toyota Prius
(LEV II SULEV)

Non blended: Vehicle 3
Blended: Vehicle 1, 2, 4, 5, 6, 9, 10

US06 capable: Vehicle 1, 2, 3
Non US06 capable: Vehicle 4, 5, 6, 9, 10

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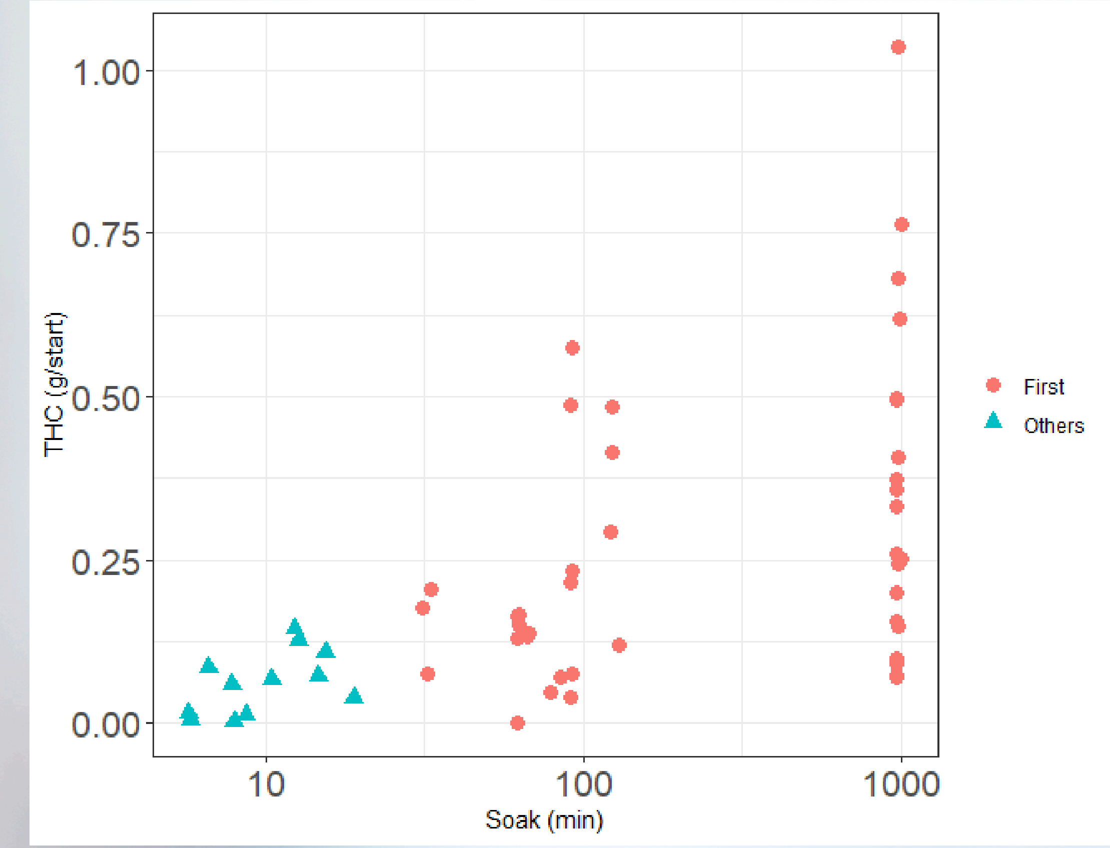
Blended vs. Non-Blended PHEVs

- Blended
  - Engine will start and provide propulsion power when driver demand is higher than what the electric powertrain can provide
  - Mostly non US06 capable
- Non-Blended
  - Electric powertrain provides all propulsion regardless of the driver demand until the car switches to charge sustaining operation when the battery reaches a low level of charge
  - US06 capable (depletes the battery first, and only when the battery is depleted, turns the ICE on to power the vehicle)

Start Emissions with Soak Time Relationship



Example: Total Hydrocarbon (THC) Start Emissions with Soak Time Relationship for Blended PHEVs

- Engine was considered to be ON (start) if RPM ≥ 100
- A duration limit of 5 to 100 secs, and soak time ≥ 5 min were set for start emissions
- Blended/non-blended PHEVs showed different starts behaviors
- Start emissions binned by soak time (mins) and applied piecewise linear regressions

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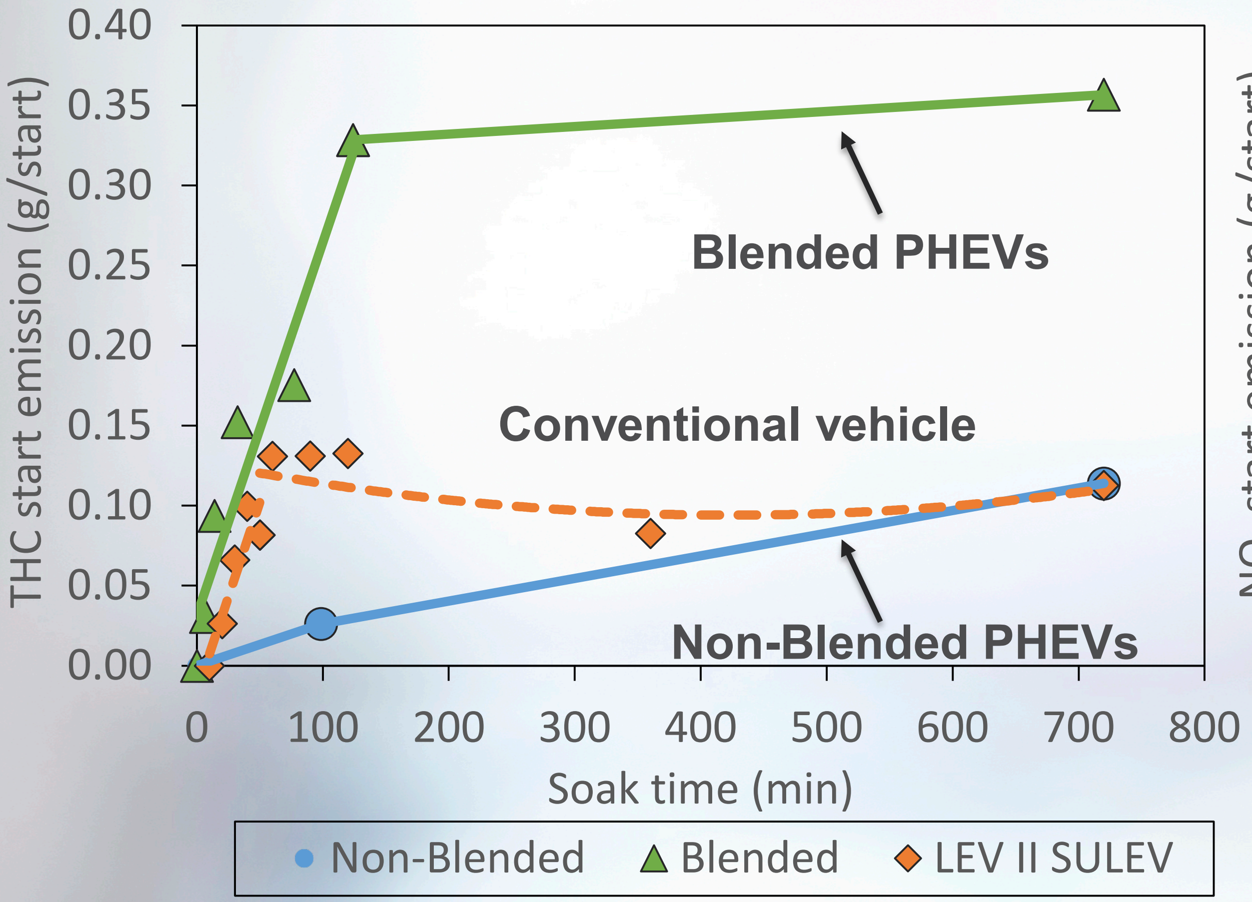
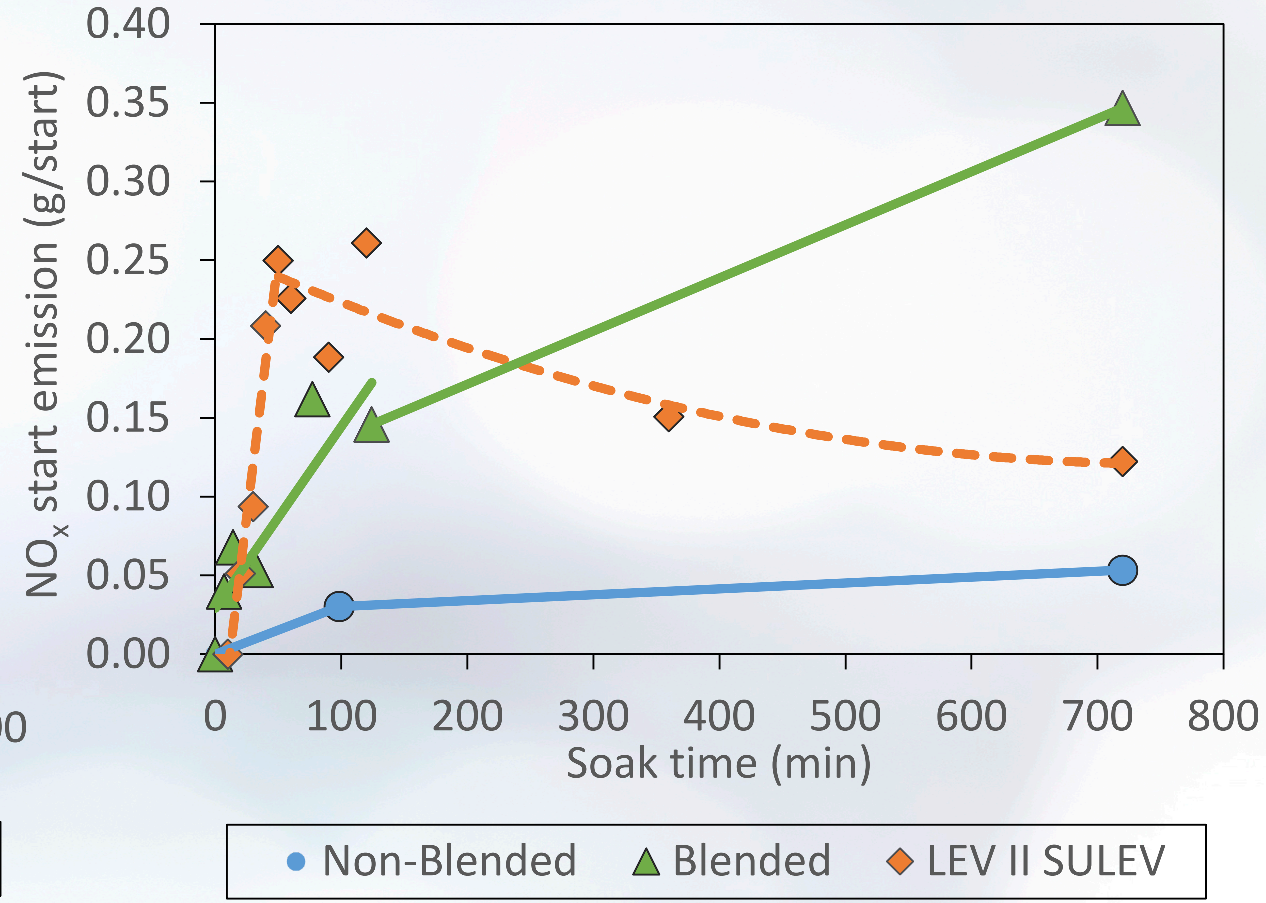
Comparison of PHEV Start Emissions with LEV II SULEV in EMFAC2017





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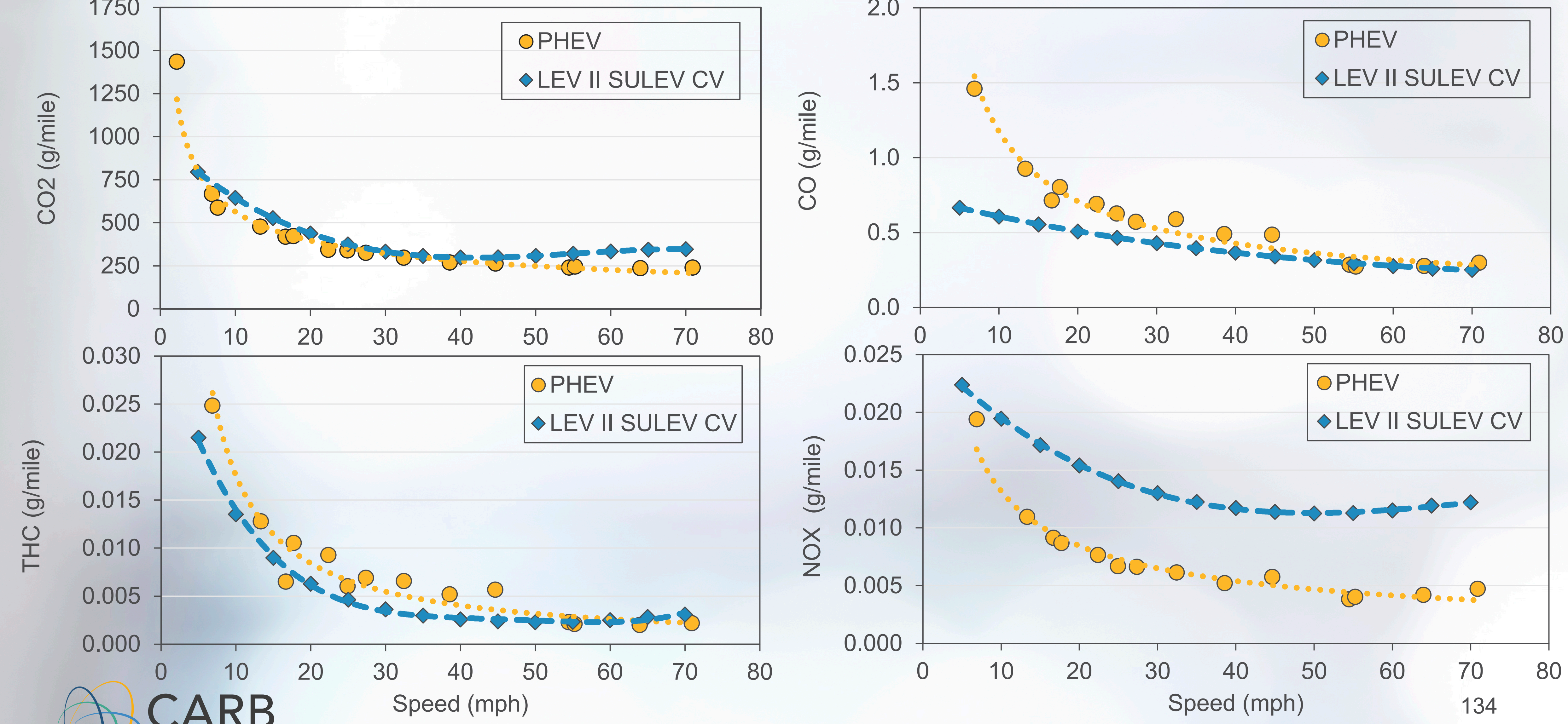
Comparison of PHEV Running Exhaust Emissions with LEV II SULEV in EMFAC2017



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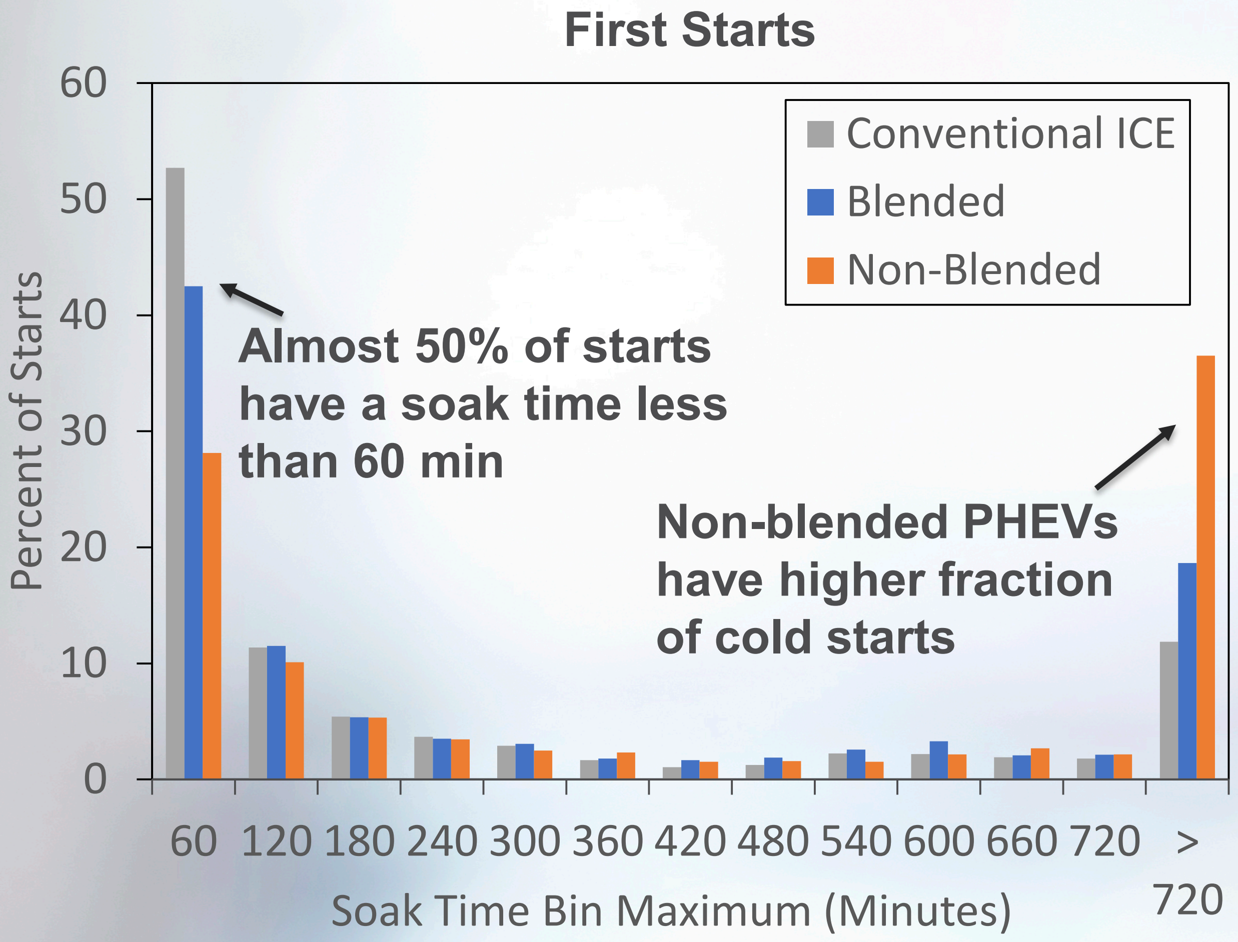
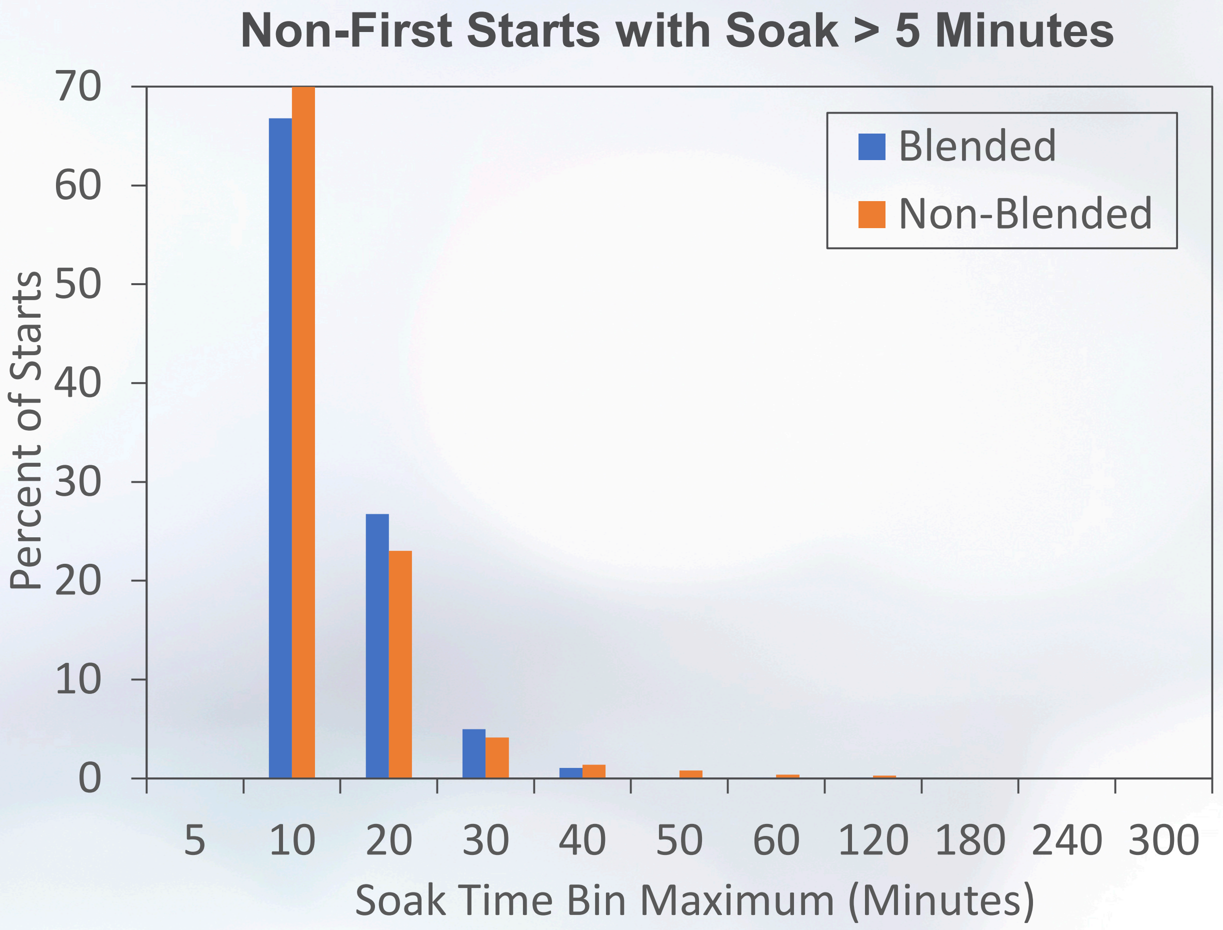
PHEV Soak Distribution from Activity Dataset





Starts Frequency Per Day from Activity Dataset

Category	Starts	First Starts	Non-First Starts > 5 mins soak
Conventional ICE	2.67 to 5.19	-	-
PHEV Non-blended	31.86	2.46	1.56
PHEV Blended	96.56	4.16	1.65

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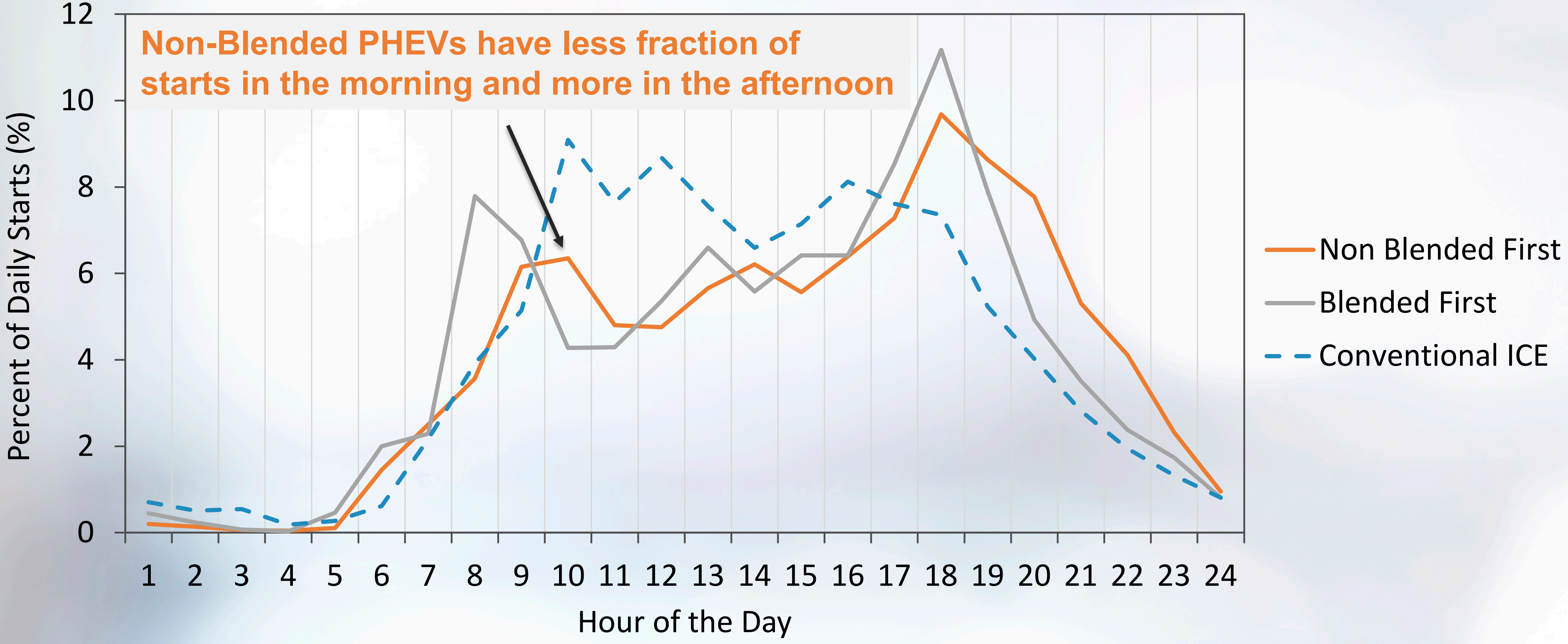
Temporal Distribution of Engine Starts from Activity Dataset



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Key Takeaways

- Cold start NOx and THC emissions from blended PHEVs can be 2 – 3x higher than the clean conventional vehicles (SULEV 30)
- In terms of running emissions, PHEVs have lower NOx and similar THC emissions as conventional vehicles
- Non-blended PHEVs have lower number of starts per day while higher fraction of cold start as compared to conventional vehicles
- PHEVs exhibit significant GHG emissions reductions

Light-Duty Vehicles

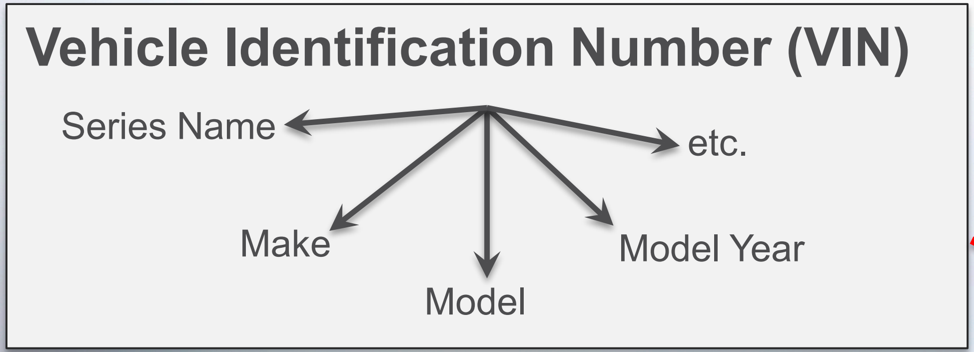
CO_2 Emission Rates

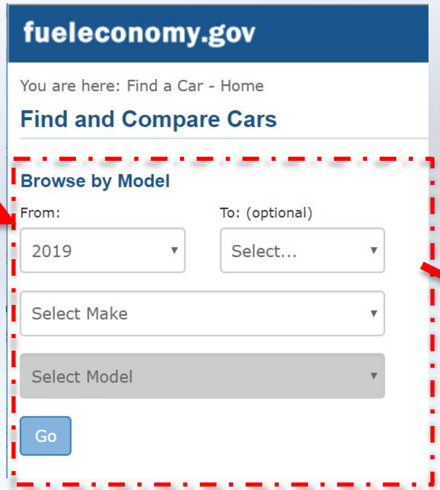
Introduction

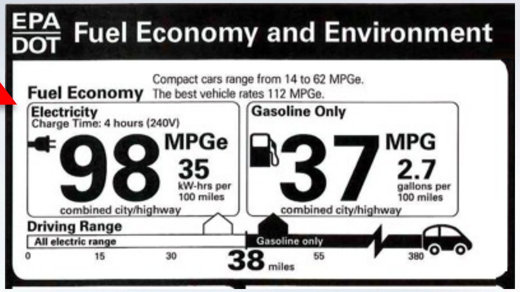
- EMFAC2017 used a new approach for estimation of CO_2 emissions
  - CO2 was calculated assuming complete combustion of fuel
  - Fuel efficiency assumptions were based on federal fuel efficiency data
  - EMFAC2017 had data for MYs 2005 through 2015
- EMFAC202x will be updated with CO_2 emission factors for new model-year vehicles (MY 2016-2020)

CO_2 Calculation Approach

- Identify the fuel efficiency ratings for California’s vehicle fleet:
  - Decode VIN numbers in DMV registration - identify make, model, and other vehicle attributes
  - Match make, model, and other vehicle attributes with records in fueleconomy.gov to obtain the EPA rated fuel efficiencies







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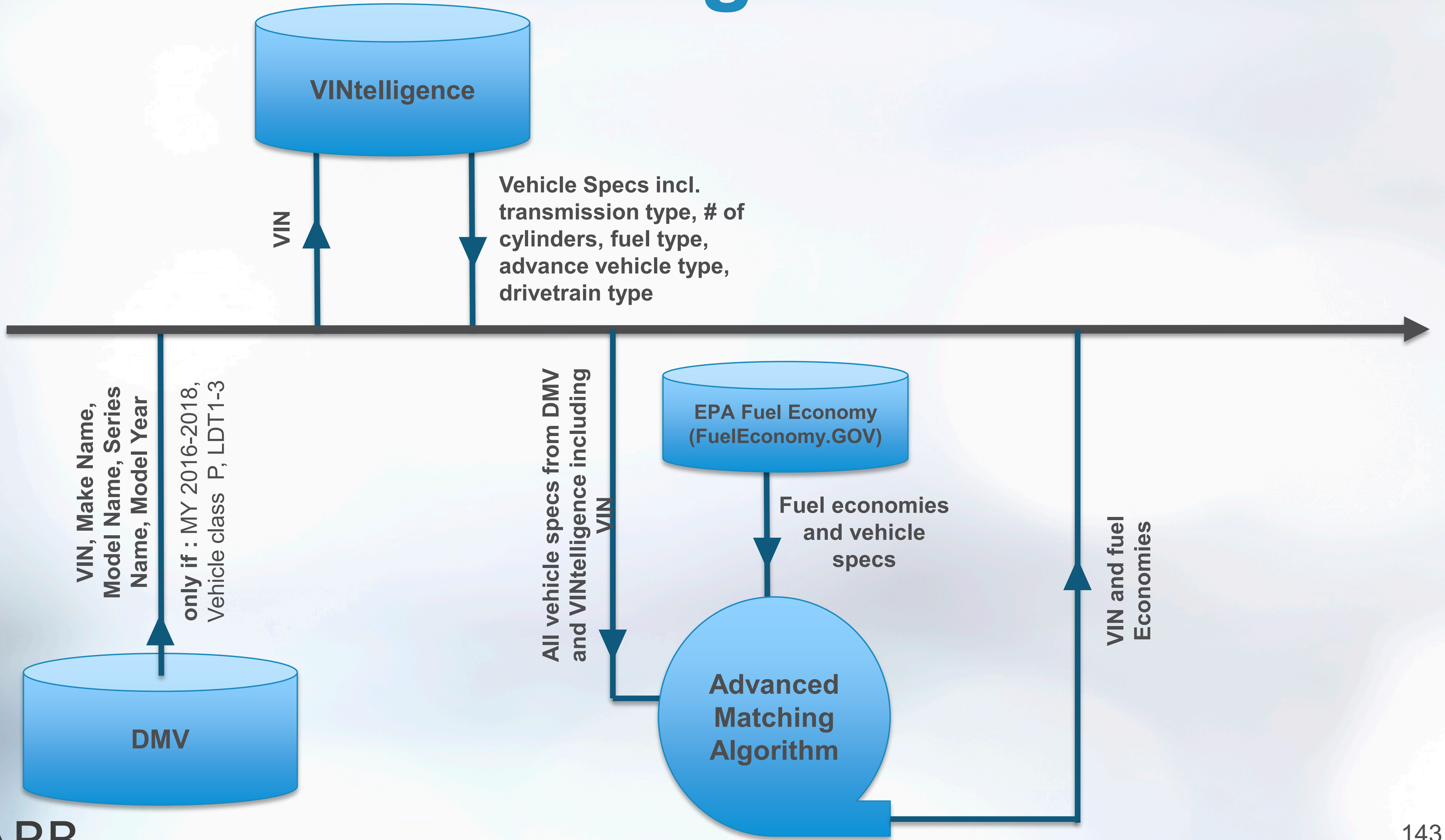
Methodology Updates

- Vehicle matching based on vehicle specifications is improved
  - Use an advanced matching algorithm to find the most similar matches between DMV and EPA's fueleconomy.gov data
    - For details refer to *SB 1014 Clean Miles Standard - 2018 Base-year Emissions Inventory Report*
- Fuel economies are no longer obtained solely using VINtelligence
- g CO_2 per mile of emissions is calculated using only the 2-cycle unadjusted EPA fuel economies

Data Processing Flow Chart



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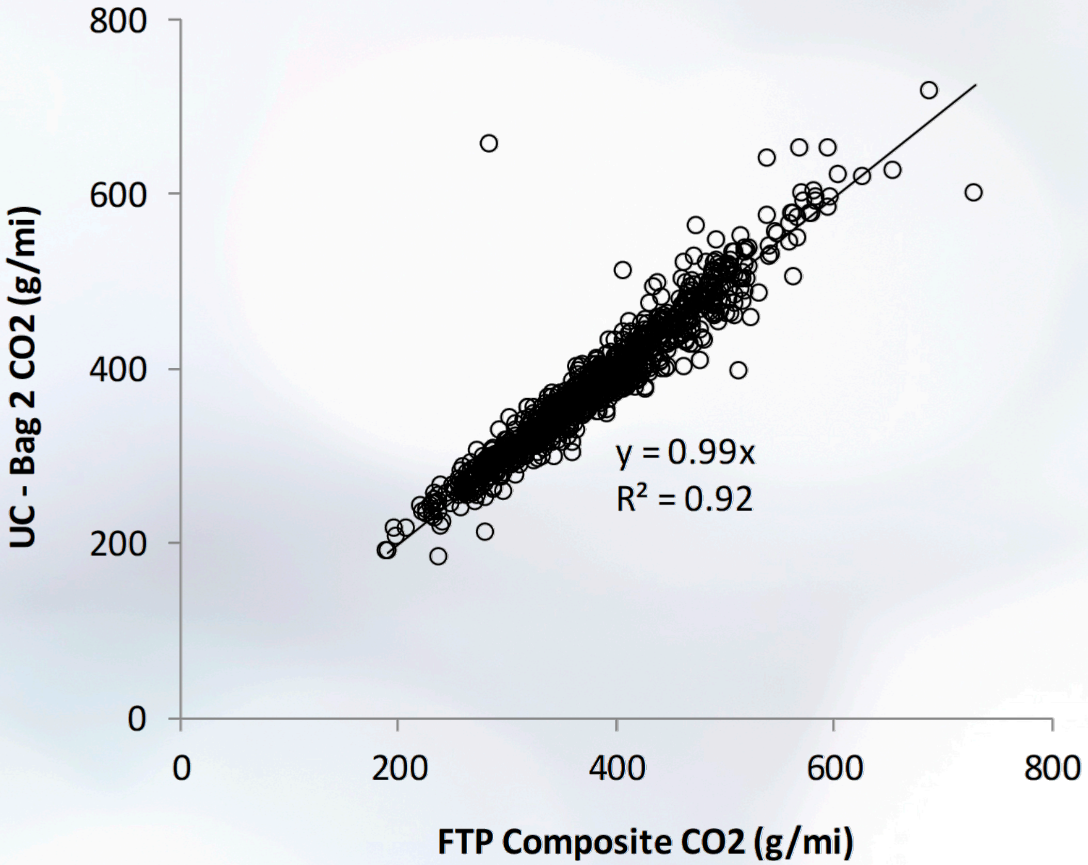
Why 2-Cycle City (Unadjusted)?

- EMFAC use the Phase 2 (Bag 2) of Unified Cycle to model running emissions from light duty vehicles
- According to emission test data, CO_2 emissions of FTP composite is almost equivalent to Phase 2 of Unified Cycle
- Staff are looking into other methods to evaluate the appropriateness of this method to characterize real world CO2 emission rates



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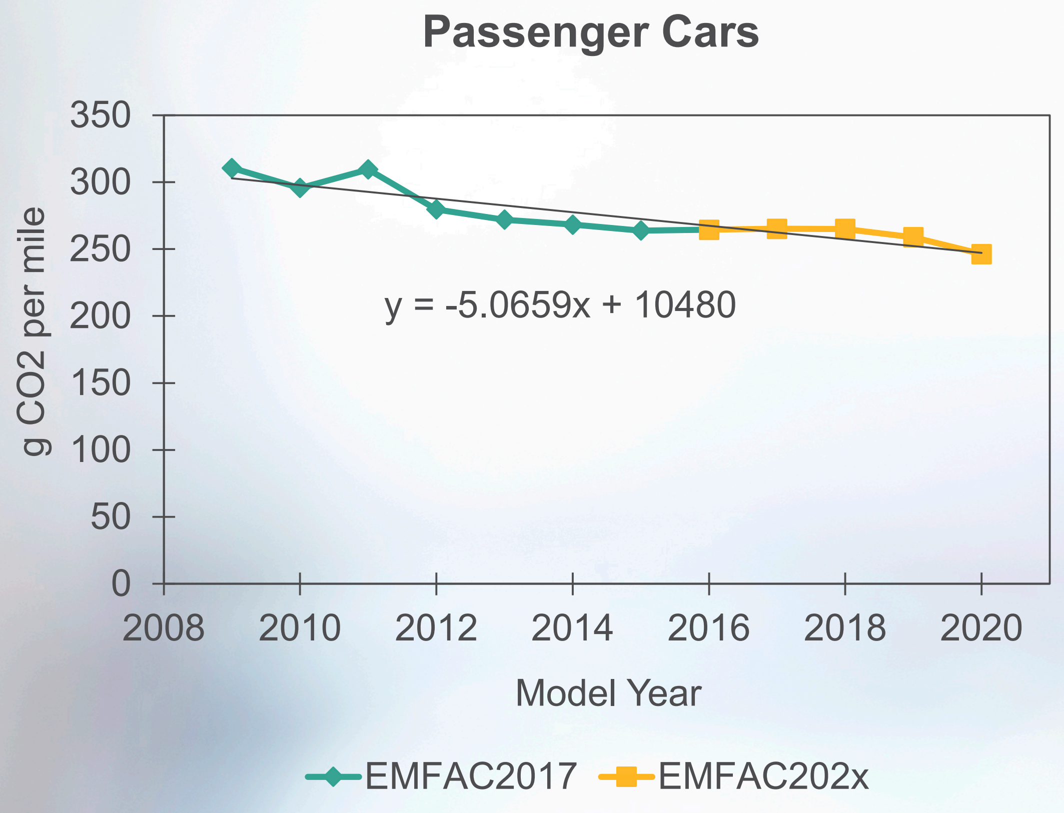
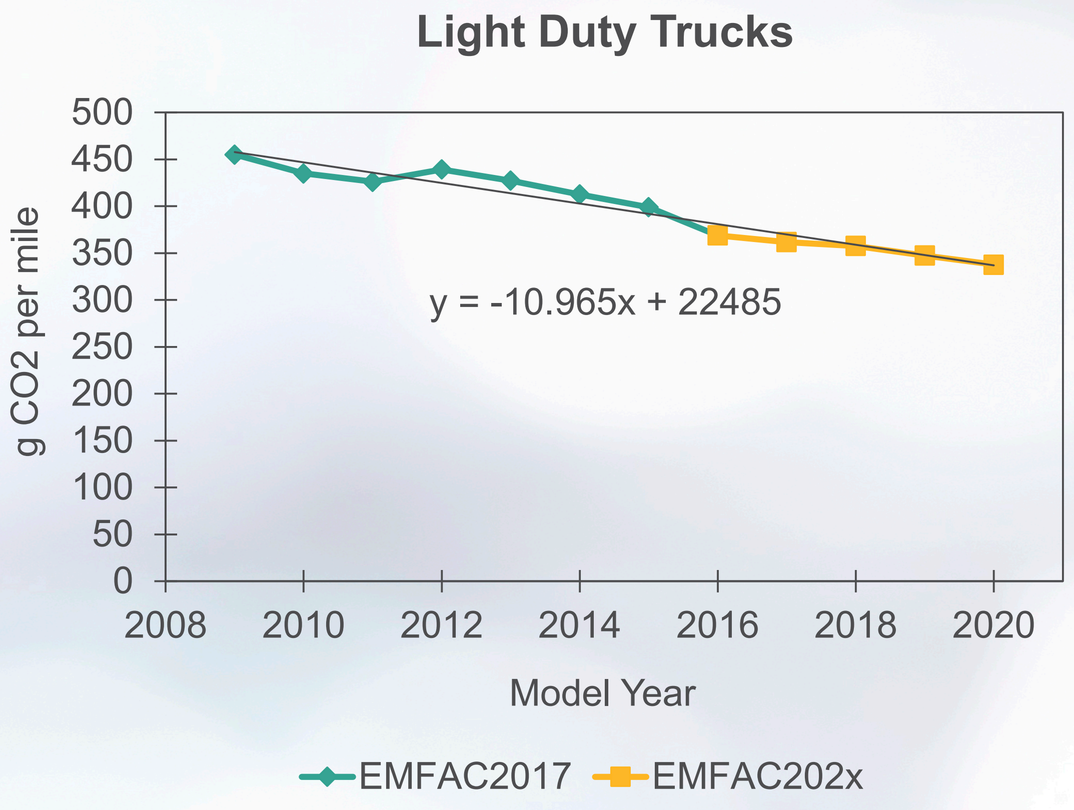
Results

California Fleet Average CO_2 Emission Factors





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SAFE Rule

- Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule
  - **Part One** (adopted September 2019): Revokes California's authority to set its own GHG emission standards and zero-emission vehicle mandate in California
  - **Final Rule** (adopted April 2020): National Highway Traffic Safety Administration (NHTSA)'s Corporate Average Fuel Economy(CAFÉ) and US EPA greenhouse gas emission standards will increase in stringency at 1.5% per year from MY2020 levels over MYs 2021-2026; relaxes current GHG emissions targets
- Staff have evaluated the impact of SAFE Vehicles Rule on GHG emissions from passenger cars and light trucks in California
- Derived from the finalized CO_2 standards rather than the finalized CAFE standards, a 1.84% and 1.75% Year-over-Year (YoY) reduction from 2020 to 2026 for the CO_2 emission factor values of gasoline passenger cars and light trucks were determined, respectively

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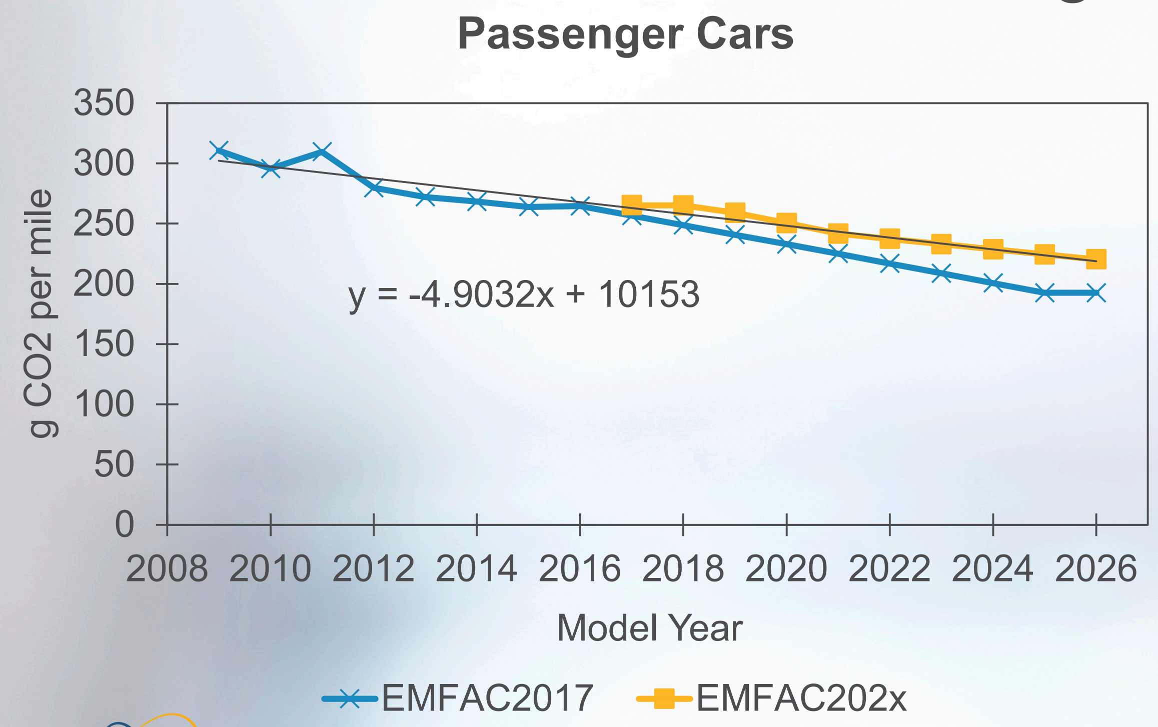
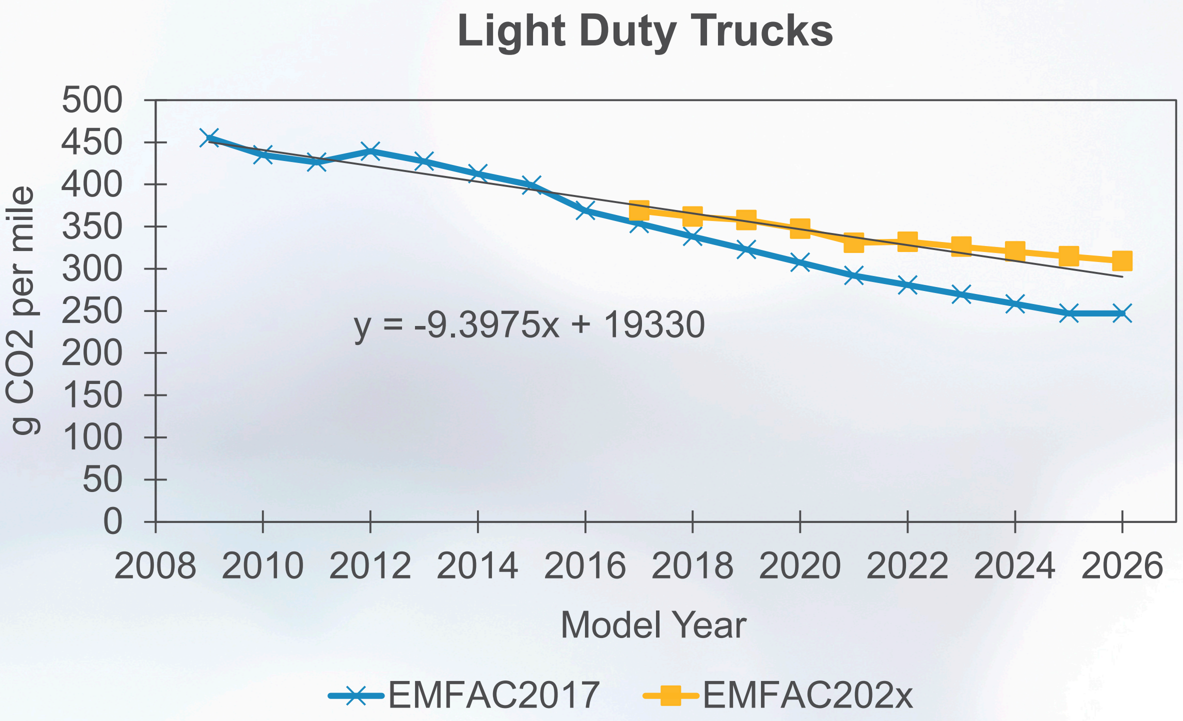
More details on staff evaluation of SAFE Vehicle Rules impact on EMFAC model can be found at:
https://ww3.arb.ca.gov/msei/emfac_off_model_co2_adjustment_factors_06262020-final.pdf

Impact of SAFE Rule on Light Duty Vehicle CO_2 Emissions

- Final Rulemaking (FRM): 1.84% YoY reduction from 2020 to 2026 for the CO_2 emission factor of gasoline passenger cars, and 1.75% YoY reduction for light trucks





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Conclusions

- CO_2 emission rates are decreasing at rates equal to 5 and 11 g CO_2/mile per year for passenger cars and light duty trucks, respectively.

- While the previously established emission standards and related “augural” fuel economy standards would have achieved about 4% per year improvements through MY 2025, SAFE rule will result in much lower reduction in CO_2 emission for cars and light trucks

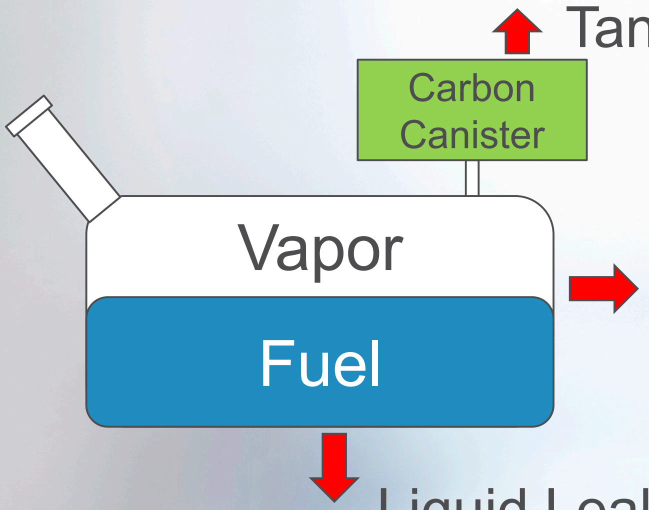
- Final SAFE Rule emission standards can increase tailpipe CO_2 emissions of light duty vehicles by almost 6.4 million metric tons in 2030

Light-Duty Vehicles

New Evaporative Emissions Module

Evaporative Emissions

- Major source of hydrocarbon emissions from gasoline vehicles
- New evaporative method implemented
  - Adopting USEPA's MOVES2014b method
  - Using California-specific activity and meteorological data



Tank Vapor Venting: Fuel vapor is vented out (or "breakthrough") when carbon canister is saturated (or cannot contain all of the generated fuel vapor)

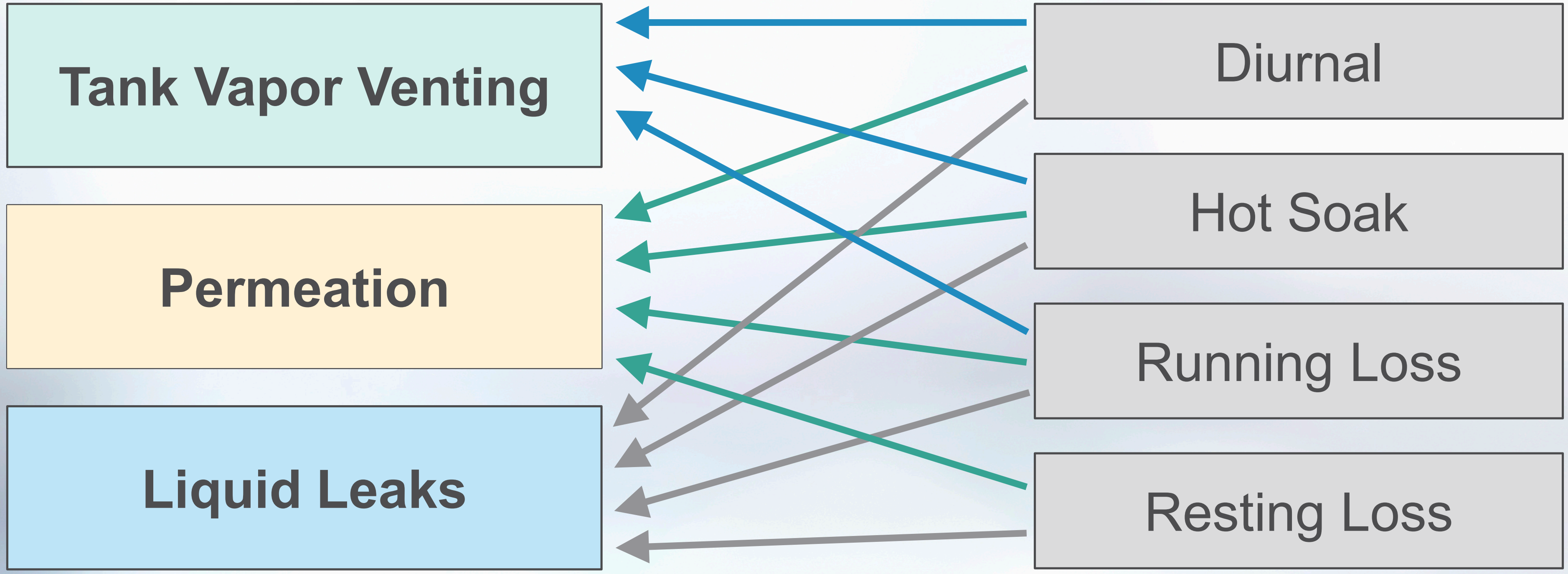
Permeation: Fuel escapes through materials in the fuel system (the tank walls, hoses, and seals)

Liquid Leaks: Non-vapor form of fuel escaping the fuel system (i.e. dripping fuel), ultimately evaporating

Evaporative Processes: EMFAC202x vs EMFAC2017

EMFAC202x
(physical processes)

EMFAC2017
(certification processes)



Development of EMFAC's new evaporative emissions module

Implementation of MOVES methods

- MOVES vehicle classes matched to comparable EMFAC vehicle classes
- Emission rates
- Porting emission algorithms from Java/MySQL to Python/MySQL

California-specific information

- Vehicle activity data from 2010-2012 California Household Travel Survey (2013)
- EMFAC's temperature and relative humidity
- Cross-validating with existing CARB testing results

Preprocessing with MOVES

- Average tank temperature
- Cold soak tank temperature
- Cold soak initial hour fractions
- Cold/Hot soak activity fractions

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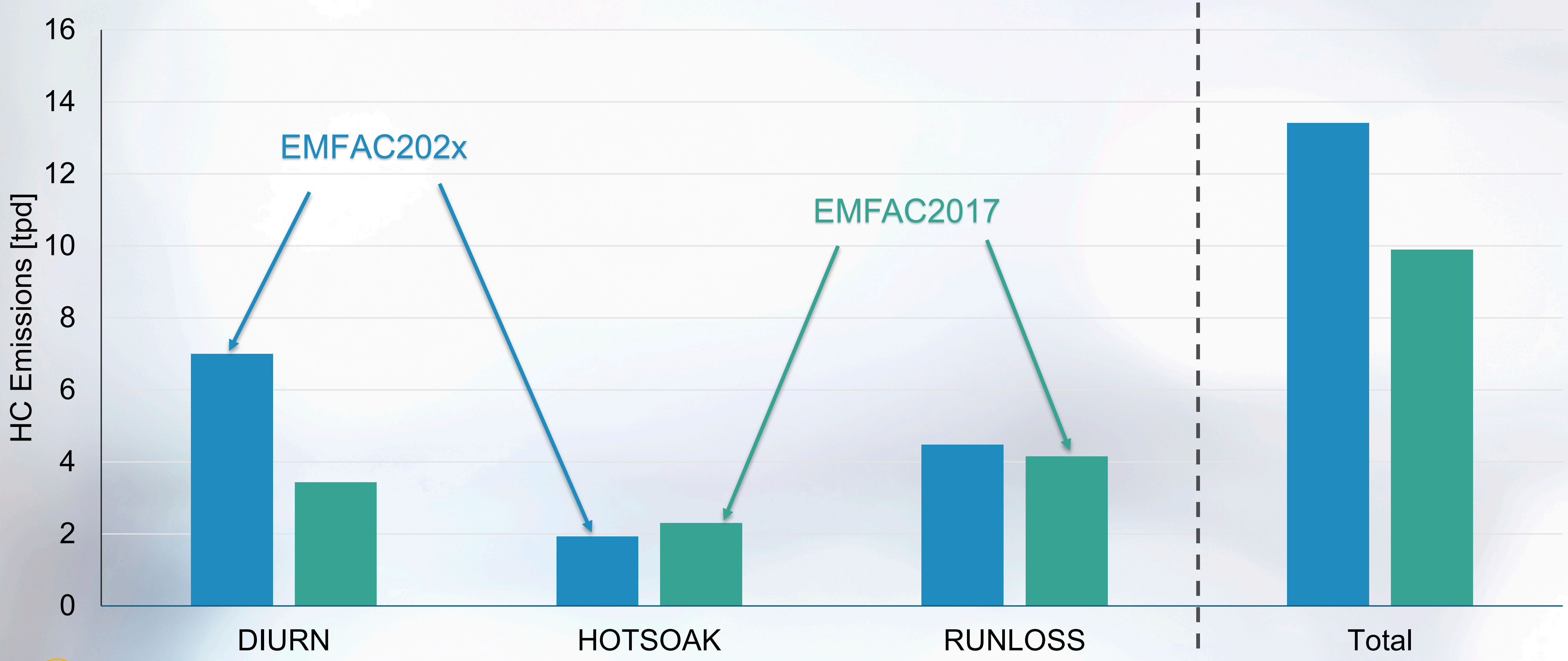
EMFAC202x vs EMFAC2017:
Passenger Cars, Los Angeles, July 2020



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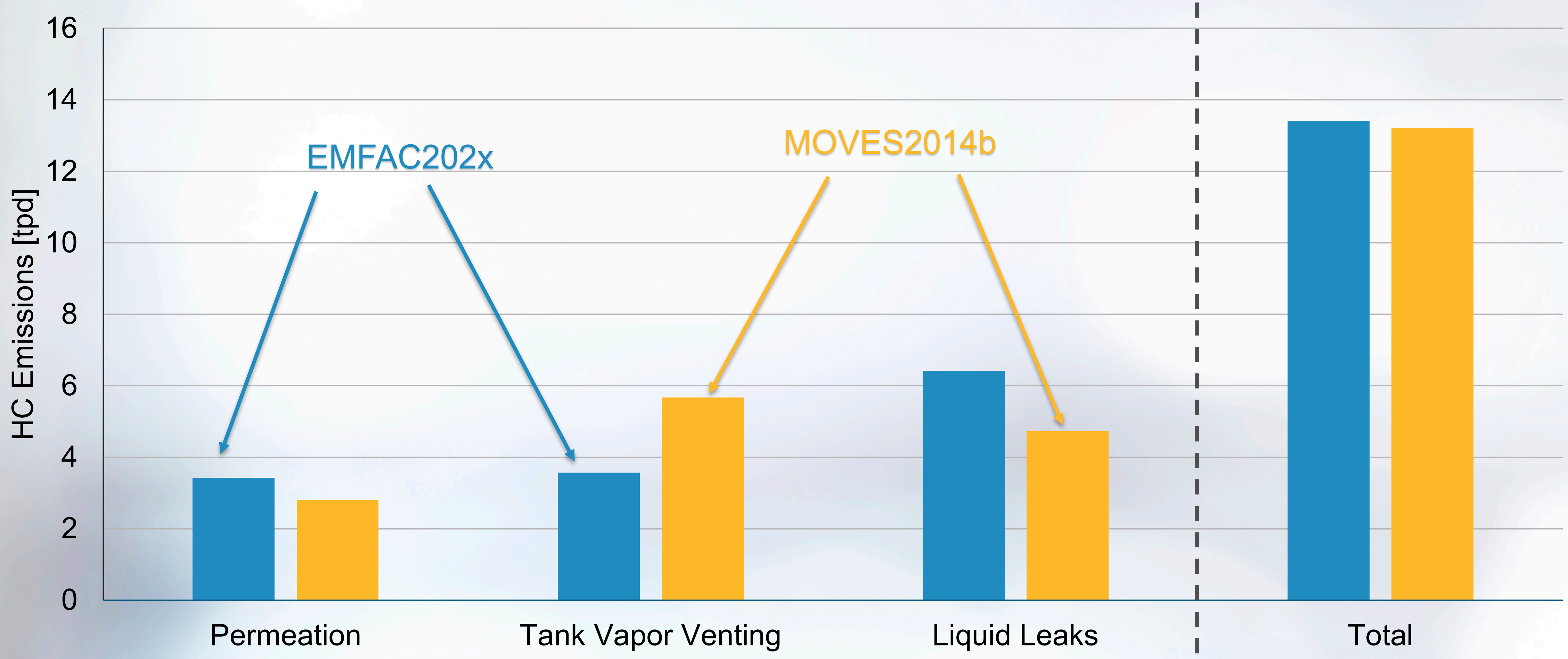
EMFAC202x vs MOVES2014b:
Passenger Cars, Los Angeles, July 2020



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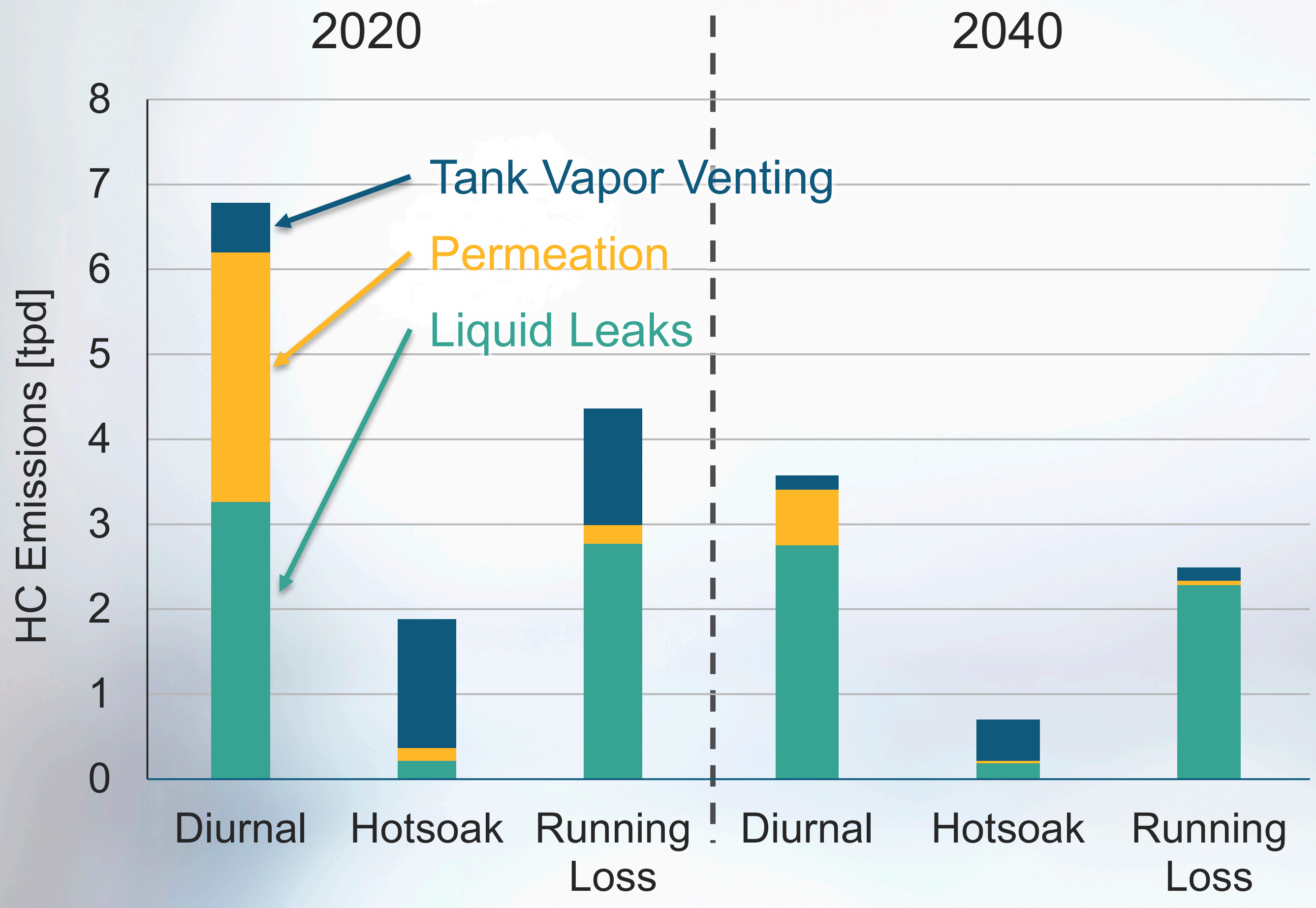
EMFAC202x: 2020 vs 2040

Passenger Cars, Los Angeles, July 2020



- Evaporative emissions are expected to decrease
- As Tank Vapor Venting and Permeation decrease, Liquid Leak process will account for more evaporative emissions

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Next Steps

- Further quality assurance
- Share the results with internal and external stakeholders
- Improve module parameters and inputs based on former California-specific test results
- Plan new tests to improve module parameters and inputs for California conditions
- Further improve the computational efficiency of the module

Light-Duty Vehicles

Brake Wear Emissions

Background

- Currently (EMFAC2017)
  - Data from 2000/2003
  - No cycle or speed effects
  - Data extrapolated to cover all technology groups/drive cycles
- New Emission Factor Development (EMFAC202x)
  - Multi-agency effort (USEPA, Caltrans, European Joint Research Committee)
  - Use modern braking materials
  - Use modern, real world driving patterns
  - Regenerative braking

Priorities for New Emission Factor Development

- Use CA relevant vehicles and brake components
- Light, medium, and Heavy-Duty vehicles
- Identify speed dependent braking cycle reflecting CA driving behavior
- Identify cycles for light, medium, and Heavy-Duty vehicles
- Use methods being adopted by European Joint Research Counsel (e.g., enclosed brake dynamometer)
- Maintain realistic temperatures
- Develop method to simulate regenerative braking

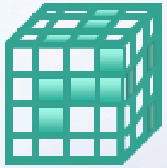
ERG/LINK Test Program

LDVs

Market Share Analysis → 6-7 vehicle choices → On-road testing → Final drive cycles, real temperatures

Real world CA activity data → Final drive cycles, real temperatures

Validated enclosed dyno and PM sampling systems → ~90 tests by 3/2020

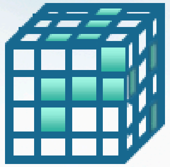


Vehicle N:
Front brake pads
Rear brake pads/drums
Popular aftermarket pads
Loaded/unloaded
Replicates

HDVs

Market Share Analysis → 4-5 vehicle choices → On-road testing → Final drive cycles, real temperatures

Validated enclosed dyno and PM sampling systems → ~40 tests by 1/2021



ERG

LINK

Caltrans

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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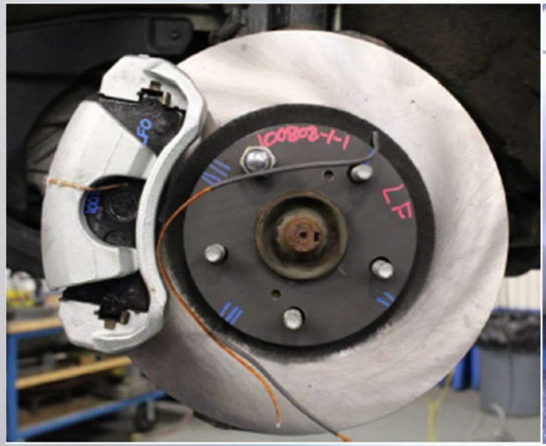
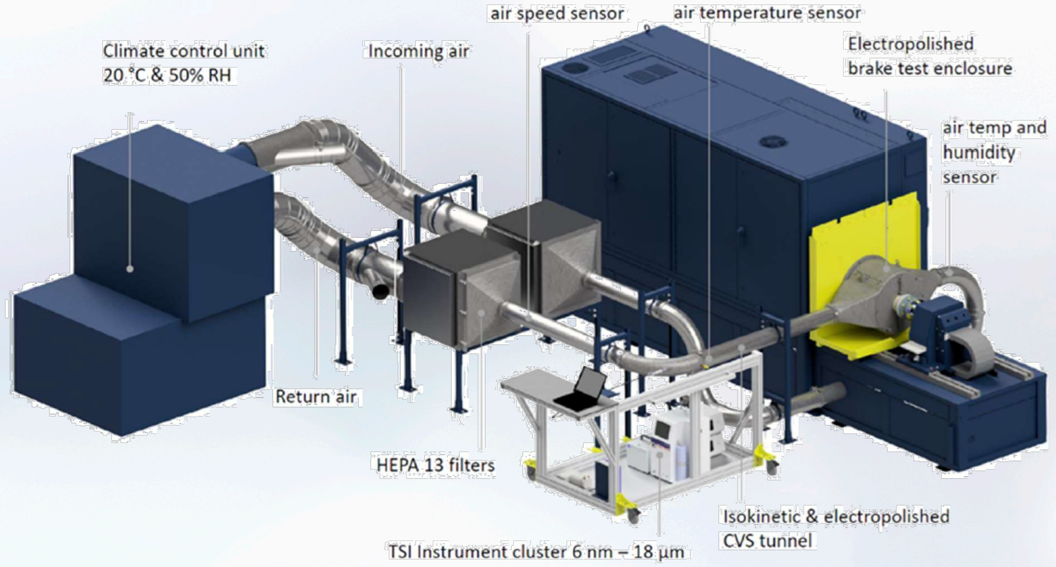
Data Collection Methods

- Survey most popular brake configurations
- Develop representative braking cycle (CBDC)
- Collect brake temperature data on test track
- Conduct braking events and controlling temperature
- Collect Brake Wear (BW) on both aluminum impactors (TSI 100S4 MOUDI) and on 47mm Teflon filters





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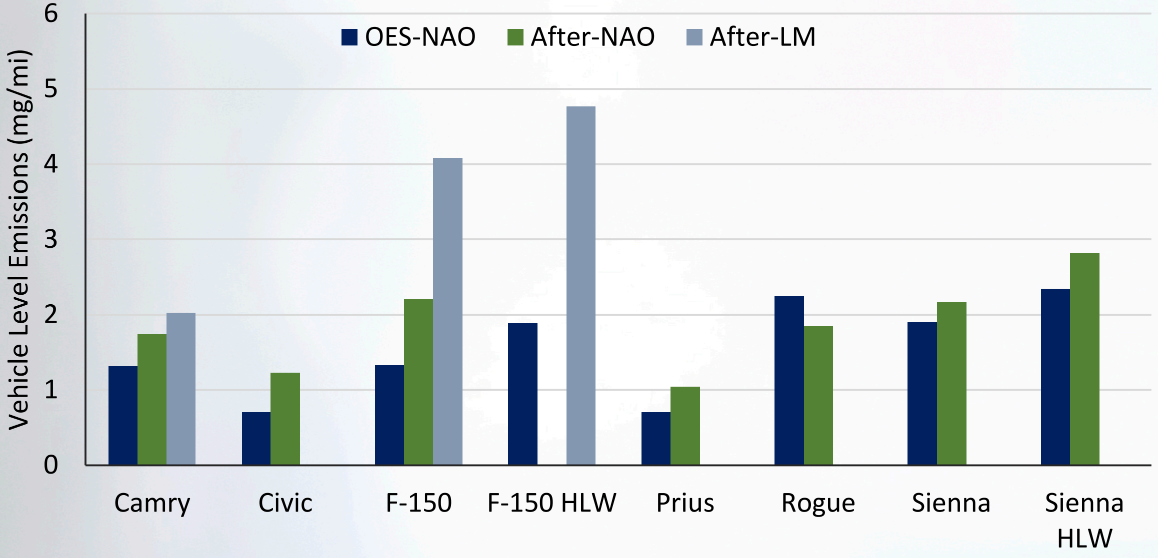
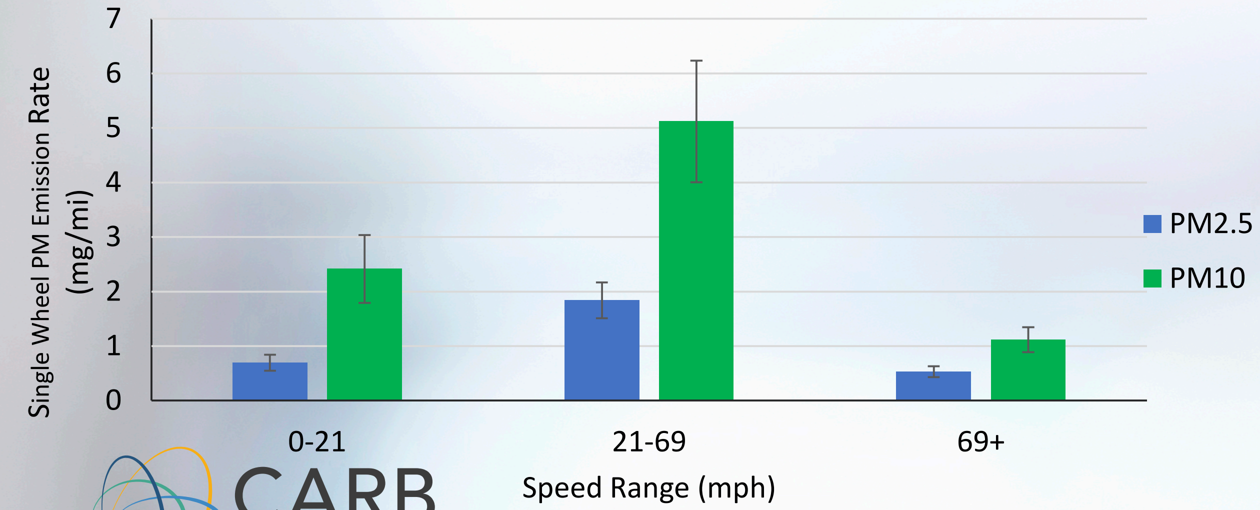
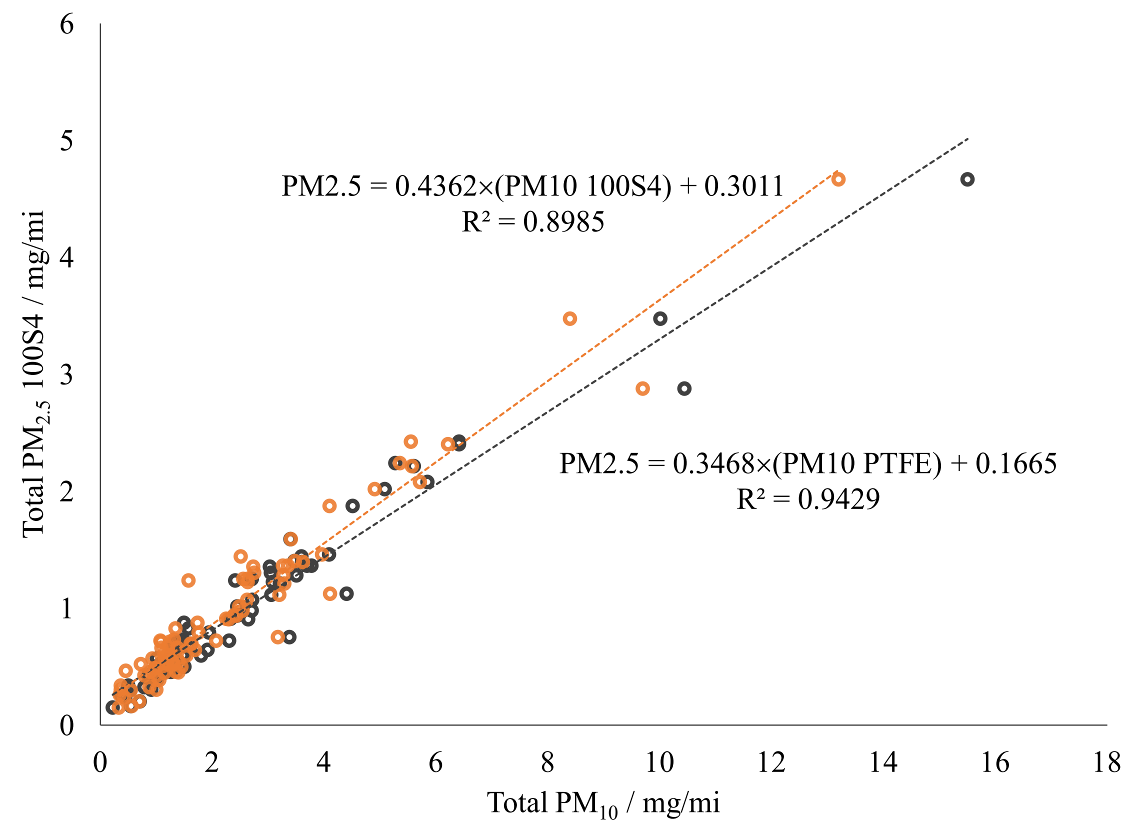
Results







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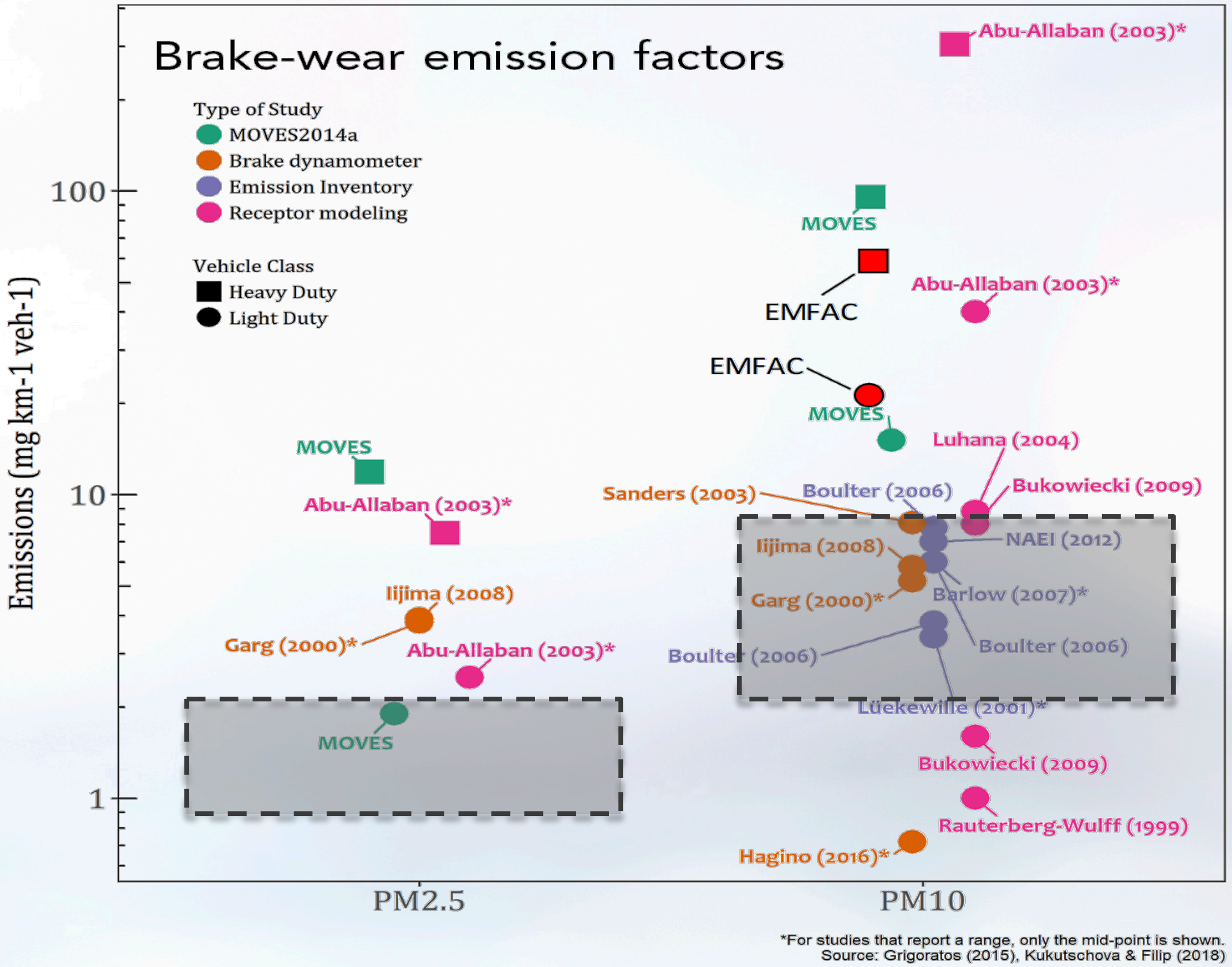
Comparison to Other Studies



* Courtesy of Darrell Sonntag (USEPA). Study results added by ERG

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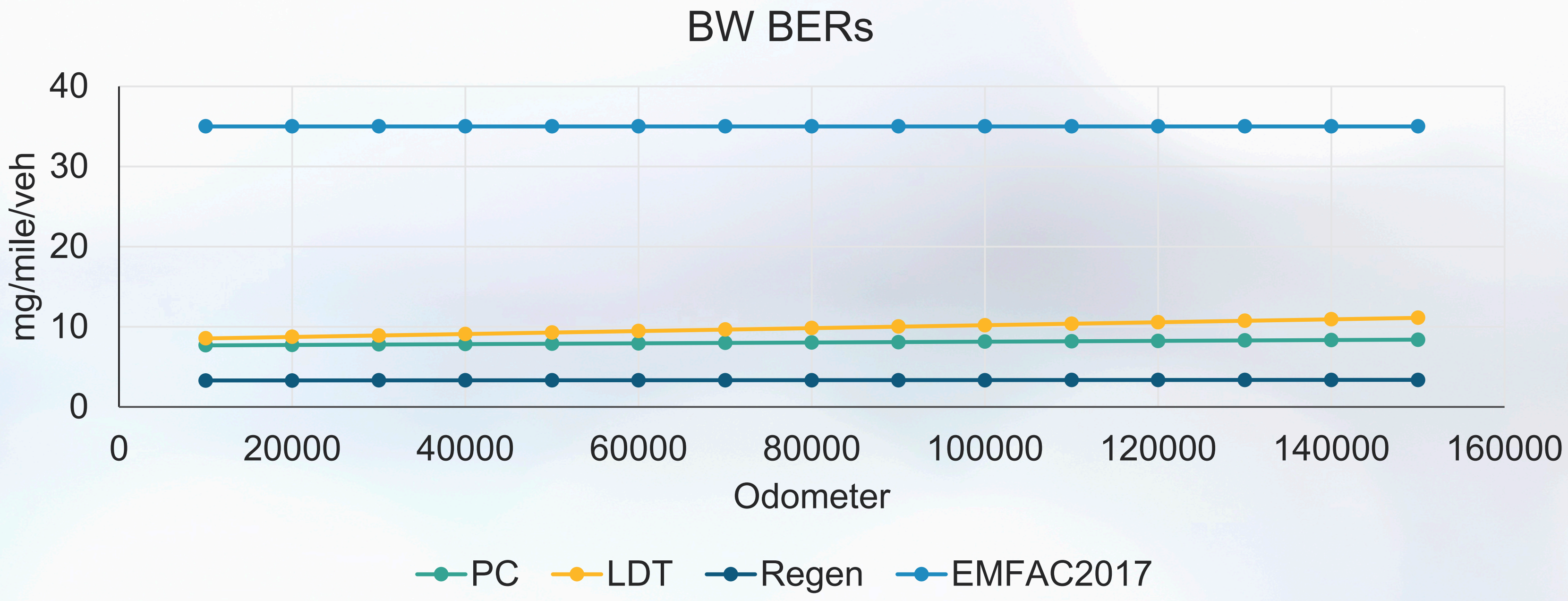
Key Findings

- Front brakes emit more PM than rear brakes
- Non Asbestos Organic (NAO) friction material brakes emit less than Low Metallic (LM) brakes
- LM is more frequently used as the vehicles age
- Speed effects are not monotonic
- There appears to be a correlation to weight
- Emissions are significantly lower than EMFAC2017

Brake Wear Basic Emission Rates

Vehicle Categories	Old PM10 BER (mg/mi)	New PM10 BER (mg/mi)
Passenger Car	37.5	7.65 + 0.0492 * (ODO/10,000)
Light-duty Truck	37.5	8.38 + 0.1825 * (ODO/10,000)
Regenerative Brakes	37.5	3.30 + 0.0047 * (ODO/10,000)



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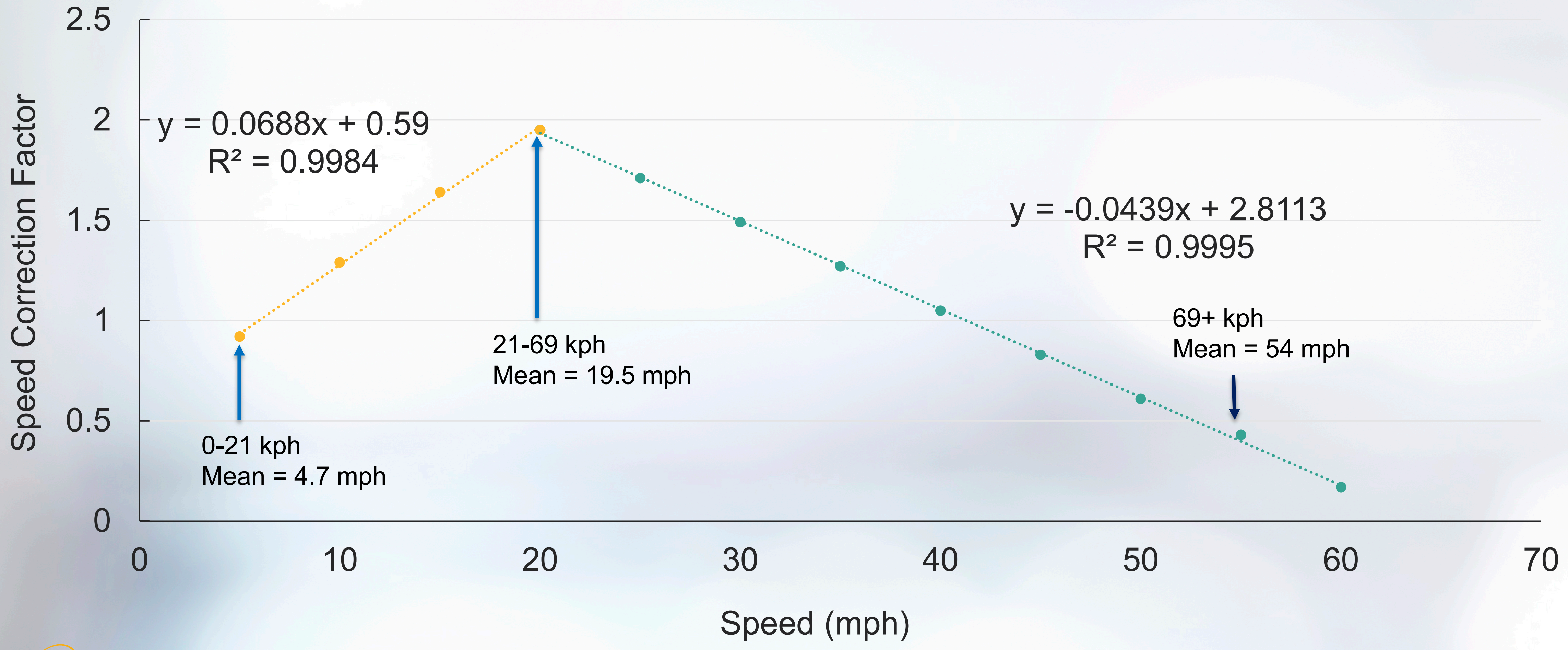
Speed Correction Factors (SCF)
ER(S) = BER*SCF(S)



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Future Efforts

- Heavy-Duty Vehicles (ongoing)
- Refine Speed Correction Factors
- Correlate emissions to vehicle weight
- More research into regenerative braking
- Tire Wear – Research/test program
- Final ERG Report: https://ww3.arb.ca.gov/research/single-project.php?row_id=66826

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Heavy-Duty Vehicles

Emission Rates

Review of EMFAC2017 HD Emission Rate Revision

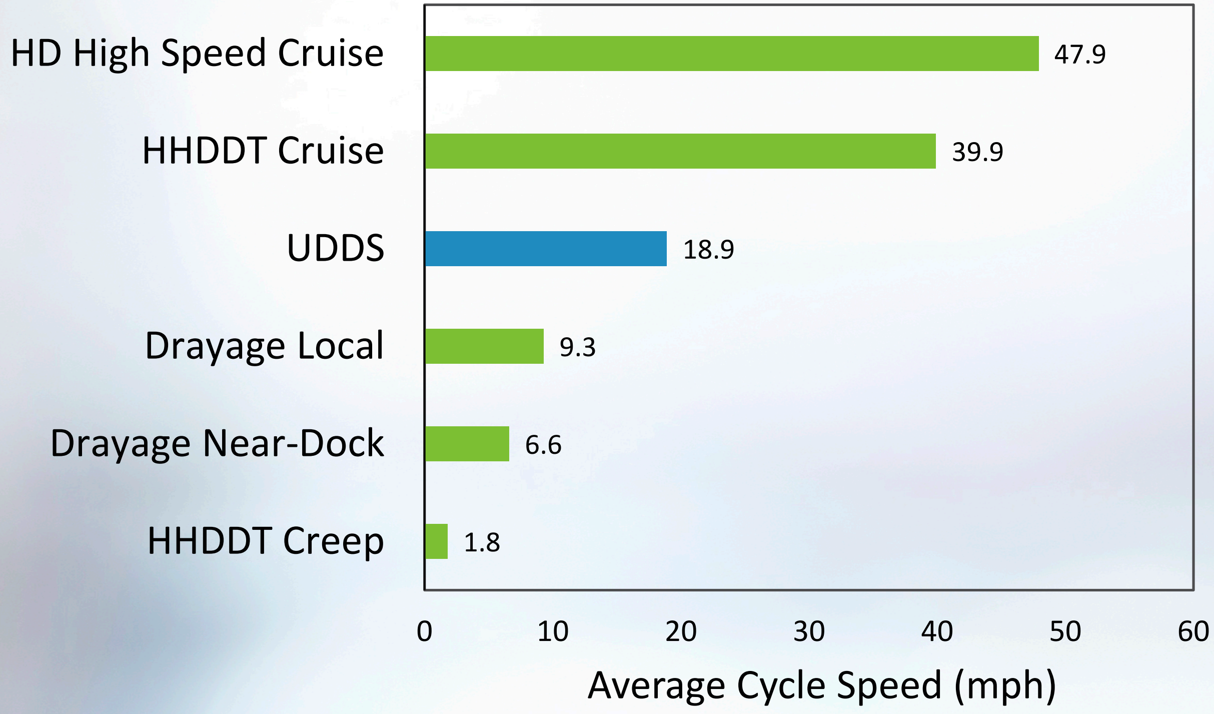
- For HHD diesel trucks:
  - Revised running exhaust emission rates of 2013+ MY using dyno data from CARB and other sources
  - Revised start and idle emission rates of 2010+ MY using PEMS data from CARB and other sources
- Estimated MHD diesel truck emission rates by scaling HHD truck emission rates
- Revised emission rates of 0.2g CNG transit buses using limited dyno data from several sources

HD Emission Rate Revision for EMFAC202x

- Running exhaust emission rates of 2013+ MY HHD and MHD based on dyno test data from CARB TBSP
- Running exhaust emission rates of natural gas HD vehicles based on PEMS data from a multi-agency 200-vehicle testing project
- Start emission rates of 2013+ MY diesel HD trucks based on PEMS data of CARB TBSP

CARB Truck & Bus Surveillance Program (TBSP)

- To date, **38** MY2013+ trucks tested on dyno over 6 test cycles
- Most trucks also tested with PEMS



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

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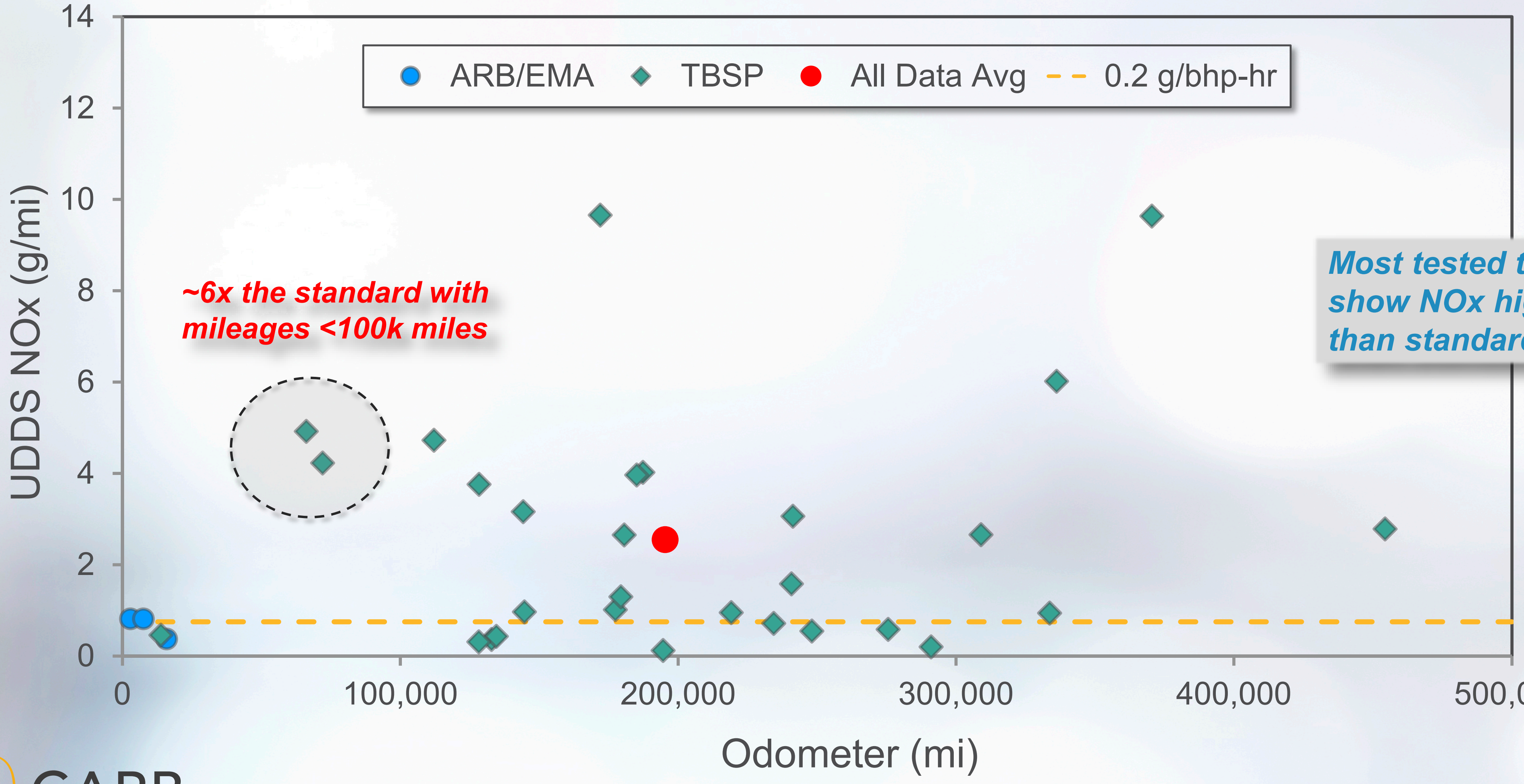
2013-15 MY HHD Truck UDDS NOx



Most tested trucks show NOx higher than standard

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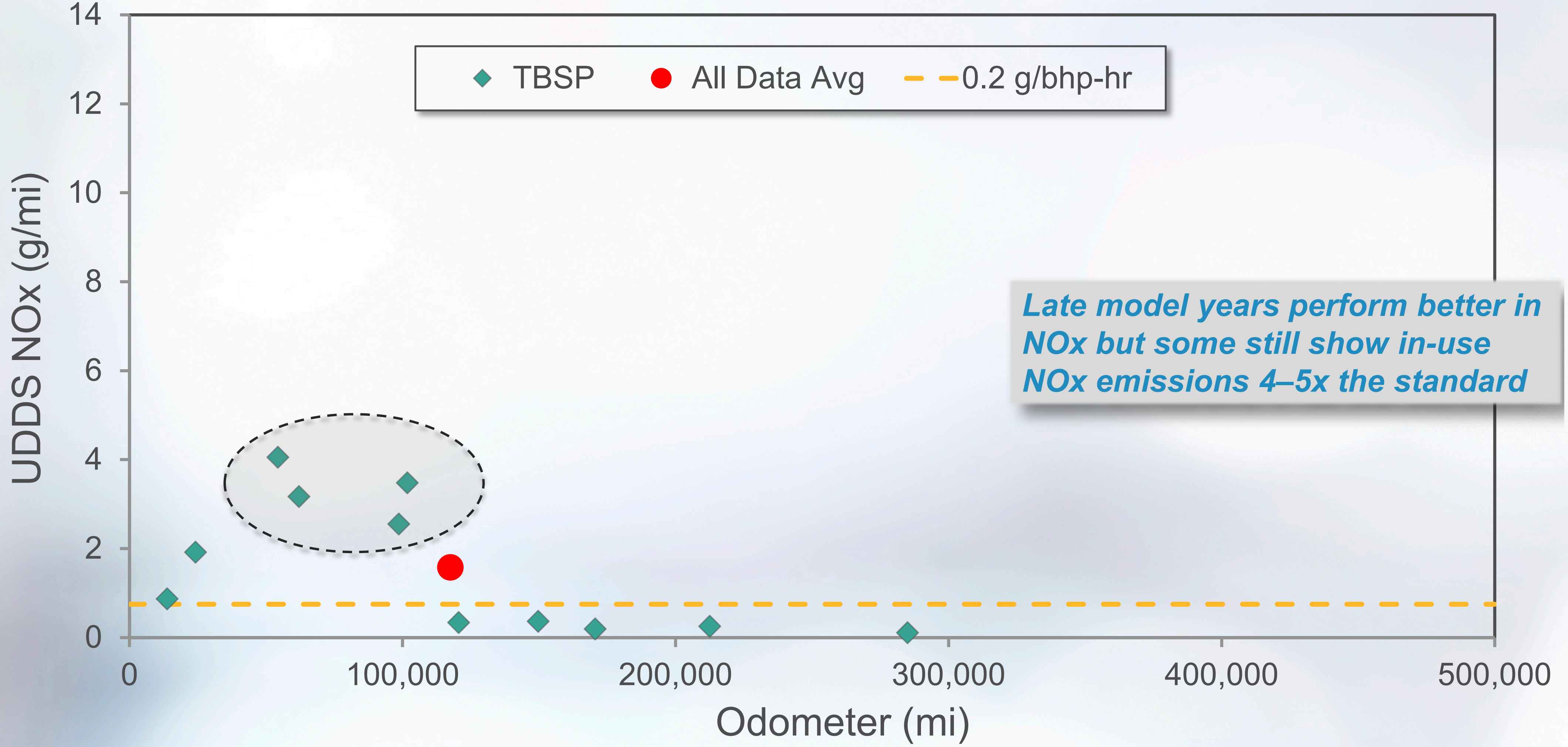
2016+ MY HHD Truck UDDS NOx



Late model years perform better in NOx but some still show in-use NOx emissions 4–5x the standard

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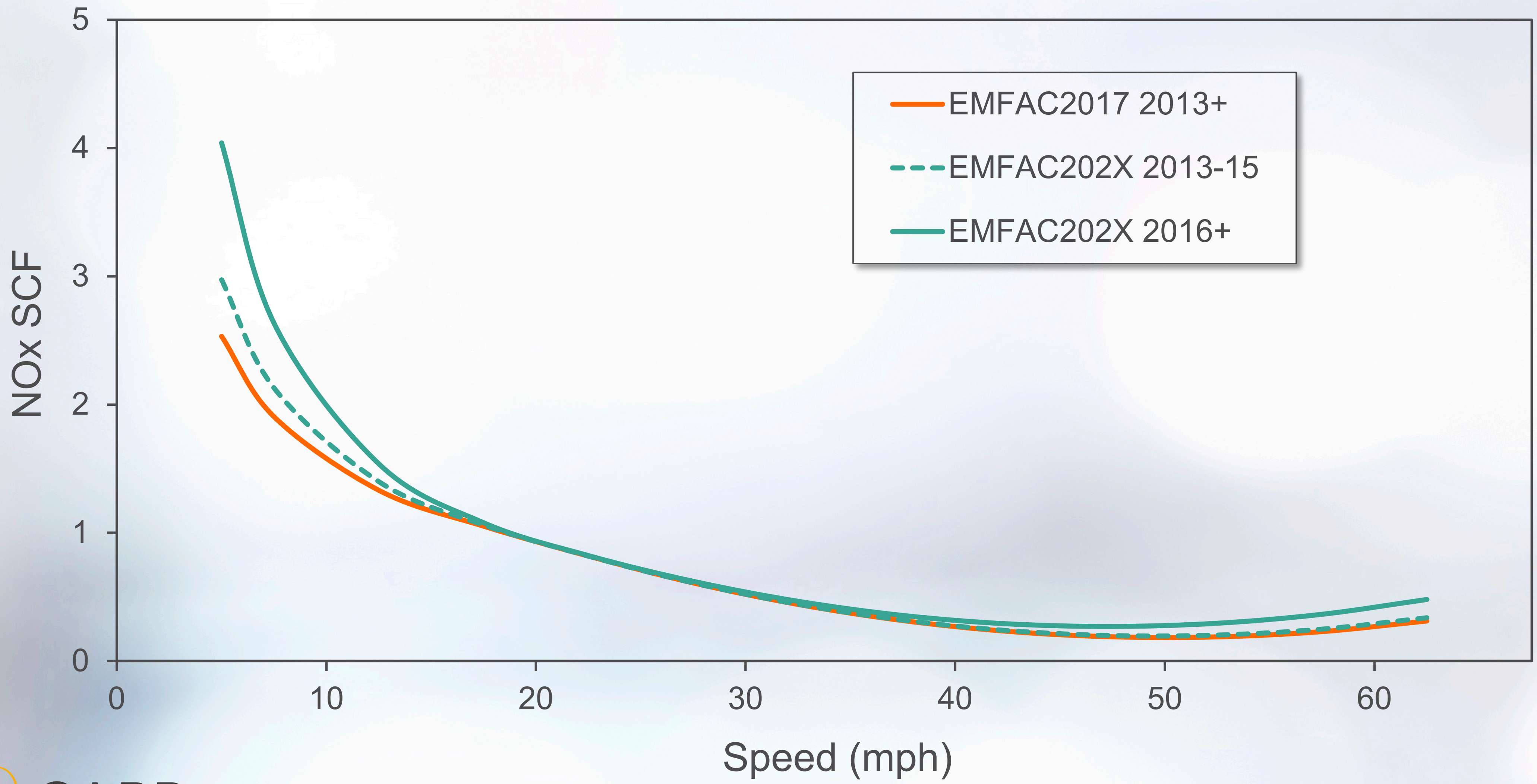
HHD Speed Correction Factors for NOx



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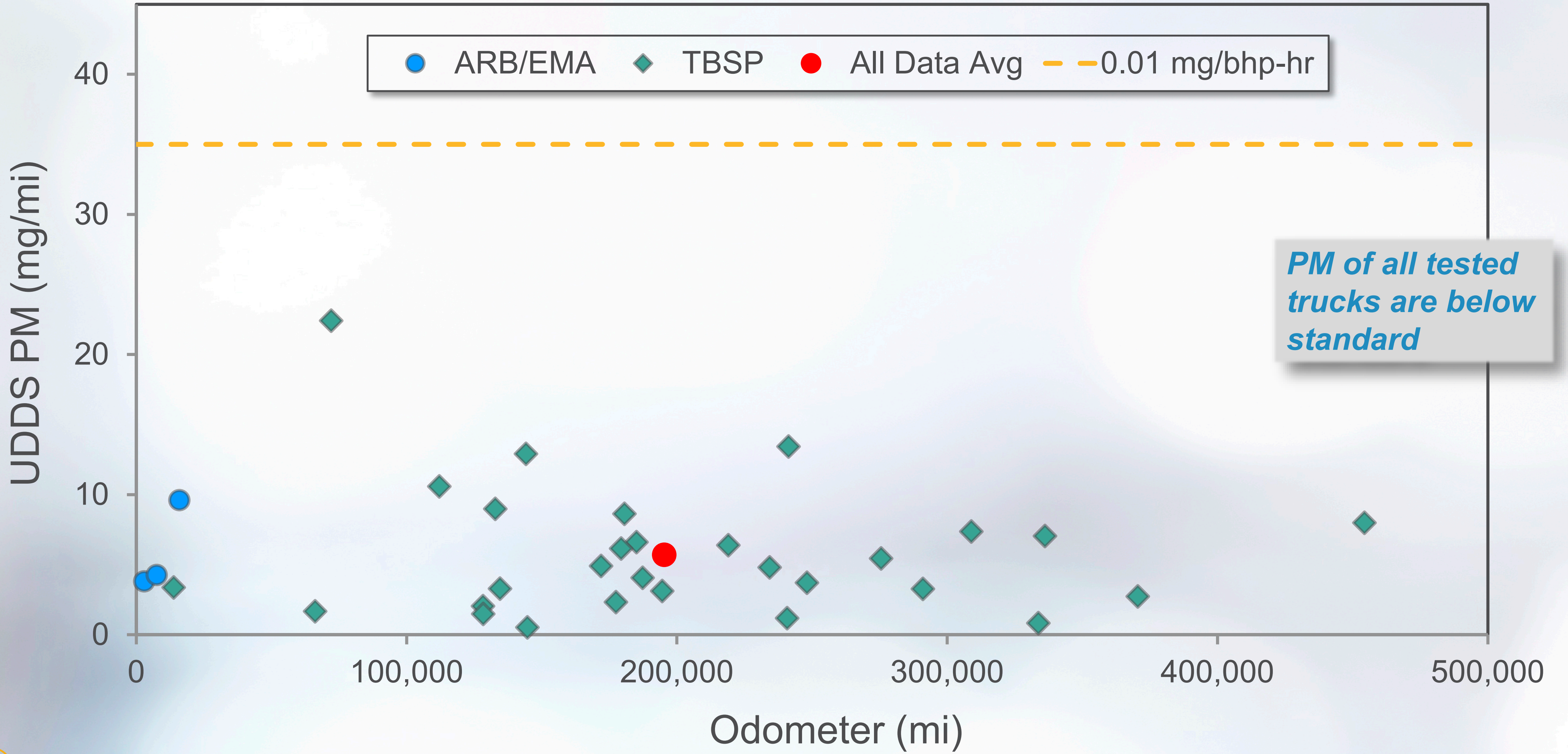
2013-15 MY HHD Truck UDDS PM



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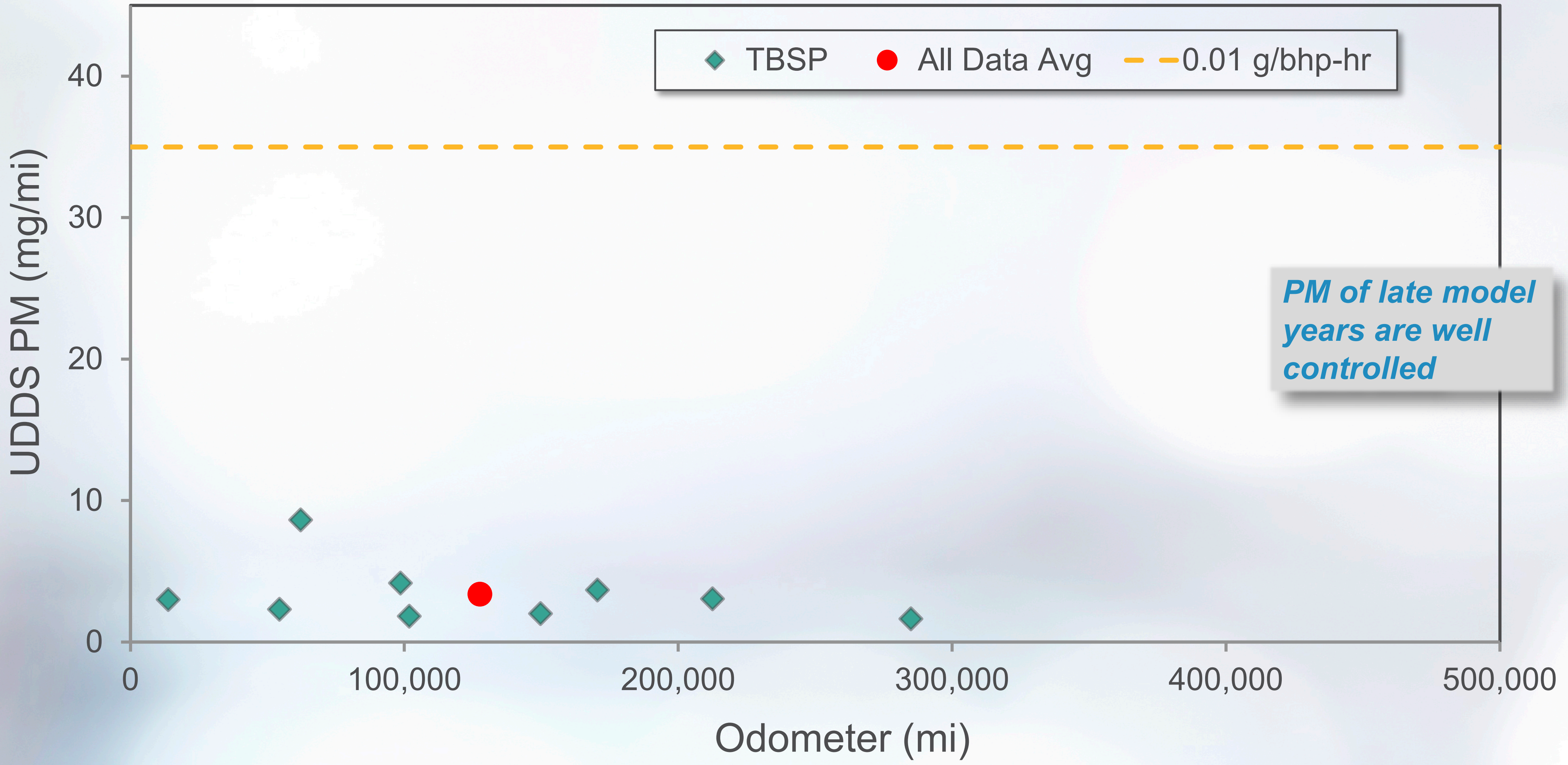
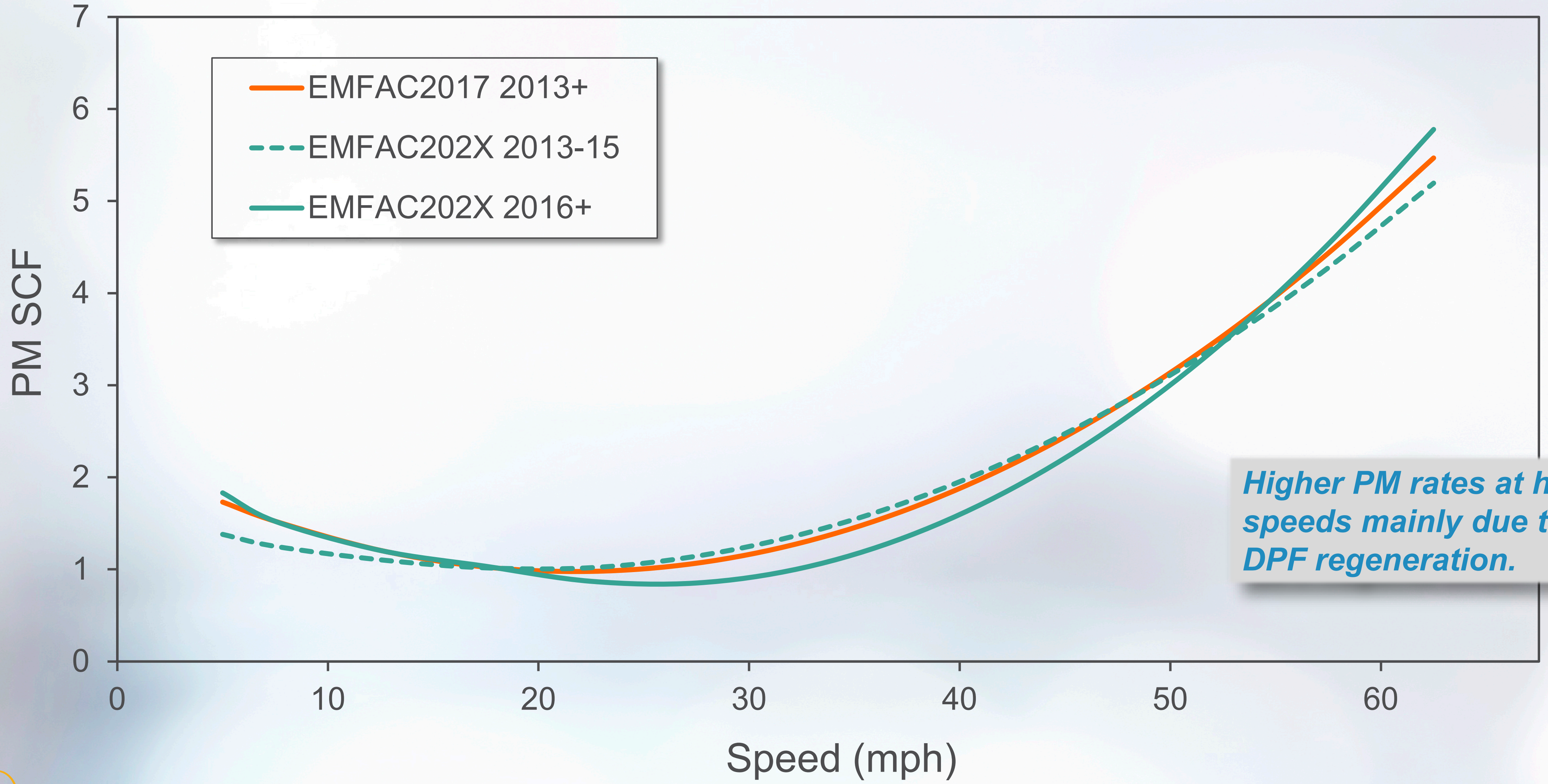
2016+ MY HHD Truck UDDS PM



PM of late model years are well controlled

HHD Speed Correction Factors for PM

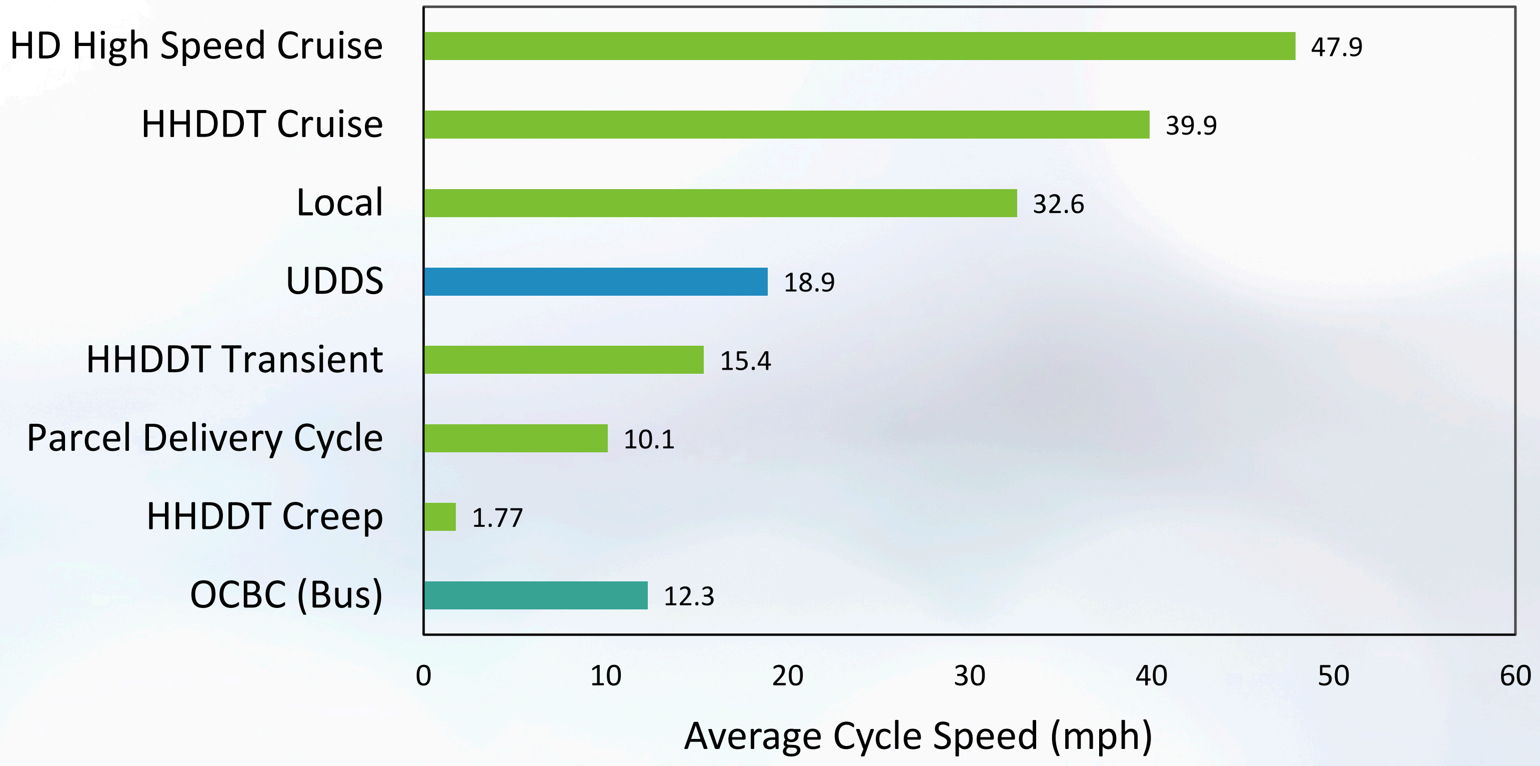


Higher PM rates at high speeds mainly due to DPF regeneration.

CARB Surveillance Program for Class 4-6 Heavy-Duty Vehicles

NEW

- To date, 6 2013+ MY vehicles were dyno tested over multiple cycles
- One vehicle was also tested with PEMS on a city-freeway route



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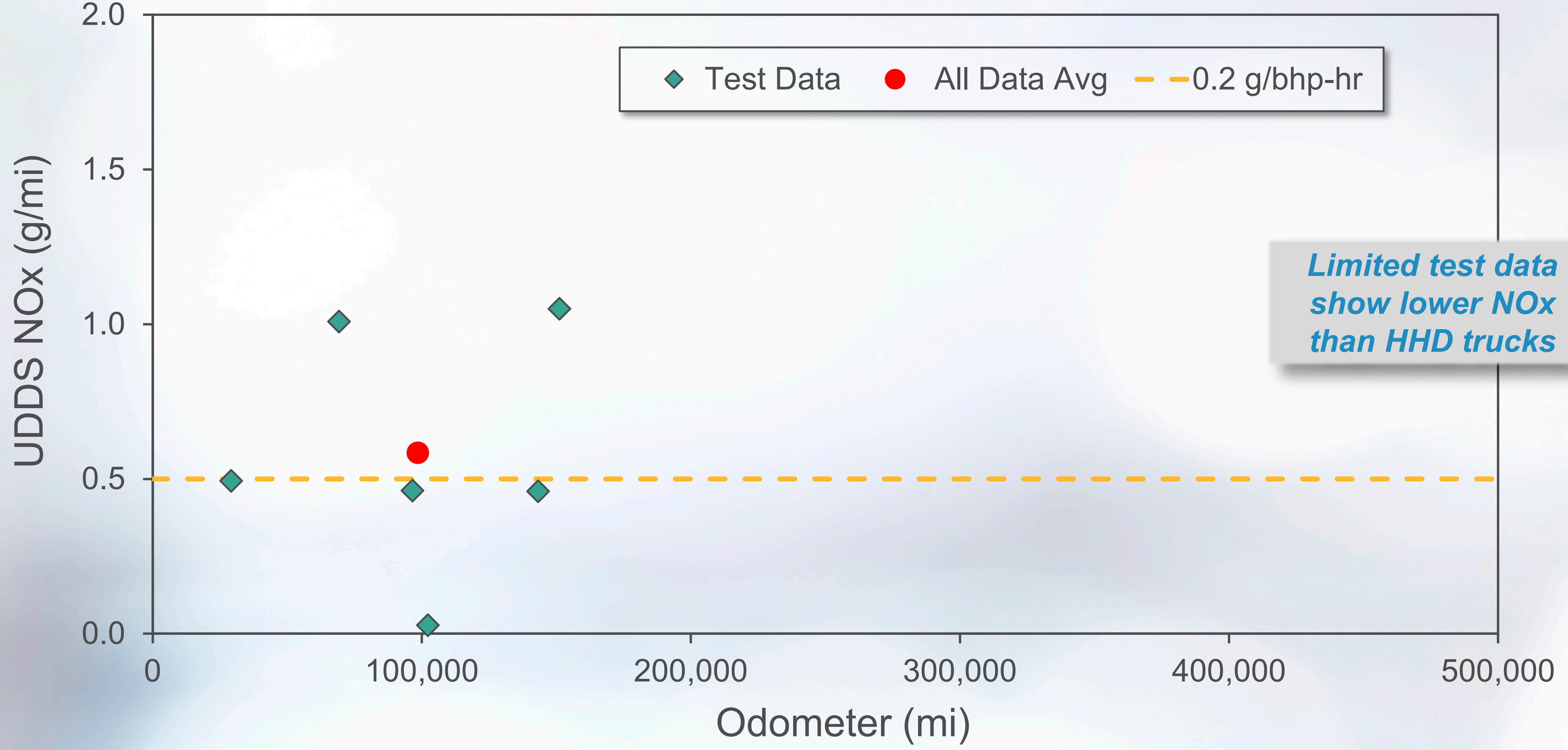
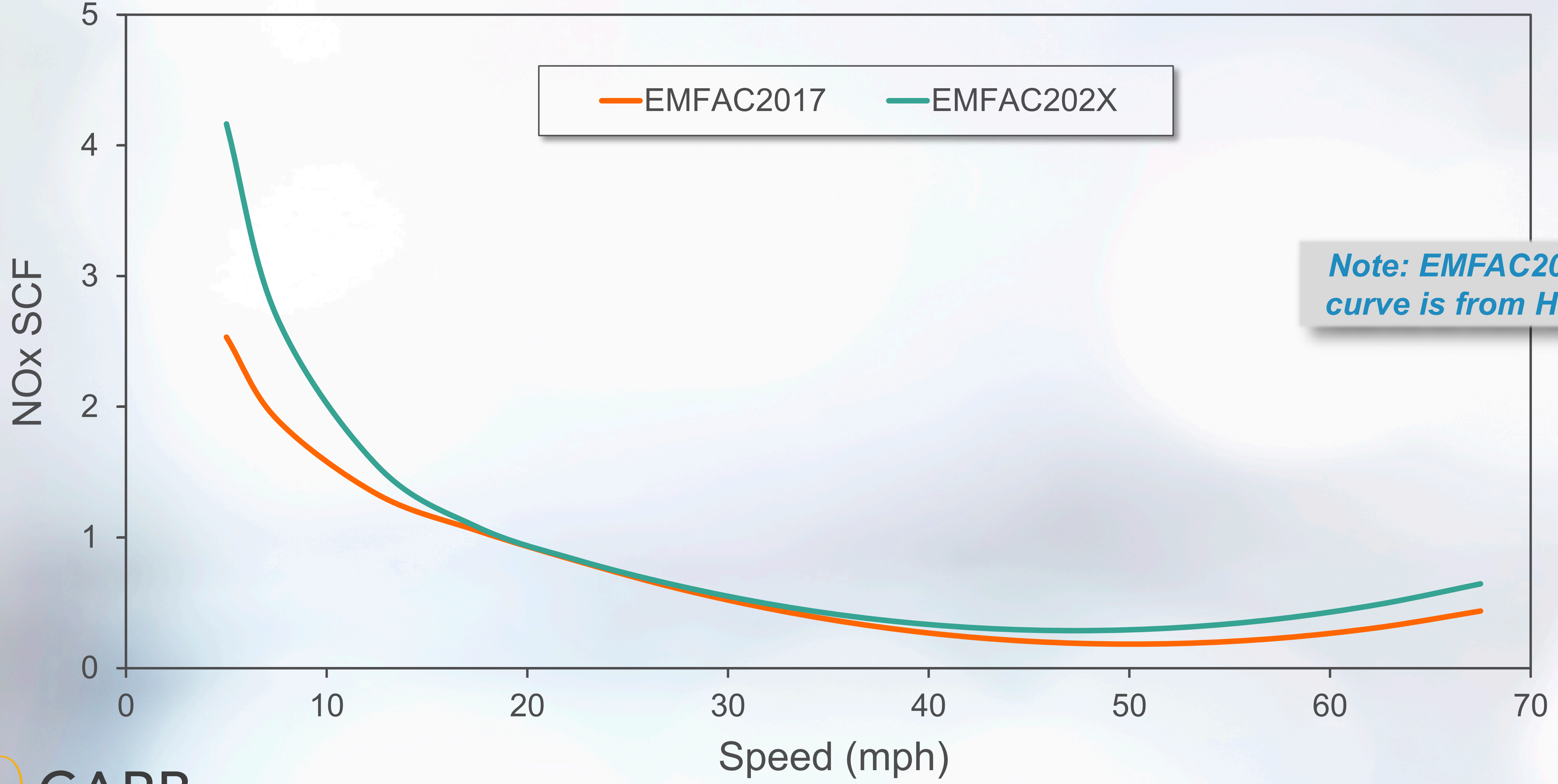
2013+ MY MHD Truck UDDS NOx



Limited test data show lower NOx than HHD trucks

CARB

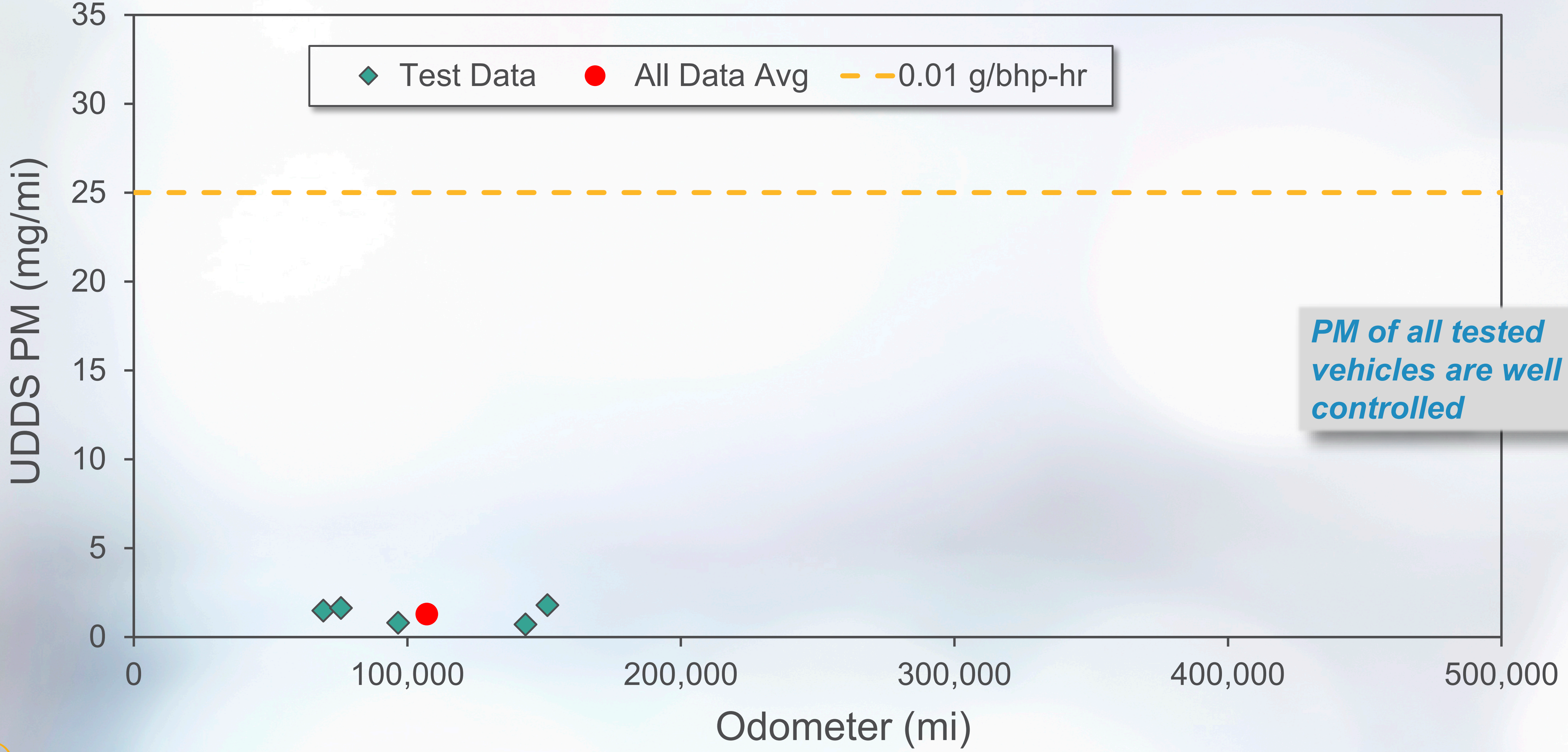
MHD Speed Correction Curves for NOx



Note: EMFAC2017 curve is from HHD

CARB

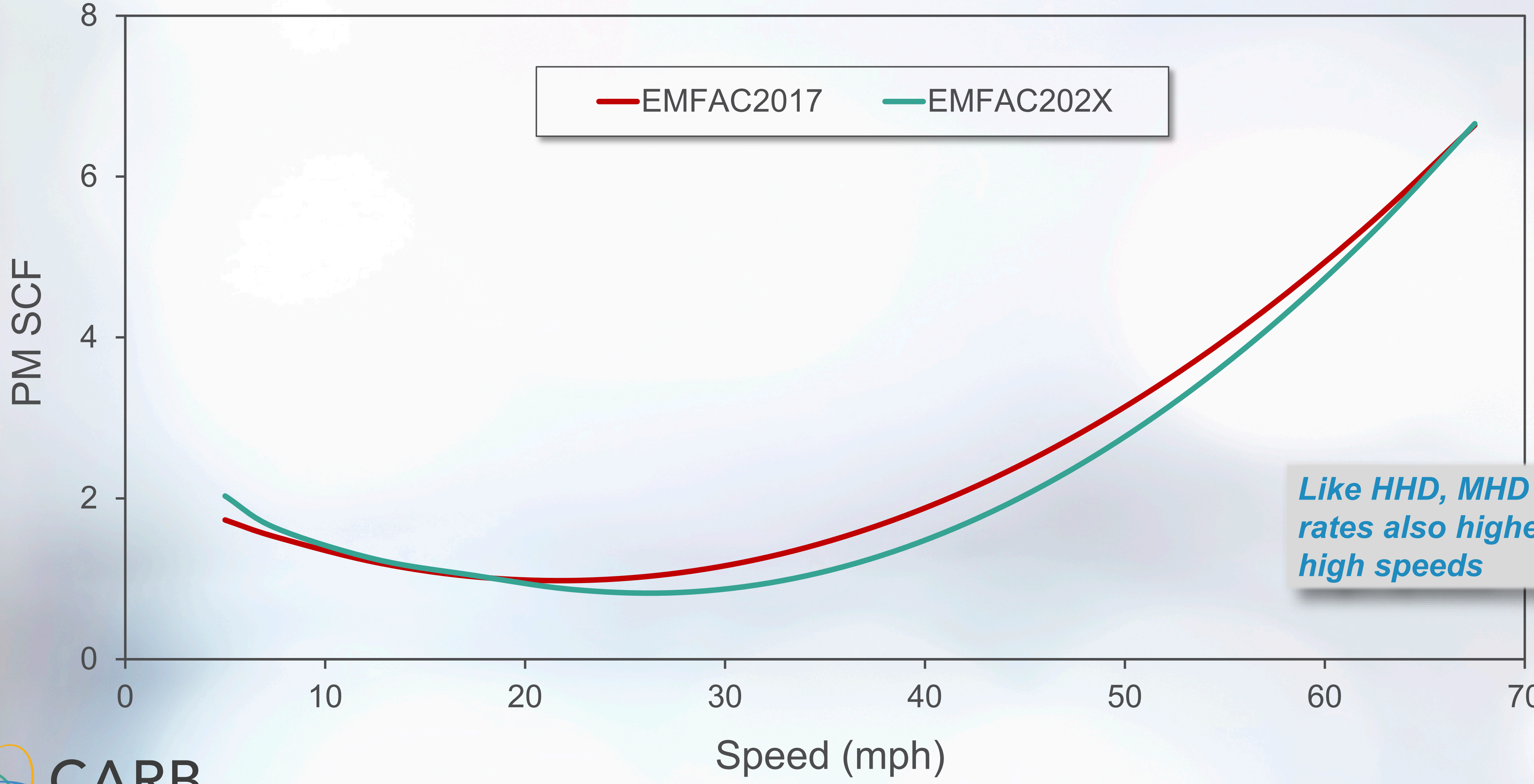
2013+ MY MHD Truck UDDS PM



PM of all tested vehicles are well controlled

CARB

MHD Speed Correction Curves for PM



Like HHD, MHD PM rates also higher at high speeds

CARB

NEW

Emission Factors for Natural Gas Vehicles

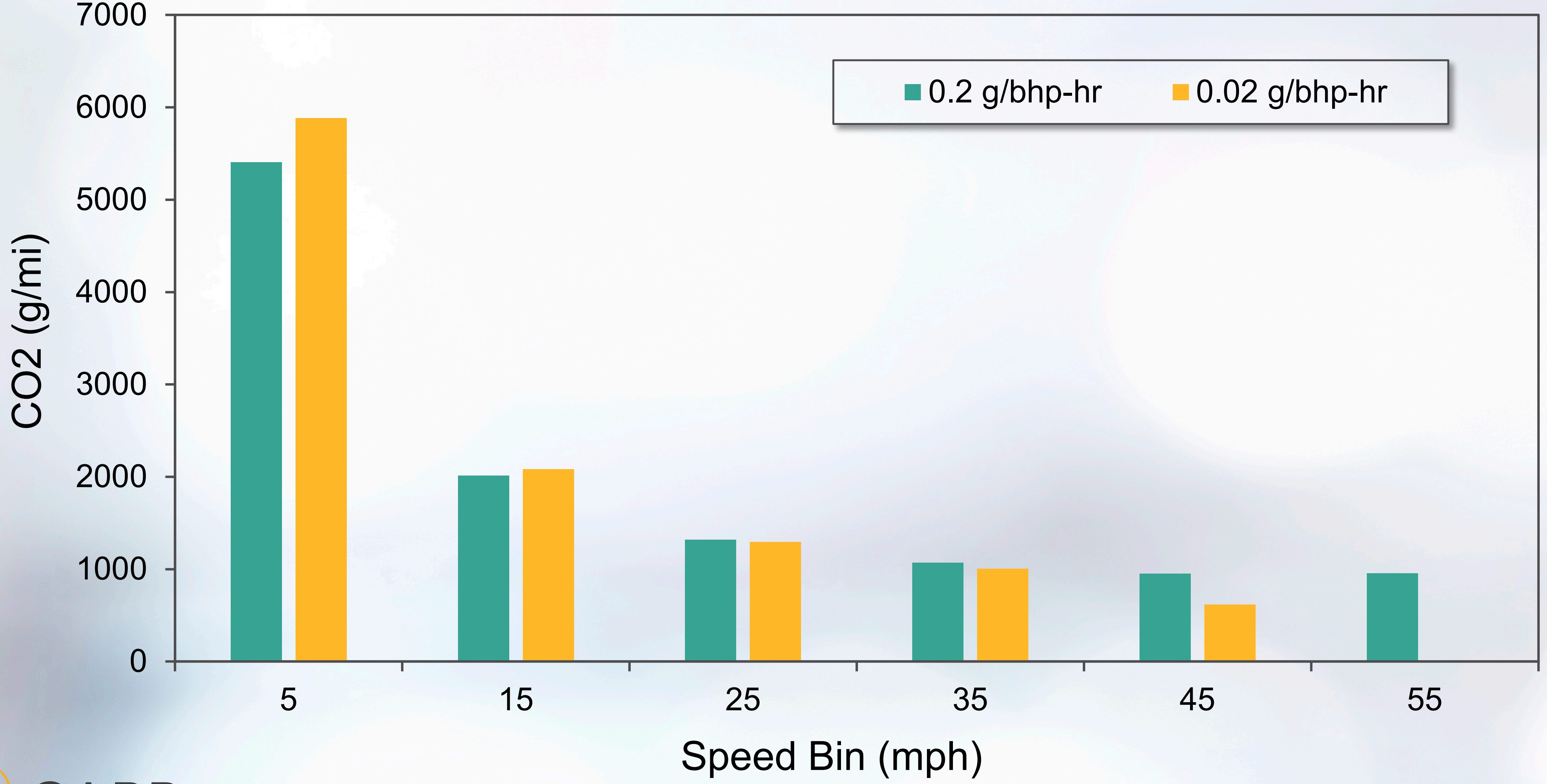
- Test data from the multi-agency 200-vehicle testing project
  - PEMS testing of ~100 vehicles
- To date, received PEMS data from 24 natural gas vehicles

Technology	Transit Bus	Refuse Truck	Goods Movement Truck	Delivery Trucks
TWC (0.2 g/bhp-hr)	3	5	3	2
TWC (0.02 g/bhp-hr)	3	2	6	

CARB

Preliminary Results

CNG Bus CO2 Rates by Speed Bin



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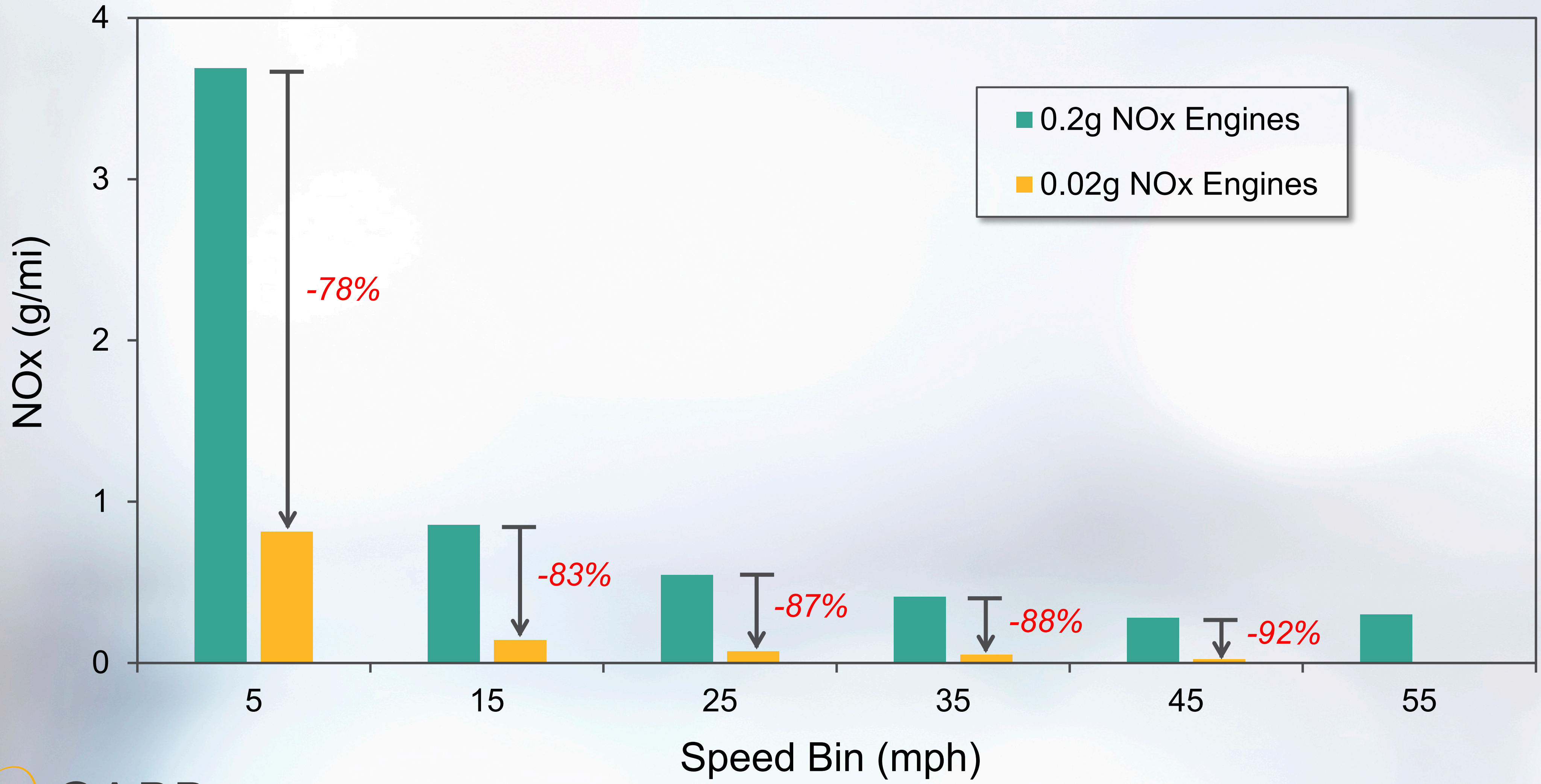
CNG Bus NOx Rates by Speed Bin



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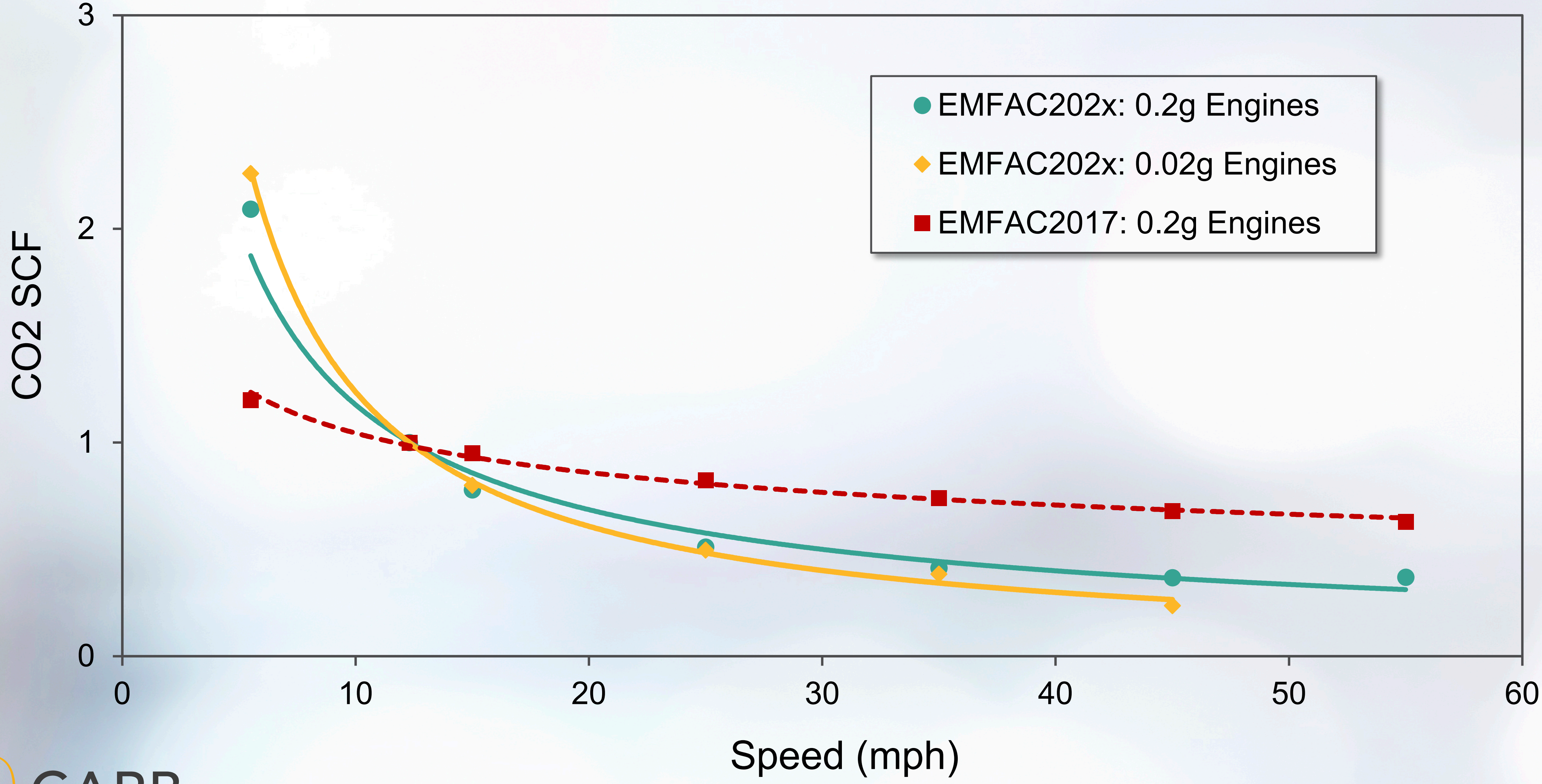
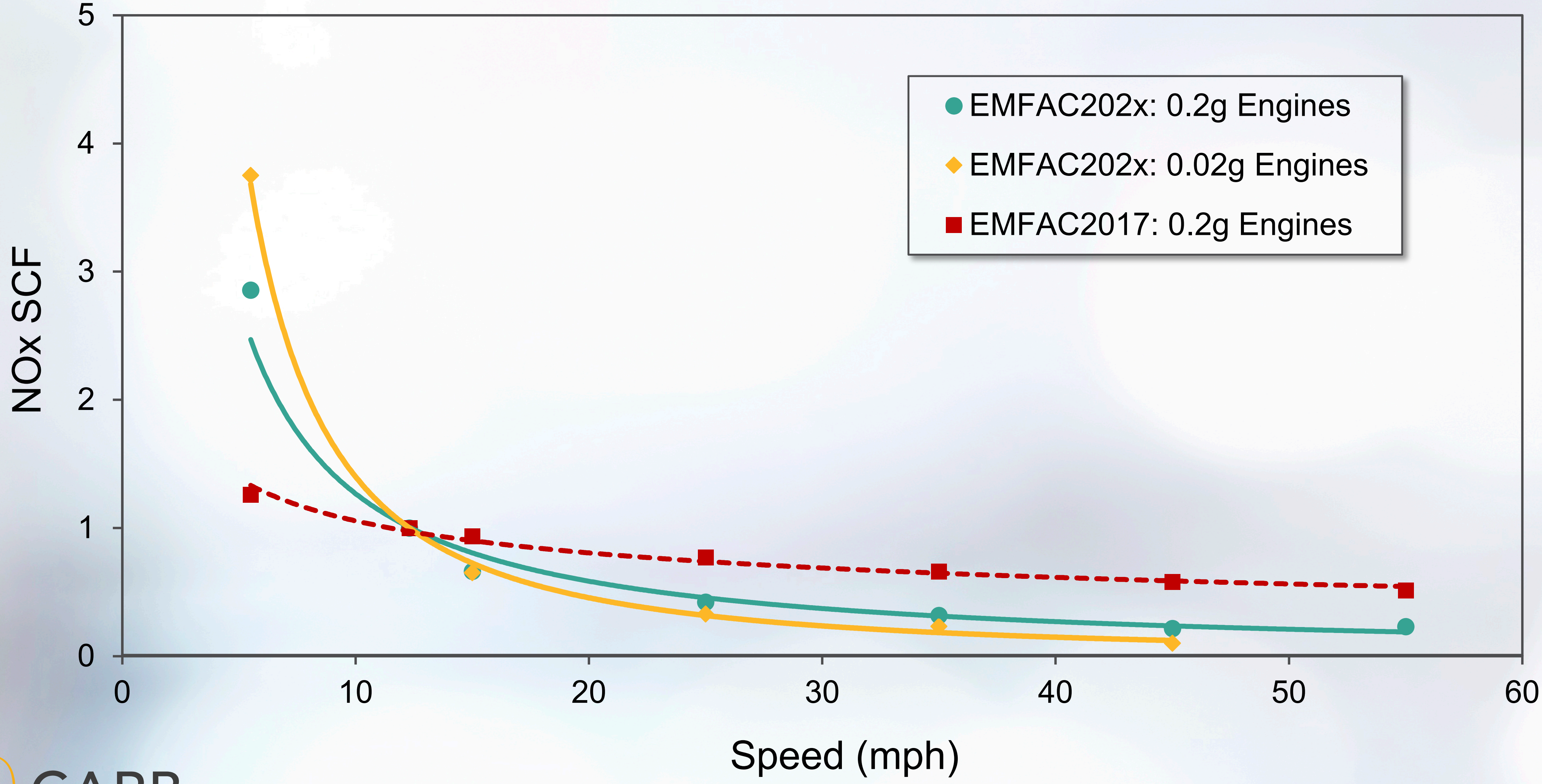
CNG Bus CO2 Speed Correction Curves



CARB

Preliminary Results

CNG Bus NOx Speed Correction Curves



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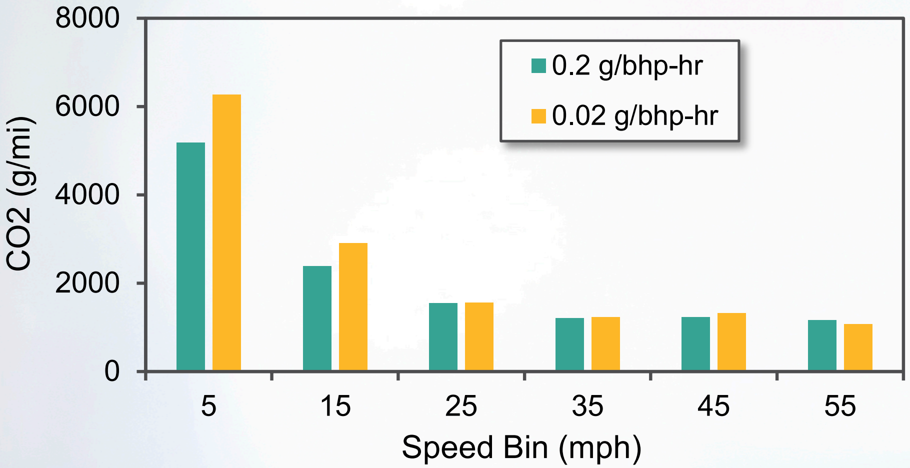
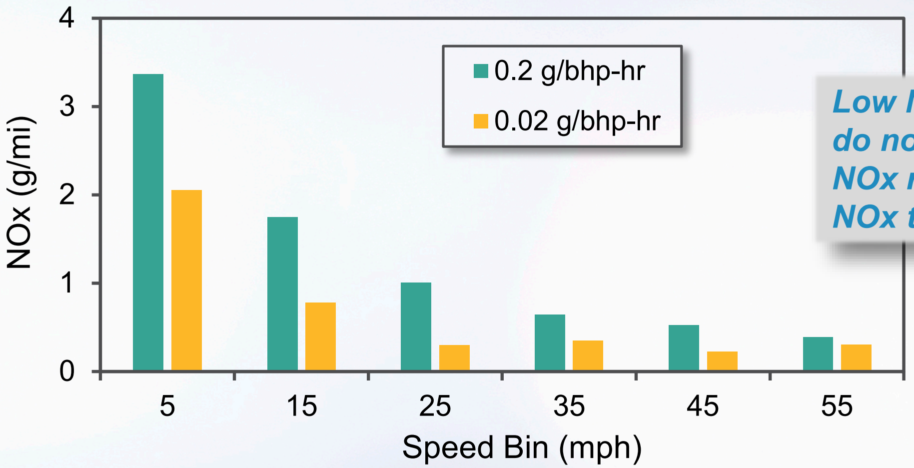
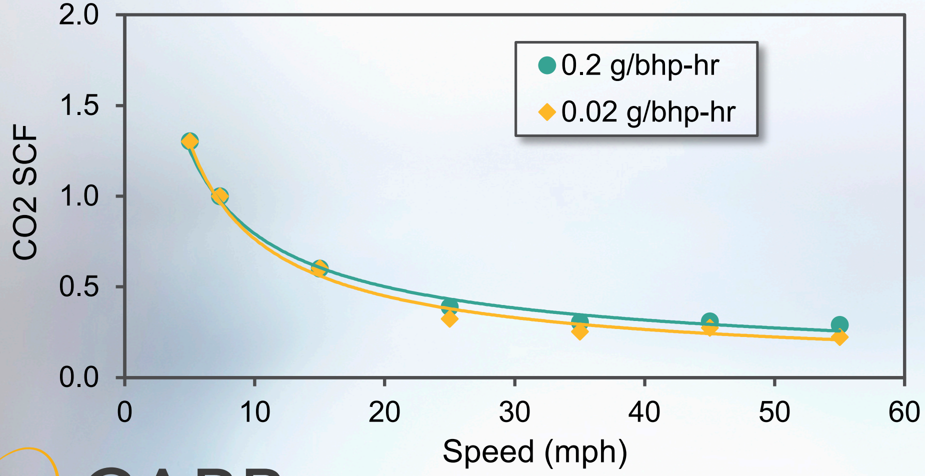
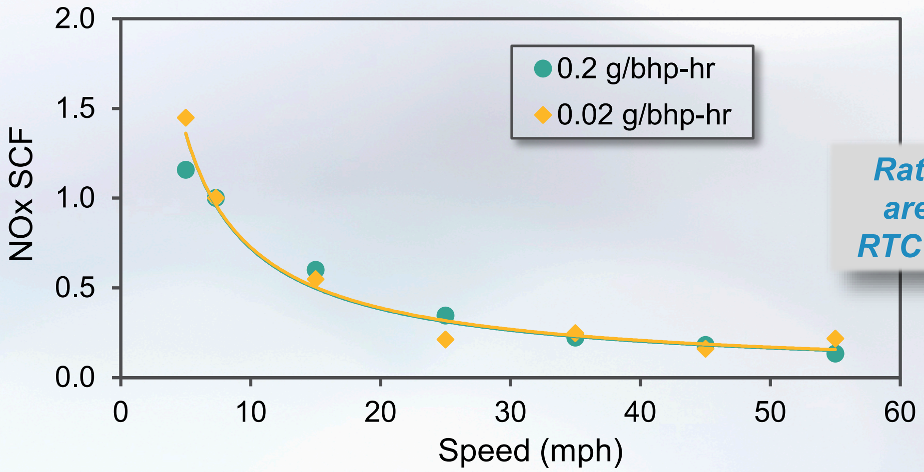
CNG Refuse Truck CO2 and NOx Emission Rates and Speed Correction Curves





Low NOx refuse trucks do not show as much NOx reduction as low NOx transit buses



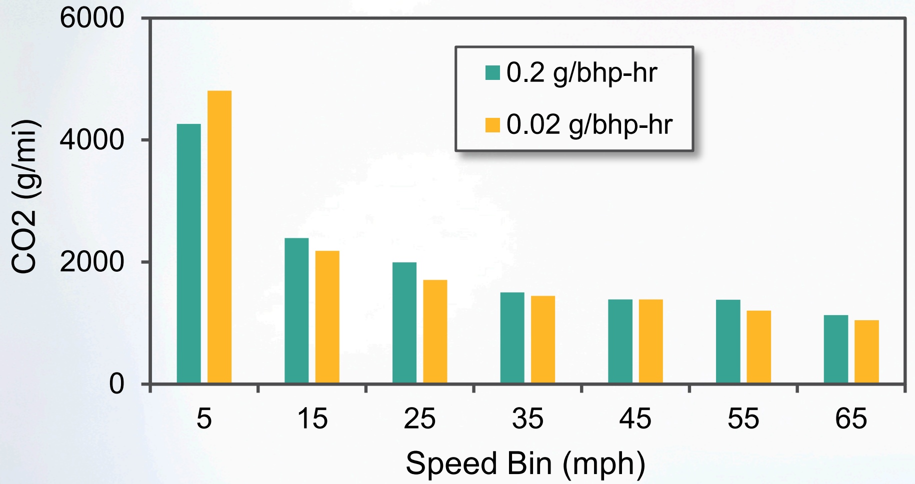


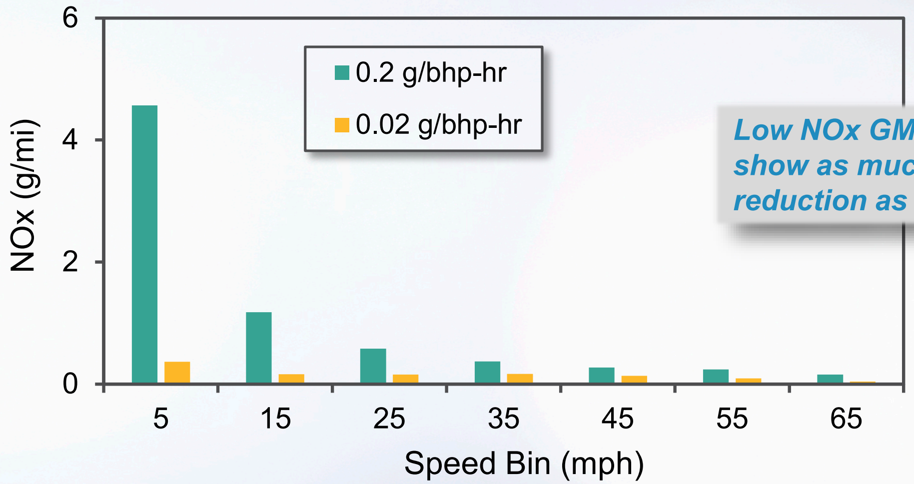
Rate-speed curves are normalized to RTC speed (7.3 mph)

CARB

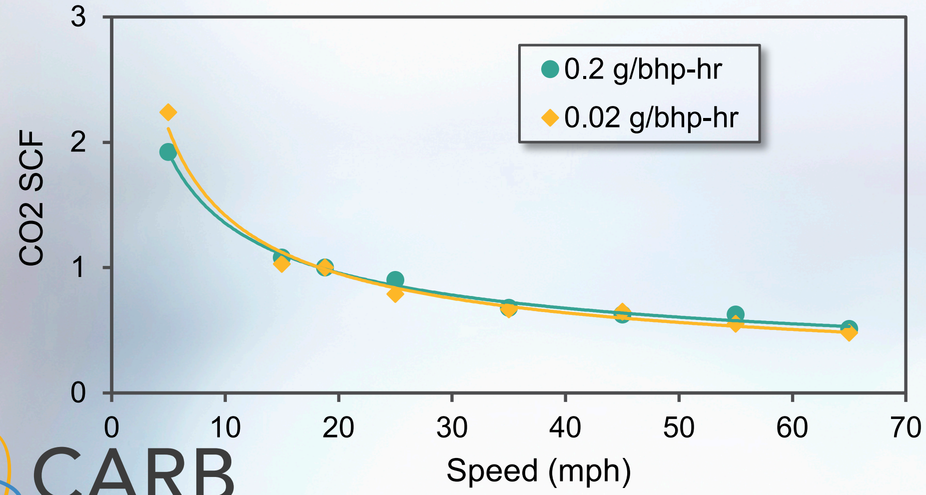
Preliminary Results

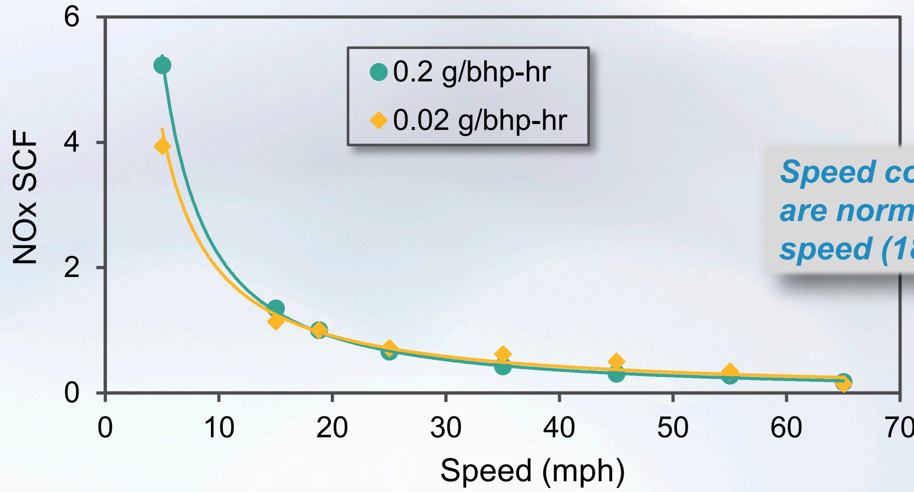
CNG Goods Movement (GM) Trucks CO2 and NOx Emission Rates and Speed Correction Curves





Low NOx GM trucks do not show as much NOx reduction as transit buses.





Speed correction curves are normalized to UDDS speed (18.8 mph)

CARB

HD Diesel Vehicle Start Emissions

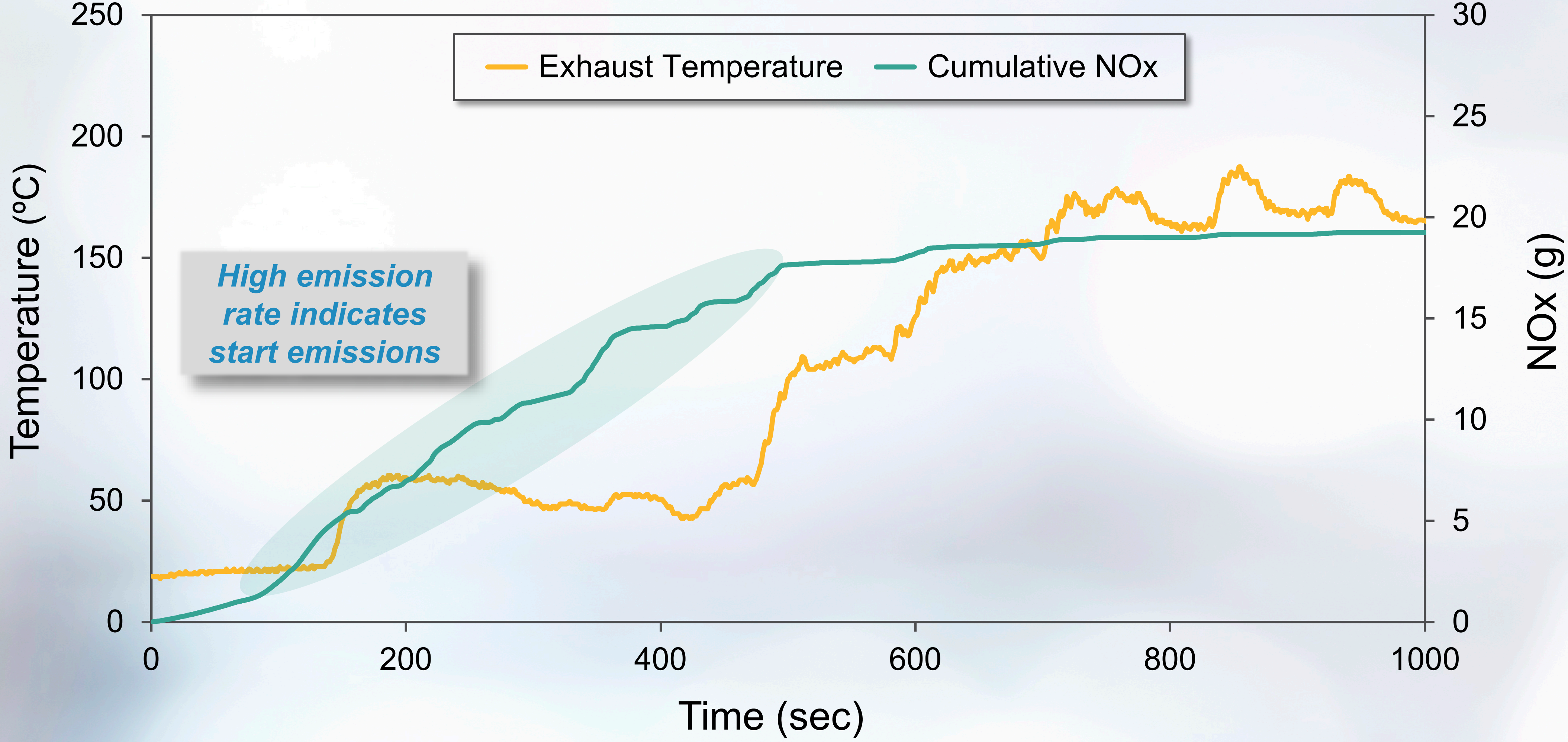
- SCR only works above light-off temperatures
- Excessive NOx emissions are generated before light-off temperatures are reached
- Start emissions are dependent on:
  - Emission rate per start
  - Number of starts per day

CARB

HD Truck Start Emission Test Data

- Start emission rates will be based on PEMS data from CARB TBSP
  - 11 vehicles were tested on a route for start emissions testing
- Test runs were conducted after each vehicle was soaked for overnight, 8 hours, 4 hours, 2 hours, and 20 min

HD Diesel Vehicle Start Emissions



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Key Takeaways

- Late model year diesel trucks are generally cleaner than but some trucks at low mileages still have very higher NOx emissions (*4-5x standard*)
- Low NOx CNG transit buses tested exhibit much lower NOx emissions than 0.2g CNG buses (*~80-90% lower*)
- Compared to 0.2g CNG engines, limited data from low NOx refuse and goods movement trucks does not show NOx reductions as high as seen in CNG transit buses (~40-70% lower)

Next Steps

- Incorporate all appropriate test data from the 200-vehicle in-use emissions project
  - Dyno data for diesel trucks
  - Additional PEMS data for natural gas vehicles
- Analyze TBSP PEMS data and revise HD diesel truck start emissions

Heavy-Duty Vehicles

Deterioration Rate

Introduction: Heavy-Duty Deterioration in EMFAC

Emission Impact Rate (EIR) = **Frequency of Engine Component or After-treatment system failure** × **% Emission Increase from Engine Component or After-treatment system failure**

- Current EMFAC assumptions
  - Emissions from diesel powered trucks remain stable in the absence of tampering, malfunctions, and mal-maintenance (TM&M)
  - The EIRs are based upon assumptions of the frequency (FREQ) of occurrence and the emissions increase of specific instances of TM&M

Modeling Heavy-Duty Deterioration in EMFAC

$$DR\left(\frac{g}{\text{mile} * 10\text{K mi}}\right) = \frac{ZMR \times EIR}{100}$$

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

- Zero-mile emission rate (**ZMR**) – Fleet average UDDS emission rates while trucks are new
- In-Use Emission Deterioration (**DR**) – Increase of emissions over time within the in-use fleet caused by tampering, malfunction and mal-maintenance (TM&M) of engine components, and emission control systems
- Speed Correction Factors (**SCF**) – A method to correct emission rates at different driving speeds

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Use On-Board Diagnostics (OBD) Data to Update Heavy-Duty Deterioration Assumptions

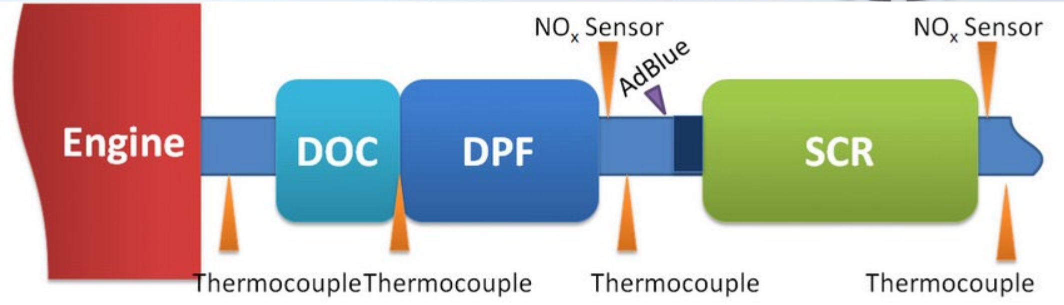
- On-board diagnostics (OBD) system are available for heavy-duty trucks with MY 2013+
- Heavy-duty truck OBD regulation requires that emissions control equipment be monitored for deterioration and malfunction
- Malfunction indicator lamp (MIL) status to improve our understanding of the frequency of engine component or after-treatment system failure

Use On-Board Diagnostics (OBD) Data to Update Heavy-Duty Deterioration Assumptions

- CARB completed an extramural contract to collect a large volume of OBD from model year (MY) 2013+ heavy-duty trucks to update deterioration assumptions. Current EMFAC 2017 assumptions are shown below.

TM&M Category	EMFAC2017	
	2010-12 MY	2013+ MY
NO_X Sensor	36%	24%
Replacement NO_X Sensor	1.8%	1.2%
SCR System	40%	27%
EGR Disabled / Low Flow	16%	11%
DPF Leaking	10%	6.7%

Data can be used to update TM&M frequencies for MY2013+ trucks



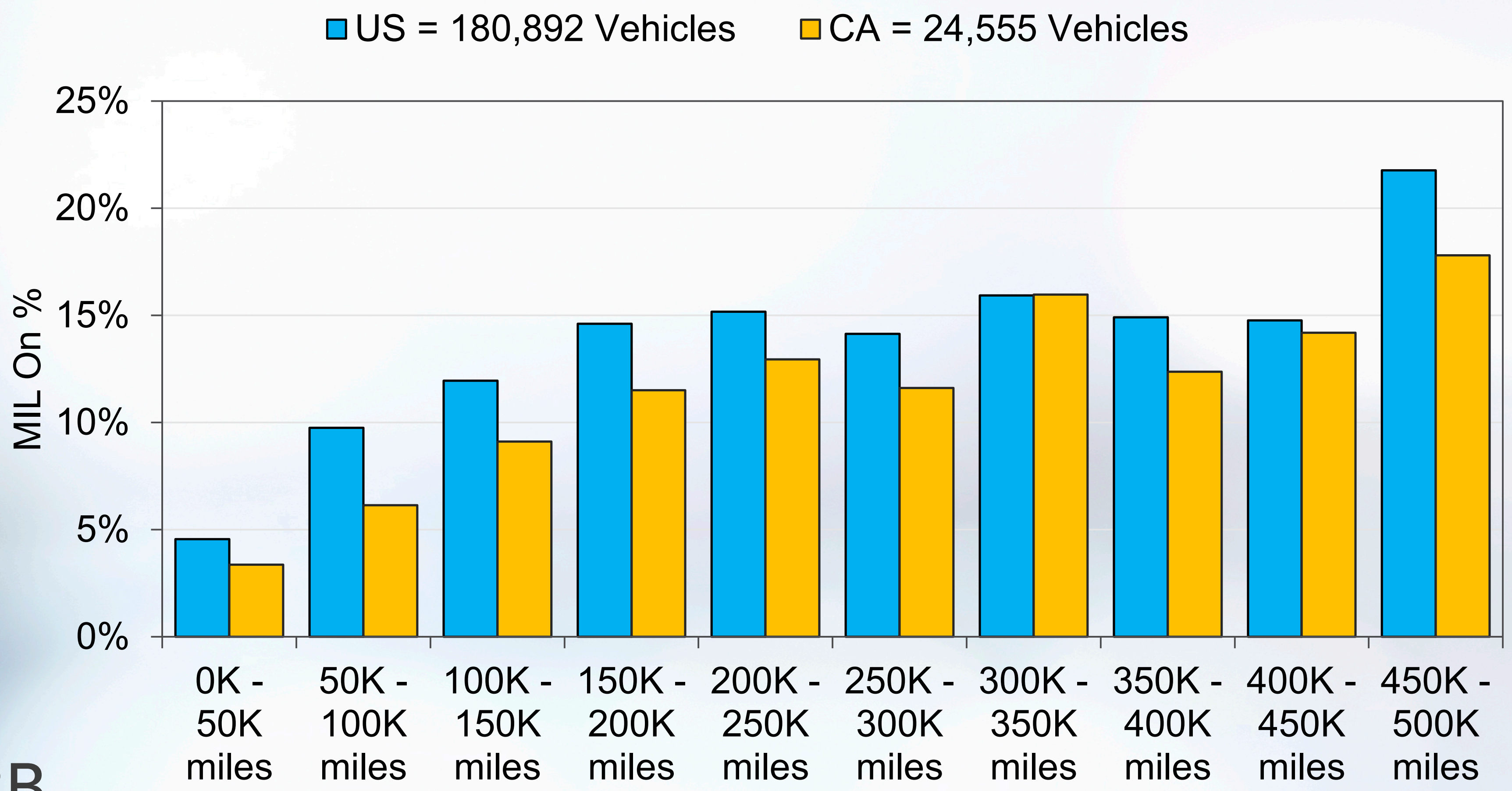
OBD Data Collected through CARB's Extramural Contract

Telematics data from 24,555 CA Vehicles and 180,892 US Vehicles GVWR > 14,000 lbs

457 Vehicles Collected through Truck Stops, Ports, and Repair Shops

Telematics Data: MIL On Rates

Californian trucks seems to have lower MIL ON rate than national fleets.



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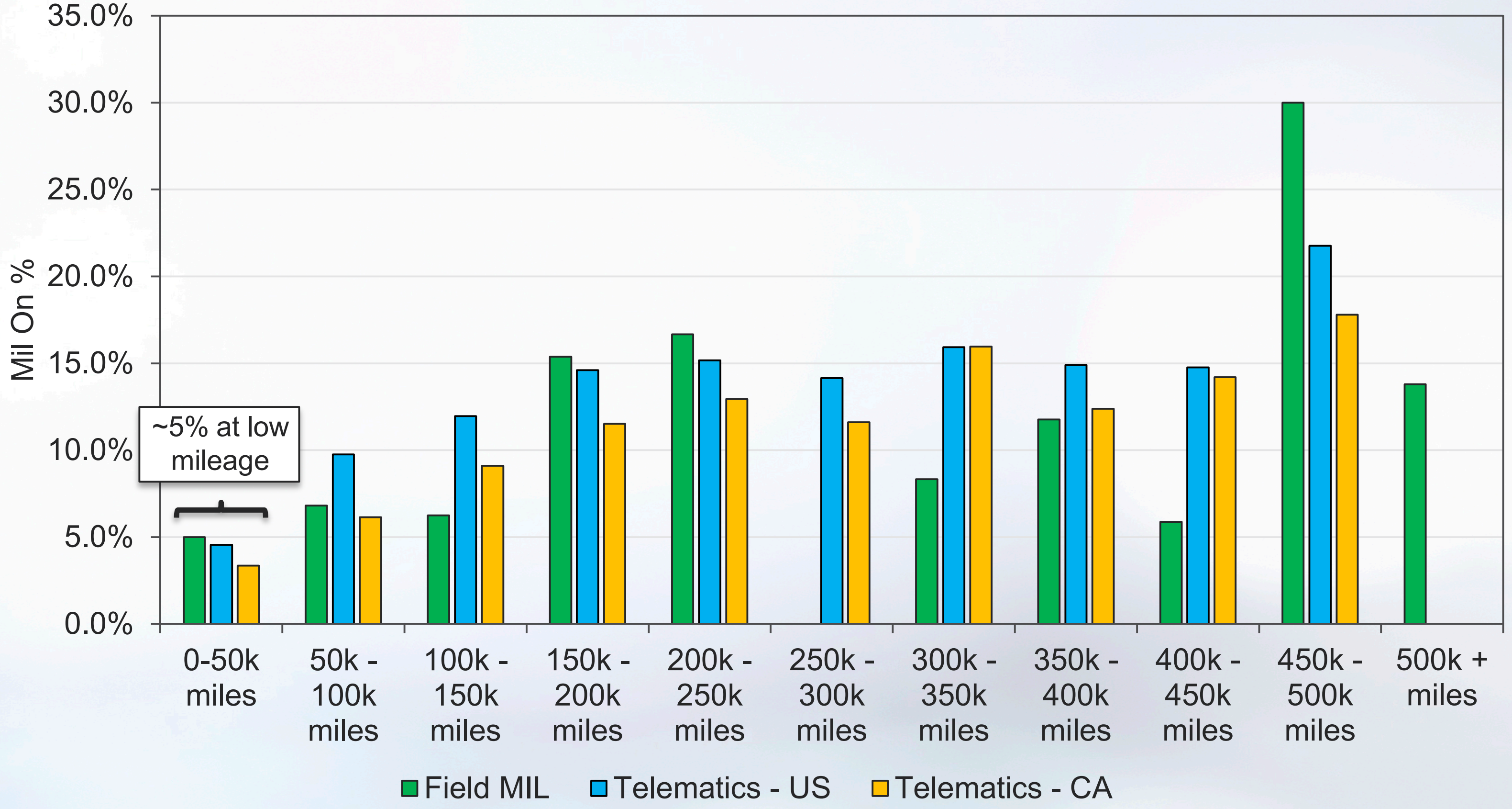
MIL On Frequency Comparison with Field Data



No systematic difference between field and Telematics Data

**Repair shop data not included in "Field" Dataset*

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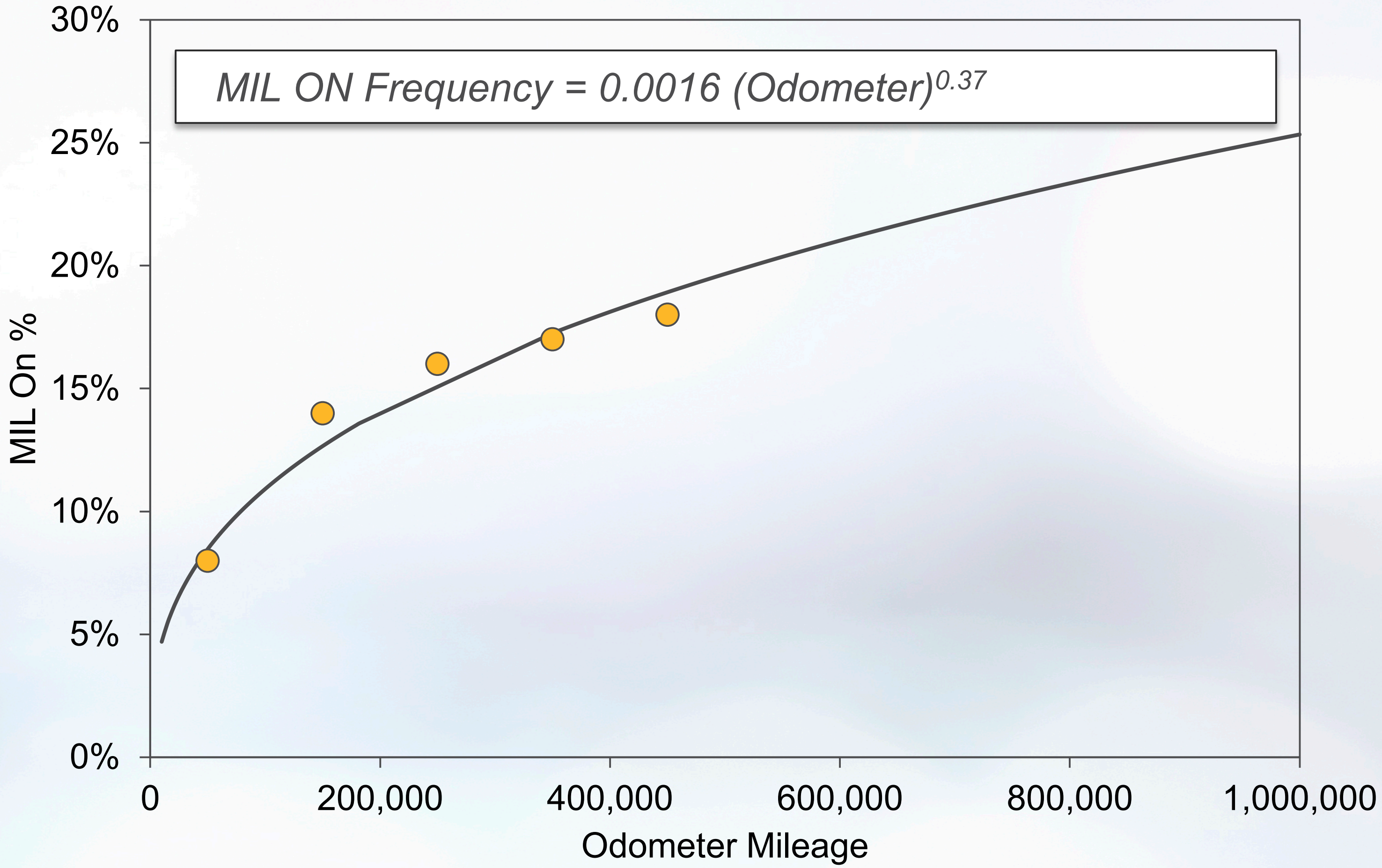
National Telematics Data: Fit to Power Function (binned by 100,000 miles)



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Heavy-Duty Deterioration in EMFAC

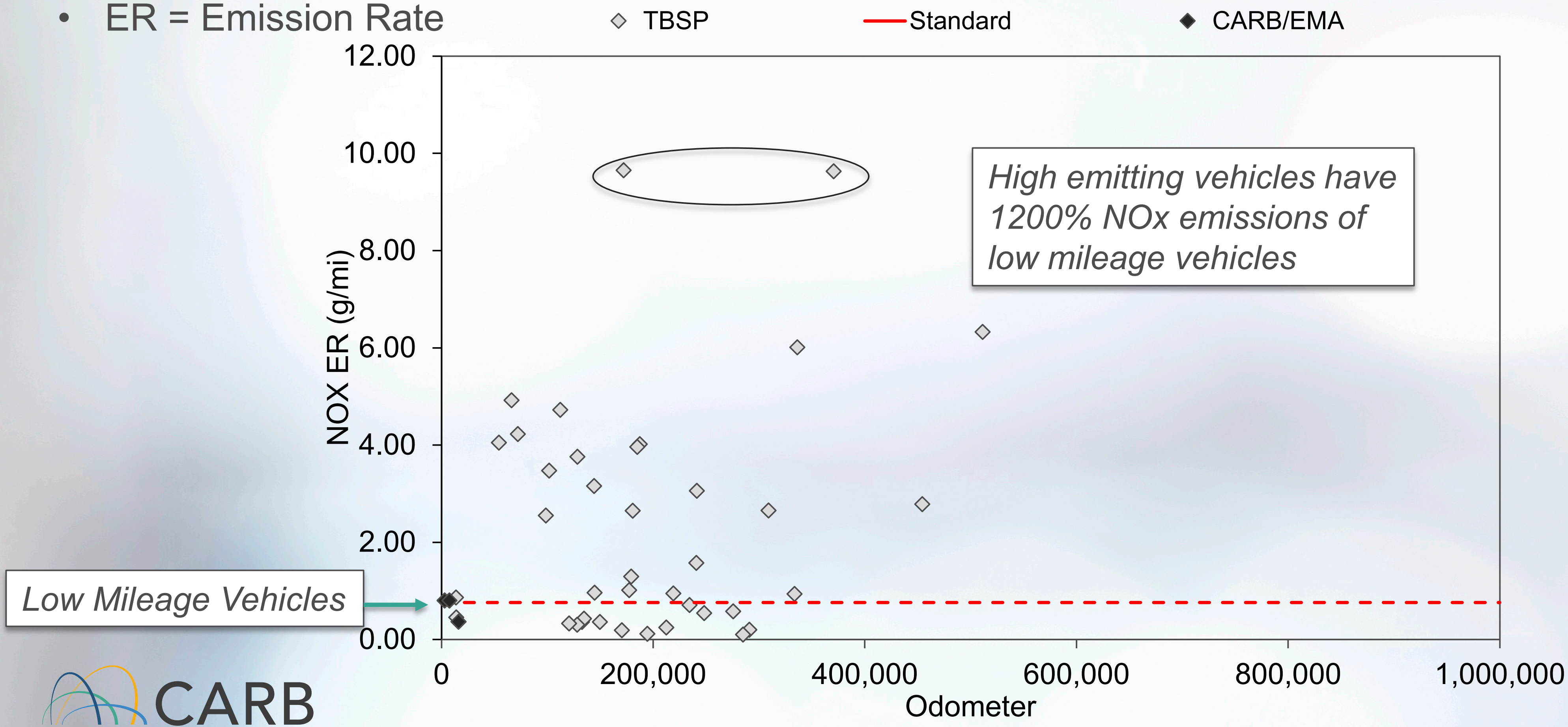
Emission Impact Rate (EIR) = **<u>Frequency</u> of Engine Component or After-treatment system failure** × **% Emission Increase from Engine Component or After-treatment system failure**

✓ OBD-based MIL On rates gives us a better handle on the frequency of failure

? Need to estimate emissions % increase associated with these failures

In-Use Vehicle Test Data

- Dynamometer test data through the Truck and Bus Surveillance Program (TBSP) at CARB
- CARB EMA Testing Project
- ER = Emission Rate



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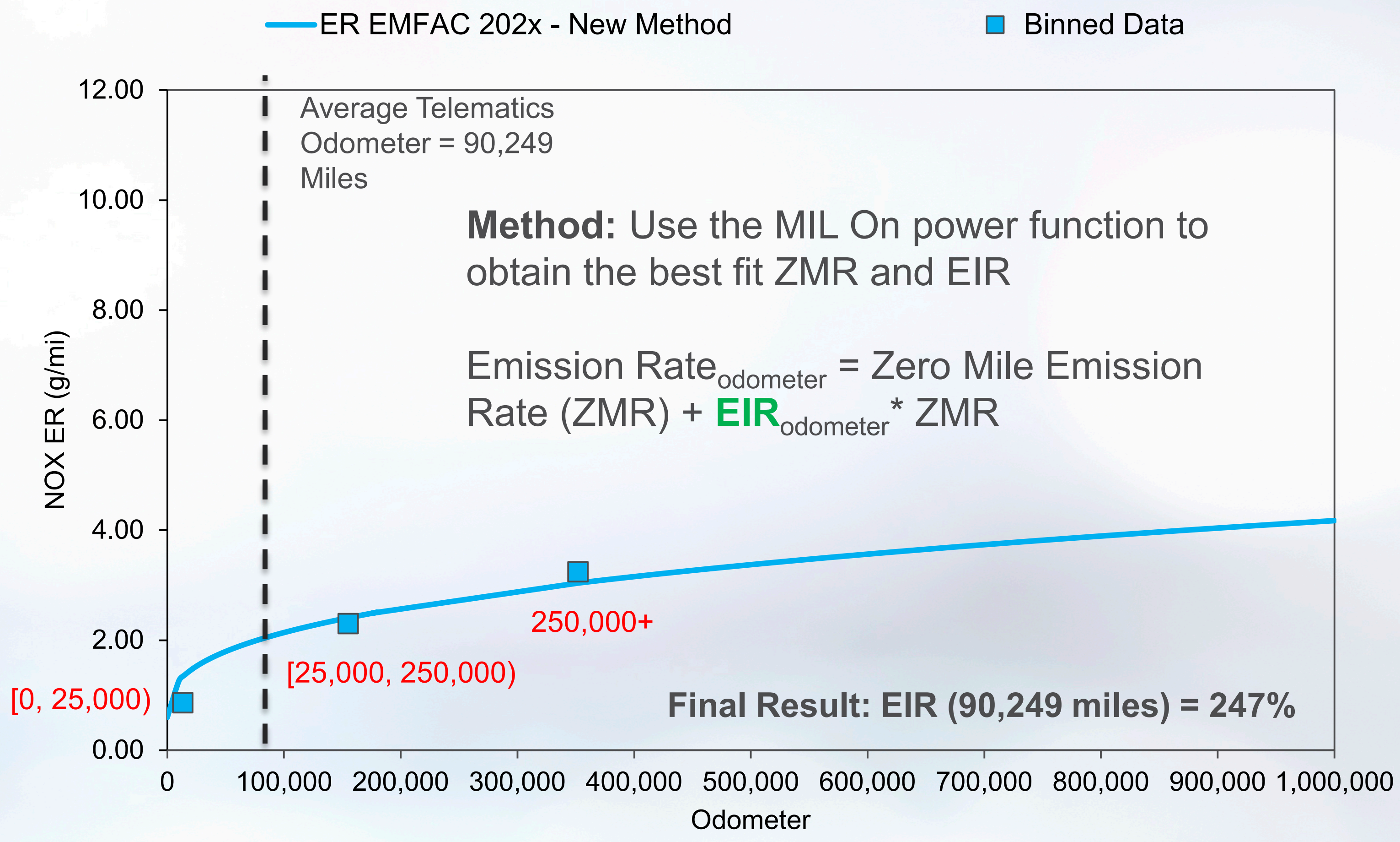
Estimate the Emission Impact Rate (EIR) Using In-Use Test Data



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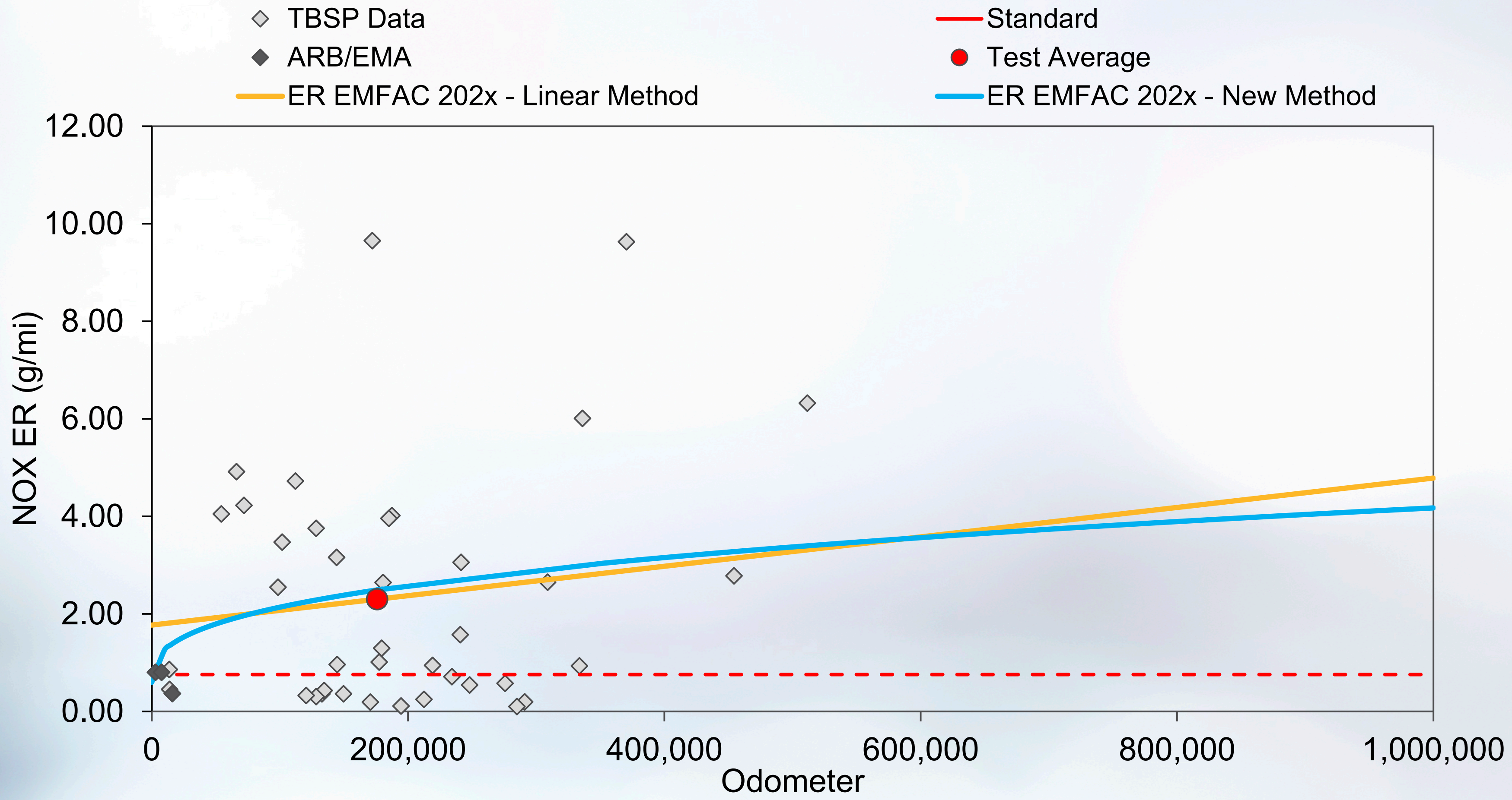
Comparison of New Deterioration Method to Linear Function



New deterioration model will result in slightly higher emission rates at mileages ~100,000-600,000 miles and lower emission rates at mileages > 600,000 miles

Recap and Next Steps

- Summary
  - ✓ A combination of OBD telematics and in-use test data were used to estimate an EIR
- Next Steps
  - ✓ Corroborate emissions increase with additional data (e.g. plume capture studies)
  - ✓ Repeat analysis for particulate matter (PM)
  - ✓ Assess impact on heavy-duty NOx and PM emissions

Light and Heavy-Duty Vehicles

Ammonia (NH_3) Emission Rates

CARB

Background

- Historically EMFAC did not estimate NH_3 emissions
- EMFAC202x will be the first version of the model that will have some preliminary estimates of NH_3 emissions using limited test data
- Will include a combination of new data and historical emission rates
- This methodology will be improved in future versions of the model

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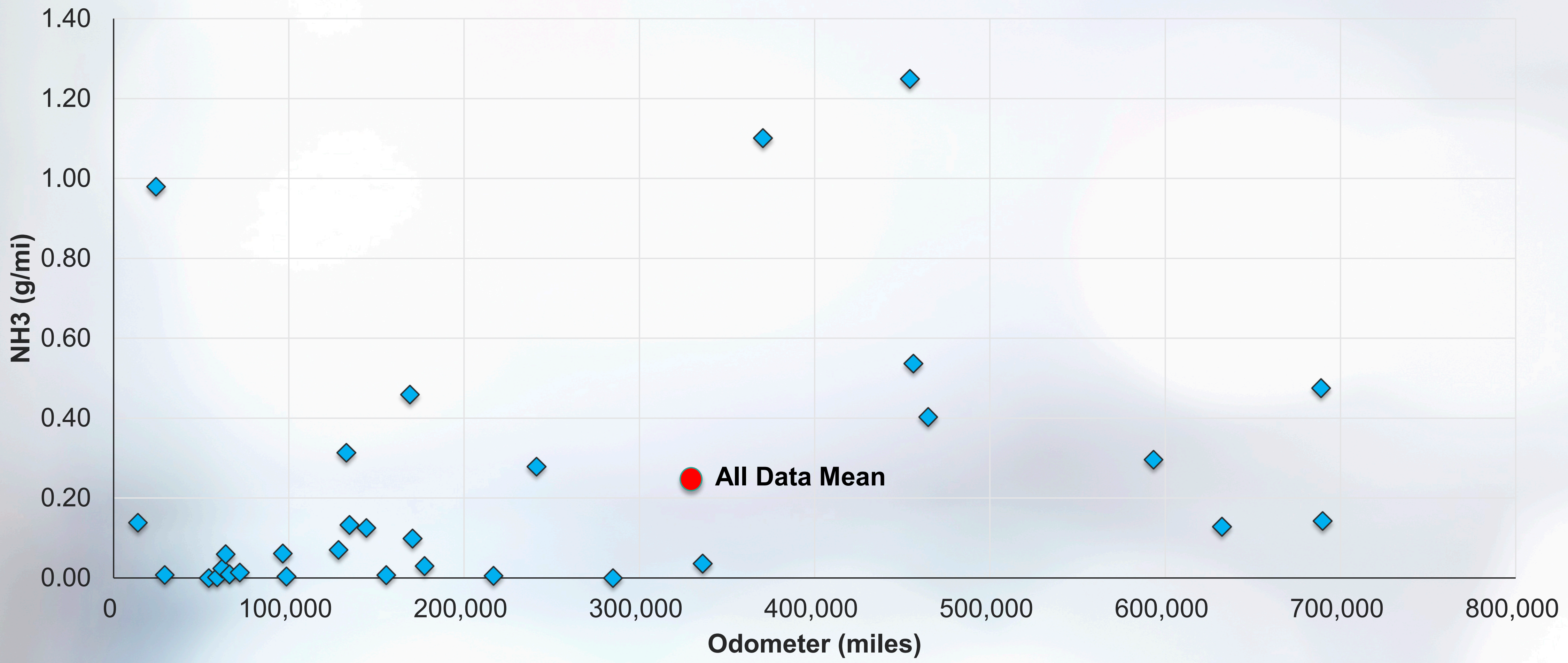
EMFAC202x NH_3 Emission Factors

Fuel	Vehicle Class	Model Year	EF (mg/mi)	Data Source
Gasoline	Light and Medium Duty Vehicles	1965-1975	5	Historical
		1975-1979	15	
		1980-1983	50	
		1984-1997	70	Dynamometer studies at UC Riverside and UCLA
		1998-2003	45	Caldecott tunnel study by UC Berkeley published in 2009
		2004-2015	20	Dynamometer studies at UC Riverside and UCLA
		2016+	42	CARB LDV Test Project*
	Heavy-Duty Vehicles	pre-77	5	Historical
		1977-1983	15	
		1984+	45	Caldecott tunnel study by UC Berkeley published in 2009
	Motorcycles	1965-1994	5	Historical
		1995-2007	6.4	
		2008+	9.2	
Diesel	Light and Medium Duty Vehicles	All	3.1	
	Heavy-Duty Vehicles	2011+	220	CARB Truck and Bus Test Project*
		2007-2010	38	SCAQMD Test Project*
		1965-2006	27	Historical
CNG	Refuse	All	580	SCAQMD Test Project*
	Transit	All	970	
	Other	All	1060	

* New Data

HDD 2011+ NH_3 Emission Rates

CARB Truck and Bus Test Project



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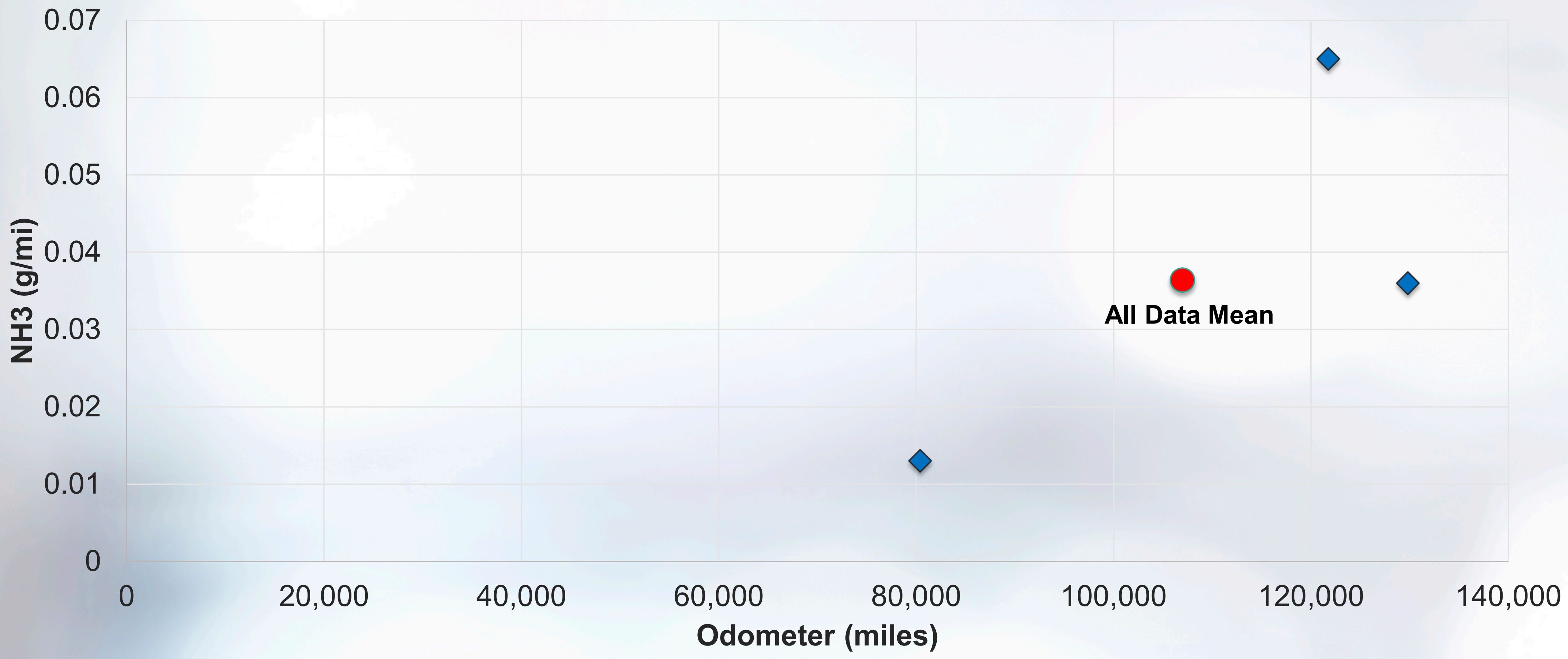
HDD 2007-2010 NH_3 BERs

SCAQMD Test Program



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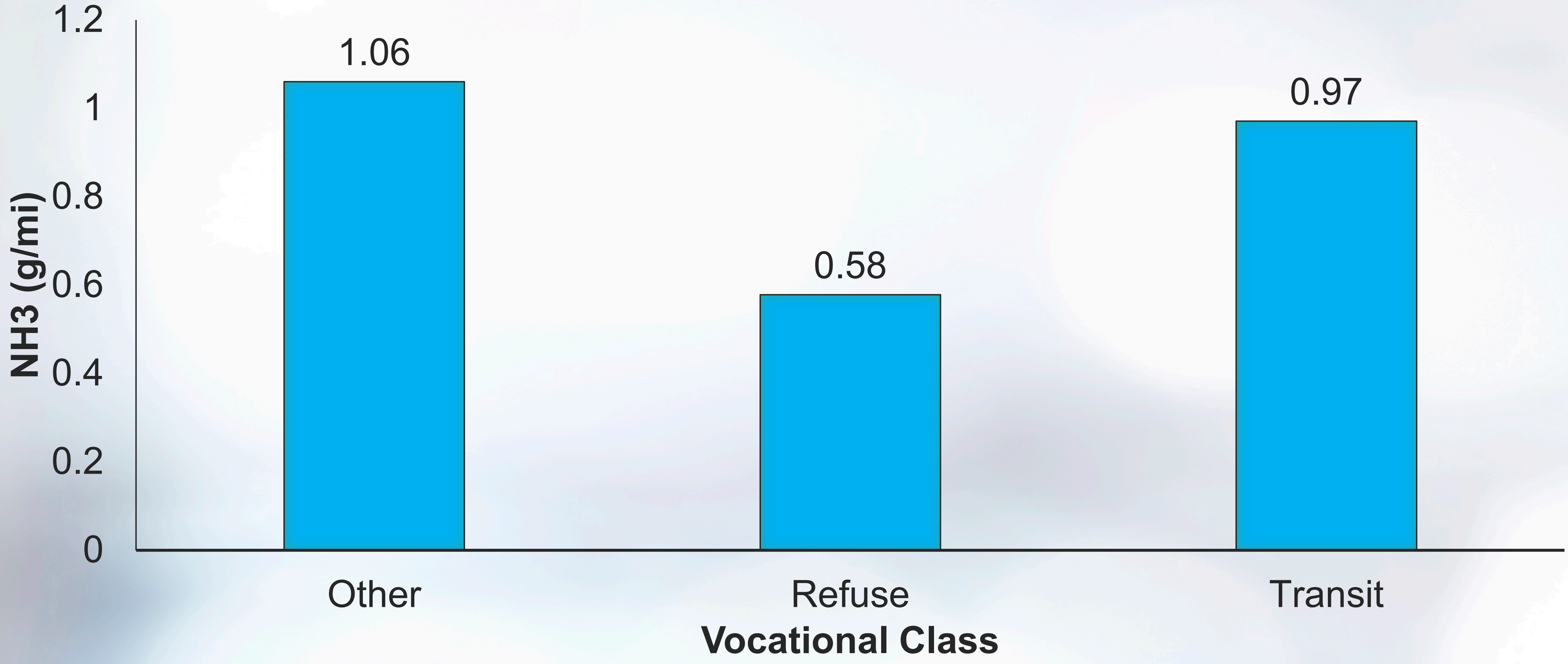
CNG NH_3 BERs

SCAQMD Test Program



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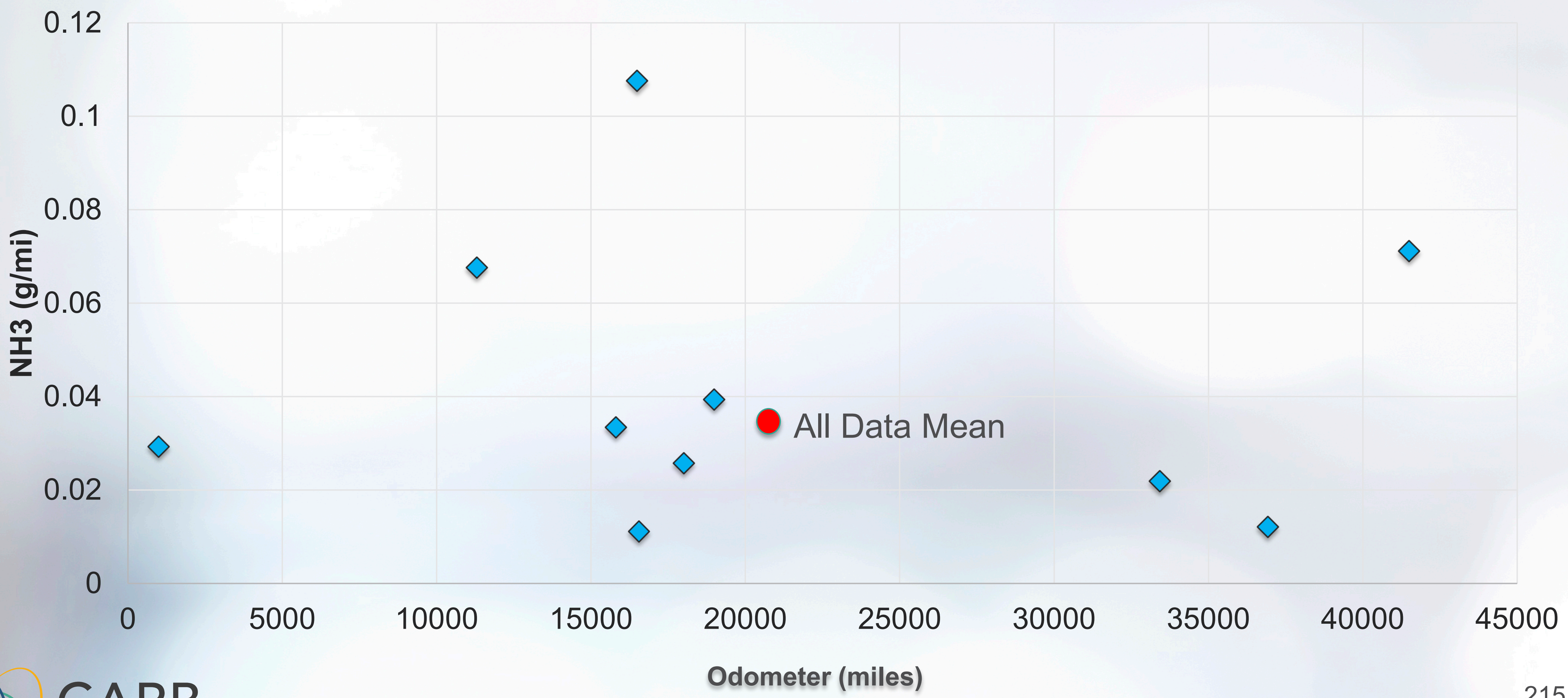
2016+ LDV/MDV Gas NH_3 BERs

CARB LDV Test Project



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NH_3 Key Findings

- SCR equipped Heavy-Duty vehicles have substantially higher emissions than older vehicles resulting from ammonia slip
- 2016+ gasoline light and medium duty vehicles have a moderately higher emissions than older three-way catalyst vehicles
- 2016+ gasoline vehicles show evidence of start effects (bag 1 is higher than bag 2 on the FTP and UC cycles) - future testing is required to confirm this
- CNG engines show much higher ammonia emissions as compared to diesel
- Similarly, future testing should address possible speed/cycle effects

NH_3 EMFAC202x Programming

- A “first generation” approach in modeling ammonia emissions due to lack of data
- All emissions will be treated as running exhaust
- May disaggregate by starts and running exhaust – future testing might be needed
- No speed correction factors - future testing to determine speed/cycle effects

CARB

Light-Duty Vehicles

On-Road Motorcycles

Background

- EMFAC on-road motorcycle activity and emission factors have not been updated since 2000
- Mileage Accrual rates
  - Provided by Motorcycle Industry Council (MIC) survey in 1990 and by MPOs in late 1990's
  - CA does not have a motorcycle Smog Check program to collect odometer data to determine annual mileage
- Emission rates
  - EMFAC uses 1978-1980 motorcycle exhaust FTP data and 1998 Unified Cycle (UC) test data (from motorcycles 1998 and older)
  - Evaporative emission factors are based on light-duty automobiles

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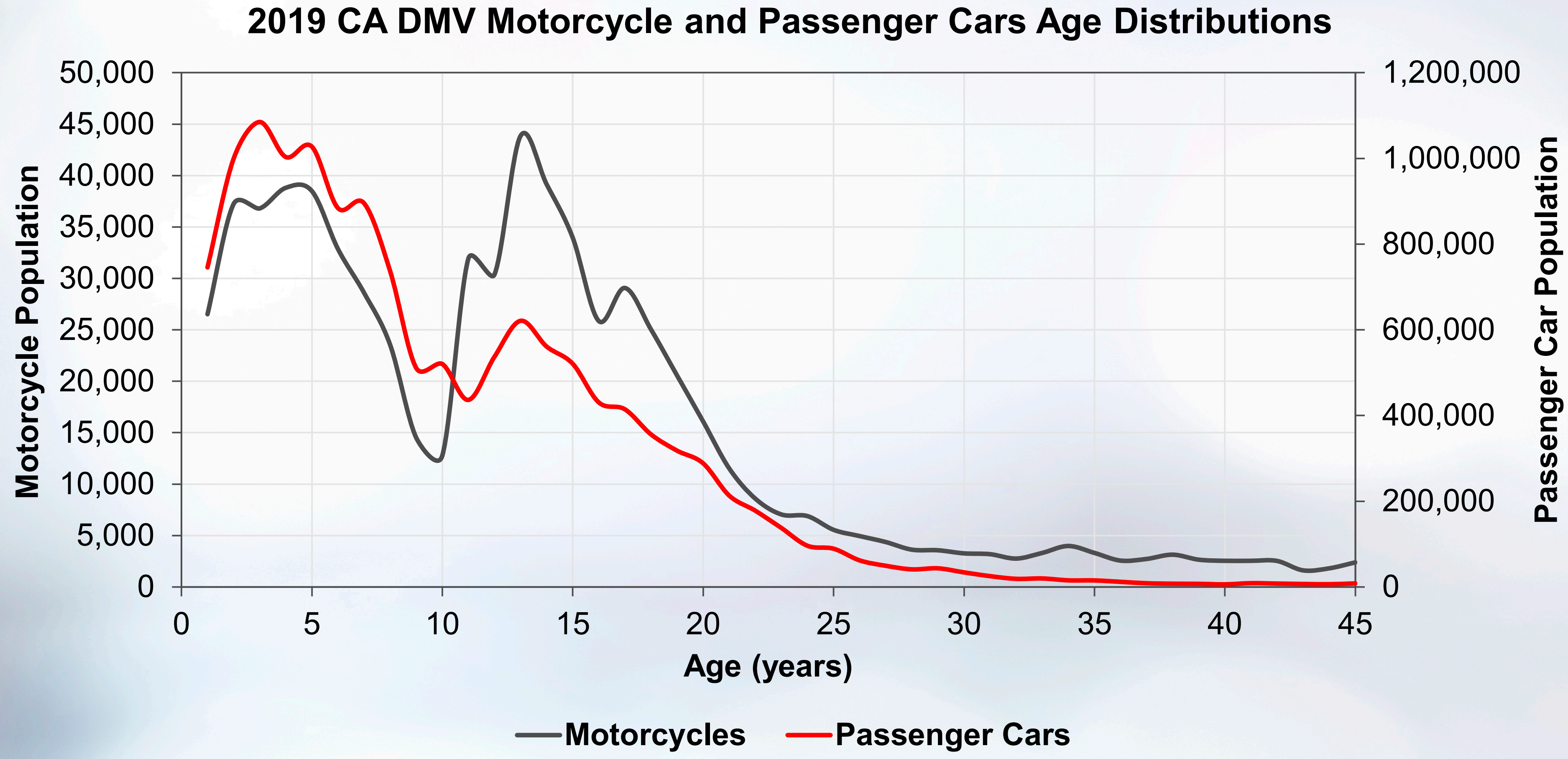
Major Updates

- Motorcycle (MCY) population will be updated using latest DMV Registration Data (Oct 2019)
- CARB is conducting extensive emissions testing on motorcycles (using both dynamometers and PEMS) to better understand emissions from motorcycles
- CARB testing includes tampered motorcycles
  - CARB studies showed an overall 29% tamper rate
- Motorcycle accrual rates will be updated using 2017 National Household Travel Survey (NHTS) – CA data
  - Odometer schedule will also be updated using NHTS-CA data

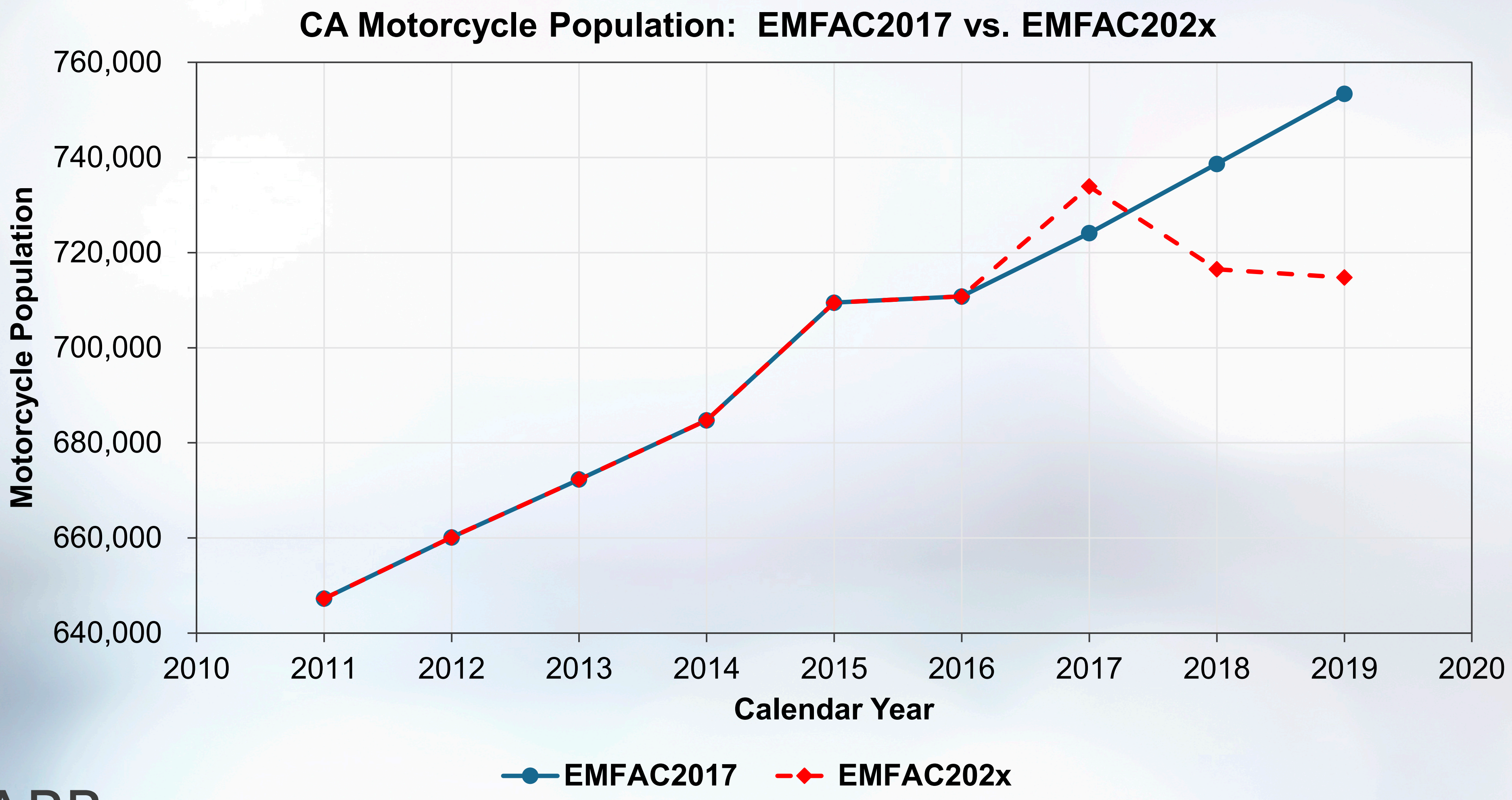
Population and Age Distribution



- CA registered 714,760 motorcycles and 14,429,917 Light-Duty automobiles

CARB

CA Motorcycle Population - EMFAC



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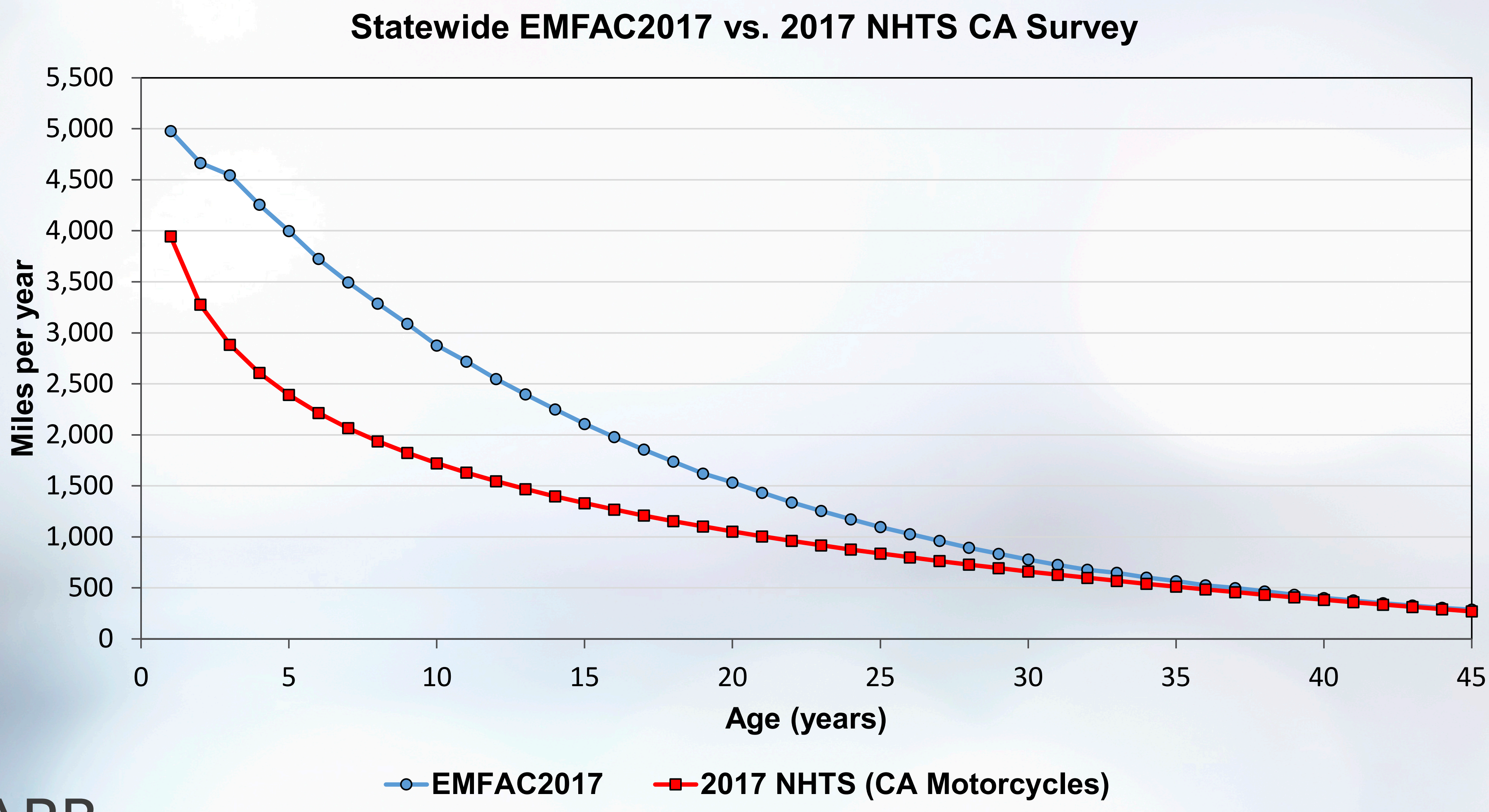
Activity: EMFAC202x Accrual Rates



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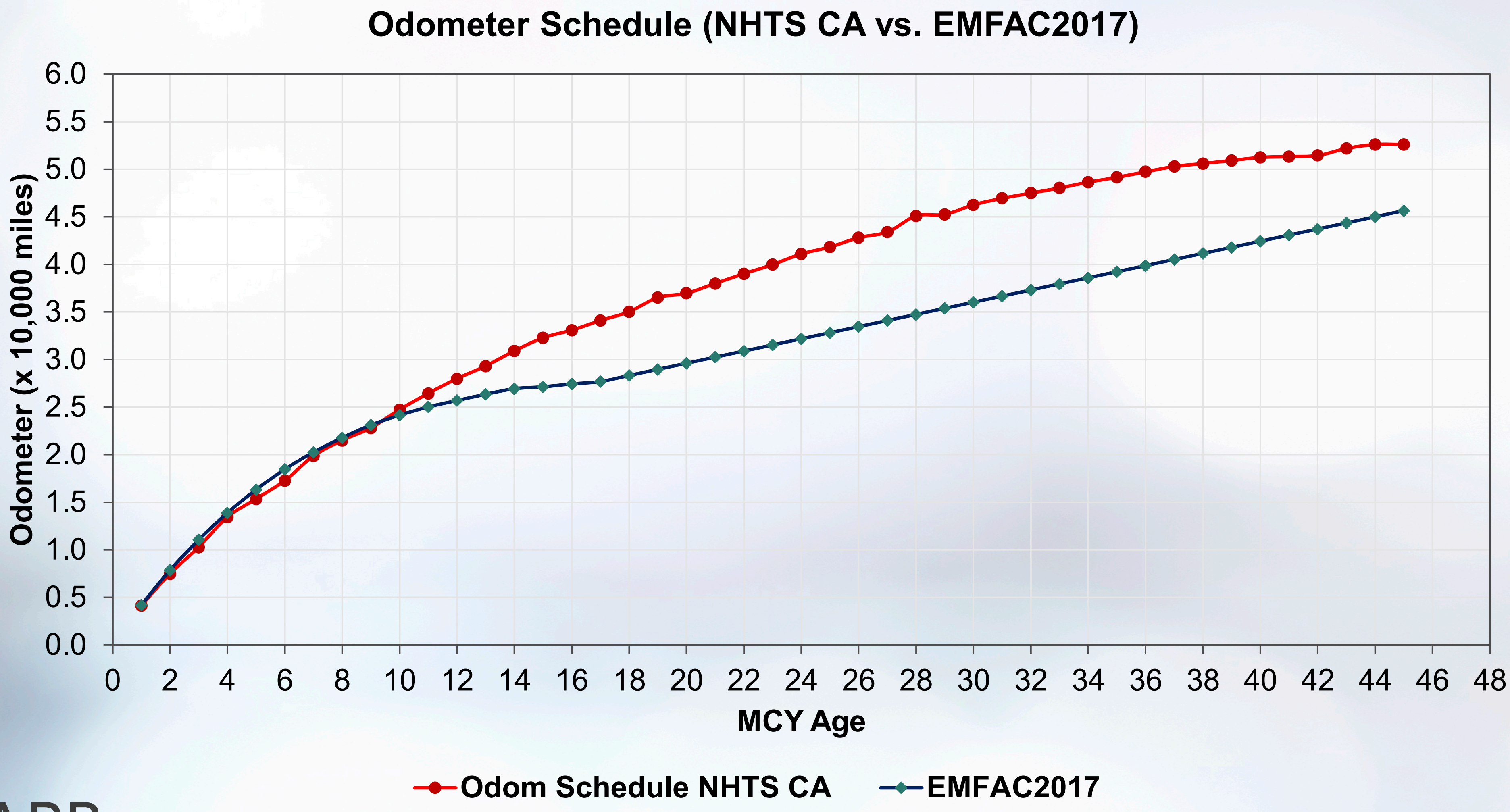
Activity: EMFAC202x Odometer Schedule



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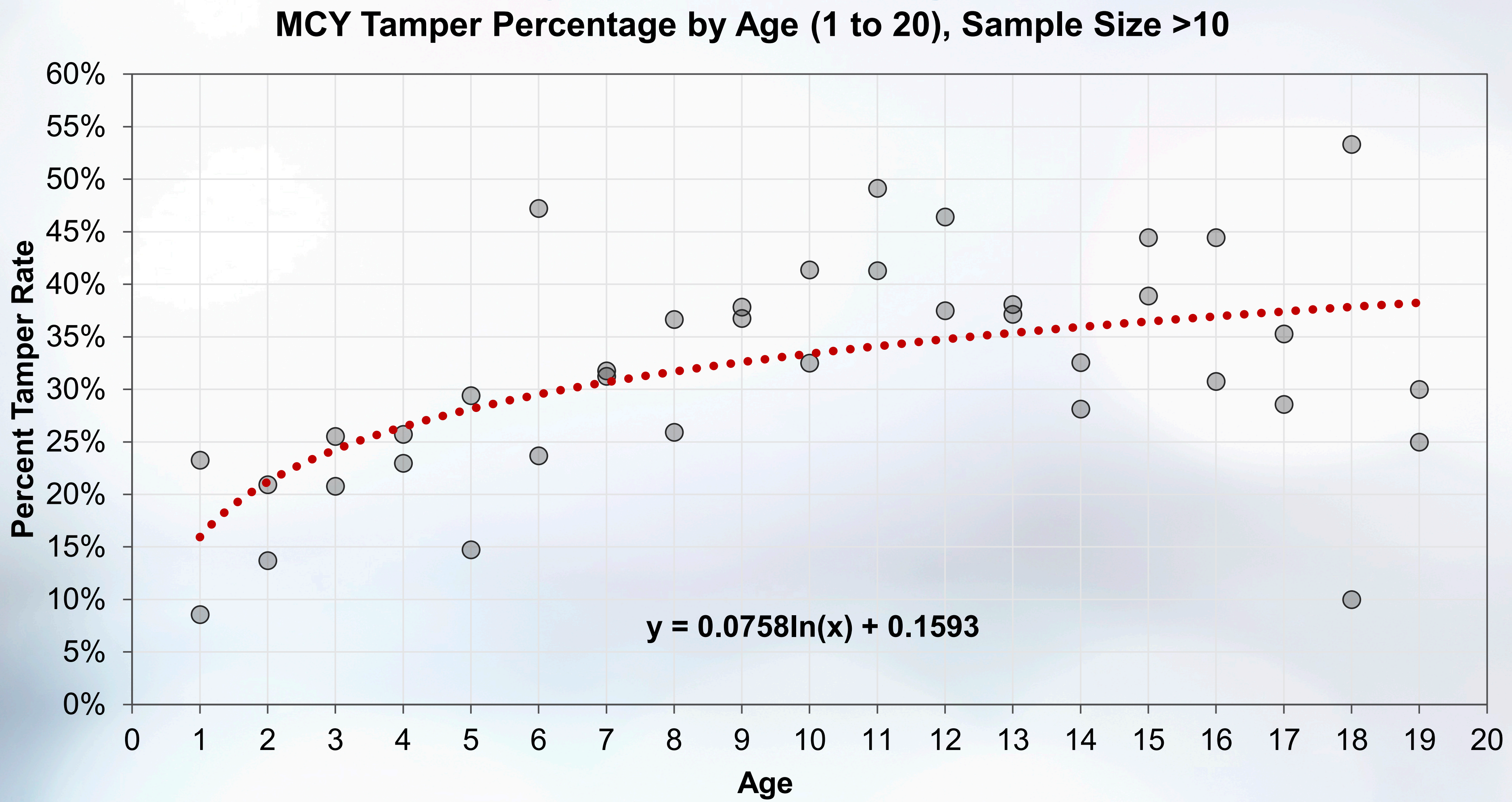
Tampered Motorcycles

- CARB staff analyzed 2,000 online CA motorcycle sales advertisements to evaluate tampered components
  - Two projects conducted Aug 2016 - Jan 2017 and Sep 2019 - Jan 2020
- Referenced CARB Executive Orders for emission controls and aftermarket parts, manuals and relevant sources to determine tampering
  - Both studies showed an overall tampering rate of <u>29%</u>
  - 31% of Class 3 motorcycles were tampered, 9% of Classes 1 and 2 were tampered

Proposed Modeling of Tampering Rates by MCY Age



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Emissions: Laboratory Testing

- 13 of 26 motorcycles tested at CARB HSL El Monte (2008 to 2020 models)
  - 7 private-owned bikes
  - 6 state-owned bikes (2 in tampered configuration)
- Exhaust tests:
  - Unified Cycle (UC) – test results used to develop proposed motorcycle emission rates for EMFAC (MY2008+, FI, Catalyst Equipped, gasoline)
  - Federal Test Procedure (FTP)
  - World Motorcycle Test Cycle (WMTC)
- Evaporative SHED tests:
  - 1-hour hot soak test
  - Multi-day diurnal test

EMFAC Emission Rates

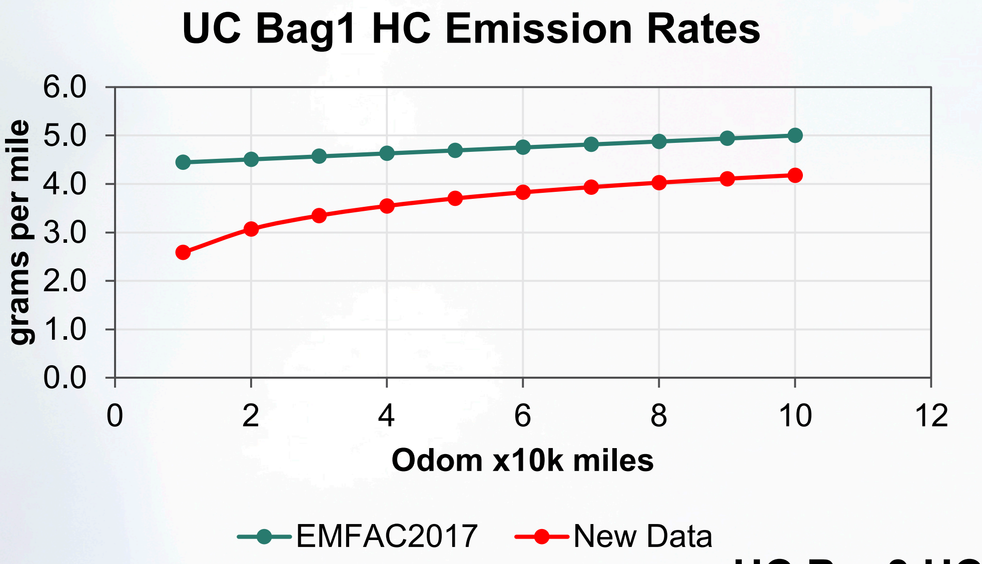
- Analysis of motorcycle exhaust emissions test data
  - By odometer
  - For each Unified Cycle phase (Bag1, Bag 2 and Bag 3)
- Calculate the weighted emission rates
  - Non-tampered and Tampered emission rates
  - Apply Tampering rates as:

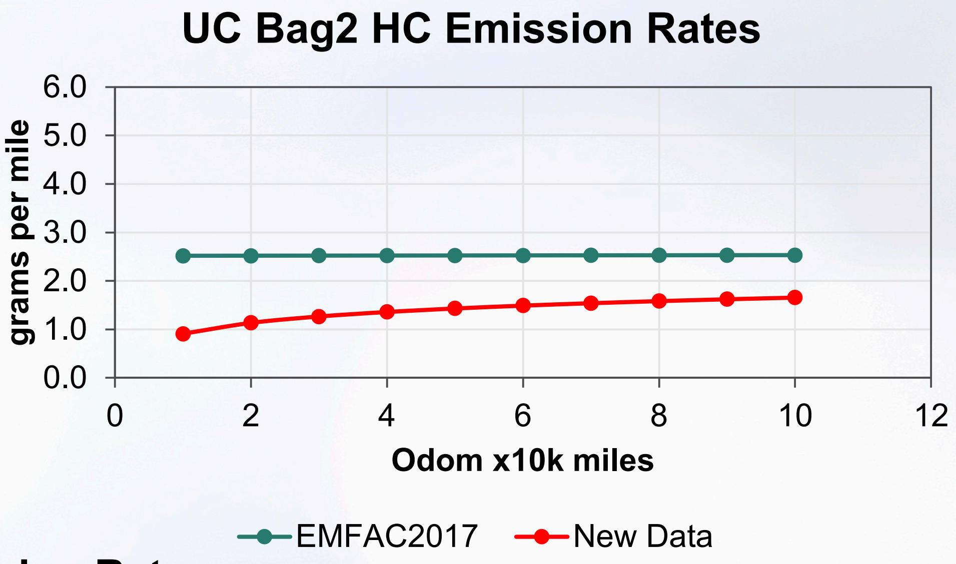
Emission rate [grams per mile] =

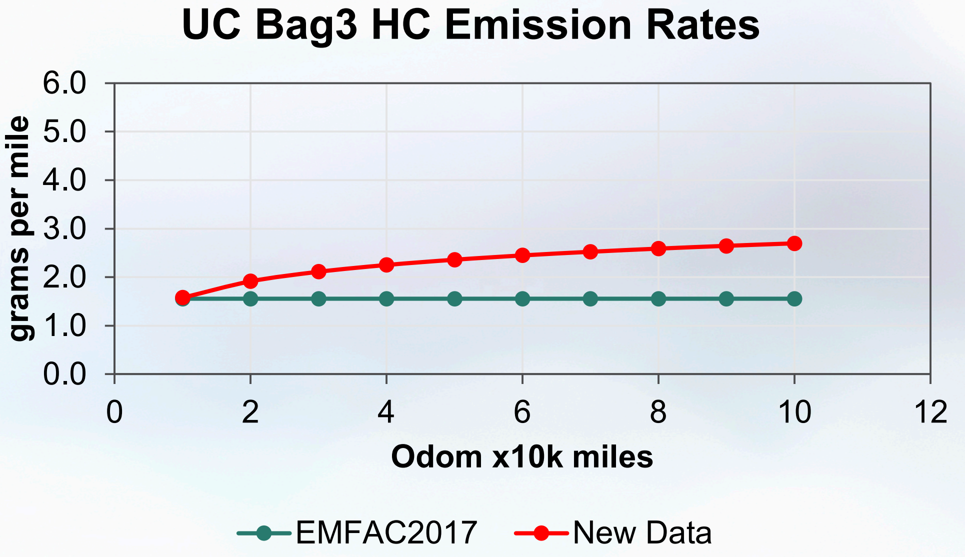
(Tamper Bag) x (Tamper Rate) + (Non-Tamper Bag) x (1 - Tamper Rate)

- Compare test data weighted rates to current EMFAC2017 emission rates for each pollutant

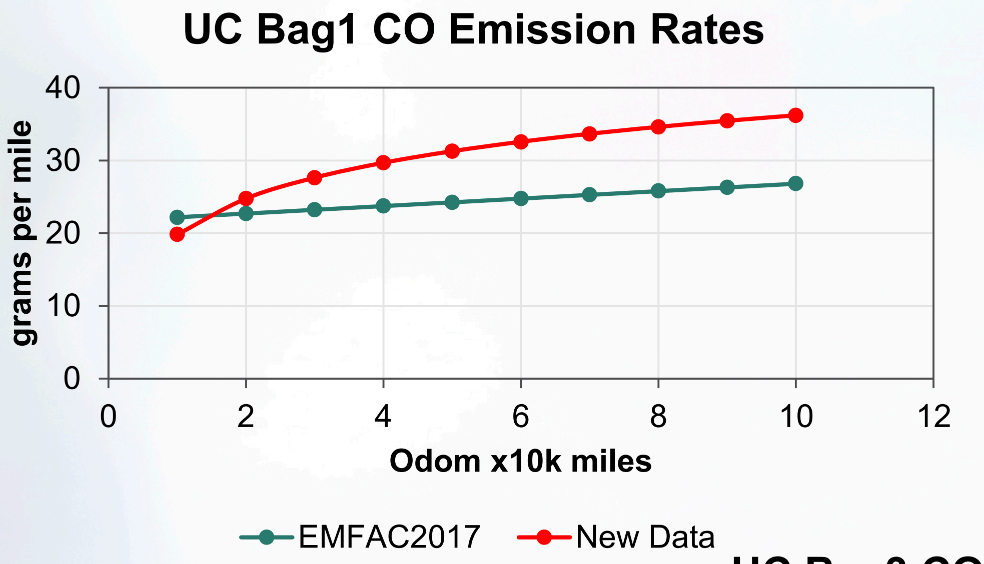
Emission Rates - HC

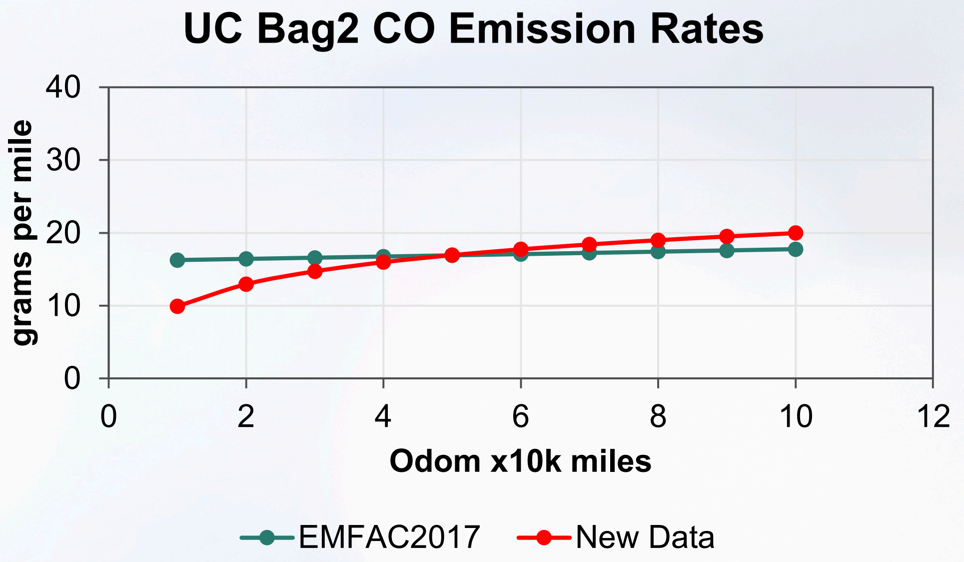


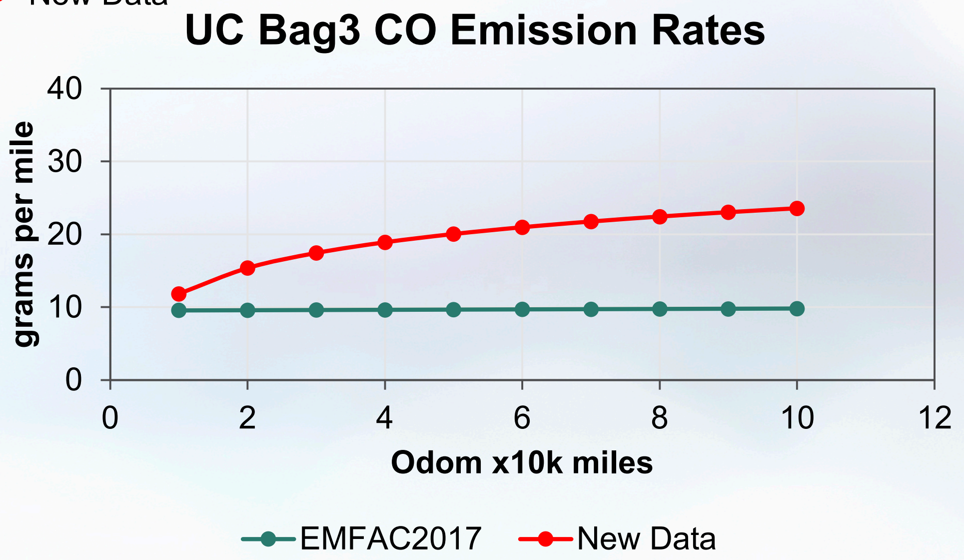




Emission Rates - CO







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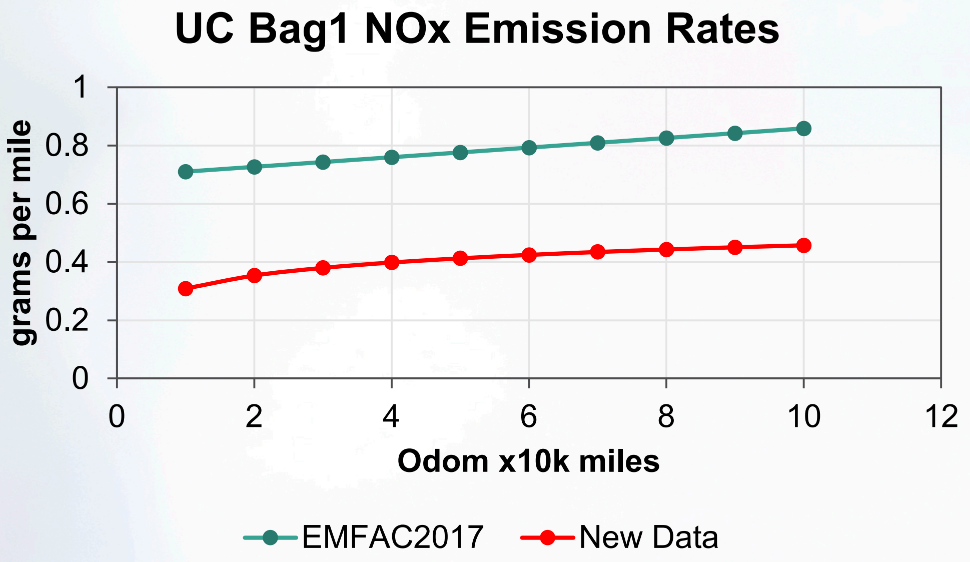
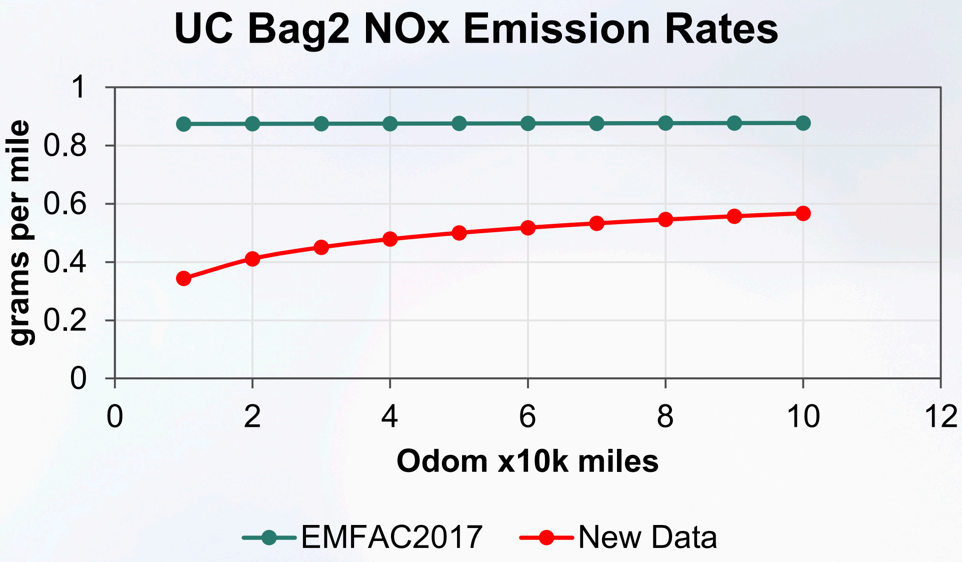
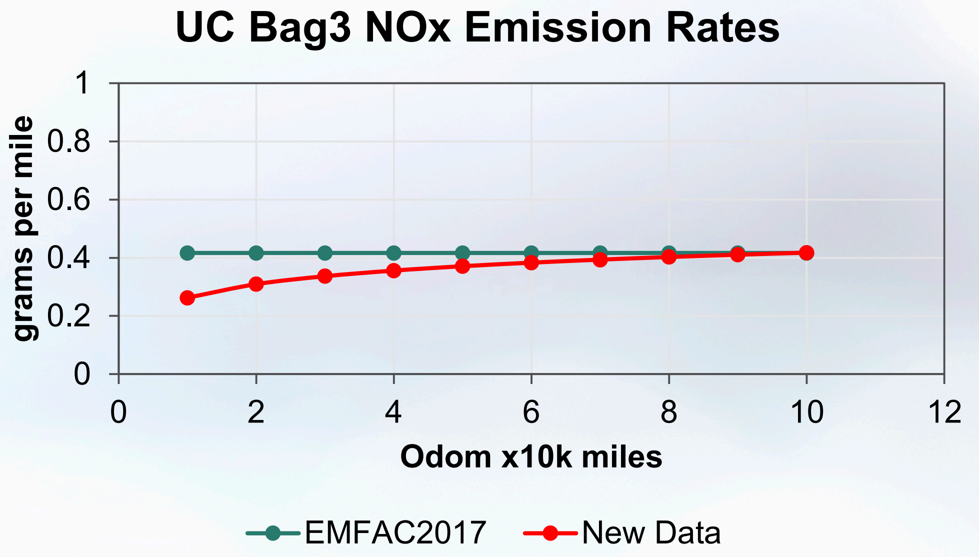
Emission Rates - NOx







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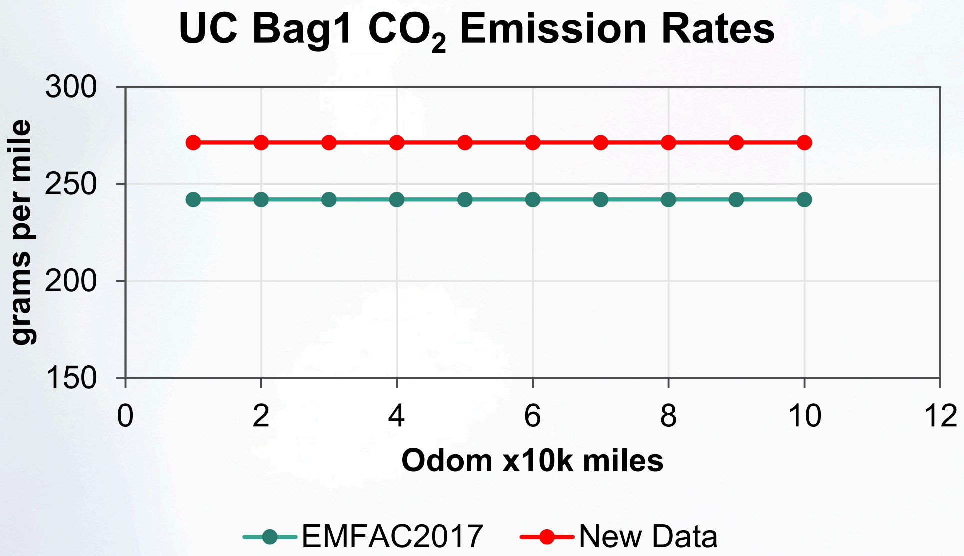
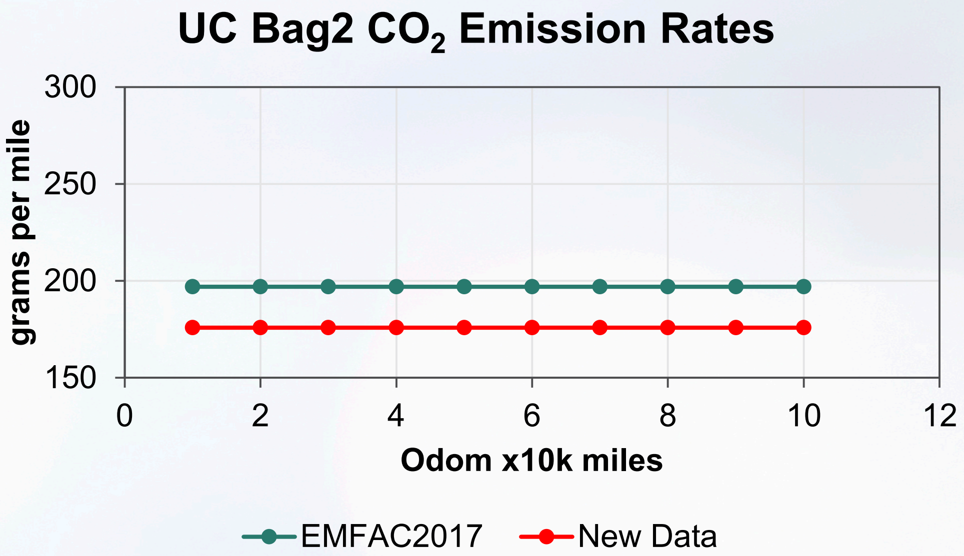
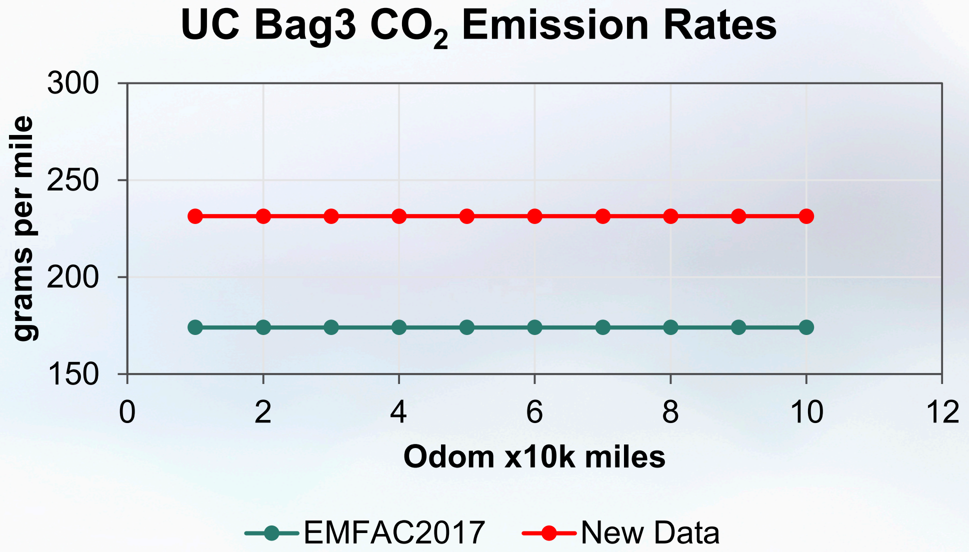
Emission Rates – CO_2







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Next Steps

- Major updates to motorcycle emissions and activity
- NHTS data will be used to update EMFAC for motorcycle accrual rates and odometer schedule
- Data collected through CARB's motorcycle emissions testing program will be used to update exhaust emission rates
  - Evaporative emission rates and SFCs to be developed in next update
- Emissions impact of these updates will be presented in the next workshop
- The new assumptions will be used in support of potential future amendments to motorcycle emissions standards

Latest Regulatory Measures

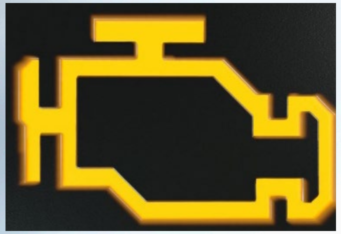
Latest Regulatory Measures

HDVIP/PSIP

Innovative Clean Transit

Advanced Clean Trucks

HD Warranty



ZE Airport Shuttle Bus

Low NOx Omnibus

CARB

Heavy-Duty Vehicle Inspection (HDVIP) & Periodic Smoke Inspection Programs (PSIP)

- **Overall Strategy**
  - *HDVIP*: Roadside inspections of any heavy-duty vehicle operating in California by CARB enforcement personnel for excessive smoke, tampering, and engine certification label compliance
  - *PSIP*: Require annual self-testing for California fleets of 2 or more vehicles
- **Primary Elements**
  - Opacity limits for all MYs
- **Board Hearing**
  - May, 2018

Engines Equipped with a Diesel Particulate Filter (DPF)	
5% Opacity Limit	
Pre-2007 Model Year (MY) Engines without a DPF	
1997–2006 MY Engines	20% Opacity Limit
1991–1996 MY Engines	30% Opacity Limit
Pre-1991 MY Engines	40% Opacity Limit
Engines Equipped with a Level 2 Verified Diesel Emission Control Strategy (VDECS)	
20% Opacity Limit	
Two-Engine Cranes Driven by a non-DPF Off-Road Engine	
40% Opacity Limit	

CARB

2018 HD Warranty

- **Overall Strategy**
  - Requires manufacturers to lengthen the mandatory emissions warranty periods of MY2022+ HD vehicles with GVWR >14,000 lbs.
- **Primary Elements**
  - Longer Warranty Periods
  - Elimination of 3,000-Hour Limit
  - Updated Maintenance Intervals
- **Board Hearing**
  - June 2018

VEHICLE / ENGINE CATEGORY GVWR	Current Warranty	Extended Warranty
Diesel Class 8 Heavy-Heavy GVWR >33,000 lbs.	100,000 miles 5 years / 3,000 hours	350,000 miles 5 years
Diesel Class 6-7 Medium-Heavy 19,500 < GVWR ≤ 33,000 lbs.	100,000 miles 5 years / 3,000 hours	150,000 miles 5 years
Diesel Class 4-5 Light-Heavy 14,000 lbs. < GVWR ≤ 19,500 lbs.	100,000 miles 5 years / 3,000 hours	110,000 miles 5 years

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Innovative Clean Transit (ICT)

- **Overall Strategy**
  - Requires all public transit agencies to gradually transition to a 100% zero-emission bus (ZEB) fleet
- **Primary Elements**
  - Applies to all transit agencies with buses of GVWR >14,000 lbs.
  - ZEB purchase requirements, starting from 2023
  - Low-NOx engines
  - Flexibility, exemptions, and credits
- **Board Hearings**
  - First hearing: September, 2018
  - Second hearing: December, 2018

Year	ZEB % of Total New Bus Purchase	
	Large Transit Agency	Small Transit Agency
2023	25%	-
2024	25%	-
2025	25%	-
2026	50%	25%
2027	50%	25%
2028	50%	25%
2029 and after	100%	100%

CARB

Zero-Emission Airport Shuttle Bus

- **Overall Strategy**
  - Requires airport shuttle operators to transition to 100 percent ZEV technologies by 2035
- **Primary Elements**
  - Applies to operators with shuttles of GVWR >8,500 lbs., which transport passengers to, from, or around a regulated airport
  - Airport shuttle operators must begin adding zero-emission shuttles to their fleets in 2027, and complete the transition to ZEVs by the end of 2035.
- **Board Hearings**
  - First hearing: February, 2019
  - Second hearing: June, 2019

Year	% of Fleet That Must Be Zero-Emission
2027	33%
2031	66%
2035	100%

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Advanced Clean Truck (ACT)

- **Overall Strategy**
  - Requires manufacturers with >500 annual California sales to sell certain percent of zero-emission truck and bus
- **Primary Elements:**
  - *A*pplies to manufacturers who certify Class 2B-8 chassis or complete vehicles with combustion engines
  - Requires to sell zero-emission trucks with an increasing percentage of their annual California sales from 2024 to 2035
- **Board Hearings**
  - First hearing: December 2019
  - Second hearing: June 2020

Model Year	% of Zero-Emission Trucks in the Total New Sales in CA		
	Class 2b-3	Class 4-8 Vocational	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035 and after	55%	75%	40%

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Low NOx Omnibus

- **Overall Strategy**
  - Requires manufacturers to meet MY2024+ California certification for heavy-duty engines with GVWR > 10,000 lbs.
- **Primary Elements**
  - A tightened standard on the Federal Test Procedure (FTP)
  - A new low-load certification cycle (LLC)
  - Improvements to the existing heavy-duty in-use testing (HDIUT) program
  - Improvements to the durability demonstration program (DDP)
  - Lengthened warranty and useful life (UL) mileages
  - Amendments to emission warranty information reporting (EWIR)
- **Board Hearings**
  - August 2020

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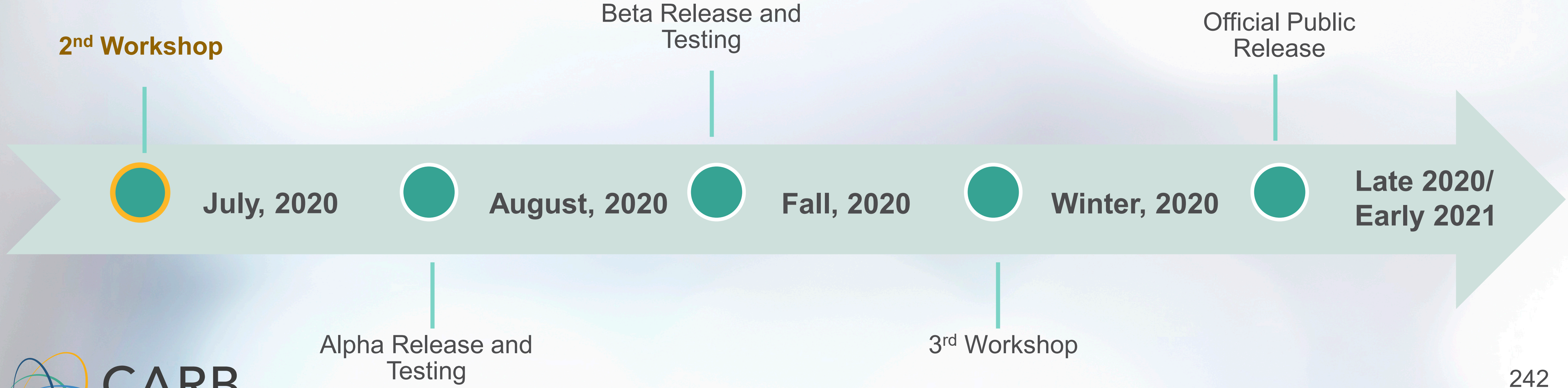
Next Steps for EMFAC202x

- Send us your comments and feedback by August 28, 2020 on the analysis presented at the second public workshop of EMFAC202x
- Continue data collection and analysis with a cut-off date of October, 2020
- Evaluate the updated emission rates and activity using real world data (e.g., remote sensing, roadside data collection, etc.)



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Questions and Comments

For questions and comments please contact us at:

EMFAC@arb.ca.gov

You can also visit our website at:

https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory

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