EMFAC202Y 3rd Public Workshop: Update to California On-Road Mobile Source Emissions Inventory

Mobile Source Analysis Branch
Air Quality Planning and Science Division

October 23, 2024

Workshop Instructions

- Telephone Call-In: (888) 363-4734
- Access Code: 493657
- Workshop is being recorded
- Slides and recording will be available on CARB's On-Road Conferences and Workshops web page

Public Process of EMFAC202Y Development

User Survey
Summer 2021

October 2022
1st Public Workshop
Discuss planned updates and regulations to incorporate

Updates on methods and preliminary results
2nd Public Workshop
January 2024

TODAY
October 2024
3rd Public Workshop
Additional updates on methods and preliminary results

Updates on final emissions inventories
Final Public Workshop
Early 2025

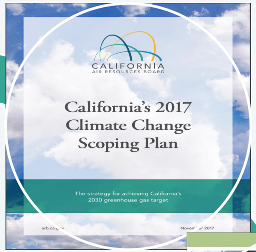
Today's Agenda

1. **EMFAC Overview**
2. **Vehicle Activity Updates**
   - Light-Duty New Vehicle Sales Forecasting
   - Light-Duty Zero-Emission Vehicle New Sales Forecasting
   - Reallocation of Heavy-Duty Vehicle Miles Traveled
   - Light-Duty Vehicle Miles Traveled Speed Distribution
3. **Question and Answer (1)**
4. **Break – 10 Minutes**
4. **Emission Rates Updates**
   - Light-Duty Tire Wear Emissions
   - Light-Duty Base Emission Rates
   - Light-Duty High-Speed Driving Testing
   - Speed Correction Factor (SCF) and Emission Rates Comparison (g/h vs. g/mi)
   - Light-Duty CO_2 Emission Rates
   - Medium Heavy-Duty Truck Emission Rate
   - Heavy-Duty Natural Gas Methane Emission Rates
   - Heavy-Duty Natural Gas NO_X Emission Rates
5. **Energy Module Updates**
   - Fuel Cell Electric Vehicle Hydrogen Consumption Rates
6. **Next Steps**
7. **Question and Answer (2)**

EMFAC Overview

Background of EMFAC

EMFAC



Scoping Plan

State Implementation Plan (SIP)

Transportation Conformity

Regulatory Development

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Background of EMFAC (continued)

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

EMFAC Updates

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

EMFAC2014
Released: 2014

EMFAC2017
Released: 2017

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

- New web-based interface
- Reflects key regulations (e.g., Advanced Clean Trucks, Innovative Clean Transit)

EMFAC2021
Released: 2021

EMFAC202Y
To be released in 2025

- Latest fleet activities and technologies
- Reflecting regulations adopted before 2025
- Incorporation of expanded PEMS data for heavy-duty diesel categories.

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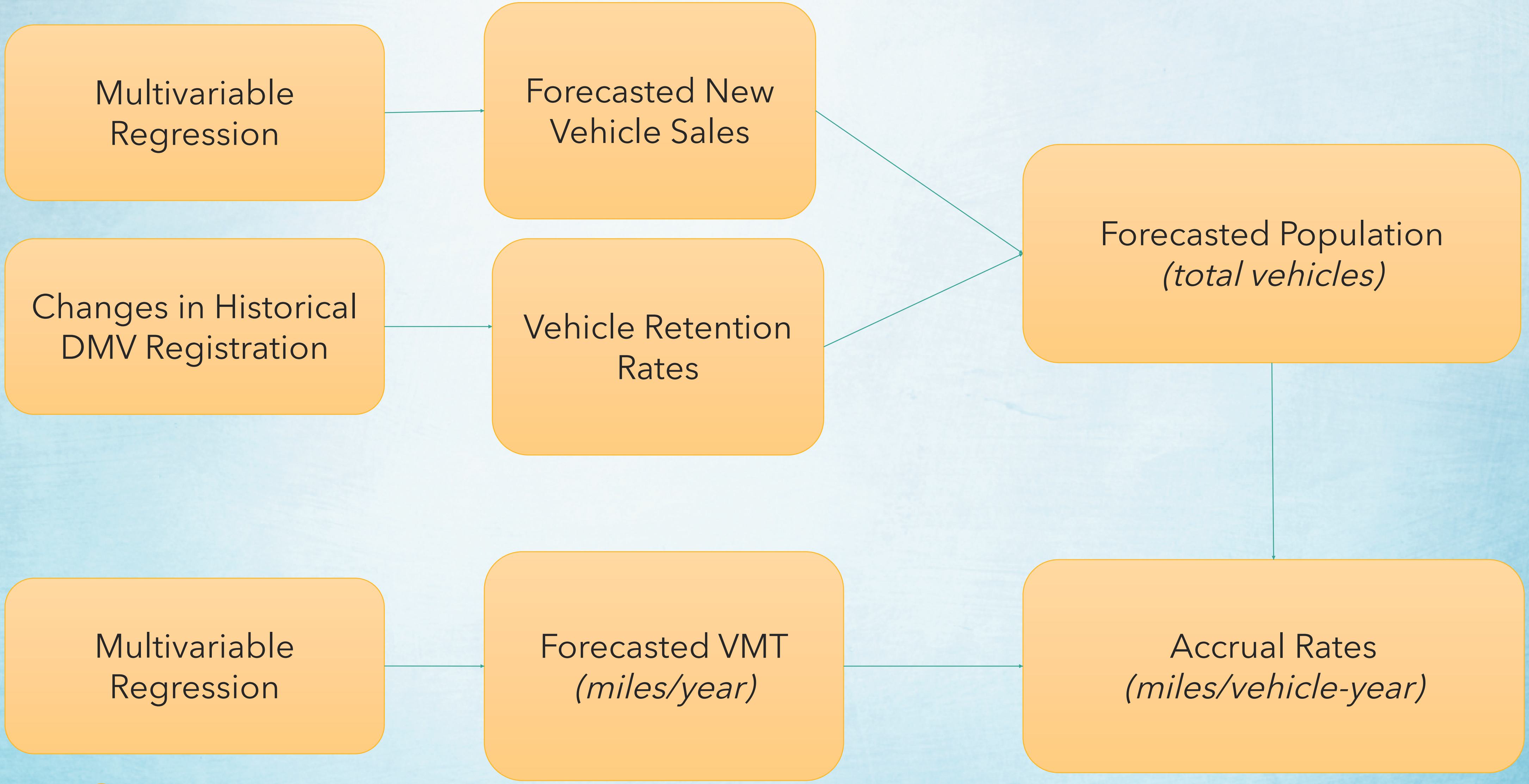
Vehicle Activity Forecasting

Light-Duty New Vehicle Sales Forecasting

EMFAC2021 Light-Duty Forecasting



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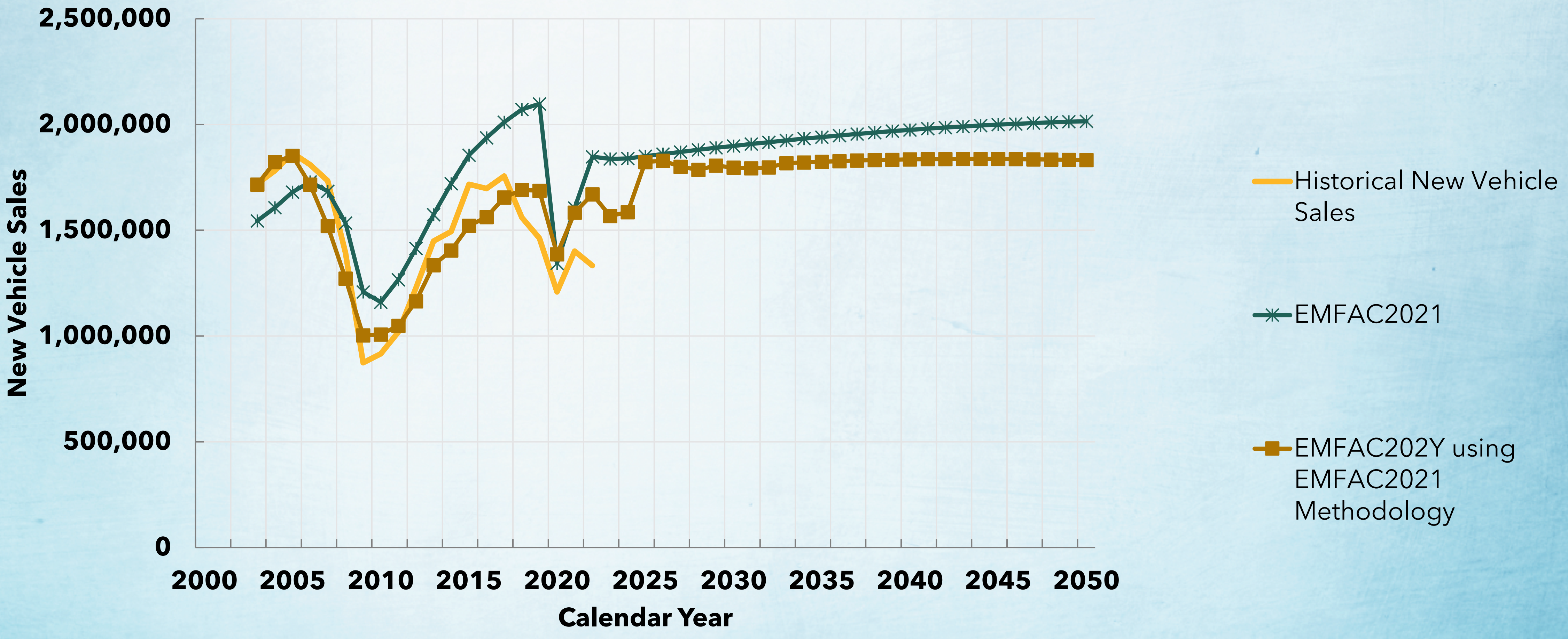
Light-Duty New Vehicle Sales Forecasting

- Based on a multi-variable regression analysis considering:
  - GDP, unemployment rate, housing starts, gas price, federal interest rates, disposable income, 1 and 2 year lagged variables
- Final regression was chosen based on best fit to data (**R^2**), **p-value < 0.05**, and the sensibility of the coefficients.
- Forecasting in EMFAC2021: Used unemployment rate and 2-year lagged housing starts as predictor variables.
- **Updated for EMFAC202Y**:

New Vehicle Sales = $1.03 \times 10^{-4} \times$ [Housing Starts] – $1.06 \times 10^{-3} \times$ [Unemployment] + 0.036

R^2 = 0.79

Comparison of EMFAC202Y and EMFAC2021



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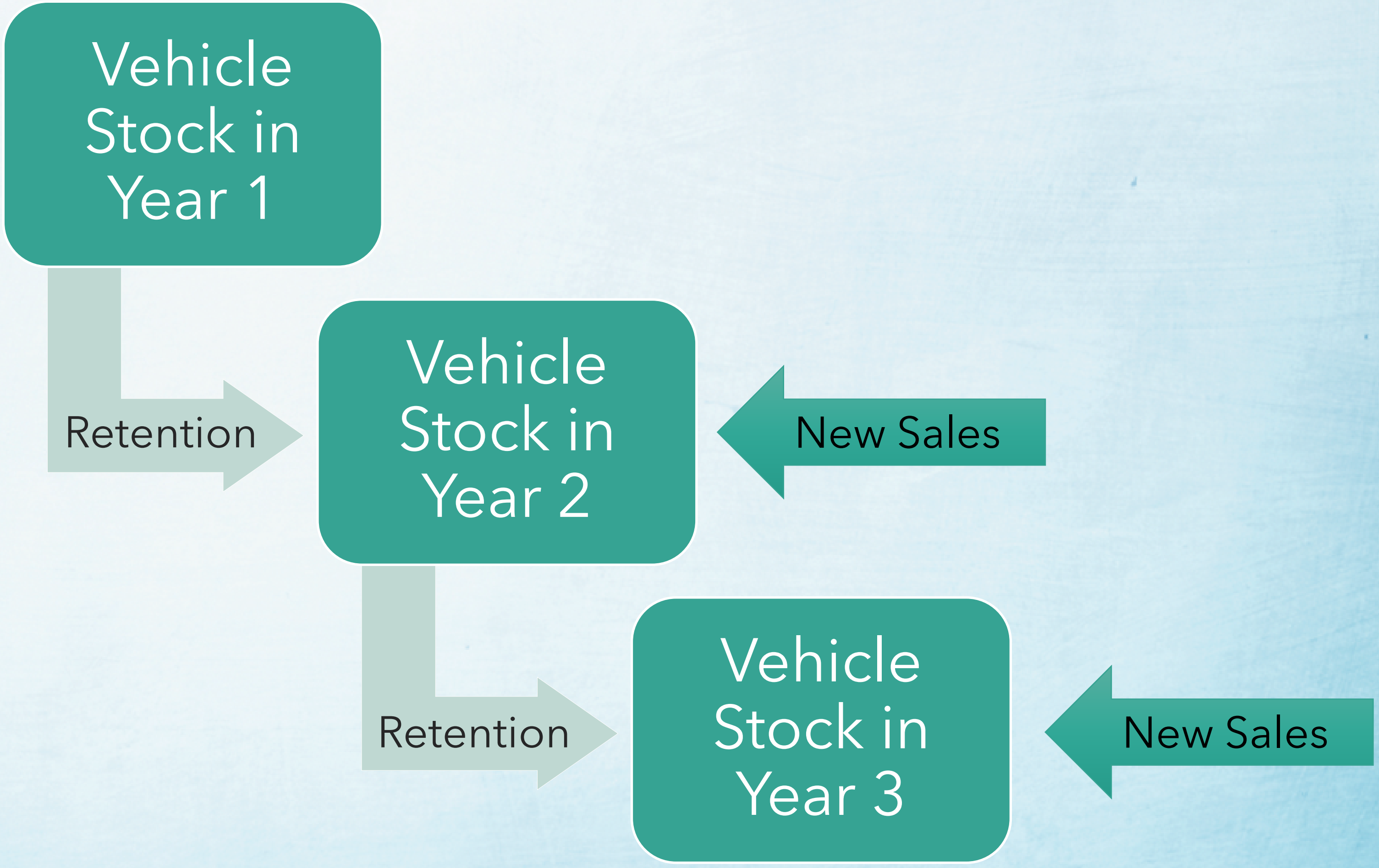
Light-Duty Population Forecasting Framework in EMFAC2021



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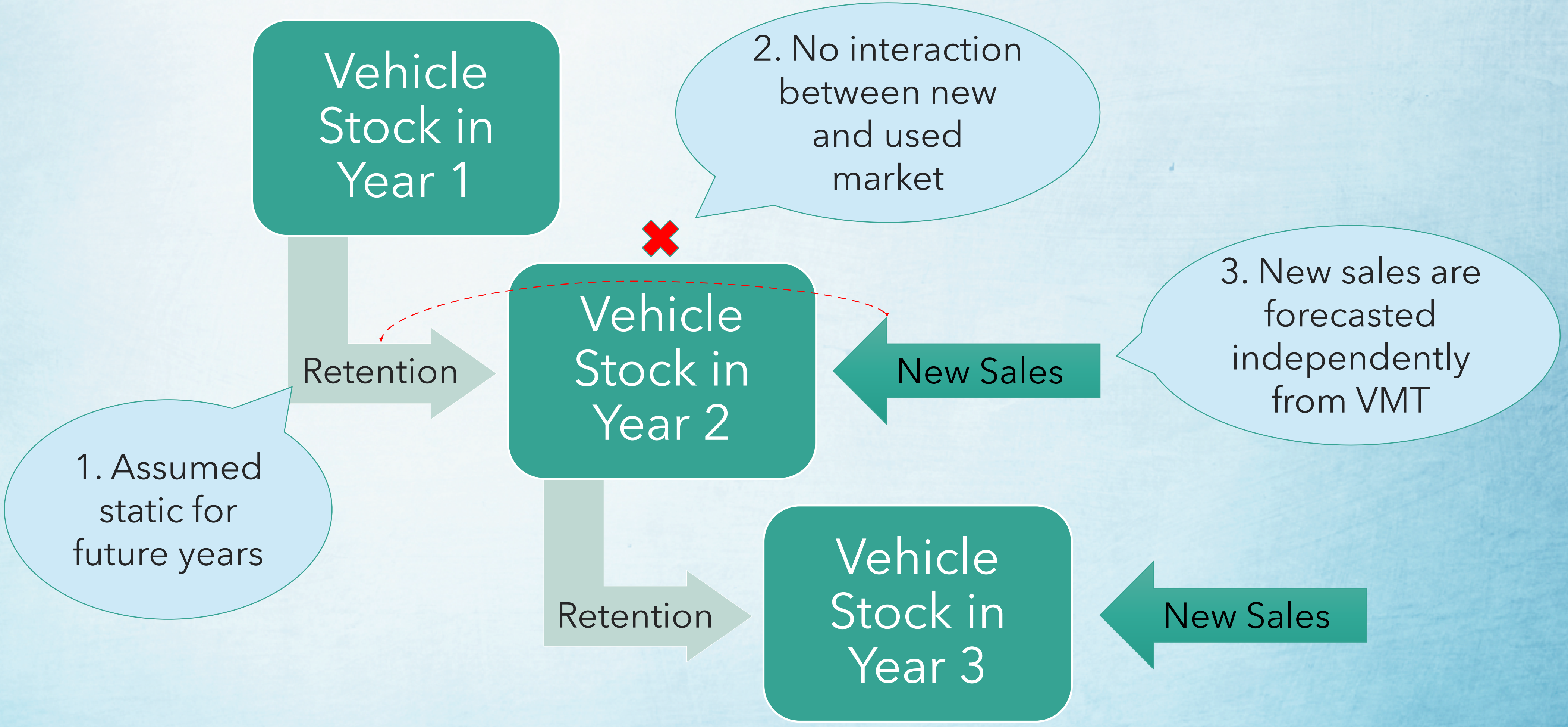
Limitations of Light-Duty Population Forecasting in EMFAC2021



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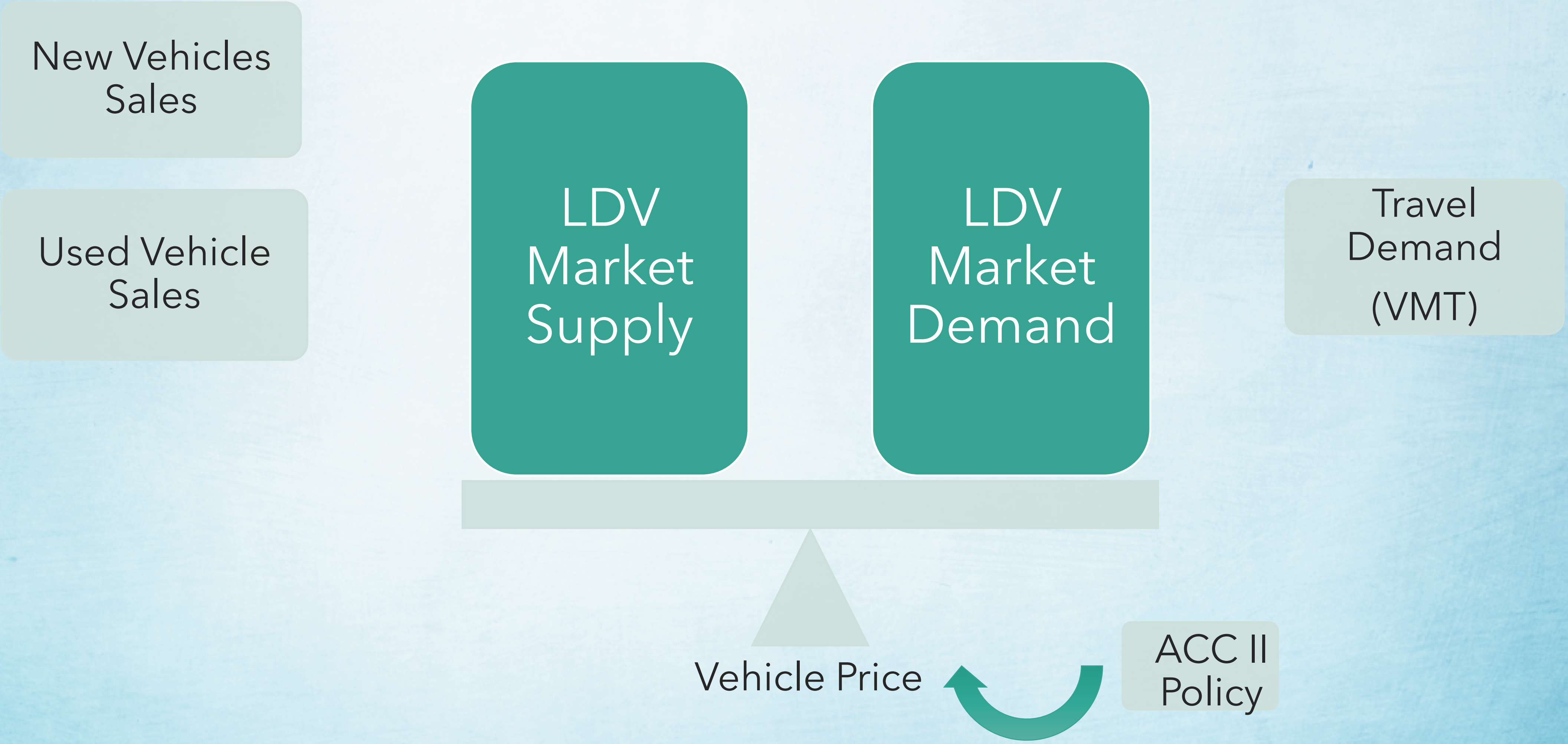
Contract with UCSD to update New Vehicle Sales Forecasting Methodology in EMFAC202Y

- Equilibrium vehicle population forecast model
  - Contract #21AQP018 with Prof. Mark Jacobsen at UCSD

- Project Goals:
  - Simulate interactions between new sales and retention rates
  - Consider the impact of vehicle price and regulations
  - Match the macro-economic forecast of VMT

Equilibrium Forecasting Model



LDV Equilibrium Forecasting Flowchart

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

Parameters and data:
- Historical retention rates
-Demand elasticities (new and used)
-Scrap elasticity

Equilibrium Model:
Solves for a dynamic sequence of vehicle prices

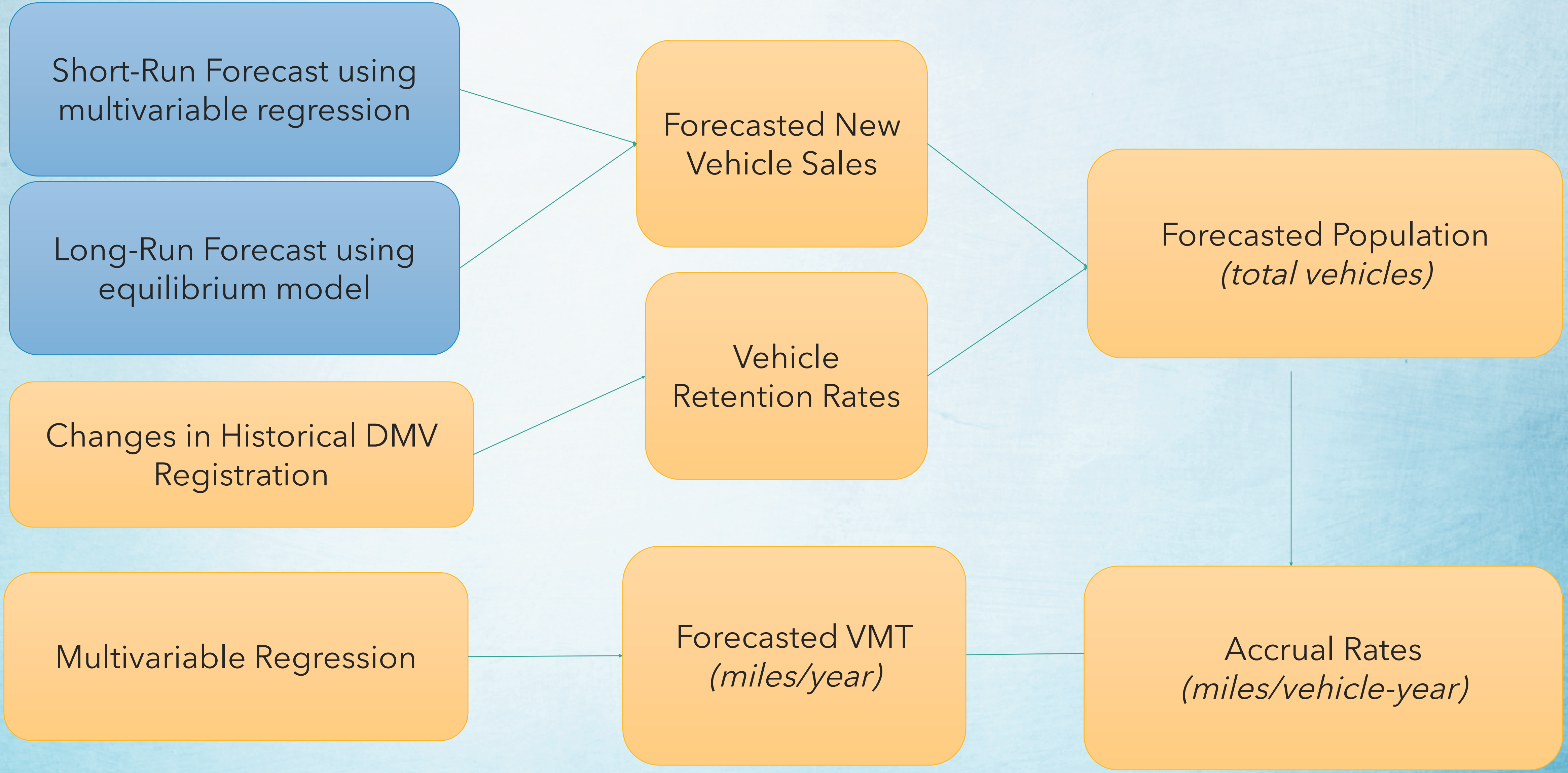
Output:
-Forecasted New sales

New Approach for EMFAC202Y

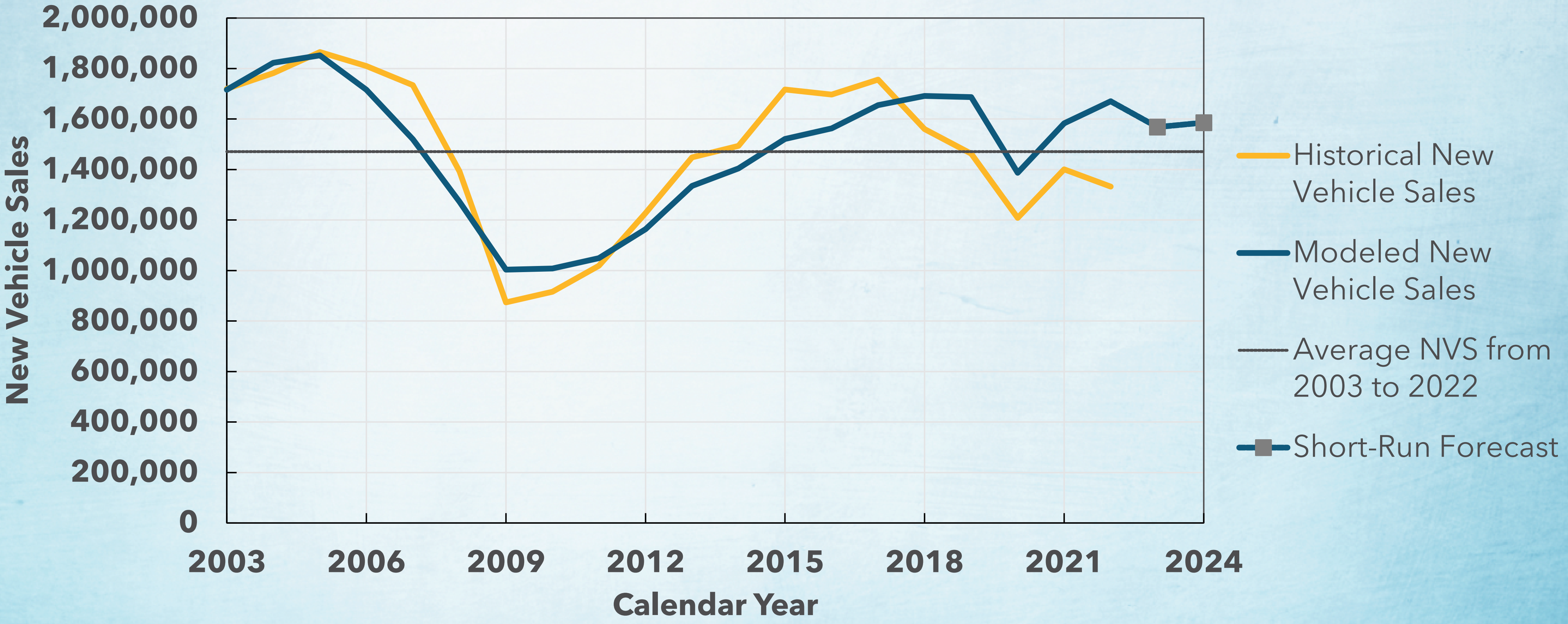
- Like EMFAC2021, Short-run forecasting (2023-2024) will use regression modeling of economic variables to predict new vehicle sales as market is still out of equilibrium due to many market externalities
- Long-run forecasting (2025-2050) will use equilibrium modeling[1] that balances supply of new and used vehicles with the travel miles demanded.
  - Considers the impact of Advanced Clean Cars II (ACC II Regulation)

[1] Contract #21AQP018 with Prof. Mark Jacobsen at UCSD

EMFAC202Y Light-Duty Forecasting



Short-Run Regression Forecasting



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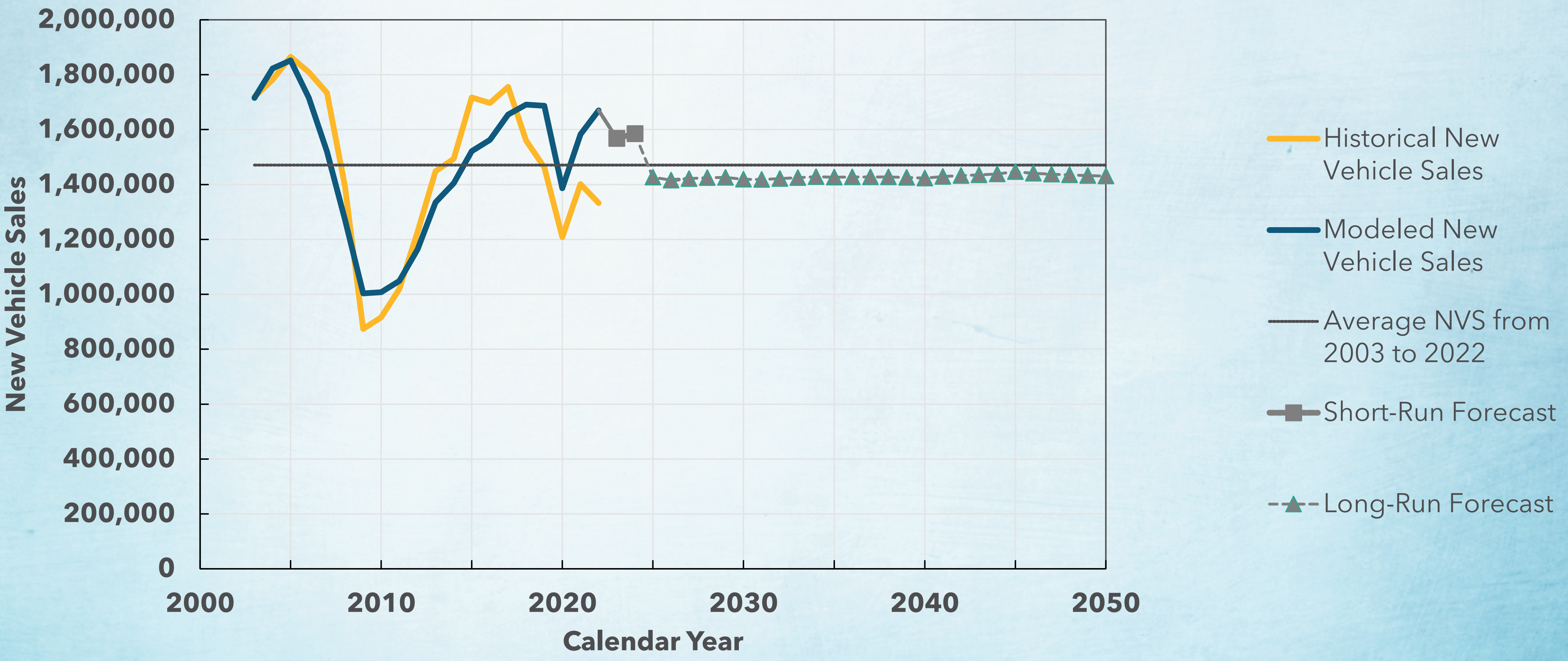
Long-Run Equilibrium Forecasting



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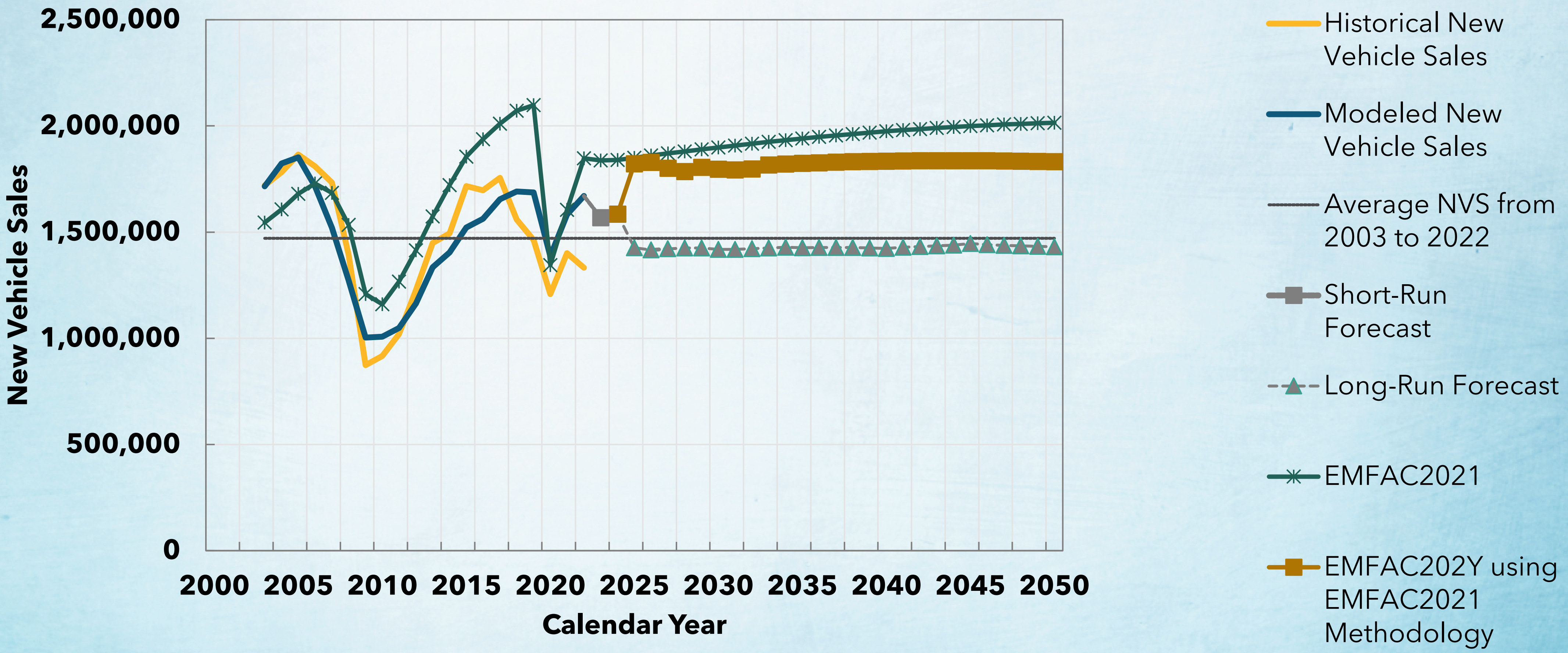

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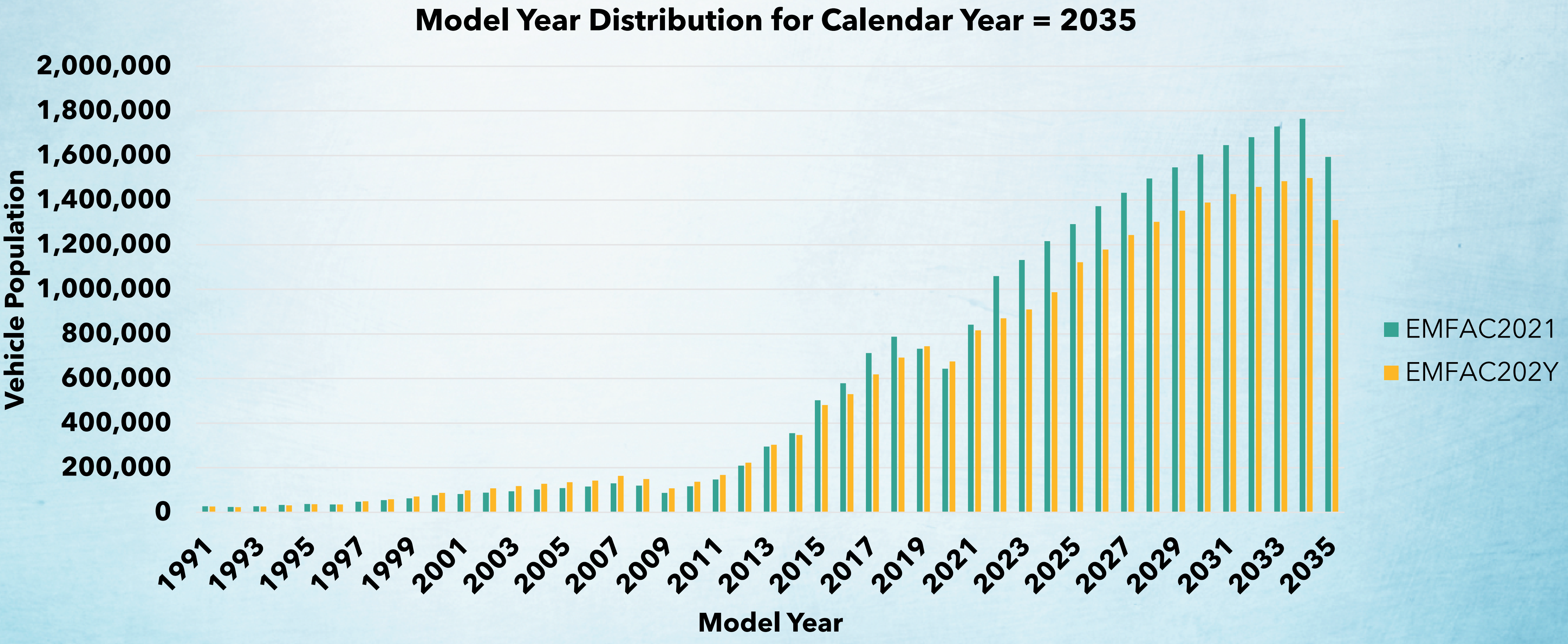
Light-Duty Model Year Distribution is Trending Older in EMFAC202Y



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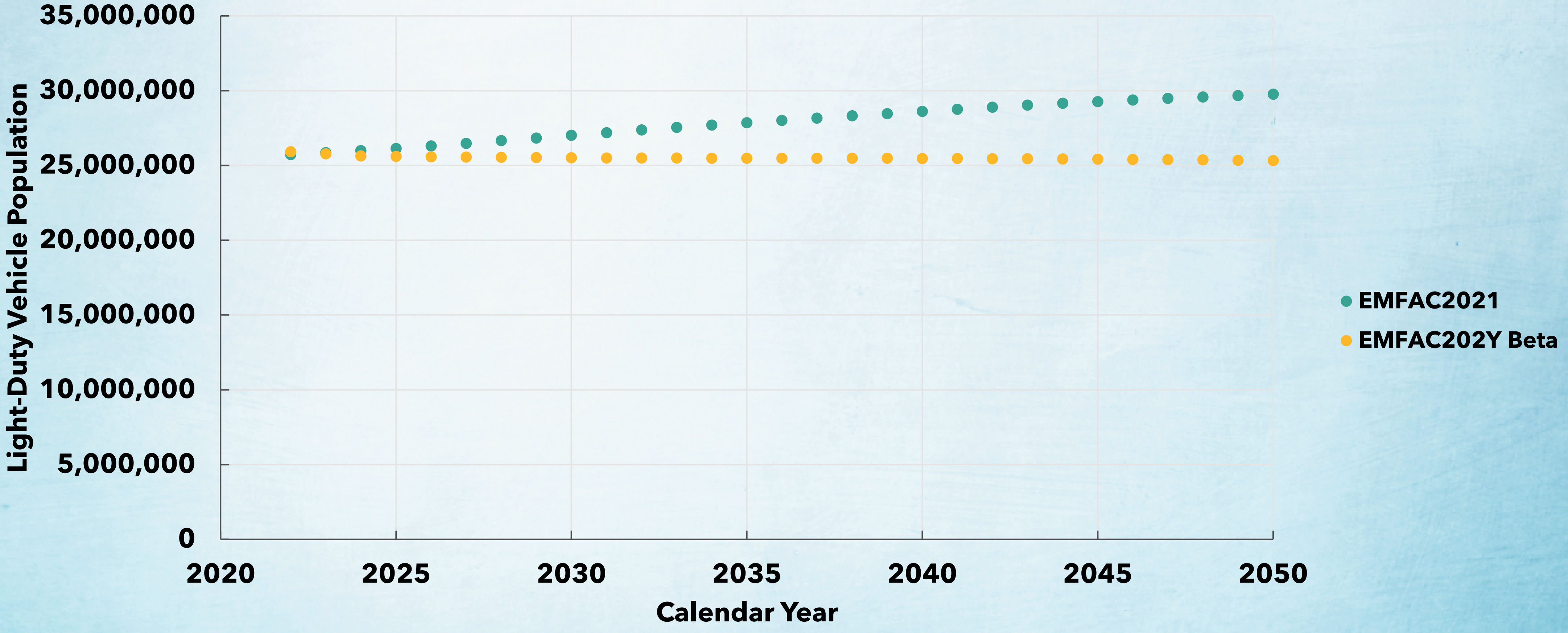
Light-Duty Population is Forecasted to be Lower in EMFAC202Y



Summary of Light-Duty Forecasting Updates for CY = 2035

	EMFAC2021	EMFAC202Y
Human population	**~43.2 Million**	**~39.8 Million**
New Vehicle Sales	**~1.9 Million**	**~1.4 Million**
Vehicle population	**~27.9 Million**	**~25.5 Million**
Total VMT	**~373 Billion**	**~300 Billion**
VMT/capita	**~8,645**	**~7,549**
VMT/vehicle	**~13,408**	**~11,792**
Average vehicle age	**~9.8**	**~10.4**

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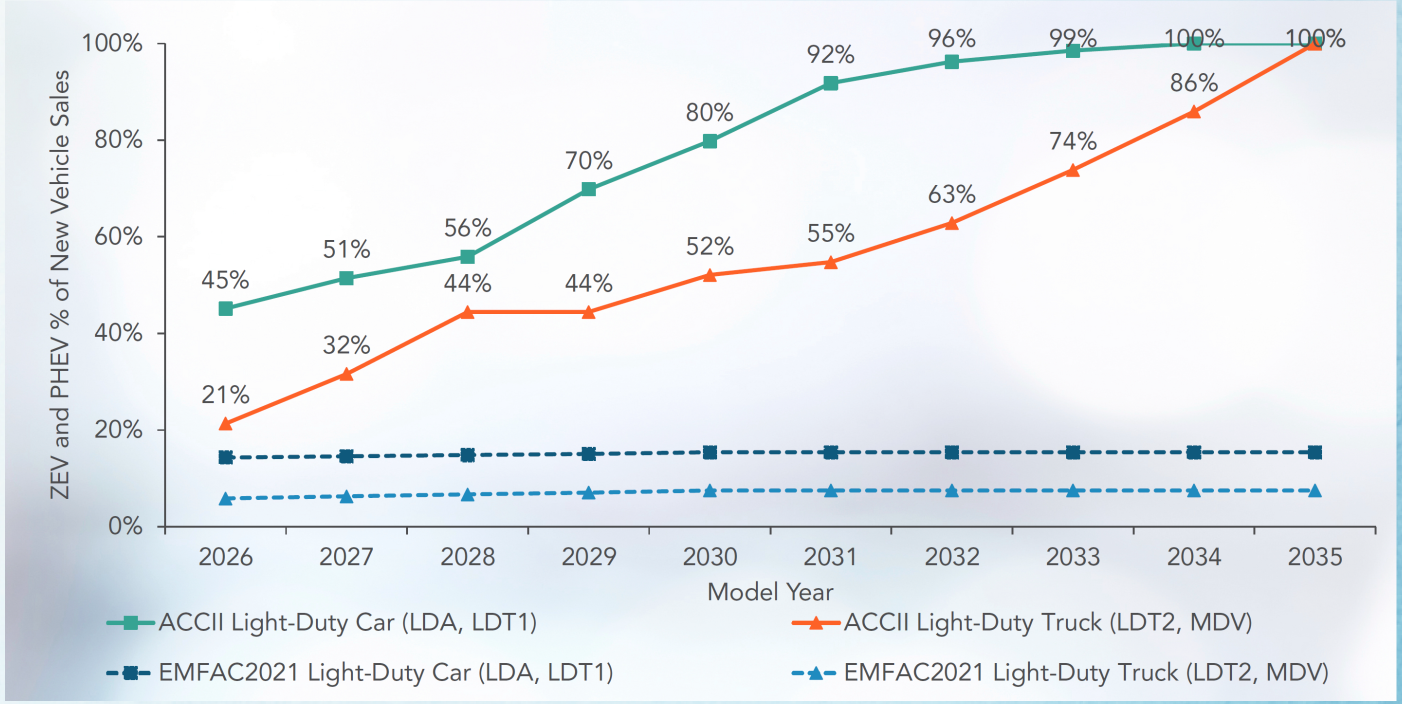
Vehicle Activity Forecasting

Light-Duty Zero-Emission Vehicle (ZEV) New Sales Forecasting

Background on ACC II Regulation

- All new passenger cars, light-duty trucks and SUVs sold in California will be zero-emission by 2035
- ACC II is expected to rapidly scale up the number of zero-emission light-duty vehicles (ZEV) starting model year 2026

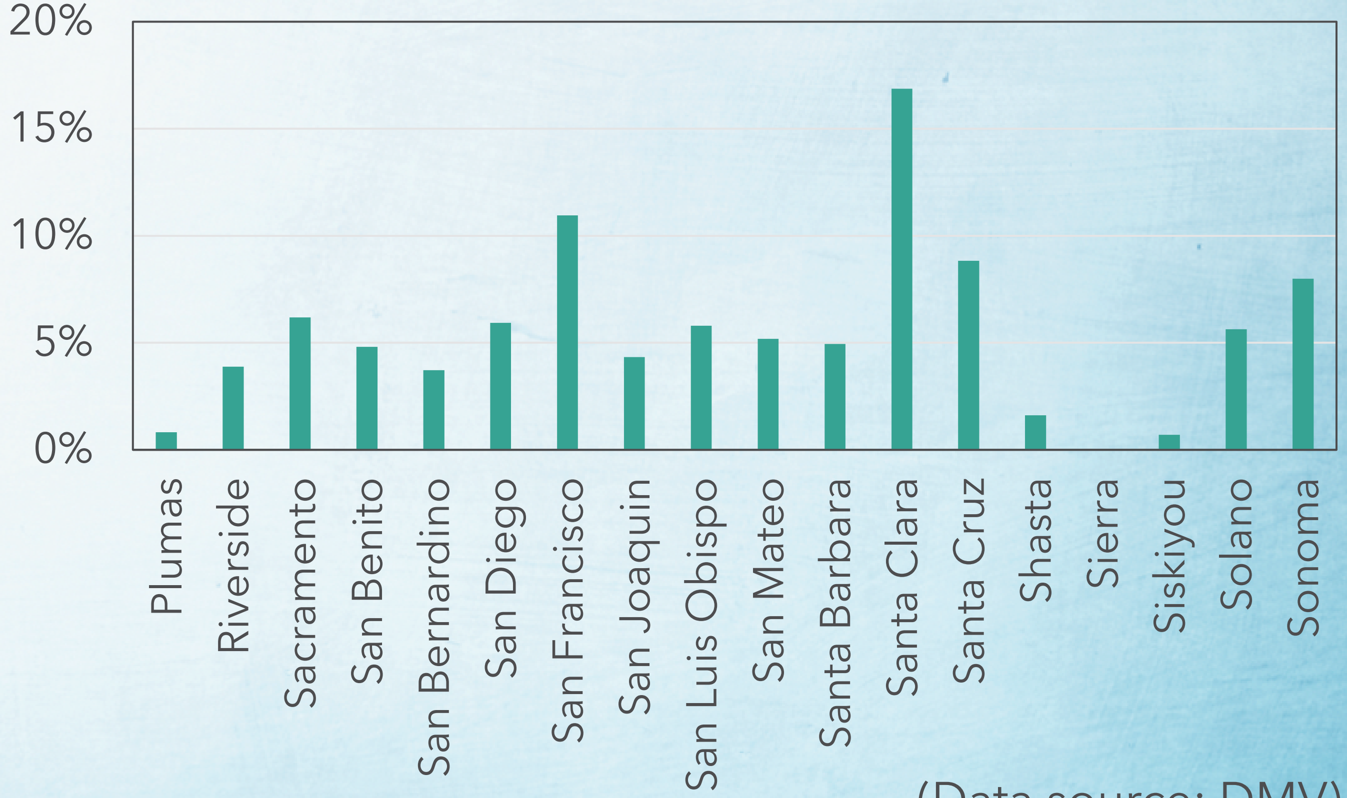
ACC II ZEV and PHEV new sales fractions vs EMFAC2021



Background: Unequal Pace of New Light-Duty ZEV Adoption at County Level

- DMV registration data indicates unequal ZEV adoption rates across regions.

ZEV new sales market share in 2019



(Data source: DMV)

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A New Light-Duty ZEV Market Share Forecasting Framework in EMFAC202Y

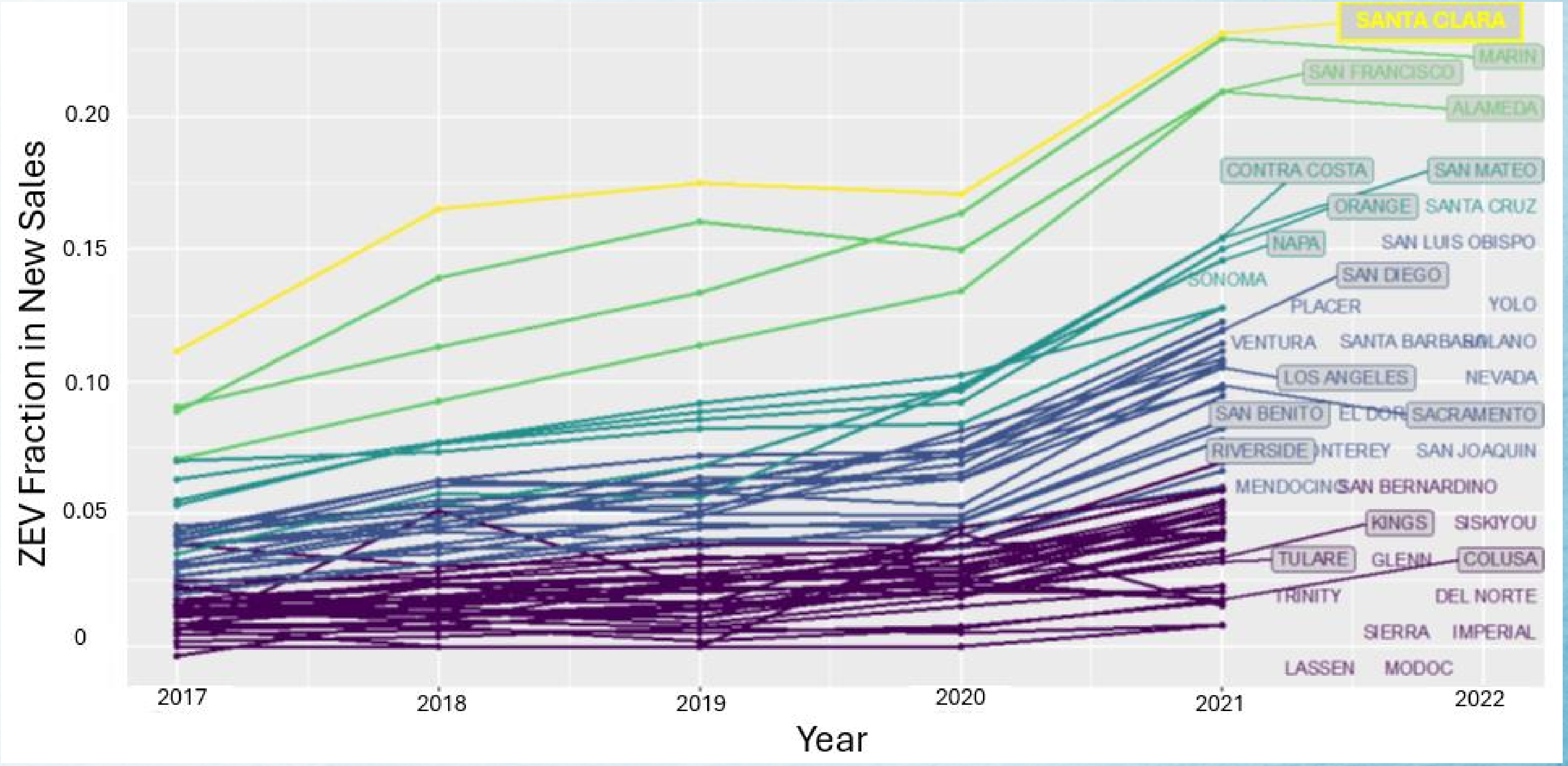
Spatially disaggregated forecasting of ZEV adoption in California

- Contract #22AQP010 with Lawrence Berkeley National Laboratory (LBNL)
- LBNL team: Ling Jin, Qianmiao (Michelle) Chen, Anna C. Spurlock, Thomas Kirchstetter

Project Goal: Forecast light-duty ZEV vehicle sales market share for EMFAC202Y

- Consider the impact of ACC II at state level
- Capture the different ZEV adoption rate in county level

ZEV Fraction in New Sales at different county in California

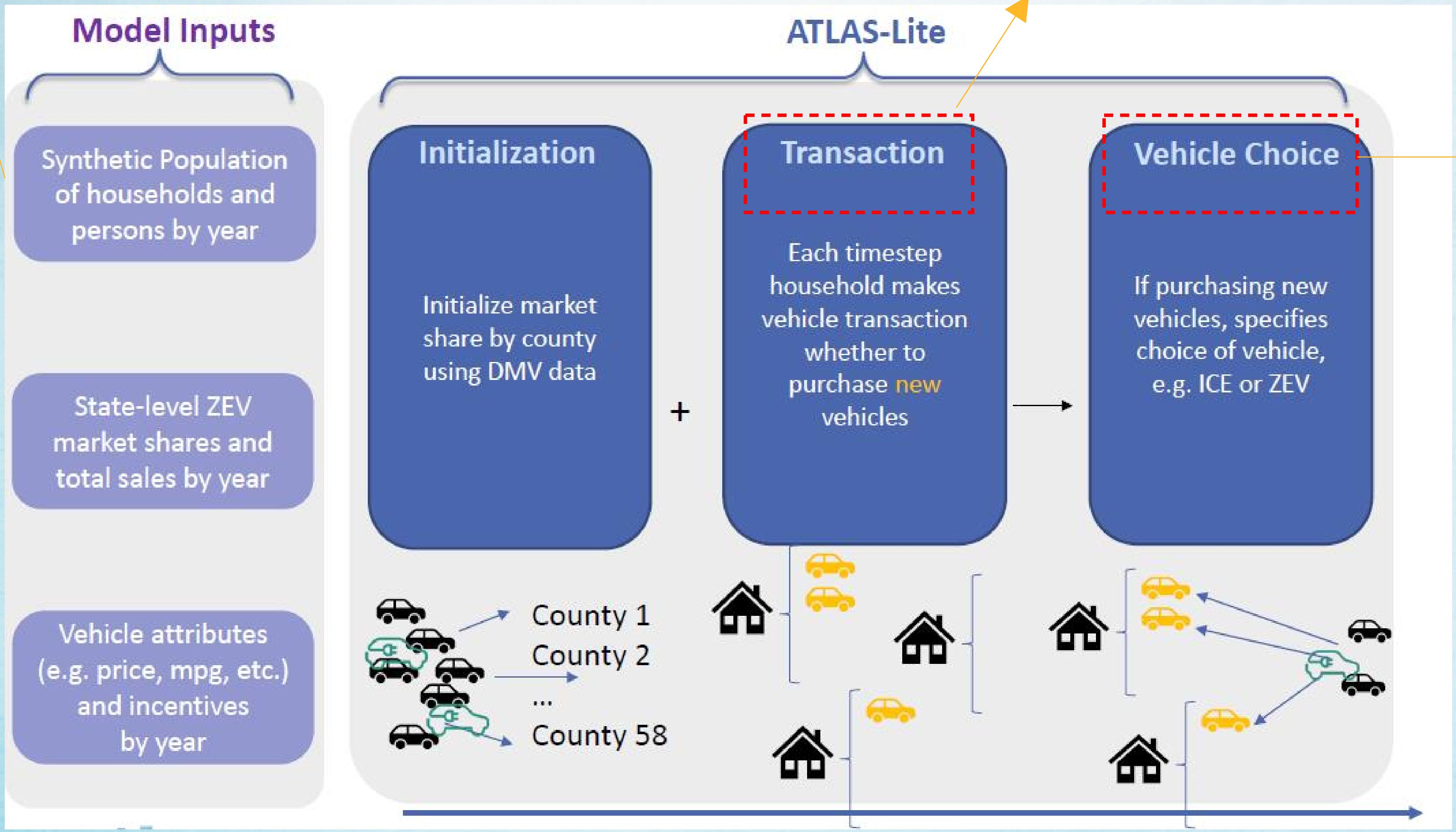


(Source: Ling Jin, final contract presentation, Aug 2024)

Model Framework

Data source:
American Community Survey (ACS)
(household size, household income etc.)

Significant predictors
- Demographic attributes (Income, household size etc.)
- Location context (Job density)

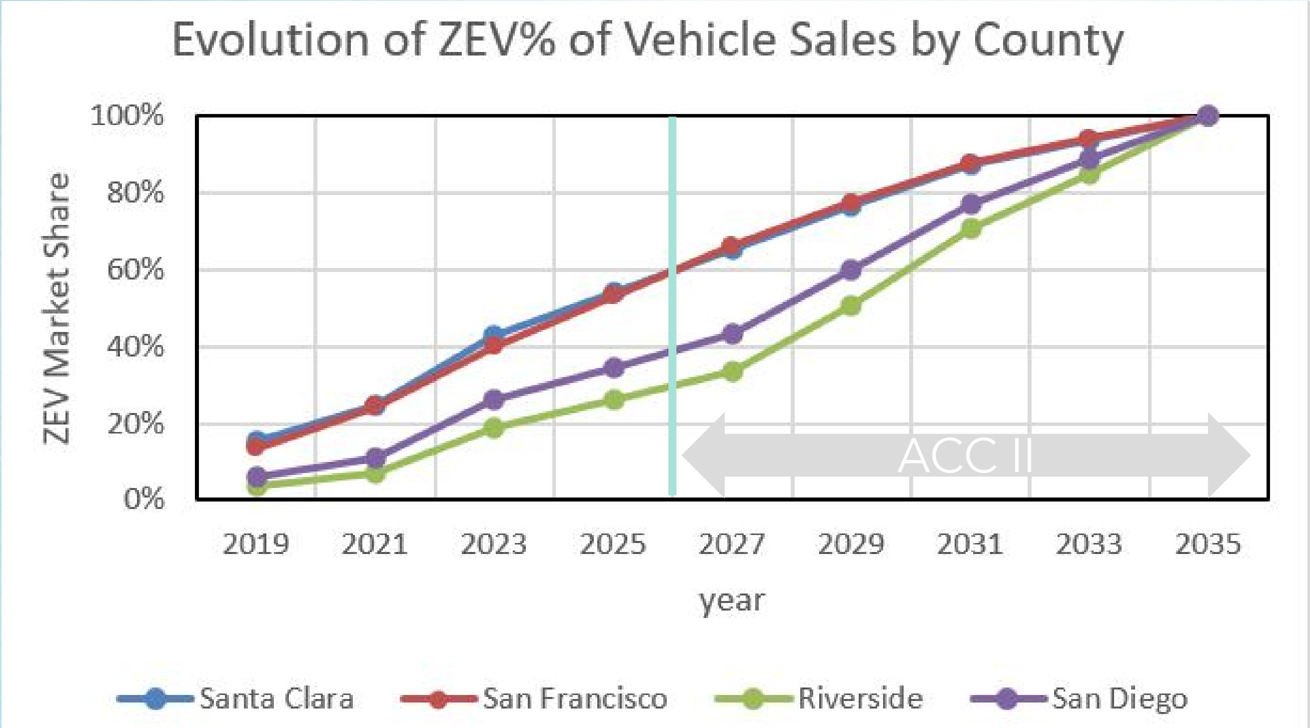


Significant predictors
- ZEV sales momentum
- Demographic attributes
- Year specific effect
- Vehicle attributes
- Political ideology

Household level ZEV penetration

County level ZEV new sales market share by calendar year

Example of Initial Model Results Based on DMV Registration in 2021



Note: Data before 2023 is sourced from the DMV; data after 2023 is from model forecast.

- ATLAS model forecasts ZEV population at county level every other year (e.g., 2023, 2025, etc.)
- Prediction for more rapid adoption in Santa Clara and San Francisco Counties; slower adoption in San Diego and Riverside Counties
- The ZEV vehicle population is updated based on this model for calendar year 2023 to 2035

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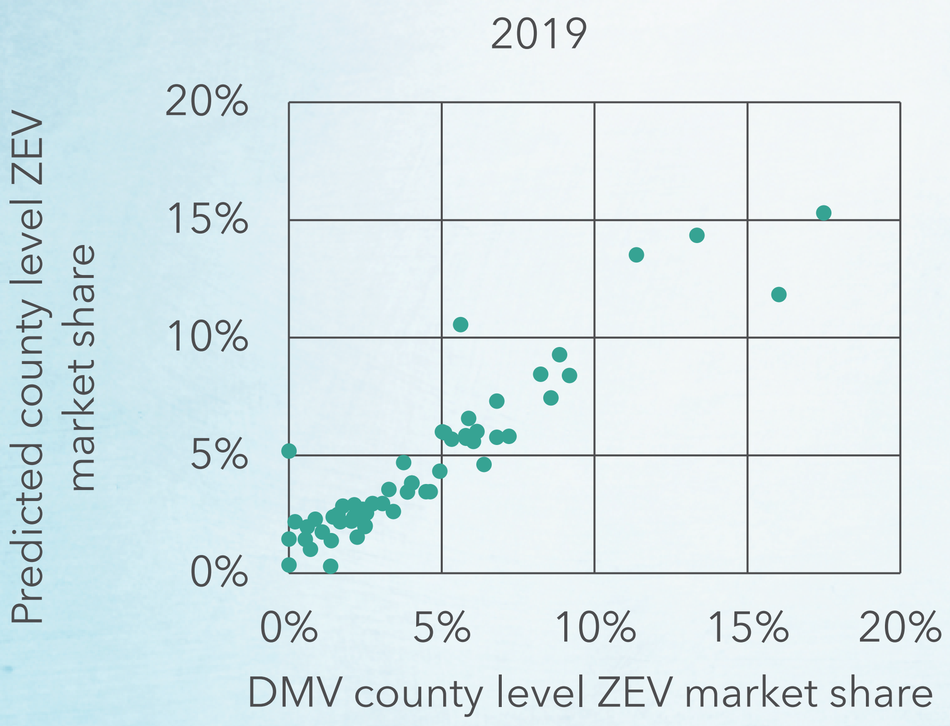
Accrual rates vs. ZEV market share

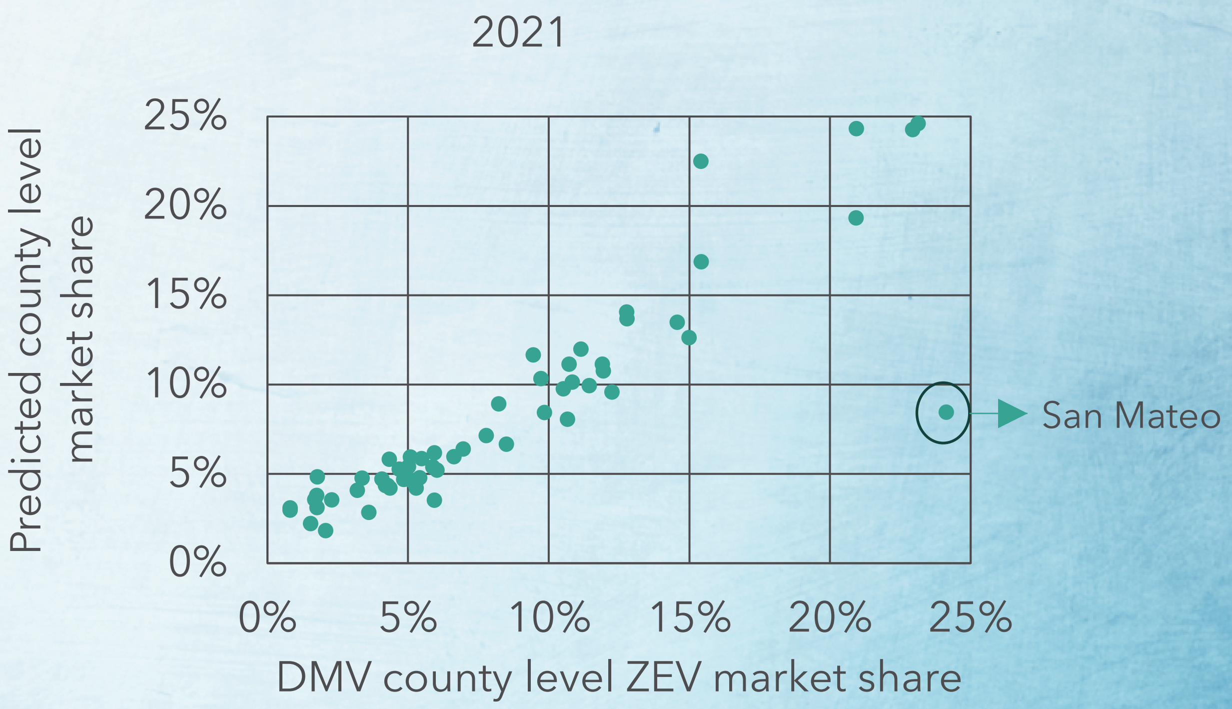
Region	Accrual rate for new cars	ZEV market share in 2023
Santa Clara	13,426	43%
San Francisco	13,426	40%
Riverside	18,029	19%
San Diego	14,968	26%

- Fleet-wide emissions would be affected both by the adoption of ZEVs and mileage accruals of vehicles in those counties
- Early penetration of ZEV take place in counties with lower accrual rates.

Model Validation

Model results are consistent with DMV fleet database for historical years





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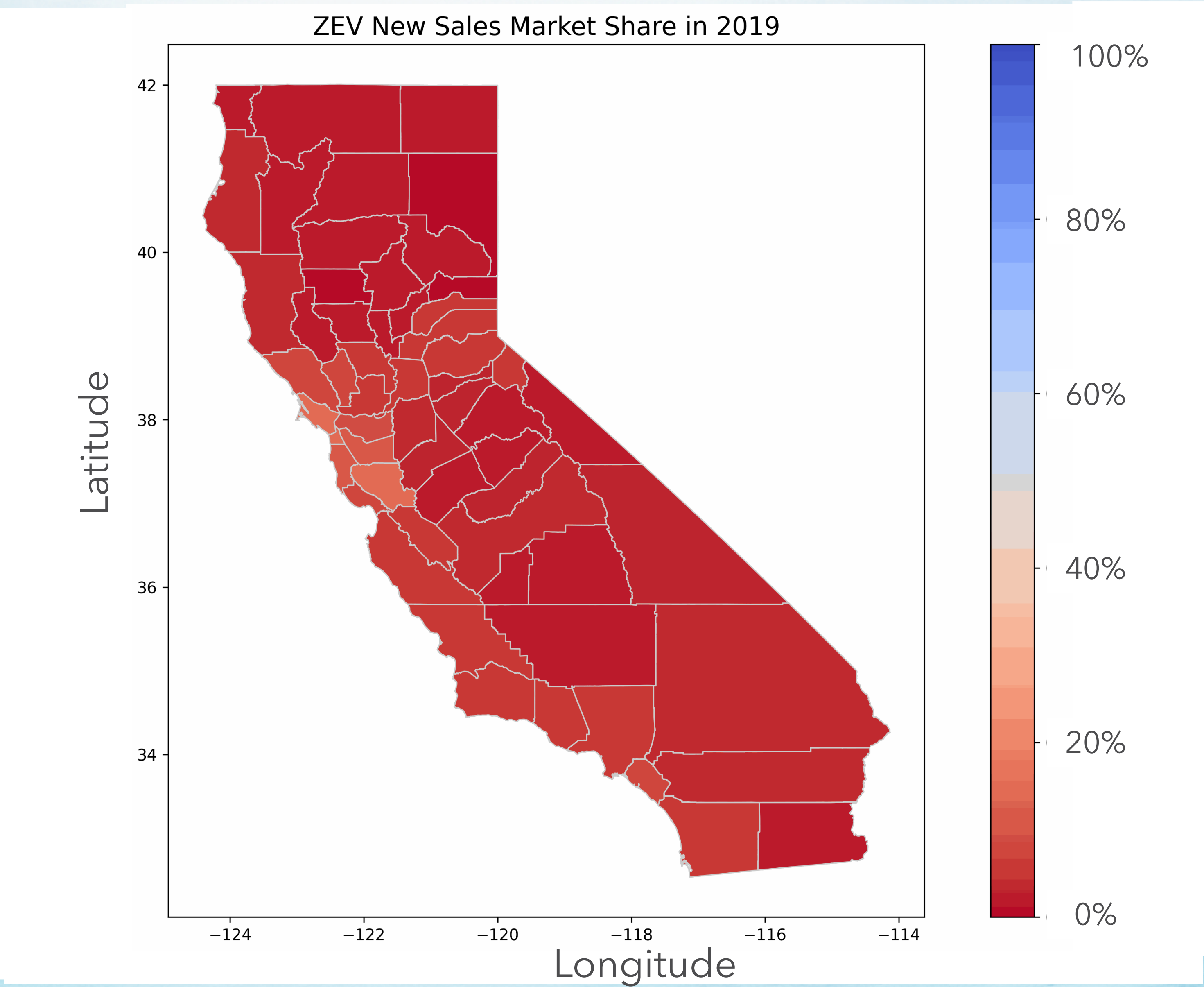
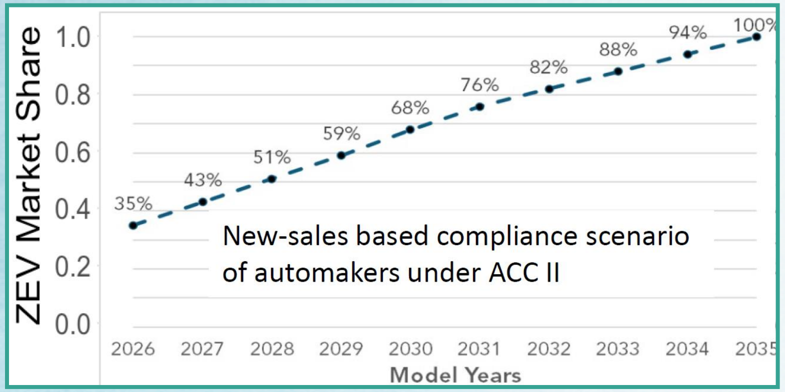
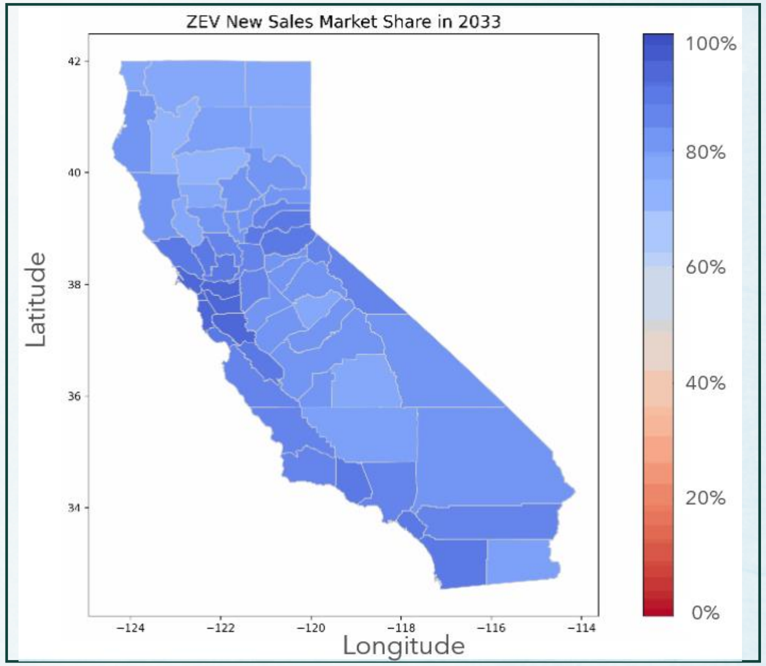
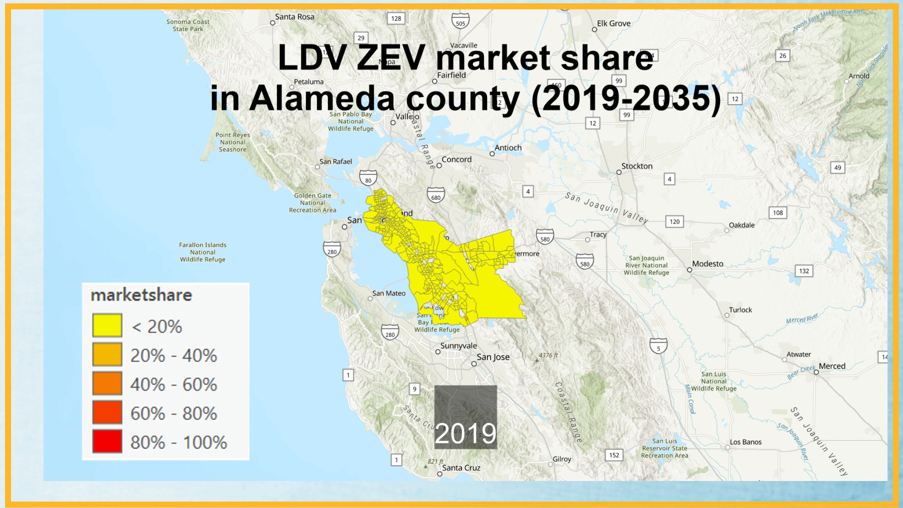
Model results – County Level ZEV New Sales Penetration



Summary







At statewide level, this update reflects ACC II regulation for LDV ZEV new sales market share

The forecasted county level LDV ZEV new sales market share is embedded in EMFAC202Y (2023-2035)

We also obtained census tract level LDV ZEV new sales market share, which can be used to better understand ZEV penetration at community level

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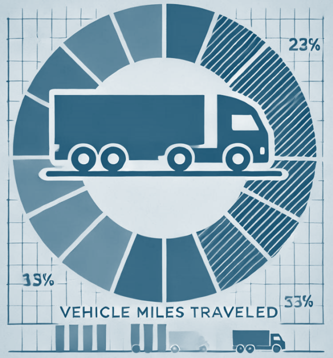
Vehicle Activity Forecasting

Reallocation of Heavy-Duty Vehicle Miles Traveled (VMT)

Background



Population Data

- HD population data is regularly updated using DMV Registration, IRP* Clearinghouse Data, IFTA** Data, etc.

*International Registration Plan (IRP) Clearinghouse Data

**International Fuel Tax Agreement (IFTA) Data

EMFAC2021 Distribution Methodology

- The current distribution of HD population for out-of-state and IRP categories is based on a Caltrans study from 1999.
- Other California categories were reallocated using Truck and Bus Origin-Destination data from 2008.
- Redistributed populations are used to calculate VMT in the base year.

Updates in EMFAC202Y

- The spatial reallocation of HD VMT is updated using most updated telematics data.

Data Sources Used for Heavy-Duty Reallocation

FHWA National Household Travel Survey

STREETLIGHT

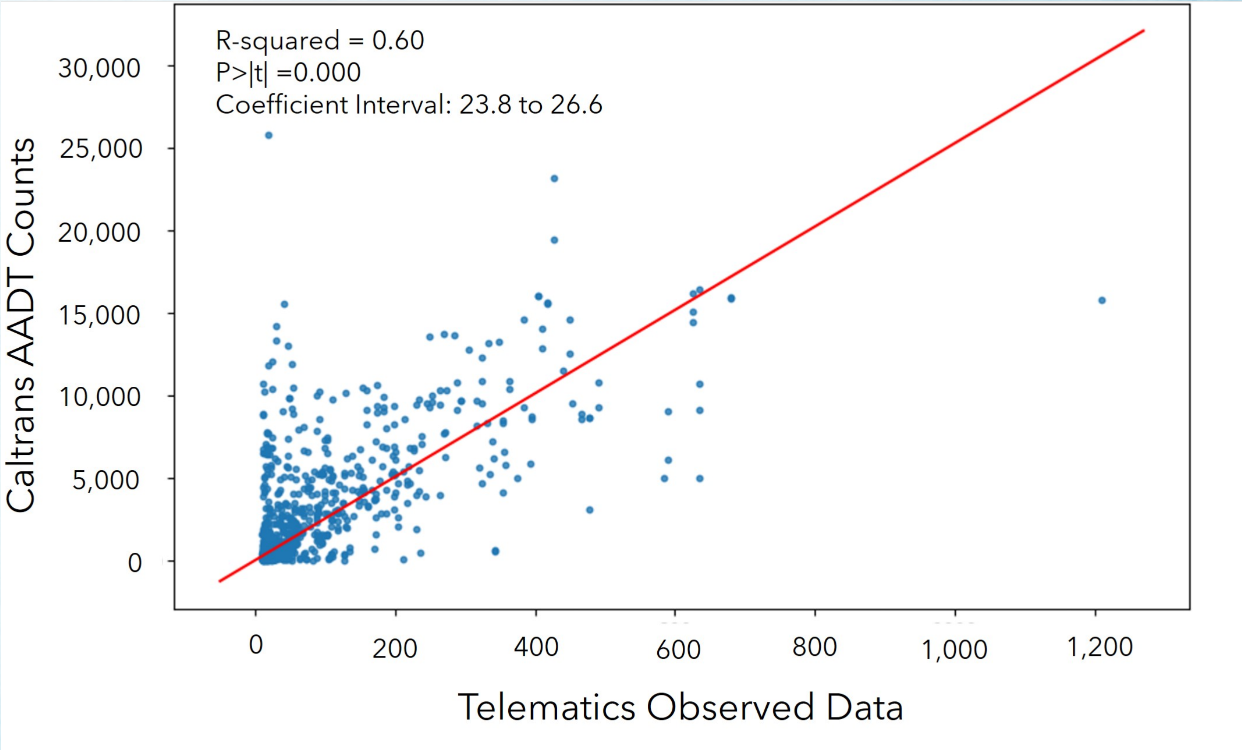
GEOTAB

- In-vehicle GPS devices
- Location sightings for freight trucks
- Real-time GPS probe data collected from commercial fleet, delivery vehicles, and taxis
- Consumer cellular floating vehicle data
- GPS-based traffic sensors
- Connected vehicles

Heavy-Duty VMT Reallocation Process

1. **Estimate HD VMT Distribution Across Geographic Area Index (GAI):**
   Use telematics data to estimate the distribution of heavy-duty vehicle miles traveled across GAIs.
2. **Develop Expansion Factors:**
   Create a set of expansion factors to adjust observed telematics data VMT by using Caltrans Annual Average Daily Traffic (AADT) data for scaling of VMT across GAIs.
3. **Reallocate VMT for Relevant Truck Categories:**
   Apply reallocation to specific truck categories, including:
   - **In-State Trucks**: Port trucks and tractors.
   - **Interstate Trucks**: International and out-of-state trucks.

Developing Expansion Factors by making a regression model between telematics data and Caltrans AADT observed data



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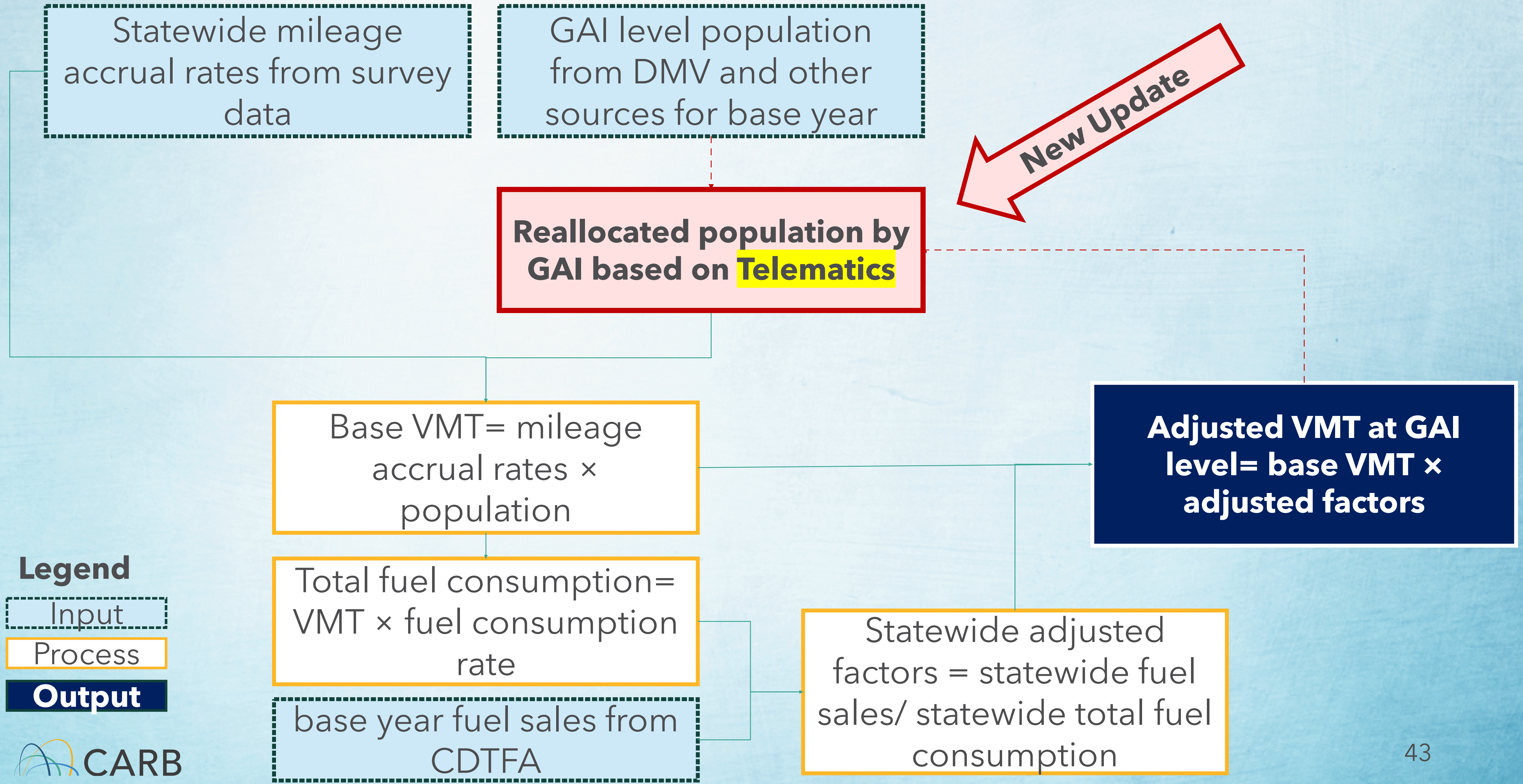
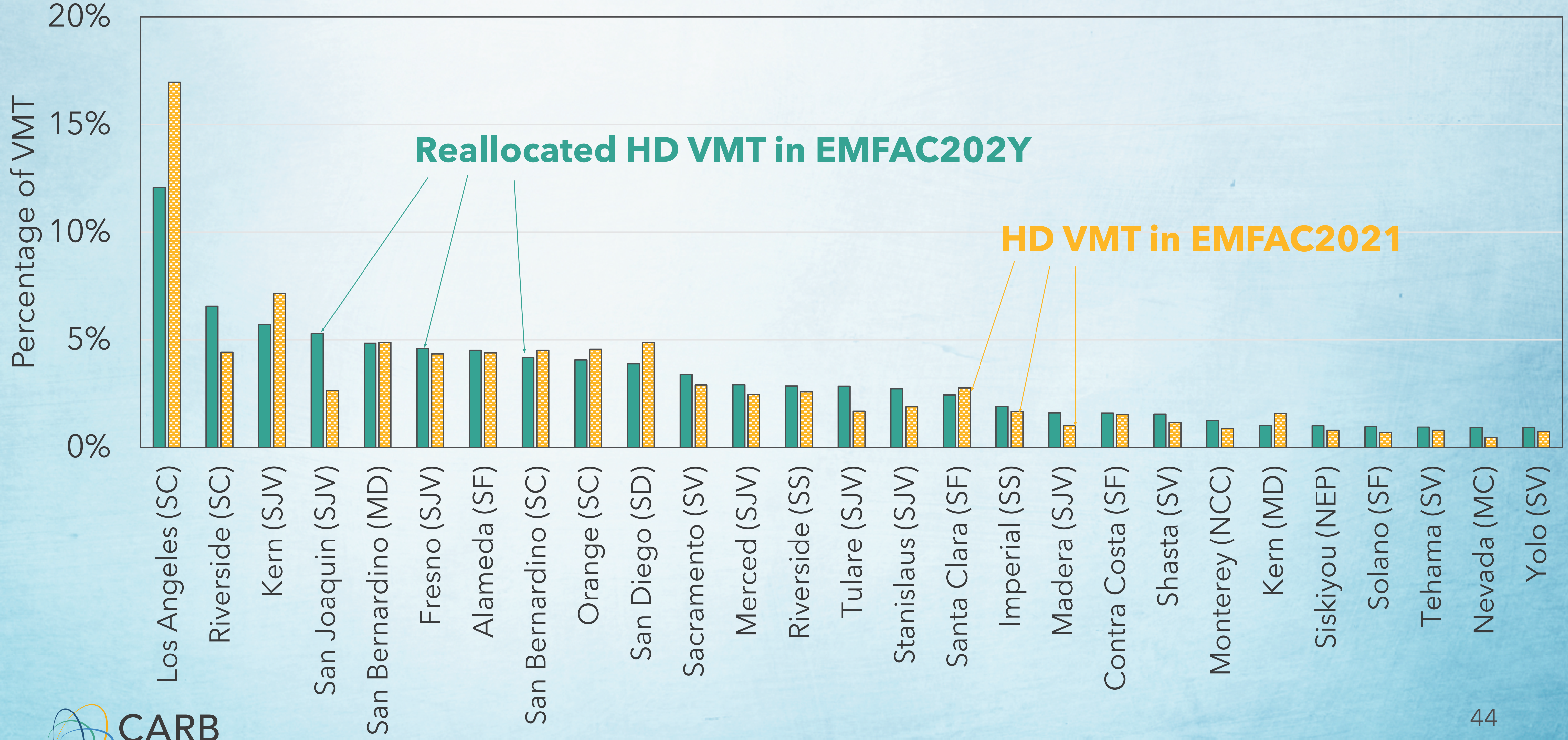
Updating Heavy-Duty VMT Allocation Methodology



Preliminary Results: HD VMT in EMFAC202Y



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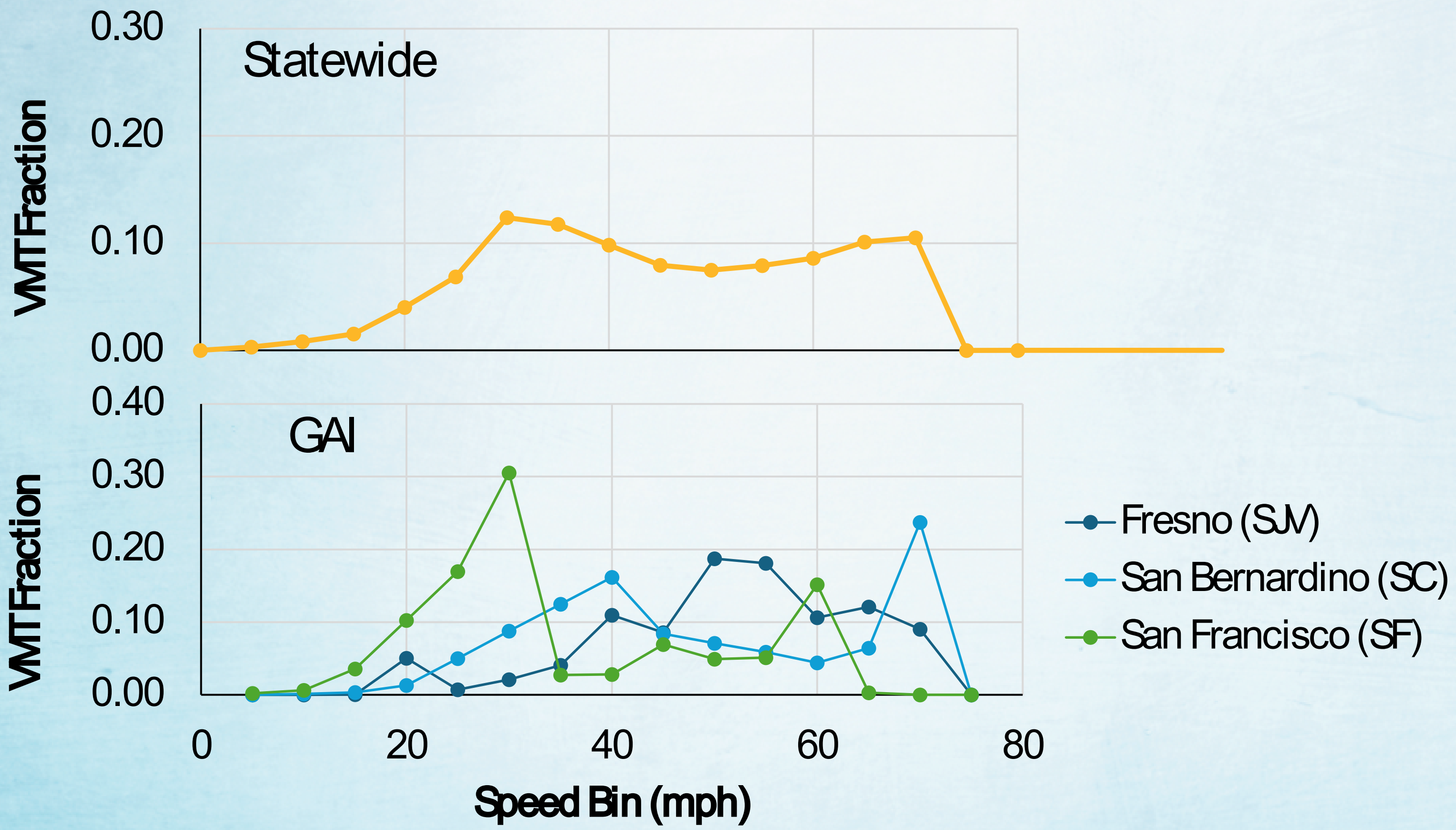
Vehicle Activity Forecasting

Light-Duty Vehicle Miles Traveled Speed Distribution

EMFAC2021 Default VMT Distributions



- All GAIs have VMT speed distributions based MPO data
- Limitations with current combustion VMT (cVMT) distribution:
  - May overestimate fraction at lower speeds
  - Cuts off after 70 mph

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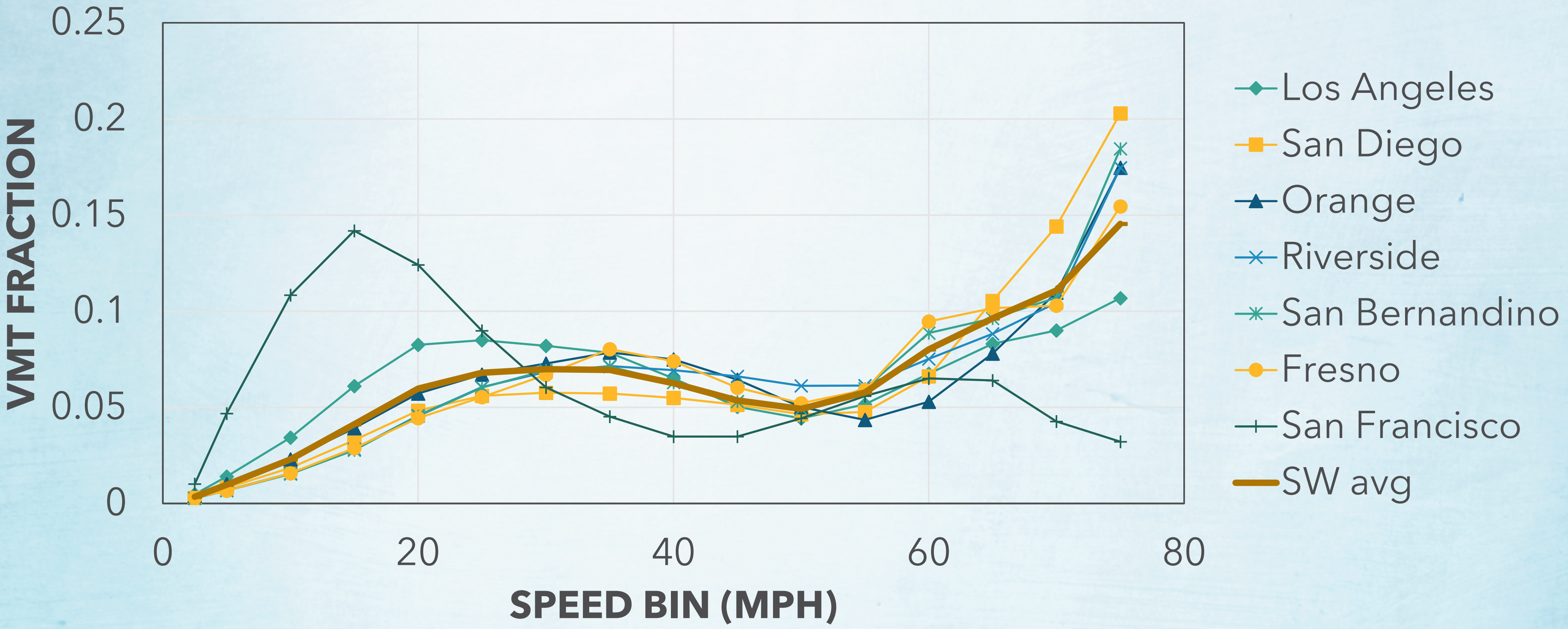
New Data Sources Used for Light-Duty VMT Distribution

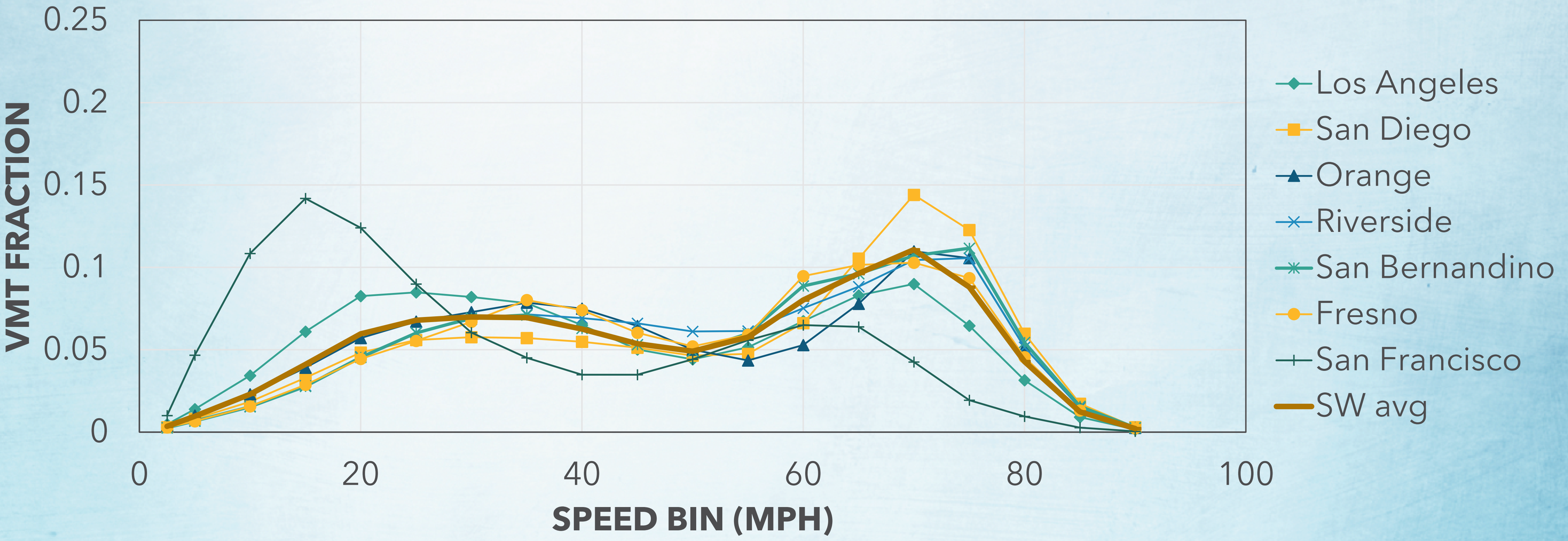
- National Emissions Inventory (NEI) Streetlight Dataset
  - A nationwide dataset of 13 billion trips, recorded by 20 million devices
  - Based on 1 year of data from CY 2020
  - Top speed bin is 75 mph
- UC Davis Datalogging study (CARB Contract 12-319)
  - 200+ ICE vehicles, data-logged for 1 year
  - Recorded from CY 2015-2020
  - Top speed bin is not limited

Light-Duty NEI Speed Distributions



- County level distribution examples, and statewide average

Adding High-Speed Tail



- 75 mph speed bin is distributed out to 90 mph, based on cVMT distribution from UC Davis data set (CARB Contract 12-319)

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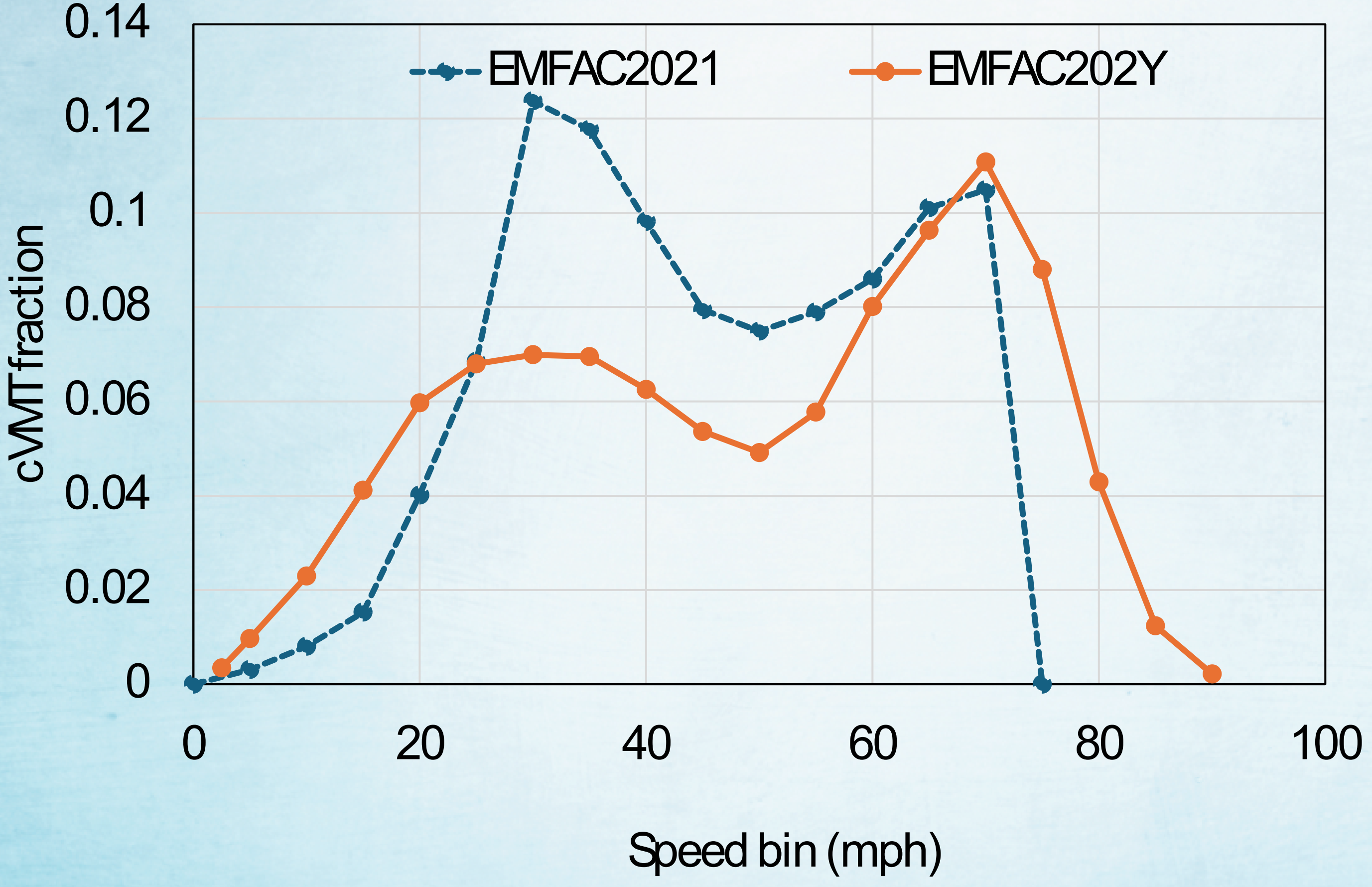
Light-Duty Speed Distributions: EMFAC2021 vs. EMFAC202Y



- This is the new VMT speed distribution that will be used in the EMFAC202Y Default mode.
- Scenario Generation (SG) mode, used by the MPOs, will still have the option to use custom VMT distribution.

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Question and Answer (1)

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

Break – 10 Minutes

Please Return by 10:10 AM.

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1. **EMFAC Overview**
2. **Vehicle Activity Updates**
   - Light-Duty New Vehicle Sales Forecasting
   - Light-Duty Zero-Emission Vehicle New Sales Forecasting
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   - Light-Duty Vehicle Miles Traveled Speed Distribution
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   - Speed Correction Factor (SCF) and Emission Rates Comparison (g/h vs. g/mi)
   - Light-Duty CO_2 Emission Rates
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   - Heavy-Duty Natural Gas Methane Emission Rates
   - Heavy-Duty Natural Gas NO_X Emission Rates
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   - Fuel Cell Electric Vehicle Hydrogen Consumption Rates
6. **Next Steps**
7. **Question and Answer (2)**

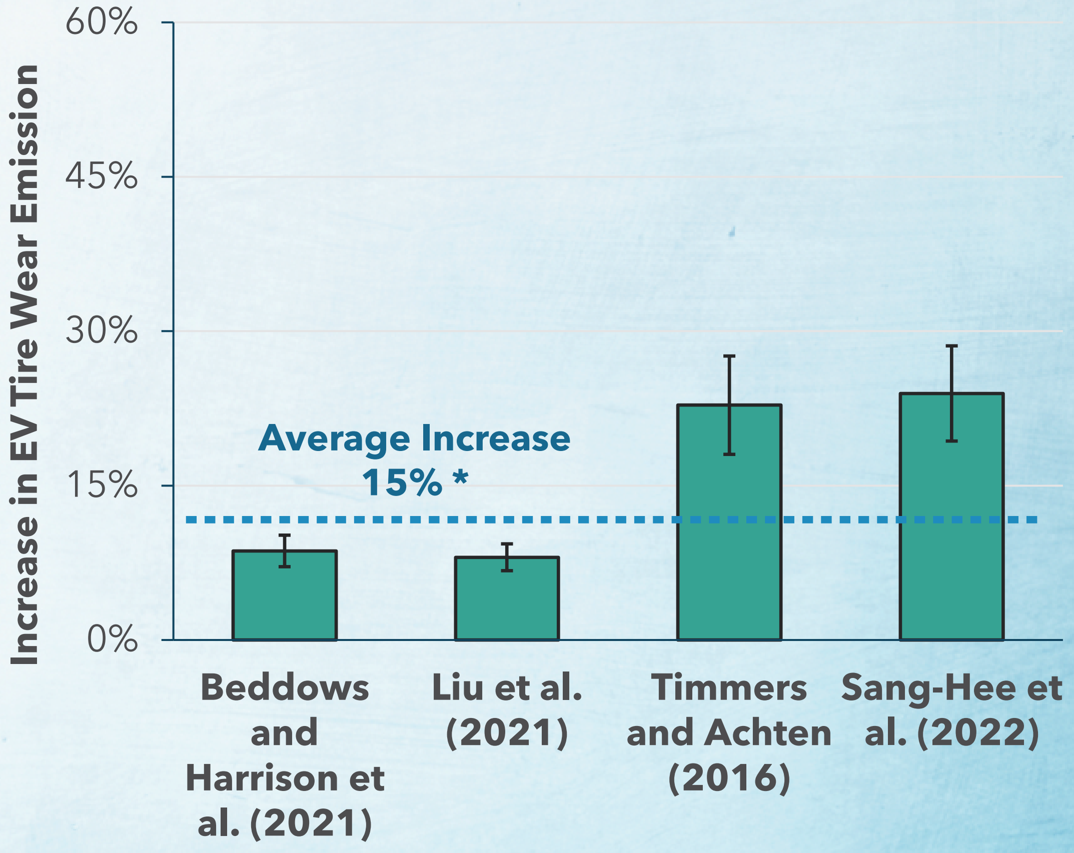
CARB

Emission Rates Updates

Light-Duty Tire Wear Emissions

Light-Duty Tire Wear Emissions

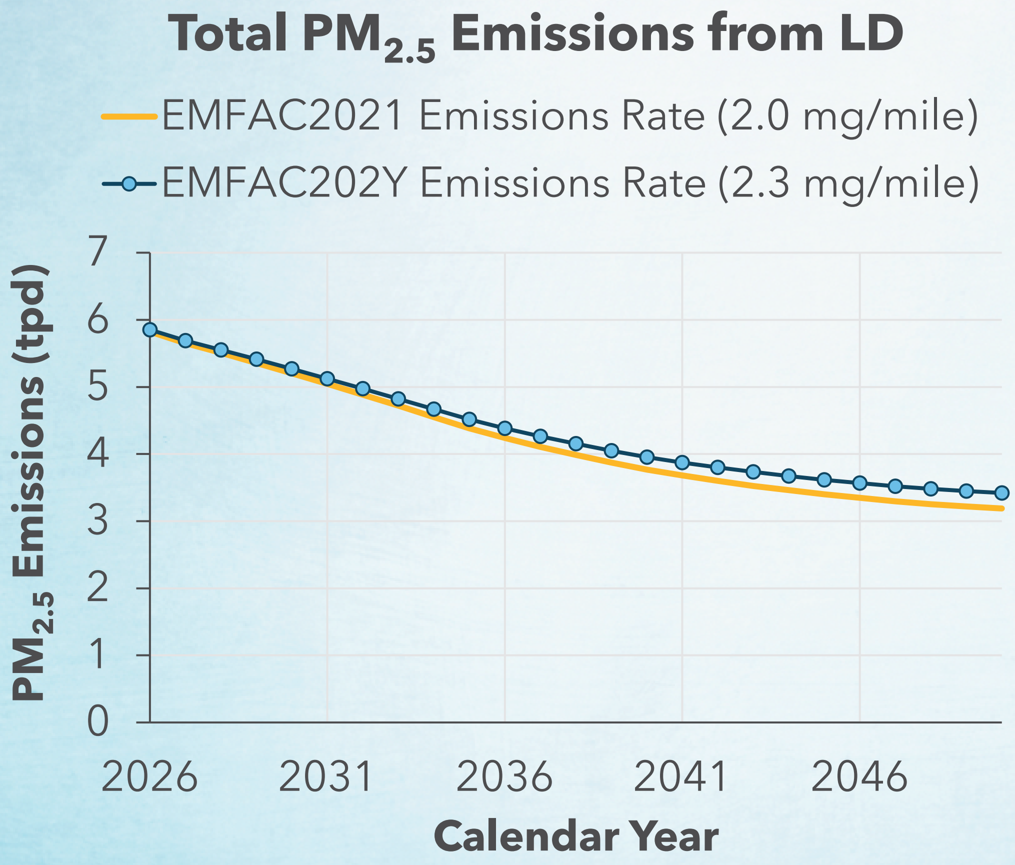
- The electric light-duty vehicle emit higher PM compared to the combustion counterparts, due to their greater weight.
- On average, tire wear emissions are 15% higher in electric vehicles compared to their combustion counterparts, based on 40 sets of tests on 11 different vehicles.
- LD tire wear generated by zero-emission fleet in EMFAC202Y were adjusted from 8 to 9.2 mg/mile for PM_{10} and 2 to 2.3 mg/mile for $PM_{2.5}$ (increased by 15%).

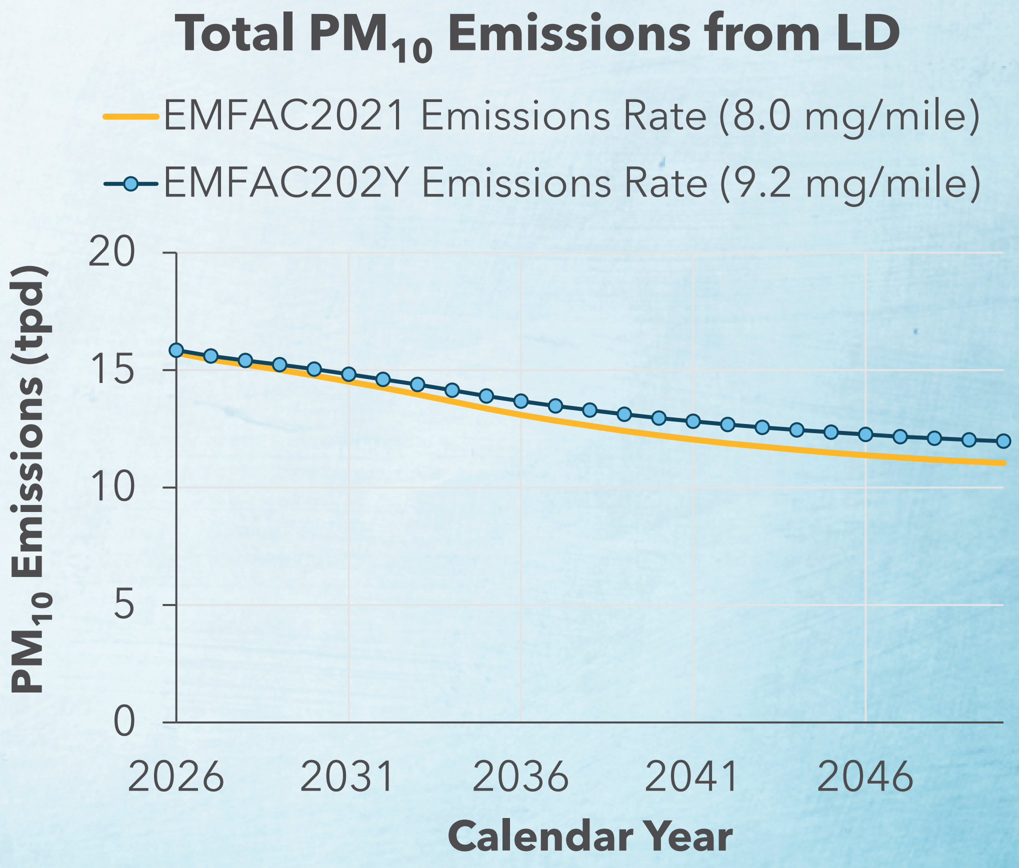


* Sang-Hee et al. directly measured the tire wear emissions from an EV, while other studies estimated emissions based on the weight difference between ICE vehicles and EVs.

CARB

Impact of Update on PM Emissions





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Emission Rates Updates

Light-Duty Base Emission Rates (BER)

Background and Motivation

- Light-Duty Base Emissions Rates (BER) are updated using data from In-Use Verification Program (IUVP) and CARB Vehicle Surveillance Program (VSP) program.

- Ratio of Standards (ROS) are used to estimate emission rates for future technologies and certification levels (e.g., LEV III certification levels such as ULEV50, ULEV70, and SULEV20).

Updates in EMFAC202Y (Methodology & Number of vehicles)

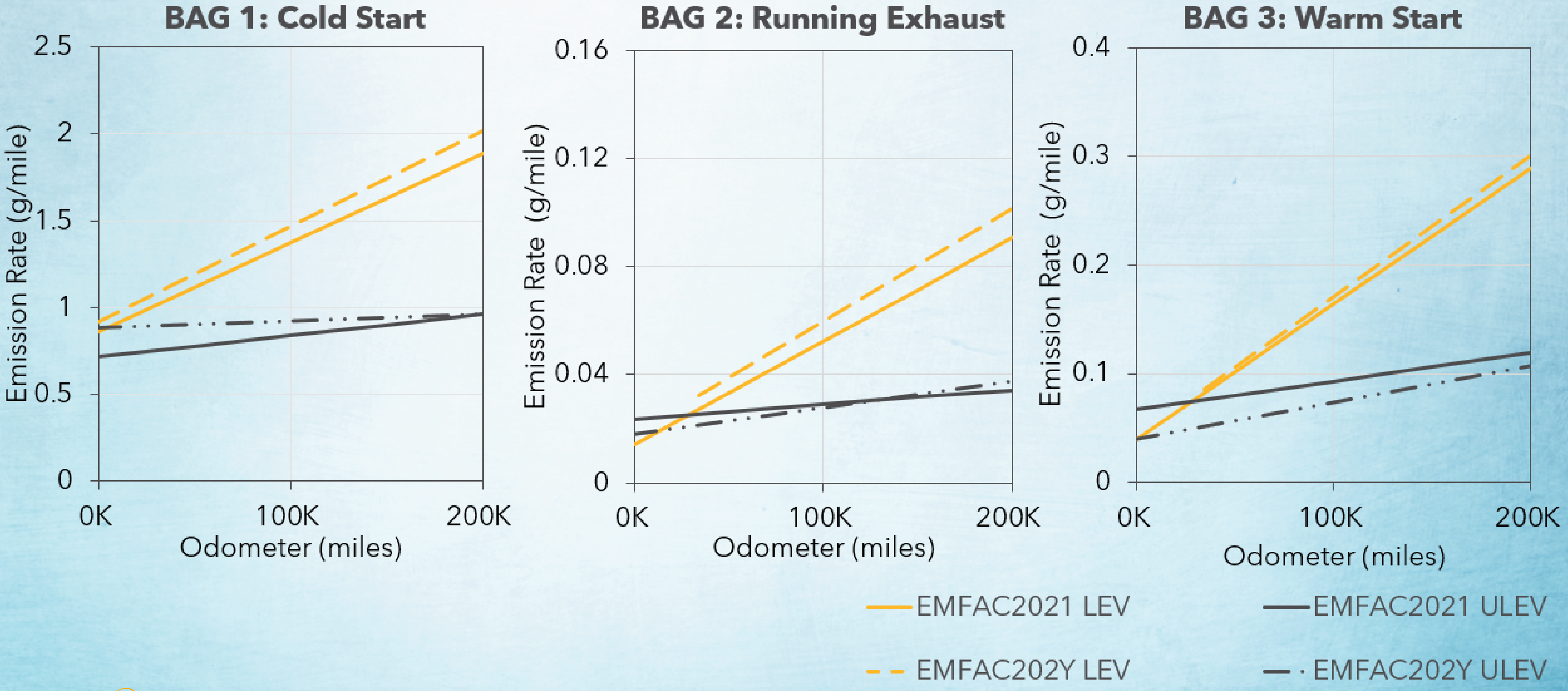
Tech Group		EMFAC2021	EMFAC202Y
LEV I	LEV	N = 237	N = 290
	ULEV	N = 72	N = 87
LEV II	LEV160	N = 33	N = 37
	ULEV125	N = 78	N = 78
	SULEV30	N = 49	N = 76
LEV III	LEV160	Same as LEV II LEV160	Same as LEV II LEV160
	ULEV125	Same as LEV II ULEV125	Same as LEV II ULEV125
	ULEV70	ROS	ROS
	ULEV50	ROS	ROS
	SULEV30	Same as LEV II SULEV30	Same as LEV II SULEV30
	SULEV20	ROS	ROS

Ratio of Standards (ROS) in EMFAC202Y

- CARB staff used ROS approach for three LEV III groups: SULEV20, ULEV50, and ULEV70 because insufficient data were available
- Approach models emissions collected for each phase of the Unified Cycle (UC) to reduce by the proportion of the standards

New Tech Group (No Data)	Base (Data Available)	ROS
LEV III ULEV70	LEV III ULEV125	70/125 = **0.56**
LEV III ULEV50	LEV III ULEV125	50/125 = **0.40**
LEV III SULEV20	LEV III SULEV30	20/30 = **0.67**

HC – LEV I



BAG 1: Cold Start
BAG 2: Running Exhaust
BAG 3: Warm Start
Emission Rate (g/mile)
Odometer (miles)
0K
100K
200K
2.5
2
1.5
1
0.5
0
0.16
0.12
0.08
0.04
0.4
0.3
0.2
0.1
EMFAC2021 LEV
EMFAC2021 ULEV
EMFAC202Y LEV
EMFAC202Y ULEV

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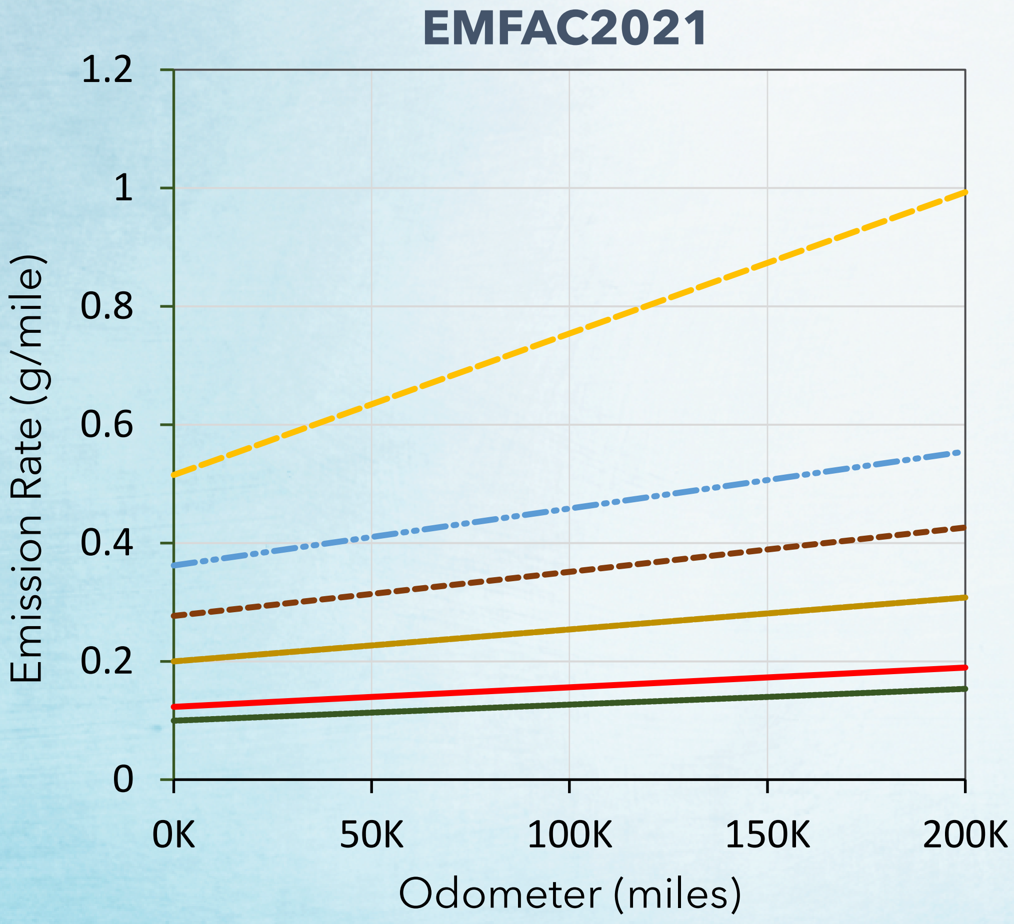
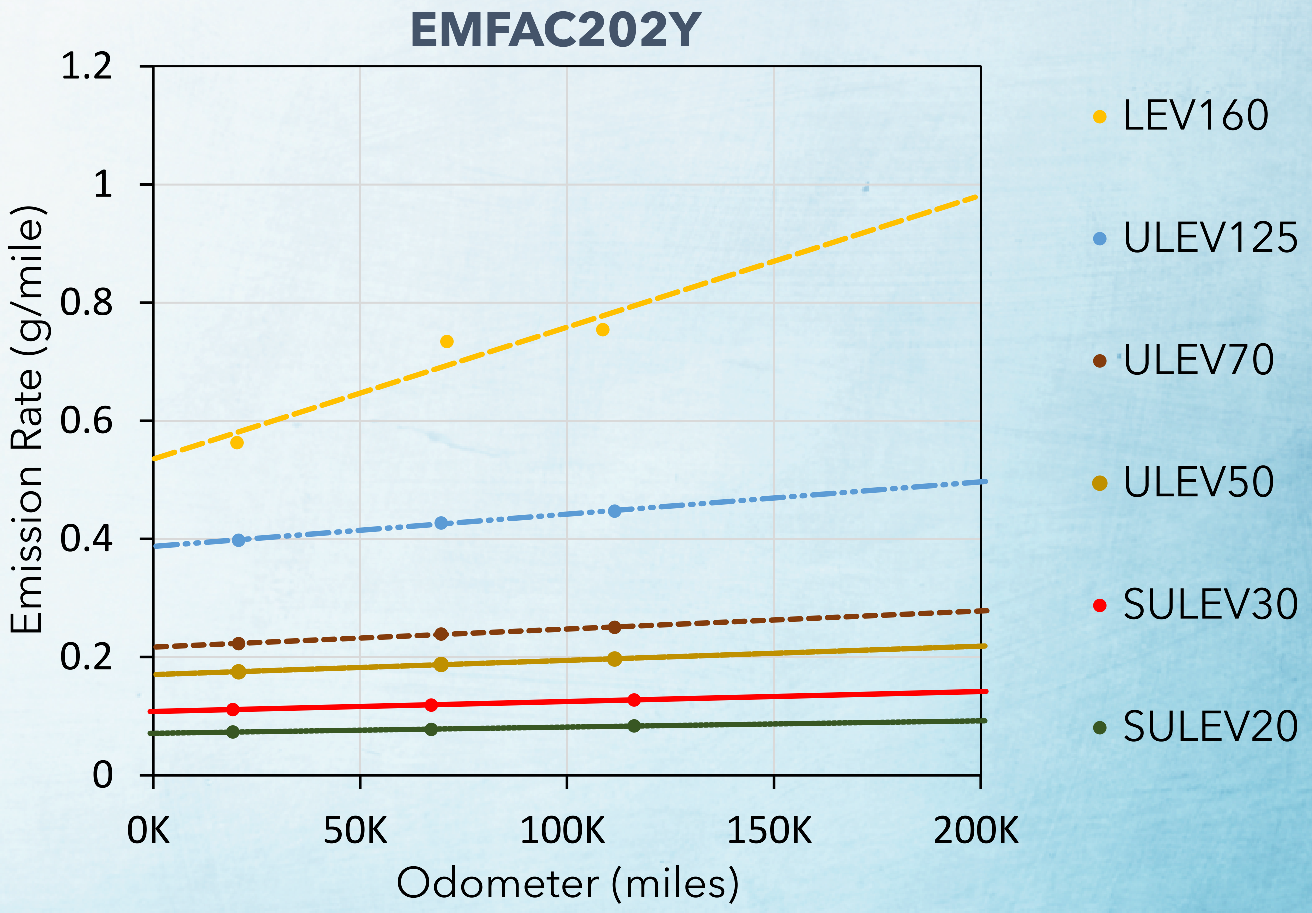
HC UC Bag 1: Base Emission Rate Cold Start





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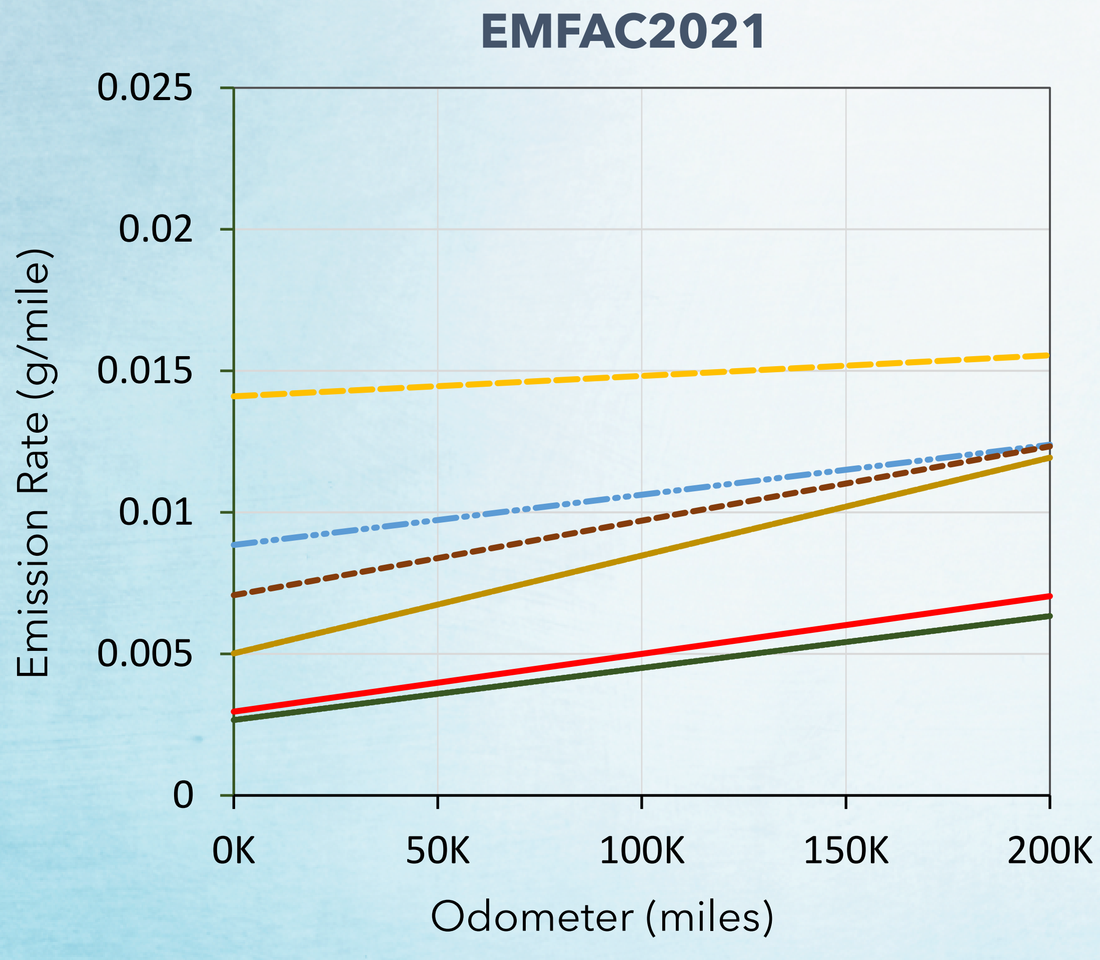
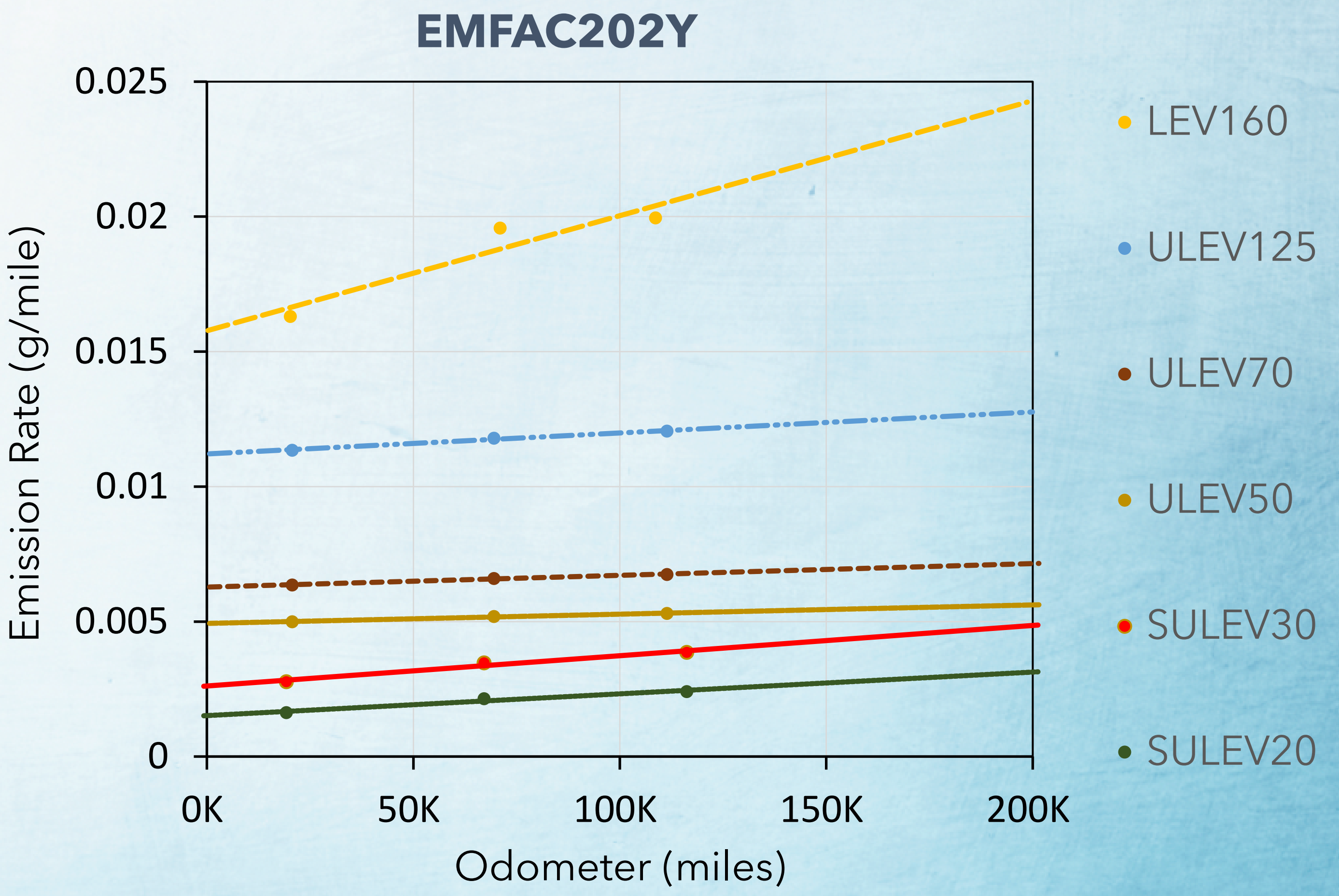
HC UC Bag 2: Base Emission Rate Running Exhaust





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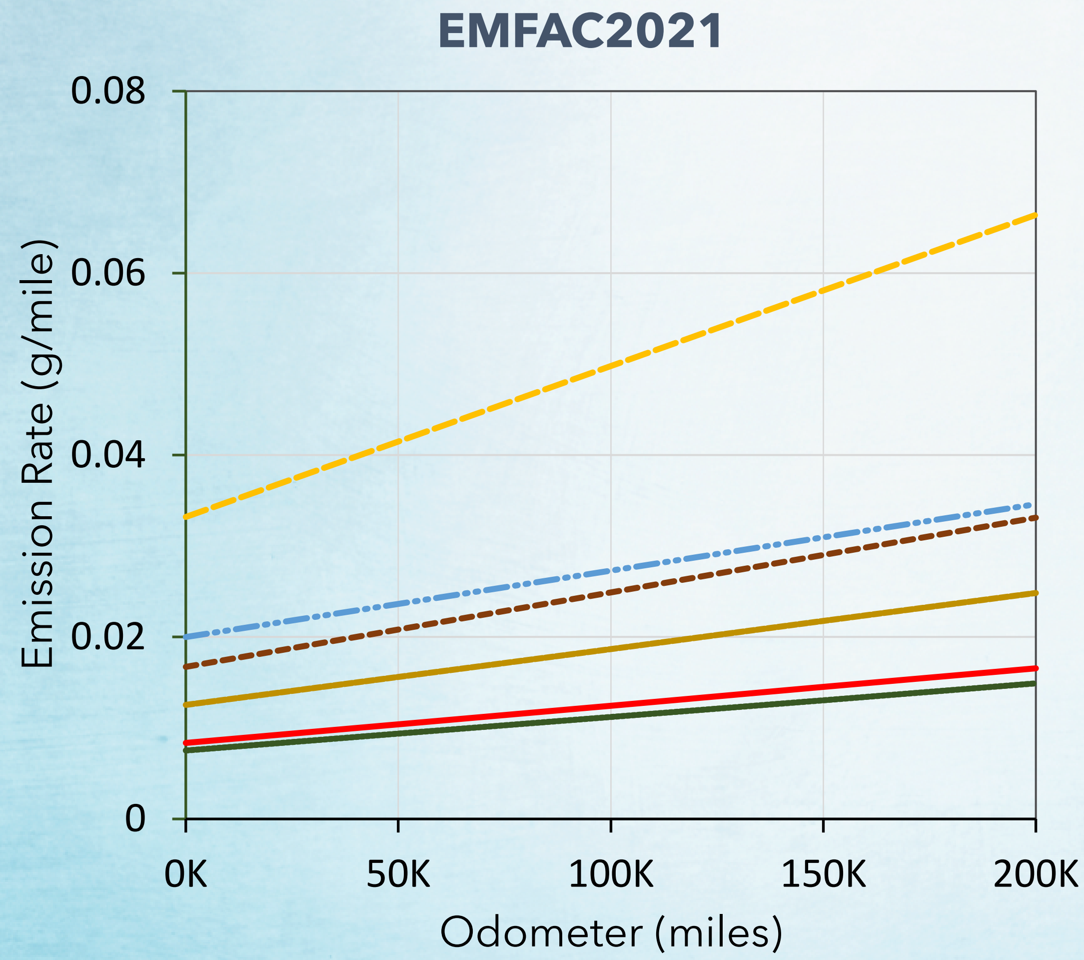
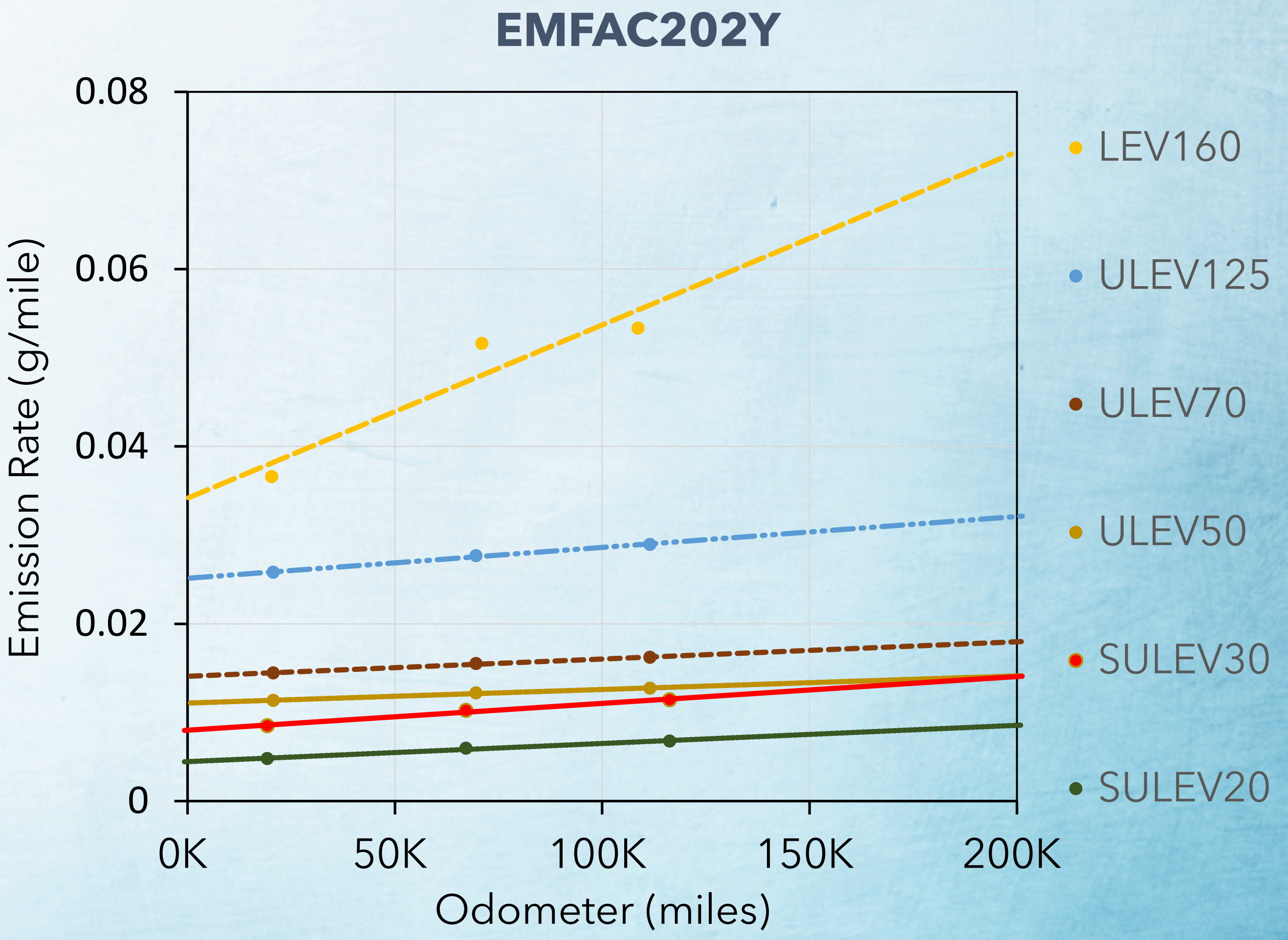
HC UC Bag 3: Base Emission Rate Warm Start





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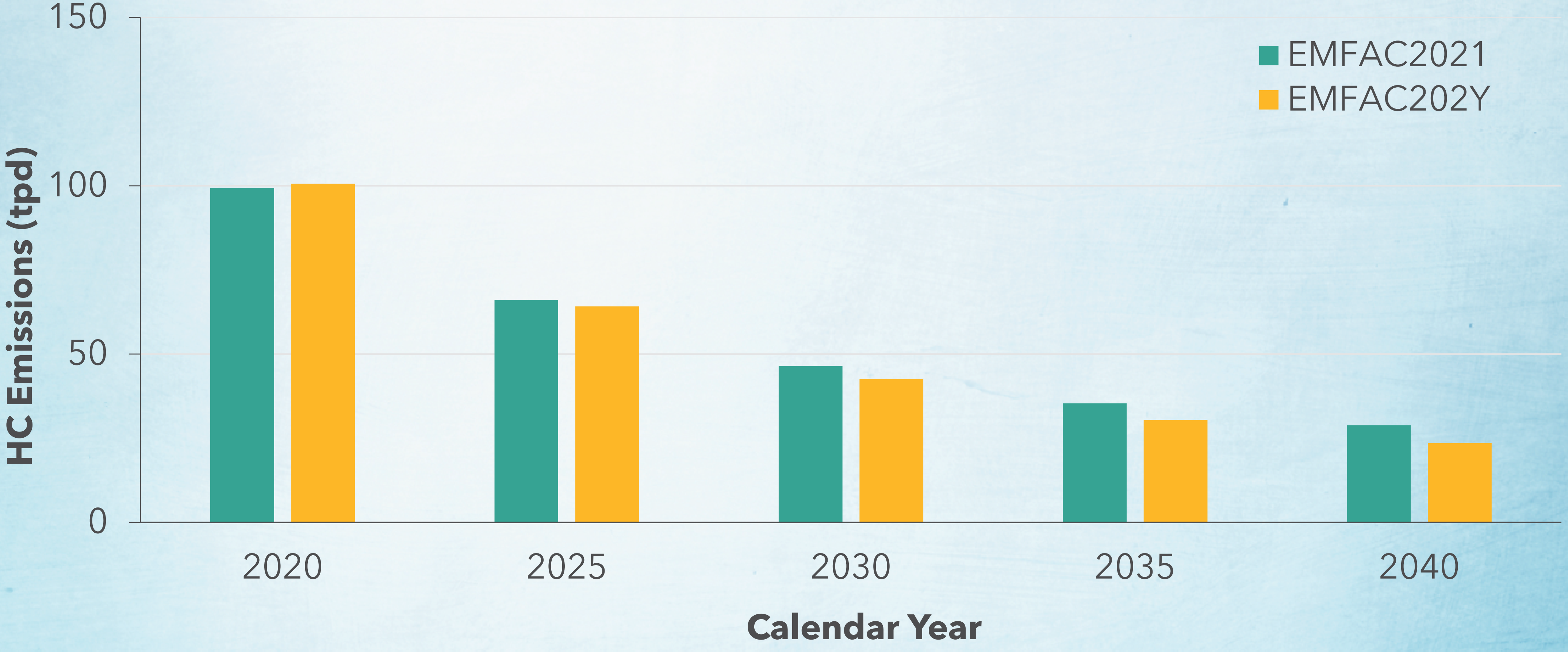
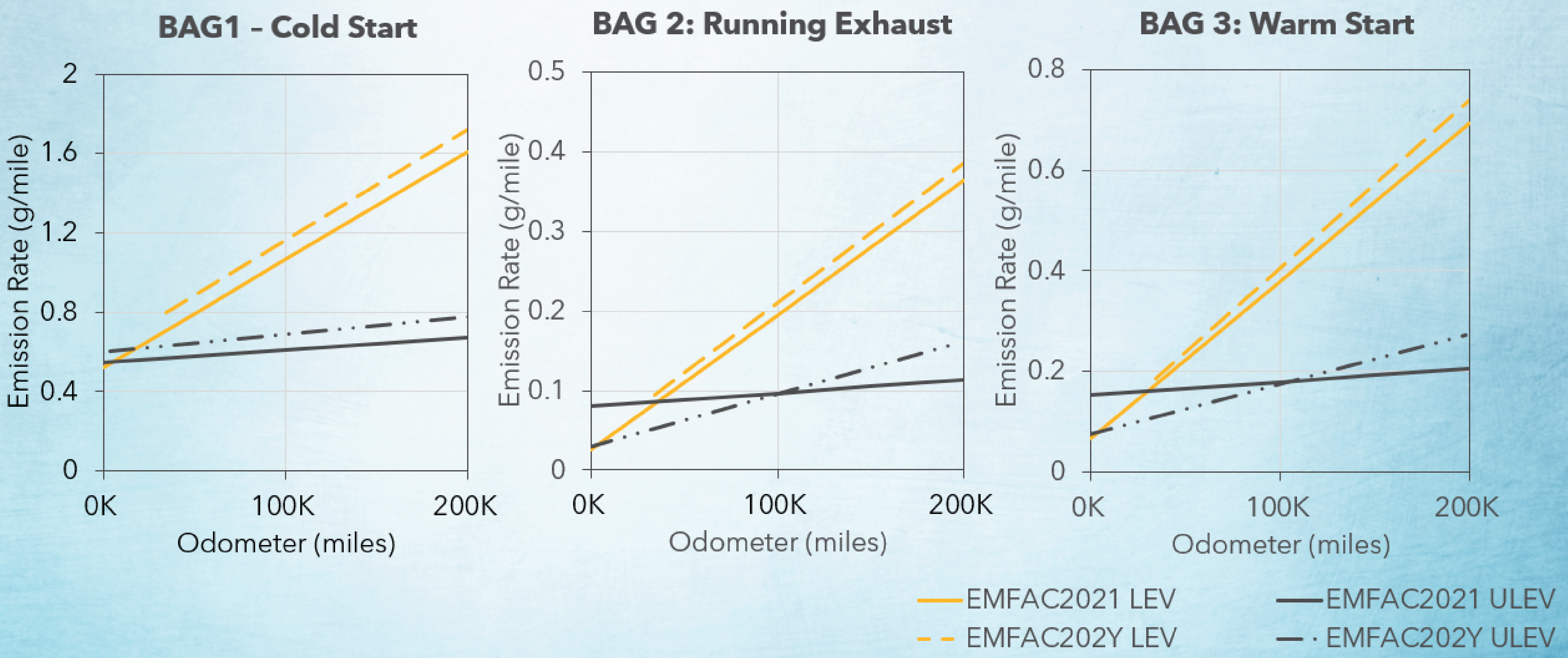
Isolated Impact of Base Emissions Rates on Light-Duty Exhaust Emissions (HC)



About 3% less emissions in 2025 and 8.5% less emissions in 2030

CARB

NOx – LEV I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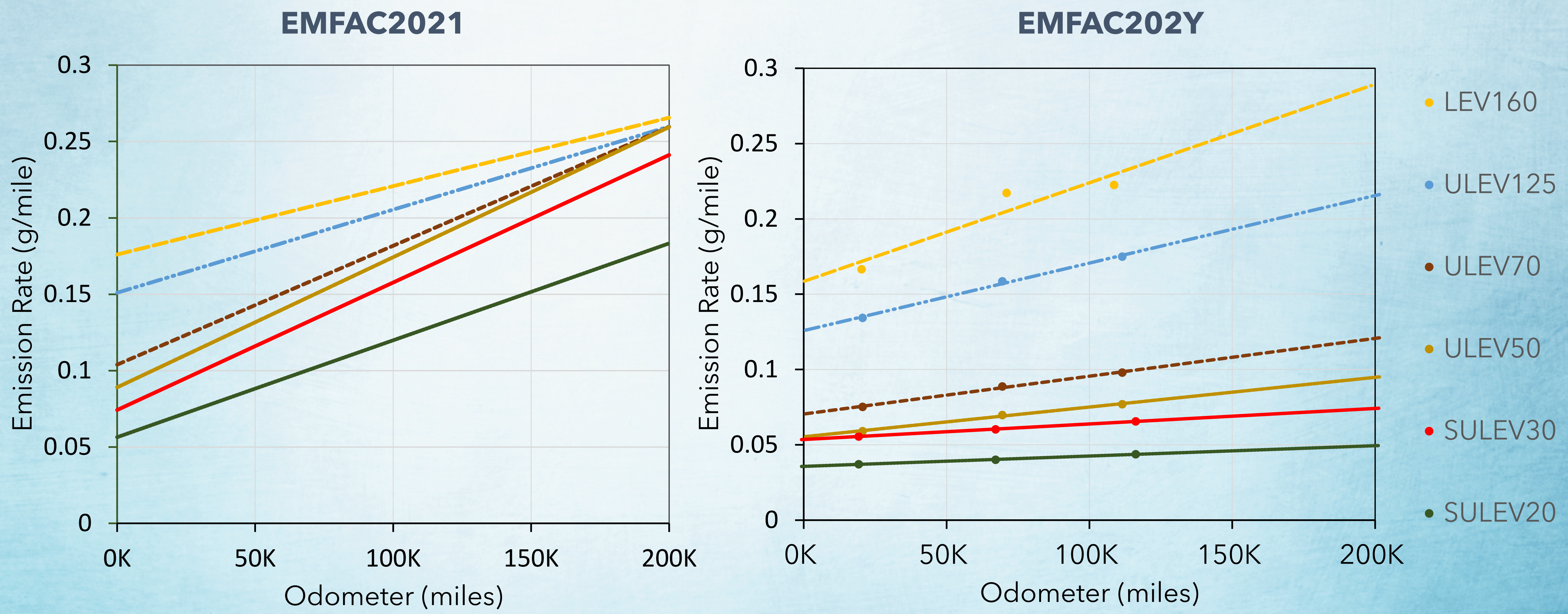
BAG 3: Warm Start
Emission Rate (g/mile)
Odometer (miles)
0
0.4
0.8
1.2
1.6
2
0.1
0.2
0.3
0.4
0.5
0.6
0.8
0K
100K
200K
EMFAC2021 LEV
EMFAC202Y LEV
EMFAC2021 ULEV
EMFAC202Y ULEV

NOx UC Bag 1: Base Emission Rate Cold Start



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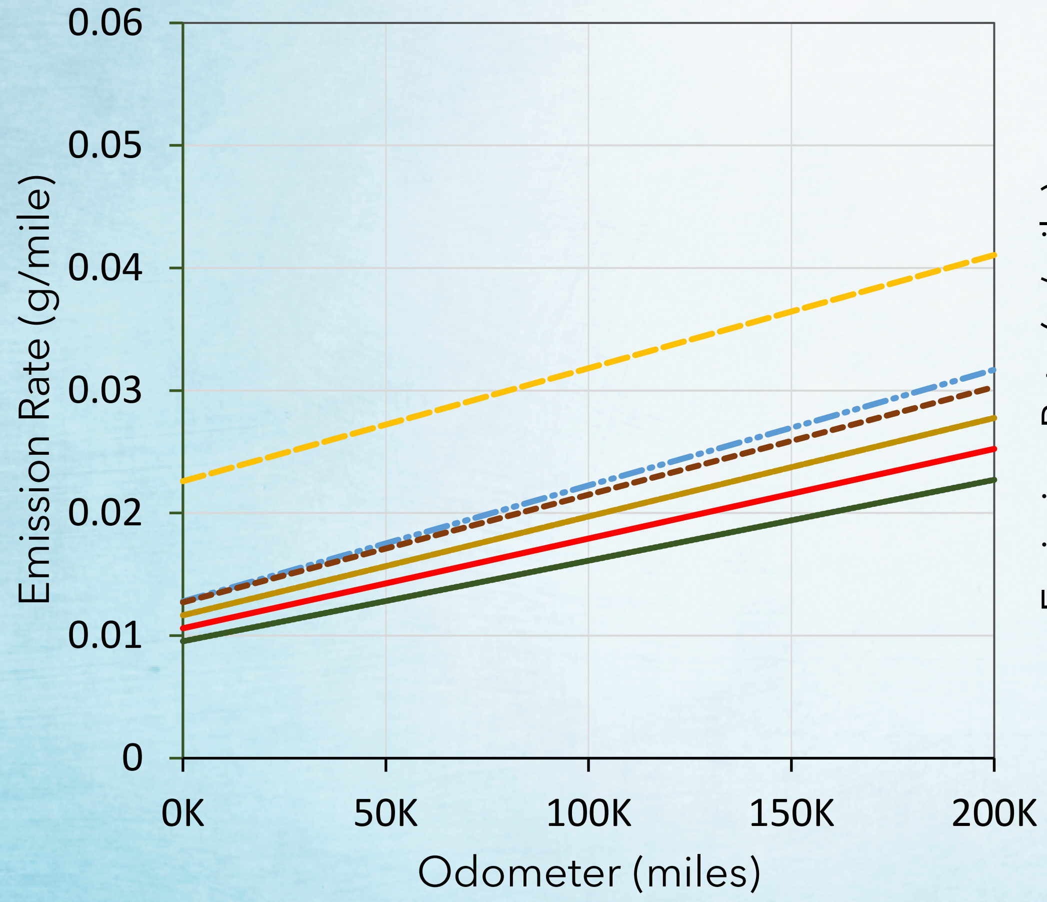
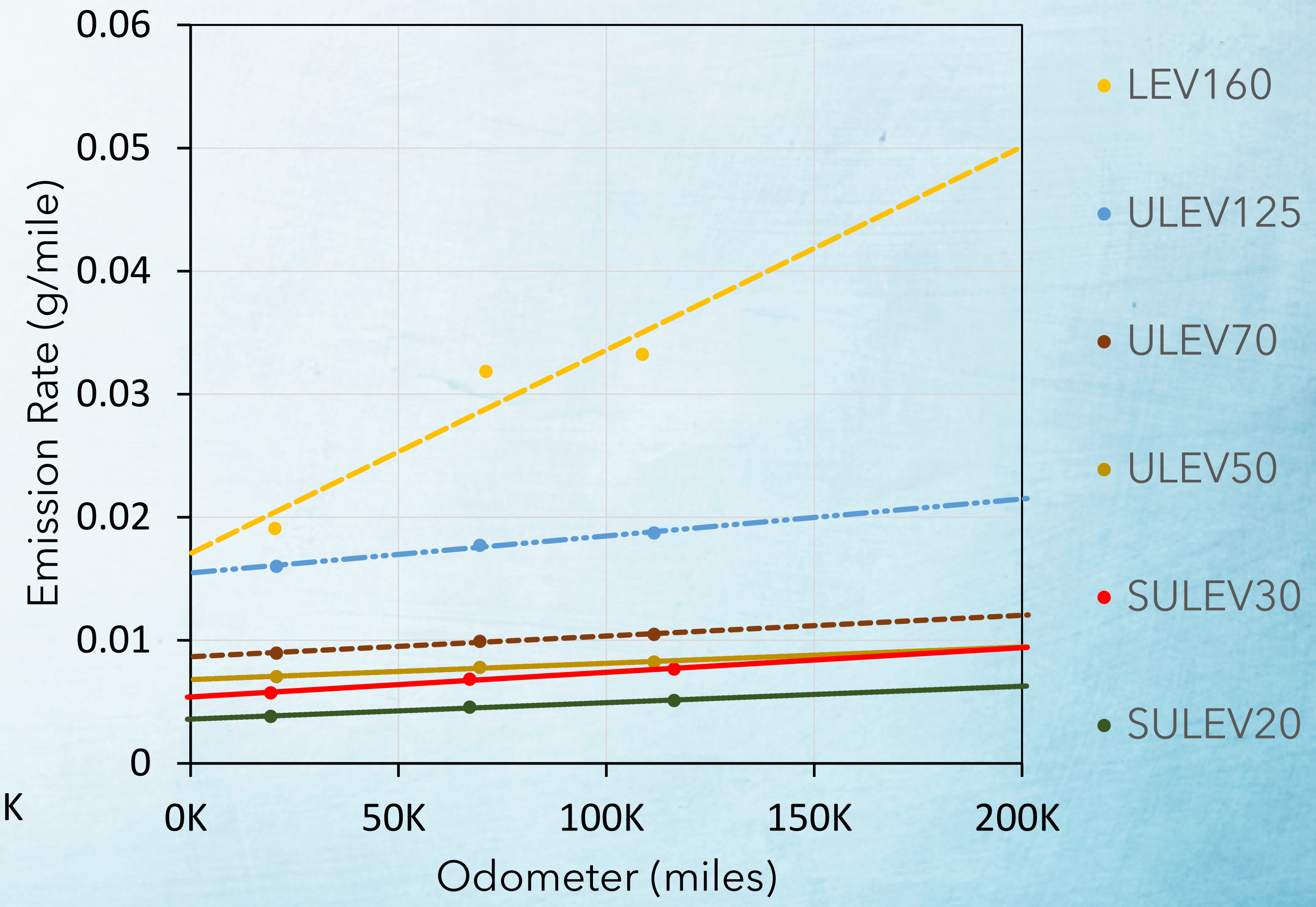
NOx UC Bag 2: Base Emission Rate Running Exhaust

EMFAC2021



EMFAC202Y



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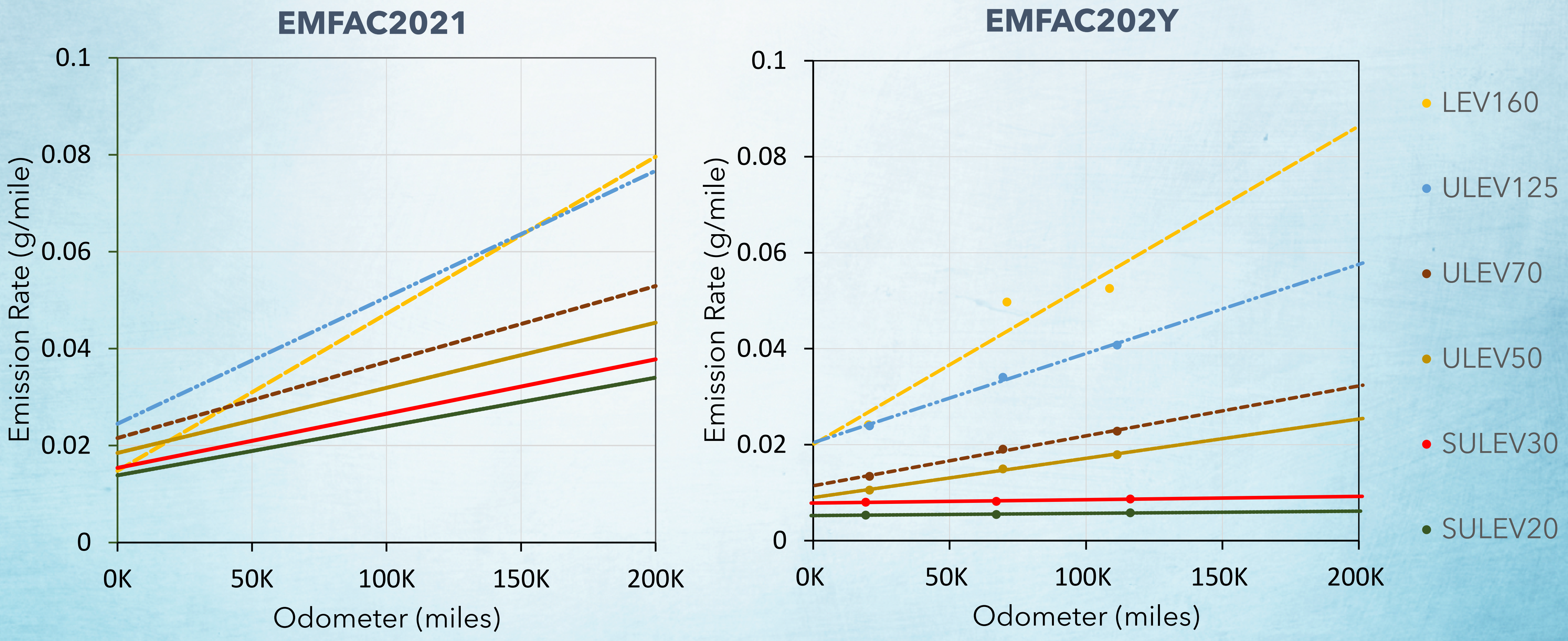
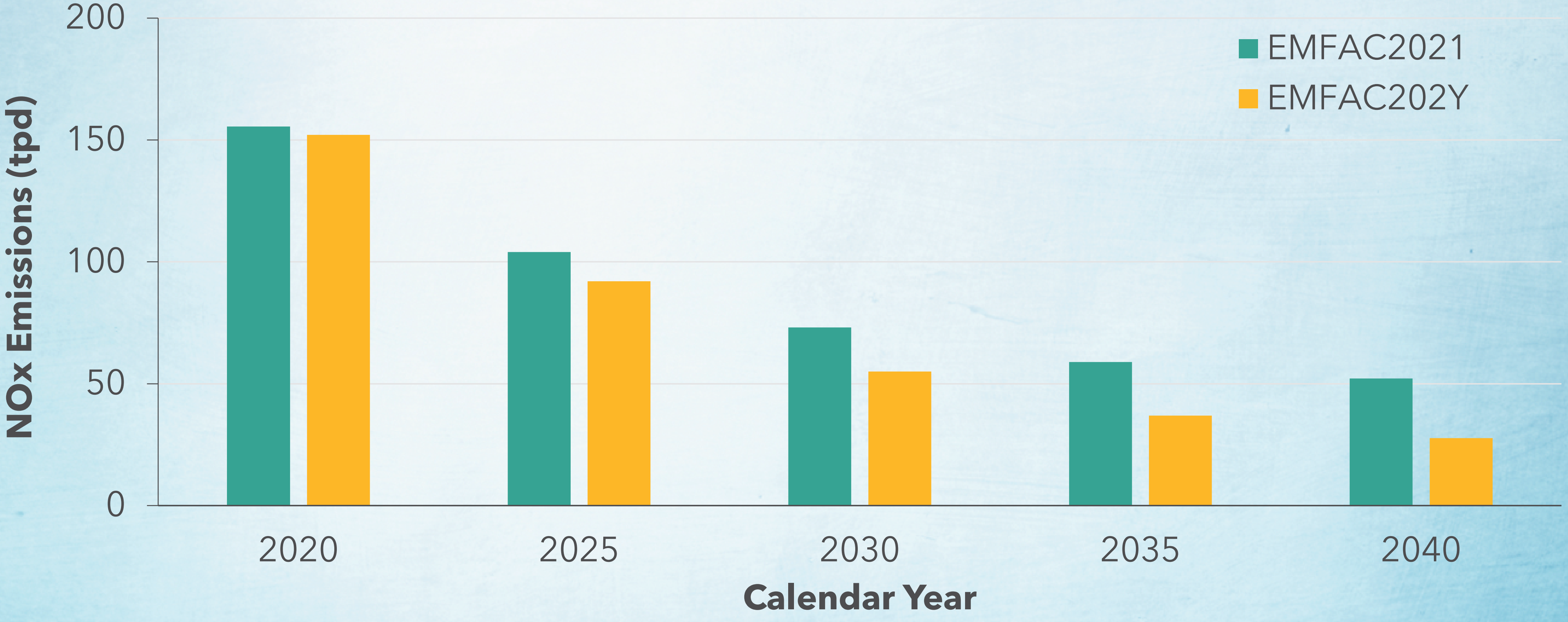
NOx UC Bag 3: Base Emission Rate Warm Start



CARB

Isolated Impact of Base Emissions Rates on Light-Duty Exhaust Emissions (NOx)



About 12% less emissions in 2025 and 25% less emissions in 2030

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Summary & Next Steps

- Reduction in BER for technology groups SULEV30, ULEV70, and ULEV50
- Reduction in HC (3% in 2025, 8.5% in 2030) & NOx (12% in 2025, 25% in 2030) emissions 2020-2050
- Procure LEV III vehicles (ULEV70, ULEV50, SULEV20) and with higher mileages for the future updates.

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Emission Rates Updates

Light-Duty High-Speed Driving Testing

Background

- CARB's previous light-duty (LD) Surveillance test plans included freeway driving cycles where the highest speed cycle, Freeway Cycle 7 (FC7) averaged 73 mph
  - Surveillance test cycles and average speeds

Test Type	Average Speed (mph)
FTP	21.2
UC	22.9

Test Type (Arterial Cycle)	Average Speed (mph)
AC1	6.8
AC2	22.5
AC3	39
AC4	55.2

Test Type (Freeway Cycle)	Speed Range/Avg (mph)
FC1	10 to 20 (15.5)
FC2	20 to 30 (25.5)
FC3	30 to 40 (32.7)
FC4	40 to 50 (45.6)
FC5	50 to 60 (56.5)
FC6	60 to 70 (65.2)
FC7	70 to 80 (72.9)

  - FC7 does not represent real-world maximum speed.

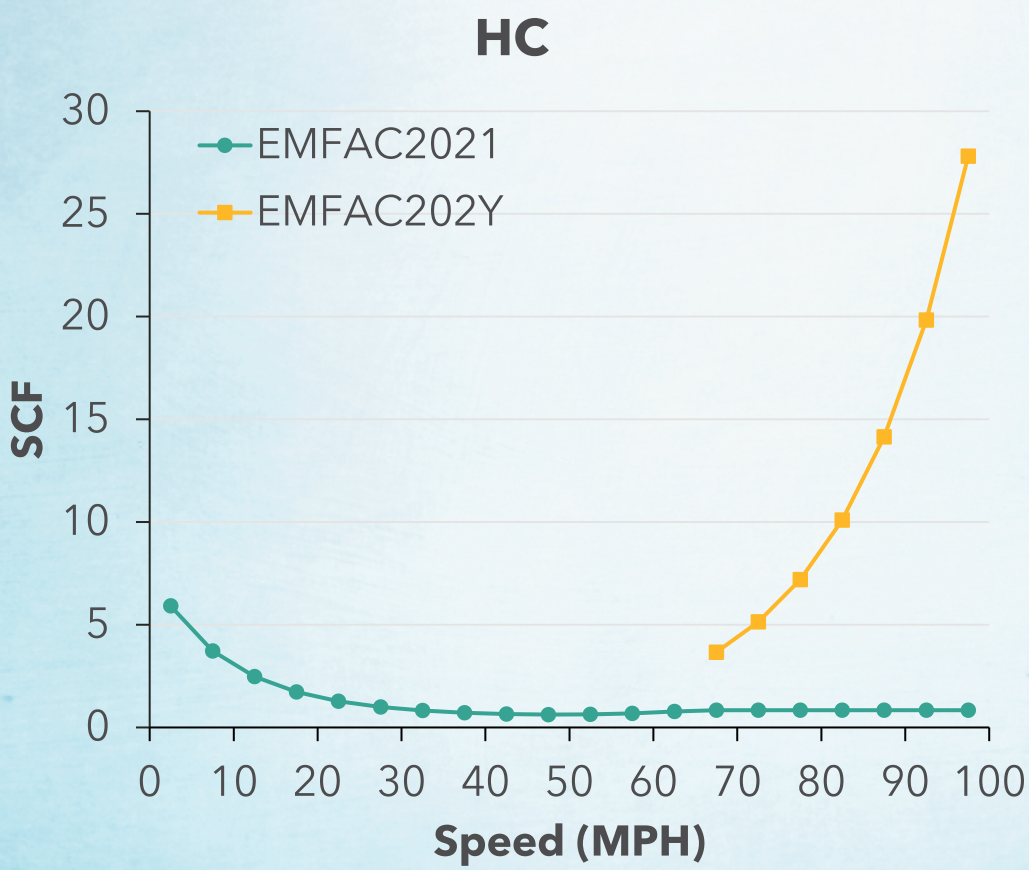
Light-Duty High-Speed Test Program

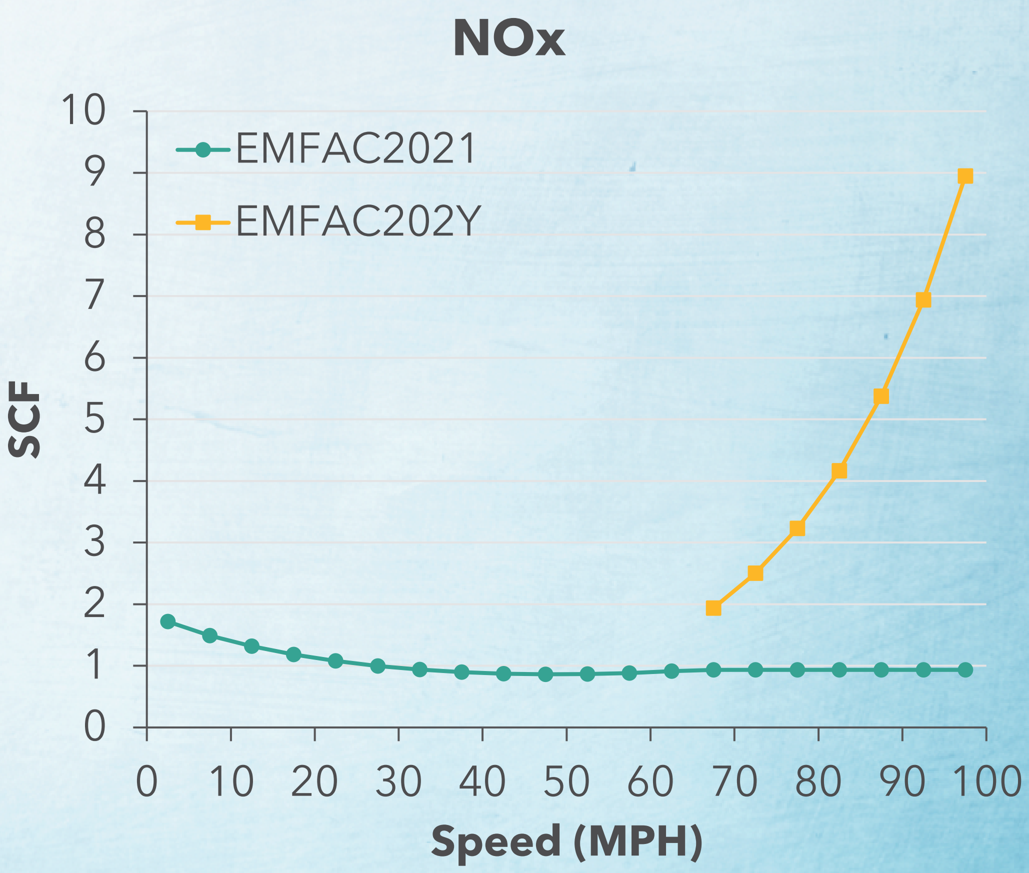
- **Goal**: Generate LD high-speed emissions data to improve EMFAC202Y
- **Vehicle Selection**
  - Passenger cars, SUVs, and trucks
  - Vehicles up to 10,000 lbs. GVWR
  - Model Years ranging from 2015-2023
- **Test Cycles**
  - FTP and UC performed for baseline
  - FC 5, 6, and 7 performed for reference
  - Three new high speed dynamometer driving cycles
    - Freeway Cycle 8 (Average speed of 83 mph)
    - Freeway Cycle 9 (Average speed of 93 mph)
    - Freeway Cycle 10 (Average speed of 103 mph)
- **Data Collection & Analysis:** January to September 2024

Vehicles Tested & Characteristics

No.	Vehicle	Tech Group	Mileage (miles)
1	2022 Nissan Altima	SULEV30	36,994
2	2023 Chevy Camaro	ULEV50	28,652
3	2022 Honda Civic	SULEV30	49,428
4	2023 Nissan Maxima	ULEV125	11,921
5	2023 Toyota 4Runner	ULEV70	11,679
6	2015 Toyota Corolla	ULEV125	115,948
7	2016 Ford F150	ULEV125	51,688

Updated Speed Correction Factors





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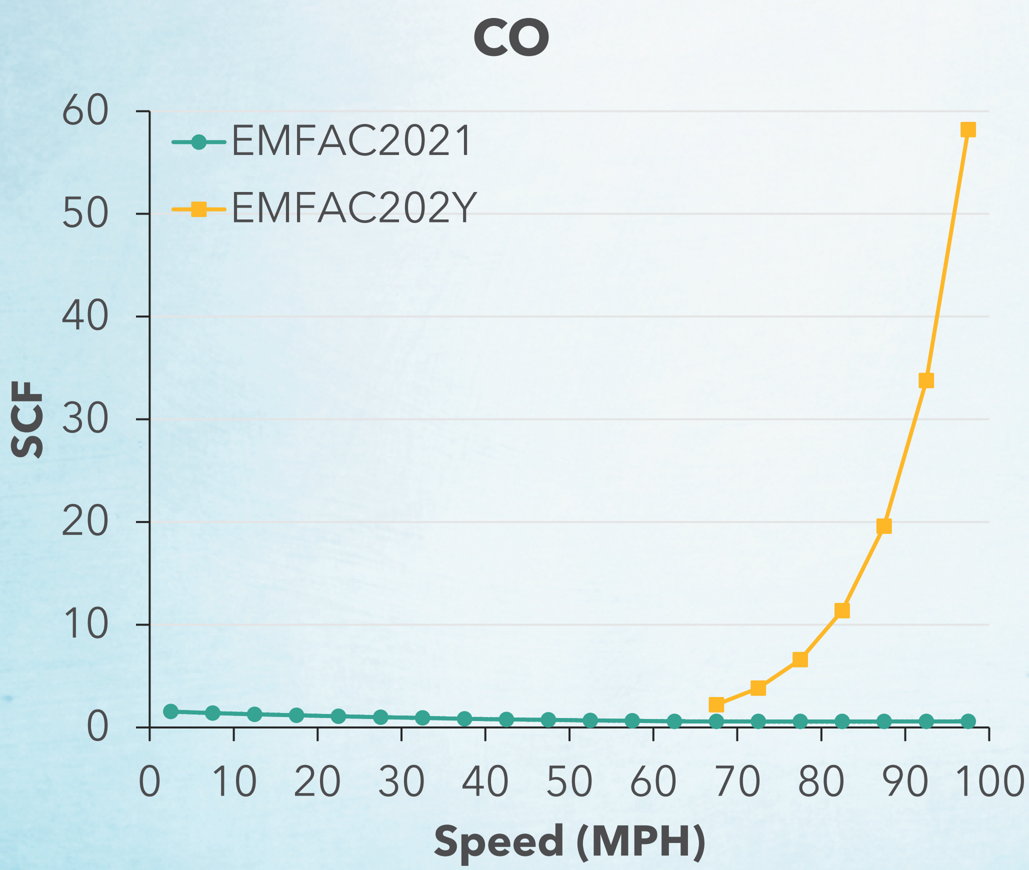
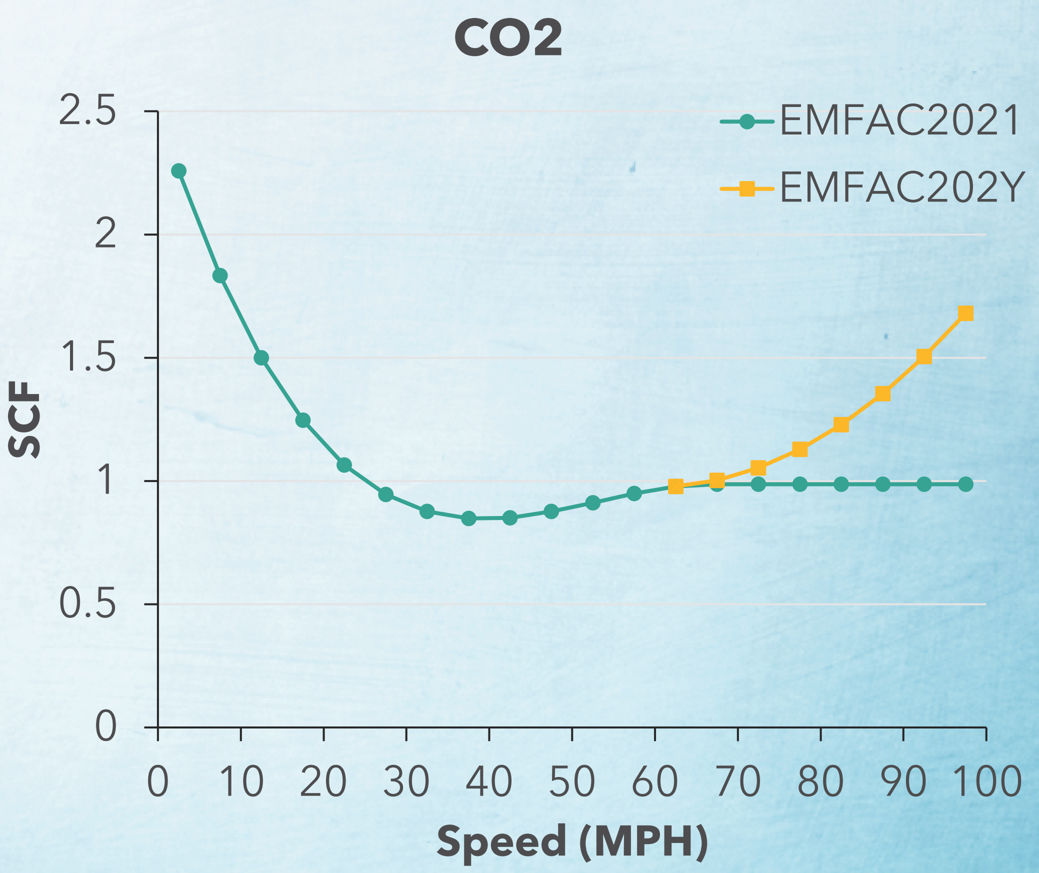
Updated Speed Correction Factors (Continued)





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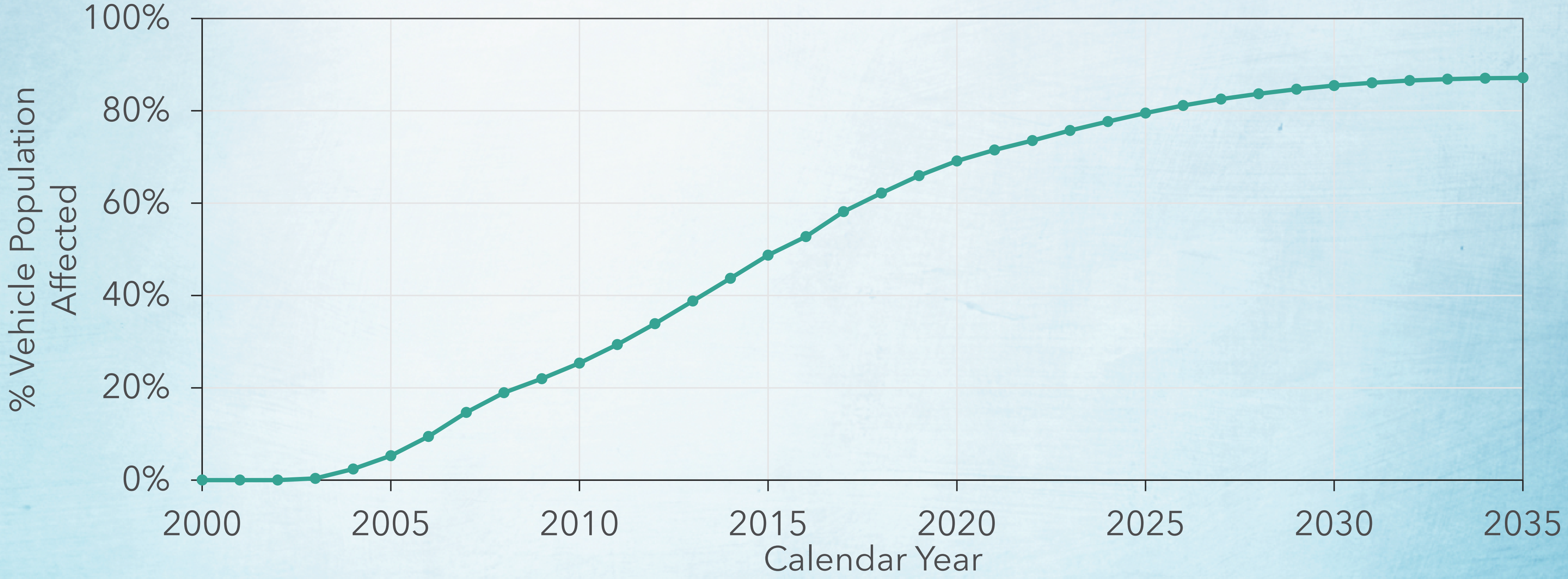
Vehicle Population Updated with High Speed SCF (%)



- Represents only the technology groups of vehicles tested
- Update does not include Pre-LEV, TLEV, LEVI and LEVII LEV160 technology groups
- Will be updated with additional data in the future.

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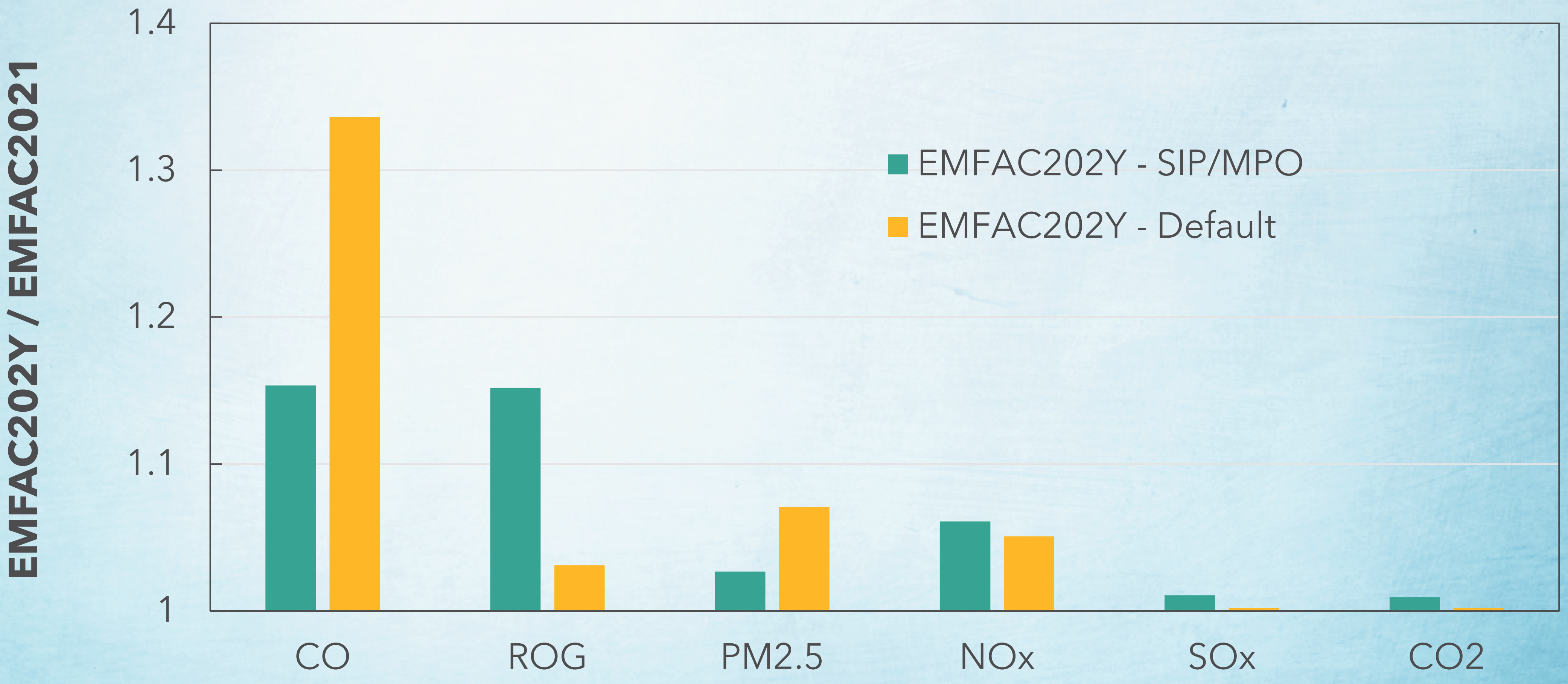
Light-Duty Emissions Impacts Statewide Emissions in Year 2030



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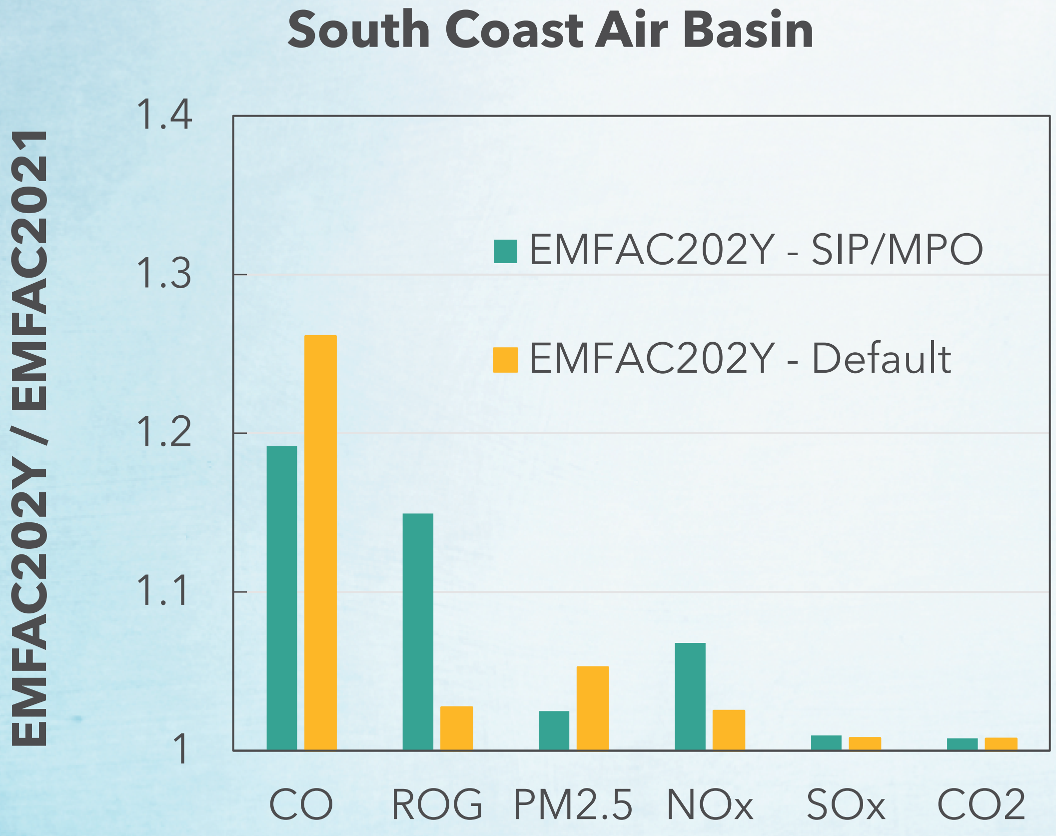
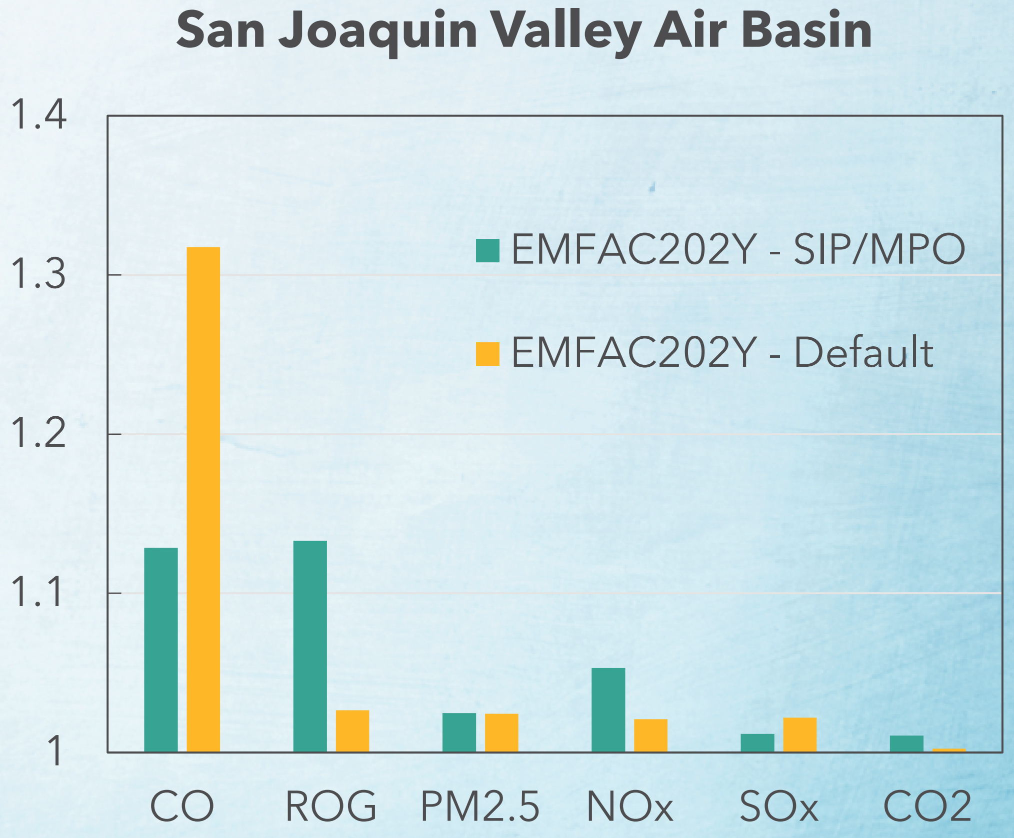
Light-Duty Emissions Impacts in CY 2030
South Coast and San Joaquin Valley





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Key Findings and Next Steps

- All else equal, statewide and fleetwide emissions in CY 2030, ROG will be 12% higher and NOx will be 2.5% higher when used for SIP and transportation conformity purposes.
- Additional vehicles may be included before EMFAC202Y is finalized.

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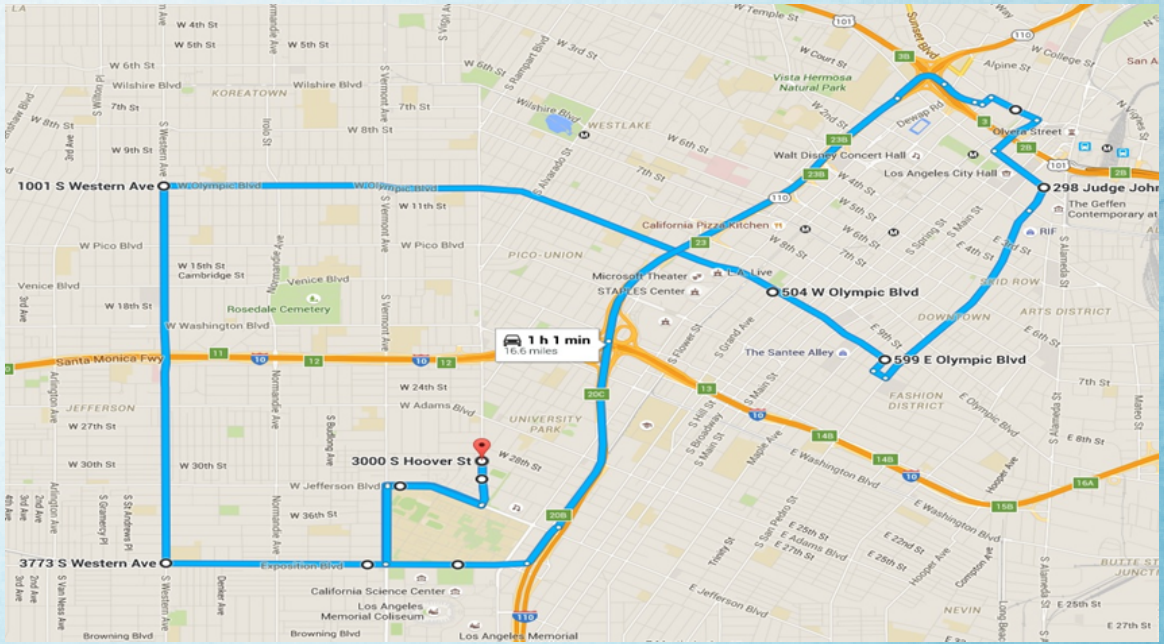
Speed Correction Factor (SCF) and Emission Rates Comparison (g/h vs. g/mi)

Background

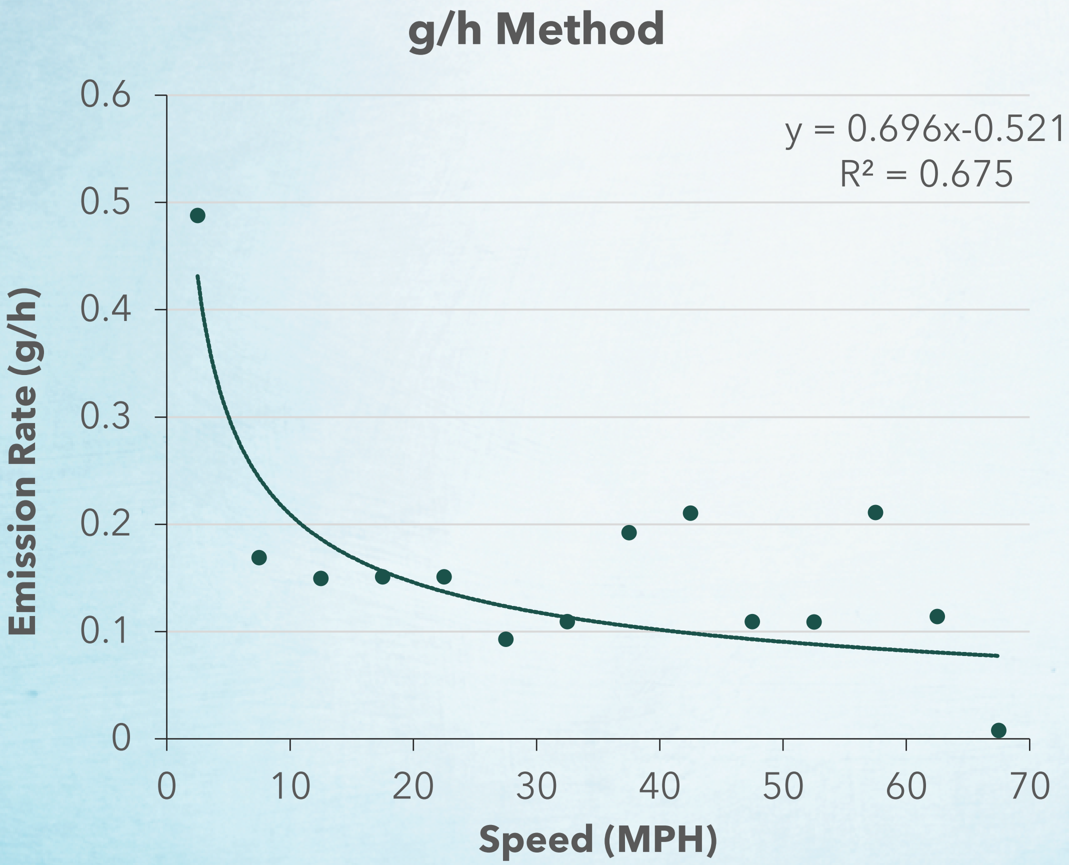
- SCF Definition
  - The ratio of the emission rate at a given speed relative to the base emission rate.
- At previous workshops, attendees asked if time based (g/h) SCFs could be more accurate than distance based (g/mi) SCFs, particularly at low vehicle speeds.
- In CY 2024, for speed < 5 mph:
  - 0.97% of the total VMT.
  - Constitutes ~1.5% of the NOx and ~4% of the ROG emissions.

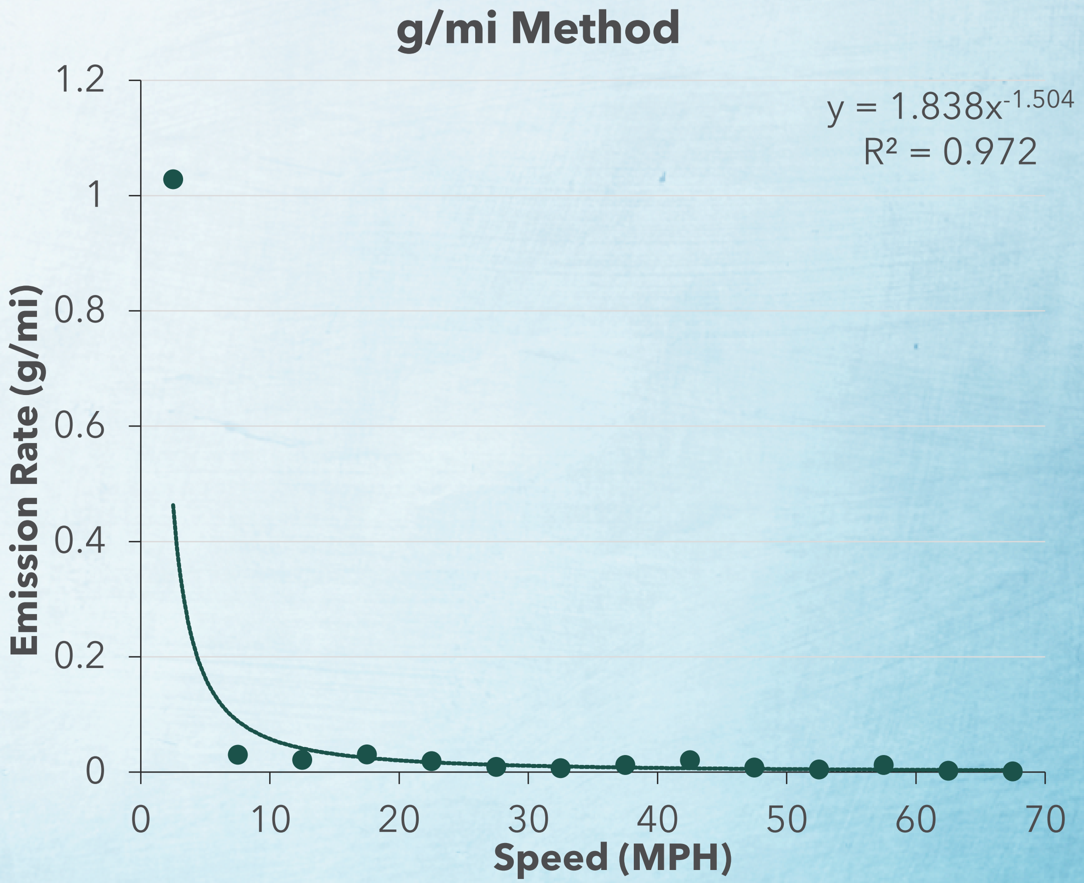
On Road Case Study Using PEMS Data

- Goal: Evaluate SCFs and emission rates by g/h and g/mi method.
- Vehicle Tested: 2018 Chevrolet Cruze.
- Test Route: Real-world PEMS Testing (Downtown Los Angeles).
  - Downtown route 16.6 miles
  - CARB HSL to downtown/back
    - Short freeway driving
- Range of data
  - 2 hours 30 minutes
  - Range of speed (min: < 1 mph & Max: 69.6 mph)



HC Emission Rate (g/h vs. g/mi)





Comparison of Methods (g/h vs. g/mi)

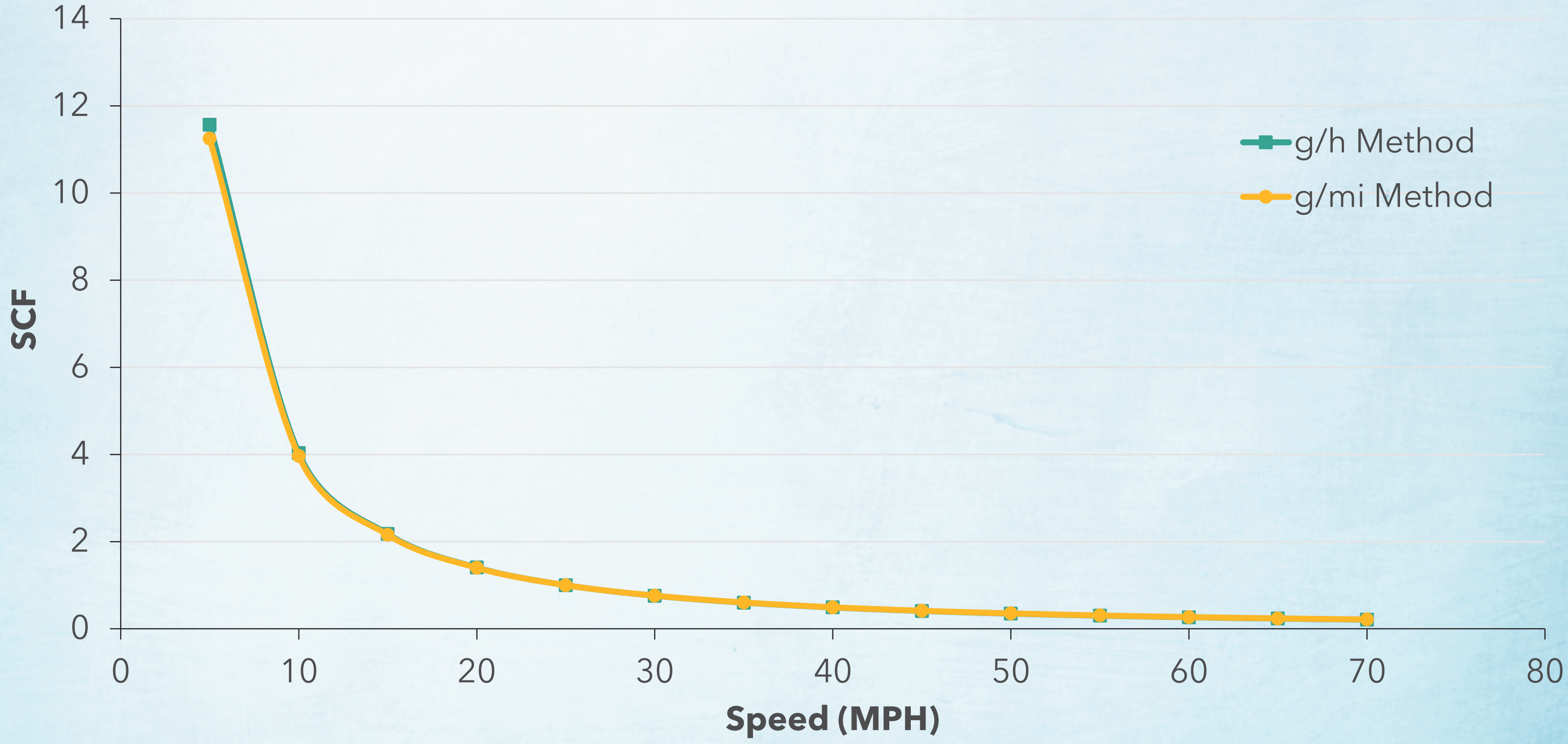
g/h Method			
Speed Bin	g/h	g/h -> g/mi	Norm @25mph
5	0.301	0.060	11.565
10	0.210	0.021	4.030
15	0.170	0.011	2.175
20	0.146	0.007	1.404
25	0.130	0.005	1.000
30	0.118	0.004	0.758
35	0.109	0.003	0.599
40	0.102	0.003	0.489
45	0.096	0.002	0.409
50	0.091	0.002	0.348
55	0.086	0.002	0.301
60	0.082	0.001	0.264
65	0.079	0.001	0.234
70	0.076	0.001	0.209

$$y = 0.696x^{-0.521}$$
$$R^2 = 0.675$$

g/mi Method		
Speed Bin	g/mi	Norm @25mph
5	0.163	11.253
10	0.058	3.967
15	0.031	2.156
20	0.020	1.399
25	0.015	1.000
30	0.011	0.760
35	0.009	0.603
40	0.007	0.493
45	0.006	0.413
50	0.005	0.353
55	0.004	0.305
60	0.004	0.268
65	0.003	0.238
70	0.003	0.213

$$y = 1.838x^{-1.504}$$
$$R^2 = 0.972$$

SCF* comparison for HC (g/h vs. g/mi)



*Normalized to 25 mph

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Conclusion and Next Steps

- Comparable SCFs using both the g/h and g/mi methods.
- For final release of EMFAC202Y, CARB staff plans to expand analysis of SCFs (all tech groups/approximately 100 vehicles) based on g/s modal data (from lab or PEMS) and compare the two methods

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Emission Rates Updates

Light-Duty CO_2 Emission Rates

Introduction & Methodology

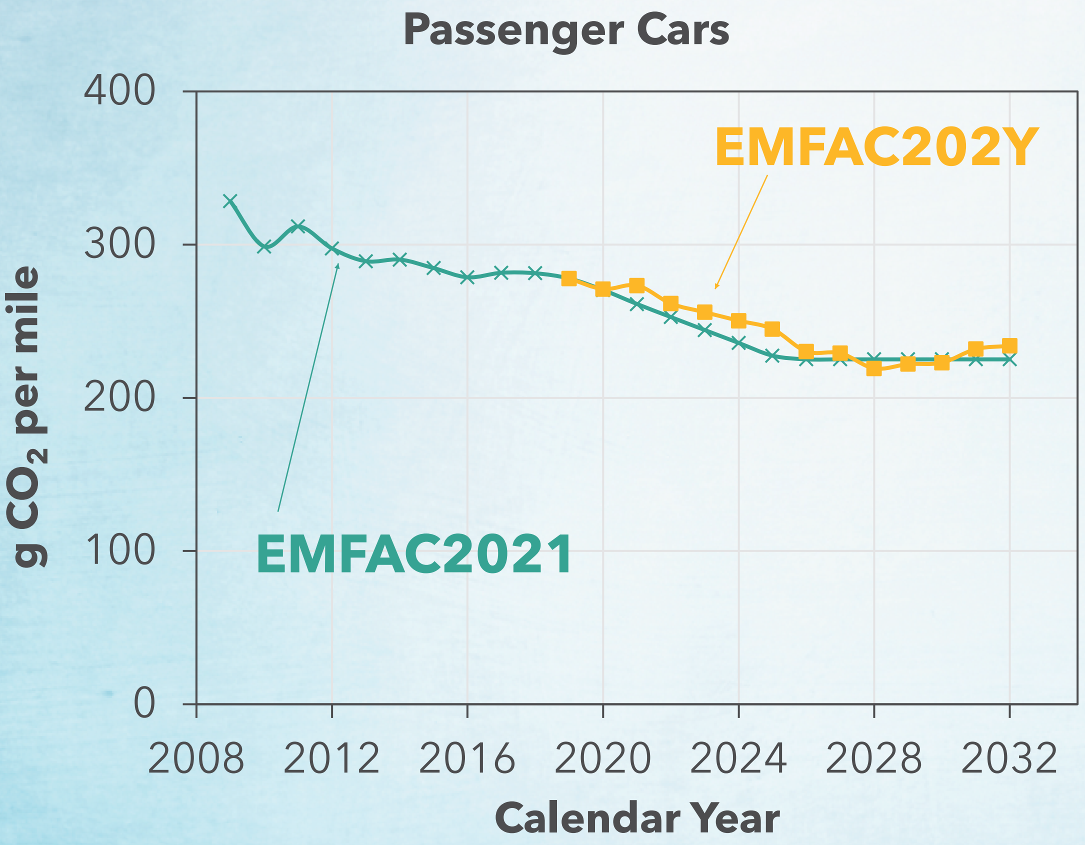
- EMFAC202Y will be updated with CO_2 emission factors for new model-year vehicles (Model Year 2020–2022)
- Identify the fuel efficiency ratings for California's vehicle fleet:
  - Analyze DMV data to identify make, model, and other vehicle attributes
  - Use an advanced algorithm to obtain the EPA rated fuel efficiencies with the vehicle attributes
  - Calculate emission rates [g CO_2/mile] using 5-cycle EPA fuel economies
- Updated CO_2 emission rates are projected for MY 2023 to 2032

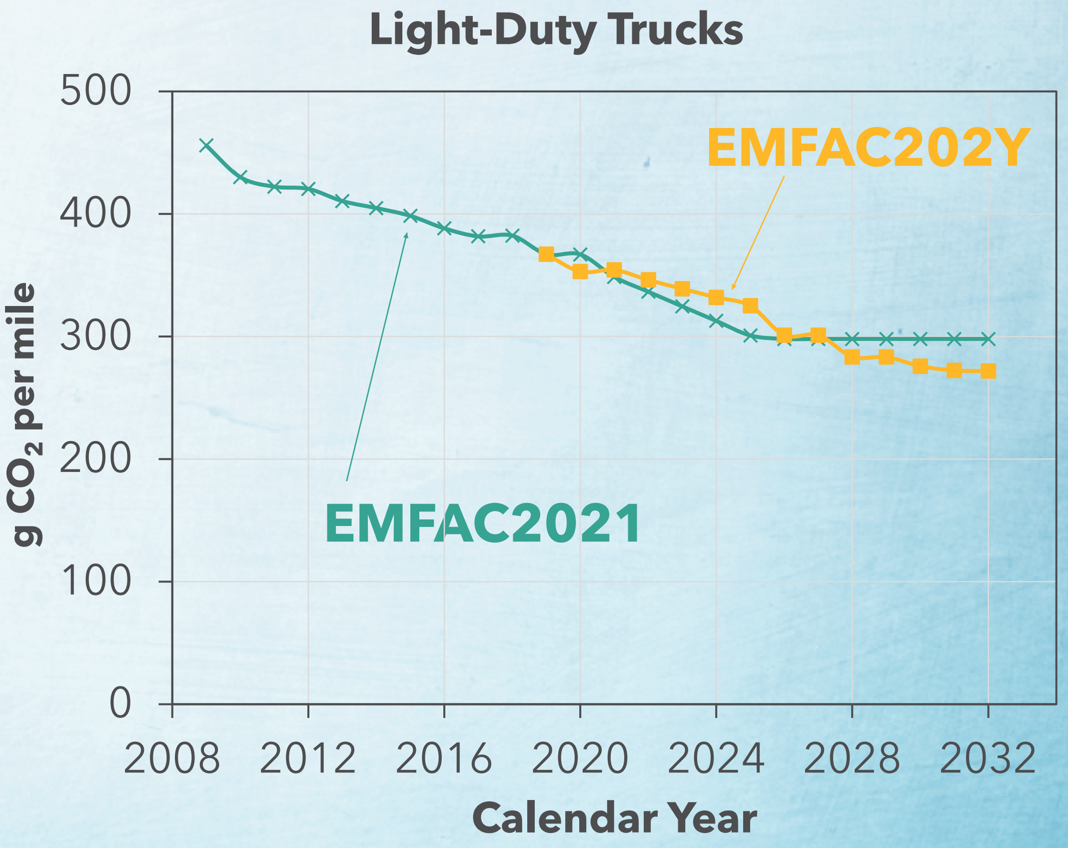
Incorporates SAFE Rule, Framework Agreement and EPA Fuel Economy Updates

- Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule[1]:
  - Final Rule (adopted April 2020): National Highway Traffic Safety Administration (NHTSA)'s Corporate Average Fuel Economy (CAFE) and U.S. EPA greenhouse gas emission standards increased in stringency at 1.5% per year for MYs 2021-2026
- Framework agreements by six participating automakers[2]:
  - Voluntary commitments for annual reductions of gasoline and diesel cars and light trucks by a rate of 2.7% per year through 2026.
- EPA's Multi-pollutant Standards for MY 2027 and later[3]

1. https://www.govinfo.gov/content/pkg/FR-2018-09-26/pdf/2018-20962.pdf
2. https://ww2.arb.ca.gov/news/framework-agreements-clean-cars
3. https://www.govinfo.gov/content/pkg/FR-2024-04-18/pdf/2024-06214.pdf

Light-Duty Vehicle CO_2 Emissions





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CARB

Emission Rate Updates

Medium Heavy-Duty Truck (T6) Emission Rate

Background

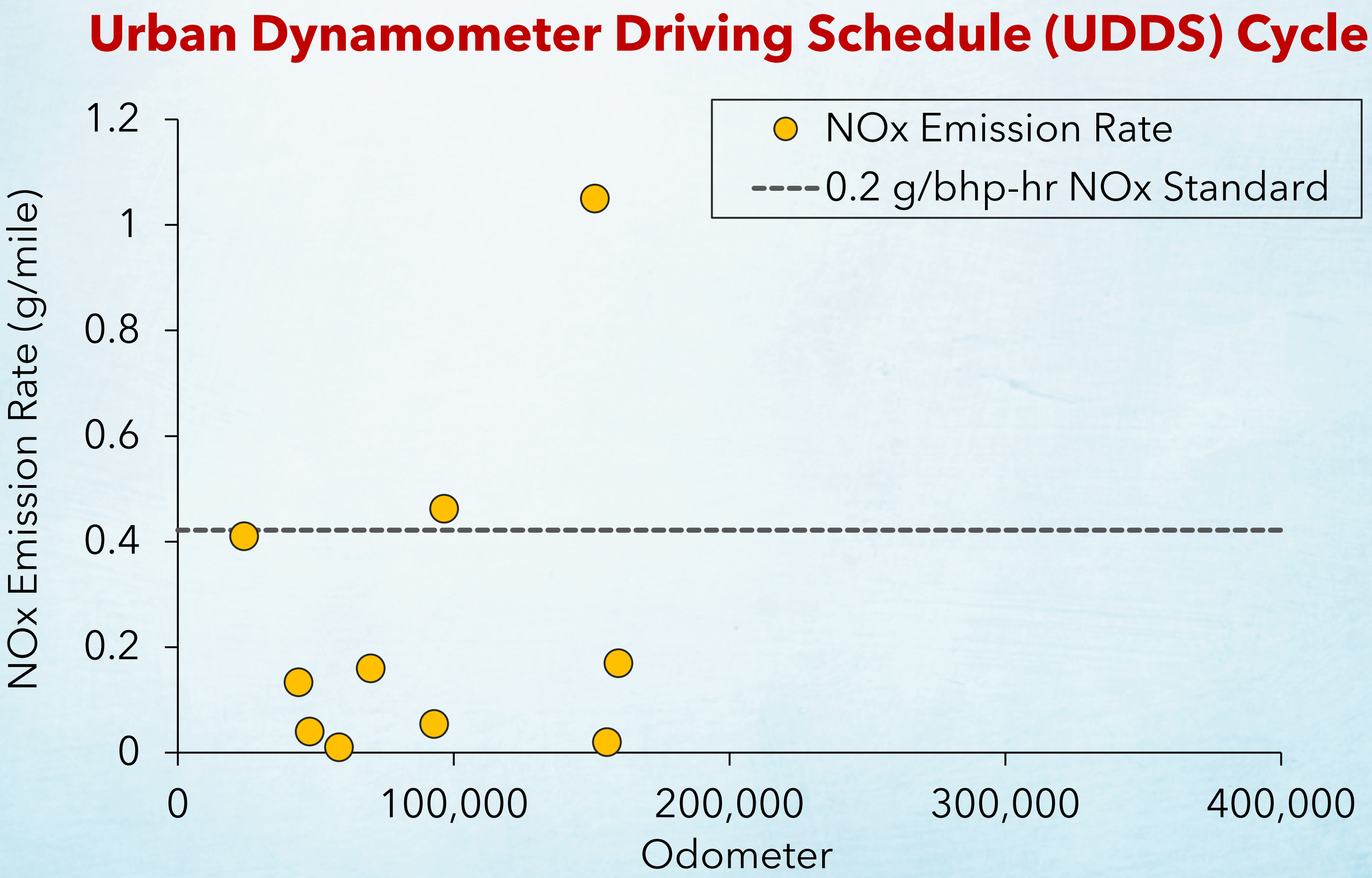
- EMFAC2021 used data collected from the Class 4-6 Surveillance Program to inform T6 or medium heavy-duty truck emission rates for engine model years 2013 and newer.
- New chassis dynamometer test data available for EMFAC202Y.
- Checked the recall status of previously tested vehicles used in EMFAC2021.
- Updated EMFAC202Y with new test data.

Updated T6 Data

- Chassis dynamometer data collected through CARB's Class 4-6 Surveillance Program.

	Number of Vehicles	Model Years
Test Vehicles in EMFAC2021	8	2013-2017
Test Vehicles Available after EMFAC2021 Release	5	2017-2020
Number of tested vehicles recalled (2024) - REMOVED	3	
Total Sample Available for EMFAC202Y	10	2013-2020

Chassis Dynamometer T6 Data Used in EMFAC202Y



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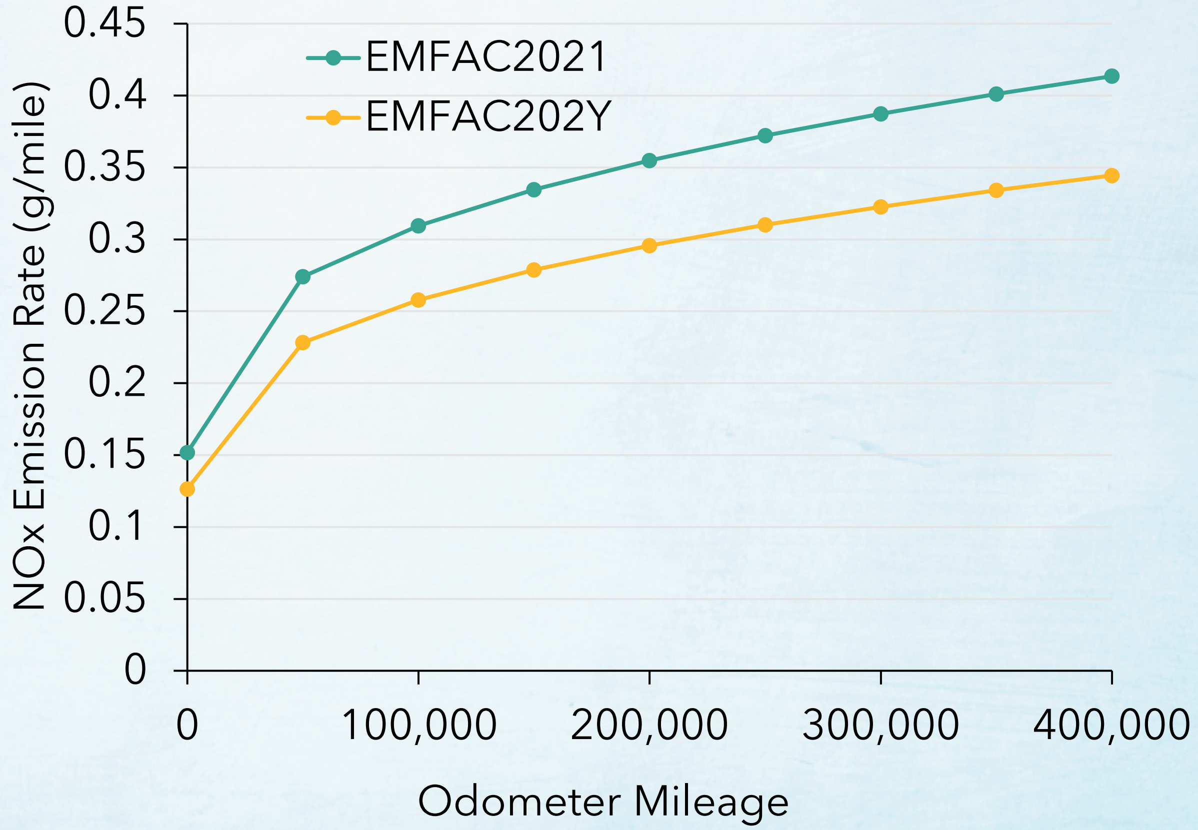
Updated T6 Emission Rates at UDDS Average Speed



Updated T6 emission rates in EMFAC202Y are 17% lower than EMFAC2021

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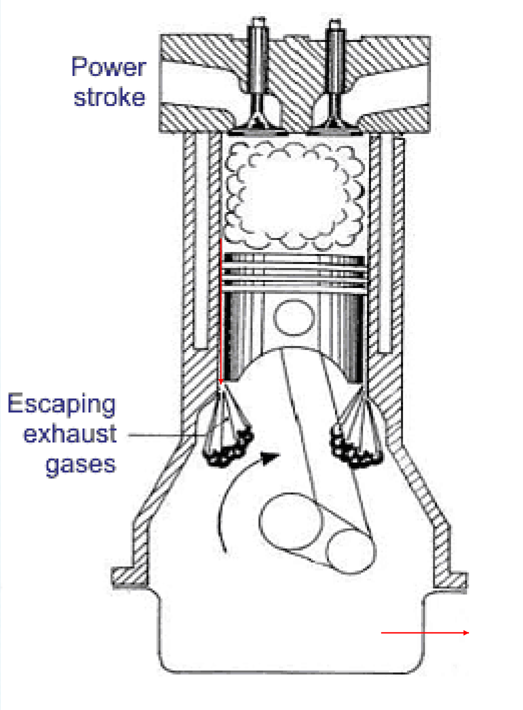
Emission Rate Updates

Heavy-Duty Natural Gas Methane Emission Rates

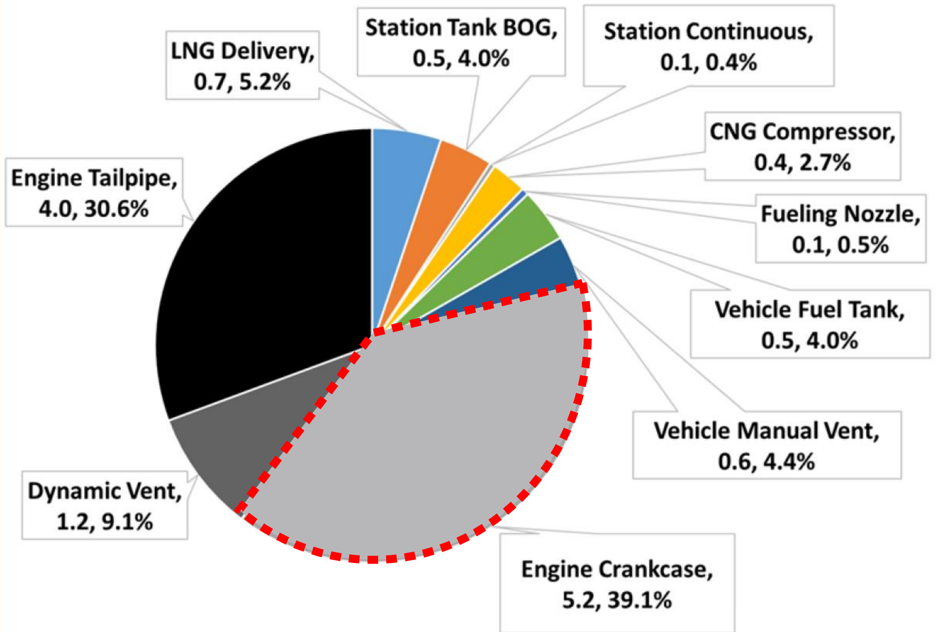
Natural Gas Methane Emissions from Crankcase

- Fuel/exhaust can leak past piston to crankcase.
  - Crankcase pressure increases and is vented to atmosphere.
- Only applies to engines before MY 2018 that are certified to 0.2 g/bhp hr NOx standard.



Data Sources used in EMFAC202Y

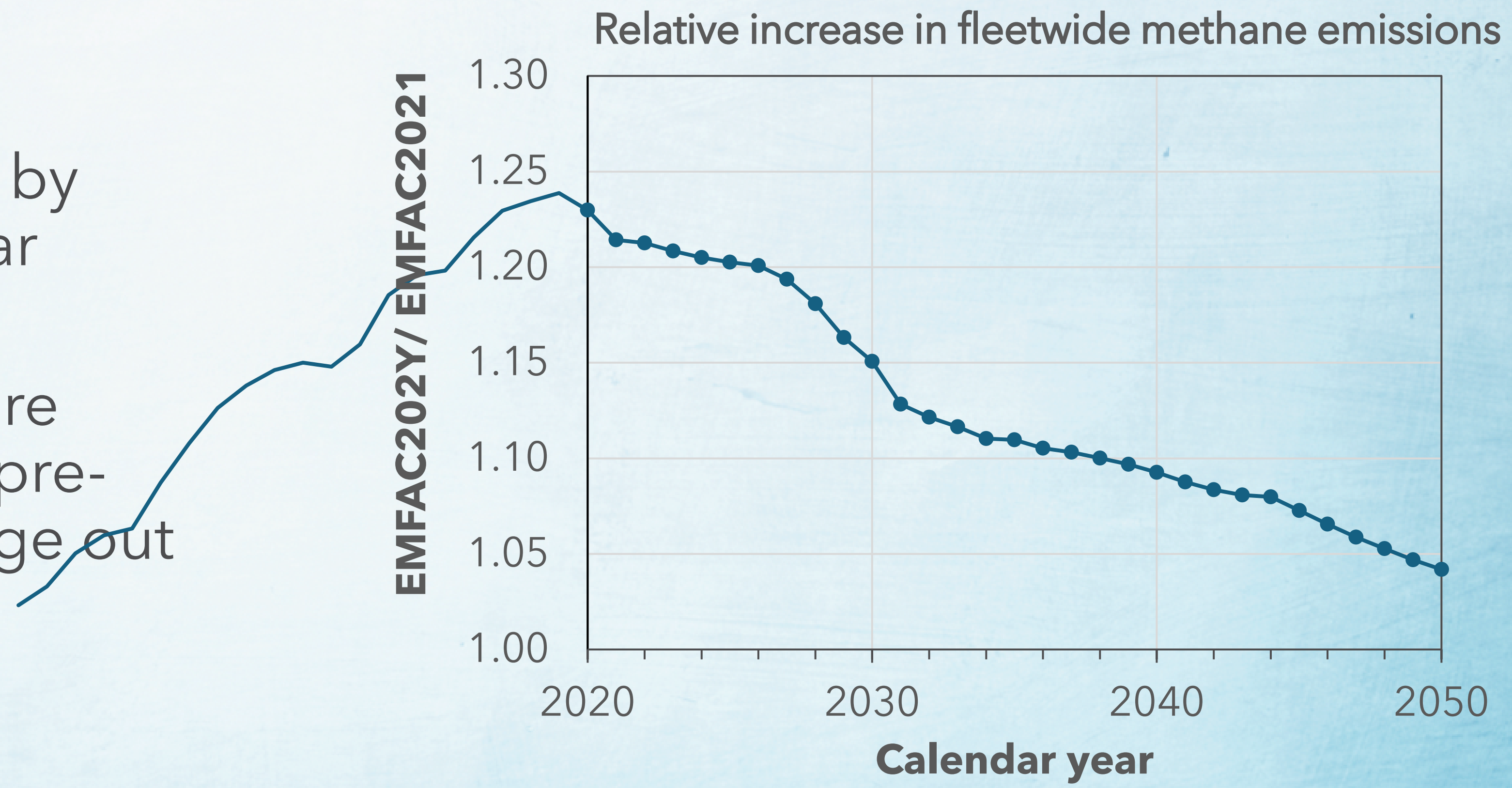
- The 200-vehicle study is used to determine Natural Gas HD emission rates in EMFAC202Y.
  - Study does not quantify the crankcase emissions.
- Literature values from Clark et al.* used to further account for crankcase emission rates in EMFAC202Y.



*Nigel N. Clark et al. **Pump-to-Wheels Methane Emissions from the Heavy-Duty Transportation Sector.** *Environmental Science & Technology* **2017** *51* (2), 968-976. DOI: 10.1021/acs.est.5b06059

Impact on EMFAC202Y Methane Emissions

- Increases fleetwide methane emissions by 20% in calendar year 2025.
- Contribution in future years decreases as pre-MY 2018 vehicles age out of fleet.



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Emission Rates Updates

Heavy-Duty Natural Gas NO_X Emission Rates

Natural Gas Heavy-Duty Vehicle (NG HDV) Emission Rates

- Emission rates calculated separately for four sub-categories/vocations of HDVs
- NOx emission rates for two model year groups were updated

Model Years	NOx Certification
2010-2017	0.2 g/bhp-hr
2018+	0.02 g/bhp-hr

Transit Bus

School Bus

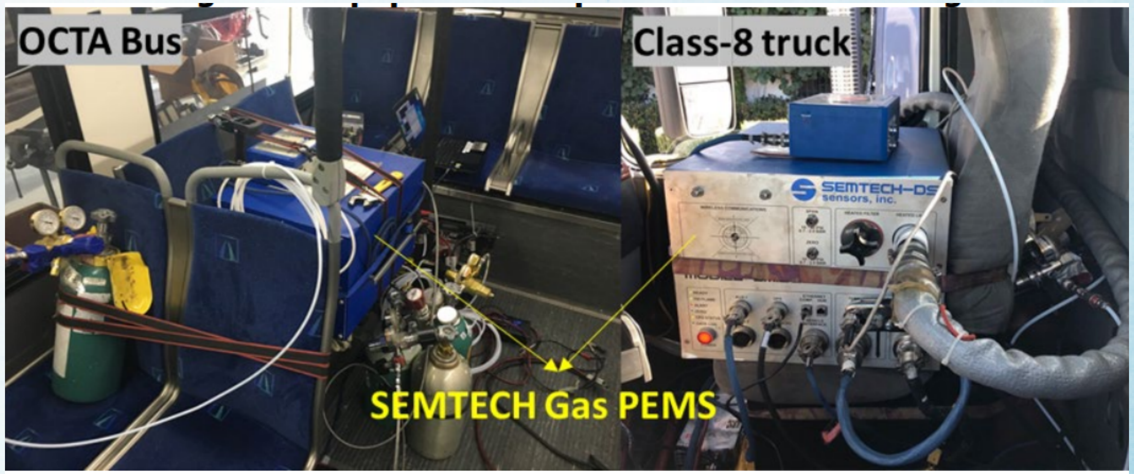
Refuse

Other Heavy-Duty Truck

Portable Emission Measurement Systems (PEMS) Data from 200-Vehicle Study

- UC Riverside and West Virginia University measured tailpipe emissions in-use during typical operations
- One test per vehicle (about one day of data each)
- PEMS data for 49 natural gas vehicles was obtained for EMFAC202Y analysis

Example equipment setup of UCR PEMS testing:



Number of PEMS tested vehicles included in EMFAC202Y analysis:

Technology	Transit Bus	School Bus	Refuse Truck	Other HD Truck
0.2 g/bhp-hr	4	5	10	11
0.02 g/bhp-hr	4	0	4	11

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Updates in EMFAC202Y

- Using finalized data from 200-Vehicle Study
  - Including 2 new vehicles that were not used in EMFAC2021
  - 47 of the 49 vehicles were already in EMFAC2021

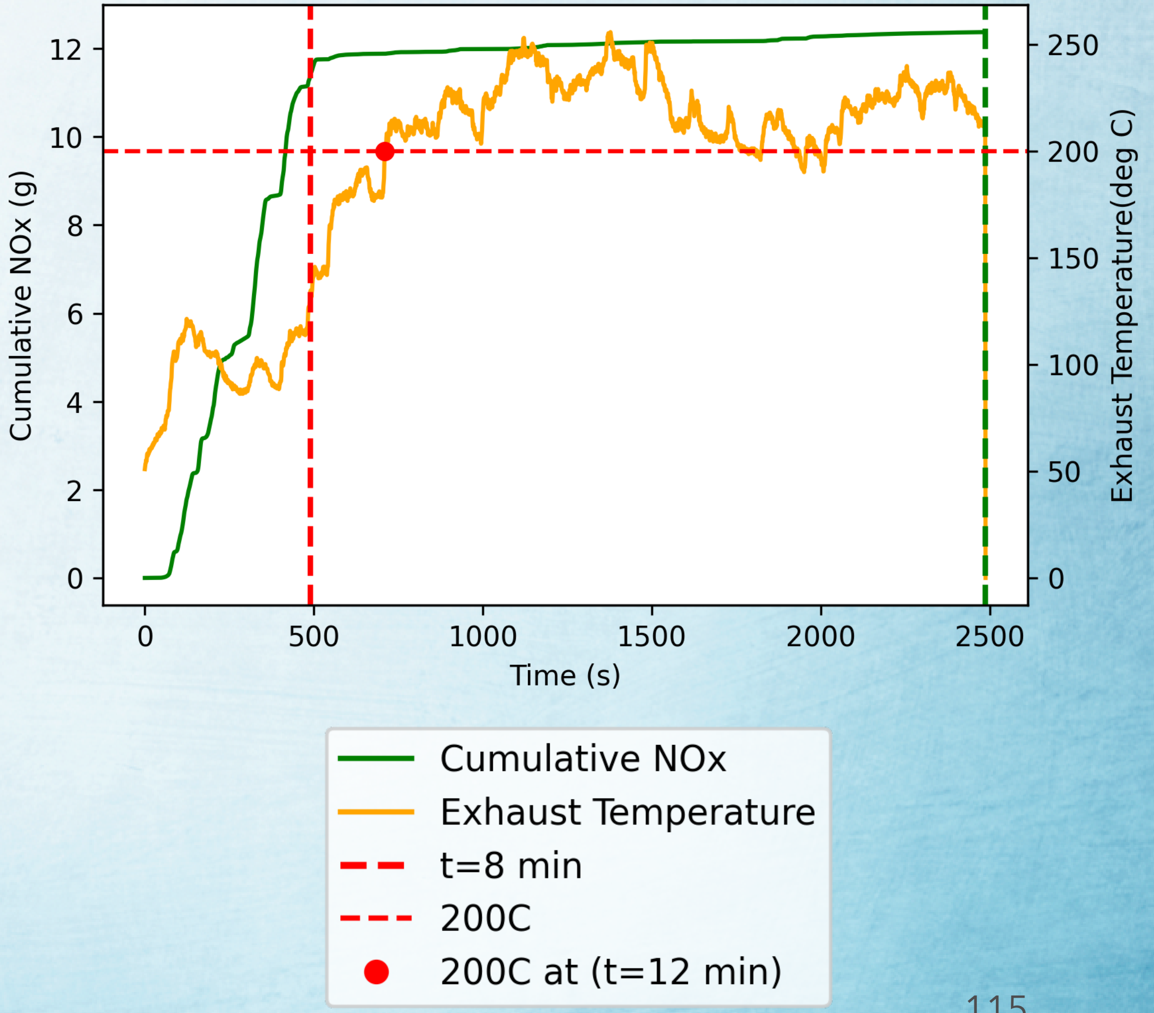
- New PEMS analysis approach
  - Standardized criteria for distinguishing start emissions
  - "Microtrip" binning for aggregating emissions into speed bins

Detecting the Start Emissions Period

Three criteria used to detect the end of the start emission period (whichever comes first):

1. Time of first cumulative NOx "plateau" (Cumulative NOx change smaller than 0.03 g for at least 100 seconds)
2. Time when exhaust temperature reaches 200°C
3. 20 minutes

These criteria were carried over from analysis of diesel heavy-duty engines certified to 0.2 g/bhp-hr



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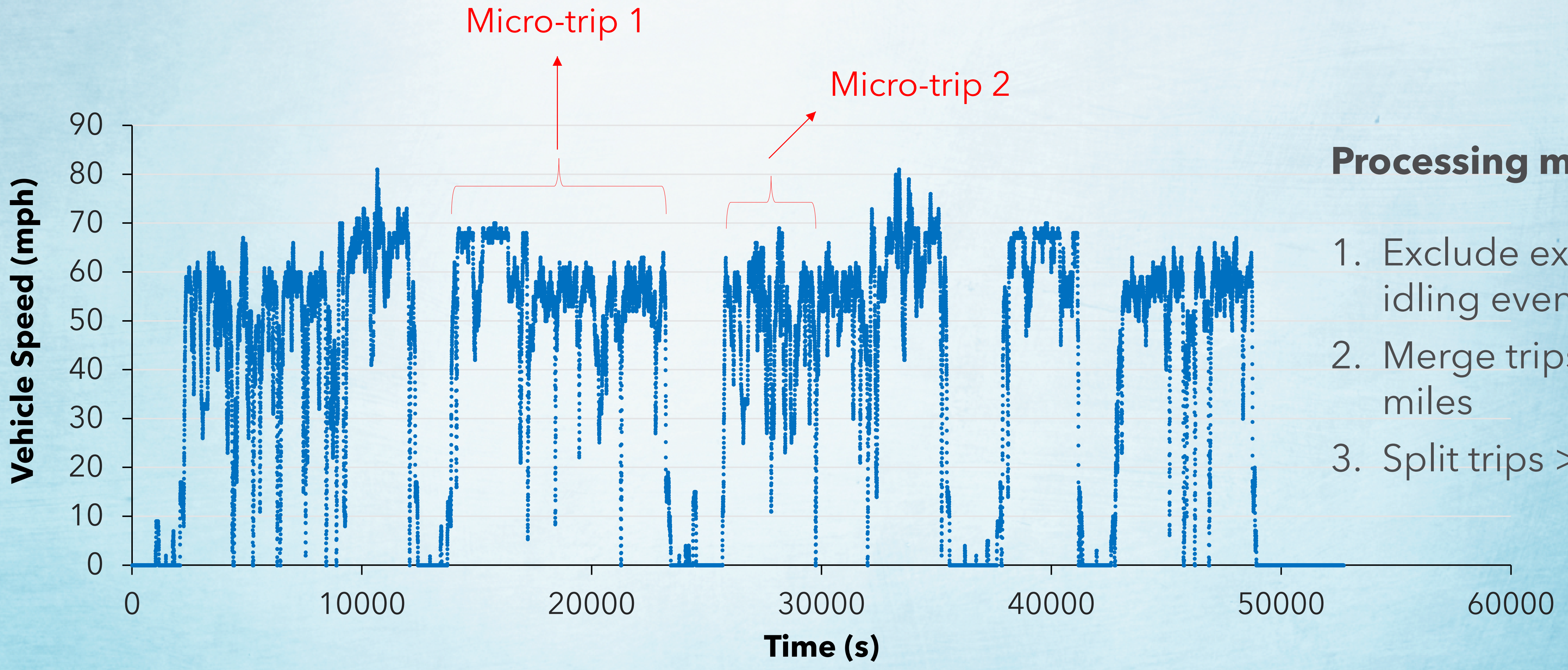
Identifying Micro Trips in PEMS Data

Micro-trips are defined as “from start to stop”



Processing micro trips:

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

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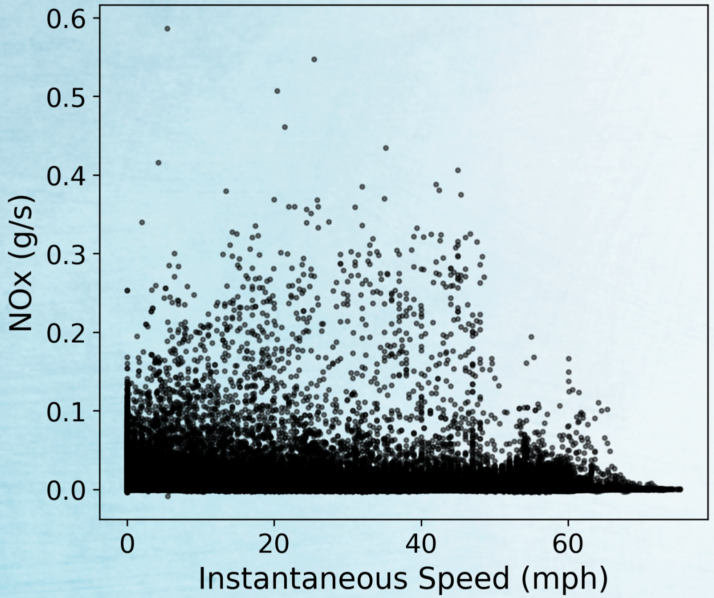
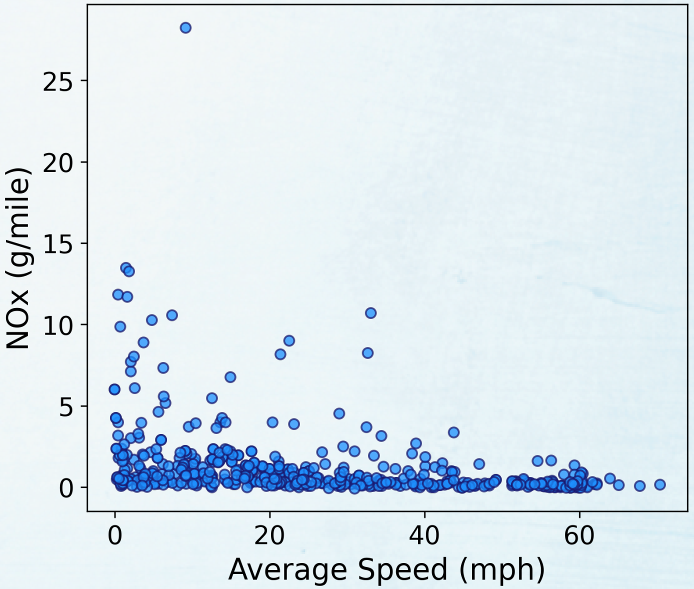
Microtrip Data was Grouped into Speed Bins to Calculate Base Emission Rates (BER)

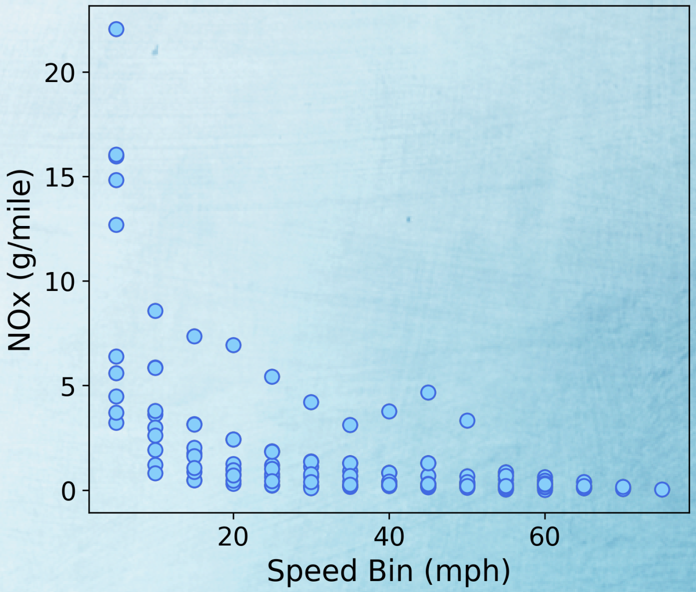
Example: Heavy-Duty Trucks (0.2 g/bhp-hr)



PEMS data (unprocessed)



PEMS data grouped into microtrips



Microtrips grouped into speed bins

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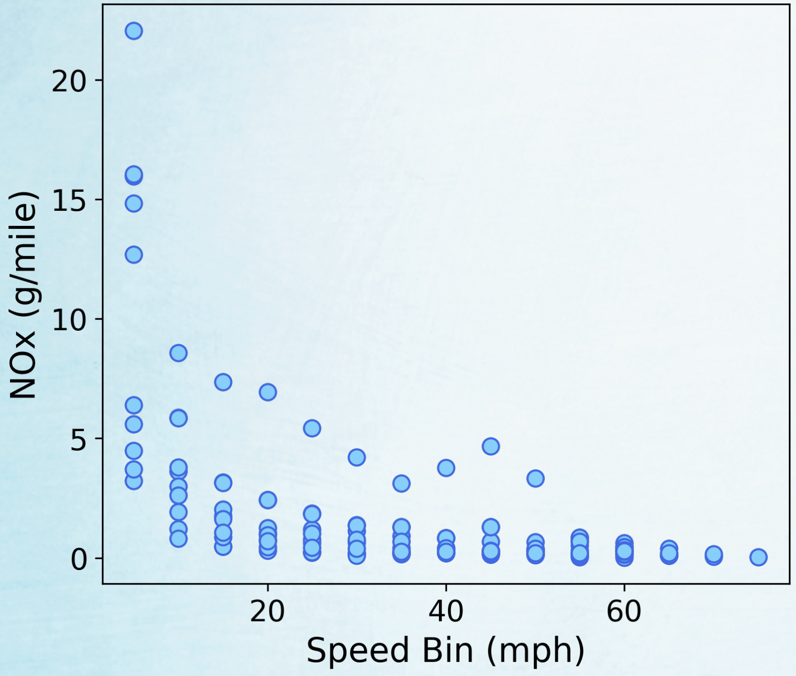

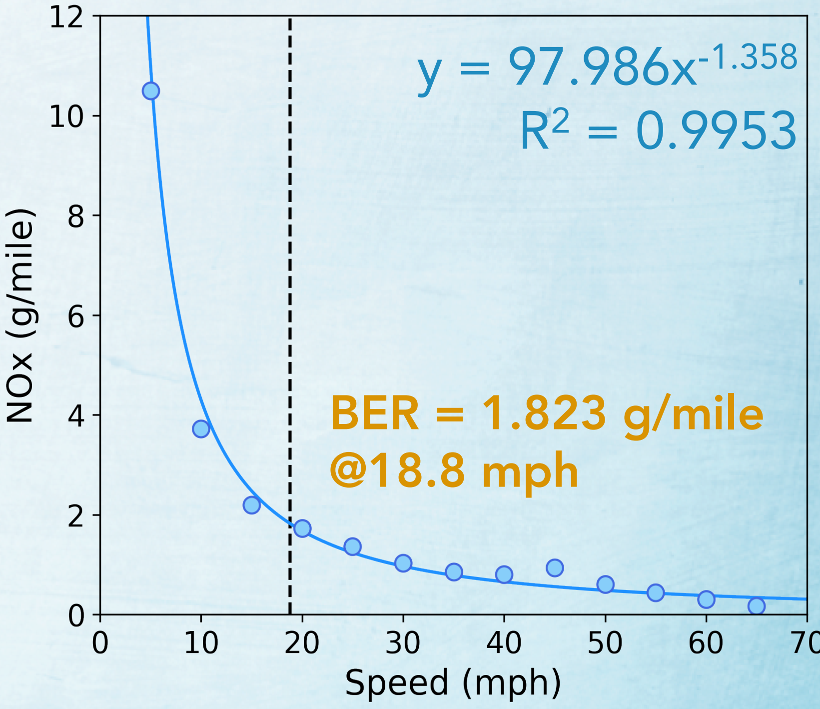

**BERs are calculated at different speeds for each vocation

	Transit Bus	School Bus	Refuse	Other HDV
BER Speed	12.1 mph	12.3 mph	7.31 mph	18.8 mph

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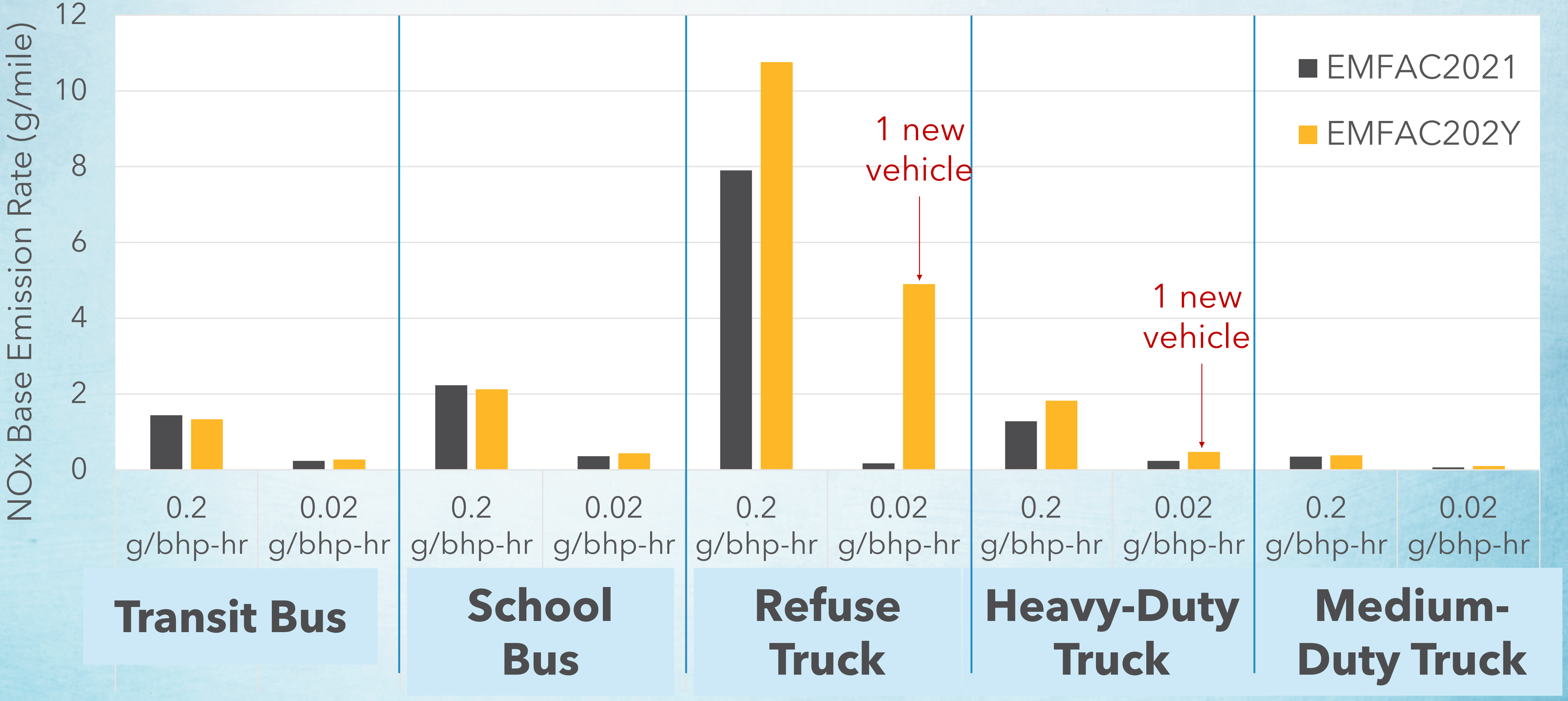
NG Base Emission Rates Generally Increased



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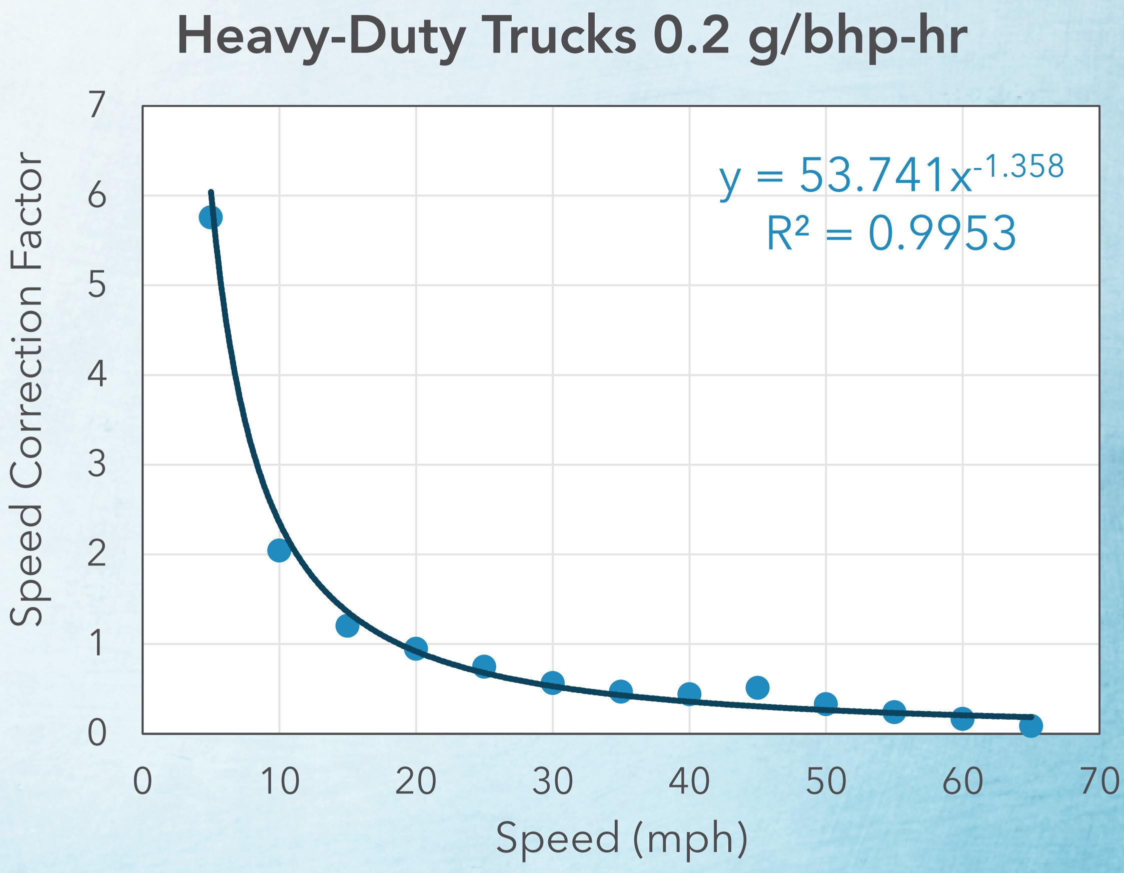
Updated Speed Correction Factors (SCFs)

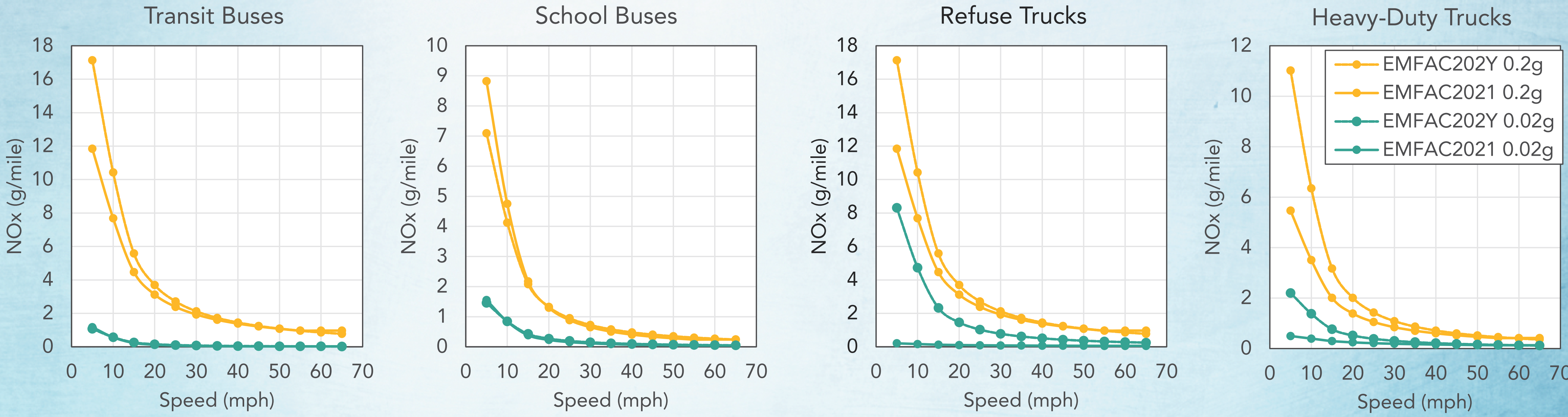
Speed Correction Factors account for variation of emissions under different speeds

Emission Rate = (BER) × (SCF)



Results: Emission Rates by Speed

EMFAC202Y vs. EMFAC2021



Emission rates generally increased at lower speeds, but are similar at higher speeds.
These updates lead to an <u>increase</u> in total natural gas vehicle NOx emissions from **0.28 tpd** to **0.33 tpd** (an 18% increase) in the Los Angeles (SC) sub-area in CY 2025.

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Fuel Cell Electric Vehicle Hydrogen Consumption Rates

Background

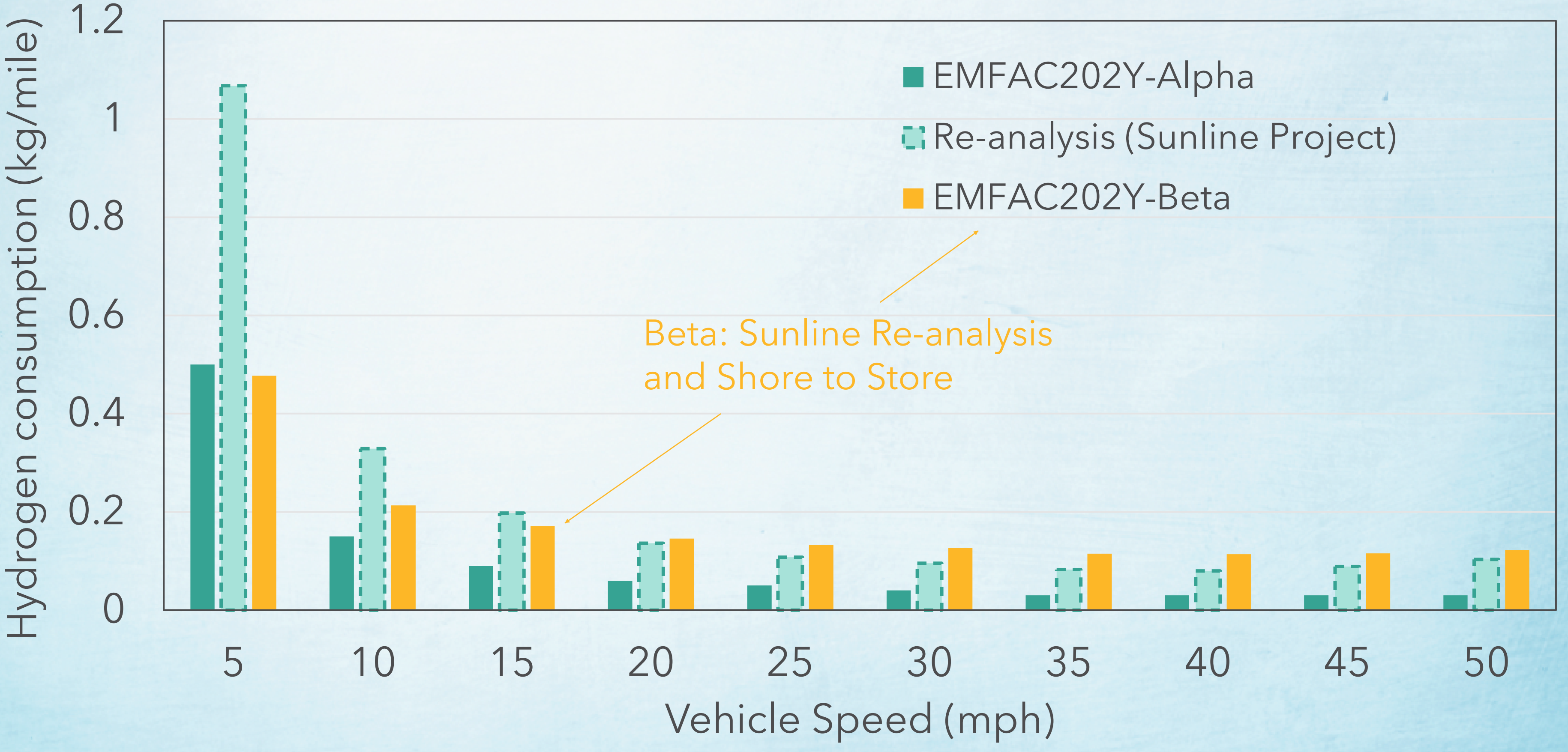
- In EMFAC2021, heavy-duty ZEV was assumed to be entirely battery electric vehicles (BEV)
- In EMFAC202Y, ZEV population will be split into BEV and fuel cell electric vehicles (FCEV) to support hydrogen demand assessment (e.g., SB 643)
- Electricity (kWh) and hydrogen (kg) demands will be output of EMFAC202Y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

Hydrogen Consumption Rate Updates

- **EMFAC202Y Alpha**
  - Light-duty FCEV (e.g., LDA, LDT1, LDT2, MDV): adopted from survey data provided by manufacturers.
  - Heavy-duty FCEV: derived from the SunLine project that included data collected from hydrogen fuel cell transit buses in the Coachella Valley for ~1 year.
- **EMFAC202Y Beta**
  - Light-duty FCEV vehicles: no change
  - Heavy-duty FCEV: updated based on data from the SunLine and Shore to Store projects. Shore to Store includes data from ten Class 8 heavy-duty hydrogen fuel cell drayage trucks operating in Southern California for over 13 months.

Updated Hydrogen Consumption Rate (Heavy-duty)

Updated hydrogen consumption rates in Beta are higher than in Alpha in all speed bins except for speed bin 5 (speed ≤ 5 mph)



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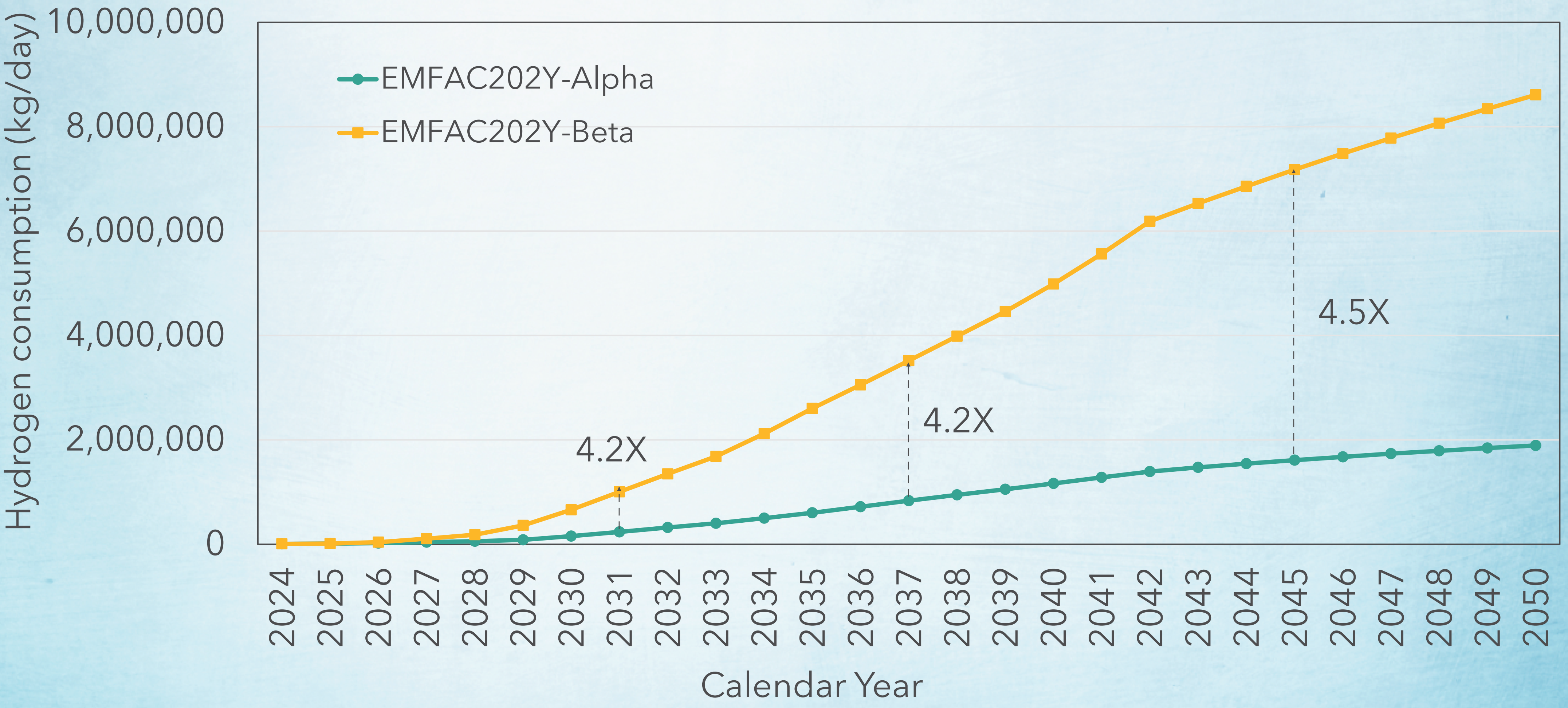
Impacts on Statewide Hydrogen Consumption



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Energy Module: Next Steps

- Implement updated hydrogen consumption rates on EMFAC202Y-Beta
- Update the energy module of EMFAC when new data becomes available in the future

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Next Steps

Public Process of EMFAC202Y Development

Today

3rd Public Workshop

Oct 23, 2024

Nov 2024

Release of EMFAC202Y Beta

Final Public Workshop

Early 2025

Spring 2025

Release of EMFAC202Y Final

Release of EMFAC Technical Documentation and Submission of EMFAC202Y to U.S. EPA

Summer 2025

Next Steps for EMFAC202Y Development

- **Beta Release (November 2024)**
  - Package includes beta web platform, desktop application, and a Questions-Answers document.
  - Opportunity to receive additional feedback from stakeholders on functionality and emissions results.
  - Reflect all feedback provided by beta testers.
- **Final Public Workshop (Early 2025)**
- **Finalize and release EMFAC202Y (Spring 2025)**
- **Request U. S. EPA approval for use in SIP development and transportation conformity in California (Summer 2025)**

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Question and Answer (2)

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