Mobile Source Emissions Inventory and Assessment Updates for 2013

California Environmental Protection Agency
AIR RESOURCES BOARD

October 8, 2013

The Air Quality and Climate Challenge

- 2023 ozone attainment: 80 ppb
  - Estimated 80% reduction in NOx emissions from current levels in the South Coast
- 2032 ozone attainment: 75 ppb
  - Estimated 90% reduction in NOx emissions from current levels in the South Coast
- 2020 and 2050 Greenhouse Gas Emissions Goals

Mobile Source Inventory Uses

- Ozone and PM2.5 Planning
- Climate Change Planning
- Regulatory Support

Ozone and PM2.5 Planning

- Air Quality Planning is region-specific
  - MPO activity data must be used
- Analyses support SIP development
  - Planning inventories
  - Spatially and temporally resolved modeling inventories
- Analyses support regional transportation planning
  - Conformity
  - Project level assessment

Greenhouse Gas Planning

- Planning activities at State and Regional levels
- Statewide GHG inventory based on fuel sales
  - CO_2 estimates need to be consistent with statewide fuel sales data
- SB375 Plans linked to MPO activity estimates
  - MPOs need a tool to support development of sustainable communities strategies under SB375

Regulatory Support

- Analyze impacts of proposed new regulations
  - Criteria and Greenhouse gases
- Emissions standards for new vehicles
- Programs to control in-use vehicle emissions
  - Fleet rules

Meeting Planning Needs

- Multiple scales and pollutants
  - Statewide (climate), regional (NAAQS), local (projects)
- Multiple future scenarios
  - Dynamic activity estimates
  - Vehicle and fuel technologies
  - Transportation efficiency
- Improved spatial and temporal resolution for air quality modeling

Tools Are Expanding

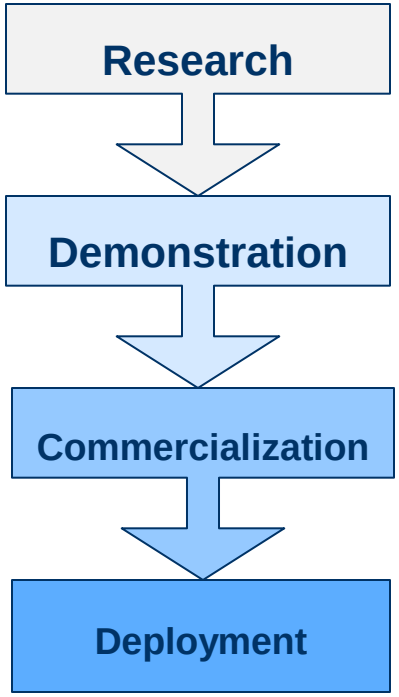
- Transportation and air quality modeling efforts are responding in light of climate change and more stringent ozone standards
- No single tool can meet all needs
- All tools need quality input data
- Need flexible tools for improvement over time

Developing Mobile Source Tools

- Analyses combine many types of information
  - Vehicle ownership and registration
  - Vehicle emissions control technologies, durability
  - Vehicle testing programs and scientific studies
  - Fuel sales, vehicle miles traveled statistics
  - Regulatory and compliance data
  - Future vehicle technology characteristics
- Goal is to synthesize data into an understanding of each vehicle category at a technology/operational level
- Vehicle testing provides scientific basis for emissions assessment

Coordinated Vehicle Testing Programs

- Testing occurs at every level of technology development



  - Control strategies, alternative fuels
  - Pilot projects - emissions testing
  - Verification, certification
  - Deployment / in-use
    - Surveillance / research level testing
    - Focus on real-world conditions

ARB's Suite of Tools

- On-Road Sources
  - EMFAC2013
  - Cal-VAD
- Off-Road Sources
  - Category-specific models
- Planning Scenario Analysis
  - ARB's Vision Tool

Today's Workshop: Mobile Source Inventory Updates

- Ocean-Going Vessels
  - Updated activity and forecast, draft results
- EMFAC2013
  - Methods, updates, draft default model results

Ocean Going Vessels

Background

- Ocean-going vessels are a significant source of emissions around the ports and coastal shipping lanes.
- 2011 OGV model used for 2011 CARB fuel rule amendments and the 2012 SIP updates.
  - Updates to the model accounting for the recession
- Proposed updates to the OGV model:
  - Updates on recession and longer term growth forecasts
  - NOx control factor calculation methodology.

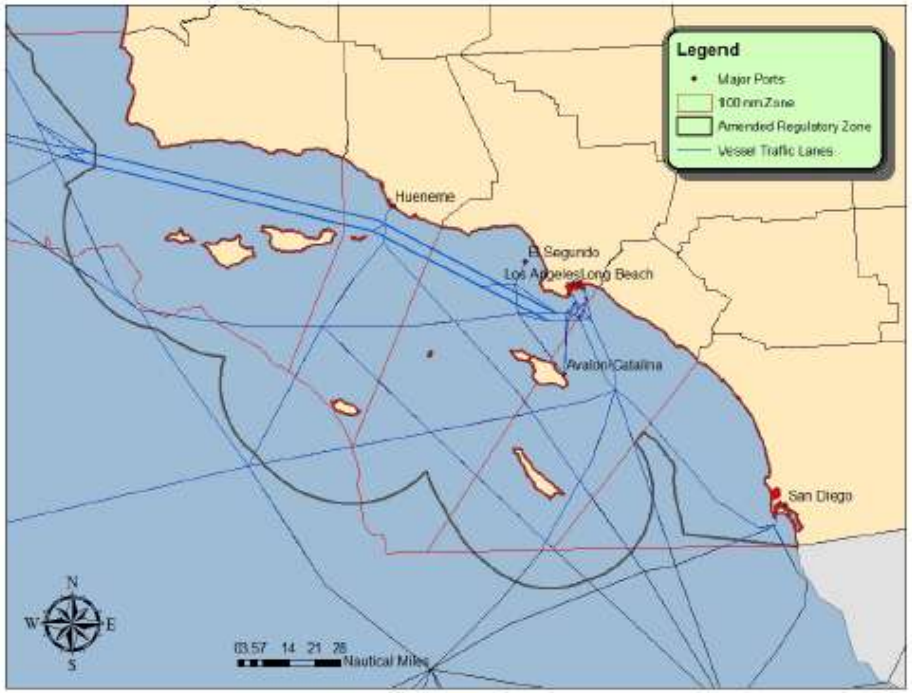
Ocean-Going Vessels in California

- There are a variety of ocean-going vessels operating in the waters off California
- Number of vessels calling on each port provided by State Lands Commission

	Description
Auto	Vessels designed to carry autos and trucks.
Bulk Cargo	Bulk carriers are vessels used to transport bulk items such as mineral ore, fertilizer, wood chips, or grain.
Container	Container vessels are cargo vessels that carry standardized truck-sized containers.
General Cargo	Vessels designed to carry non-containerized cargo such as steel, palletized goods, and heavy machinery.
Passenger	Passenger cruise vessels are passenger vessels used for pleasure voyages.
Reefers	Vessels used to transport perishable commodities which require temperature-controlled transportation, mostly fruits, meat, fish, vegetables, dairy products, and other foods.
Ro-Ro	A vessel designed to carry large wheeled cargo such as large off-road equipment, trailers or railway carriages. Ro-Ro is an acronym for "roll on/roll off".
Tankers	Vessels designed to transport liquids in bulk.

Vessel types

OGV Operating Modes



- **Transit Operation**: operation between ports within 100 nm of California coastline.
- **Maneuvering**: slow-speed operation within port areas.
- **Hoteling**: in-port operation while moored to a dock.

OGV Activity Data Sources

- Transit Activity (hours):
  - Lane length and vessel speed acquired from USACE and Lloyd's Fairplay.
  - Applies to main engines and auxiliary engines.
- Maneuvering Activity (hours):
  - Lane length and vessel speed acquired from discussions with port officials.
  - Applies to main engines, auxiliary engines, and boilers.
- Hoteling (hours):
  - Values obtained from port-specific Wharfinger data.
  - Applies to auxiliary engines and boilers.

Other Inventory Inputs and Data Sources

- Engine Horsepower
  - Acquired from Lloyd's Fairplay Register.
  - Specific to vessel type and engine type.
- Load Factors
  - Based on vessel boarding programs and surveys done at the Ports of Los Angeles and Long Beach.
  - Specific to vessel type and transit mode.
- Emission Factors (NOx, SOx, PM)
  - Based on published literature.
  - Specific to engine speed and fuel type.

Current OGV Forecasting

- Emissions forecasting (2006-2040):
  - Based on growth factors developed from trends in net registered tonnage (NRT) from 1994-2005 reported by US Army Corps of Engineers.
  - Specific to port and vessel type.
  - Adjustments made to emissions based on adopted regulations (i.e. CARB fuel rule, ECA) and economic recession (2007-2010).

Ocean Going Vessels

Growth Factor Update

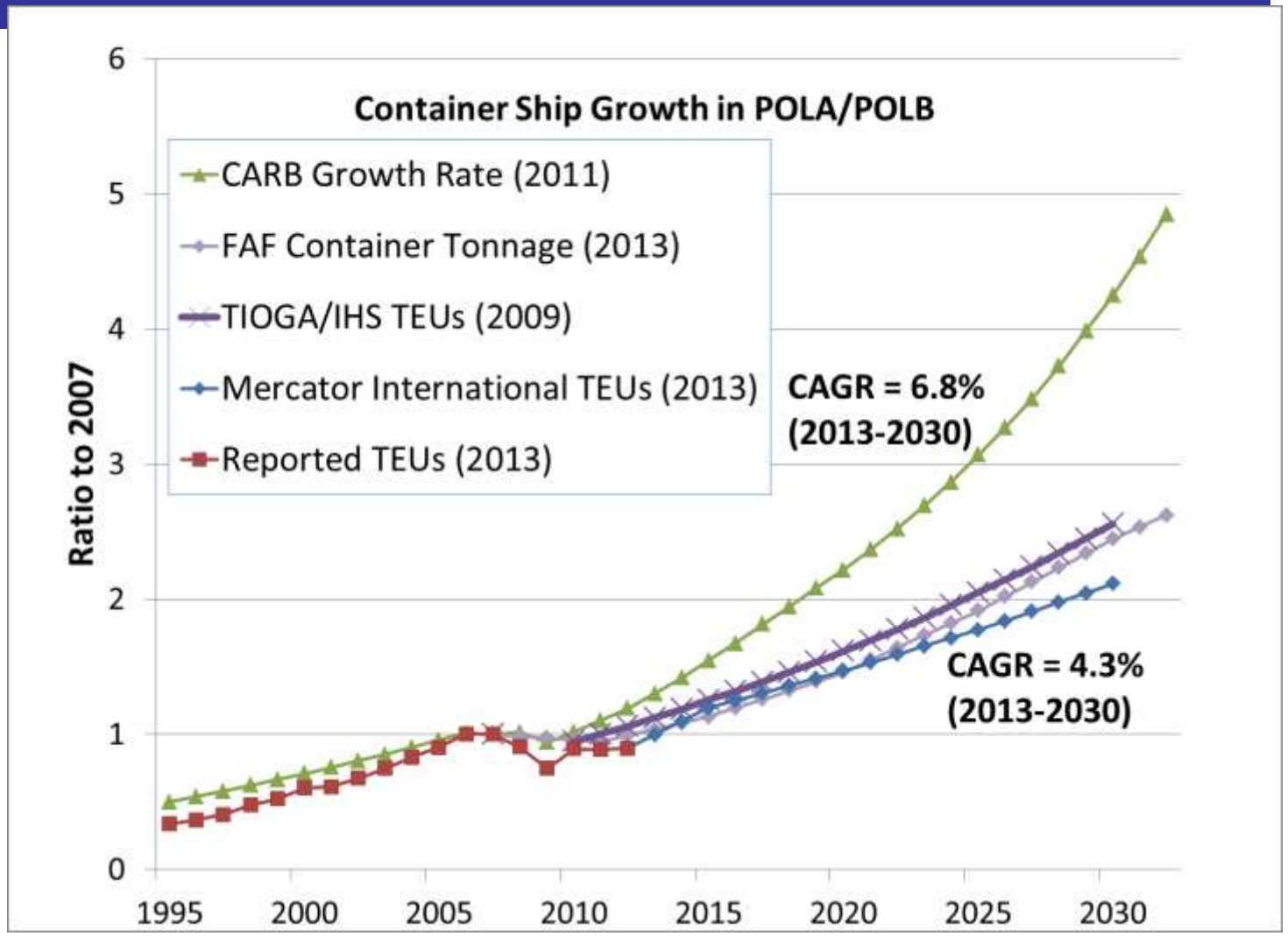
Re-evaluating Our Long-Term Growth Assumptions with New Data

- **San Pedro Bay Ports Forecast (2009)**: provides container ship forecast data for POLA and POLB out to 2030.
- **Mercator International Forecasts (2013)**: provides container ship forecasts for POLA and POLB out to 2030.
- **FHWA FAF Forecast (2013)**: provides freight tonnage by commodity type for various port regions in California out to 2040.
- **San Diego Unified Port District – Cruise Market Update (2011)**: provides cruise forecast for Port of San Diego out to 2040.

Re-evaluating Our Recession Assumptions with New Data

- **POLA/POLB and POAK**: Container ship TEU throughput (2007-2012).
- **San Diego Unified Port District** (2011): Cruise ship activity 2007-2011.
- **U.S. Maritime Administration:** Container, tanker, and auto ship tonnage (2007-2011). Used for developing recession adjustment factors for non-container ship activity.

New data are consistent and indicate current growth rates need to be adjusted



Why use the FAF Forecasts?

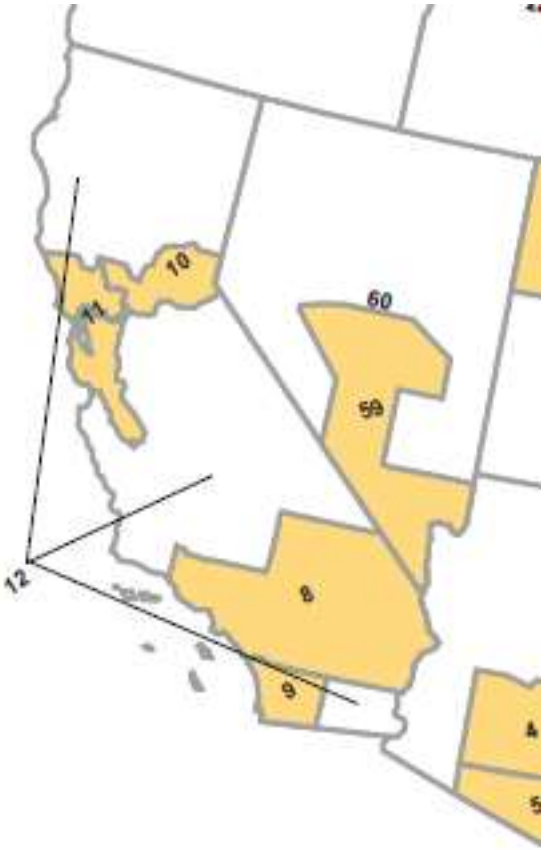
- FAF forecasts are consistent with other projections for container ships.
- FAF model provides growth rates for other vessel types (i.e. tankers, auto, etc.) while other studies only provide container ship forecasts.
- Used for CalTrans Freight Model efforts.

What is the FAF Freight Forecast?

- A forecast of freight transport activity in California and the US based on a model developed for the FHWA in 2013.
- Developed using inputs from the national Commodity Flow Survey (CFS) including origin/destination data, commodity values, weight and transportation mode.
- Provides estimates of water freight tonnage from 2007 – 2040 by FAF region

California FAF Regions

FAF #	FAF Region	California Port
8	Los Angeles CA CSA	**Avalon/Catalina**
8	Los Angeles CA CSA	**POLA**
8	Los Angeles CA CSA	**POLB**
8	Los Angeles CA CSA	**LA-LB**
11	San Francisco CA CSA	**POak**
9	San Diego CA CSA	**POSD**
11	San Francisco CA CSA	**POSF**
10	Sacramento CA-NV CSA	**Stockton**
10	Sacramento CA-NV CSA	**Sacramento**
11	San Francisco CA CSA	**Richmond**
11	San Francisco CA CSA	**Carquinez**
8	Los Angeles CA CSA	**El Segundo**
12	Remainder of CA	**Humboldt**
12	Remainder of CA	**Monterey**
8	Los Angeles CA CSA	**Hueneme**
12	San Francisco CA CSA	**Redwood**

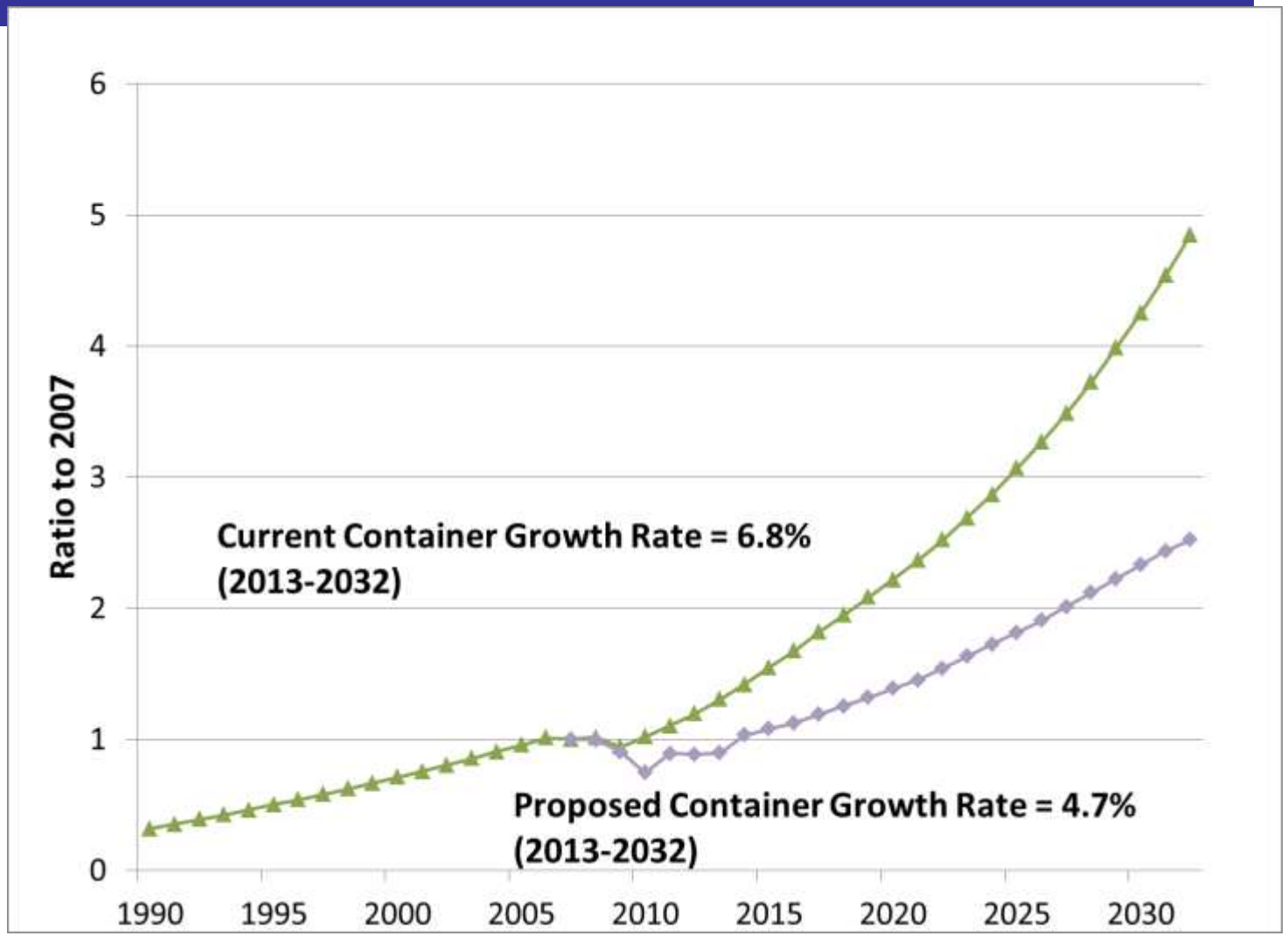


Proposed Updates to Growth

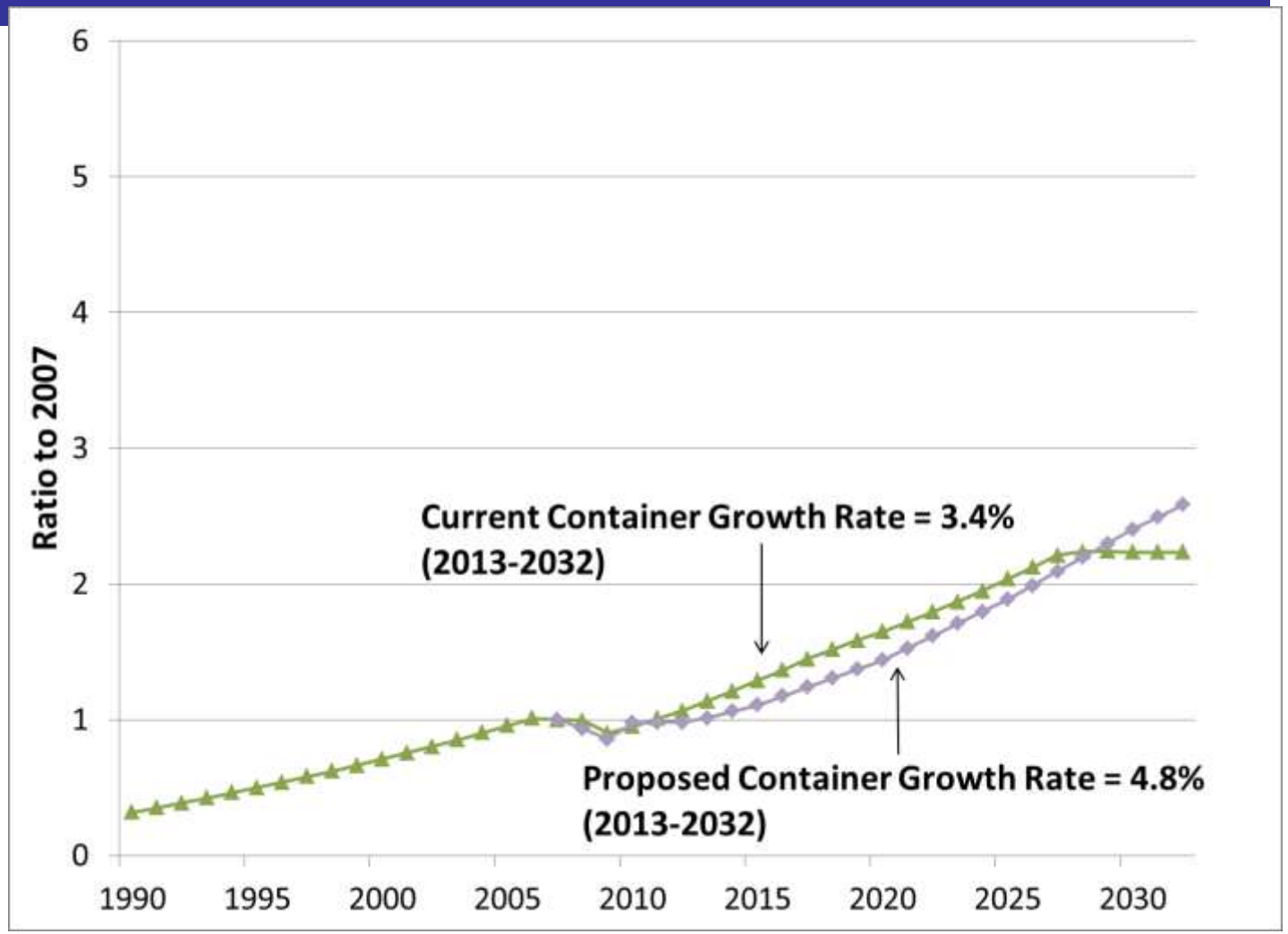
- Will focus on most common vessel types visiting California ports
  - Container ships (46% of all port calls)
  - Tanker ships (20% of all port calls)
  - Cruise ships (9% of all port calls)
  - Auto ships (7% of all port calls)

- In total, updates to growth factors will affect about 82% of statewide port calls

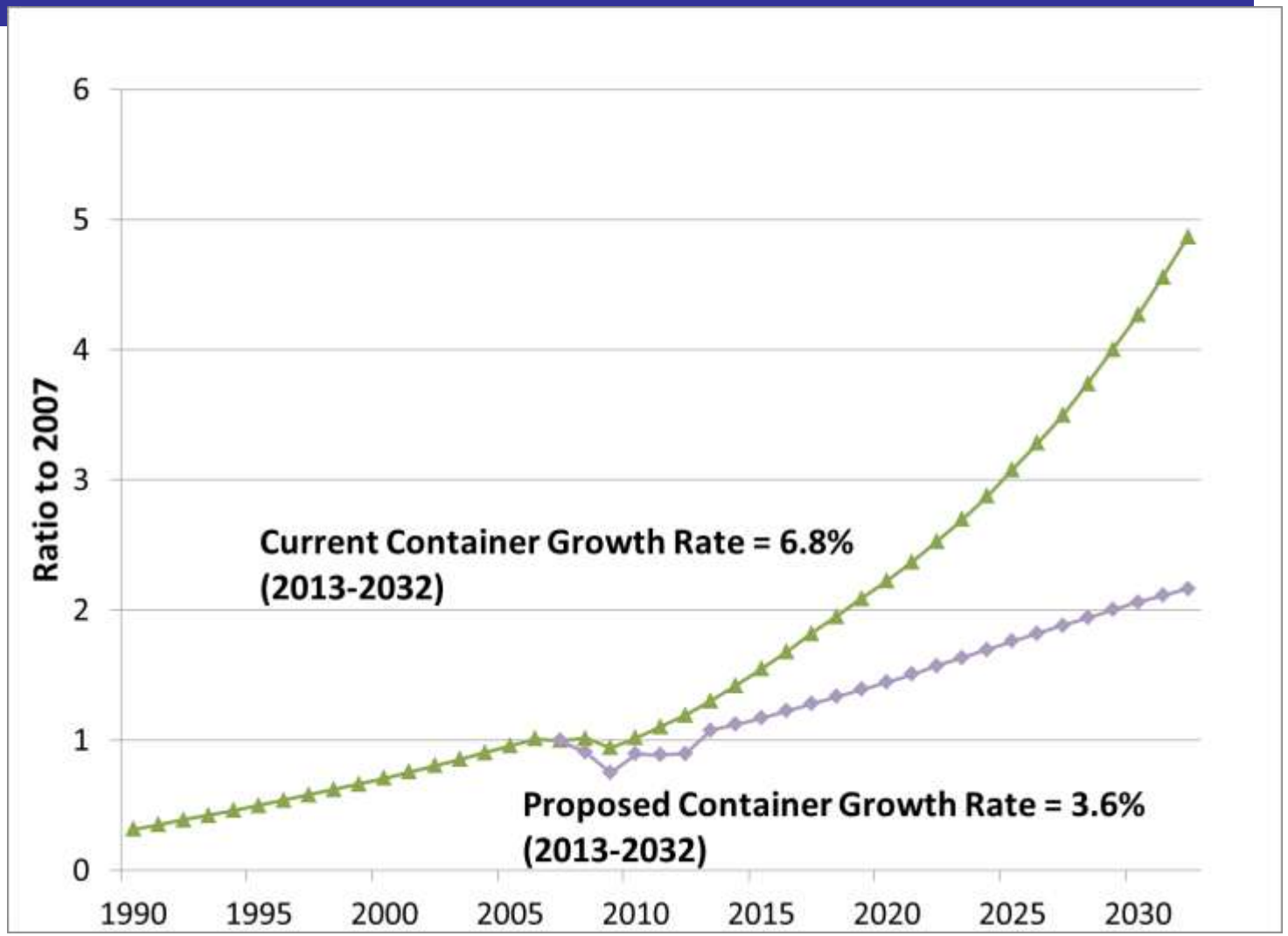
Proposed growth will reduce future container ship activity at LA/LB



Proposed growth will reduce future container ship activity at POAK



Proposed growth will reduce future container ship activity at POSD



Proposed Growth Rates: (2013-2032)

- Proposed growth rates at the Ports of Los Angeles and Long Beach are generally lower:

Vessel Type	% Port Calls	Current Growth Rate	Proposed Growth Rate
Container	51%	6.8	4.7
Tanker	19%	1.3	0.7
Auto	4%	1.7	3.1
Cruise	10%	4.1	8.3

- Proposed growth rates at the Port of San Diego are lower:

Vessel Type	% Port Calls	Current Growth Rate	Proposed Growth Rate
Container	0.4%	6.8	3.6
Tanker	0.4%	5.1	0.1
Auto	23%	4.1	2.4
Cruise	41%	8.6	8.3

Proposed Growth Rates: (2013-2032)

- Proposed growth rates at the Port of Oakland and other Bay Area ports are higher for containers, tankers and cruise ships and lower for autos.

Vessel Type	% Port Calls	Current Growth Rate	Proposed Growth Rate
Container	57%	3.4	4.8
Tanker	24%	0.3	1.1
Auto	3%	4.6	2.8
Cruise	2%	5.3	8.3

Proposed Growth Rates: (2013-2032)

- Proposed growth rates at the Port of Stockton are higher for tankers:

Vessel Type	% Port Calls	Current Growth Rate	Proposed Growth Rate
Tanker	24%	5.4	6.0

Ocean Going Vessels

NOx Control Factors

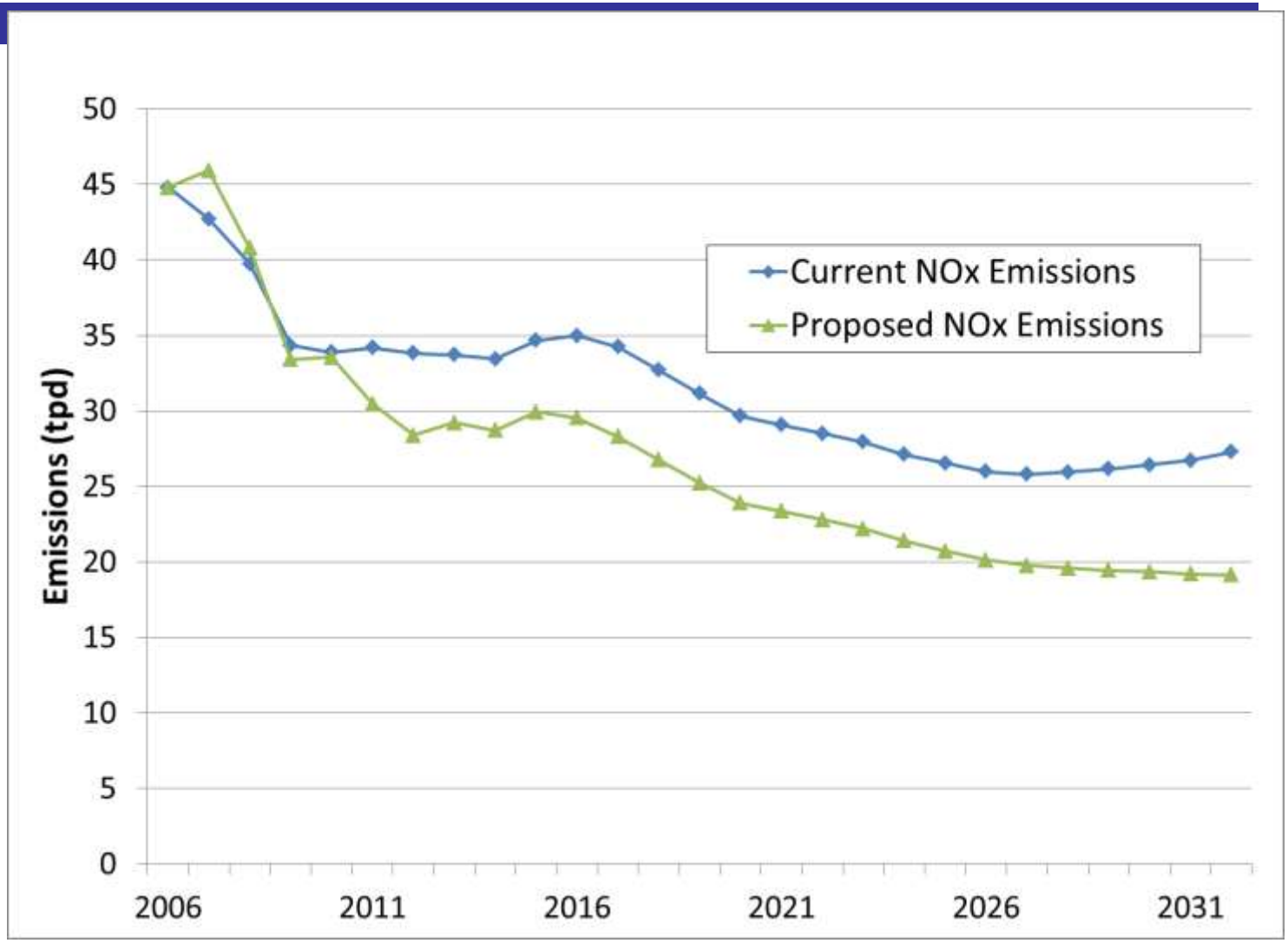
Calculating NOx Control Factors

- Emission factors are a function of certified control level or Tier
- The previous calculation did not weigh the Tier distributions properly
- Updated calculation properly weighs the Tiers to calculate weighted NOx control factors
- Change in calculation methodology decreases overall NOx emissions approximately 6% in 2032 in SCAB.

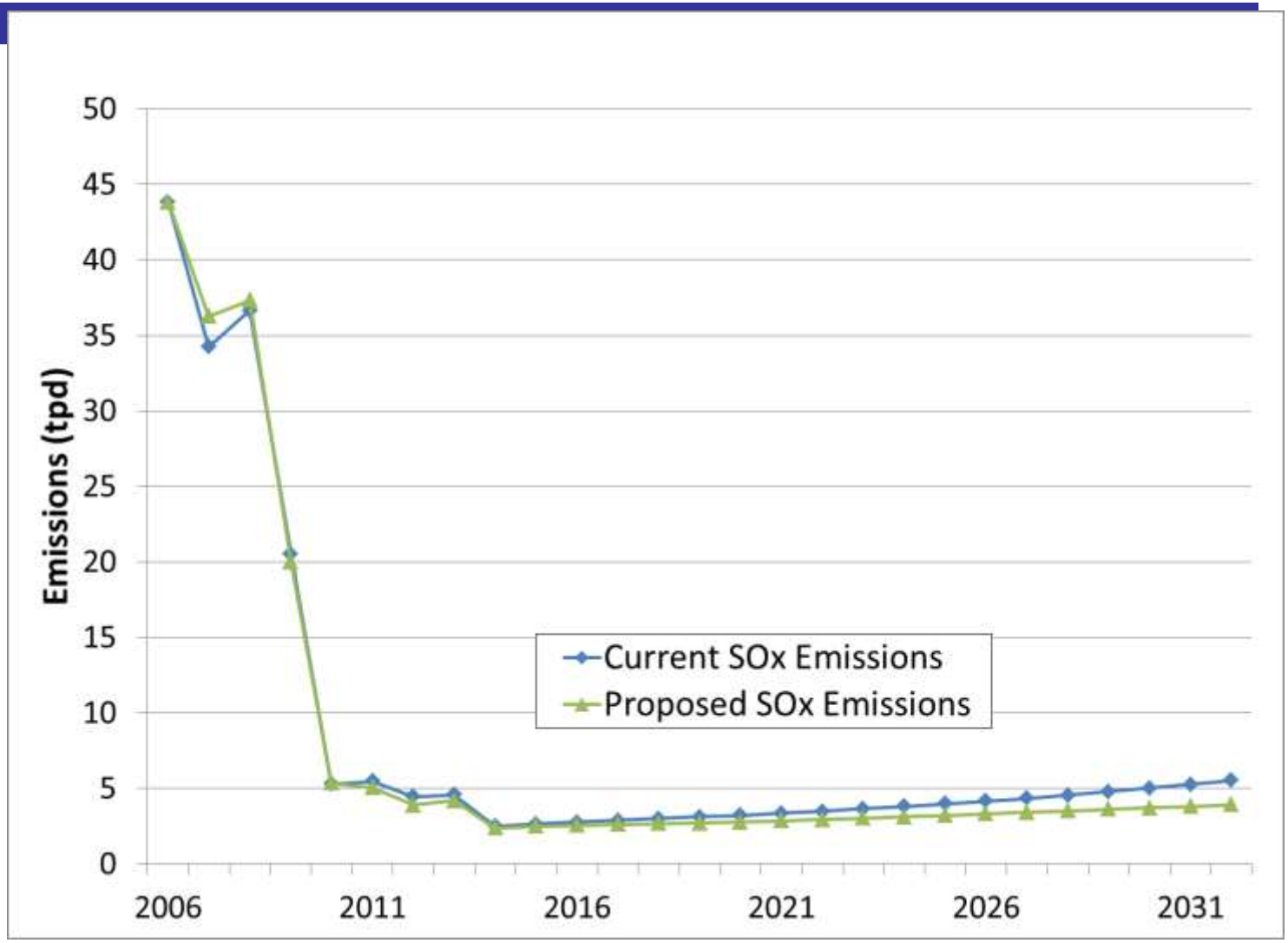
Ocean Going Vessels

Updated Emissions

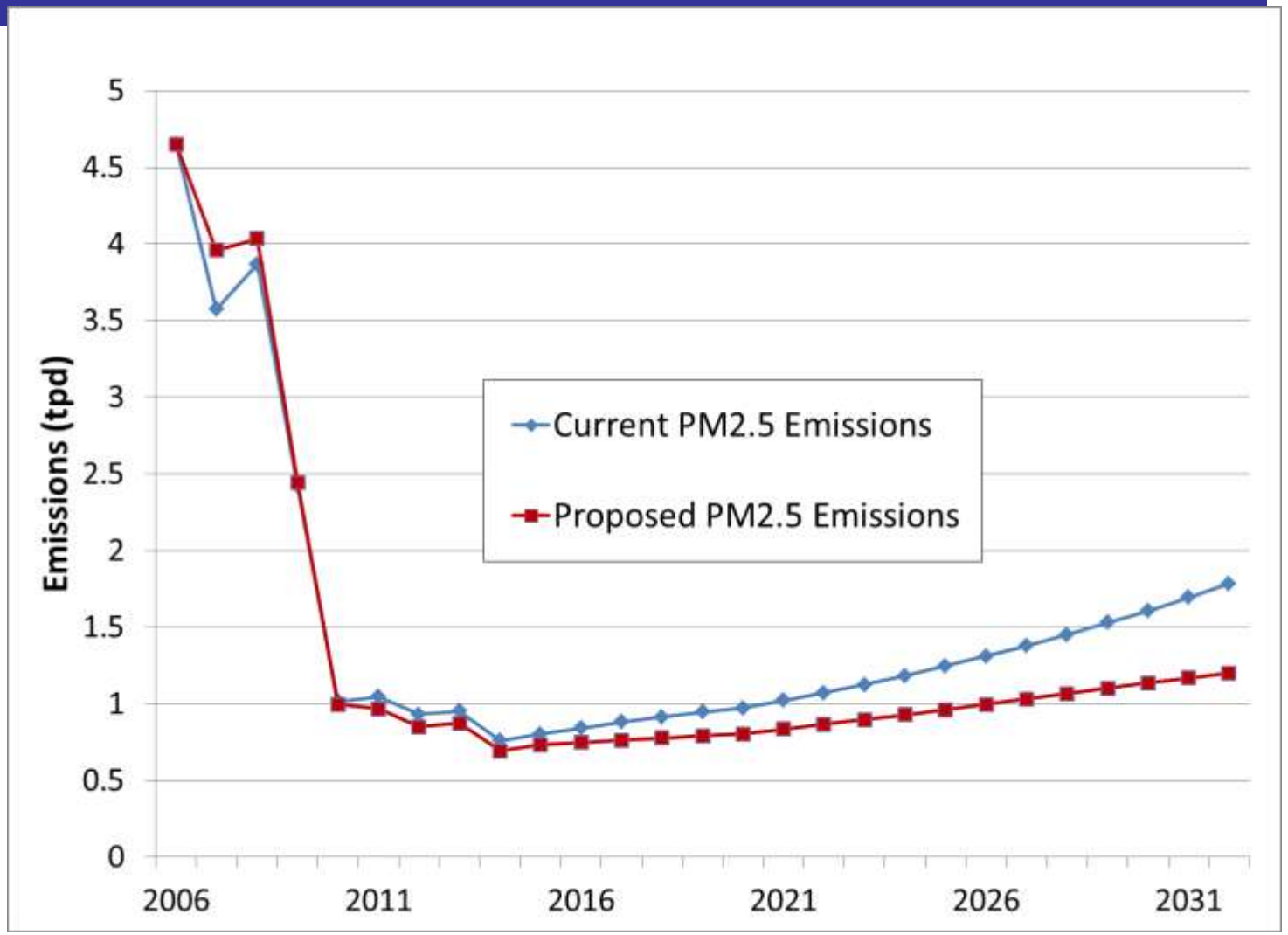
Proposed model updates result in overall lower NOx emissions in SCAB



Proposed model updates result in overall lower SOx emissions in SCAB



Proposed growth rates result in overall lower PM emissions in SCAB



Conclusions

- Updates to the OGV activity growth factors would result in overall lower forecasted emissions for NOx, SOx, and PM in 2032.
- Updates to the NOx control factor calculations result in lower NOx emissions for all ports and vessel types.
- The combined effect of both changes is lower overall forecasted emissions for NOx, SOx, and PM in 2032.

EMFAC2013

EMFAC2013 - Outline

- Overview and Review
- EMFAC2013-LDV
- EMFAC2013-HD
- Combined Emissions Results
- EMFAC2013-SG

EMFAC2013

Overview and Review

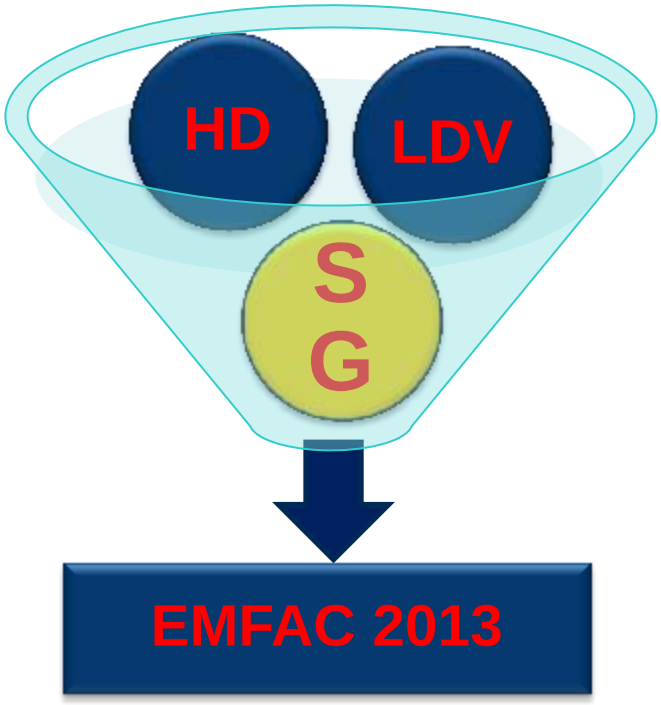
EMFAC Update Plan

- EMFAC2011
  - First step to more flexible structure
- EMFAC2013
  - Ensures consistency with historical fuel use
  - Improves ability to evaluate technology penetration

EMFAC 2013 Model Overview

- One model with new programming architecture
- Match historical fuel sales
- New forecasting methods
  - Vehicle age distribution
  - Statewide and regional VMT
- Integrates Advanced Clean Cars and LCFS
- Updates truck emission factors
- Updates regional planning tools

Model Architecture



- Programming flexibility
- Python/MySQL platform
- HD
  - Diesel T7, T6, non-transit buses
- LDV
  - all gasoline vehicles + urban transit buses and light heavy gas+diesel
- SG
  - Tool for matching regional VMT estimates

Updates Regional Planning Tools

- MPO data must be used for regional planning and conformity
  - SG is the scenario planning tool for these assessments
  - Planning inventories will be based on MPO VMT
- Climate change planning requires consistency with statewide fuel use
  - EMFAC2013 base model estimates will match statewide historical fuel sales data

EMFAC2013

EMFAC-LDV

EMFAC2013-LDV

- Population
- Activity
- Emission Factors
- Advanced Clean Cars
- DRAFT Default Model Output
- Next steps

EMFAC2013

EMFAC-LDV

Population

Population

- Base year population: 2011 DMV Registration
- Retention rates: A combination of attrition and migration rates
- New vehicle sales projections

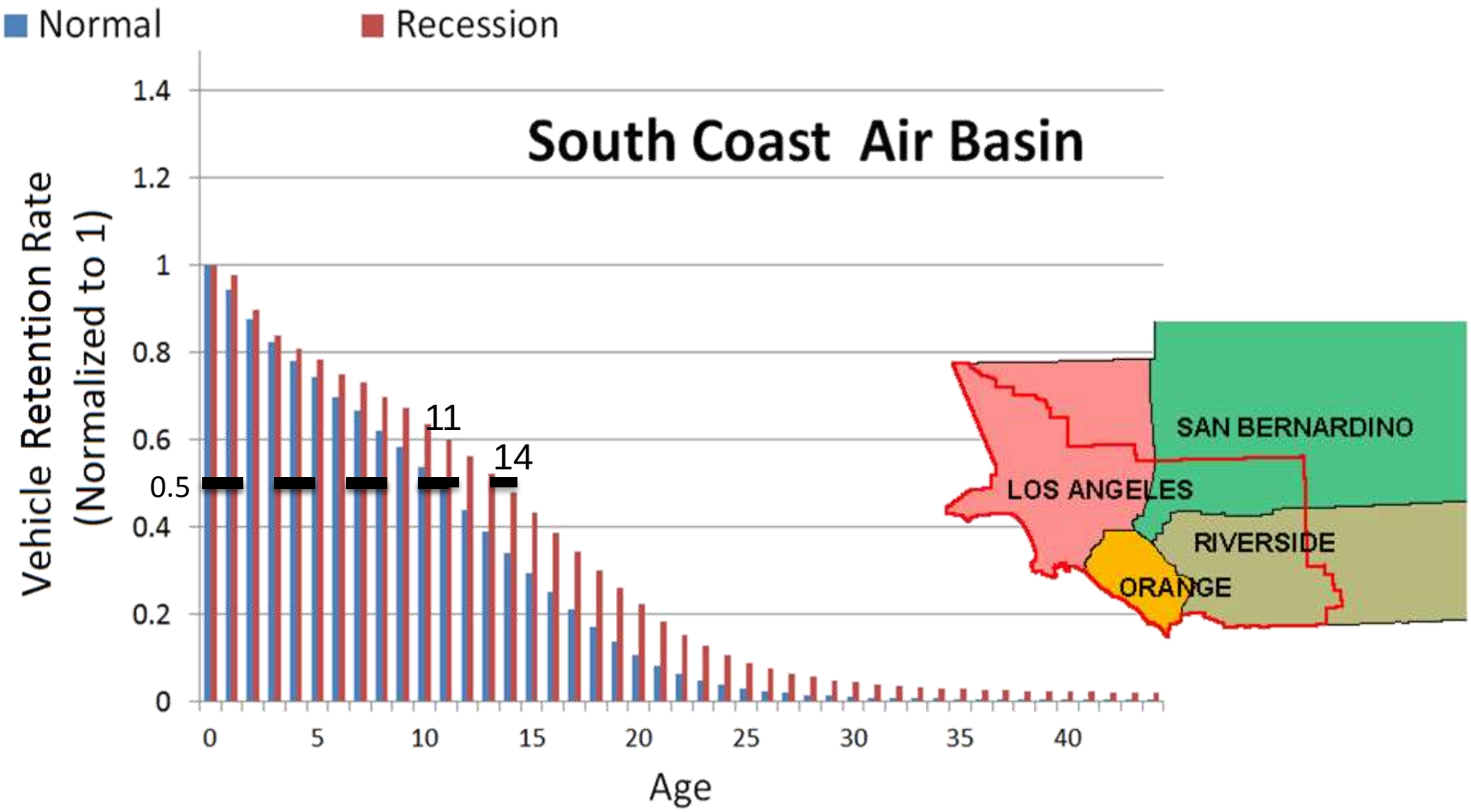
Population: Base Year

- Receive DMV registration data twice a year
- Classify vehicles into vehicle class, fuel, model year, region
  - Based on make/model, weight class, body type, owner/service

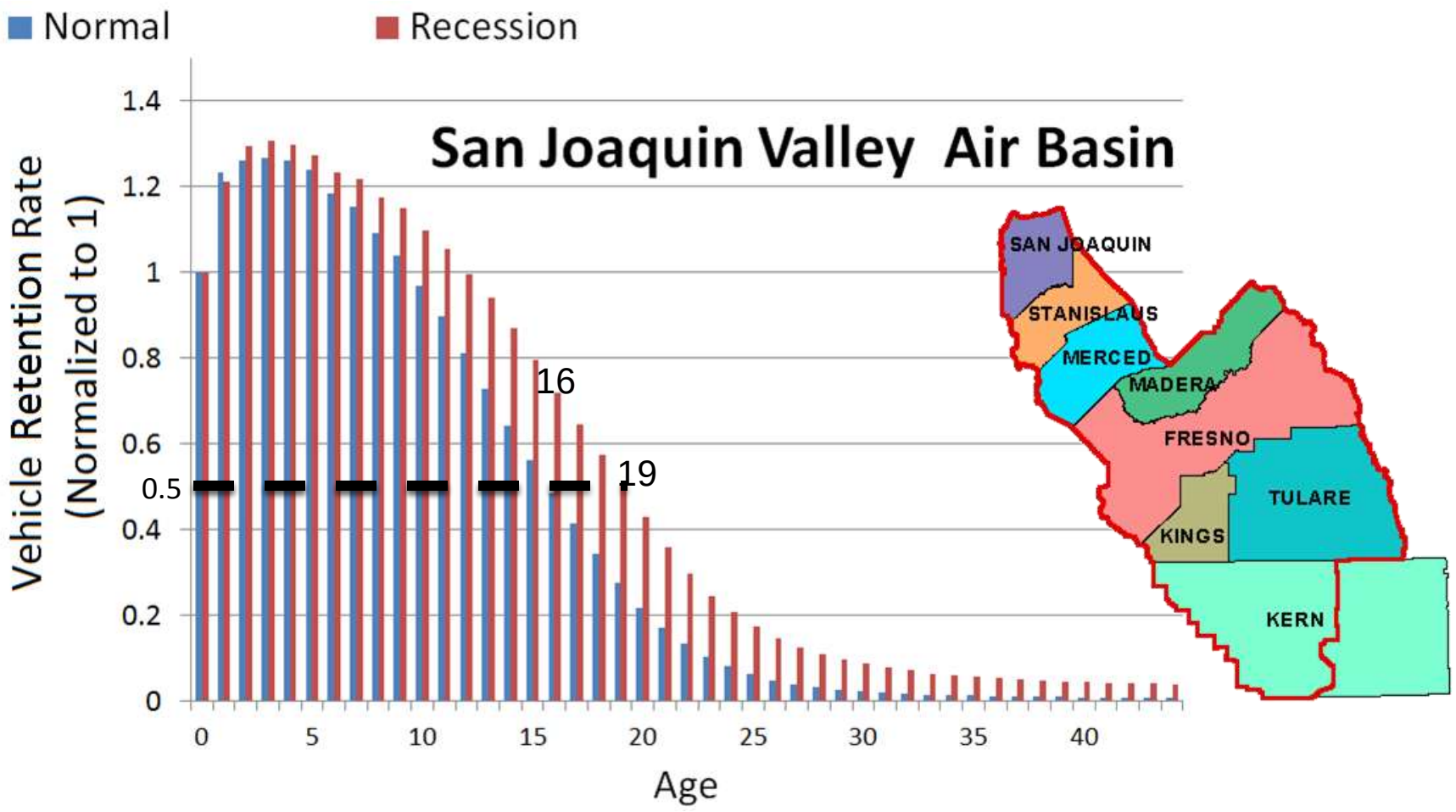
Population: Vehicle Retention

- Forecasting population requires an estimate of retired vehicles
- EMFAC2011 used statewide attrition rates
- EMFAC2013 uses regional retention rates:
  - Estimate retention rates based on year to year changes for a given model year
  - Includes both attrition and migration
  - Recession (2008-2010) vs. Business As Usual (BAU) period (2006-2008)
- People in the San Joaquin Valley keep their vehicles 5 years longer on average than those in South Coast.
- The recession caused people to keep their vehicles 3 years longer on average.

Regional Vehicle Retention



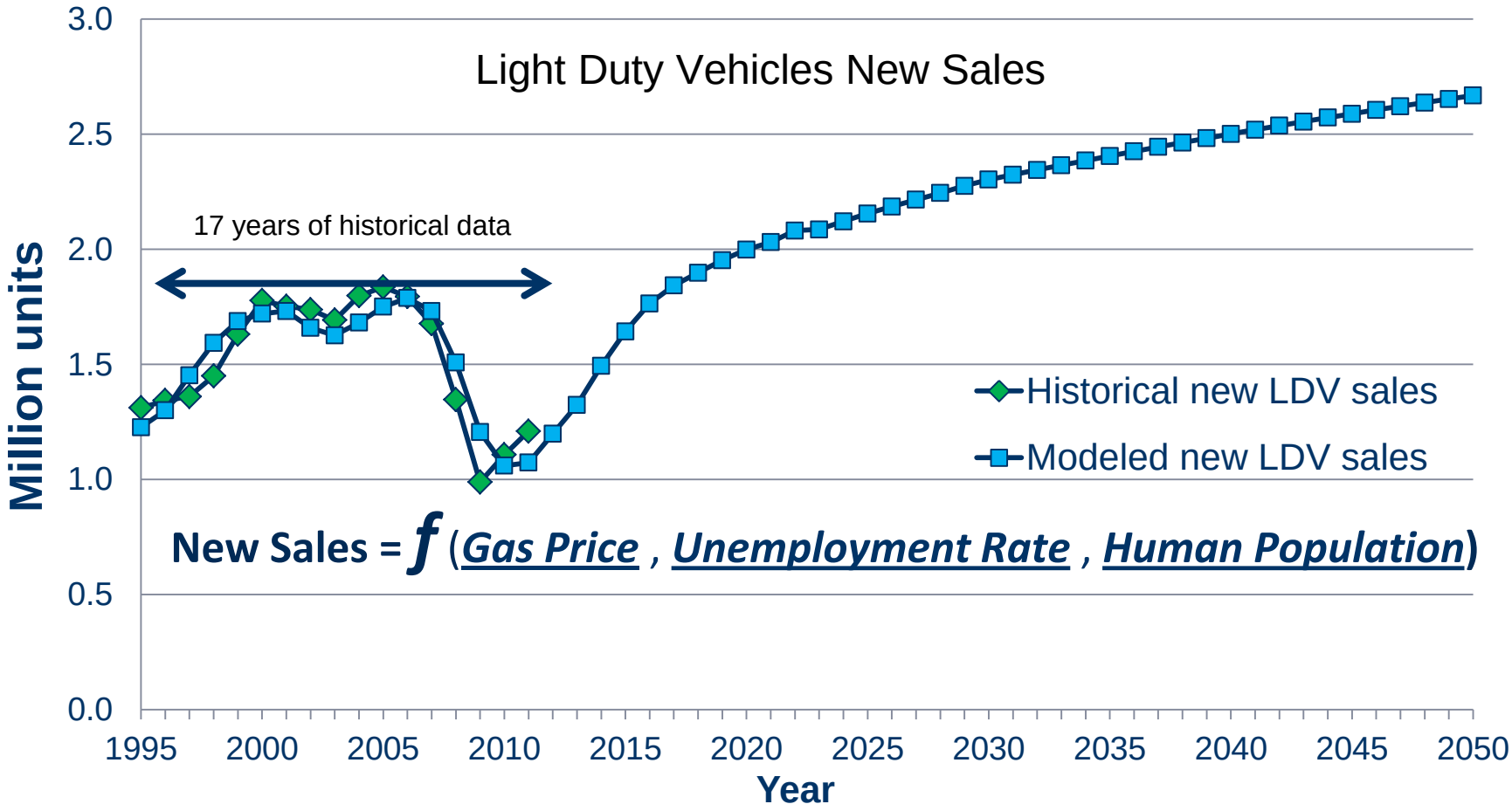
Regional Vehicle Retention



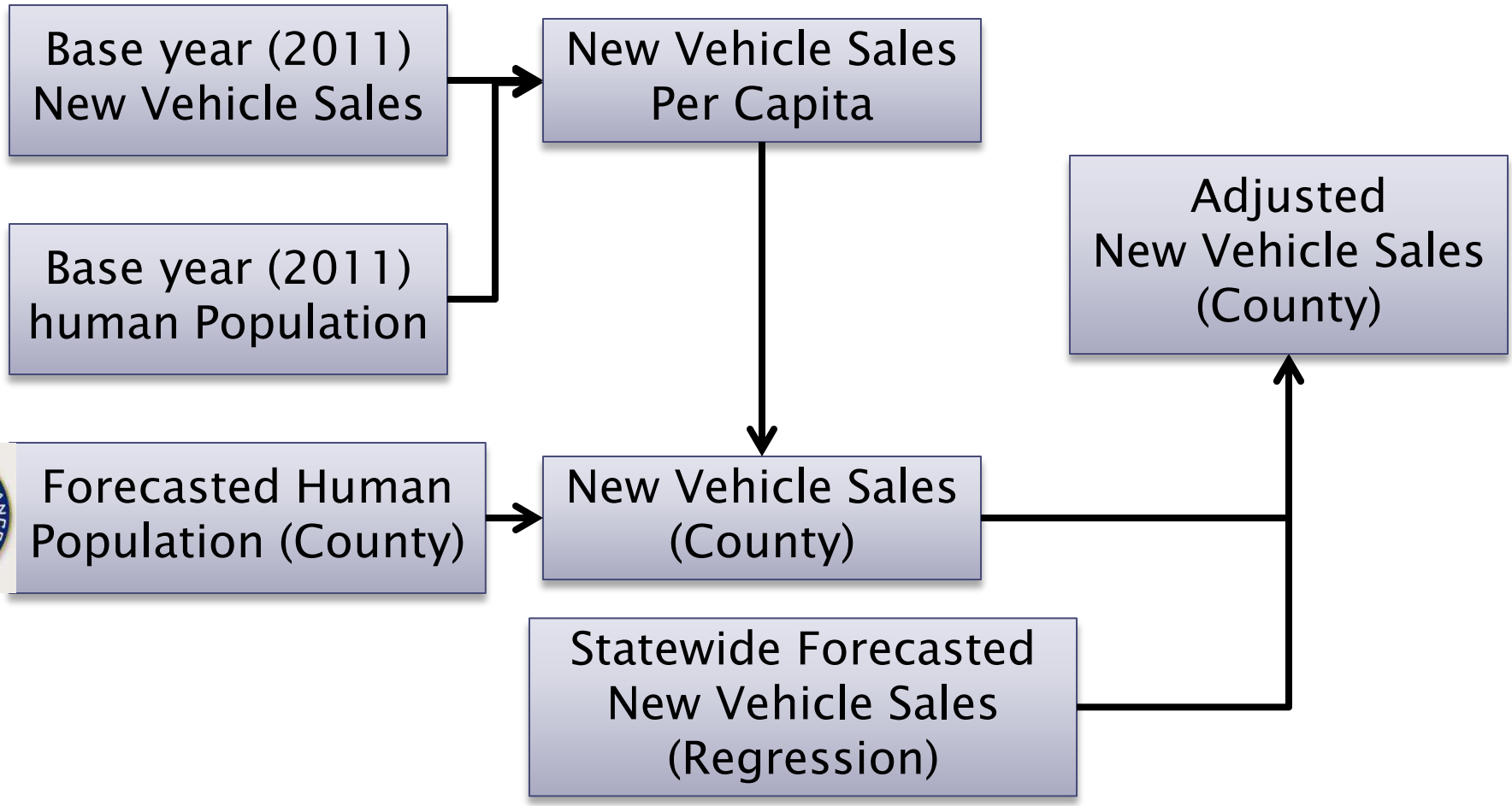
Population: New Vehicle Sales

- Estimated from DMV registration data
  - Supplemented by UCLA forecast historical data
- Forecasted using econometric model
- Approach under development
  - Currently evaluating AEO and other data to corroborate approach

Population: New Vehicle Sales



Population: Distributing New Vehicle Sales



Population: Modeling Methods

Base year (2011) Population

Regional Vehicle Retention Rates

New Vehicle Sales

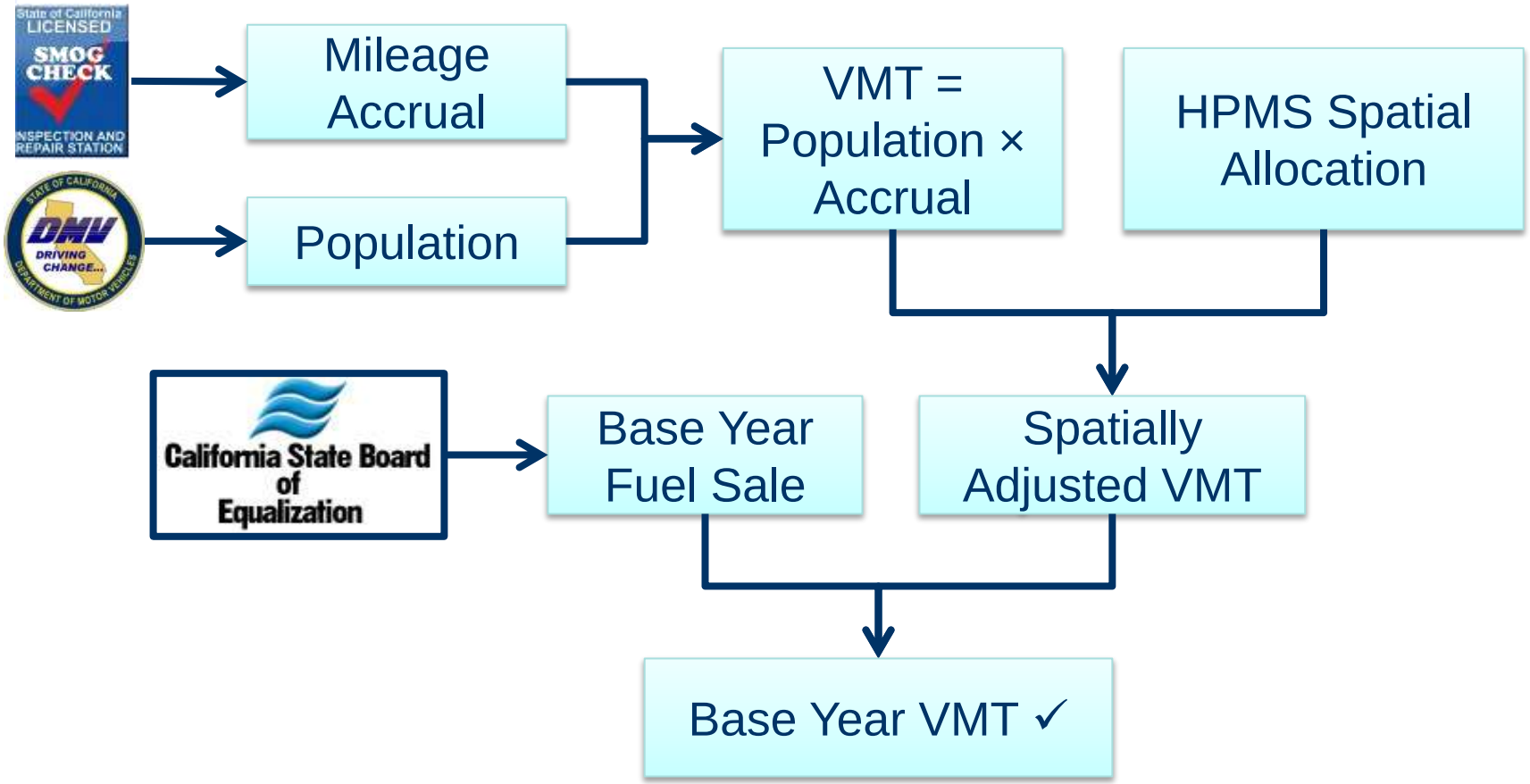
Forecasted Population

EMFAC2013
EMFAC-LDV
Activity

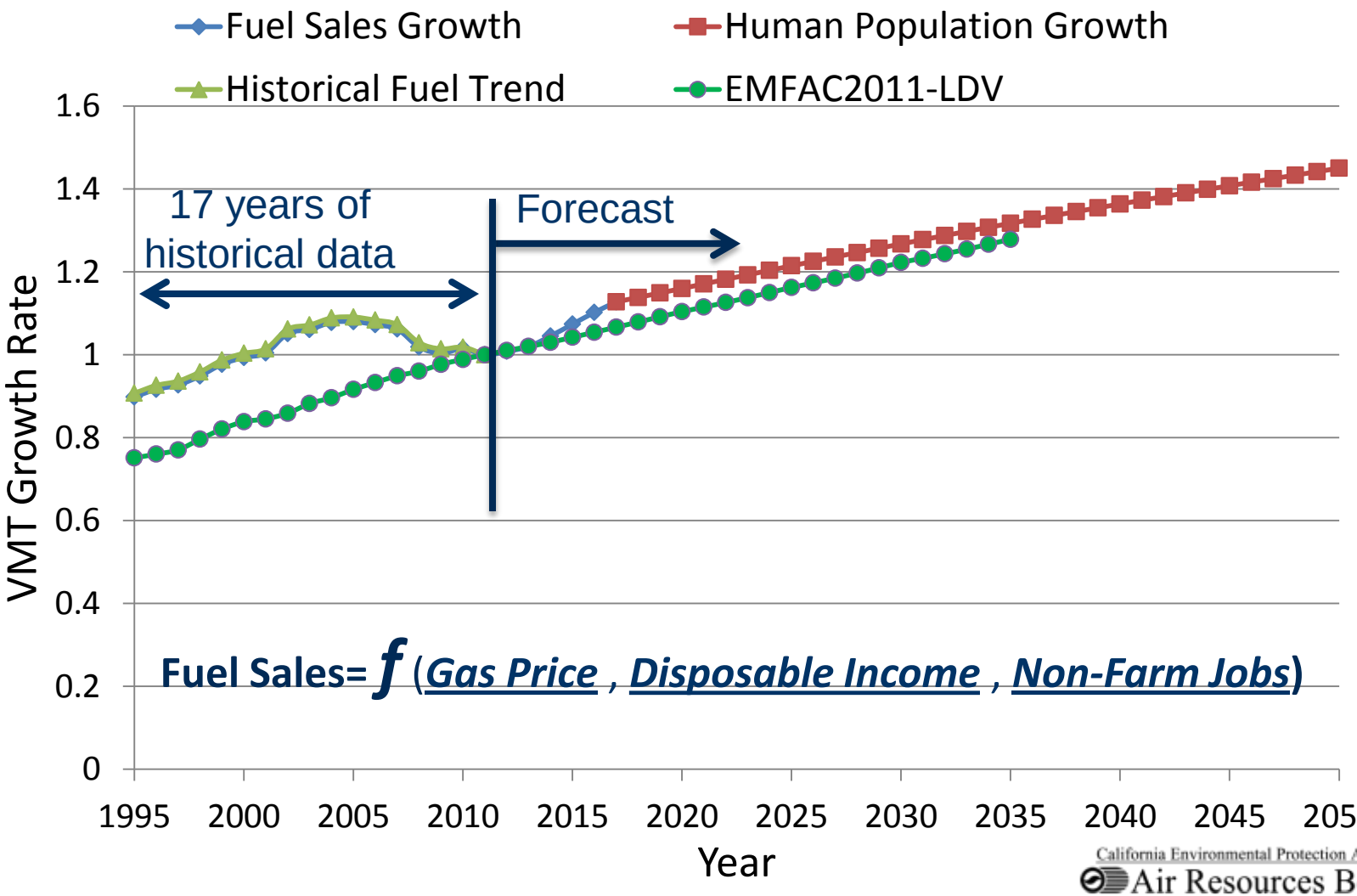
Activity

- Statewide activity matches historical fuel use
- Regional activity estimated
  - Disaggregation using HPMS
- Base mileage accrual from Smog Check reported data
  - Mileage accrual adjusted for each calendar year to match fuel use and population
- Odometer estimated from Smog Check data

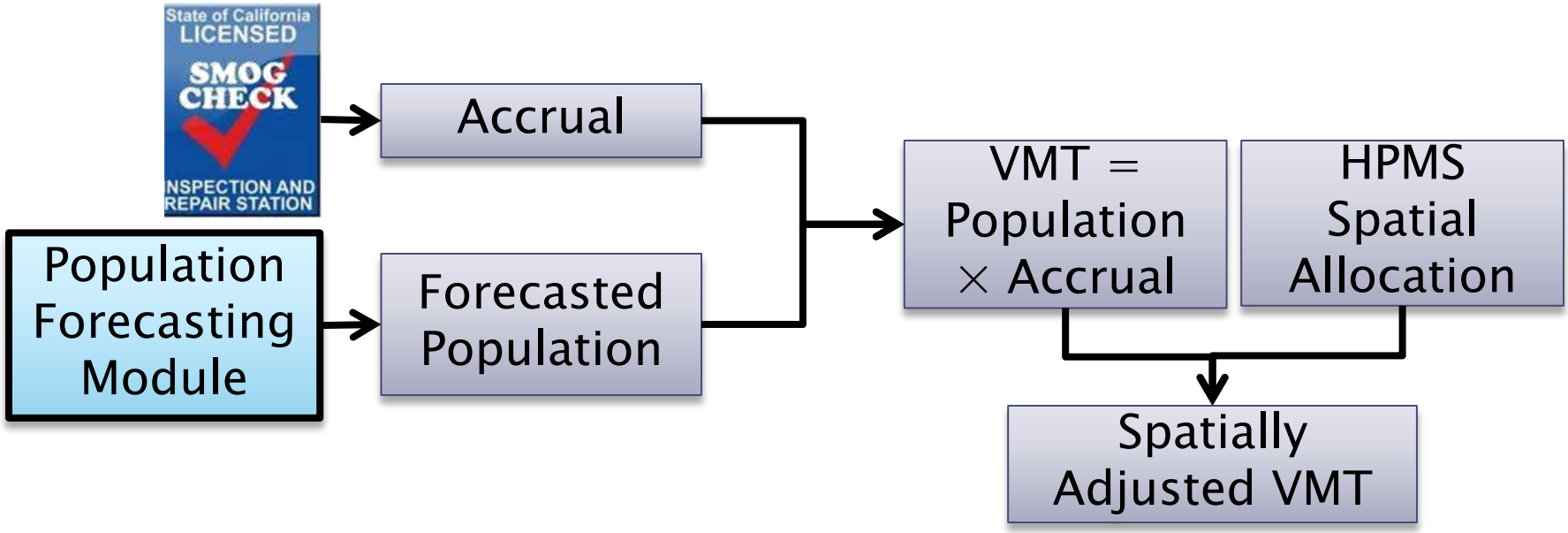
Activity: Base Year VMT Methods



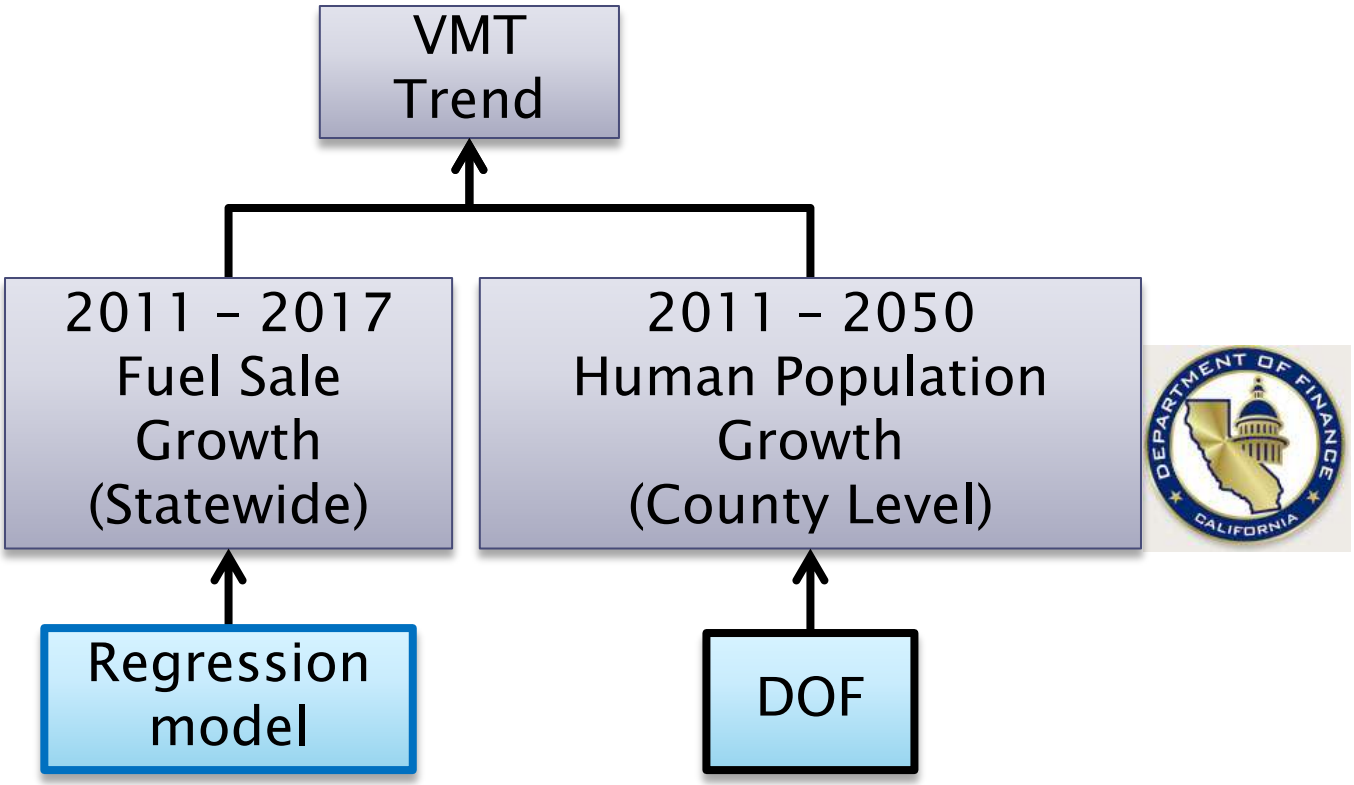
Activity: Forecasting VMT



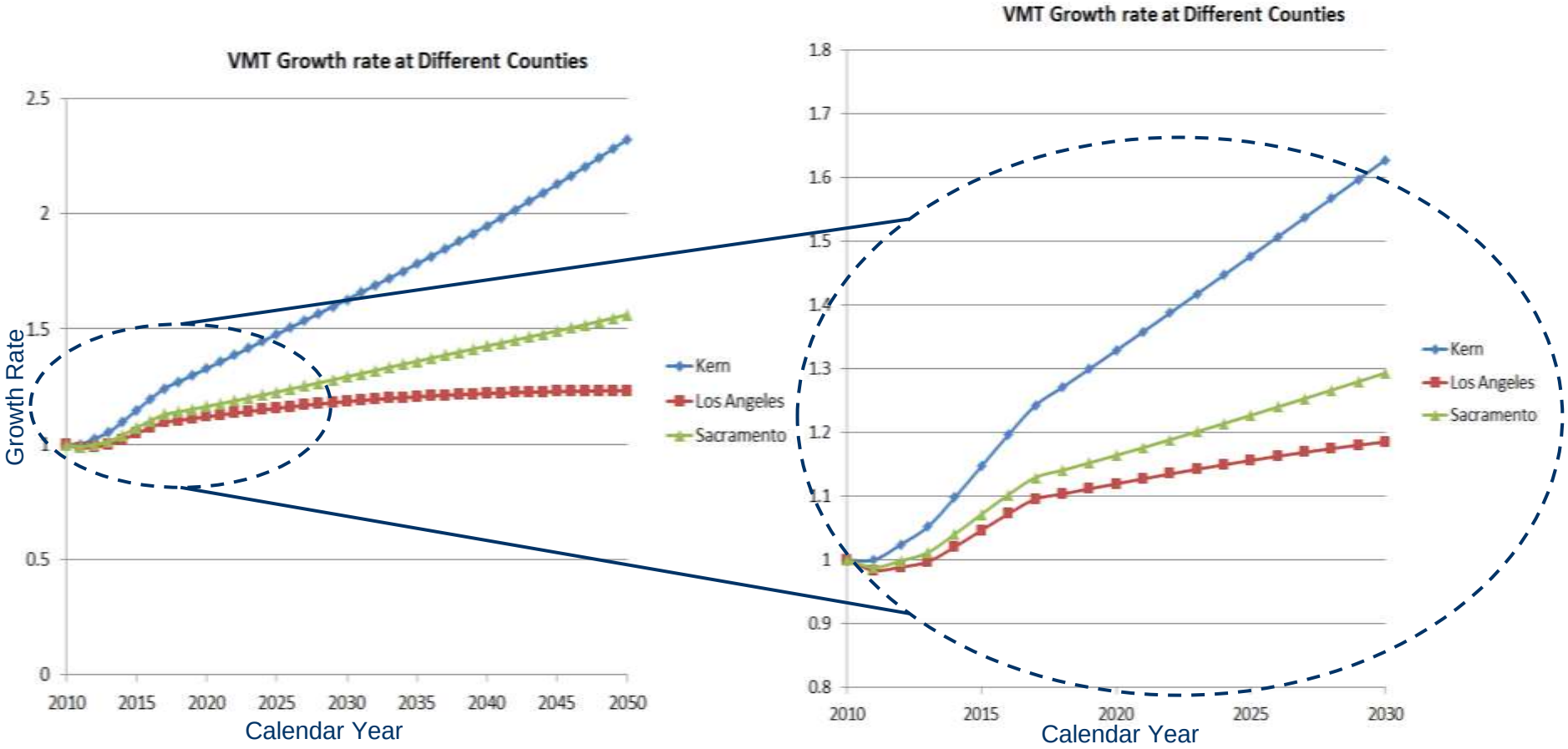
Activity: Allocating VMT Spatially



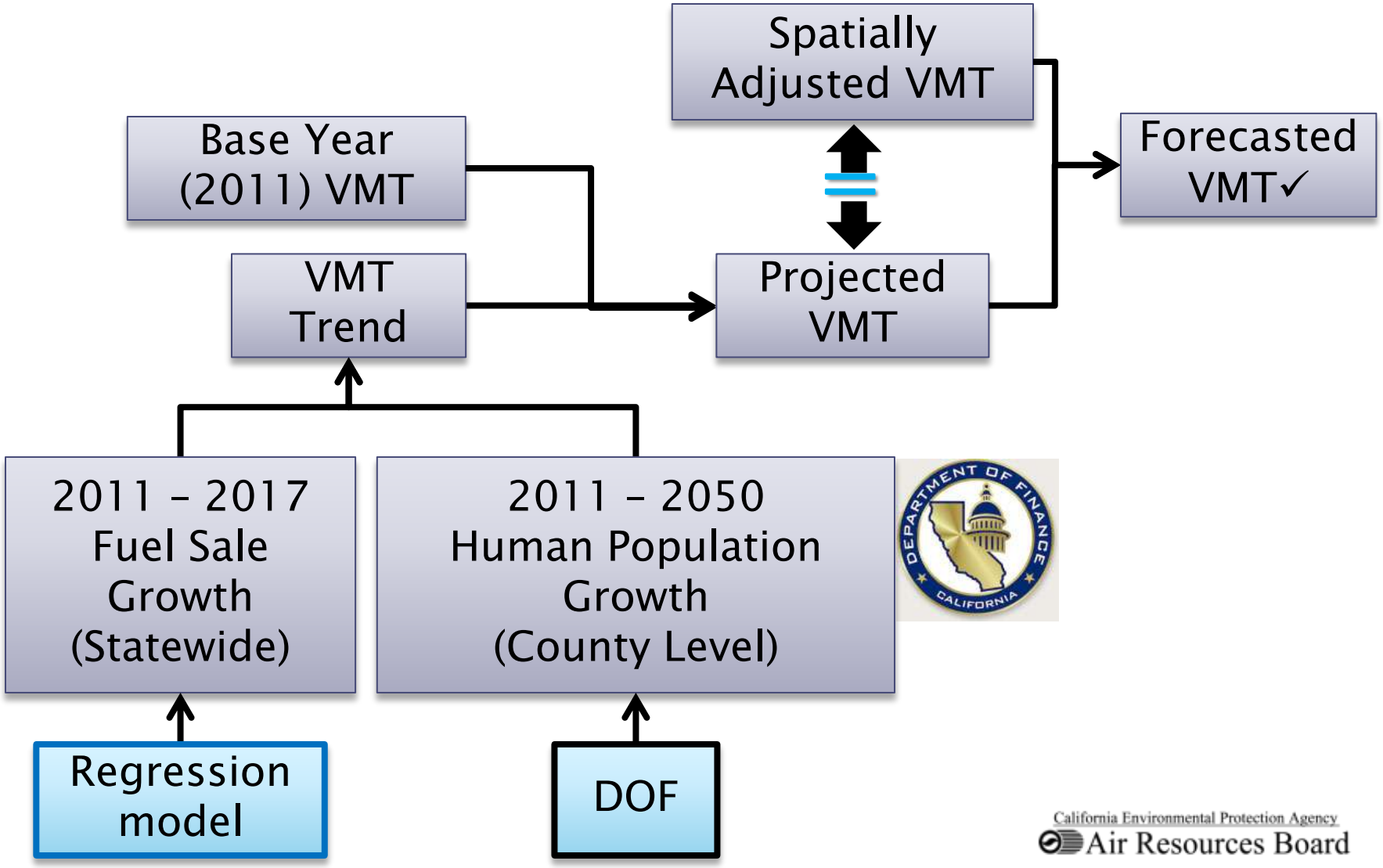
Activity: Forecasting VMT Trend



Activity: Regional Growth Differences



Activity: Regionally Forecast VMT



Activity: Accrual Rates

- Activity (VMT) = Population x Accrual
  - Accrual rates are the average amount of VMT/year per vehicle derived from Smog Check data.
- EMFAC2011 assumed constant accrual rates across all calendar years
  - Calculated population x accrual to match MPO VMT in each calendar year
- EMFAC2013 calculates accrual rates
  - Accrual = VMT/Population
  - Assumes shape of base accrual rates (by age) from Smog Check

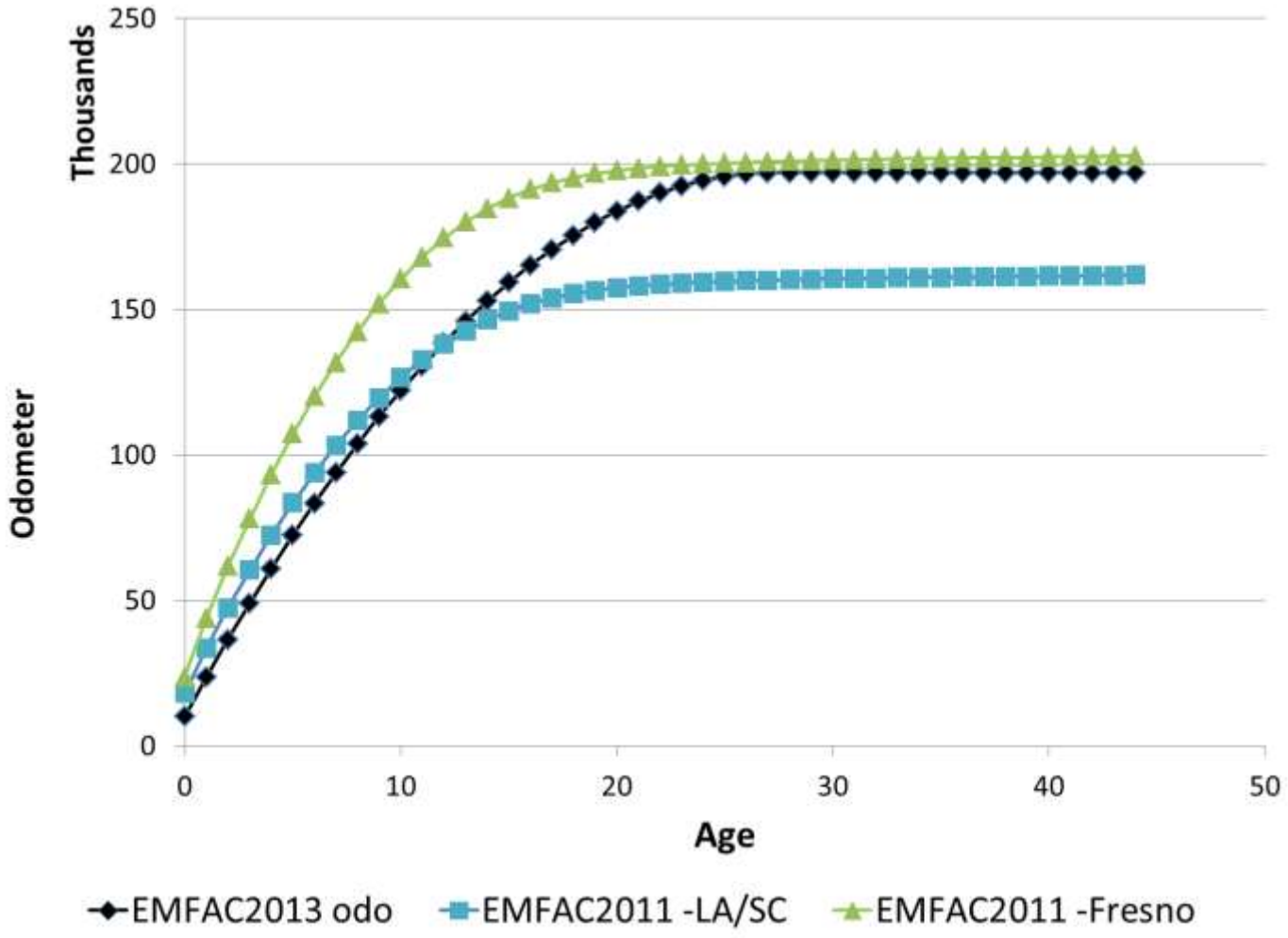
Activity: Odometer

- The odometer measures total vehicle mileage
- EMFAC emission rates are a function of mileage
- EMFAC2011 modeled odometer as a function of accrual rates and vehicle survival rates

$$\sum_{Age} Accrual \times Survival\ Rate$$

- EMFAC2013 uses odometer data directly from Smog Check reported data
  - Odometer does not vary by region in EMFAC2013

Activity: Odometer Results (LDA)

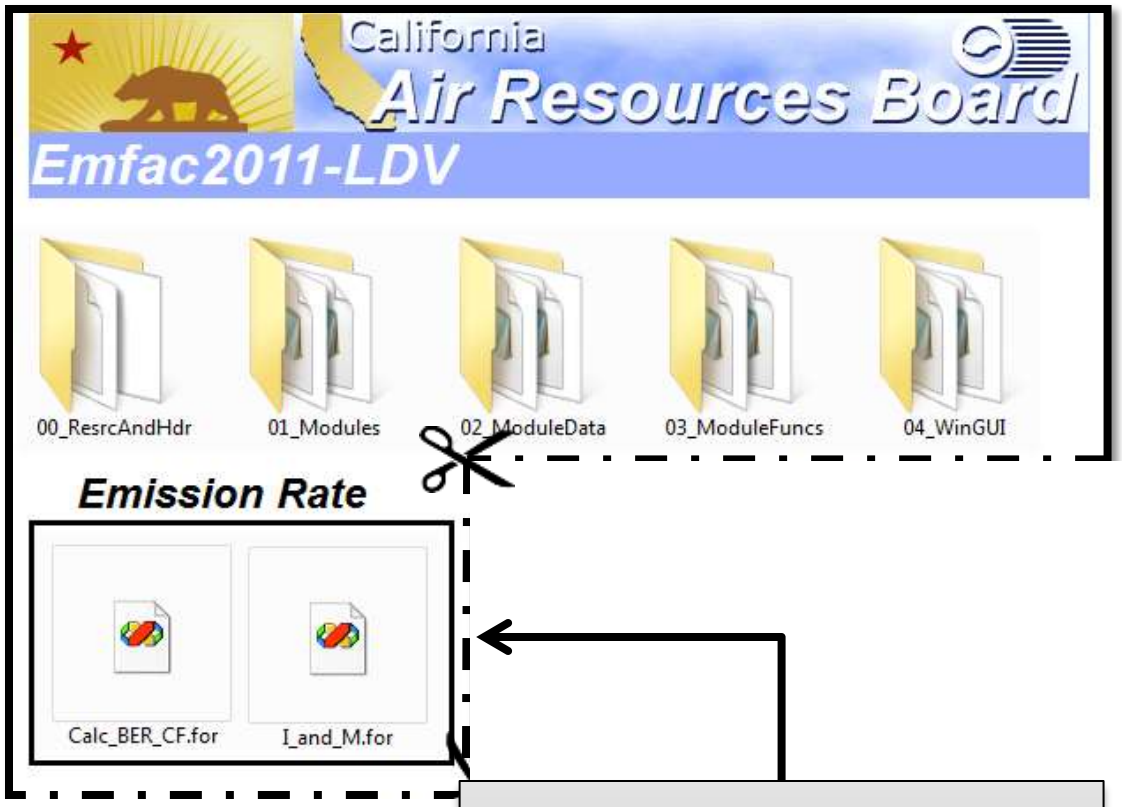


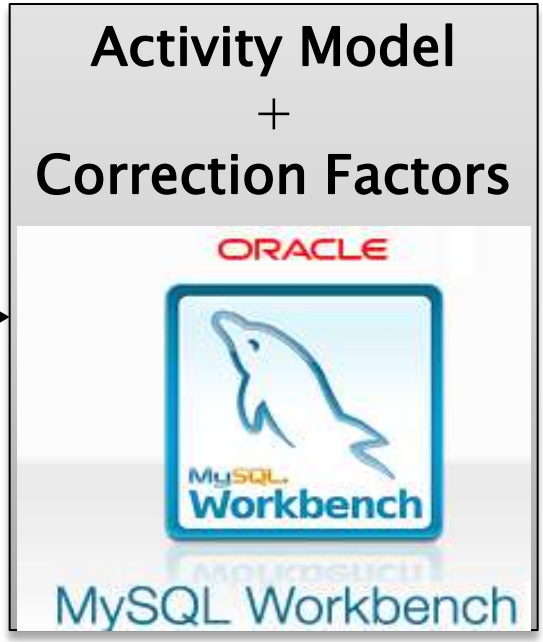
EMFAC2013

EMFAC-LDV

Emission Factors

Emission Factor Implementation

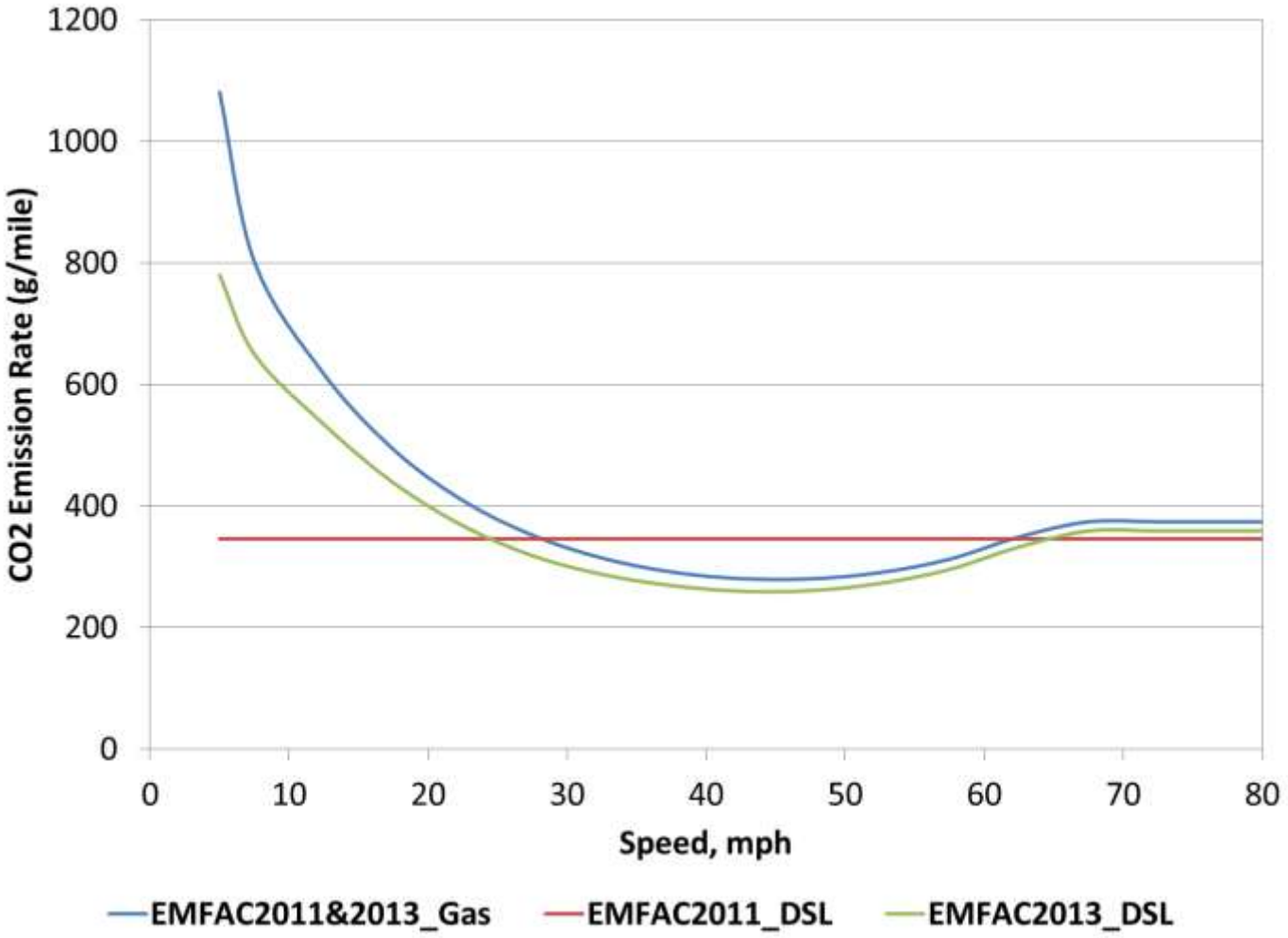




Emission Factors

- Consistent approach with EMFAC2011-LDV
- Updates
  - PM emission factors for PFI and GDI engines
  - CO2 emission factor/speed correction
    - Update to reflect relations among weight classes and fuels
    - Diesel – GVWR <14,000 lbs (PC~ LHDT2)
    - Gasoline – GVWR >10,000 lbs (LHDT2~T7)
    - Develop gasoline/diesel ratios by speed based on EPA's Physical Emission Rate Estimator (PERE) model
    - Apply ratios to "anchor" vehicle classes/fuel

CO2 Emission Rate by Speed - LDA



EMFAC2013

EMFAC-LDV

Advanced Clean Cars

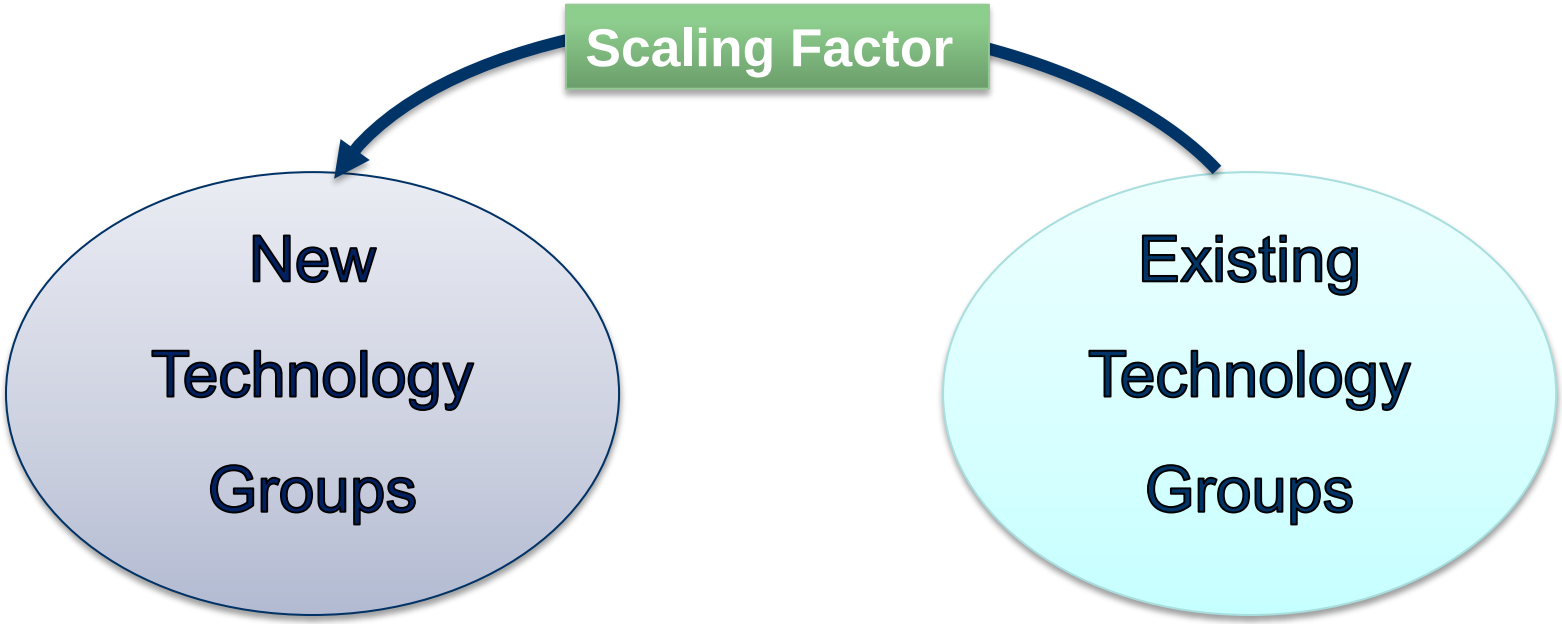
Advanced Clean Cars
Low Emission Vehicles (LEVIII)

- Phase-in 2014-2022
- Fleet average requirement equivalent to SULEV by 2022
- Combined NMOG and NOx standards
- More stringent particulate matter standard
- ZEV program requires ZEVs to comprise 15% of total new sales by 2025
- Requires automakers to meet ACC emissions levels with a mixture of ZEV and conventional technologies

Modeling Advanced Clean Cars (ACC) Emission Factors

- Follows assumptions in ACC emissions inventory technical support document
- Similar to LEV-III tool but built into EMFAC2013
  - New technology groups with new emission rates
  - New technology group fractions
  - Aggregated light duty fleet (gasoline + electric) average meets ACC/Pavley CO2 standards
  - Low Carbon Fuel Standards (LCFS)
  - Rebound – lower operational cost, higher activity

ACC: New Technology Groups



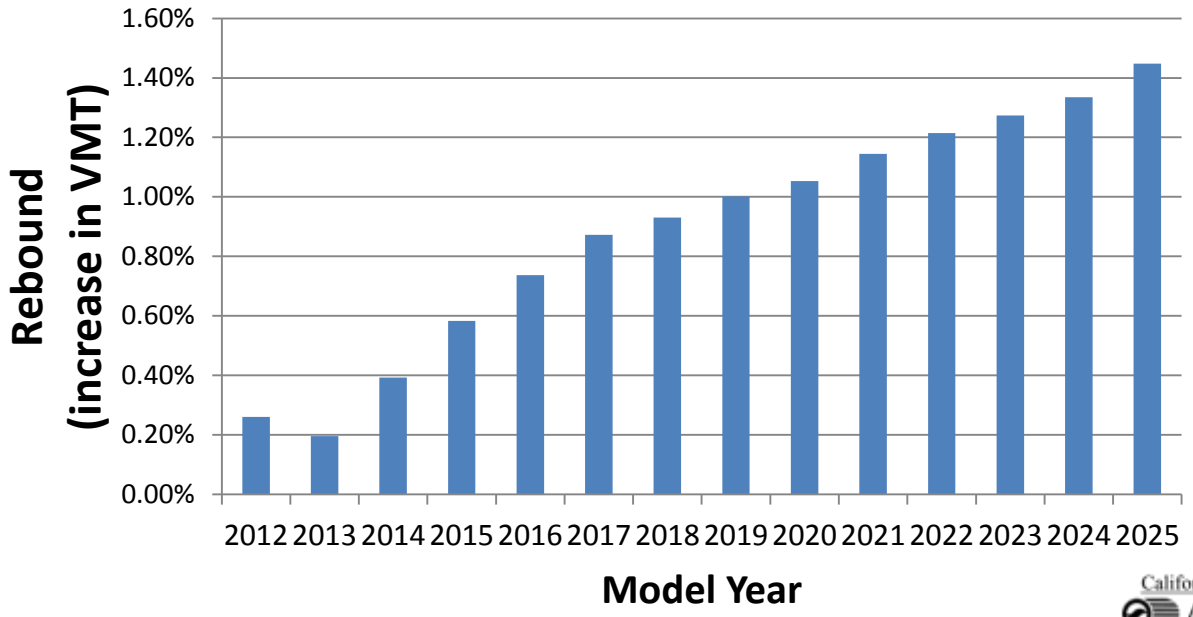
New Tech Group	Emission Group Name	Emission Standard	Fuel	Vehicle Categories	Scaling Factor	Existing Tech Group	Existing Emission Group name
EX038	SULEV20	20 mg/mi	Gasoline	PC, LT1, LT2, LT3	20/30	Ex 31	PZEV
EX039	ULEV50	50 mg/mi	Gasoline	PC, LT1, LT2, LT3	50/125	Ex 29	ULEV II
EX044	ULEV70	70 mg/mi	Gasoline	PC, LT1, LT2, LT3	70/125	Ex 29	ULEV II

ACC: GHG and ZEV Requirements

- Aggregated light duty fleet (gasoline + electric) average meets ACC/Pavley CO2 standards
  - 45% reduction by 2025
- Starting 2011, LCFS calls for reduction in carbon intensity of California's transportation fuels
  - 10% reduction by 2020.
- New passenger car population are re-distributed based on ZEV requirements
  - 15% of total new sales should be ZEV by 2025

ACC: Rebound Impact on VMT

- Rebound effect: as driving cost decreases, amount of driving increases
  - Effect is marginal: <4% extra driving per year
- Example: percent driving increase by model year for calendar year 2025, adopted Rule scenario (LDA)



EMFAC2013

EMFAC-LDV

Current Draft Output

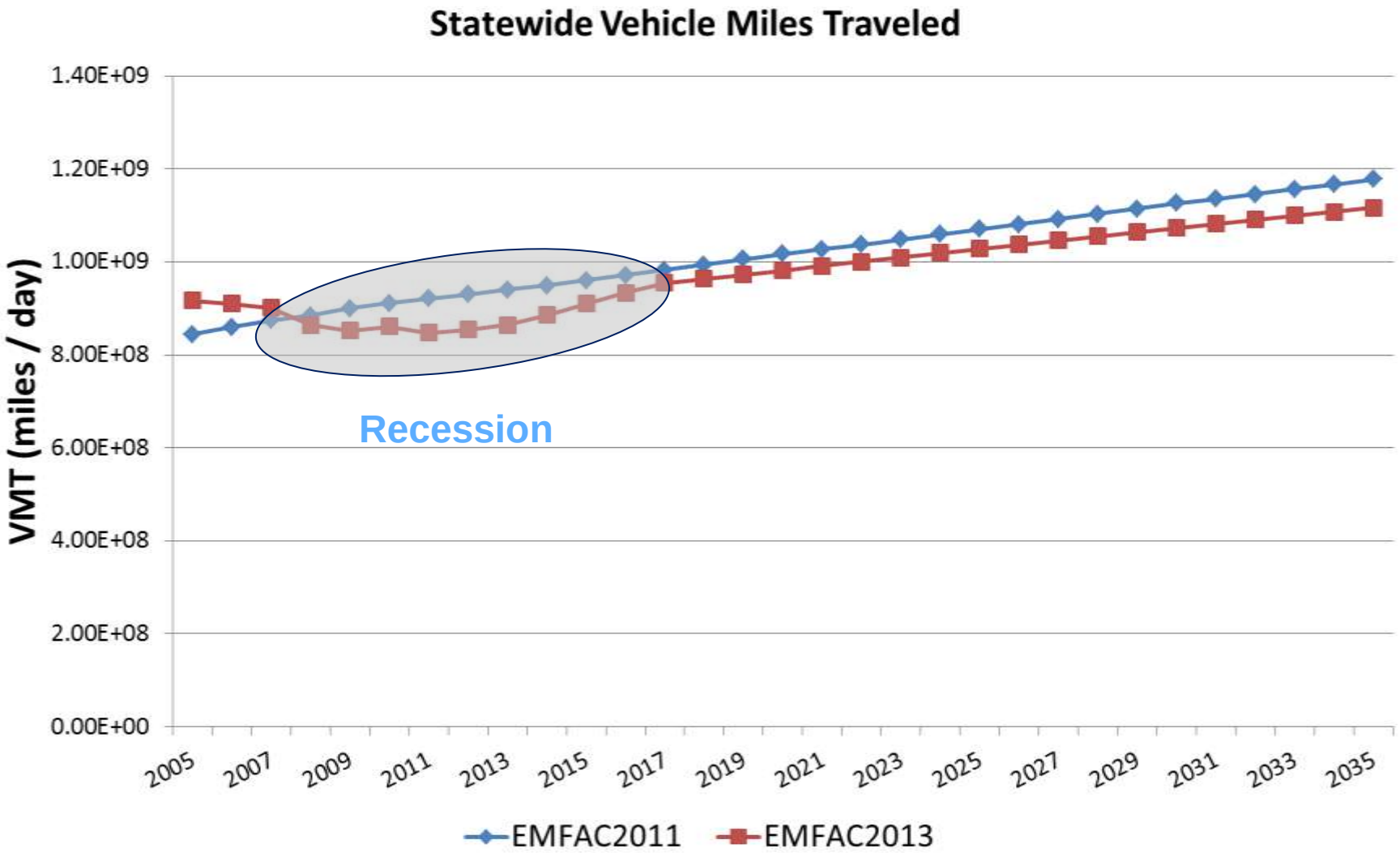
Current Draft Output

- Quality assurance and control work is on-going
- These numbers will change

Draft Model Output – Statewide, All LDV Vehicle Classes

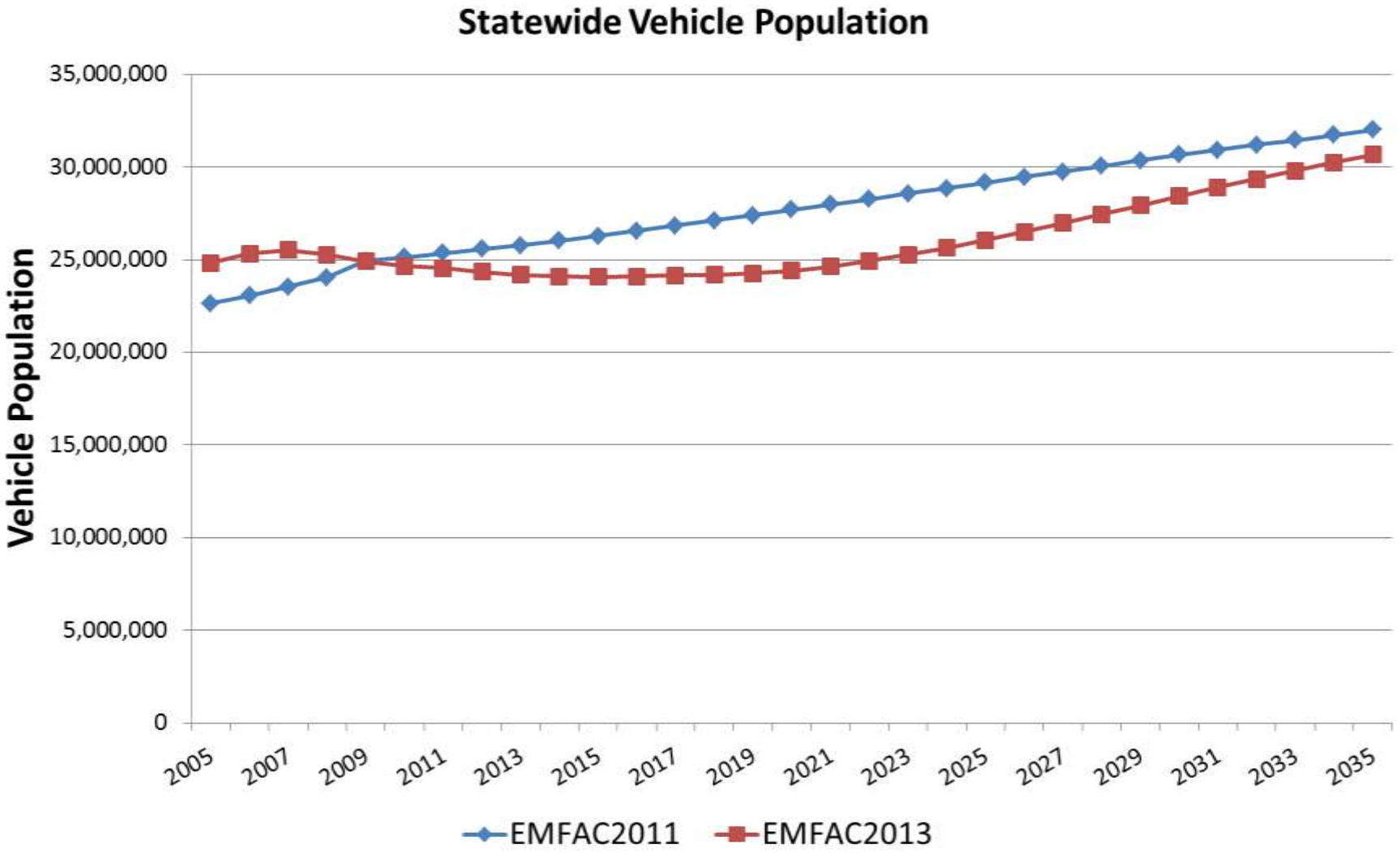
- VMT and Population
  - Reflects recession
  - Recovers to a level lower than previously estimated
  - Grows similarly to EMFAC2011 after 2017
  - Mileage accrual increases as VMT growth temporarily exceeds population growth
- CO2 is lower than EMFAC2011 due to ACC and lower VMT
- NOx, ROG, PM2.5 lower due to lower emissions standards and lower VMT
  - PM2.5 reflects emission rate adjustments documented in ACC which partially offsets the reductions

Statewide VMT, All LDV Vehicle Classes



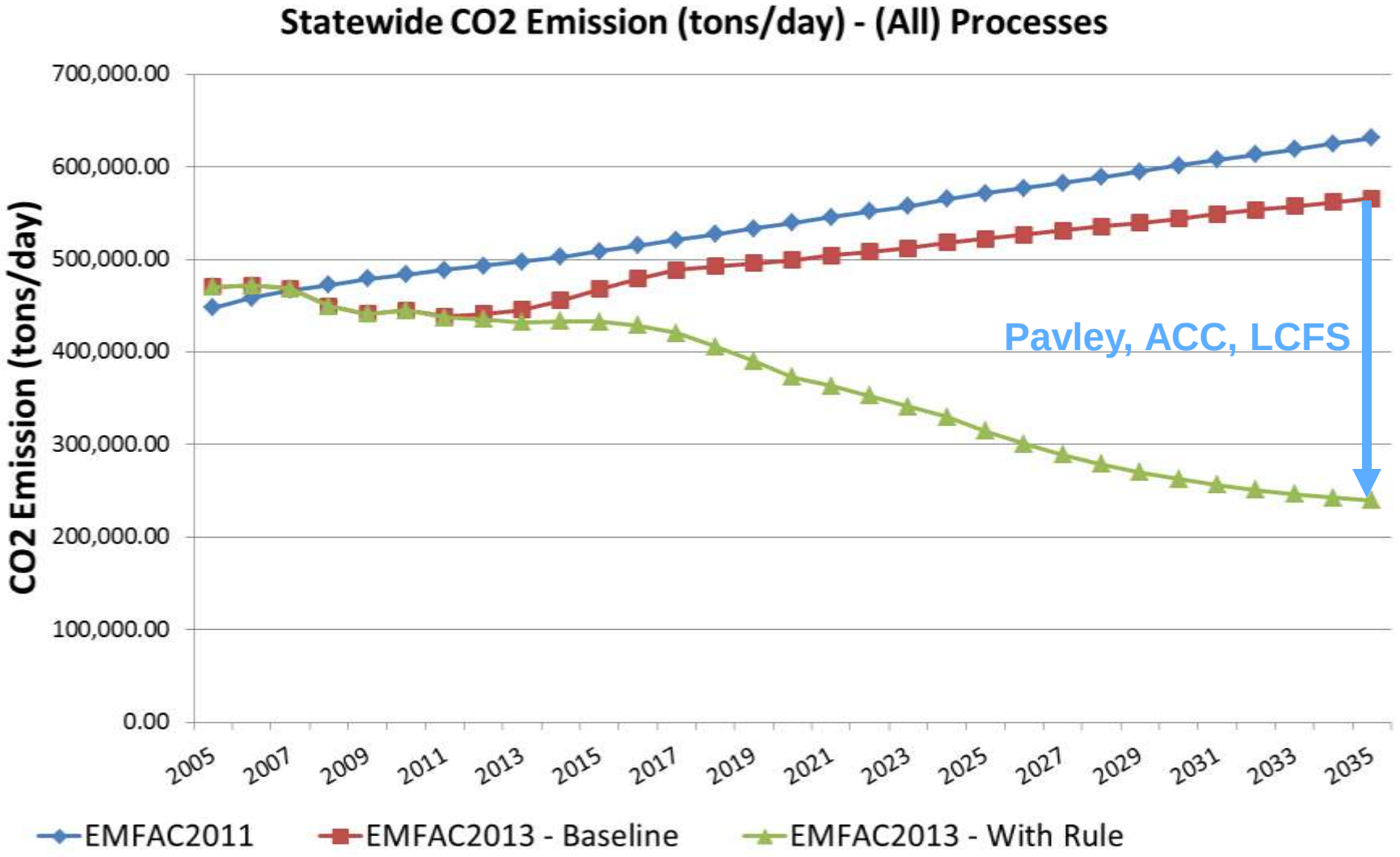
DRAFT

Statewide Population
All LDV Vehicle Classes



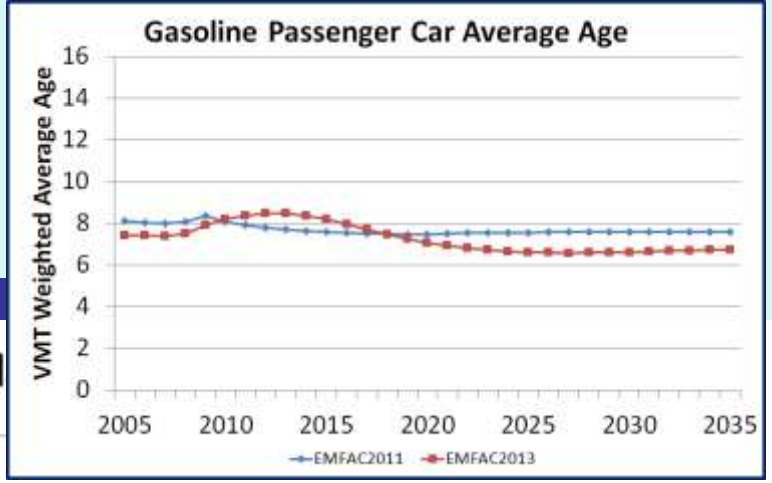
DRAFT

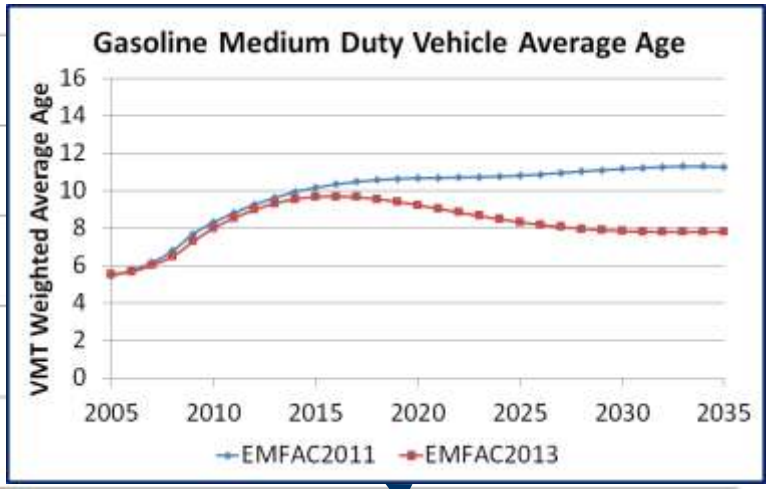
Statewide CO2
All LDV Vehicle Classes



DRAFT

Statewide NOx
All LDV Vehicle Classes

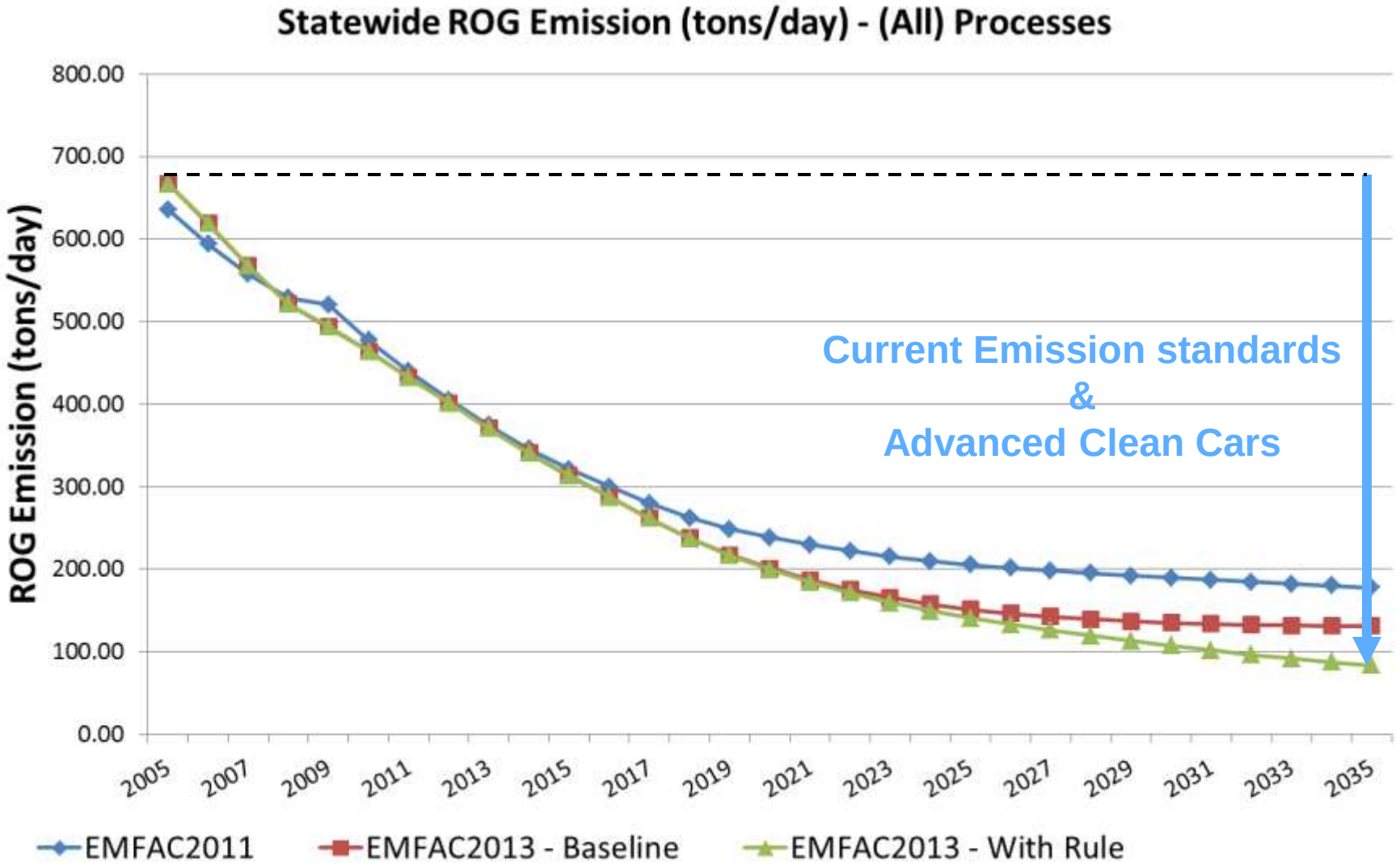




VMT% allocation	EMFAC2011	EMFAC2013
Passenger Cars	55%	58%
Light Truck	28%	29%
Medium Duty Trucks	17%	13%

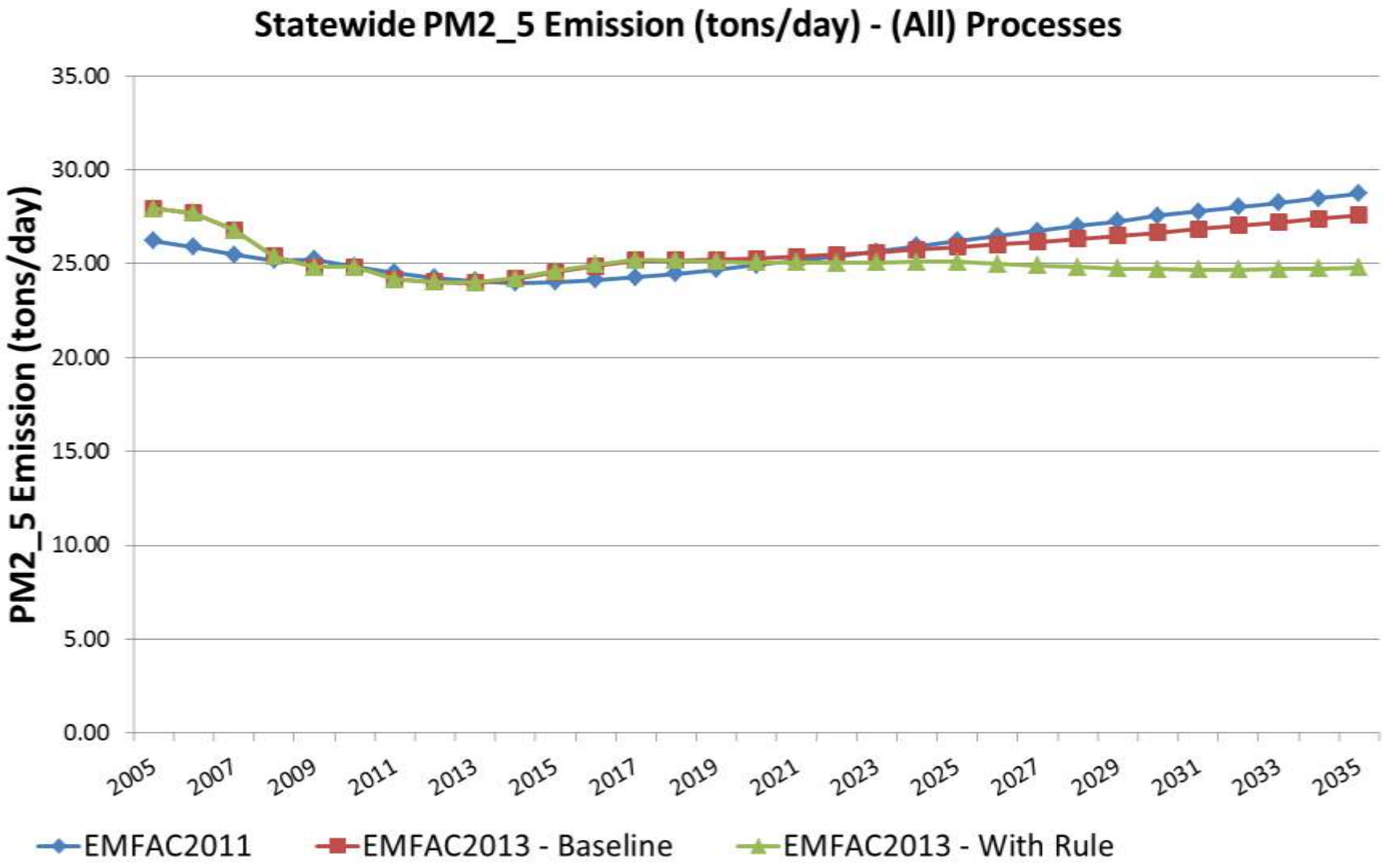
DRAFT

Statewide ROG
All LDV Vehicle Classes



DRAFT

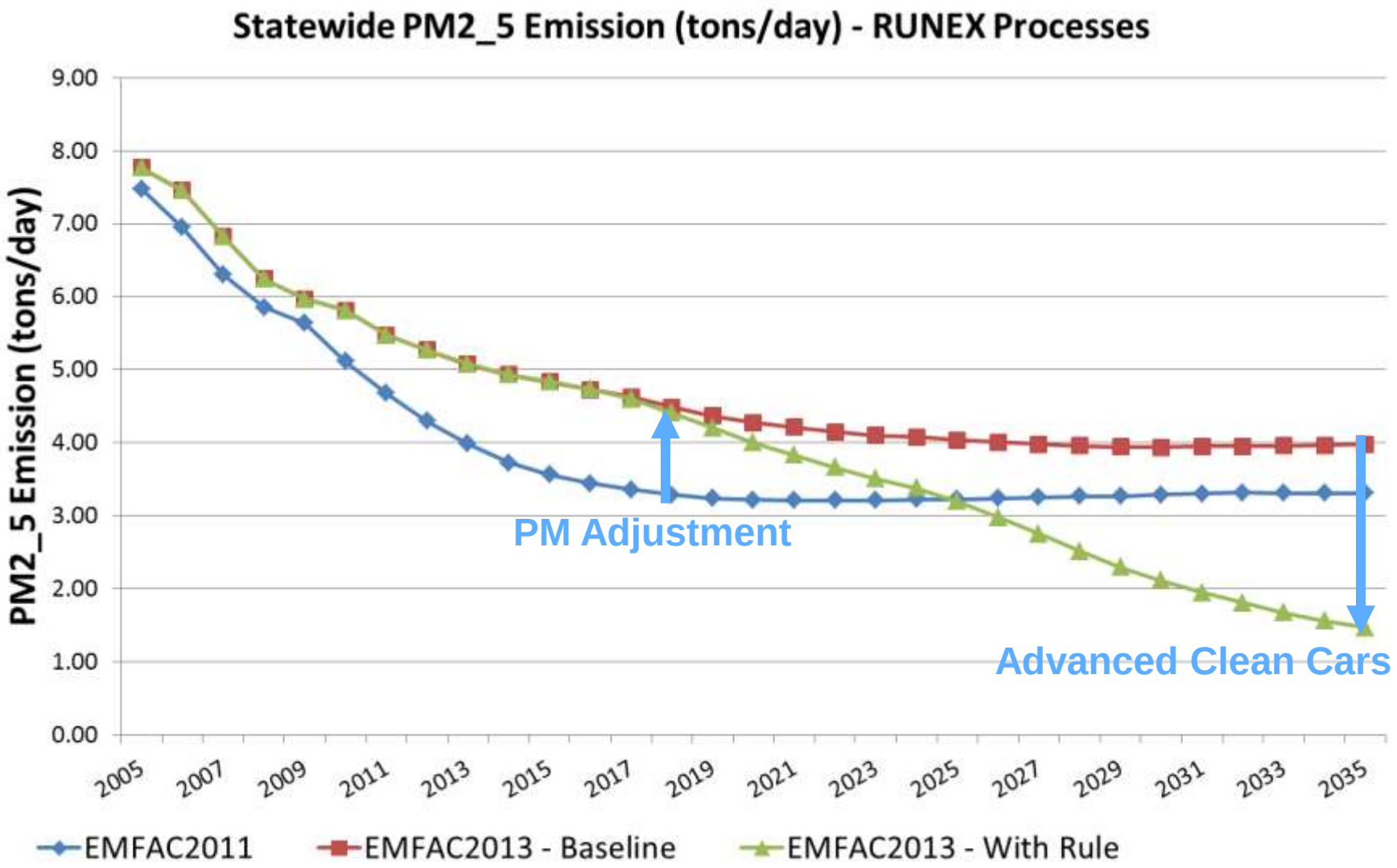
Statewide PM2.5
All LDV Vehicle Classes



DRAFT

Statewide PM2.5
All LDV Vehicle Classes

DRAFT



EMFAC2013

EMFAC-LDV

Next Steps

EMFAC2013-LDV Module Next Steps

- On-going quality assurance and control
- Continue to evaluate population forecasting approach
- Continue model updates
  - Updates for latest population estimates
  - Odometer schedule
  - CO2 speed curves
- Use model for SG-based planning inventories in late fall

EMFAC2013

EMFAC-HD

EMFAC2013-HD

- Overview
- Population
- Activity
- Emission Factors
- Fleet Rules
- Greenhouse Gas Standards and Rules
- DRAFT Default Model Output
- Next steps

EMFAC2013

EMFAC-HD

Overview

EMFAC2013-HD: Overview

- Inventory evolved with fleet rules, culminating in major update for Truck and Bus Rule and EMFAC2011
- Updates focus on
  - Vehicle population and activity forecast
  - Improved vehicle population forecasting methods
  - Emission factors
  - Integrating GHG Rules and Standards

HD Activity Model – EMFAC2011 vs. EMFAC2013

Methodology	EMFAC2011-HD	EMFAC2013-HD
Population Forecasting	Age Distribution Approach	Estimate of New Vehicle Sales + Retention Rates
VMT Growth Rates	MPO's VMT Growth Trend	Estimate Diesel Fuel Sales Growth Rate
Rule Implementation	Snap Shot	Iterative

EMFAC2013

EMFAC-HD

Population

Population

- Base Year Population
- Vehicle Retention Rates
- New vehicle sales
- Disaggregation
- Results

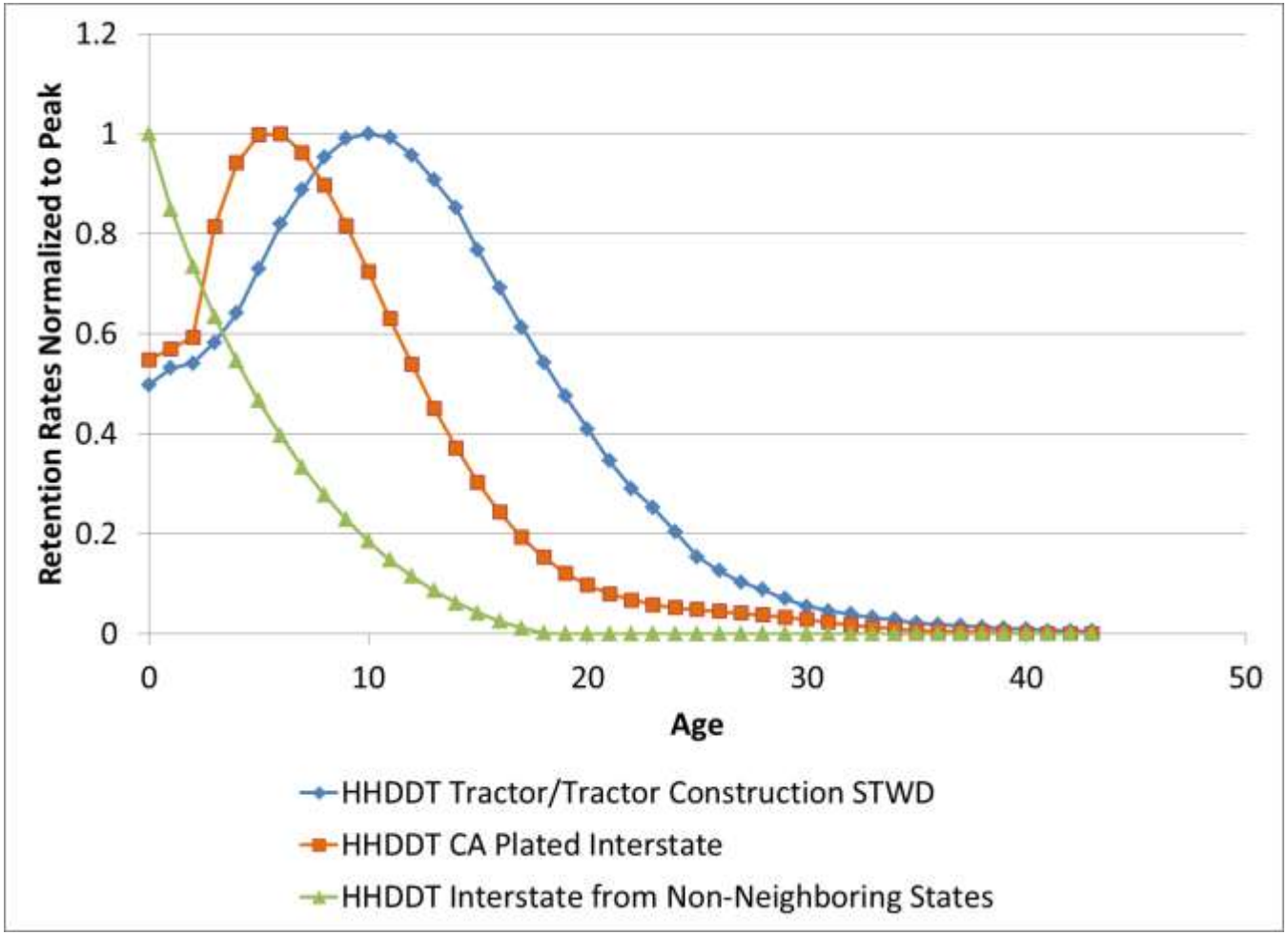
Population: Base Population

- Data Sources
  - CA intra-state – DMV registration
  - CA inter-state – International registration Plan (IRP) records from DMV
  - Out-of-State – survey and IRP Clearinghouse
- Fleet Categories
  - Body type, weight class, license type and fleet size from registration data
  - Service type specifics from survey and compliance
    - VIUS – Vehicle Inventory and Use Survey
    - TRUCRS – Truck and Bus Regulation Reporting System
    - DTR – Drayage Truck Registry

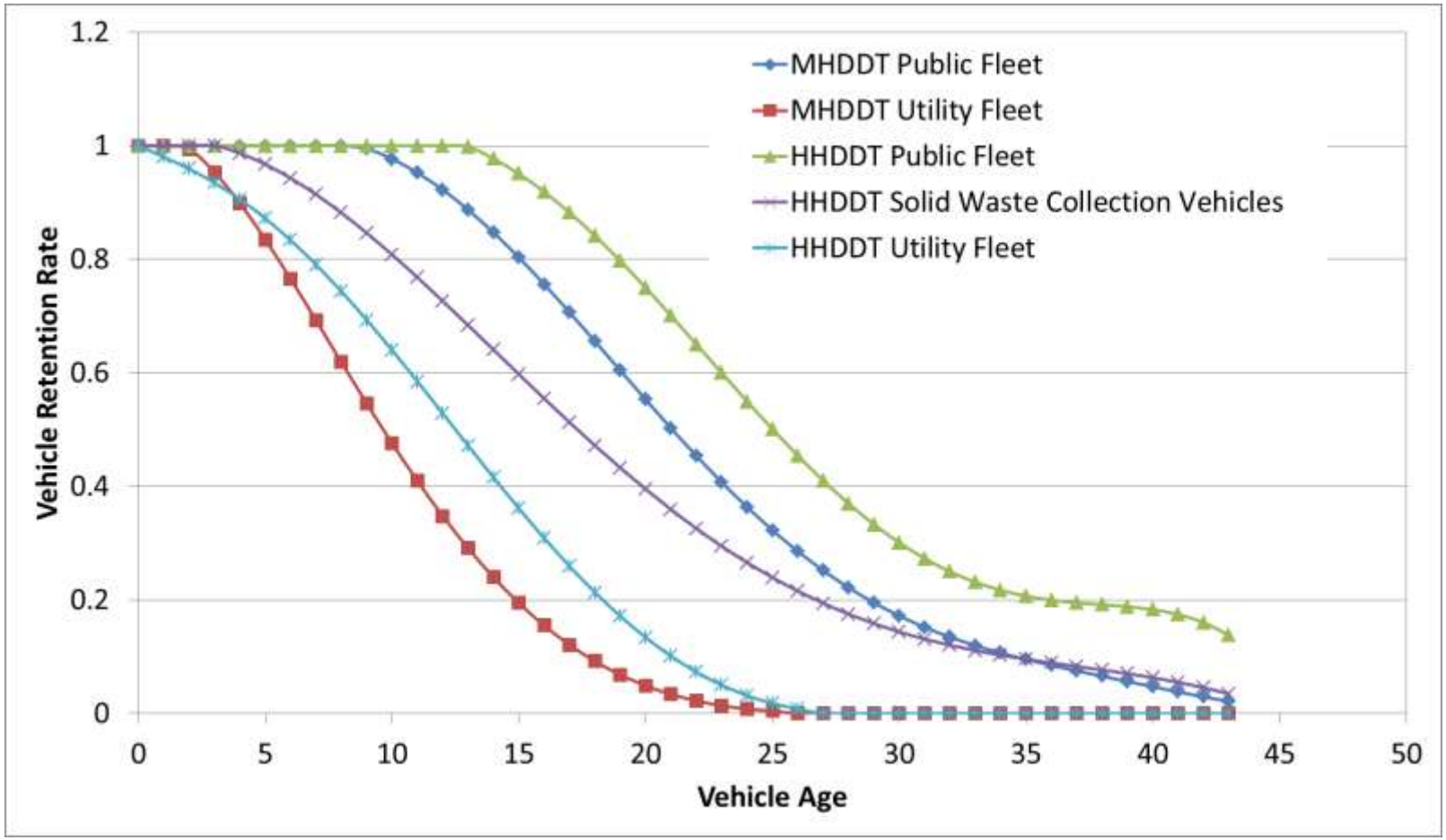
Category-Specific Retention Rates

- A combination of attrition and migration rates
  - Migration among fleet categories
    - Long-haul interstate trucks tend to buy new
    - Regional haul fleets tend to buy trucks retired from interstate services
    - Local intrastate trucks are more likely to buy older trucks
  - Migration among regions – less important
    - Regional differences for some intra-state categories
- Preliminary retention rates
  - Derived from Year-to-year age distribution
  - Modeled based on age distribution

Results: Retention Rates



Public/Utility/SWCV Retention Rate



New Vehicle Sales

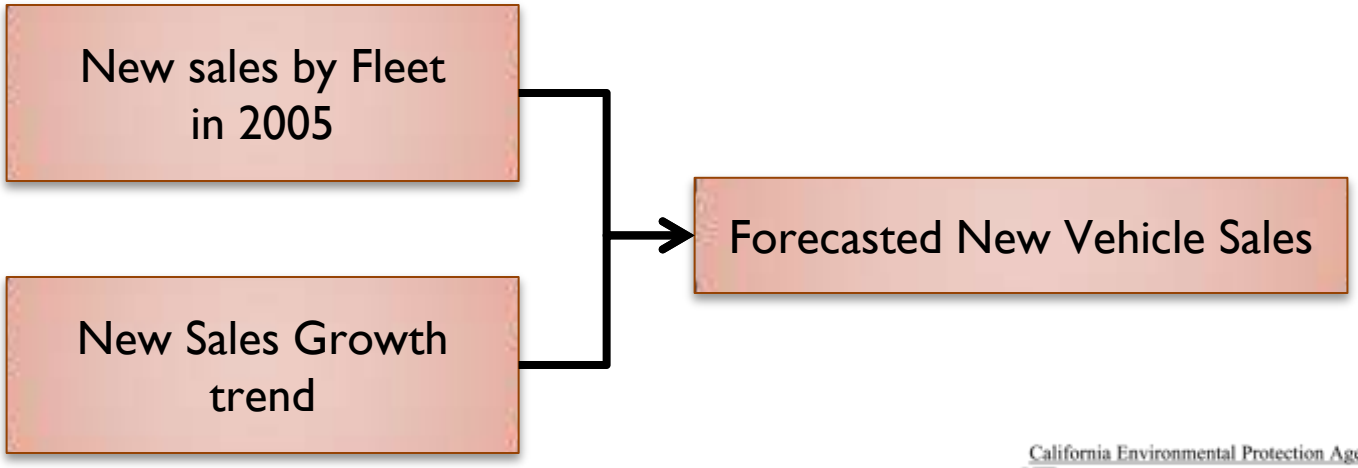
- New vehicle sales follows similar growth trend as projected in Annual Energy Outlook (AEO) by U.S. Energy Information Administration
  - Separate projections for MHDDT, HHDDT
- Distributed to vehicle categories using projected VMT growth by category
- New vehicle sales in 2005 are used as the starting point for new sales projections

New Vehicle Sales Projection

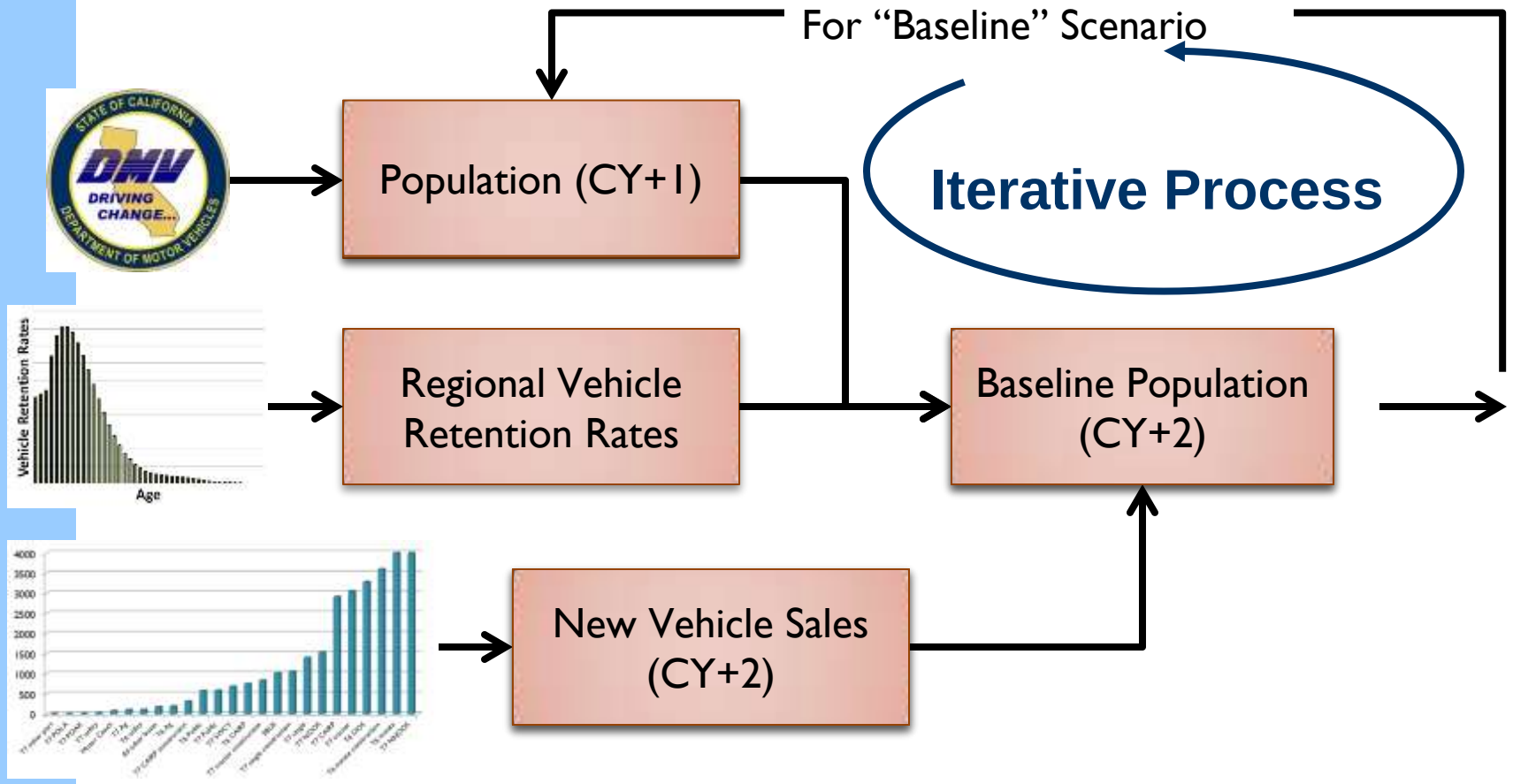
$$New\ Vehicle\ Sales =$$

$$pop\ of\ new\ sales\ in\ \mathbf{2005}\ DMV\ data \times VMT\ Growth\ Rate$$

$$\times \frac{\left(AEO\ sales\ CY / AEO\ VMT\ CY\right)}{\left(AEO\ sales\ 2005 / AEO\ VMT2005\right)}$$



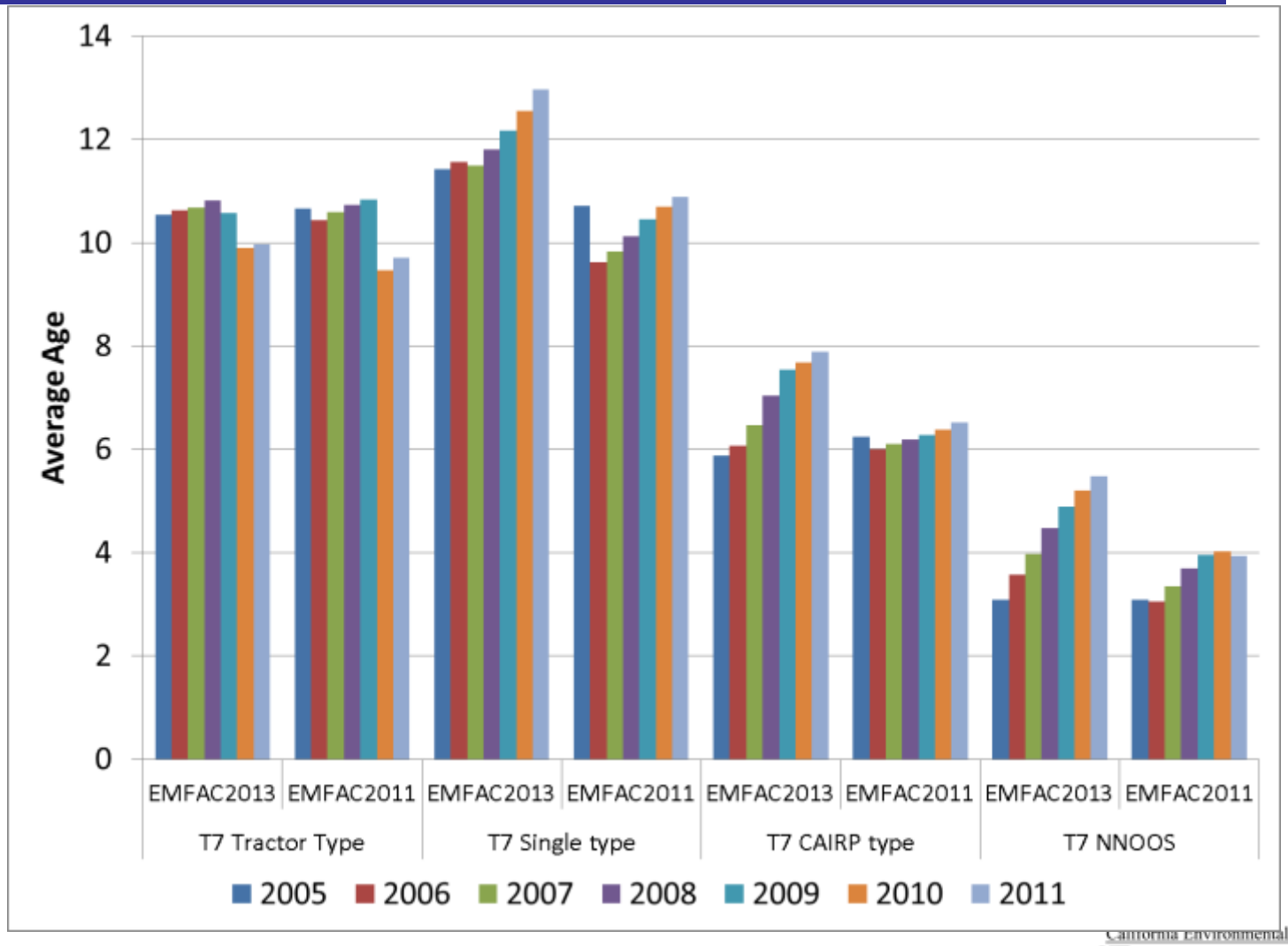
EMFAC-HD: Population Forecast



Population: Recession Impacts

- During recession the truck population aged as fleets shrank and curtailed new truck purchases
- Drayage fleets expanded purchases to comply with the regulation
- Recession impact on fleet age exceeded EMFAC2011 projections

Average Age During Recession

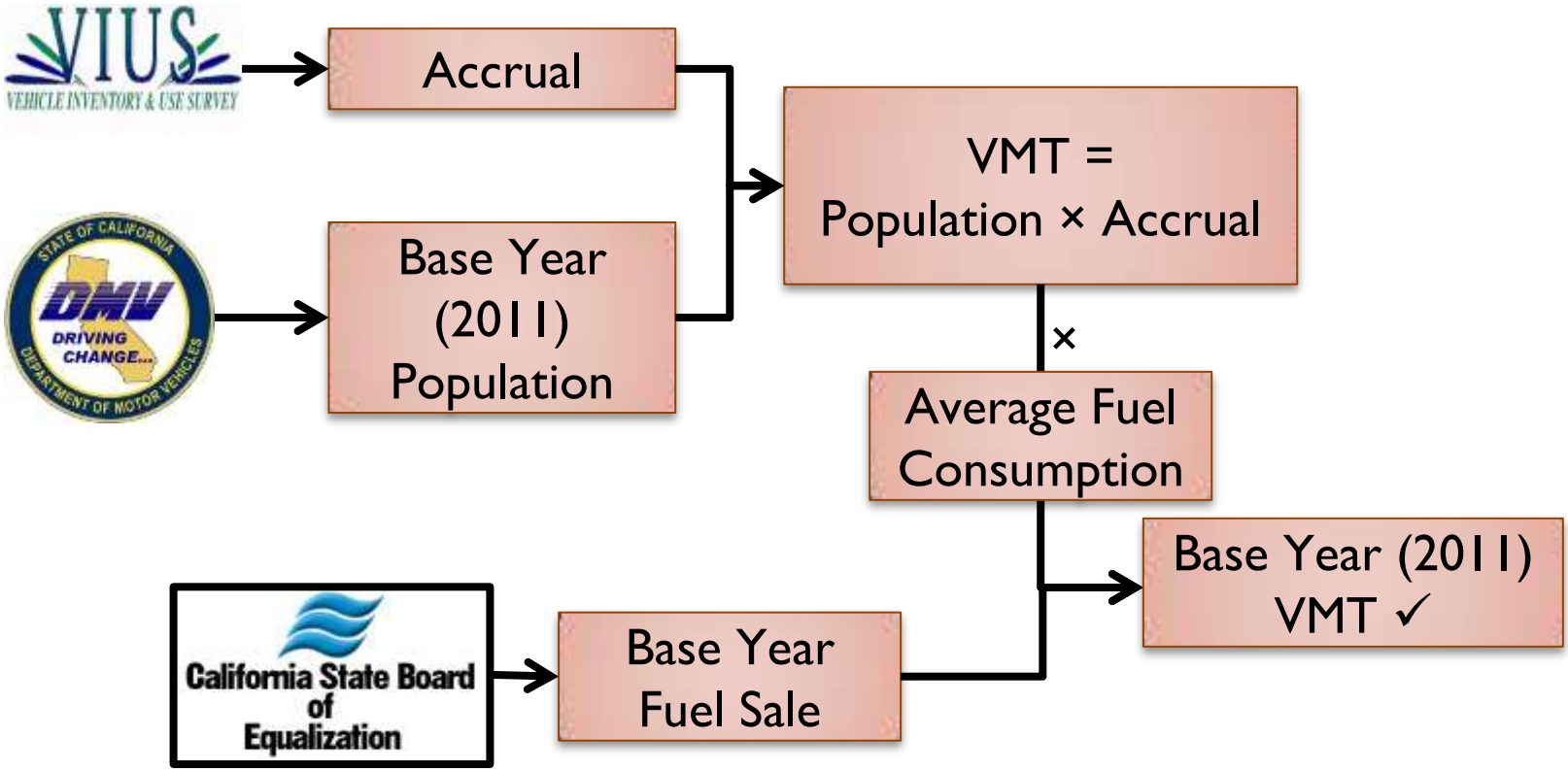


EMFAC2013

EMFAC-HD

Activity

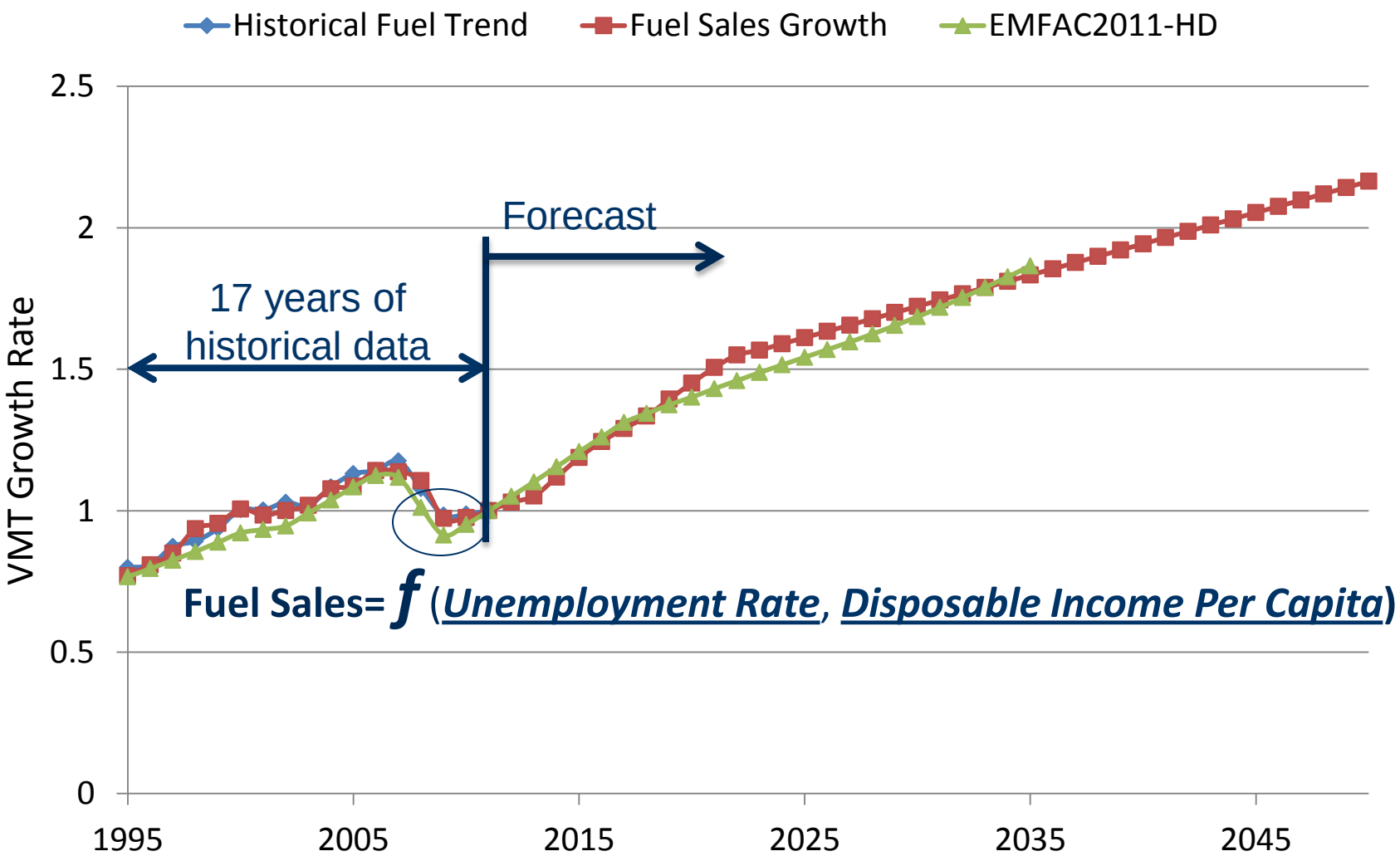
Modeling Base Year VMT



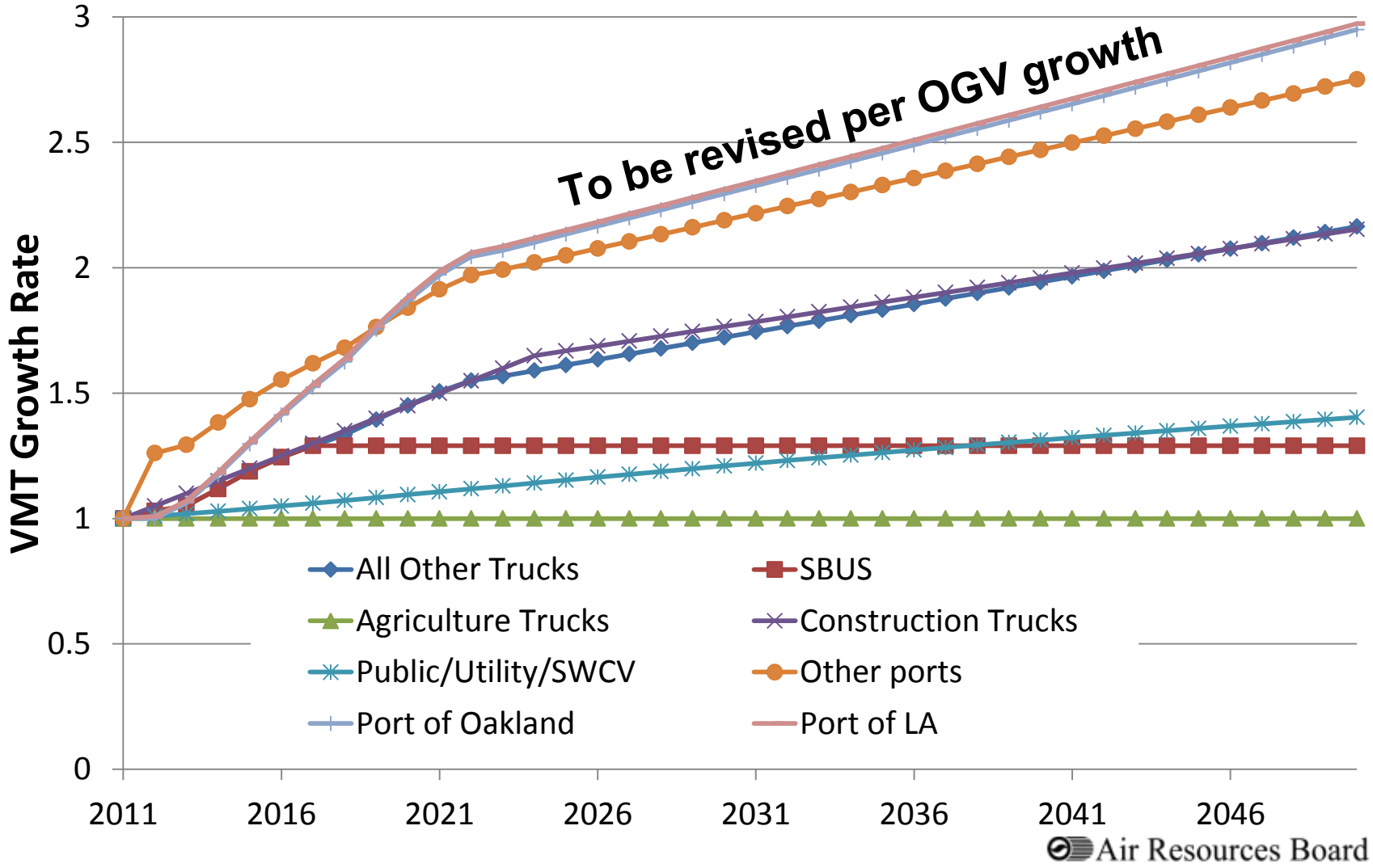
Improvements to Fuel Matching

- Updates to fuel matching methods improve accounting for non-taxable fuel
- Several categories now excluded from fuel match
  - Urban Transit Bus
  - Power Take-Off
  - School Bus
- Leads to marginal increase in VMT in some categories

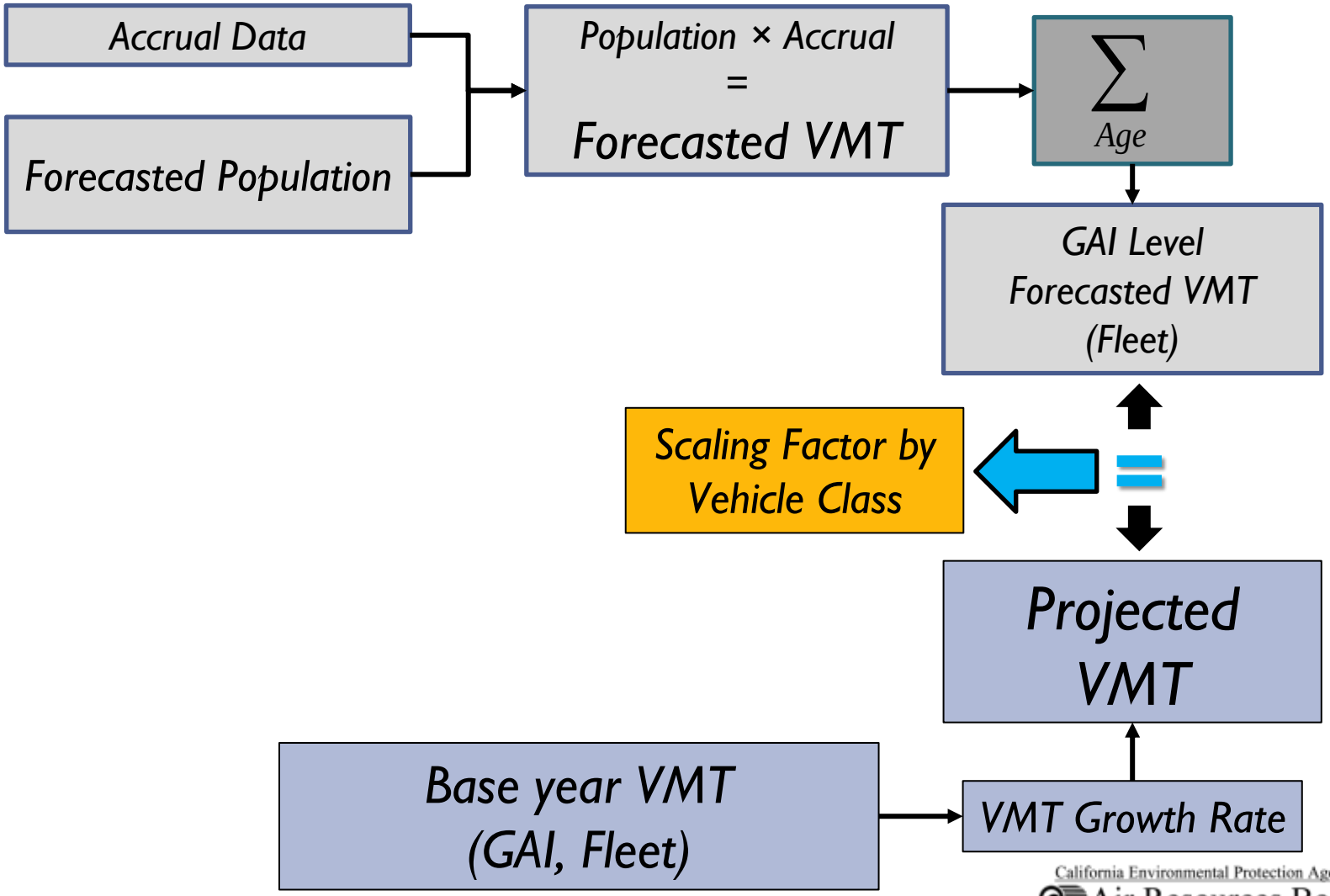
Diesel VMT Growth Forecast



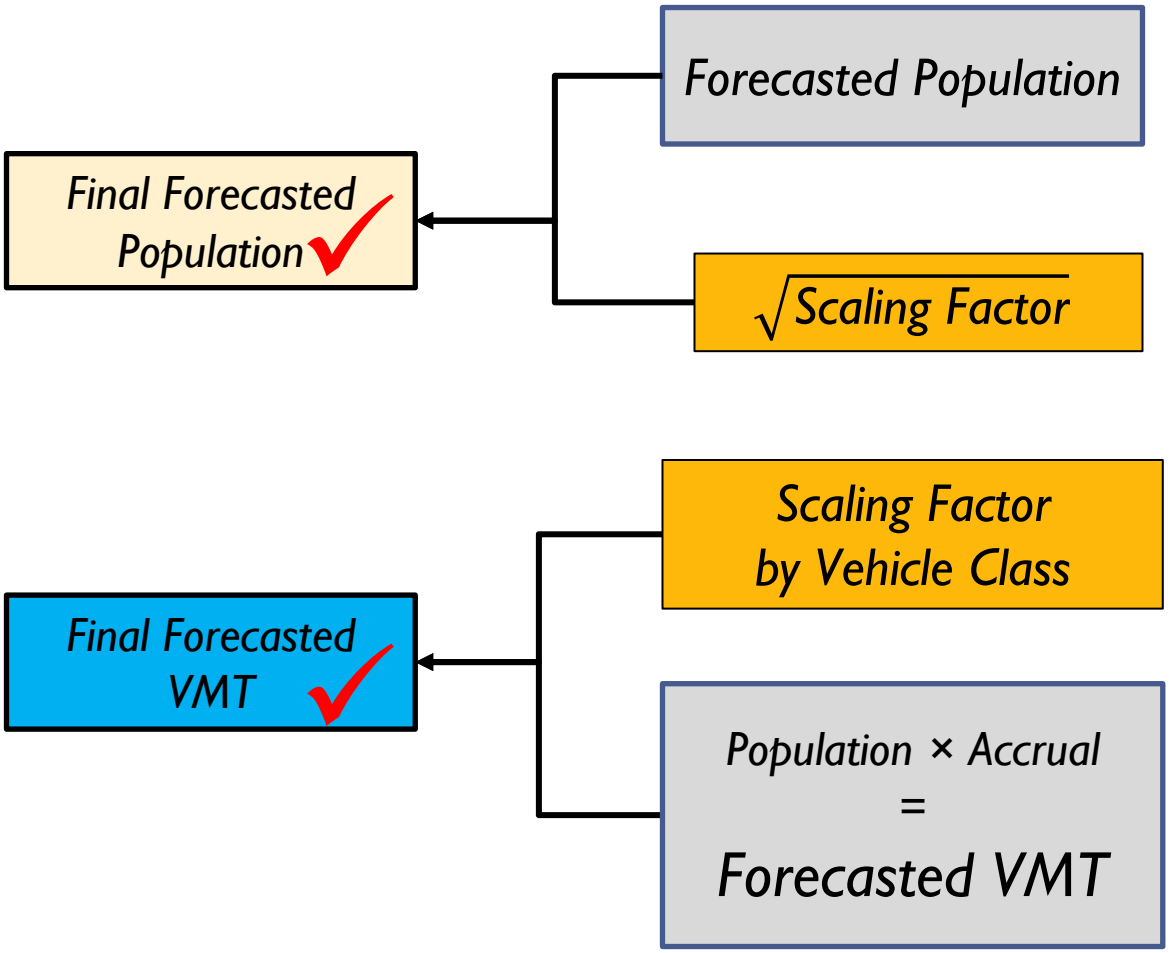
Projected Growth by Category



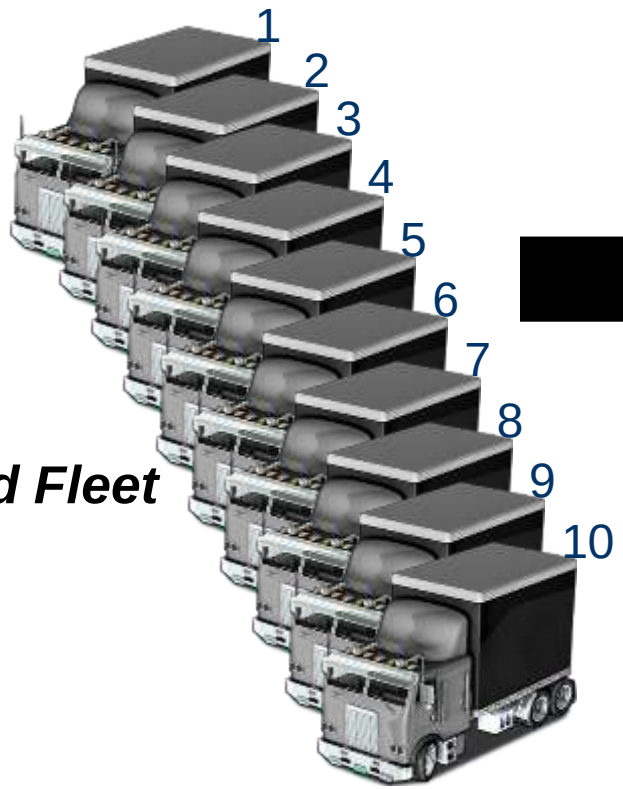
Activity: Forecasting VMT



Activity: Forecasting VMT



Activity: Example



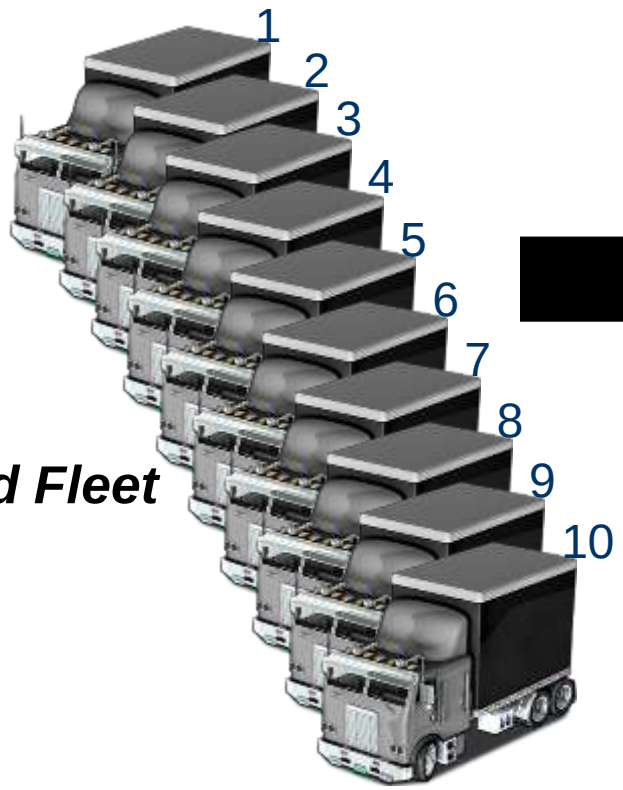
Old Fleet

Each driving at 10K miles/year

Under normal condition can drive at 20K miles/year

Total VMT = 100 K miles/year

Activity: Option 1



Old Fleet

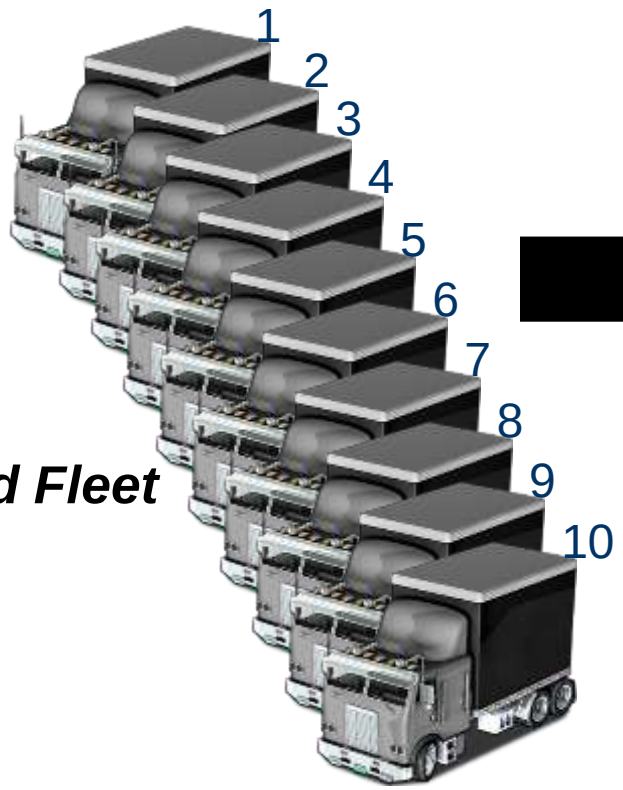
Each driving at 10K miles/year

Total VMT = 100 K miles/year

Each driving at 10K miles/year

Total VMT = 100 K miles/year

Activity: Option 2



Old Fleet

Each driving at 10K miles/year

Total VMT = 100 K miles/year

Each driving at 14.2K miles/year

Total VMT = 100 K miles/year

Activity: Mileage Accrual

- Base mileage accrual rate curves from VIUS and surveys
- Accrual is category specific
- New method in EMFAC2013
  - Accrual calculated in each calendar year by category using forecast VMT, population, and accrual curves
  - Accrual rates vary by calendar year

Activity: Odometer

- Same as EMFAC2011
- Capped at 800,000 miles for heavy-heavy and 400,000 for medium-heavy duty diesel trucks
- Based on evaluation of VIUS, Goods Movement Bond Program, and “for-sale” records from Truckpaper.com
- Lifetime Mileage assumptions documented in EMFAC2011 and Rule inventory

EMFAC2013

EMFAC-HD

Emission Factors

HD Emission Factor Updates

- Introduction to HD emission factors
- Updates to:
  - Running exhaust emission rates
  - Speed correction factors
  - Idle emission rates
- Start emissions for 2010 technology trucks
- Impact of updates on emissions

HD Emission Factor Methods

- Running exhaust emission factors
  - Zero-mile emission rates (ZMR) and deterioration rates (DR)
    - *Emission Rate $_{(odo)}$ = ZMR + DR x Odo*
  - Speed correction factors
    - Ratio of rates at other speeds relative to rate at 18.8 mph (UDDS)
- Idle emission rates
- Start emission rates

Introduction to Emission Factors

- EMFAC2007
  - Test data from CRC E55/59 project
  - Emission factor projected for 2007+ MY
- EMFAC2011
  - Reflected different NOx certification levels
  - CO2 emission rate refinement
- EMFAC2013
  - Focus on new PM and NOx control technologies
  - Test data from 2007+ MY trucks

New Control Technologies

- 2007+ MY trucks use DPF
  - More than 95% reduction in PM emissions
  - Significant HC and CO benefits
- Increased use of SCR starting 2010 MY
  - At least 80% reduction in NOx emissions
- Challenges in modeling emissions
  - Emissions testing
  - Emissions deterioration

Natural Gas Heavy Duty Vehicles

- Diesel and natural gas HD vehicles treated equivalently in EMFAC2011
  - Both certified to identical standards so similar emission rates assumed
- Many urban buses and refuse trucks operated on CNG/LNG
  - To be included in final version of EMFAC2013
- Natural gas vehicles may grow in popularity
  - A focus of ARB Vision Tool
  - Future testing projects

Truck Emissions Studies

- Testing sponsored by ARB, SCAQMD
  - Dynamometer testing
    - Multiple cycles
  - PEMS over-the-road testing
    - Two routes and three different loads
- Focus on heavy-heavy duty diesel trucks
  - Three 2007-2009 engine model year trucks
  - Six 2010+ engine model year trucks

Test Vehicles

	Engine	Odometer (mi)	Emission Control	NOx Cert (g/bhp-hr)
1	2007 Cummins	390,000	EGR, DPF	2.4
2	2007 DDC	10,700	EGR, DPF	1.2
3	2010 Navistar	70,000	EGR, DPF	0.5
4	2010 Cummins	13,500	SCR, DPF	0.35
5	2010 Volvo	68,000	SCR, DPF	0.2
6	2010 DDC	23,000	SCR, DPF	0.2
7	2009 Navistar	80,400	EGR, DPF	1.2
8	2011 Navistar	67,300	EGR, DPF	0.5
9	2011 Volvo	36,900	SCR, DPF	0.2

Dynamometer Test Cycles

Test Cycle/Mode	Average Speed (mph)	Duration (sec)	Length (mi)
UDDS	**18.8**	**1063**	**5.55**
Creep	1.8	253	0.12
Transient	15.4	668	2.85
Cruise	39.9	2,083	23.1
Hi Speed Cruise	50.2	757	10.5
Idle	0	600	N/A

Truck Running Exhaust Emissions Zero-Mile Emission Rates

- Emission rates based on test data collected over UDDS cycle
- Test results back-projected to “zero-mile” using emission increase rates
- For 2007-2012 model years, NOx zero-mile rates weighted by sales fractions of different certification levels

CA Sales Fractions by NOx Cert Level

Engine Model Year	Fraction of Engines Certified to Different NOx Levels (g/bhp-hr)				
	2.4	1.2	0.5	0.35	0.2
2007-09	10%	90%			
2010-12			5%	25%	70%
2013+					100%

Results: Zero-Mile Rates (g/mi)

Engine Model Year	EMFAC2011			EMFAC2013		
	NOx	PM	CO2	NOx	PM	CO2
2007-09	7.12	0.035	2,171	7.31	0.017	2,350
2010-12	**1.44**	**0.035**	2,099	**2.33**	**0.004**	2,056
2013+	**1.14**	**0.035**	2,094	**1.89**	**0.004**	2,056

Truck Running Exhaust Emissions Deterioration

- Emissions increase over time
- For diesel engines, deterioration caused by
  - Tampering and mal-maintenance
  - Component malfunction
- Deterioration rates modeled as a function of
  - Frequency of engine tampering and malfunction
  - Emissions impact of tampering and malfunction

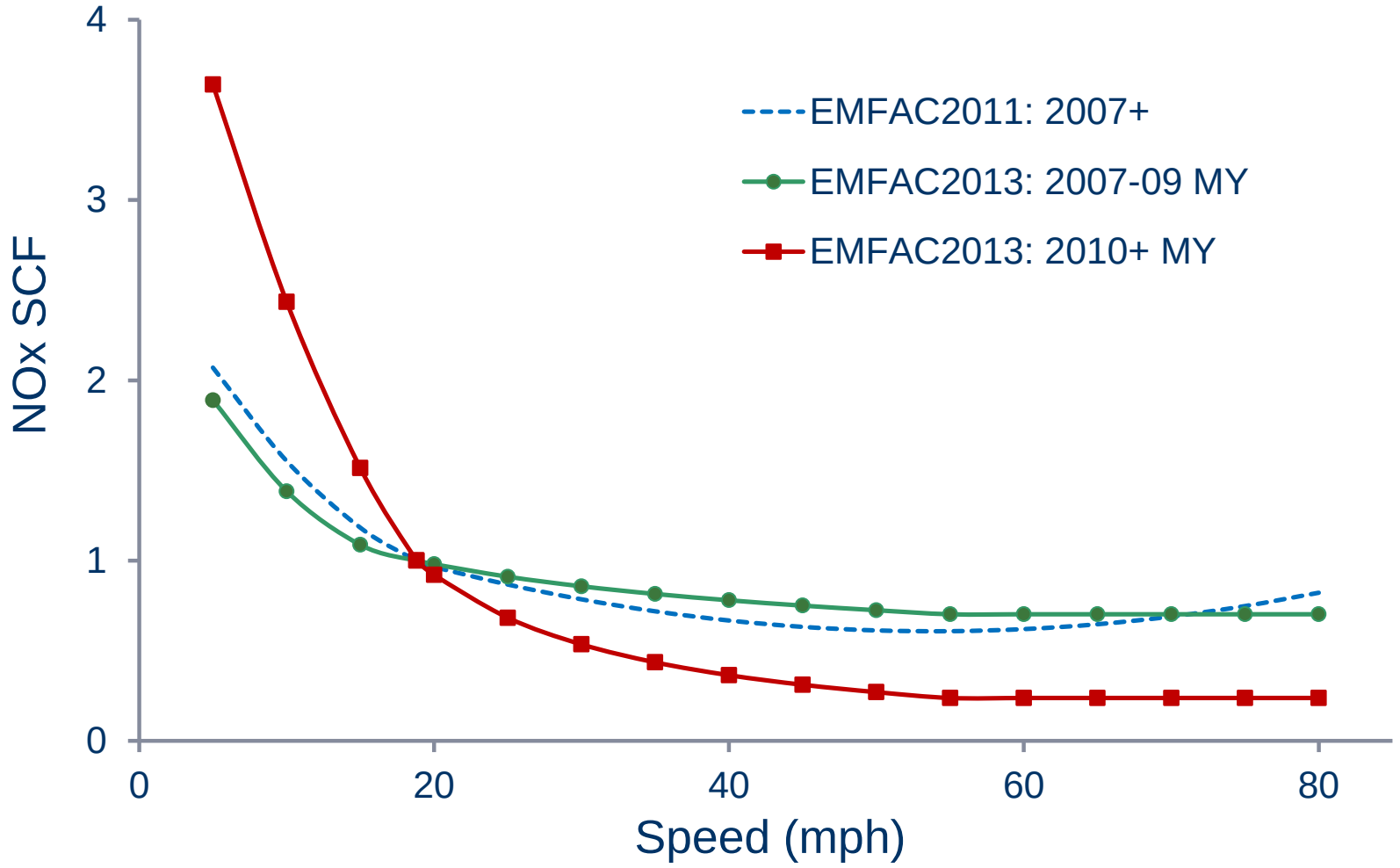
Emission Increase over 500,000 Miles

Model	NOx		PM
	2007-09	2010+	2007+
EMFAC2011	100%	178%	144%

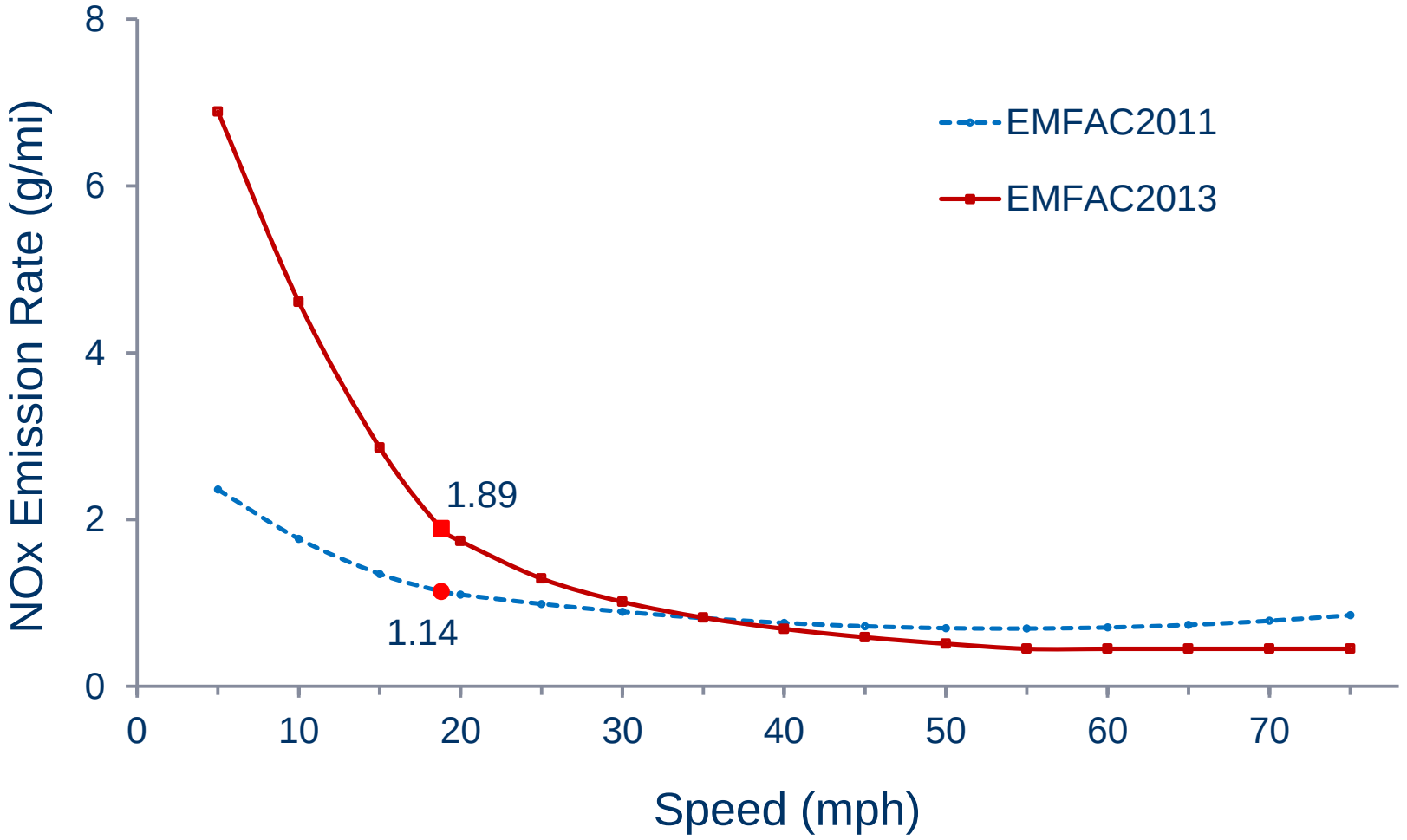
Truck Running Exhaust Emissions Speed Correction Factors

- Running exhaust emission rates vary by speed
- Speed correction factors developed from dynamometer test data
  - ARB 5-mode cycle provide emission rates at several different average speeds

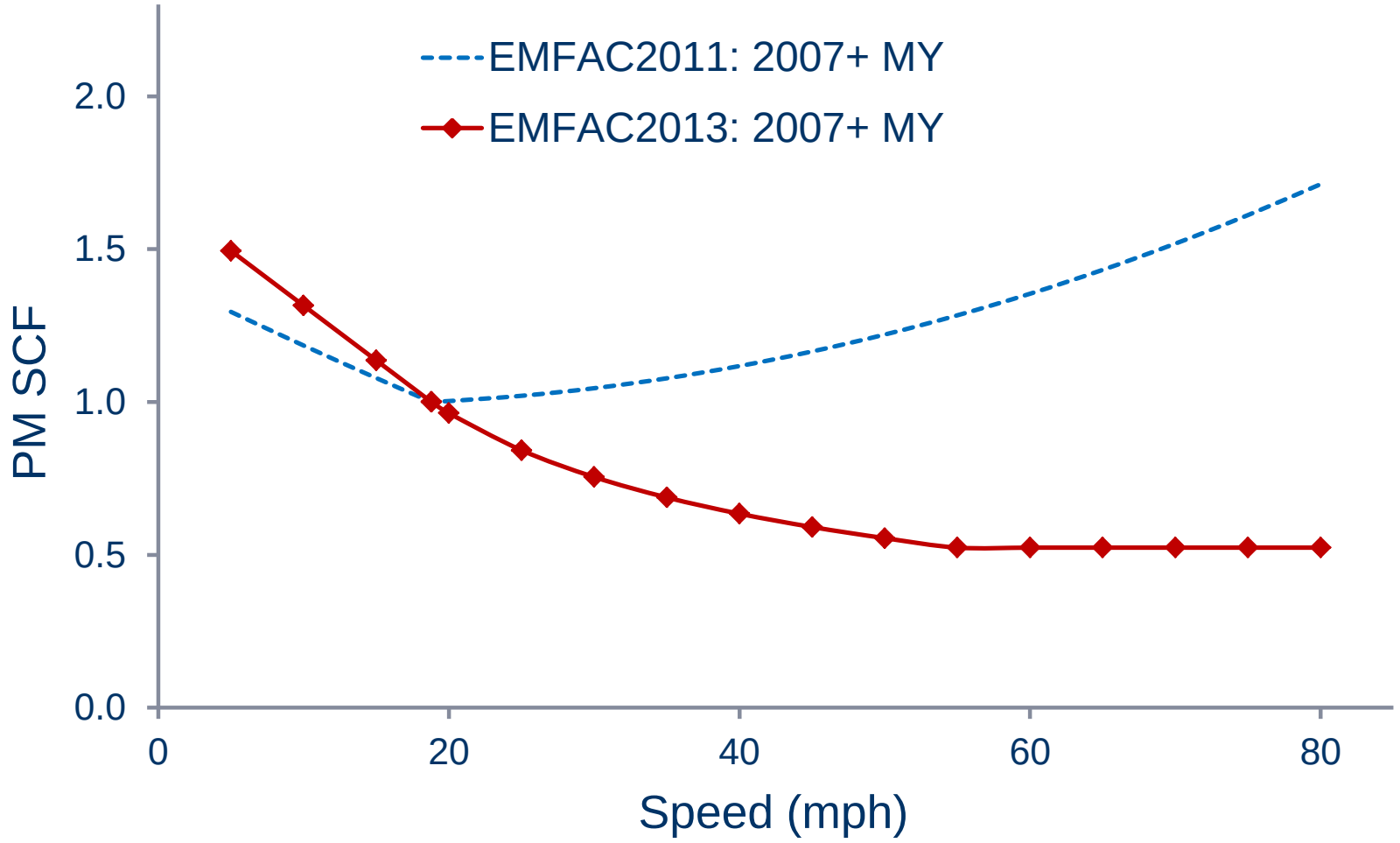
NOx Speed Correction Factors



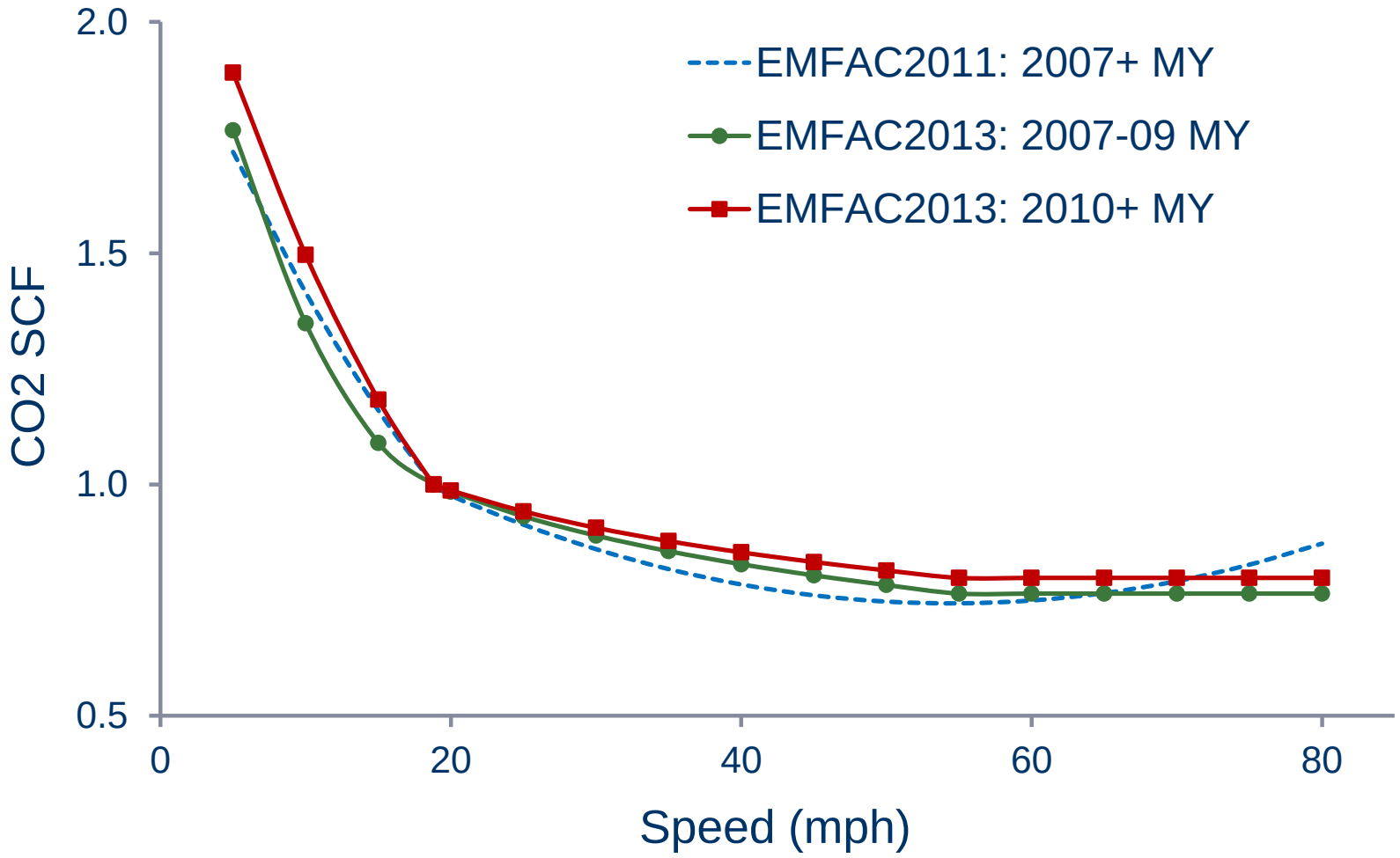
Effect of Speed Correction on NOx Zero-Mile Rate - 2015 MY



PM Speed Correction Factors



CO2 Speed Correction Factors



Speed Correction Factors

- NOx
  - For 2010+ MY, higher at low speeds but lower at higher speeds than EMFAC2011
- PM
  - Lower at high speeds than EMFAC2011

Truck Idle Emission Rates

- Many trucks operated in extended idle mode at truck stops or waiting for goods loading/unloading
- Idle emission rates based on Idle mode of ARB 5-mode cycle

Results: Idle Rates (g/hr)

Engine Model Year	EMFAC2011			EMFAC2013		
	NOx	PM	CO2	NOx	PM	CO2
2007-09	30.0	**0.072**	4,934	33.0	**0.001**	5,318
2010+	**30.0**	**0.072**	4,934	**12.1**	**0.001**	4,547

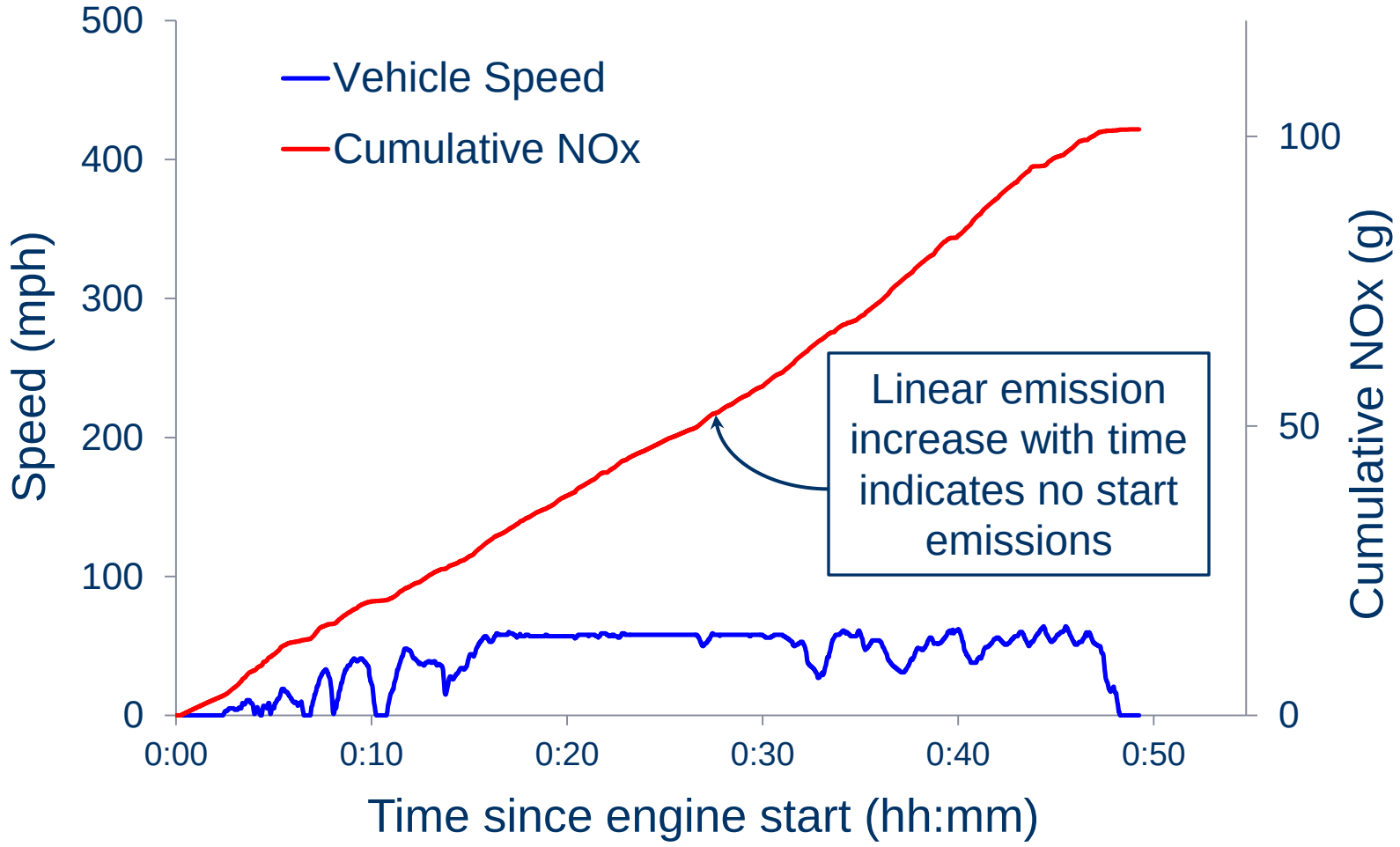
Truck Start Emissions

- Warm-up required for SCR to function
- Start emissions produced before SCR light-off temperatures reached
- Start emissions depended on:
  - Emission rate per start
  - Number of starts per day
- Start emission rates derived from PEMS testing data

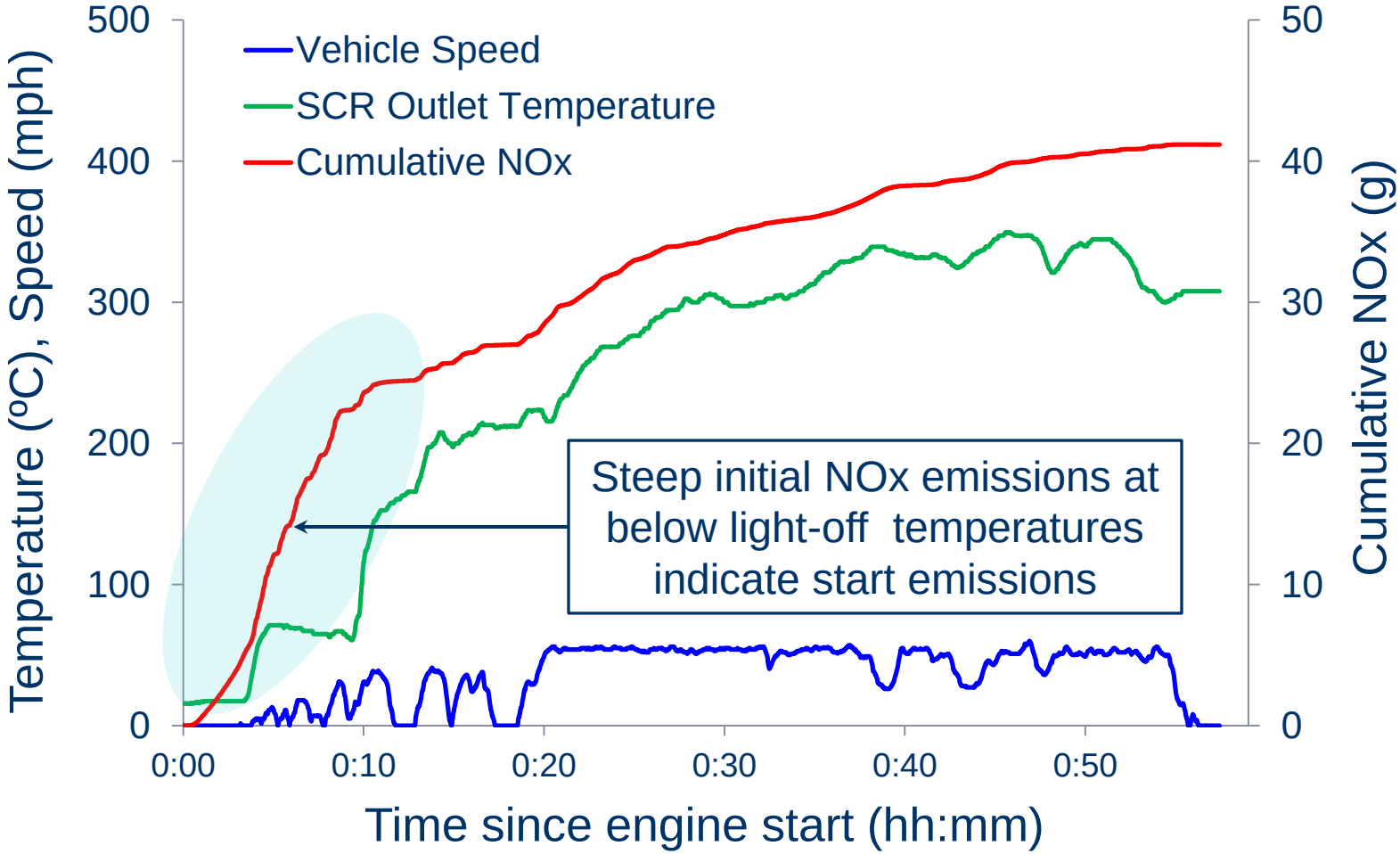
Type of Starts

- Test runs:
  - AM outbound: after overnight resting
  - AM/PM inbound: 30 min break
  - PM outbound: 60~90 min lunch break
- Defining starts by engine-off times
  - Cold start: overnight soaking
  - Warm start: ≥30 min to hours soaking
  - Hot start: <30 min soaking

2007 Technolgy Truck NOx Emissions (EGR Engines)



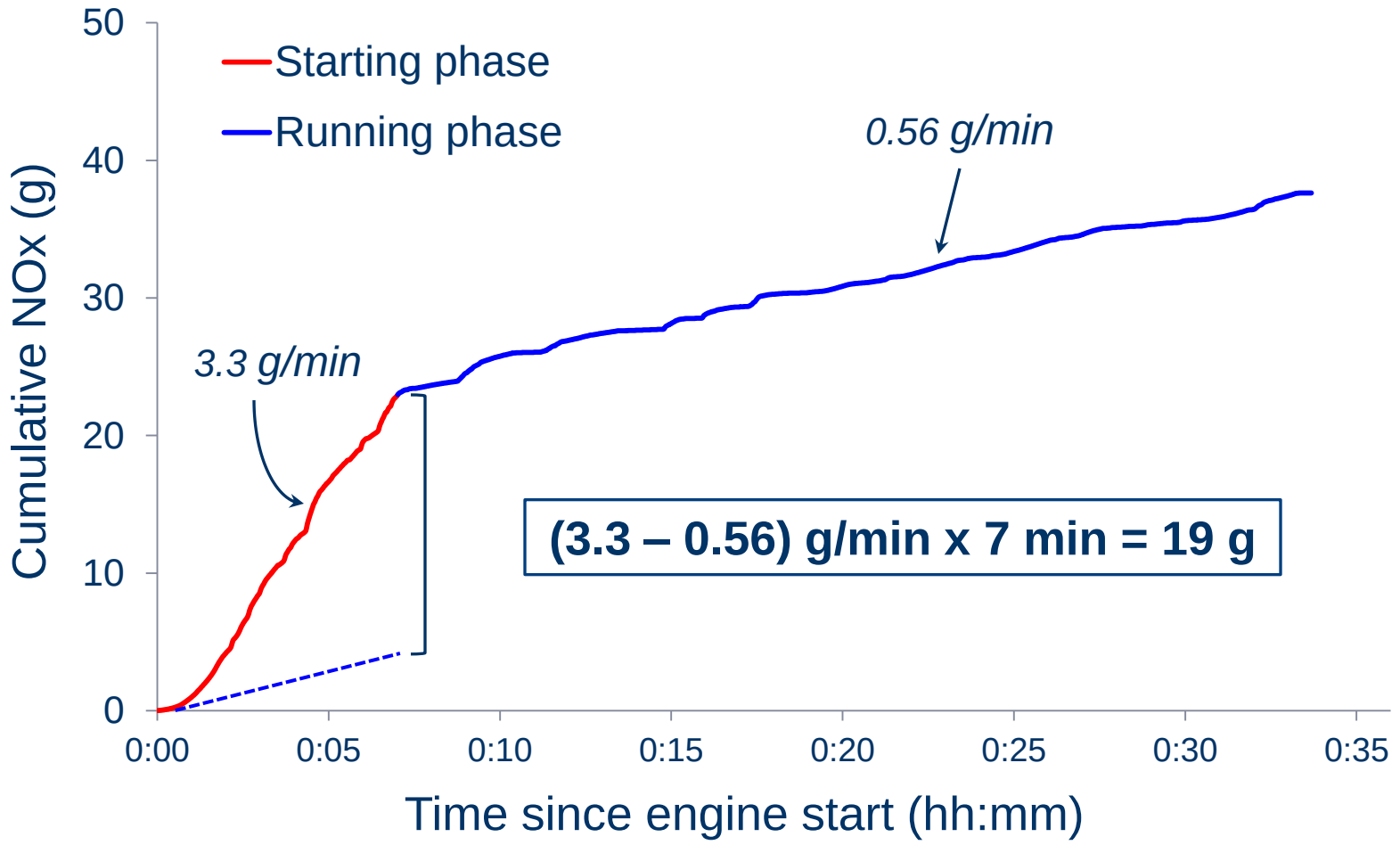
2010 Technology Truck NOx Emissions (SCR Engines)



Average Start Duration (min)

Direction	AM/PM	High Load	Med Load	No Load
Outbound	AM	9.7	9.8	10.7
Outbound	PM	7.8	9.1	9.6
Inbound	AM	5.9	6.8	8.3
Inbound	PM	5.8	6.7	7.9

NOx Start Emission Calculation



NOx Start Emission Rate (g/start)

Start Type	High Load	Med Load	No Load	All Load Avg
Cold Start	32.8	33.5	24.9	30.4
Warm Start	12.9	15.2	16.7	14.9

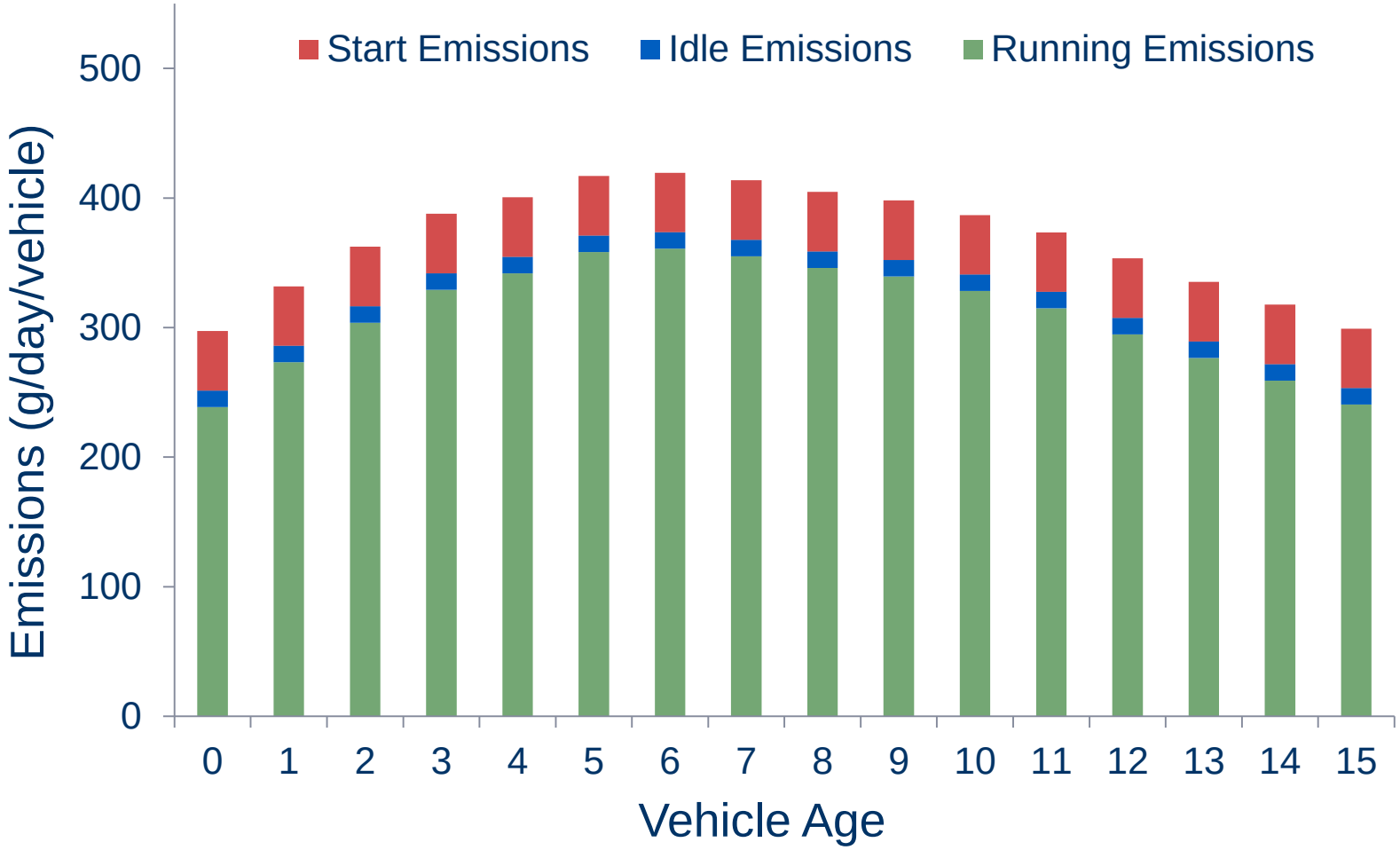
Number of Starts

- Study by UC Riverside
- Data sources used:
  - Telematics
  - PierPass program (POLB and POLA)
- Number of all engine-off events
  - Lasting ≥30 min
  - Segregated by type of services

Number of Cold & Warm Starts

Truck Service Type	Type of Start	Starts/Veh /Day
Long-Haul	Cold Start	1.00
	Warm Start	1.53
Short-Haul	Cold Start	1.00
	Warm Start	1.04
Drayage	Cold Start	1.00
	Warm Start	1.76

Impact of NOx Start Emissions



Adjustments to Engine Model Year Specific Emission Factors

- All emission factors obtained on engine model year basis
- Truck activity data collected on vehicle model year basis
  - Each vehicle model year includes several engine model years
- Adjustment based on information from Drayage Truck Registry (DTR)

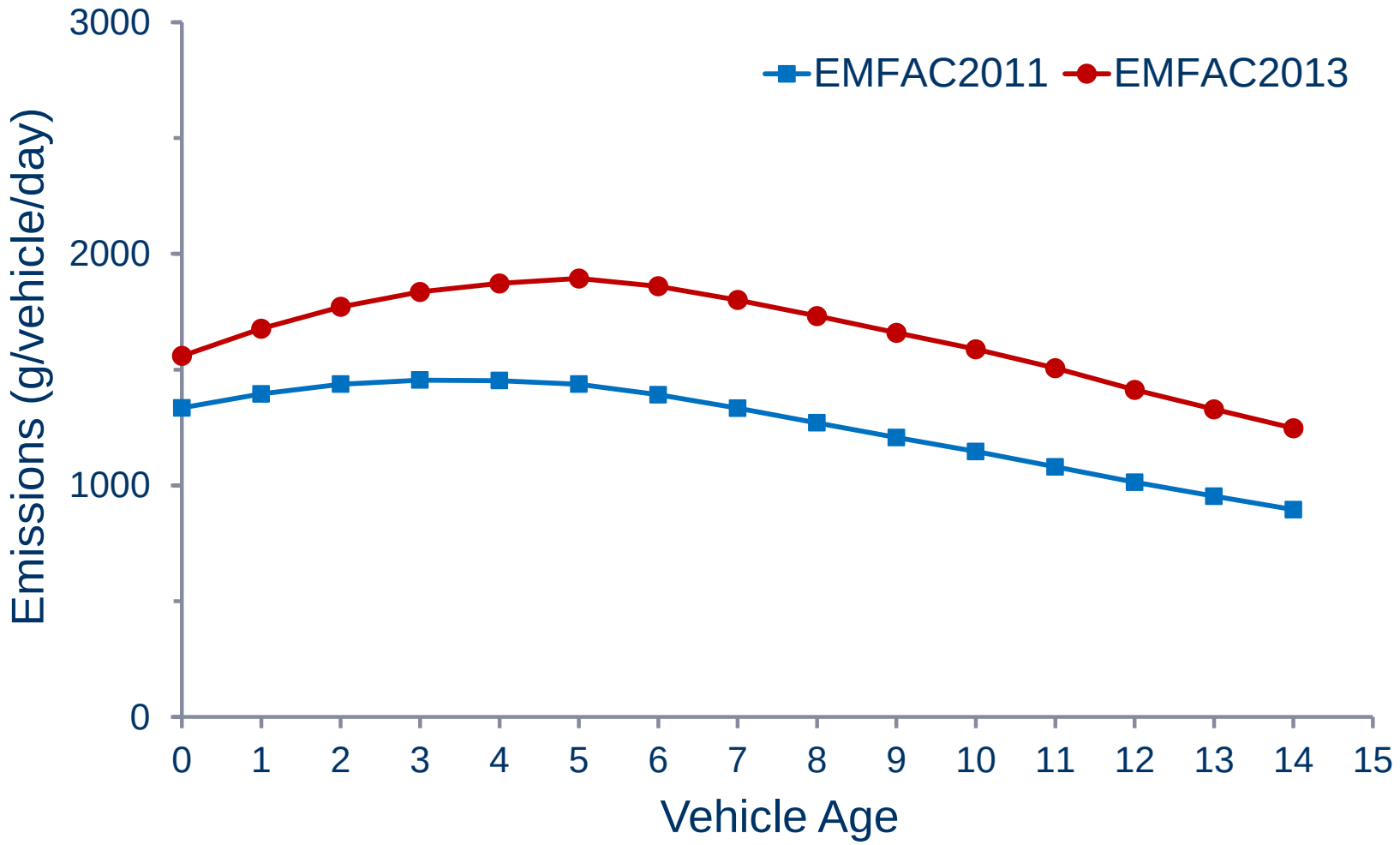
DTR Data: Truck Engine Model Years

Truck Model Yr	Engine Model Year								
	2005	2006	2007	2008	2009	2010	2011	2012	2013
2007	4%	72%	24%						
2008		3%	62%	35%					
2009			5%	62%	33%				
2010					83%	17%			
2011					18%	67%	15%		
2012						15%	68%	17%	
2013						8%	16%	66%	10%

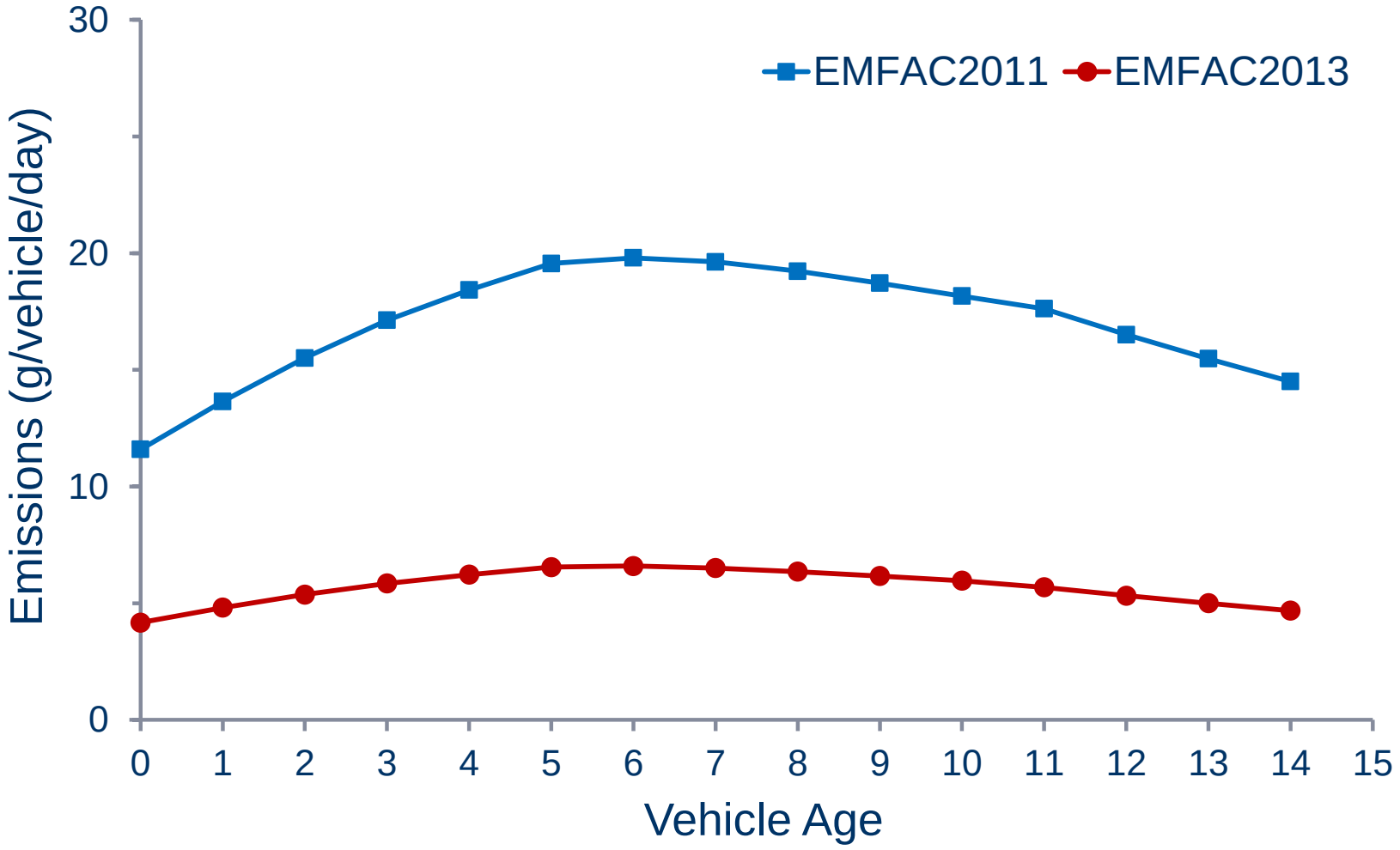
Emissions Changes: 2008 MY Trucks

- NOx higher than EMFAC2011
  - Slightly higher ZM rate and largely higher SCF for high speeds
- PM10 lower EMFAC2011
  - Mainly lower ZM rate but also lower SCF at high speeds

NOx Emissions: 2008 MY Trucks



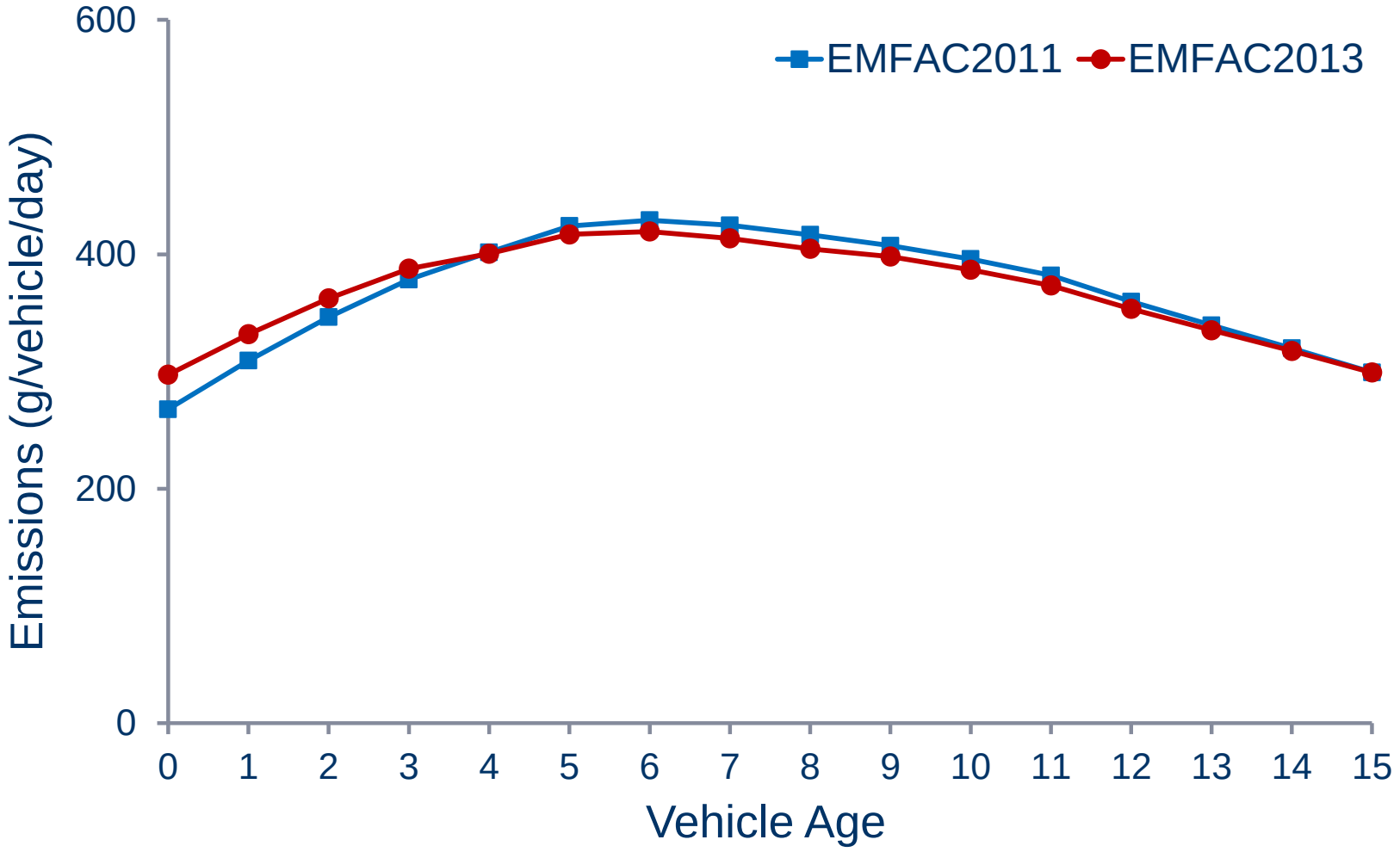
PM10 Emissions: 2008 MY Trucks



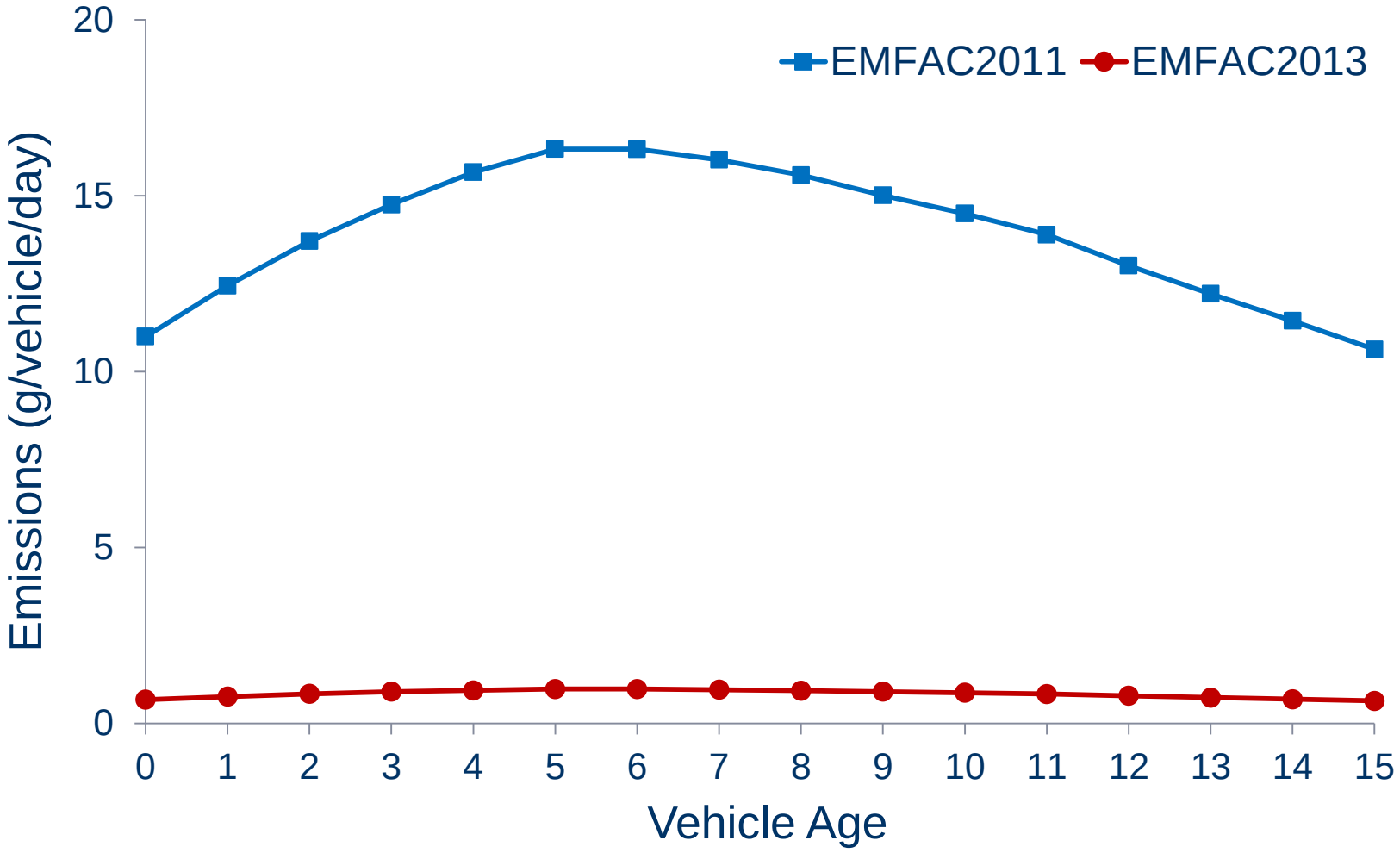
Emissions Changes: 2015 MY Trucks

- NOx: overall no significant change
  - Higher NOx ZM rate plus start emissions but largely offset by smaller SCFs at high speeds
- PM: much lower than EMFAC2011
  - Lower ZM rate and smaller SCFs
- 2010 technology trucks
  - Engines tuned for high engine-out NOx then controlled by SCR, leading to low engine-out PM and less frequent DPF regeneration

NOx Emissions: 2015 MY Trucks



PM10 Emissions: 2015 MY Trucks



EMFAC2013

EMFAC-HD

Fleet Rules

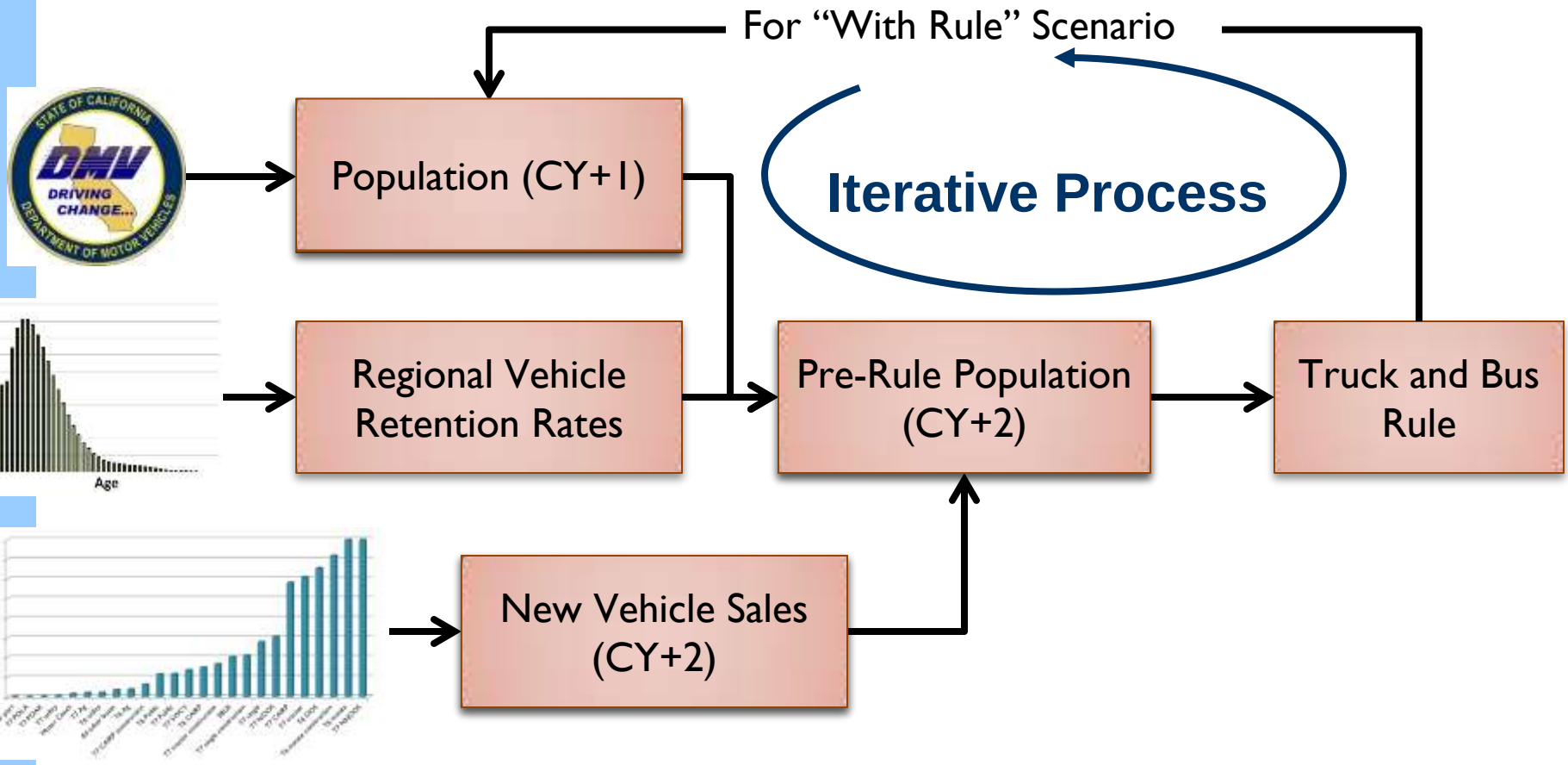
Fleet Rules

- Early fleet rules targeted diesel PM reductions
  - Public Fleet and Solid Waste Collection Vehicles (SWCV) regulations
  - Require diesel control device
- Recent fleet rules considered reductions in NOx as well as diesel PM
  - Truck and Bus and Drayage Truck regulations
  - Require fleet turnover
- Compliance assumptions consistent with EMFAC2011

Estimating Rule Benefits

- Iterative process
  - Every year, check for compliance and assume turnover/retrofit to meet the requirements
  - Turnovers assumed to have the survival rates of new model year
  - Retrofit will stay in fleet until required turnover kick-in
- Total VMT conserved

Modeling Vehicle Population / Rules



EMFAC2013

EMFAC-HD

GHG Standards and Rules

HDV GHG Rule

- Became effective January 1, 2010
- Applicable to
  - Long-haul tractors pulling 53’ or longer box-type trailers
  - 53’ or longer box-type trailers (dry-van & refrigerated van trailers) pulled by long-haul tractors
  - All owners operating affected vehicles in California regardless of where their vehicle is registered
  - Optional phase-in for small fleets (2013-2016) and large fleets (2010-2015)
- Requires fuel efficiency improvements

Phase I Regulation

- ARB intends to adopt a new heavy-duty vehicle GHG new truck and engine standard that largely follows the structure of the U.S. EPA HDV GHG Standard recently adopted (called “Phase I”).

EMFAC2013

EMFAC-HD

Draft Results

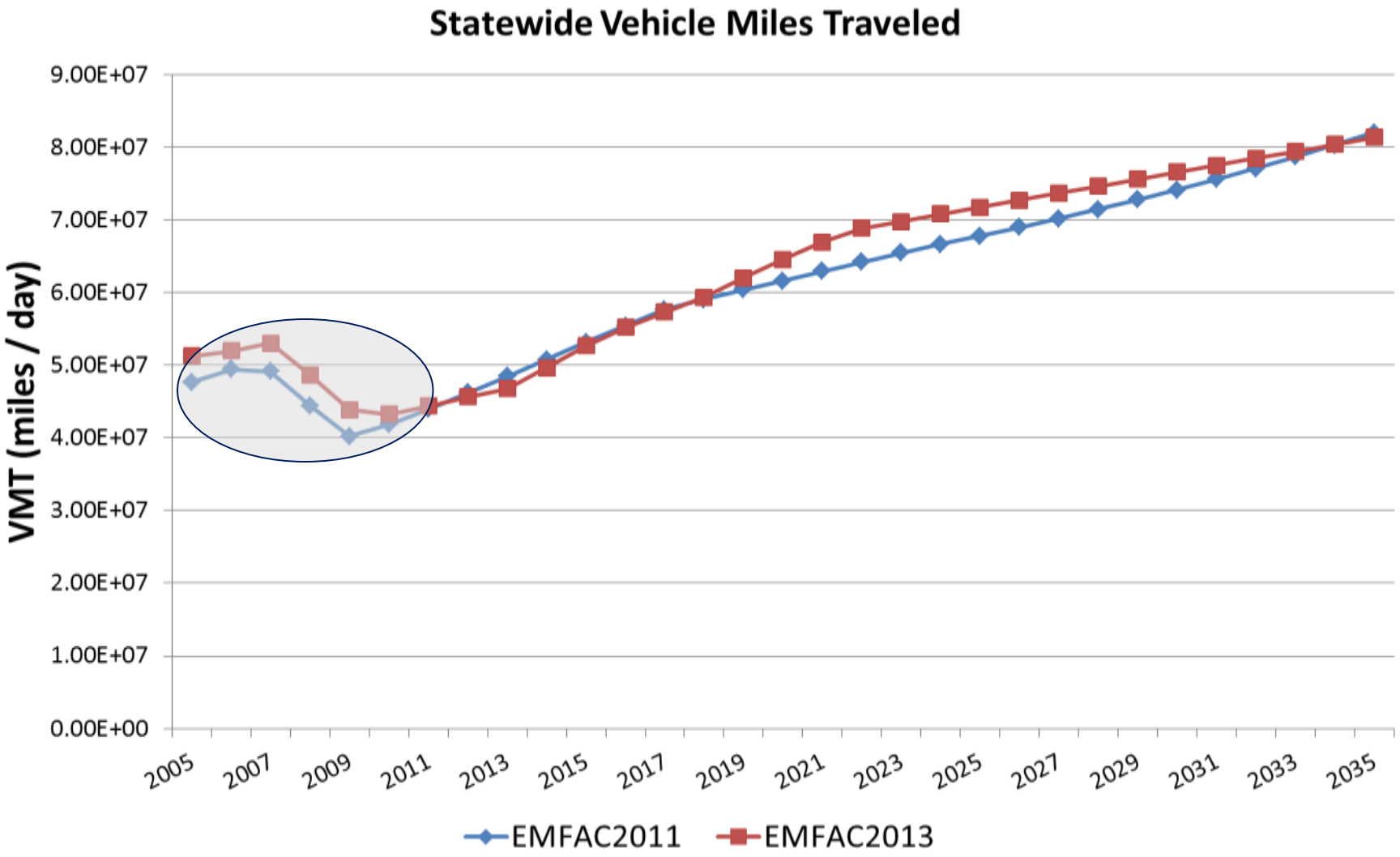
Current Draft Output

- Quality assurance and control work is on-going
- These numbers will change
- These numbers do not reflect MPO VMT

Draft Model Output
Statewide, All HD Vehicle Classes

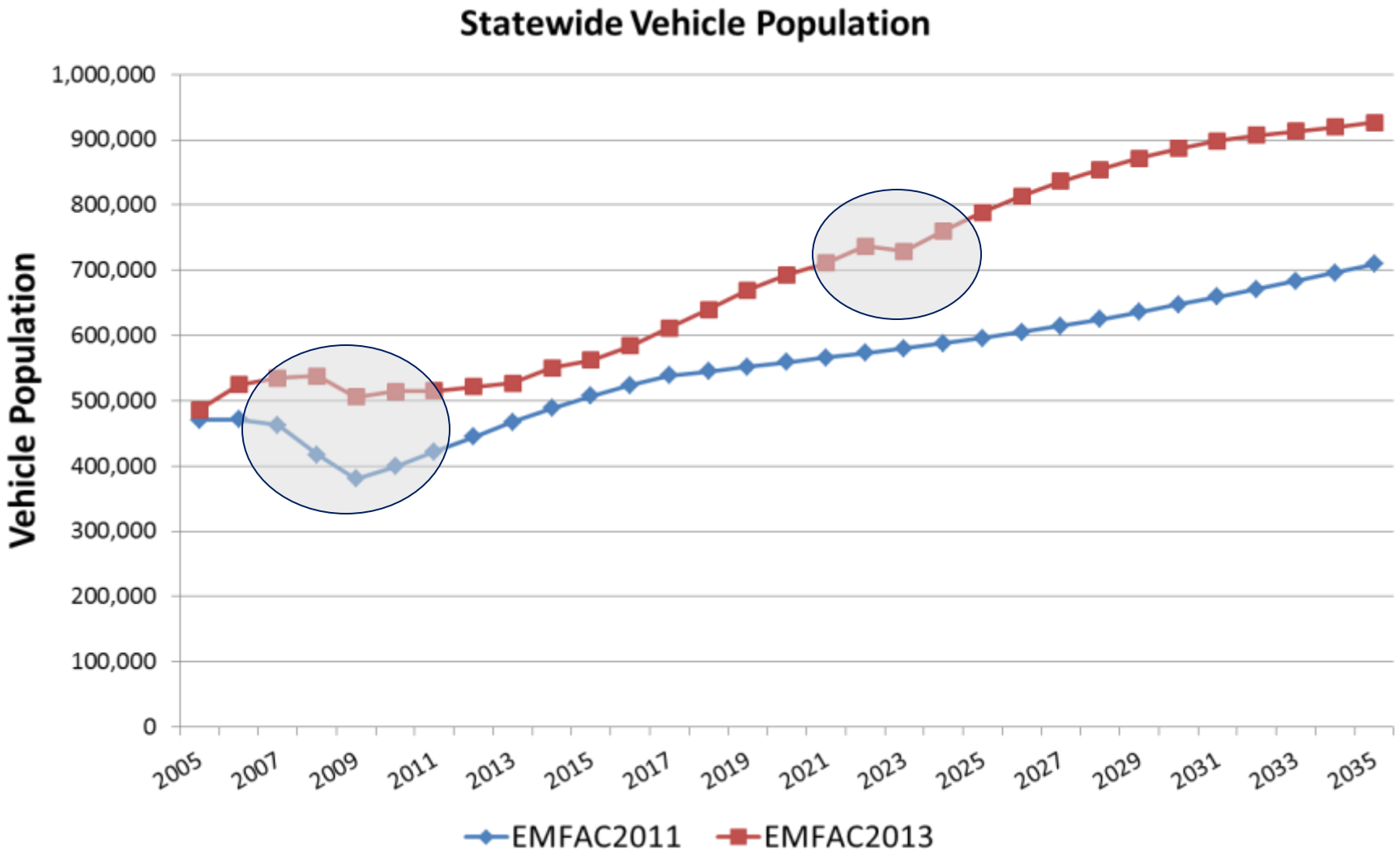
- VMT generally consistent with EMFAC2011
- Populations are less sensitive to recession and higher than EMFAC2011
- NOx is 10% or more higher than EMFAC2011
  - Similar VMT
  - higher emission rates
- PM is lower than EMFAC2011 after 2014
  - DPF equipped trucks with lower emission rates than EMFAC2011
- CO2 shows the benefit of Tractor Trailer regulation and federal fuel standards
  - Baseline would track VMT

Statewide VMT, All HD Vehicle Classes



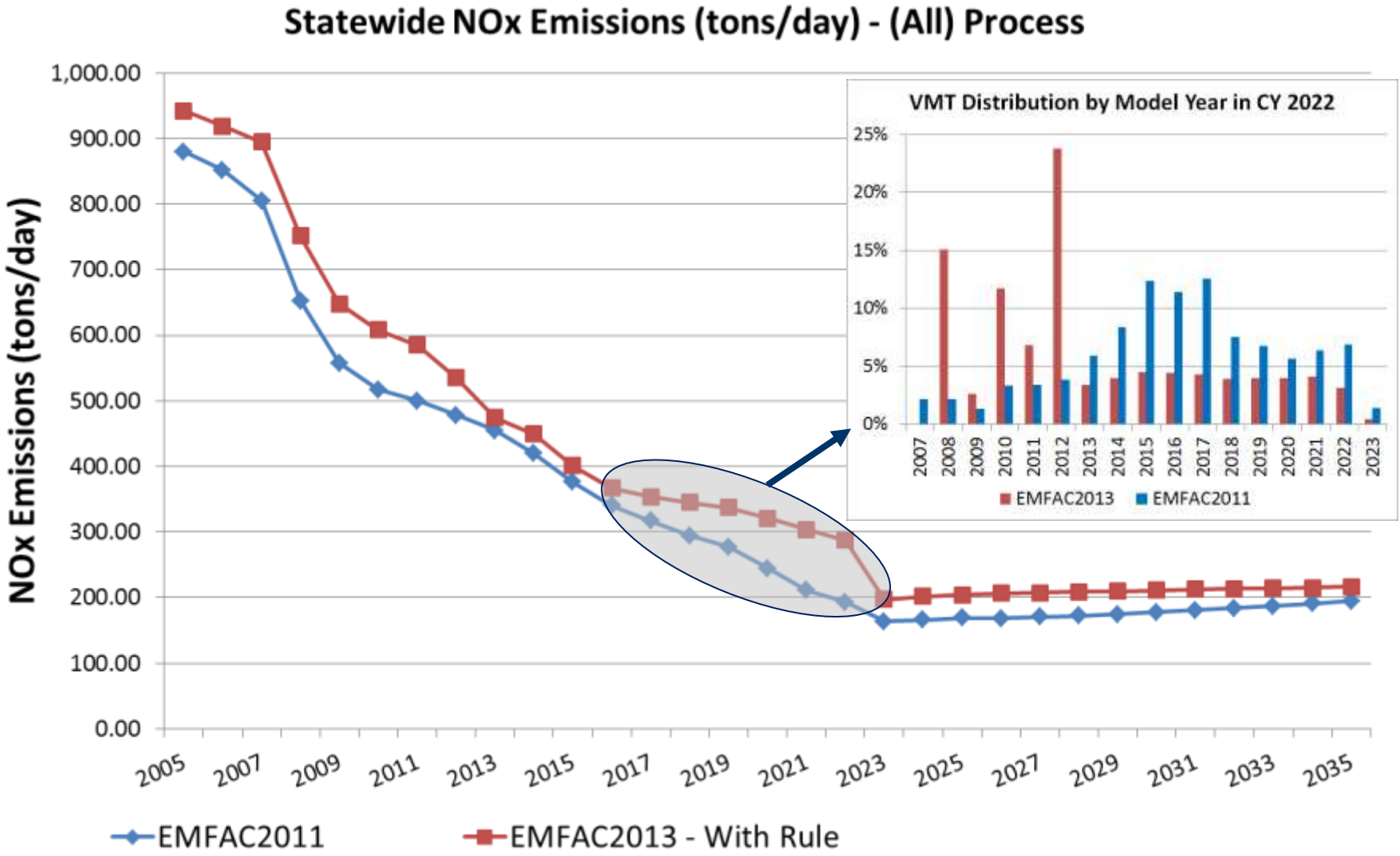
DRAFT

Statewide Population, All HD Vehicle Classes



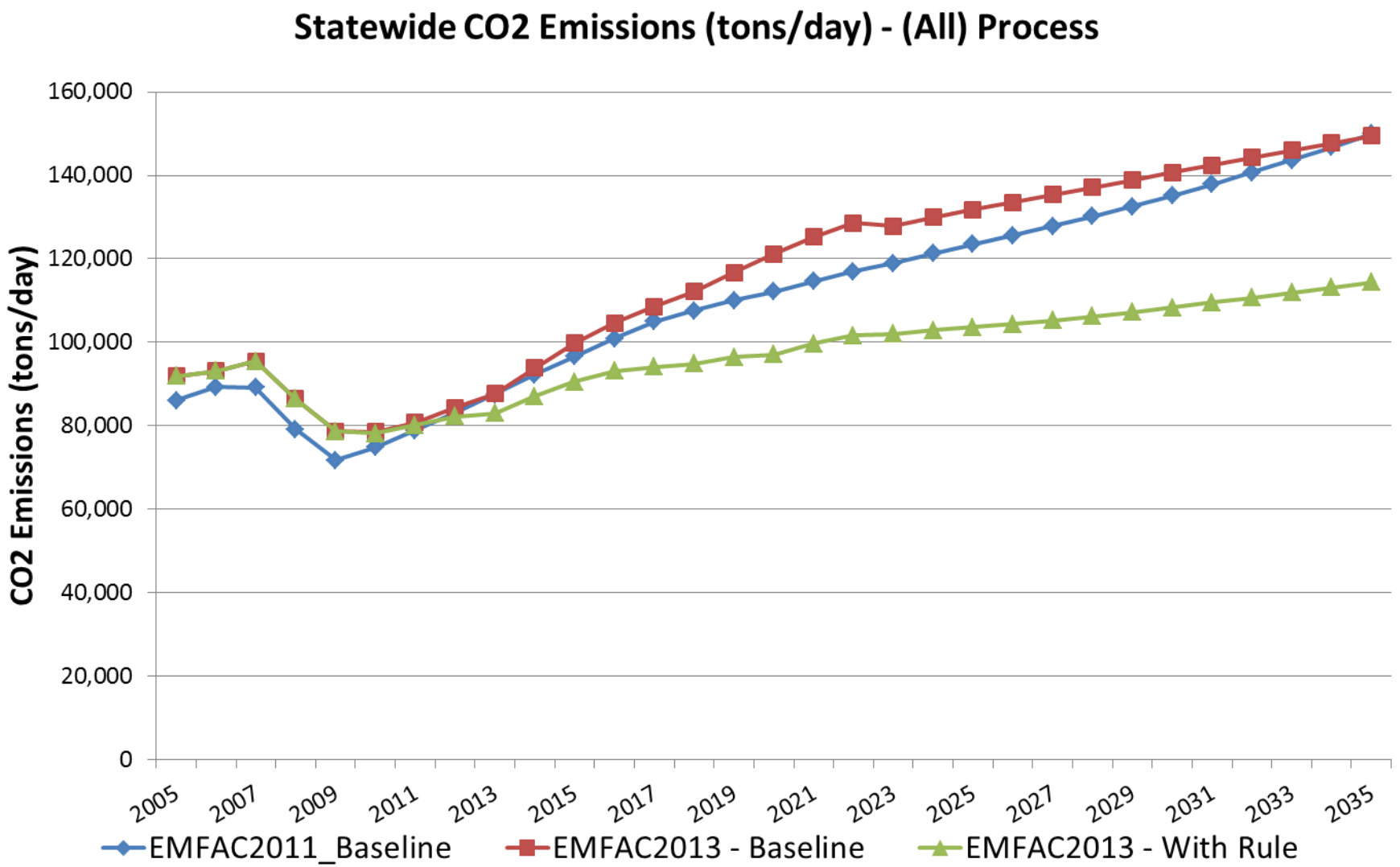
DRAFT

Statewide NOx, All HD Vehicle Classes



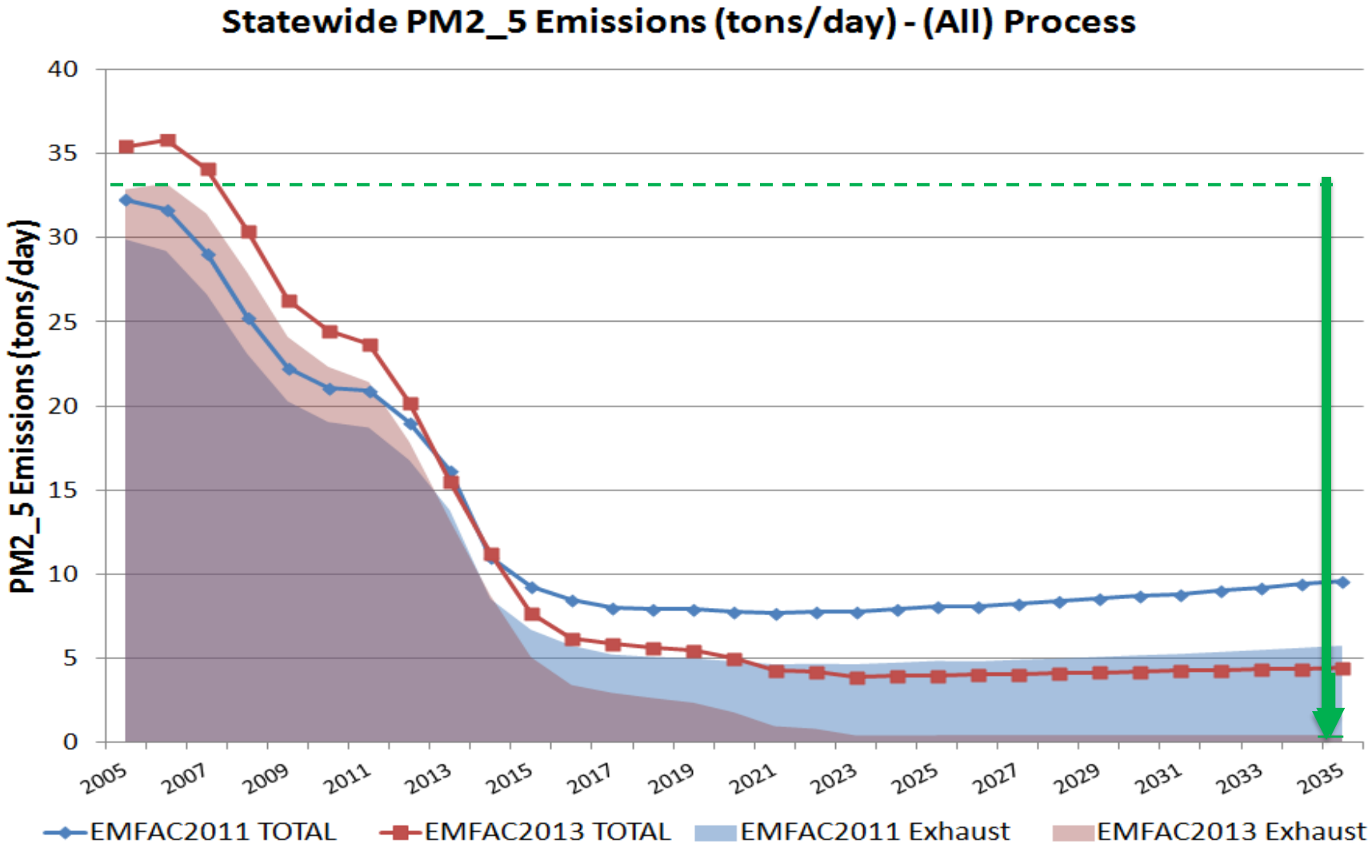
DRAFT

Statewide CO2, All HD Vehicle Classes



DRAFT

Statewide PM2.5, All HD Vehicle Classes



DRAFT

EMFAC2013

EMFAC-HD

Next Steps

EMFAC2013-HD Next Steps

- Continue quality assurance and control
- Reflect new OGV growth trend to drayage trucks

EMFAC2013

Combined Emissions Results

Significance of Model Results

- Model results have many implications that are beginning to be considered
  - Ozone modeling
  - Previous air quality plans and attainment demonstrations
  - Incentive funding programs
  - Health risk assessment and environmental justice
  - New vehicle standards and certification programs
  - State strategy development and Vision modeling for 2015 SIPs

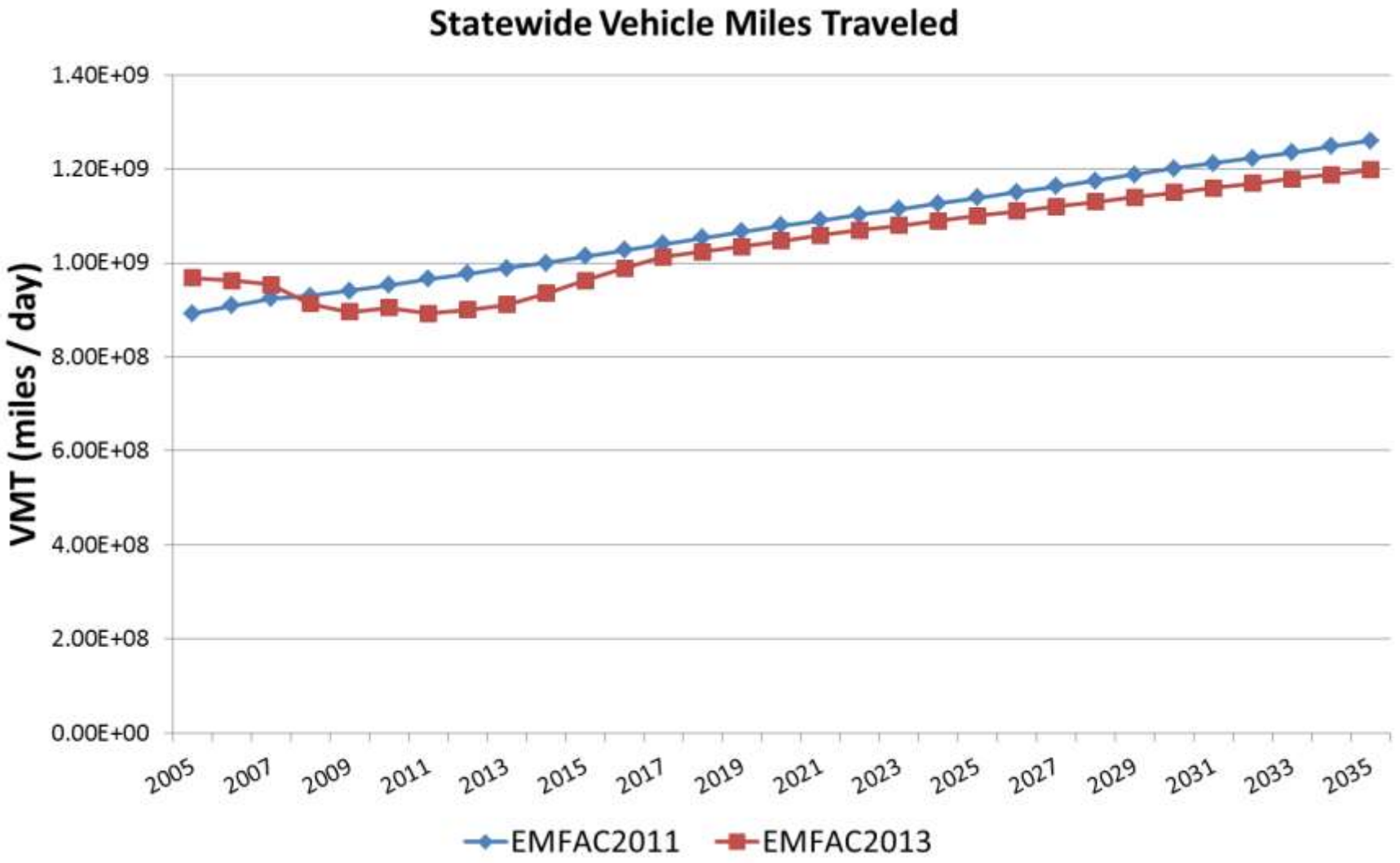
Current Draft Output

- Quality assurance and control work is on-going
- These numbers will change
- These numbers do not reflect MPO VMT

Statewide Draft Model Results

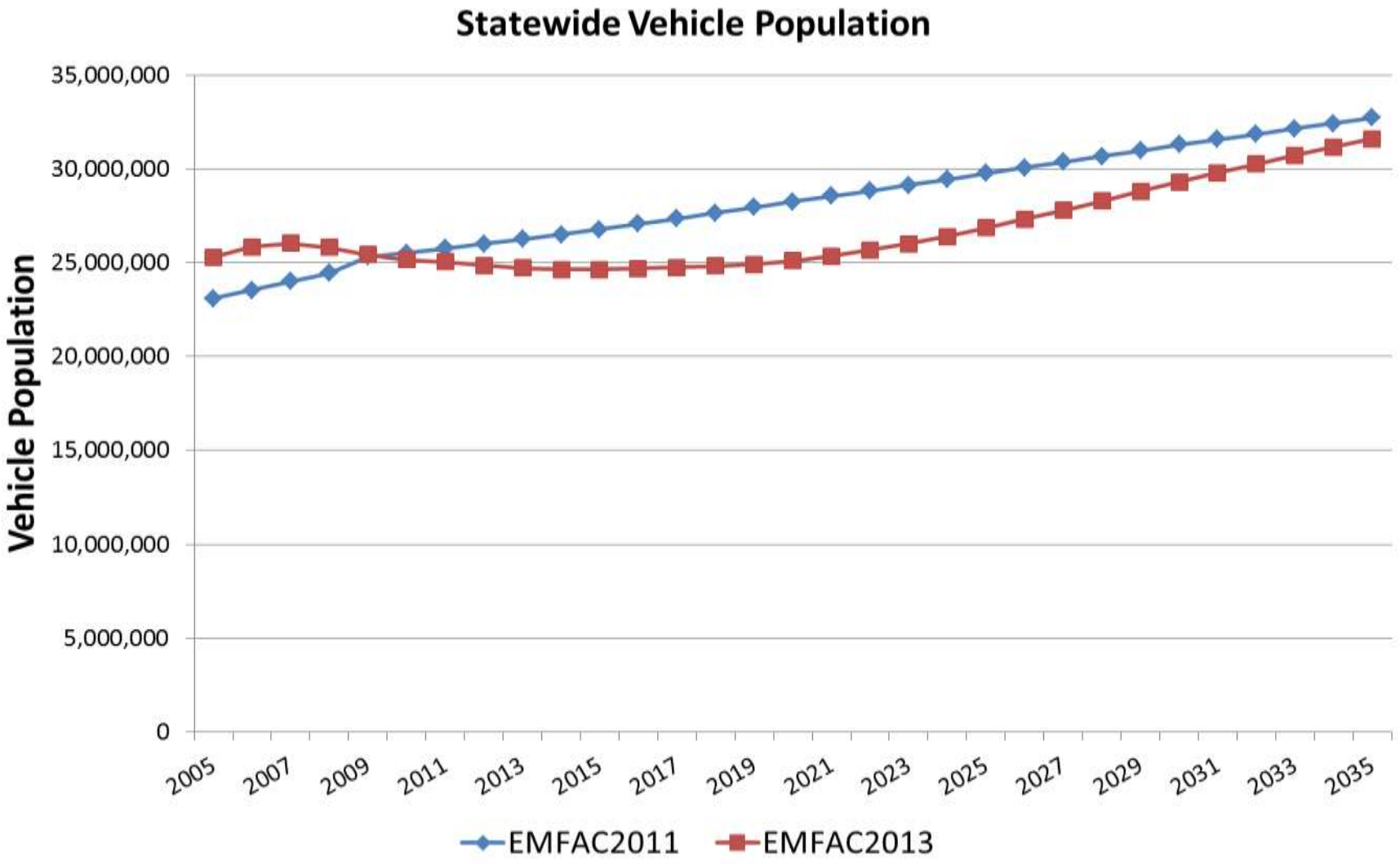
- NOx and ROG emissions
  - Higher HD emissions offset by lower LDV emissions in EMFAC2013
  - NOx emissions marginally lower than EMFAC2011 after 2023
- PM25 emissions
  - Higher in EMFAC2013: 2005-2015
  - Lower in EMFAC2013: 2015-2035

Statewide VMT
All Vehicles



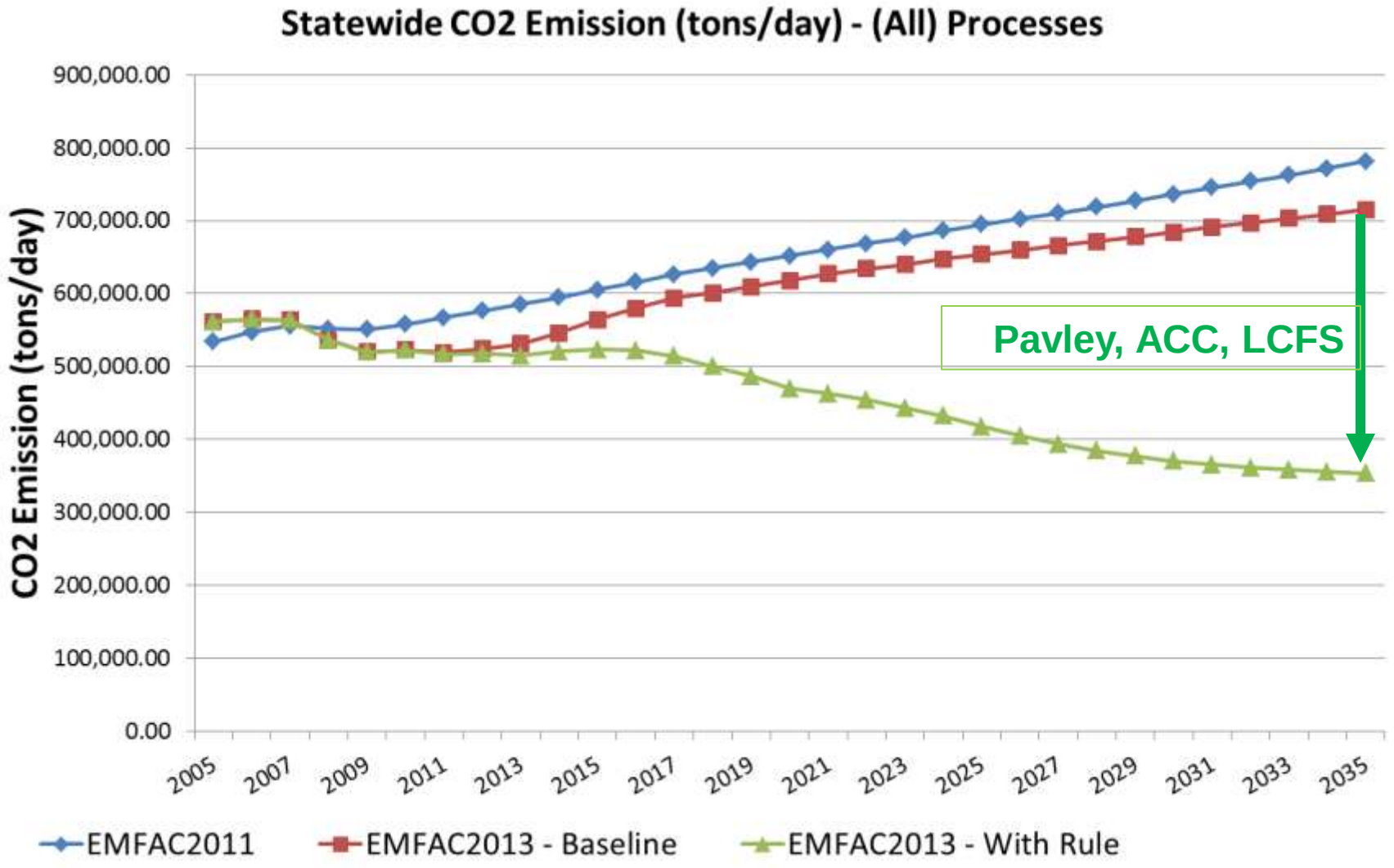
DRAFT

Statewide Vehicle Population
All Vehicles



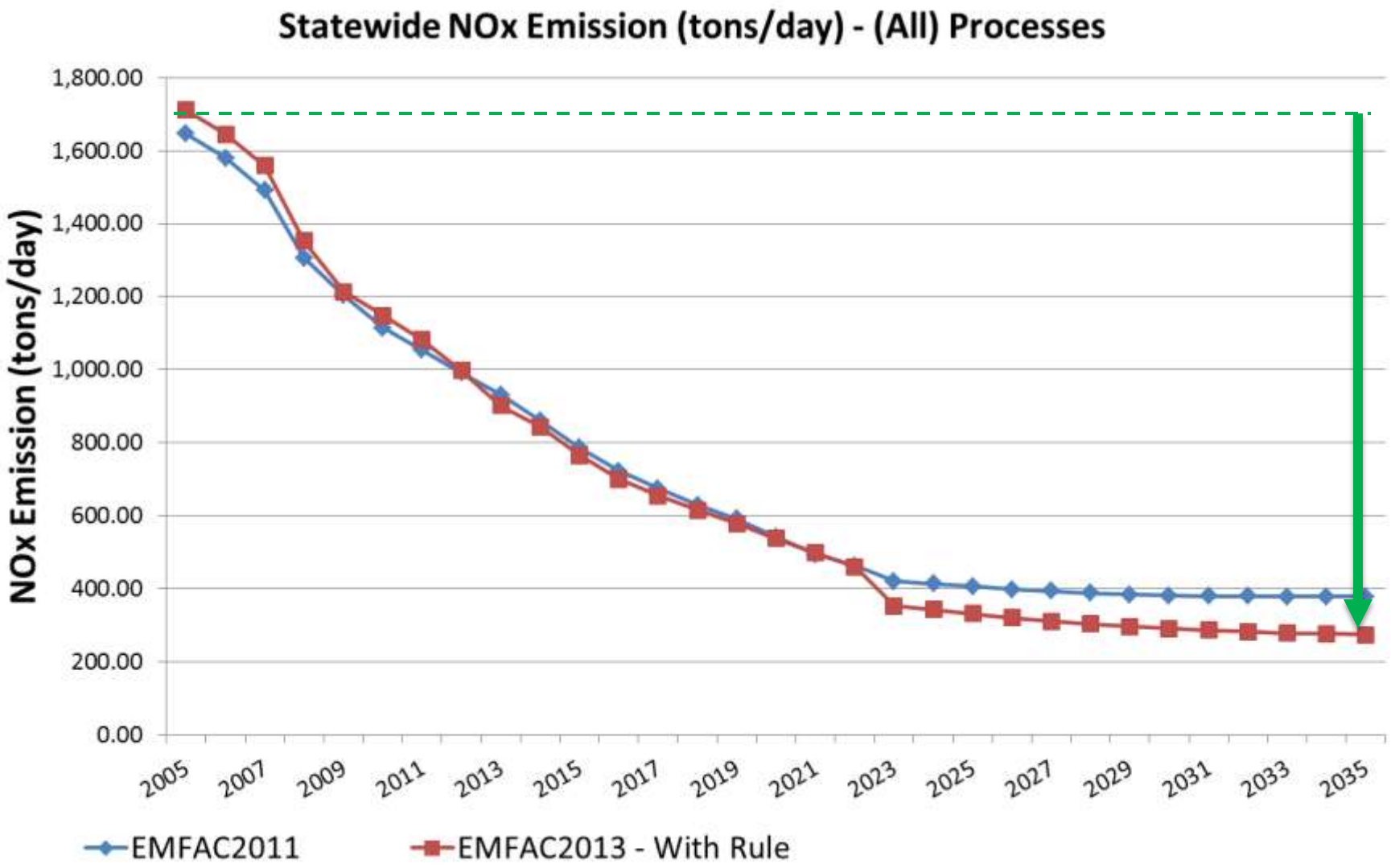
DRAFT

Statewide CO2, All Vehicles



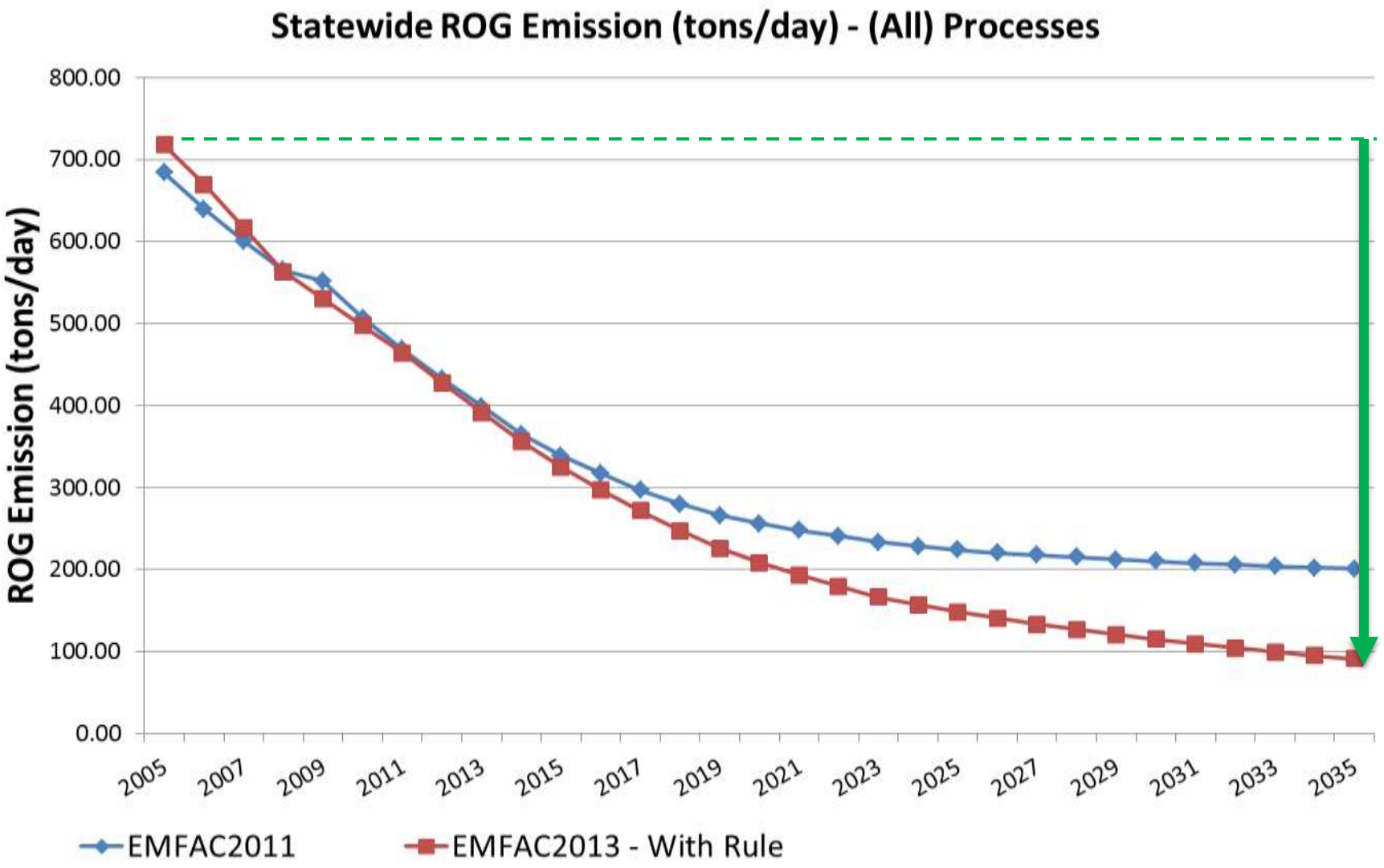
DRAFT

Statewide NOx, All Vehicles



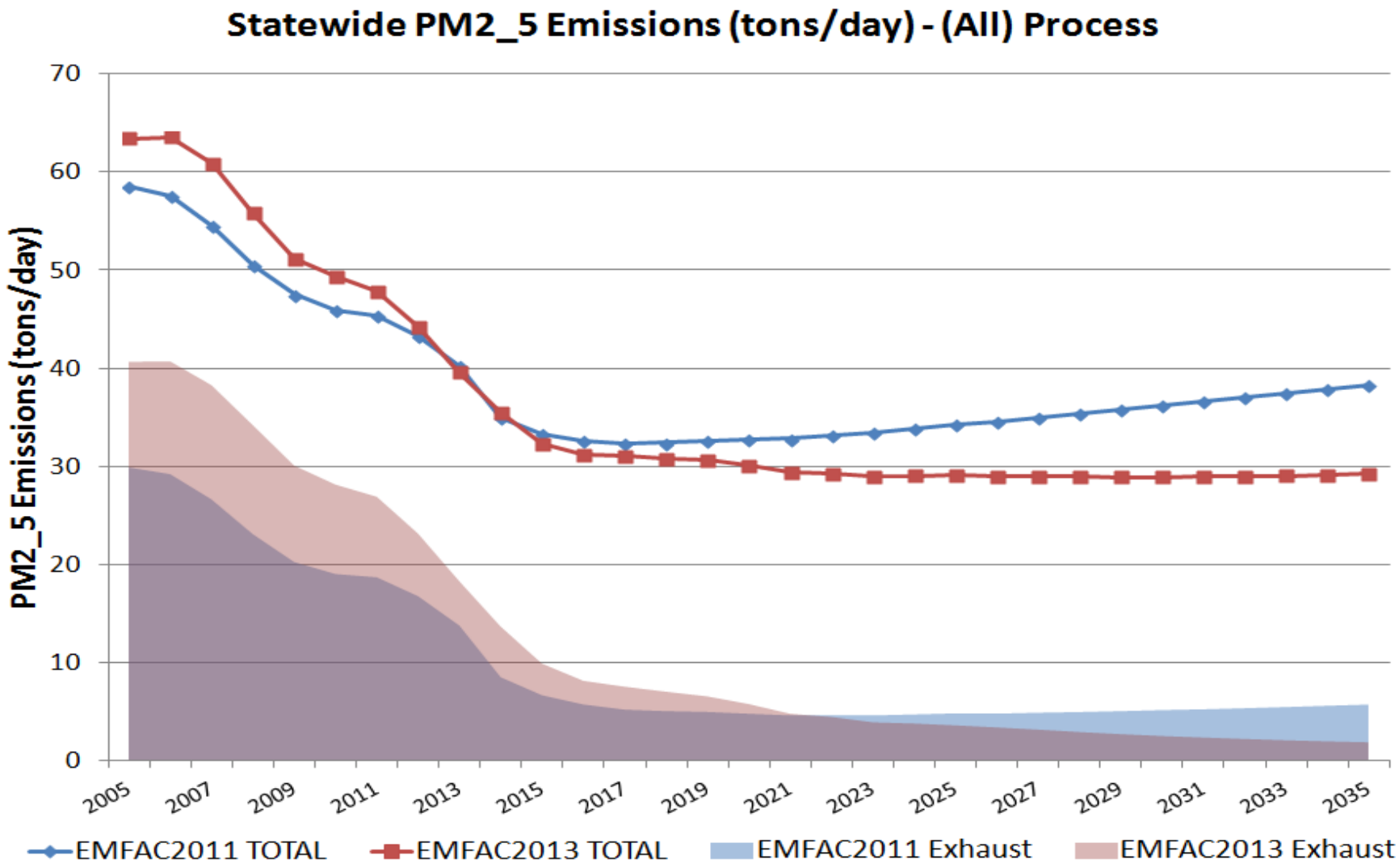
DRAFT

Statewide ROG, All Vehicles



DRAFT

Statewide PM2.5, All Vehicles



DRAFT

EMFAC2013

EMFAC-SG

Latest Planning Assumptions

- Conformity assessments based on latest emissions data
  - Travel activity (MPO VMT and speed data)
  - Vehicle and Fleet assumptions (EMFAC)
- EMFAC2013 forecasts fleets using econometric models
  - Based on historical data regression
  - Based on 2013 economic forecasts and fuel sales
  - Differently than previous EMFAC versions
  - Differently than MOVES

EMFAC-SG

- SG matches EMFAC to regional VMT estimates and forecasts
  - Conformity analyses required by federal law;
  - State Implementation Plan inventories; and
  - Alternative growth scenarios associated with regional transportation planning for GHG reductions (SB375)
- Methods
  - Combines output from EMFAC-LDV and EMFAC-HD
  - Applies scaling factors to estimate emissions consistent with user-defined VMT and speeds

Updates for EMFAC2013-SG

- Integrated into EMFAC2013
  - One platform and uniform user interface
  - One installation package that is easier to install
- Backwards compatible with EMFAC2011-SG
  - Daily speed profile format same as EMFAC2011-SG
- Allows hourly as well as daily VMT and speed profiles
- Provides options to scale with or without Rules
  - Trucks: Fleet Rules, GHG
  - Cars: ACC, Pavley, LCFS

Scaling Factor Calculation

- Daily scaling factor :
  - Running: $\frac{VMT_{user}\,(Veh,Fuel,Speed)}{VMT_{default}(Veh,Fuel,Speed)}$
  - other processes: $\frac{VMT_{user}\,(Veh,Fuel)}{VMT_{default}(Veh,Fuel)}$
- Hourly scaling factor :
  - Running: $\frac{VMT_{user}\,(Veh,Fuel,Speed,hour)}{VMT_{default}(Veh,Fuel,Speed,hour)}$
  - Other processes: $\frac{VMT_{user}\,(Veh,Fuel,hour)}{VMT_{default}(Veh,Fuel,hour)}$

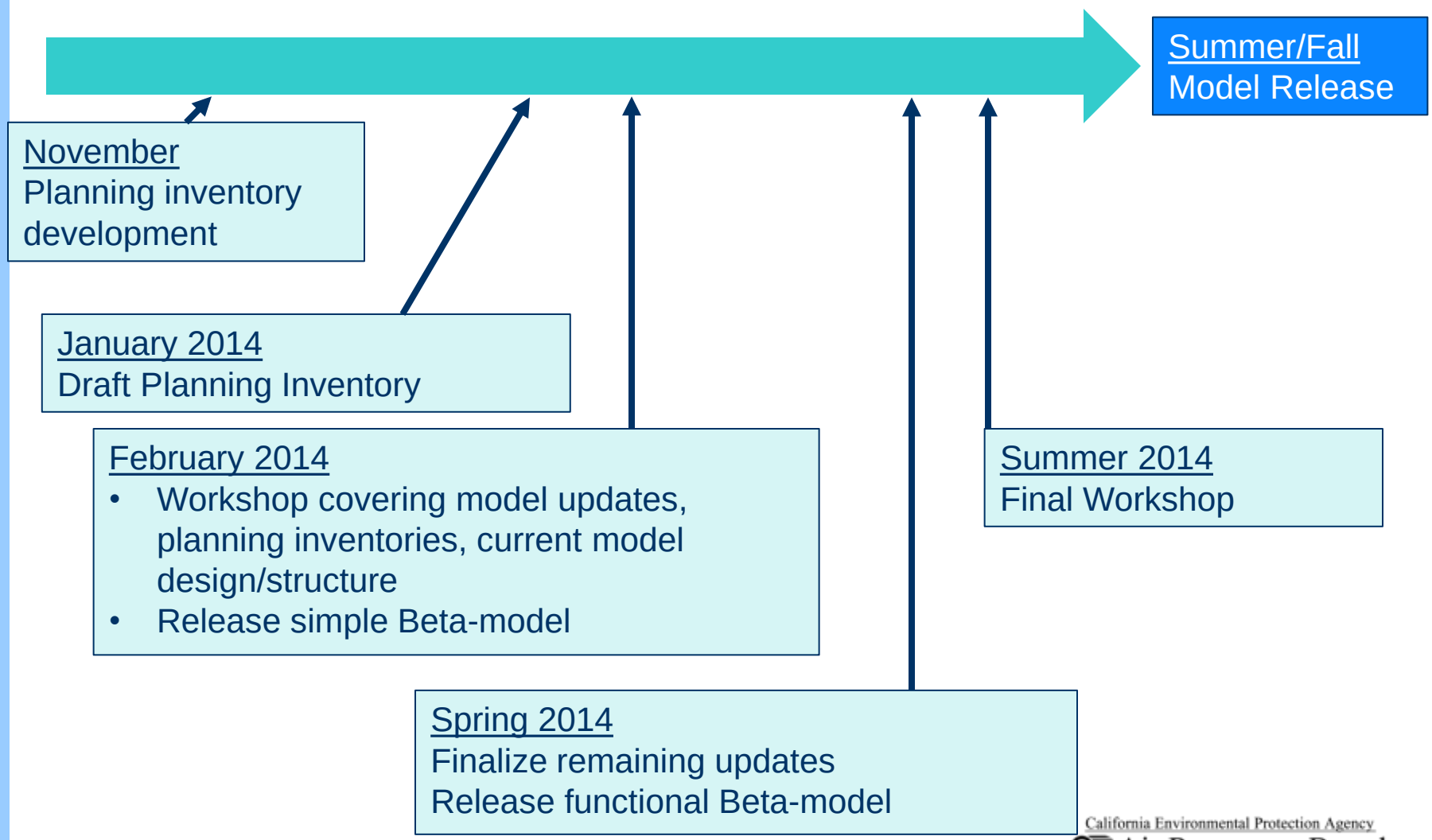
EMFAC2013

Next Steps

Work Plan

- Anticipate release fall 2014
- Iterative work plan approach
  - Method development
  - Quality assurance and control
  - Model programming / systems integration
  - Report development and testing
- Public process

General EMFAC2013 Timeline



Method Refinements

- Evaluate population forecast and results
- Distinguish natural gas urban buses and trash trucks in the inventory
- Integrate vocation-specific driving cycles
  - For example, drayage and refuse trucks
- Quality assurance and control is on-going
  - Focus on methods including emission factors
  - Focus on model inputs and results
  - QA will continue until model is released

Model Development

- Model system integration is beginning
- Expect an iterative process with several draft models
  - These models will evolve sequentially
  - The first model will provide one output type
  - Functionalities will improve in subsequent drafts
- Model testing will involve stakeholders
- Process not yet determined

For More Information

- Mobile Source Emission Inventory
  - Website: http://www.arb.ca.gov/msei/msei.htm
  - Email list: http://www.arb.ca.gov/listserv/listserv_ind.php?listname=msei
  - Email: msei@arb.ca.gov