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Clearing California Skies for 50 Years

Mobile Source In-use Emissions Compliance - A Reality Check and Future Vision

9th Annual PEMS Conference

March 14th, 2019

Overview

- Agency changes, accomplishments and goals
- Current MS contribution on NOx and GHG inventories
- Reductions accomplished and planned

Overview (cont'd)

- Reality check - Current HD In-use emissions and warranty rates
- CARBs PEMS program only growing
- Paradigm shift to continuous monitoring of In-use emissions performance
- Preview REAL
- SCCP Update

Organizational Changes to Align with Priorities (Establishing New Divisions)

Sustainable Transportation and Communities Division

Emissions Certification and Compliance Division

Mobile Source Laboratory Division

Major 2018 Accomplishments

- Launched AB617 Community Protection Program
- Reduced emissions below 2020 Greenhouse Gas Target
- Made Significant Progress on Zero Technologies
- Enhanced Cap-and-Trade and Low Carbon Fuel Standard
- Adopted Criteria Pollutant and Toxics Emission Reporting Regulation

Major 2019 Priorities

- Implementing AB 617
- Pursuing Carbon Neutrality
- Executing Scoping Plan and State Implementation Plans
- Approaching Transportation Holistically
- Strengthening Collaboration with States/Nations

Themes

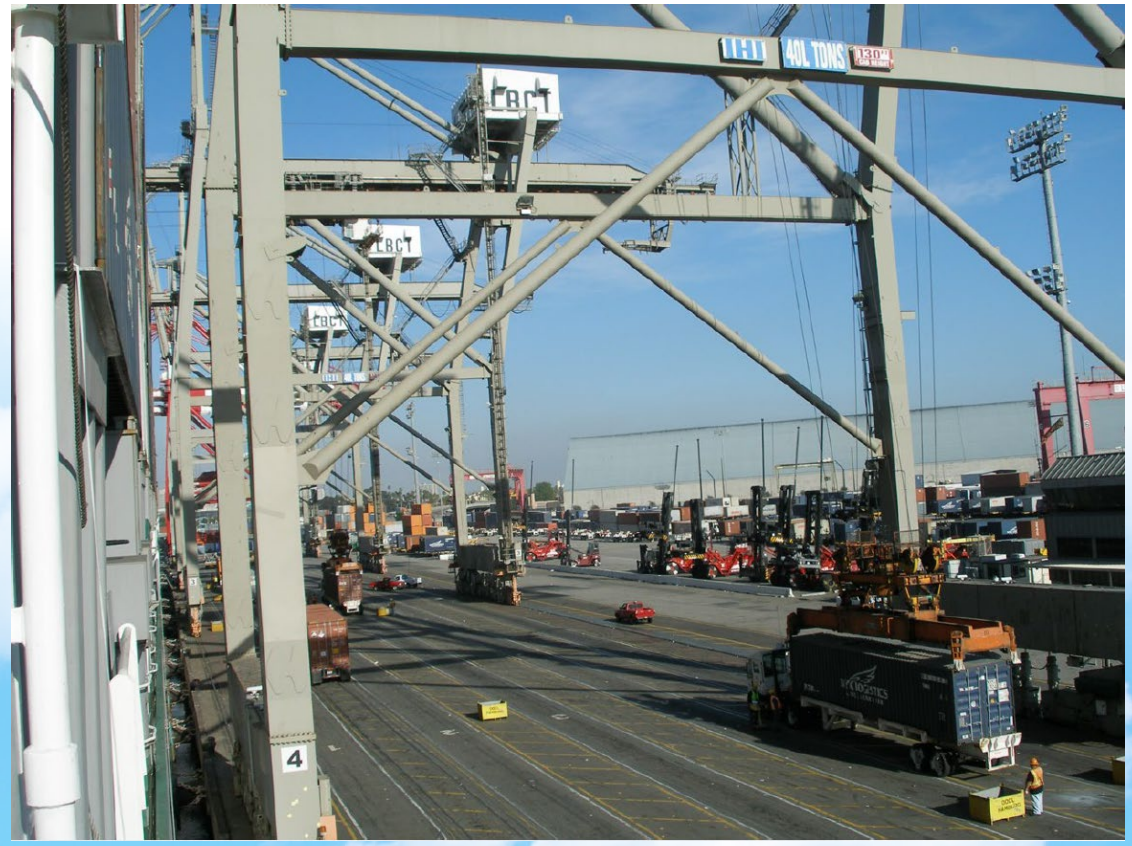
- Focusing on Communities
- Acting on Climate Change
- Advancing Clean Transportation
- Collaborating with Partners

Reduced Community Impacts From Freight

2018 Accomplishments

- Awarded $415 million to freight projects in disadvantaged communities

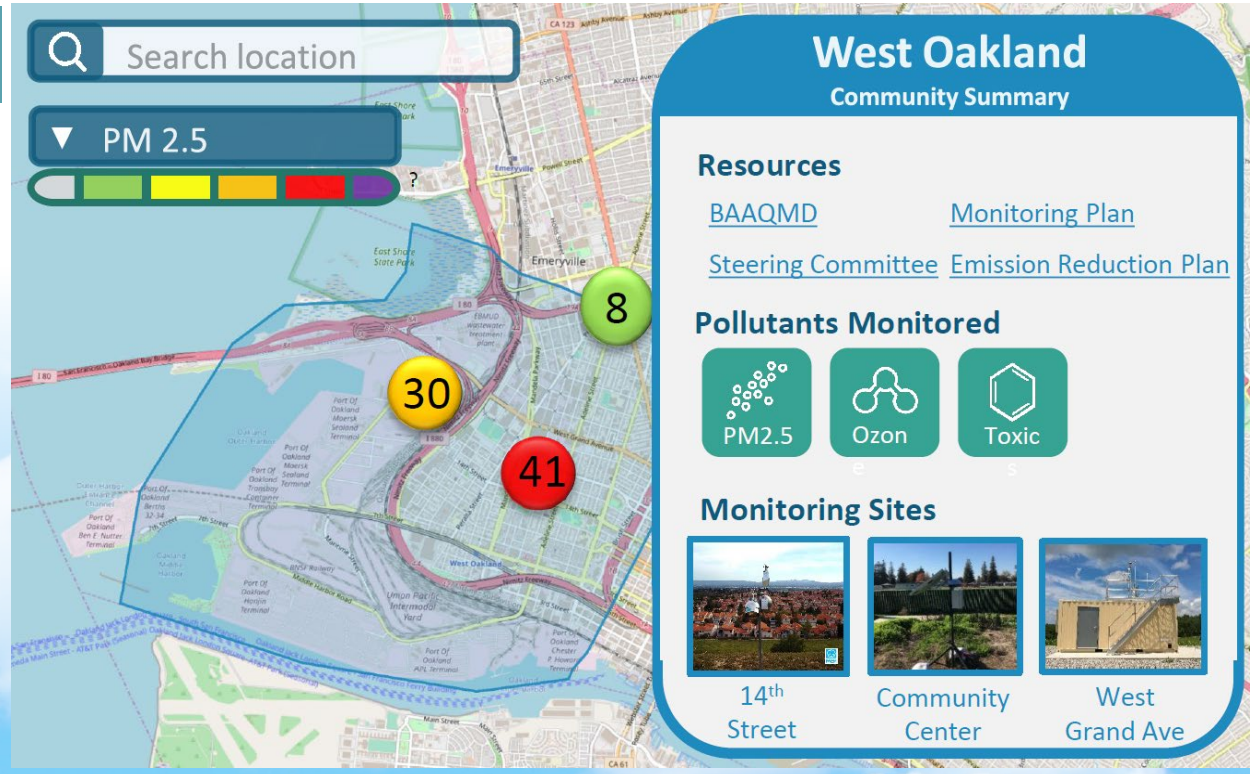
- Provided formal comments on 10 proposed freight projects



Enhancing Community Data

2019 Priorities

- More granular mobile source data
- Update Pollution Mapping Tool
- Statewide Community Air Monitoring Data Portal
- Update toxics emissions data
- Board hearing on amendments to Air Toxics "Hot Spots" Emission Inventory Criteria and Guidelines Regulation



Transitioned to Cleaner Trucks

2018 Accomplishments

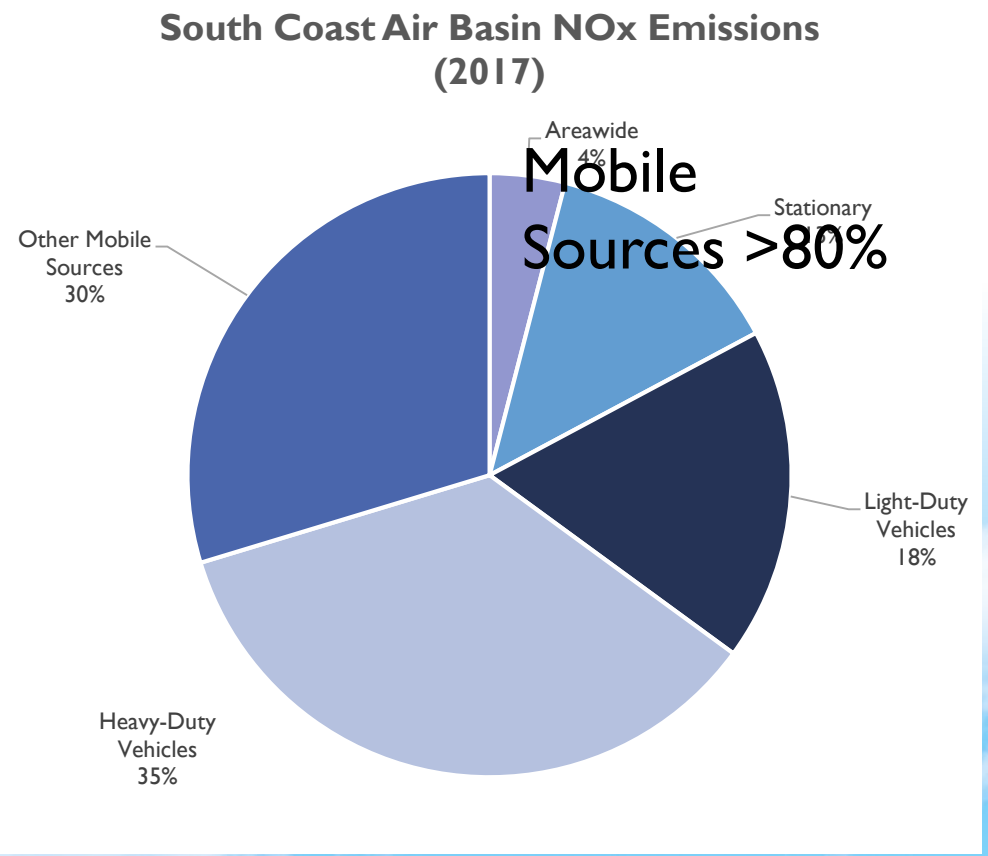
- Cummins truck recall: 500,000+ vehicles
- Board approved:
  - Tractor-Trailer GHG regulation amendments
  - Innovative Clean Transit regulation
  - Heavy-duty Vehicle Inspection Program (HDVIP)/Periodic Smoke Inspection Program (PSIP) amendments
  - Heavy-duty Warranty amendments
- Enhanced truck and bus enforcement leading to implementation of SB 1

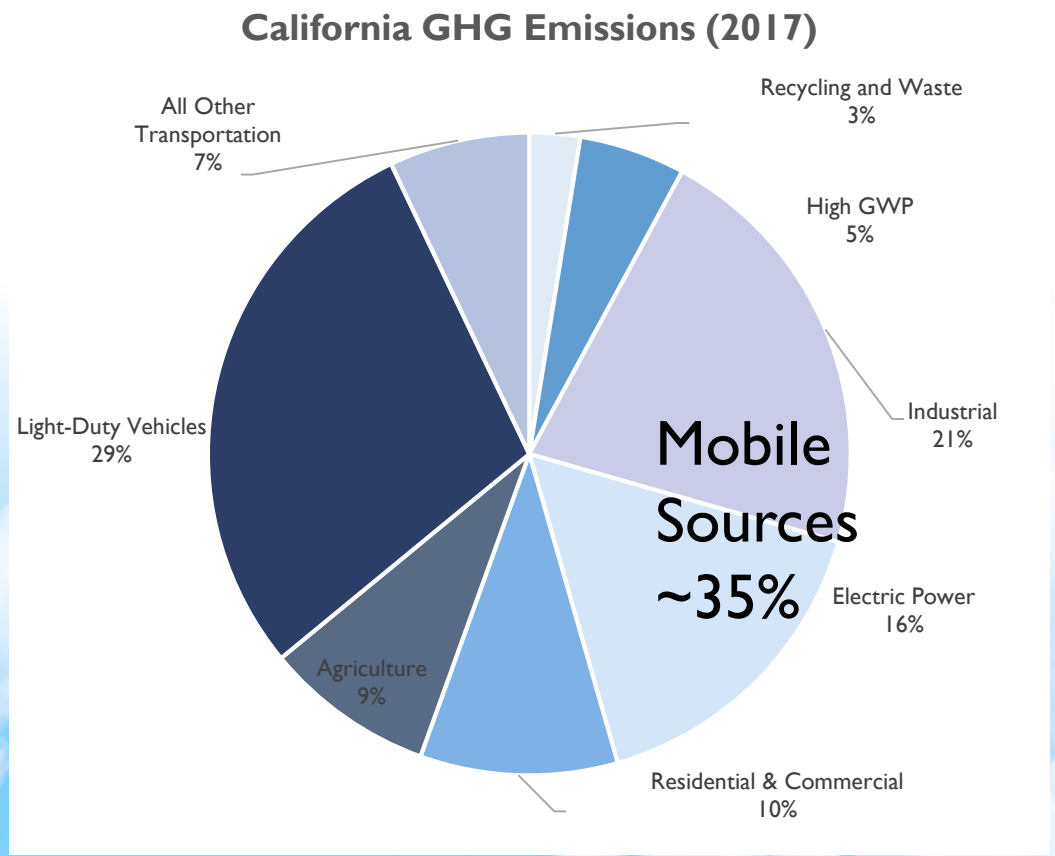
Establishing Next Generation Clean Trucks

2019 Priorities

- Heavy-Duty Omnibus including low NOx standard
- Zero emission truck fleet rules per recent Governor's Executive Order
- Board Hearings on
  - Zero-Emission Truck Manufacturing
  - Zero-Emission Airport Shuttle
  - Emission Powertrain Certification Regulation

After 50 Years of Standards, Mobile Source Emissions Still Significant Share of Inventory

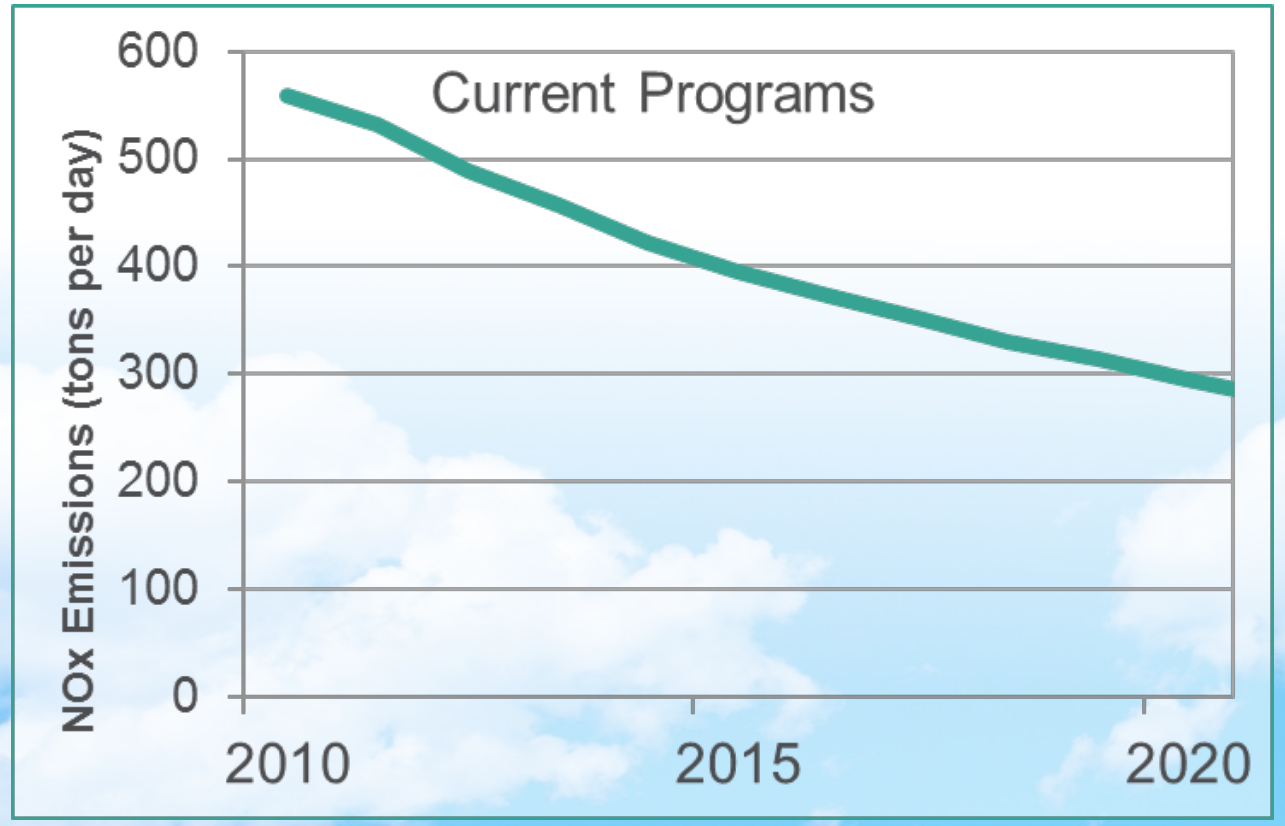




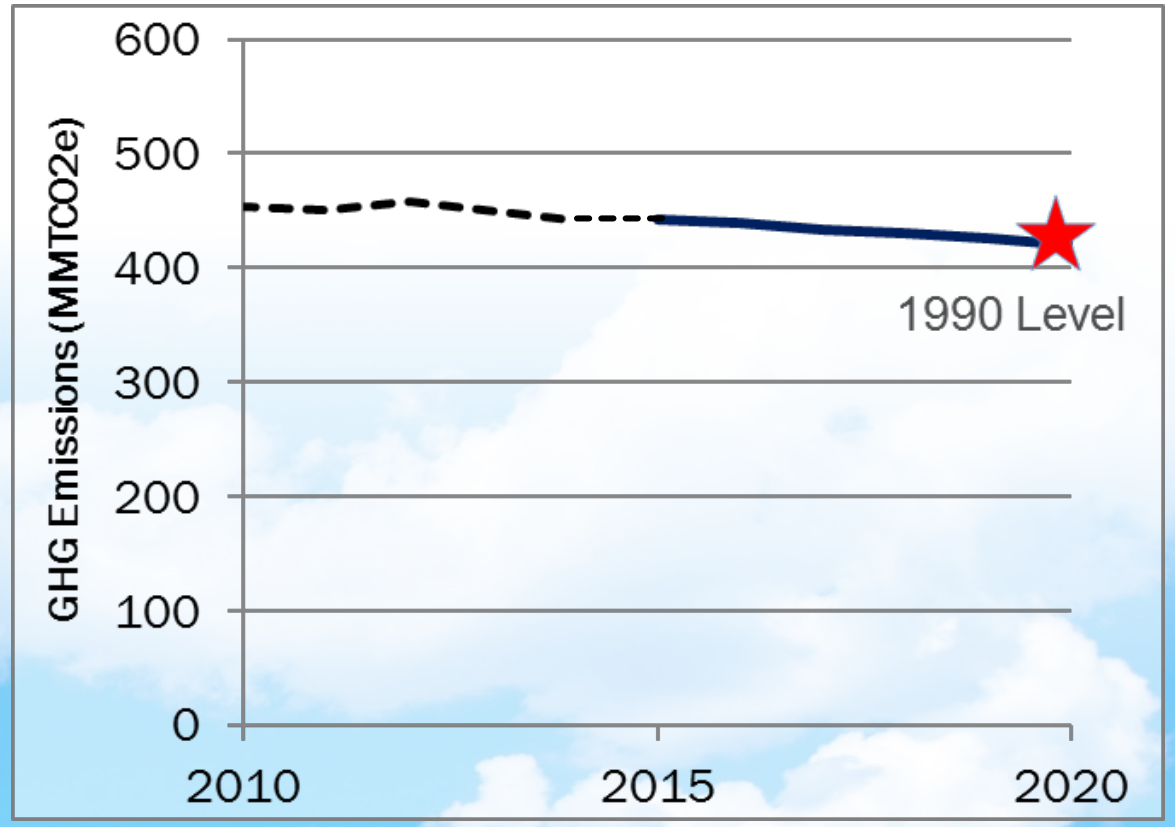
Mobile sources represent ~50% of GHG inventory when including emissions from fuel production

Current Programs Have Achieved Significant Reductions

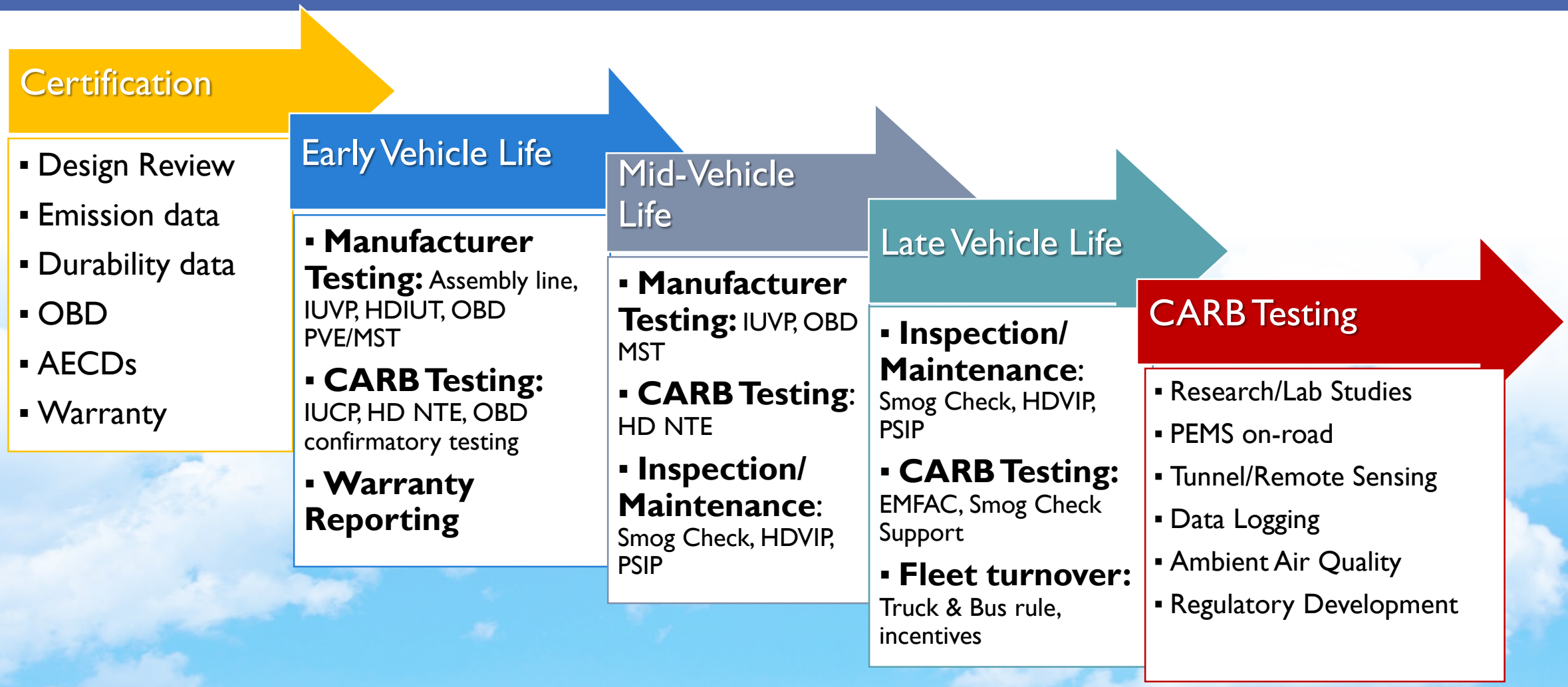
NOx, South Coast, All Sources



GHGs, Statewide, All Sources

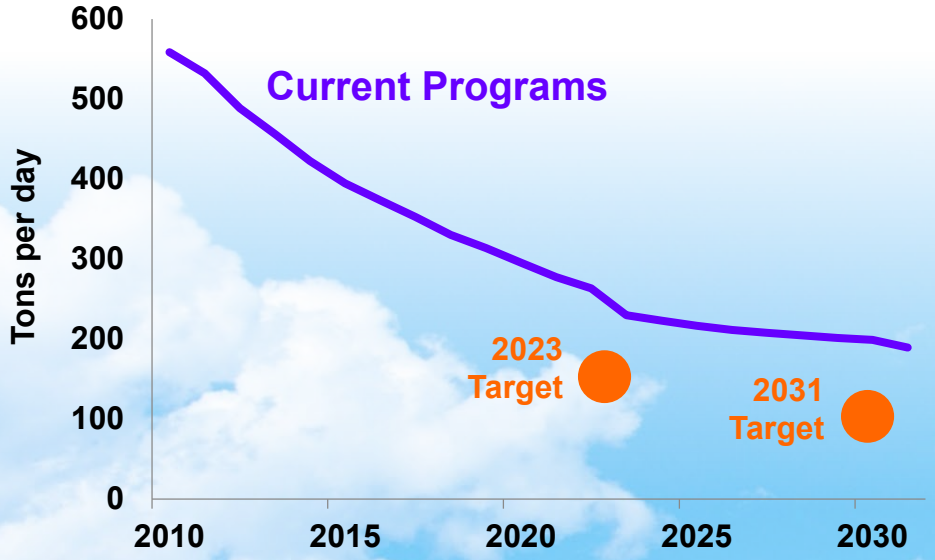


Reductions Achieved via Many Individual Elements



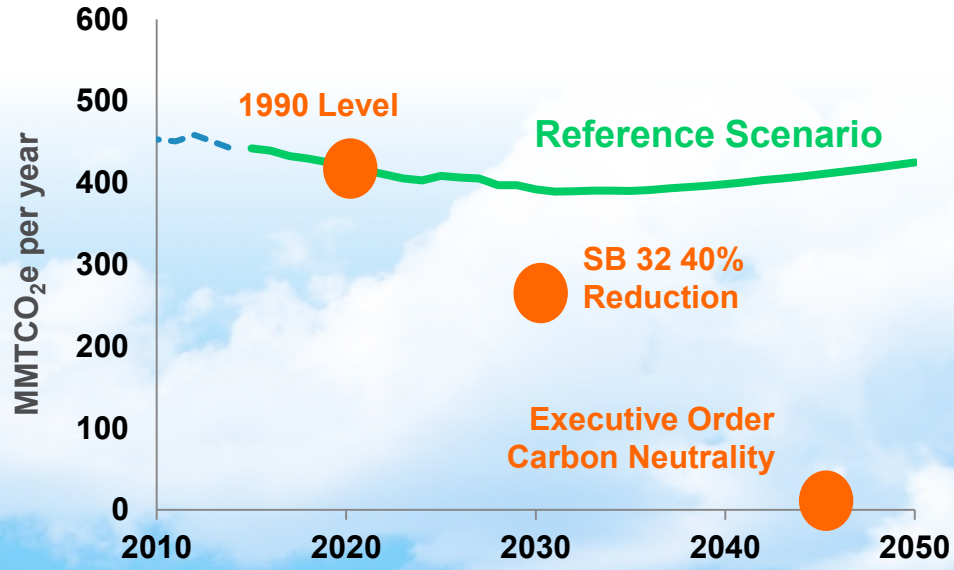
But We Still Need More

NO_X Emissions, South Coast Air Basin (All Sources)



Source: CARB, 2016 Mobile Source Strategy

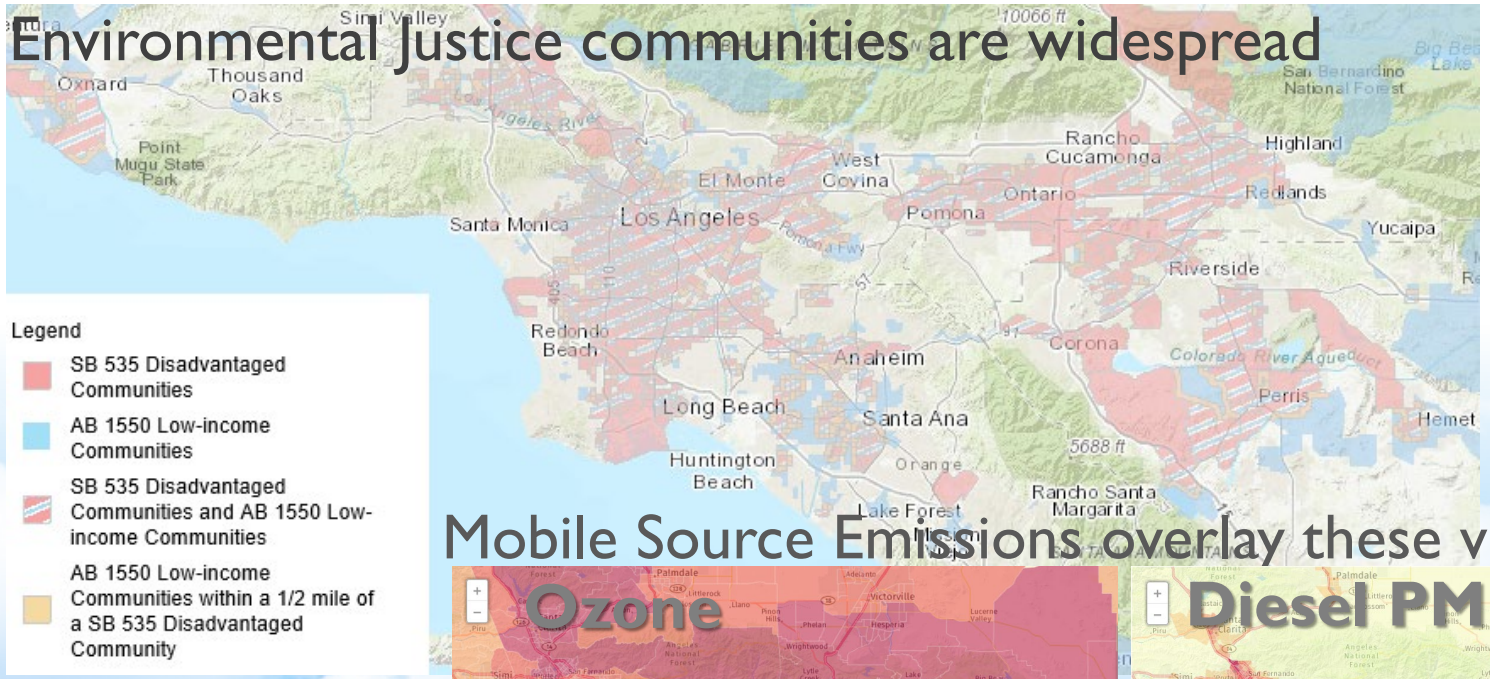
Greenhouse Gas Emissions, Statewide (All Sources)



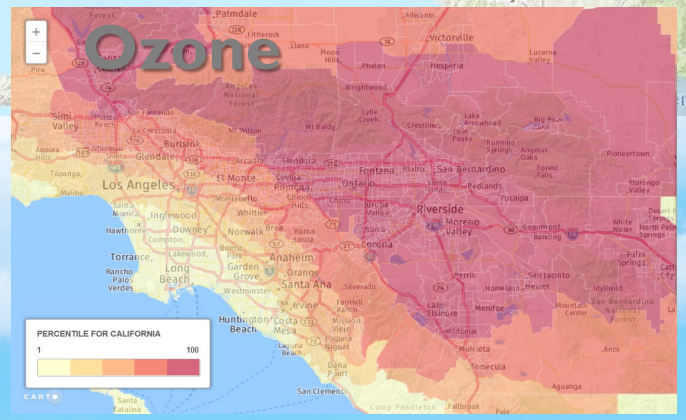
Source: CARB, 2017 Climate Change Scoping Plan; 2018 Exec. Order B-55-18

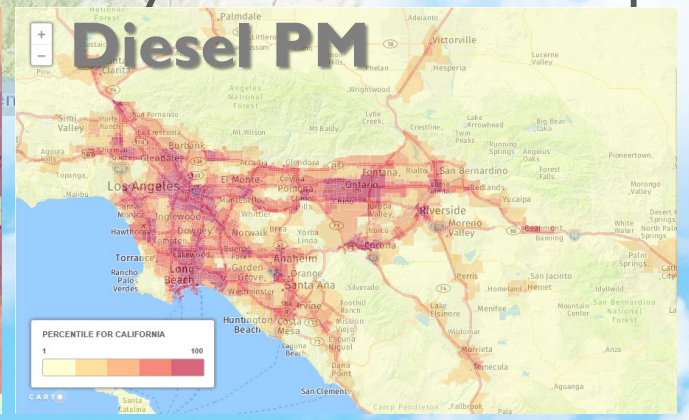
And In The Most Critical Areas

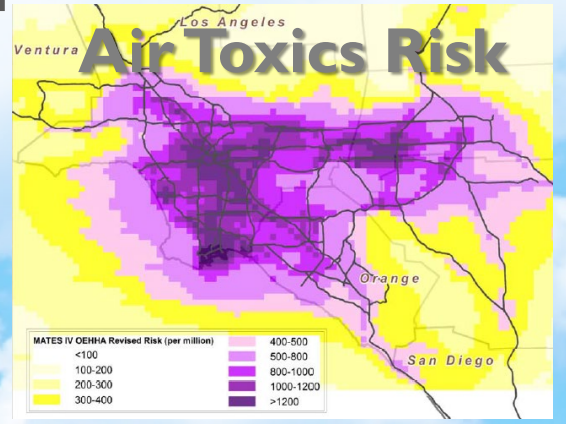
Environmental Justice communities are widespread



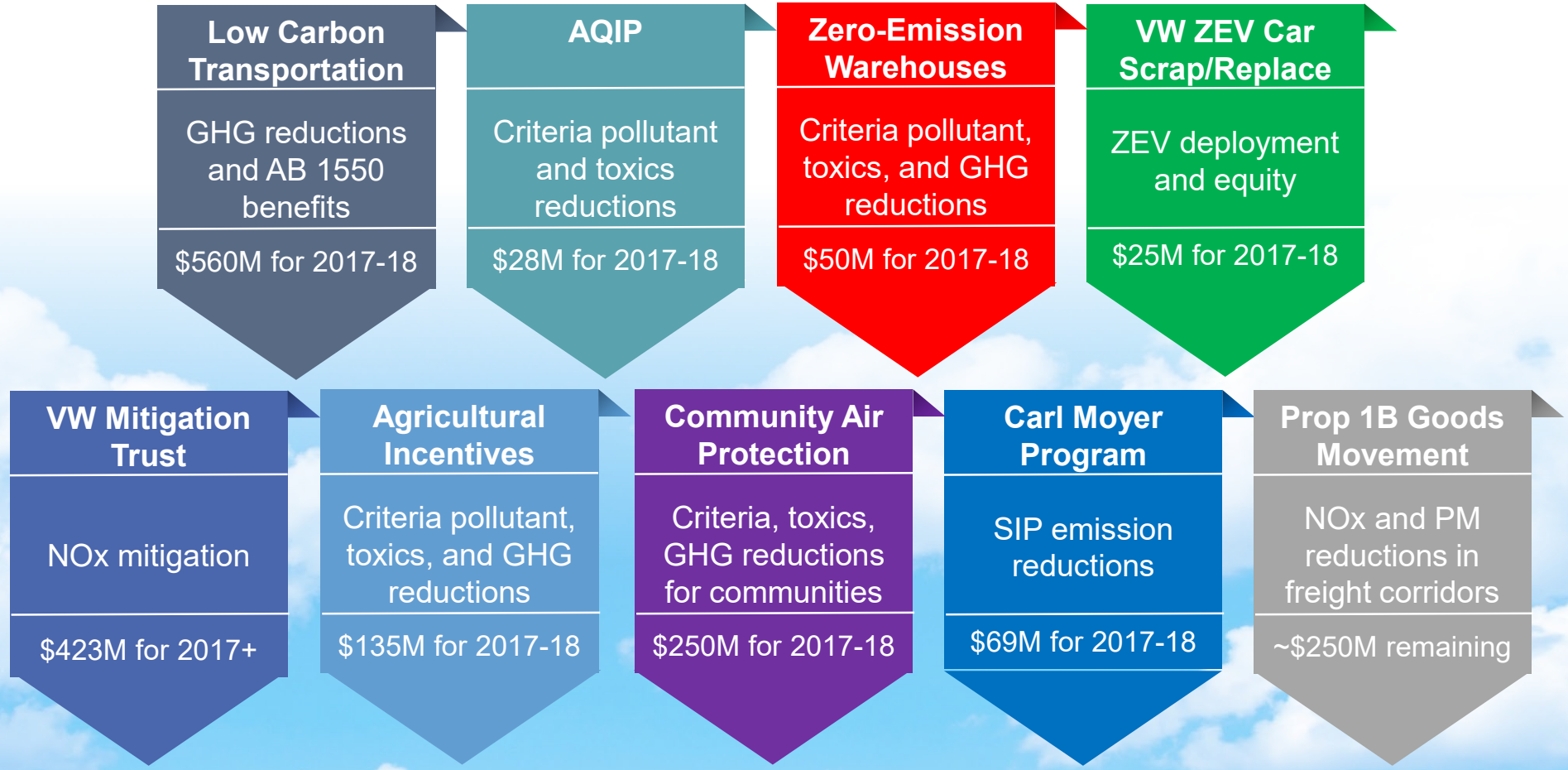
Mobile Source Emissions overlay these vulnerable populations







Investing in the Transformation: Incentive programs



Reality Checks – Many Programs in Place to Assess Emissions

- Certification
- Warranty Reporting
- Manufacturer In-Use Testing
  - Light Duty In-Use Verification Program (IUVP)
  - Heavy-Duty In-Use Testing (HDIUT) Program
  - HD OBD Manufacturer Self Testing program
- Laboratory Dynamometer Testing
  - Engine and chassis dynamometer testing
  - Confirmatory and compliance testing
- On-Road Emissions Measurements
  - Portable Emissions Measurement Systems
  - Remote Sensing
- Vehicle and Smoke Inspections
  - Smog Check
  - Periodic Smoke Inspection Program (PSIP)
  - Heavy-Duty Vehicle Inspection Program (HDVIP)

Vehicles and Engines Must Stay Clean In-Use

- Enhanced programs for HD being developed based on LD history
  - Comprehensive inspection and maintenance program
    - OBD, visual, opacity elements
  - Expanded warranty requirements
  - Revise in-use testing program
  - Lengthen useful life
  - Improved durability demonstrations

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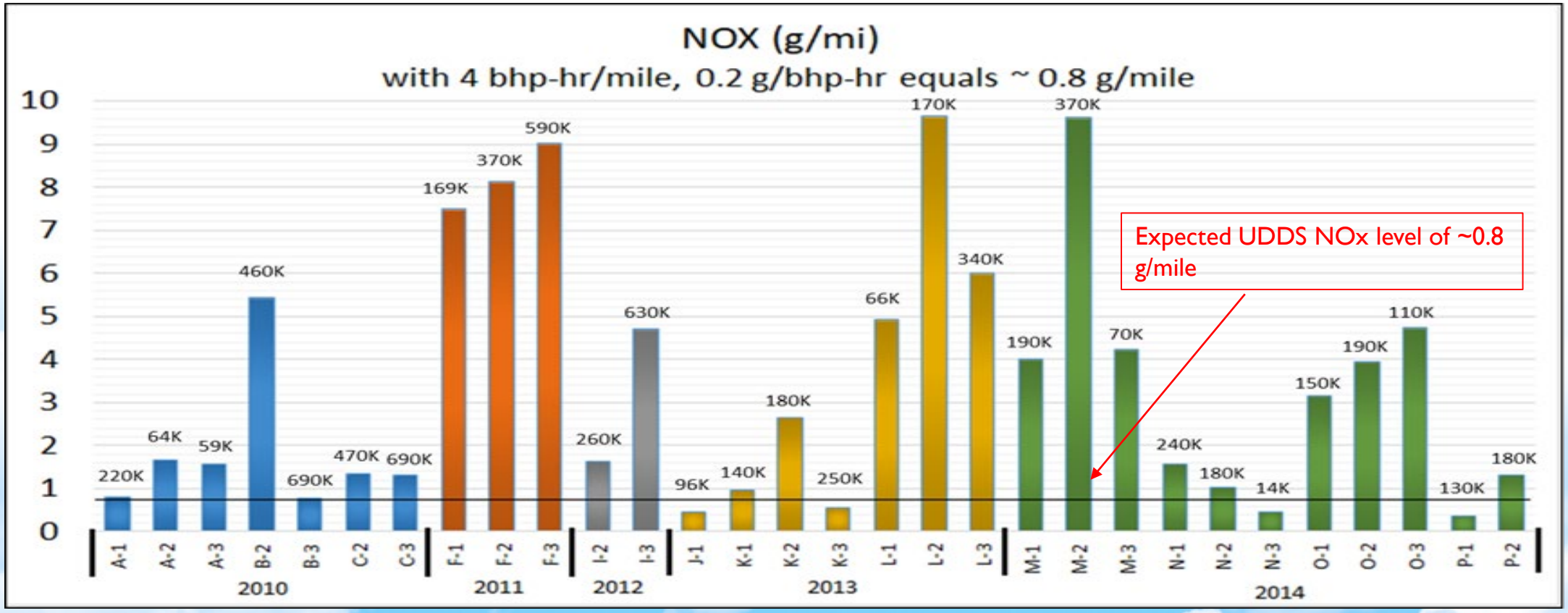
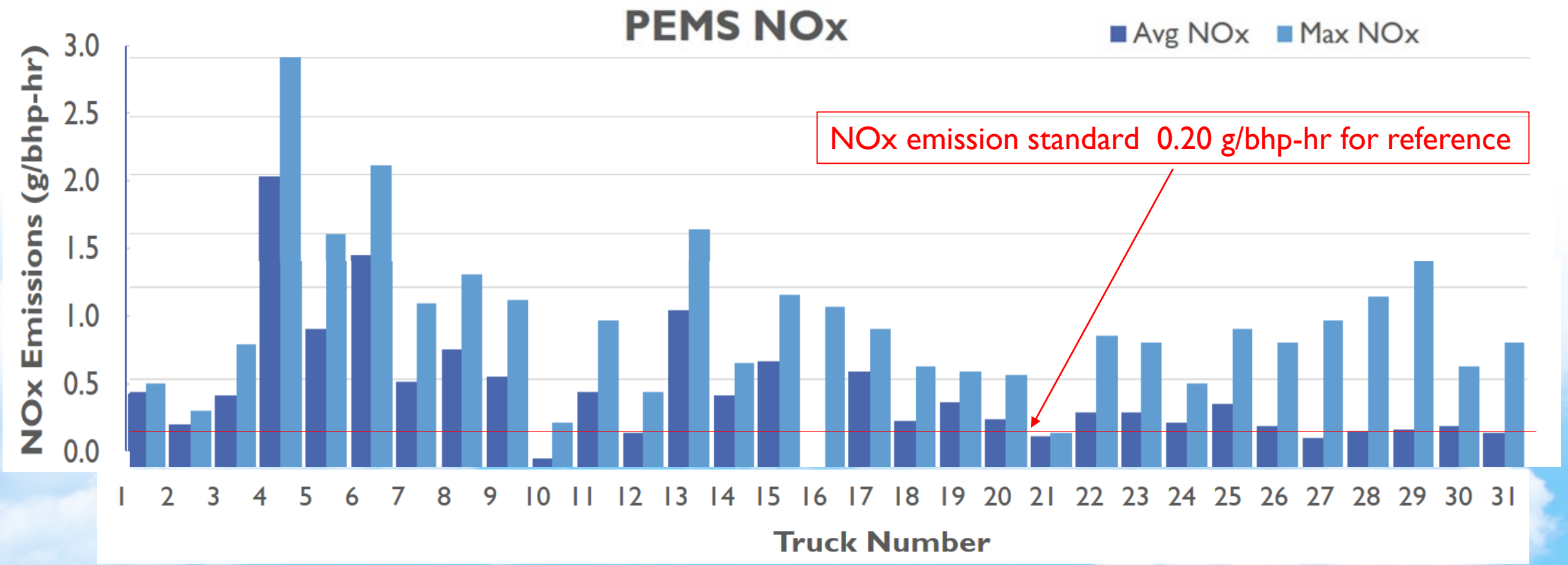
How are heavy-duty vehicles really performing?

Heavy Duty Emissions Higher Than Expected



Truck and Bus Surveillance Program: UDDS chassis test cycle (65,000 lbs., chassis UDDS power ~ engine FTP for many engine platforms)

Heavy Duty In-Use NTE Compliance PEMS Data



In-Use Compliance Program: 45% Compliance based on NTE regulation, CFR 86.1912

Mostly Freeway Driving, 31 Trucks, All SCR equipped

Overall Warranty Claims Rates Improving

Component	2010 Industry Average Rate	2014 Industry Average Rate
Diesel Particulate Filter	15.1%	4.1%
EGR Cooler	28.8%	5.3%
EGR System	11.7%	4.4%
Fuel Injector	22.2%	5.6%
NOx Sensor	20.5%	2.4%
SCR Catalyst	12.7%	3.3%
Turbocharger	11.7%	2.5%

However Individual Component High Warranty Claims Rates Persists*

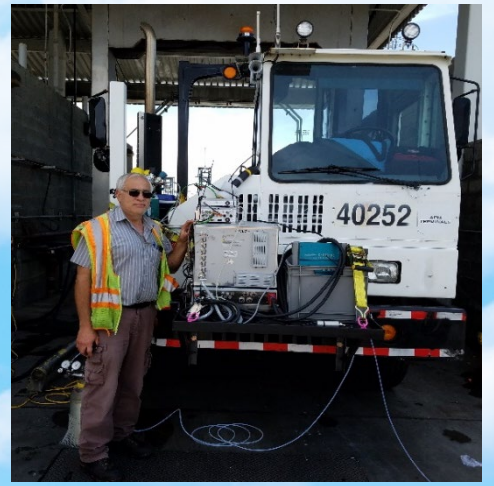
Component	Warranty Rate
Catalytic Converter	>14%
Diesel Particulate Filter	>14%
EGR Cooler	>53%
Exhaust Manifold	>2%
Fuel Injector	>23%
Fuel Pump	>1%
Turbocharger	>50%

*High warranty examples based on 2014 MY data

Introduction

- PEMS testing demand at CARB has been increasing exponentially
- CARB has been PEMS testing heavy-duty, light-duty, and off-road vehicles/engines for various reasons such as inventory, screening, in-use compliance, research, etc.
- CARB has 10 PEMS at the El Monte facility

CARB's PEMS Staff



CARB's PEMS Staff

PEMS Supported Programs

- Regulatory Development
- Certification
- Defeat Device Screening
- Light and Heavy-Duty In-Use Compliance and Enforcement
- Emission Modeling and Inventory
- Off-Road Equipment Evaluation
- Small On- and Off-road Engine Testing
- Road-to-Rig Correlation
- Research

Dedicated PEMS Workshop in New Riverside Facility

- CARB will be purchasing 10 new and improved Gaseous and PM PEMS
- CARB's new facility will implement a futuristic PEMS testing approach and will enable testing of more light-duty, heavy-duty, and off-road vehicles
- 14 light-duty and 4 heavy-duty testing stations
- Plumbed calibration and span gases, and power at each station
- EV chargers
- Dashboards for remote monitoring

Dedicated PEMS Workshop in New Riverside Facility

CARB Future PEMS Expectations

- Wider PEMS operational envelope
  - Thermal control housing for constant temperature
  - Wider temperature tolerance
  - Better Lab-to-PEMS correlation
- Enhanced PEMS usability and efficiency
  - Full automation: QC, warm-up, and testing automated and unattended
  - Remote viewing and control options
  - Real-time emissions metric availability
- Increased PEMS capabilities
  - Electrified drivetrain energy flow quantification and integration
  - New species detectable NH_3 and N_2O
  - Better small engine exhaust flow

Is It Time for A Paradigm Shift?

- **Goal**: Ensure actual in-use emissions are well controlled

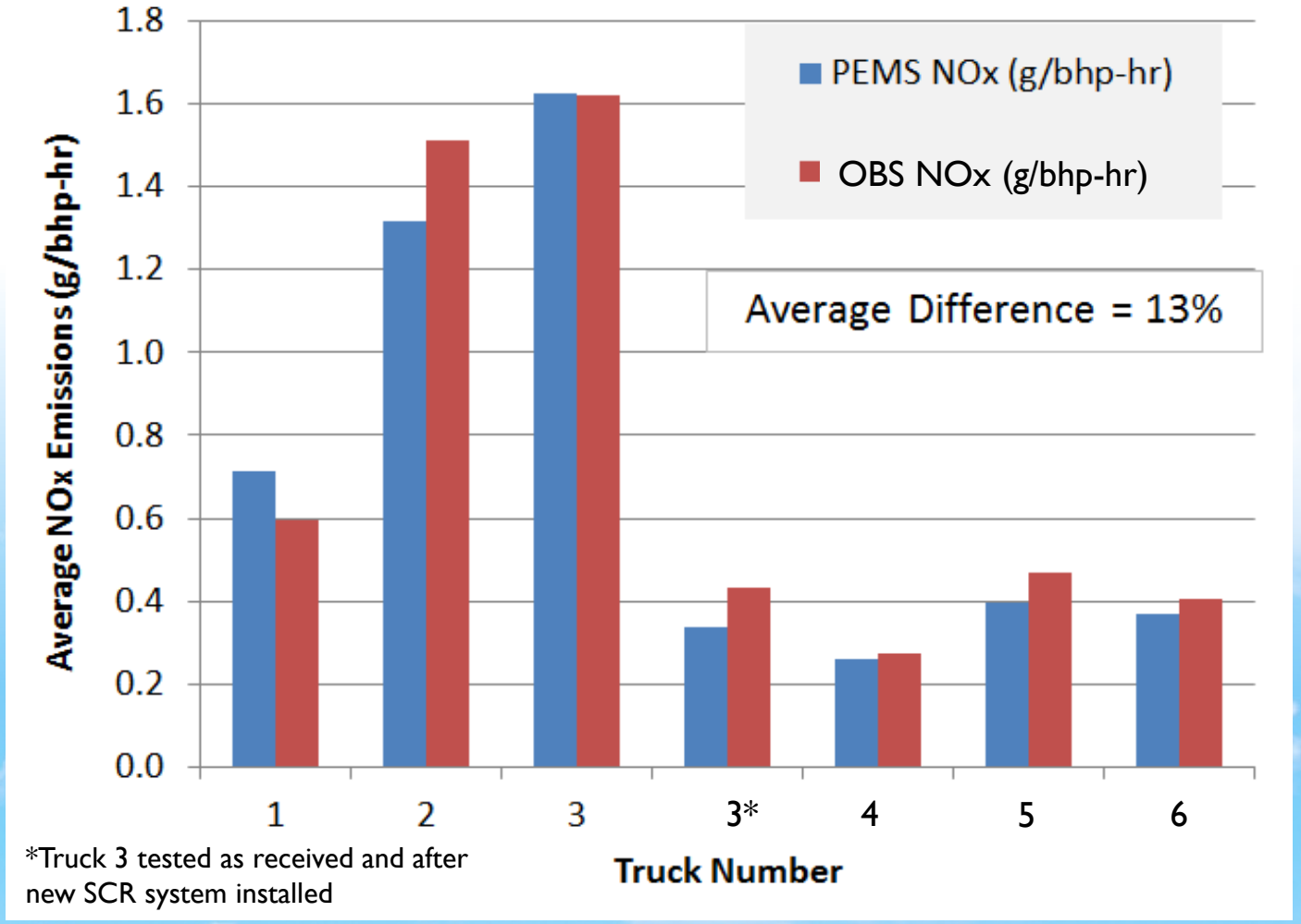
- **California's air quality targets mean future powertrains need to be**:
  - cleaner
  - more durable
  - better maintained, and
  - when they aren't clean, durable or maintained, they need to be identified sooner and resolved more quickly

Continuous Monitoring of Emission Performance

- Concept:
  - Use on-board sensors and algorithms to measure, track and report in-use emissions performance
  - Accuracy of on-board sensors has been established to be less than 15% different than laboratory analyzers
- Potential uses/benefits:
  - Motivate optimal control during all driving conditions
  - Powerful feedback on actual performance
  - Faster and cheaper than laboratory or PEMS testing
  - Potential for streamlined certification or in-use compliance
  - New approaches for diagnostic and repair

On-Board Sensor Data vs PEMS

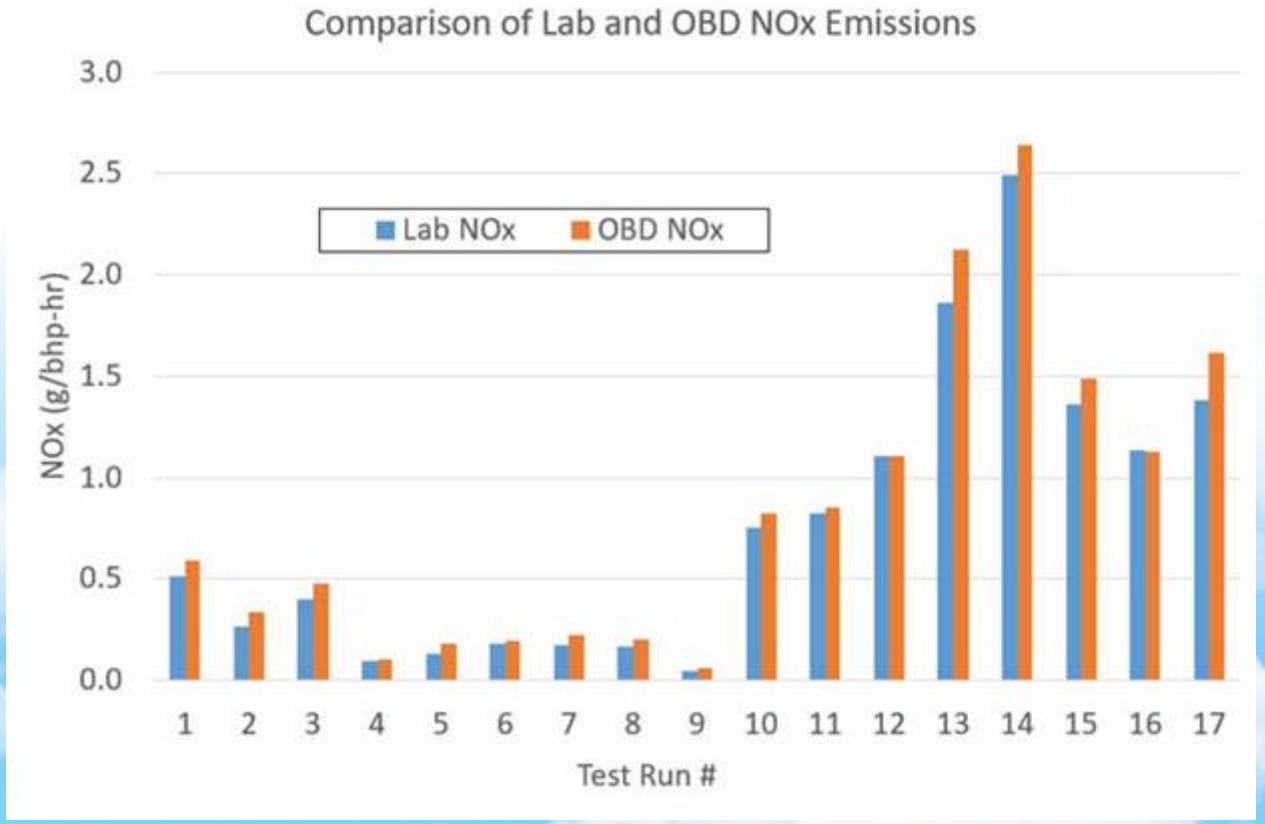
- 7 diesel HD trucks
  - 2 different engine families
  - All equipped w/SCR and NOx sensors
- Mostly freeway driving
  - Data excluded when NOx sensor reported as not active



*Truck 3 tested as received and after new SCR system installed

On-Board Sensor Data vs Lab

- 11 different engines
  - 3 engine makers
  - 4 displacement
- Overall average difference is 15%



How Does This Concept Intersect with OBD?

- **OBD is a logical place for the portion related to on-board data requirements**
  - Standardized data has always been integral to OBD
  - Single regulation to follow for all required data
- **OBD already includes data to support other ARB needs:**
  - Smog Check inspections (VIN, etc.)
  - OBD compliance testing (rate-based, etc.)
  - Tailpipe testing (torque, modeled exhaust flow volume, etc.)
  - Certification review (EI-AECD tracking, PM filter regeneration frequency)

How Could The Data Be Used?

- **Screening?**
  - Simpler way to identify problems for follow-up investigation/testing?
- **Compliance?**
  - Develop in-use standards to compare the stored data to?
  - Limit and confirm emission impact of IRAFs and AECDs?
  - Retroactively adjust (up or down) certified emission levels?
- **Certification?**
  - Use past data to support certification?
- **Future Regulatory Development?**
  - Use data to identify areas of needed improvement?
- **Inventory Modeling?**
  - Improve accuracy of inventory to better inform future policies?

Implementation Concepts

Near term: Adopt requirement to track and report

- Standardized OBD data stream (upon request)
- Could be reported to ARB as part of required post certification activities
- ARB/contractor could get data from vehicles
- Could eventually be collected during Smog Check or HD IM program inspections

Longer term: Data collected remotely?

- Quickly and thoroughly identify underperforming vehicles for corrective action
- Redesign certification and compliance

Next steps: REAL Concept

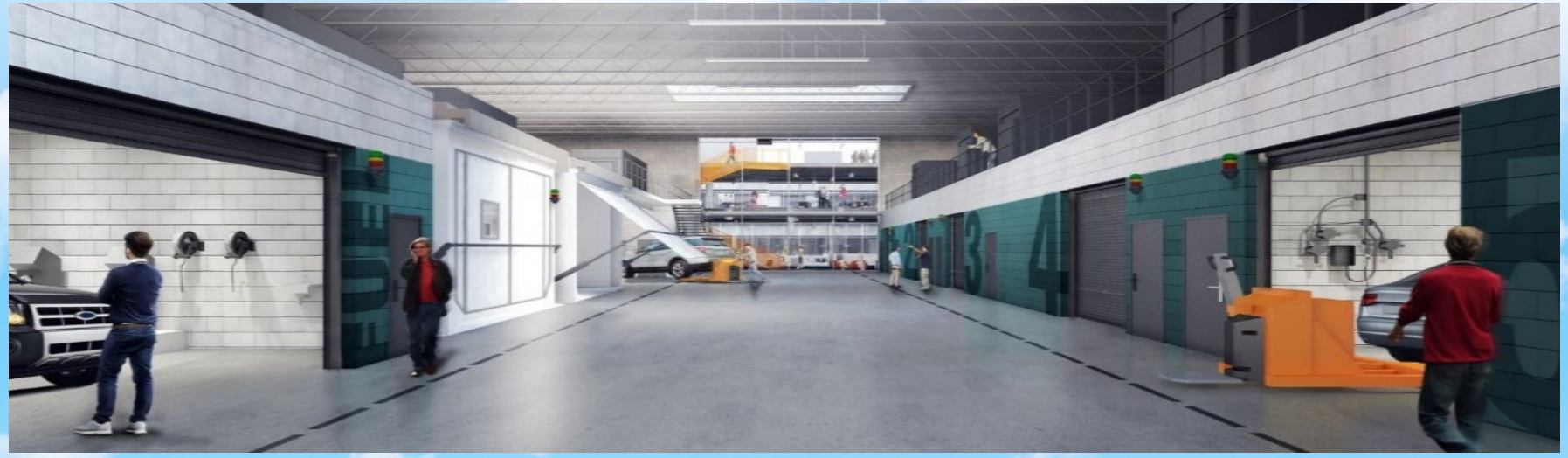
Real Emissions Assessment Logging

- Require vehicles to track emission performance
  - Add software to store aggregated data on vehicle
- Start with existing sensors
  - Accuracy of on-board NOx sensors already within 15%
  - Fuel usage (to infer CO_2 emissions) already even more accurate
- Potential benefits:
  - Comprehensive feedback
  - More efficient than laboratory or PEMS testing
  - Future standards linked to on-road performance

Next Steps: Expanding Testing

- New Southern California Laboratory
  - Increased HD and LD dyno and on-road PEMS & OBD testing capacity

Scheduled for 2021 opening



Groundbreaking Emissions Testing and Research

2018 Accomplishments

- New laboratory facility began construction July 2018
- Procurement of lab equipment underway
- Lab to host public artworks addressing climate change
- LEED Platinum and ZNE Facility
- Anticipated move-in early 2021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