



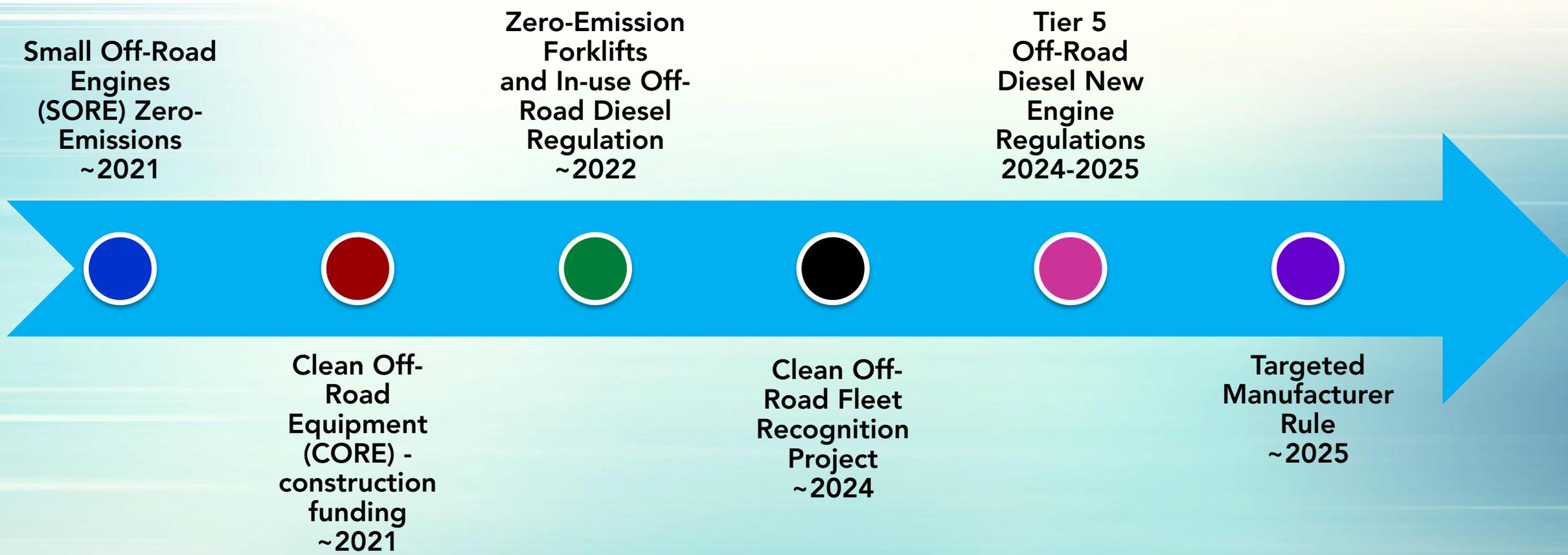
**Tier 5 Rulemaking Workshop**  
**Potential Amendments to the**  
**Off-Road Diesel New Engine Regulations**  
**November 3, 2021**

# Outline

- Off-Road Strategies Timeline
- What is the Tier 5 Rulemaking?
- Emission Standards
  - Criteria Pollutants
  - Greenhouse Gases (GHG)
- Certification
  - Low Load Cycle (LLC)
  - Hybrid Powertrains
  - Useful Life and Warranty
  - Idle Reduction
  - Inducements
  - On-Board Diagnostics (OBD)
- In-Use Testing and Compliance
- Other Potential Amendments
- Next Steps



# Off-Road Strategies Board Dates Timeline



# What is the Tier 5 Rulemaking?

- The proposed next generation of stringent emission standards for new off-road diesel engines
- Helps ensure that off-road diesel engines produced in the future will be as clean as possible
- Combustion standards important for off-road equipment where zero emission technology is not feasible
- One of several complementary programs to clean up the off-road sector in California

# Current U.S. EPA and CARB Emission Standards

## Tier 4 Final Criteria Pollutants

Tier 4 Final Exhaust Emission Standards after 2014 Model Year (g/kW-hr)						
Power Category	Application	PM	NO <sub>x</sub>	NMHC	NO <sub>x</sub> +NMHC	CO
< 19 kW (< 25 HP)	All	0.40			7.5	6.6
19 ≤ kW < 56 (25 ≤ HP < 75)	All	0.03			4.7	5.0
56 ≤ kW < 130 (75 ≤ HP < 175)	All	0.02	0.40	0.19		5.0
130 ≤ kW ≤ 560 (175 ≤ HP ≤ 750)	All	0.02	0.40	0.19		3.5
> 560 kW (> 750 HP)	Gen Sets	0.03	0.67	0.19		3.5
	Mobile Machines	0.04	3.5	0.19		3.5

# Current Off-Road Certification Cycles

- **Transient Testing**
  - Nonroad Transient Test Cycle (NRTC)
  - Applies to variable speed off-road diesel engines  $\leq 560$  kW only
- **Steady-State Testing**
  - Various modal cycles, e.g., C1, C2, D1, D2, depending on power and speed type
  - Applies to all variable and constant speed off-road diesel engines
- **Opacity Testing**
  - Percent limits for in-use confirmation, 20% acceleration, 15% lugging, 50% peak
  - Limits generally do not apply to Tier 4 engines (FEL  $< 0.07$  g/kW-hr)
- **Not-To-Exceed (NTE) Limits**
  - Certification requirement only
  - Same criteria and zones (control areas) as on-road NTE

# The Need for Tier 5 Standards

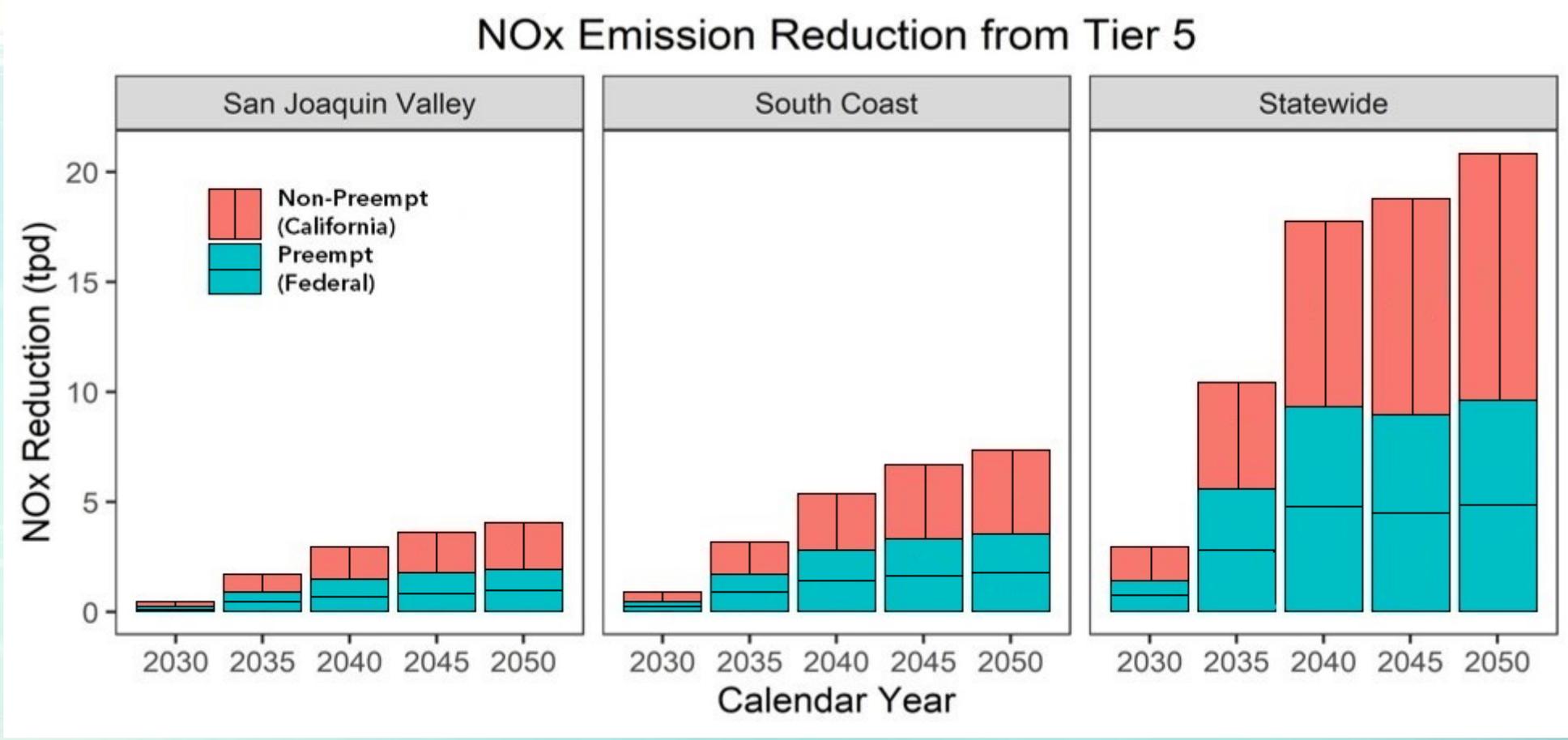
- Current Tier 4 Final off-road diesel standards for new engines do not reflect best available control technologies (BACT)
  - Over 50% of Tier 4 Final engines are certified without Diesel Particulate Filters (DPFs)
- Additional emission reductions are needed for attainment of federal and State ambient air quality standards
- Off-road emissions disproportionately affect disadvantaged communities
- Current test cycles may not adequately demonstrate emissions control during low load off-road engine operation

# Federal Preemption

- Only U.S. EPA can set emission standards for farm and construction equipment with engines less than 175 hp (130 kW)
- Preempted equipment include most equipment powered by engines between 25 and 175 hp (19-130 kW)
- Examples of preempted equipment  $\leq$  25 hp (19 kW) include:
  - Backhoes
  - Compressors
  - Excavators
  - Pumps
  - Skid steers
  - Wheel loaders
- Emissions from preempted equipment are significant in California and could become more so in the future without U.S. EPA adoption of more stringent off-road diesel standards
- California needs U.S. EPA cooperation in cleaning up the off-road

# Projected Tier 5 NOx Benefits in California

## 2020 Mobile Source Strategy Proposal



# Potential Tier 5 Standards

## Criteria Pollutants

- Staff is considering (with respect to Tier 4f standards):
  - Up to 75% reduction in NO<sub>x</sub> and PM for diesel engines < 56 kW
  - 90% / 75% reduction in NO<sub>x</sub> / PM for engines  $56 \leq \text{kW} \leq 560$
  - 50% reduction in NO<sub>x</sub> and PM for engines > 560 kW
  - No changes for NMHC and CO
  - Equipment  $\leq 19$  kW to be zero emission
    - Electric equipment is already commercially available

# Considering an Off-Road Diesel GHG Standard

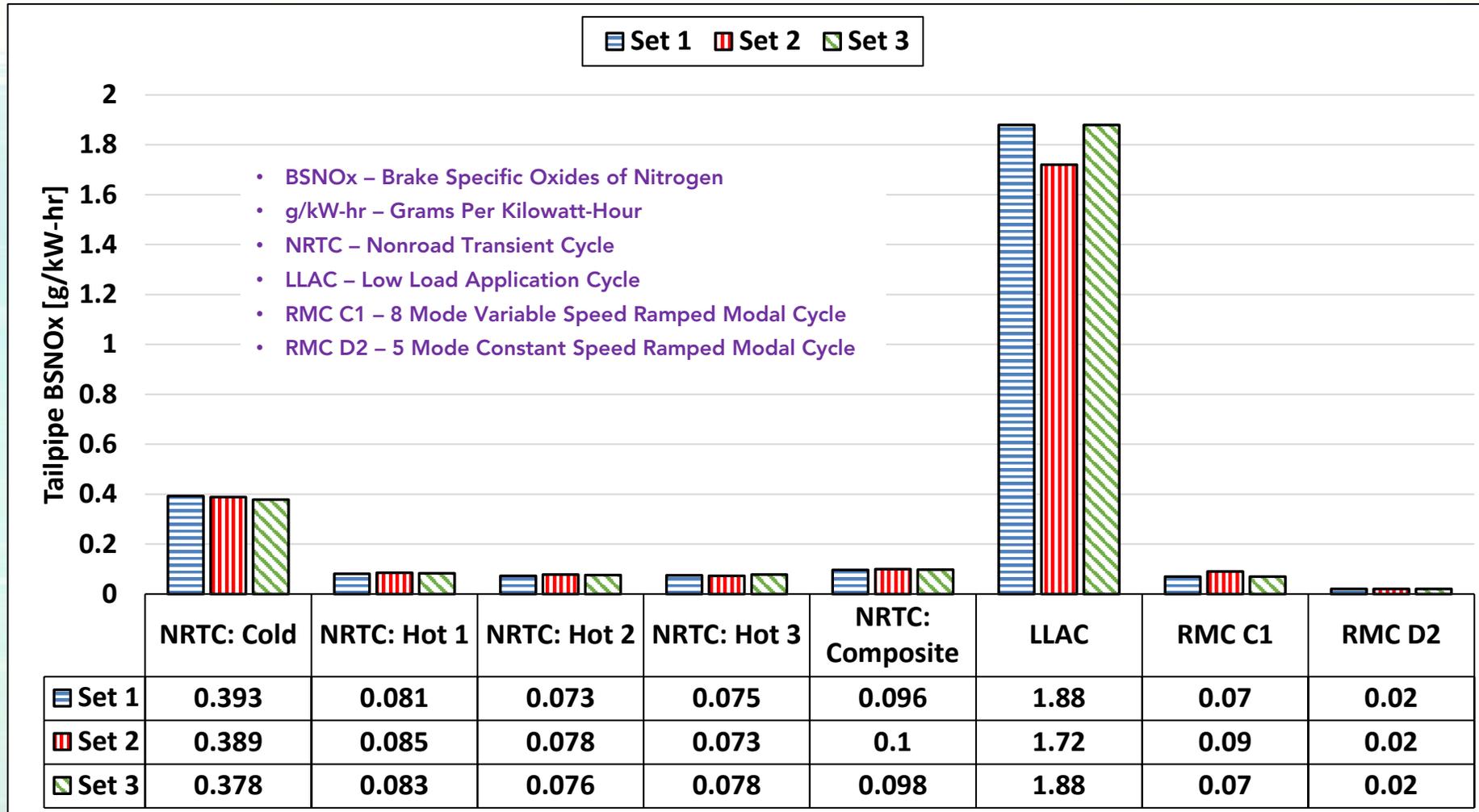
- Currently there are no GHG standards for off-road diesel engines
- CO<sub>2</sub> emissions from off-road equipment have been steadily increasing each year
- SB 32 requires State GHG levels to be 40% and 80% below 1990 levels by 2030 and 2050, respectively
- CARB staff is considering a CO<sub>2</sub> tailpipe standard for off-road diesel engines targeting a 5-8.6% reduction using the SwRI demonstration project's engine as a baseline

# Considering an Off-Road Low Load Cycle (LLC)

- Currently, there is no low load cycle for off-road engines
- Off-road engines frequently operate at low load up to 50% of the time
- SwRI data show NO<sub>x</sub> emissions from their proprietary Low Load Application Cycle (LLAC) are up to 19 times higher than NO<sub>x</sub> emissions from the NRTC used to certify off-road engines
- A representative LLC is critical for controlling real-world emissions
- **Staff requests feedback on whether SwRI's LLAC can serve as an off-road certification cycle to ensure emissions are controlled during low load off-road operation.**

# Low Load Emissions Greatly Exceed Certification Emissions

## Deere 6.8L Baseline Individual Tailpipe NOx Results - SwRI



# Potential Off-Road Hybrid Powertrain Concepts

- Hybrid powertrains are currently available for the off-road
- Off-road hybrid powertrains use certified on- and off-road engines
- Emission credits are based solely on engine performance
- Heavy-duty on-road hybrid powertrains are certified using a modeling approach to characterize both engine and vehicle criteria and GHG emissions performance
- **Staff requests feedback on whether there is a demand for a dedicated off-road hybrid powertrain certification procedure.**
- **Staff requests feedback on whether the heavy-duty on-road hybrid powertrain certification procedure\* is sufficient for certifying off-road hybrid powertrains.**

\* <https://ww3.arb.ca.gov/board/rulemaking/hdomnibuslownox/froa-1.pdf>

# Potential Useful Life Concepts

- Useful Life is the period of an engine's service life during which the engine is required to conform to the standards
- Current useful life for engines  $\geq 37$  kW is 10 years / 8,000 hours
- More representative useful life periods would reduce emissions by more than reducing the standards alone
- Staff is considering increasing useful life from 8,000 hours to 12,000 hours for off-road diesel engines between 56 - 560 kW
  - Industry publications suggest major overhaul typical from 12,000 - 15,000 hours
  - SwRI is currently demonstrating the feasibility of 12,000-hour useful life
- **Staff requests feedback on extending useful life.**

# Potential Lengthened Minimum Warranty Periods

- Currently required new off-road diesel engine warranty is:
  - 2 years / 1,500 hours < 19 kW, or < 37 kW constant speed engines > 3,000 RPM
  - 5 years / 3,000 hours  $\geq$  37 kW
- Longer warranty periods provide emission benefits
- Emissions-related malfunctions that occur outside of warranty may go unrepaired to avoid expenses, especially if the malfunction does not drastically affect equipment performance
- **Staff requests feedback regarding:**
  - What extended warranties do off-road manufacturers currently offer?
  - Why are the current emissions warranty periods adequate or inadequate?

# Possible Idle Reduction Concept

- Idling restrictions are not currently required for off-road diesel engines
- Prolonged idling can adversely affect exhaust temperature and Selective Catalytic Reduction (SCR) function resulting in higher NOx emissions
- Idling time for off-road diesel engines is at least as prevalent as idling time for heavy-duty on-road engines
  - Off-road diesel engines can operate at idle 50% of the time
- **Staff requests data to appropriately stop engines after prolonged idle, or for setting an off-road diesel idling standard.**

# Possible Selective Catalytic Reduction (SCR) Inducement Concepts

- Currently manufacturers are required to derate engine performance to induce vehicle operators into maintaining their SCR systems
- SCR is the dominant off-road technology for controlling NO<sub>x</sub>
- Staff proposes to codify the federal requirements of 40 CFR 1039.110 and 1039.665 (adopted in 2014/16)
- Staff is also considering revisions to the emergency derate override provisions to minimize occurrences of abuse
- **Staff requests comments on whether inducements should apply beyond SCR.**

# Possible On-Board Diagnostics (OBD) Concepts

- OBD currently not required for off-road engines
- Benefits of an OBD program
  - Clear identification of minimum repairs covered by emission warranty
  - Facilitates diagnosis and repair leading to less downtime
  - Leads to durability improvements
  - Lower in-use emissions
  - Facilitates inspections, screening of in-use engines, and in-use compliance testing
- Many OBD features from existing on-road heavy-duty diesel engines could be applied to off-road engines

# Possible On-Board Diagnostics (OBD) Concepts Cont.

- Possible OBD Requirements:
  - Circuit continuity and out-of-range checks
  - Major component monitoring (e.g., SCR, DPF, NOx sensor monitoring)
  - Monitoring of hardware leading to inducement or derate
  - Standardization:
    - Connector
    - Fault information (fault codes and freeze frame)
    - Data stream parameters
  - NOx and CO<sub>2</sub> tracking – Real Emissions Assessment Logging (REAL)
- **Staff requests feedback on what off-road OBD requirements should be included in the Tier 5 rulemaking.**

# Manufacturer-Run Off-Road In-Use Testing Program

- Currently, there is no manufacturer-run in-use testing program for off-road diesel engines
- Manufacturers only attest that their engines comply with Not-To-Exceed (NTE) requirements
- In-use testing is necessary to ensure that emissions are being controlled during real-world operation
- The European Union has work-based in-use off-road testing and reporting requirements
- California has manufacturer-run in-use testing programs for light- and heavy-duty on-road engines
- **Staff requests suggestions for a manufacturer-run program.**

# Other Potential Amendments

## Overview

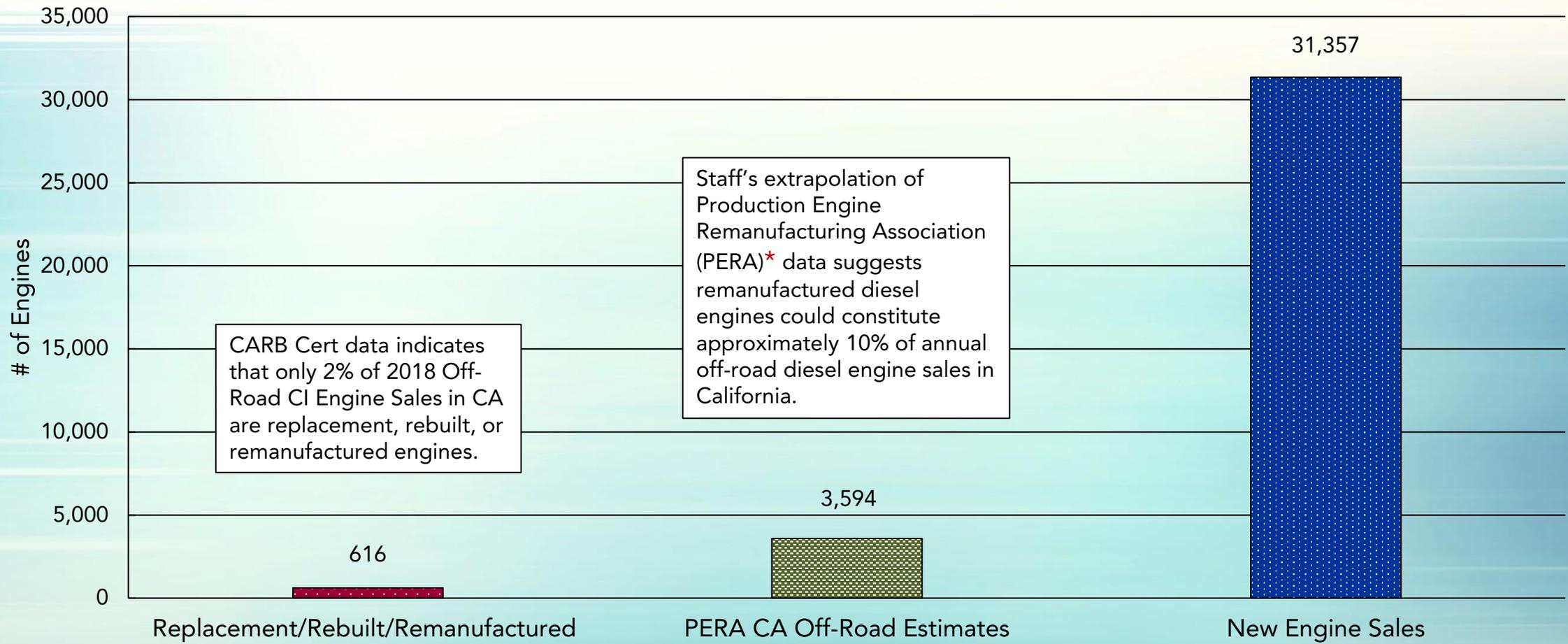
- Out-of-State Purchases
- New Replacement Engines (40 CFR 1068.240)
- Remanufactured and Rebuilt Engines (40 CFR 1068.120)
- Flexibility (40 CFR 1039.625)
- Averaging, Banking, and Trading (40 CFR 1039 Subpart H)

# Out-of-State Purchasing

- Out-of-state purchases have the potential to greatly diminish emission benefits in California
- The incentive to purchase off-road engines and equipment out-of-state is currently small, but could rise if differing standards exist
- Federal alignment with CARB's Tier 5 off-road diesel standards would prevent circumvention of California's regulations and loss of future emission benefits

# 2018 CA Off-Road CI Engines

## New Replacement/Rebuilt/Remanufactured vs. New Engine Sales



CARB Cert data indicates that only 2% of 2018 Off-Road CI Engine Sales in CA are replacement, rebuilt, or remanufactured engines.

Staff's extrapolation of Production Engine Remanufacturing Association (PERA)\* data suggests remanufactured diesel engines could constitute approximately 10% of annual off-road diesel engine sales in California.

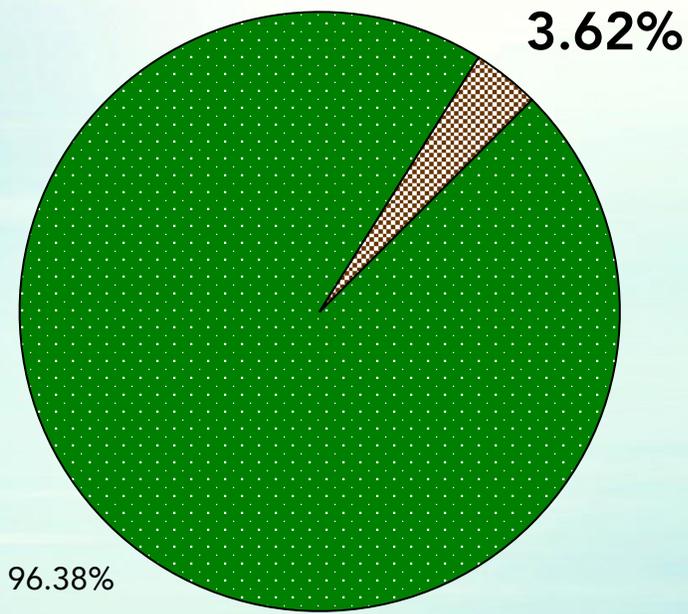
\* <https://www.pera.org/faq/>

# Flexibility/Transitional Program for Equipment Manufacturers (TPEM)

- Flexibility is an optional compliance provision that grants additional lead-time to equipment manufacturers
- Flexibility dilutes the emission benefits of the new standards
- Additional flexibility allowances may not be necessary to comply with the Tier 5 standards
- **Staff requests feedback and data showing the need for additional flexibility allowances under Tier 5.**
- **If granted, should flexibility allowances apply to manufacturers that produce both engines and equipment?**

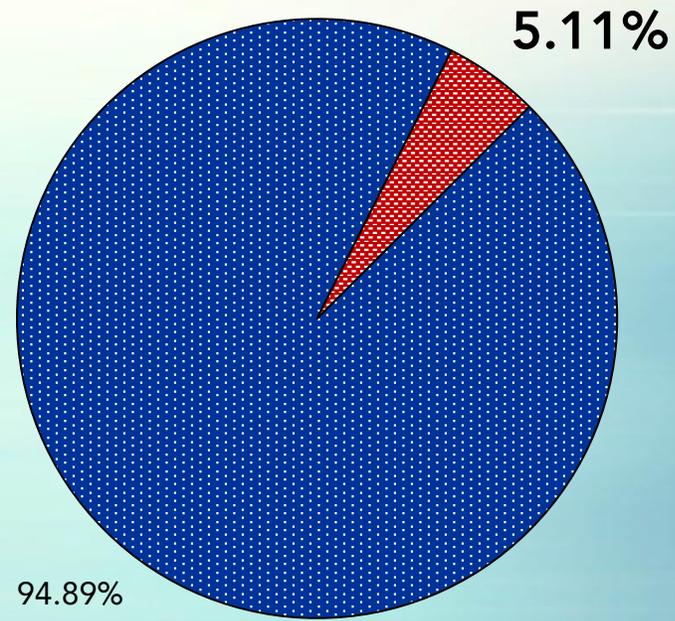
# 2018 Flexibility Off-Road CI Engines

50-state Sales



■ Non-Flex 50-state Sales   ■ Flex 50-state Sales

CA Sales



■ Non-Flex CA Sales   ■ Flex CA Sales

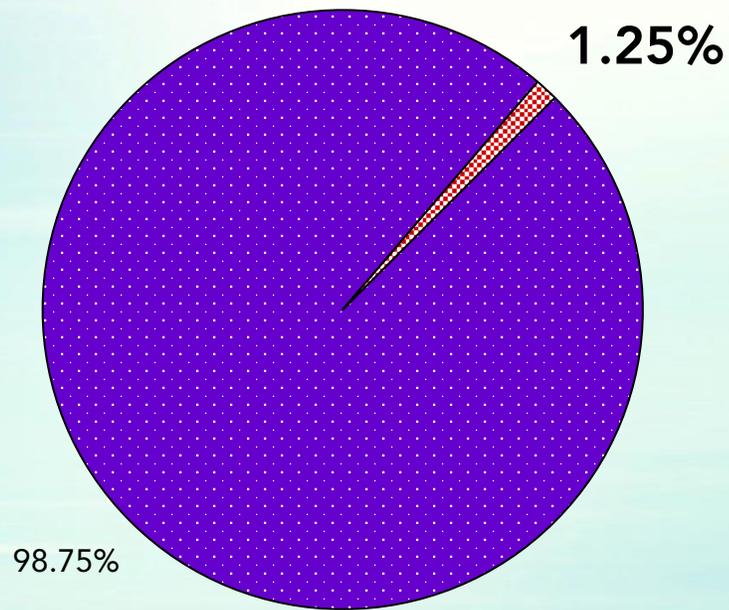
# Averaging, Banking, and Trading (ABT)

40 CFR 1039 Subpart H

- ABT is a federal provision that allows engine manufacturers to comply with the standards by averaging emission levels
- ABT could subject some areas of the State to higher emissions depending on the imported population of equipment with less stringent family emission limits (FEL)s
- ABT record keeping and reporting requirements are insufficient at both the State and federal levels
- **Staff requests feedback and suggestions on how to improve the current ABT recordkeeping and reporting requirements to better track FEL engines in California.**

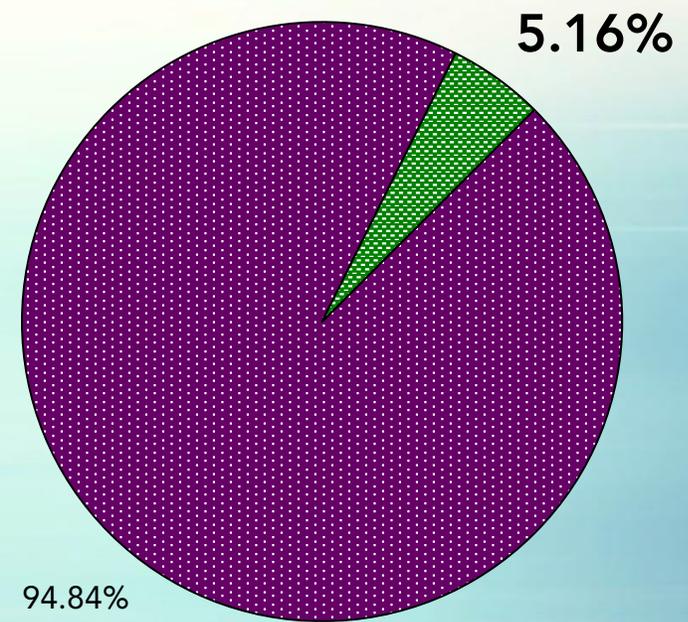
# 2018 ABT Off-Road CI Engines

50-state Sales



■ Non-ABT 50-state Sales    ■ ABT 50-state Sales

CA Sales



■ Non-ABT CA Sales    ■ ABT CA Sales

# Questions?

- CARB staff welcomes comments and suggestions
- We request feedback regarding the potential concepts as indicated on slides
- Support data is requested\*, especially with respect to low load operation and the development of hybrid powertrain certification procedures

\* Submitted information may be subject to the California Public Records Act (PRA), but information marked as confidential, including trade secrets, will be redacted. Data received may be aggregated and anonymized for use in the rulemaking record as needed to support the proposal.

# Next Steps

- Upcoming specialized workgroups:
  - Off-Road Tier 5 Standards
  - Off-Road Low Load Cycle Development
  - Off-Road On-Board Diagnostics
  - Off-Road In-Use Compliance and Testing
- Subscribe at the link on the Tier 5 webpage (<https://ww2.arb.ca.gov/our-work/programs/tier5>)
- Staff will hold future workshops to update stakeholders on the Tier 5 proposal throughout the development process
- Board consideration in 2024-2025; implementation 2028-2029
- Staff requests data or alternative concepts/proposals by Q4 of 2023, at the latest

# Contacts

- Contact information: Tier5@arb.ca.gov

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Tier 5 webpage: <https://ww2.arb.ca.gov/our-work/programs/tier5>