CALIFORNIA
AIR RESOURCES BOARD

Potential Tier 5 Rulemaking Greenhouse Gas (GHG) Reducing and Capping Standards

August 8, 2022

Outline

- Potential Carbon Dioxide (CO_2) Reducing Standards
- Need for GHG Capping Standards
  - CO_2
  - Nitrous Oxide (N_2O)
  - Methane (CH_4)
- Setting Potential Capping Standards
  - Statistical Analysis of:
    - Certification Data
    - Power Categories
    - Duty Cycles
- Potential Alternatives and Requests

Potential CO_2 Reducing Standards

- California Air Resources Board (CARB) staff introduced the concept of first-time CO_2 standards at the Tier 5 Kickoff Workshop on November 3, 2021.
- As envisioned, the new standards would conceptually apply to:
  - Non-preempted off-road Tier 5 diesel engines
  - 56 to 560 kilowatt (kW) power categories
  - Nonroad Transient Cycle (NRTC) and Steady-State certification cycles
- These potential new CO_2 standards could represent a 5 to 8.6 percent decrease from current certification averages for each power category based on 2020-2022 data from manufacturers.

Need for Potential GHG Capping Standards

- CO_2, CH_4, and N_2O are the most abundant GHGs that contribute to global warming (excluding water vapor).
- GHGs trap heat in the atmosphere, causing extreme weather, fires, droughts, and food supply disruptions.
- Some Oxides of Nitrogen (NOx) aftertreatment emission control technologies can increase N_2O if not properly engineered.

GHG Pollutant Comparison

- Carbon Dioxide (CO_2)
  - Reference gas for characterizing global warming potential (GWP)
  - Typically lasts 20-200 years in the atmosphere
  - GWP = 1
- Methane (CH_4)
  - Typical lifetime: 12 years
  - GWP 27-30 (100 year)
- Nitrous Oxide (N_2O)
  - Typical lifetime: 100 years
  - GWP 273 (100 year)
- Water Vapor (H_2O)
  - Strongest infrared absorption
  - Typical lifetime: hours to weeks
  - GWP Negligible

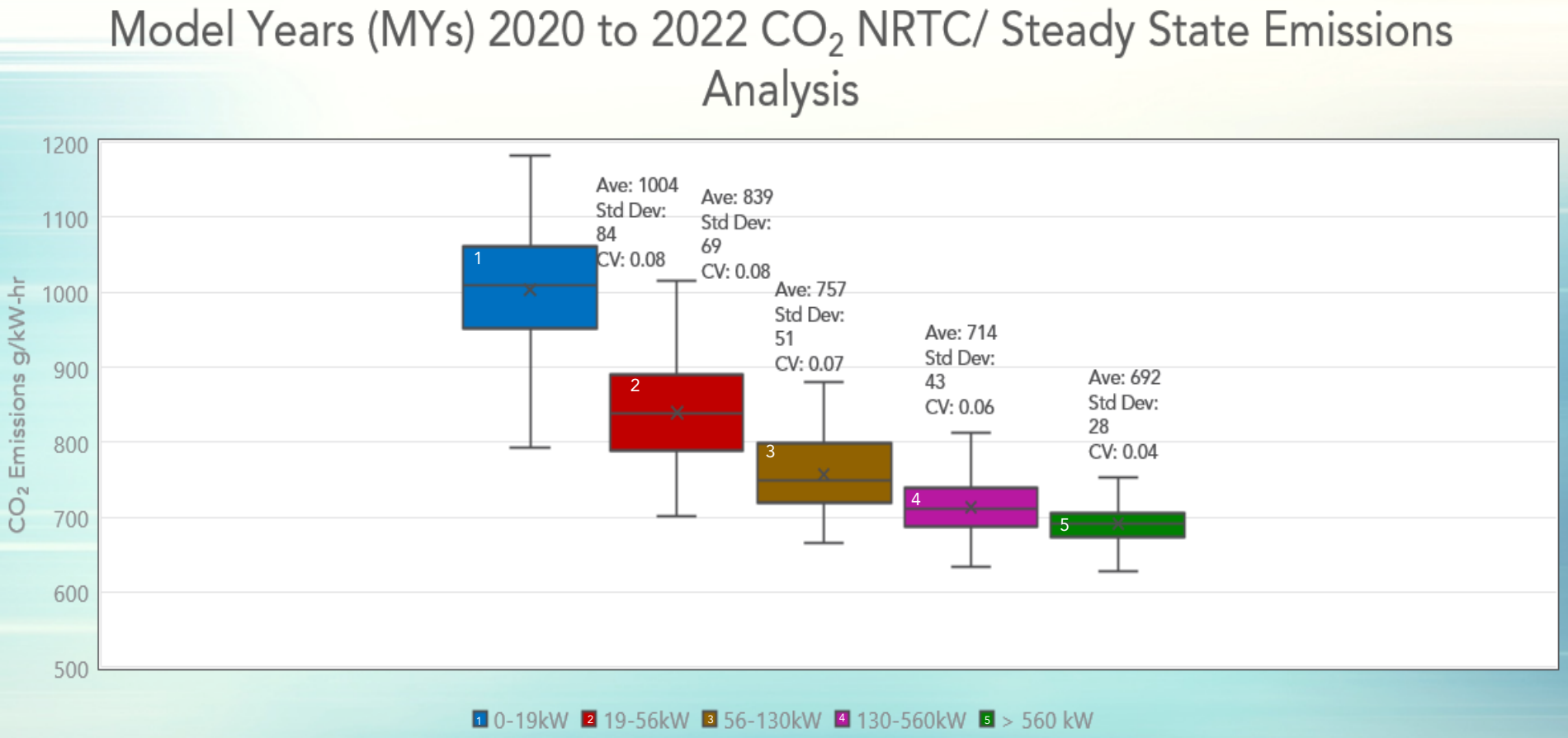
Exhaust Aftertreatment N_2O Tradeoff

- Platinum diesel particulate filters (combined oxidation catalyst plus diesel particulate filter) can produce N_2O during low temperature light-off and in the presence of hydrocarbon emissions.
- Selective Catalytic Reduction with advanced copper zeolites
  - Ammonia (NH_3) and nitrogen dioxide (NO_2) form ammonium nitrate (NH_4NO_3) that subsequently decomposes to N_2O at low temperatures (< 250 degrees Celsius (C)).
  - NH_3 oxidizes to N_2O at high temperatures (> 450 degrees C).
- Ammonia Oxidation Catalysts can oxidize NH_3 to N_2O during lean operation (e.g., acceleration, in instances of excess ammonia slip).
- Proper emission control system engineering is necessary to minimize increases in N_2O when reducing NOx.

Setting GHG Capping Standards

- Engine manufactures are currently required to provide CO_2, CH_4, and N_2O emission measurements to CARB under 1039.235(g) of the California Test Procedures for Off-Road Diesel Engines.
- CARB staff aggregated the data from all manufacturers by pollutant and power category between the 2020 and 2022 model years.
- The conceptual tailpipe capping standards for N_2O and CH_4 are the same for each power category and represent interquartile-filtered averages based on the concatenation of all data, increased by 50 percent over the highest emission levels from the NRTC or steady-state certification cycles and rounded up to the nearest 0.01 grams per kilowatt-hour (g/kW-hr) for N_2O and 0.005 g/kW-hr for CH_4.
- The conceptual tailpipe capping standards for CO_2 represent discrete, interquartile-filtered power category averages rounded upwards to the nearest 10 g/kW-hr.

Statistical Analysis of California CO_2 Certification Data



*CV: coefficient of variation

CARB

Summary of Conceptual GHG Standards

(Based on MYs 2020 to 2022 Certification Data)

Conceptual Tier 5 Tailpipe GHG Standards (Full Useful Life)					
POLLUTANT	POWER CATEGORIES				
	kW < 19 (g/kW-hr)	19 ≤ kW < 56 (g/kW-hr)	56 ≤ kW < 130 (g/kW-hr)	130 ≤ kW ≤ 560 (g/kW-hr)	kW > 560 (g/kW-hr)
CO_2 Reducing	n/a	n/a	700 to 720 5 to 8.6% below Tier4F	660 to 680 5 to 8.6% below Tier4F	n/a
-	-	-	-	-	-
CO_2 Capping	n/a	840	n/a	n/a	700
N_2O Capping	n/a	0.120	0.120	0.120	0.120
CH_4 Capping	n/a	0.010-0.017	0.010-0.017	0.010-0.017	0.010-0.017

Alternatives and Requests

- Are there other or additional metrics to consider in formulating appropriate capping standards?
- Staff requests that industry share additional emissions data with CARB by October 7, 2022, especially N_2O and CH_4 data, to be considered for setting the potential Tier 5 capping and CO_2 reduction standards.
- Staff also requests CH_4 data on natural gas or dual fuel engines certified to the Compression Ignition standards.
- Should GHG capping standards be considered for engines < 19 kW?
- How can we encourage equipment-based GHG improvements under Tier 5 without adopting equipment-specific standards, which is beyond the scope of this potential rulemaking (but possible for a future rulemaking)?