CALIFORNIA
AIR RESOURCES BOARD

Tier 5 Rulemaking Workshop II

Proposed Emission Standards

October 30-31, 2023

Outline

- Criteria Pollutant Standards
- Greenhouse Gas (GHG) Standards and Credits
- Low Load Cycle (LLC) Standards
- Idle Standards
- California Small-Volume Manufacturer Provisions

Criteria Pollutant Standards

U.S. EPA and CARB Tier 4f 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_x	NMHC	NO_x+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

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U.S. EPA = United States Environmental Protection Agency, HP = horsepower, kW = kilowatt, g/kW-hr = grams per kilowatt-hour, NO_x = oxides of nitrogen, PM = particulate matter, NMHC = non-methane hydrocarbon, CO = carbon monoxide

Criteria Pollutant Standards

NO_x, PM, NMHC, CO

- Off-road diesel engines are one of the largest sources of NO_x and PM in California
- There are many air basins in California that are in nonattainment for the State and National Ambient Air Quality Standards for ozone and fine particulate matter
- Diesel exhaust PM is a toxic air contaminant and a carcinogen for which safe levels of exposure have not been determined
- Demonstration testing performed by Southwest Research Institute (SwRI) in San Antonio, Texas has shown reductions on the order of 90% from current NO_x standards and 75% from current PM standards are feasible

Tier 5 Exclusions

The following engines/equipment would not be subject to California's Tier 5 regulations:

(A) New engines which are used in construction equipment or vehicles or used in farm equipment or vehicles and which are smaller than 175 horsepower

- Engines and equipment exempt from California's regulations must be predominantly used in construction or farming

(B) New locomotives or new engines used in locomotives

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Non-Methane Hydrocarbon Standards (NMHC)

- Staff is proposing a more stringent Tier 5 NMHC standard for the NRTC and Steady-State certification test cycles
- This standard would be applicable to Tier 5 final engine families greater than 56 kW
- Although not initially considered as part of the Tier 5 rulemaking, SwRI testing showed 97%+ NMHC reductions compared to the Tier 4 final standard
- U.S. EPA recently promulgated a similarly stringent NMHC emission standard for heavy-duty on-road diesel engines on the FTP cycle equal to 0.060 g/hp-hr
- The proposed Tier 5 NMHC standard would be equal to 0.080 g/kW-hr, and is the kilowatt-hour equivalent of the heavy-duty on-road NMHC standard
- The proposed NMHC standard would not apply to the new off-road low load cycle
- Lean-burn Natural Gas engines would be exempt from the proposed 0.080 NMHC standard as would engines used in mobile machines > 560 kW

Proposed Tier 5 Criteria Standards (g/kW-hr)

Nonroad Transient Test Cycle (NRTC) and Steady-State/Ramped Modal Cycles (RMC)

<table>
<tr><th>Power Category</th><th>Implementation Period</th><th>NO_x Interim</th><th>NO_x Final</th><th>PM Interim</th><th>PM Final</th><th>NMHC* Final</th><th>CO</th></tr>
<tr><td rowspan="2">< 8 kW
(< 11 HP)</td><td>2031-2033</td><td>6.0*</td><td>-</td><td>0.3</td><td>-</td><td rowspan="2">-</td><td rowspan="2">8.0</td></tr>
<tr><td>2034 +</td><td>-</td><td>5.0*</td><td>-</td><td>0.2</td></tr>
<tr><td rowspan="2">8 ≤ kW < 19
(11 ≤ HP < 25)</td><td>2031-2033</td><td>5.5*</td><td>-</td><td>0.2</td><td>-</td><td rowspan="2">-</td><td rowspan="2">6.6</td></tr>
<tr><td>2034 +</td><td>-</td><td>4.0*</td><td>-</td><td>0.1</td></tr>
<tr><td rowspan="2">19 ≤ kW < 56
(25 ≤ HP < 75)</td><td>2031-2033</td><td>3.7</td><td>-</td><td>0.015</td><td>-</td><td rowspan="2">0.19</td><td rowspan="2">5.0</td></tr>
<tr><td>2034 +</td><td>-</td><td>2.5</td><td>-</td><td>0.008</td></tr>
<tr><td rowspan="2">56 ≤ kW < 130
(75 ≤ HP < 175)</td><td>2031-2033</td><td>0.22</td><td>-</td><td colspan="2">0.005</td><td rowspan="2">0.080[1]</td><td rowspan="2">5.0</td></tr>
<tr><td>2034 +</td><td>-</td><td>0.040</td><td colspan="2">0.005</td></tr>
<tr><td rowspan="2">130 ≤ kW ≤ 560
(175 ≤ HP ≤ 750)</td><td>2029-2032</td><td>0.22</td><td>-</td><td colspan="2">0.005</td><td rowspan="2">0.080[1]</td><td rowspan="2">3.5</td></tr>
<tr><td>2033 +</td><td>-</td><td>0.040</td><td colspan="2">0.005</td></tr>
<tr><td rowspan="2">> 560 kW (Gen Sets)
(> 750 HP)</td><td>2030-2033</td><td>0.50</td><td>-</td><td>0.015</td><td>-</td><td rowspan="2">0.080[1]</td><td rowspan="2">3.5</td></tr>
<tr><td>2034 +</td><td>-</td><td>0.35</td><td>-</td><td>0.008</td></tr>
<tr><td rowspan="2">> 560 kW (Mobile)
(> 750 HP)</td><td>2030-2033</td><td>3.5</td><td>-</td><td colspan="2" rowspan="2">0.040</td><td rowspan="2">0.19</td><td rowspan="2">3.5</td></tr>
<tr><td>2034 +</td><td>-</td><td>3.0</td></tr>
</table>

*** NMHC + NO_x** **- Not applicable**

[1] The NMHC standard for lean-burn NG engine families remains at 0.19 g/kW-hr

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NO_x Compliance Margin

- Staff is proposing a ~20 mg/kW-hr margin (CCV) for complying with the Tier 5 NO_x standard to alleviate manufacturer concerns of emission measurement liability and uncertainties in the laboratory
  - Approximately the same compliance margin is afforded by U.S. EPA in the Clean Truck Plan NO_x standards for heavy-duty on-road diesel engines
- In-use conformity factors would provide additional margin in the field, where the diversity of off-road operation may be harder to predict than in the laboratory

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mg/kW-hr = milligrams per kilowatt-hour; CCV = closed crankcase ventilation

GHG Standards and Credits

Initial Concept Presented at the November 2021 workshop

- The baseline CO_2 emissions for each power category was calculated as the average value
- Potential capping standards ($19 \leq kW < 56$; $kW > 560$) were defined using the baseline
- Potential reducing standards ($56 \leq kW < 130$; $130 \leq kW \leq 560$) were calculated as a 5-8.6% reduction from the baseline
- Staff received feedback from industry and the public

GHG Standards

Carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4)

- There are no GHG standards for new off-road diesel engines in California
- California's 2022 Scoping Plan for Achieving Carbon Neutrality has a target of reducing anthropogenic GHG emissions to 85% below 1990 levels by 2045 or earlier
- The focus of these Tier 5 regulations is to reduce engine exhaust emissions
  - Further GHG emissions reductions would likely be addressed in future off-road rulemakings such as the planned Zero-Emission Off-Road Targeted Manufacturer Rule, tentatively scheduled for Board consideration in 2027

Industry Feedback

- A continuous function of power may better represent the decreasing trend of CO_2 emissions than step-wise constant values
- If a curve is used instead of constant values:
  - < 56 kW has a steep slope despite the large variation
  - > 560 kW continuously decreases which results in lower CO_2 values for extremely large engines
- Some manufacturers argue that engine-based CO_2 standards could motivate engine manufacturers to de-speed the engine, which could result in lower performance of the equipment and higher overall CO_2 emissions
- However, others believe that engine speed is such a crucial factor for equipment performance that manufacturers are unlikely to make inappropriate reductions

CO2 Data Used in Staff's Updated Analysis (1 of 2)

- U.S. EPA Nonroad Compression-Ignition Engines Certification Data*
- Model years: 2015-2022
- Applicable regulations: "Part 1039" and "Part 60 and 1039"
- Unreasonably high data (above 5,000 g/kW-hr) and low data (below 100 g/kW-hr) were removed
- Data from variable speed engines were used
  - Generally, more data points and higher emissions compared to constant speed engines
- The worst-case data between transient and steady-state tests were used

* https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment

Data Used in Staff's Updated Analysis
(2 of 2)

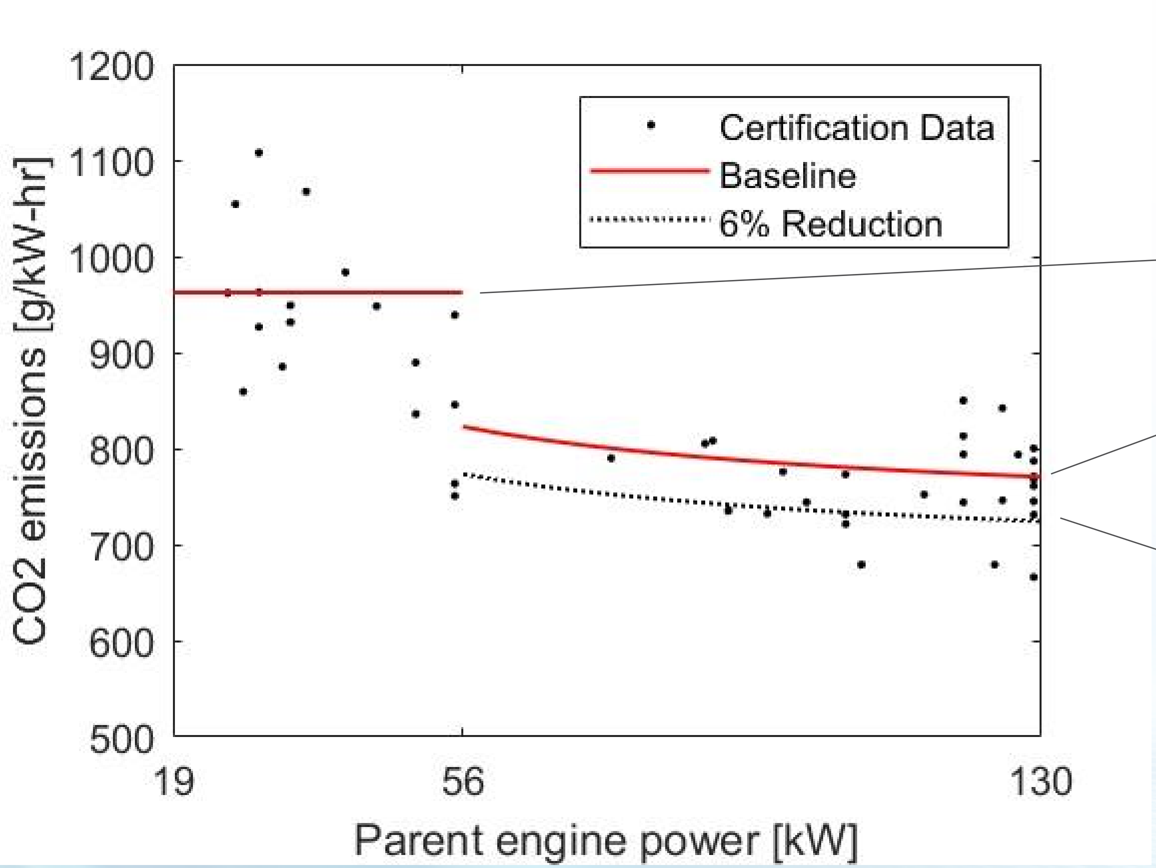
- Staff incorporated datapoints provided by the Truck and Engine Manufacturers Association that are missing/incorrect in U.S. EPA's public spreadsheet
- Multiple data points for the same engine family were averaged
- Data from engine families that were carried over from a previous year were averaged
- Data was screened for engines with advanced technologies:
  - $19 \leq kW < 56$: Electronic control, Exhaust Gas Recirculation
  - $56 \leq kW \leq 560$: Selective Catalytic Reduction, Diesel Particulate Filter (DPF)
  - $560 < kW$: DPF

Proposed Standard Types and Applicability

Standard types	Description	Applicability in Tier 5 Interim	Applicability in Tier 5 Final
Capping	Based on 80th percentile of CO_2 emissions from Tier 4 Final engines	n/a	$19 \leq kW < 56$; $560 < kW$
Reducing	6% reduction from the baseline*	n/a	$56 \leq kW \leq 560$

* For $56 \leq kW \leq 560$, an offset was added to the curve-fit result such that 80% of the data are below the adjusted curve

Analysis Results (< 130 kW)



Capping (same as Baseline) standard: 1054 g/kW-hr

Baseline

Reducing standard (94% of baseline for a 6% reduction):
= 677.5 + 2976*(Power[kW])^(-0.8535)

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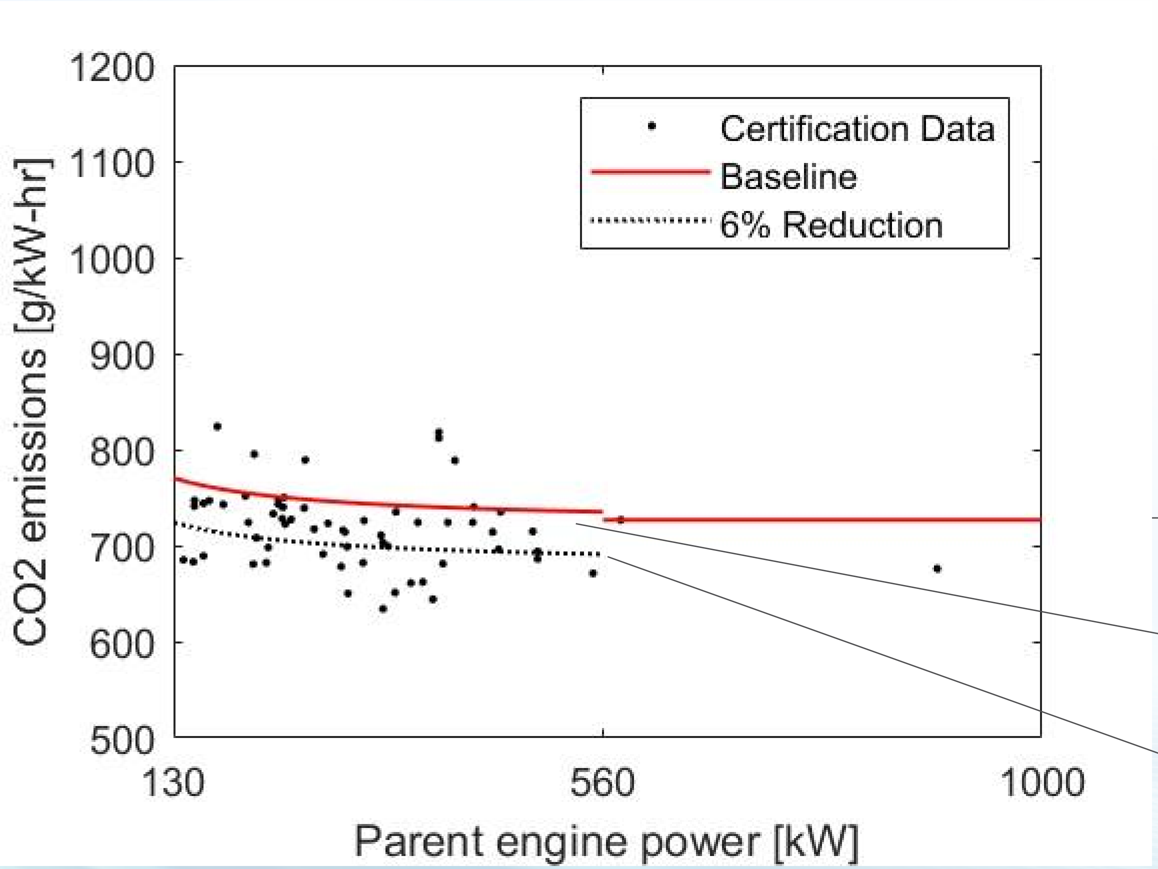
Analysis Results (≥ 130 kW)



Capping (same as baseline): 732

Baseline

Reducing standard (94% of baseline for a 6% reduction):
= 677.5 + 2976*(Power[kW])^(-0.8535)

Summary of Proposed GHG Standards Tier 5 Final

Nonroad Transient Test Cycle (NRTC) and Steady-State/Ramped Modal Cycles (RMC)

TIER 5 FINAL 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	773-724*	724-691*	n/a
CO_2 Capping	n/a	1054	n/a	n/a	732
N_2O Capping	n/a	0.150	0.150	0.150	0.150
CH_4 Capping	n/a	0.130	0.130	0.130	0.130

Calculated using the reducing standard equation: CO_2 (g/kW-hr) = 677.5 + 2976(Power[kW])^(-0.8535)

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Treatment of Child Variant Engines

- Engine families are represented by parent configurations for certification purposes that typically exhibit the highest emission levels for criteria pollutants
- A child variant is an engine in the same family substantially similar to its parent regarding emission control technologies and hardware, but calibrated differently such that GHG exhaust emissions may exceed the parent's emissions levels
- Child variants comprise the majority of engines sold in California and nationwide
- **Staff considered setting separate CO_2 emission standards for child variants to better ensure their performance in-use. After weighing the benefits and challenges, staff now proposes to use the same method U.S. EPA uses for on-road heavy-duty GHG emissions from child variant engines.**

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What are the Federal CO_2 Certification Provisions?

- 40 Code of Federal Regulations (CFR) 1036.235 (a)(3) requires engine manufacturers to apply the same (or equivalent) emission controls to all parent and child engines
- 40 CFR 1036.205(l)(2) requires that at least 1% of the production volume for an engine family have CO_2 emission rates at or below the Family Certification Level (FCL)
- The FCL is declared by the manufacturer to be equal or greater than the certified emission level for the engine family
- The FCL is the de facto standard for CO_2 credit generation and certification testing requirements (40 CFR 1036.801)
- Manufacturers must declare a CO_2 Family Emission Limit (FEL) equal to the FCL multiplied by 1.03
- The FEL serves as the standard that applies for testing individual certified engines

One-way Use of CO_2 Credits to Offset N_2O and CH_4 Emissions

- Staff proposes the inclusion of GHG tailpipe emission credits in the Tier 5 off-road diesel engine Averaging Banking and Trading (ABT) program
- Borrowing from U.S. EPA's highway provisions in 40 CFR 1036.108(c), staff proposes that CO_2 credits may be used to offset N_2O and CH_4 FELs, but N_2O and CH_4 credits may not be used to offset CO_2 FCL
  - Allowing credit generation against N_2O and CH_4 capping standards could provide a windfall credit without any GHG reduction
- To ensure GHG parity when offsetting standards, individual pollutants must be weighted by their global warming potential
  - 298 megagrams of CO_2 credits are needed to offset 1 megagram of negative N_2O credits
  - 34 megagrams of CO_2 credits are needed to offset 1 megagram of negative CH_4 credits

Proposed Tier 5 GHG ABT Credit Equation

- *Emission Credits (Mg) = (Std – FL) · Volume · AvgPR · UL · 10^{-6}*
  - Mg = Megagram
  - Std = emissions standard in grams per kilowatt-hour (g/kW-hr)
  - FL = Family Certification Level (FCL) for CO_2
    Family Emission Limit (FEL) for N_2O and CH_4
  - Volume = California directed production of engines in the engine family
  - AvgPR = California sales-weighted average of maximum engine power (PR) for engines within an engine family
  - UL = useful life for an engine family in hours
  - 10^{-6} = conversion factor from grams (g) to megagrams (Mg)

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Low Load Cycle Standards

Method for Developing the LLC Certification Cycle

- CARB staff analyzed the activity data of 240 off-road diesel engines in different applications (data provided from UC Riverside contracts and engine manufacturers)
- Staff pre-processed and cleaned-up data
  - Staff examined engine speed and engine load data
- Staff formed an LLC working group with industry, met 18 times, to address methodology, assumptions, and conducted additional analyses in response to their concerns
- Staff's initial analysis and window selection consisted of:
  - Conducting a micro-trip window analysis (different numbers of micro-trips per window)
  - Generating a frequency distribution of average load using percent load relative to the maximum power and percent load at the current speed
- Staff determined the overall distribution and definition of the low load region
- Staff performed k-means clustering analysis, selected profiles, and refined them
- SwRI translated profiles into 16 candidate cycles; several were tested on the demonstration engine and at manufacturer labs and at CARB's Southern California lab
- Chris Sharp, SwRI, will discuss the LLC separately as part of the next topic on the agenda

Proposed LLC Standards

Power Category	Implementation Period	NO_x Final Standard (g/kW-hr)	PM Final Standard (g/kW-hr)	NMHC Final Standard (g/kW-hr)	NO_x Idle Standard (g/hr)*
< 8 kW (< 11 HP)	-	-	-	-	-
8 ≤ kW < 19 (11 ≤ HP < 25)	-	-	-	-	-
19 ≤ kW < 56 (25 ≤ HP < 75)	-	-	-	-	10.0 – 30.0
56 ≤ kW < 130 (75 ≤ HP < 175)	2034+	0.060	0.005	0.19	5.0 – 10.0**
130 ≤ kW ≤ 560 (175 ≤ HP ≤ 750)	2033+	0.060	0.005	0.19	10.0 – 15.8**
> 560 kW (Gen Sets) (> 750 HP)	-	-	-	-	-
> 560 kW (Mobile Machines) (> 750 HP)	-	-	-	-	50.0

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- Not applicable * Option to conduct stand alone idle testing ** Equation based

Idle Standards

Idle Reduction Requirements

- The In-Use Off-Road Diesel-Fueled Fleets Regulation* in California contains a 5-minute idle restriction** and a requirement for affected fleets to have a written idle policy
  - Excludes idling during queuing; for testing, servicing, repairing, or diagnostic purposes; for warming up; and for ensuring safe operation
  - Excludes agricultural equipment
- California's and U.S. EPA's existing standards for new off-road compression-ignition (CI) engines do not include idling restrictions

*Title 13 California Code of Regulations (CCR) § 2449
** Idling limit exclusions described in 13 CCR § 2449 (d)(2)(A) apply.

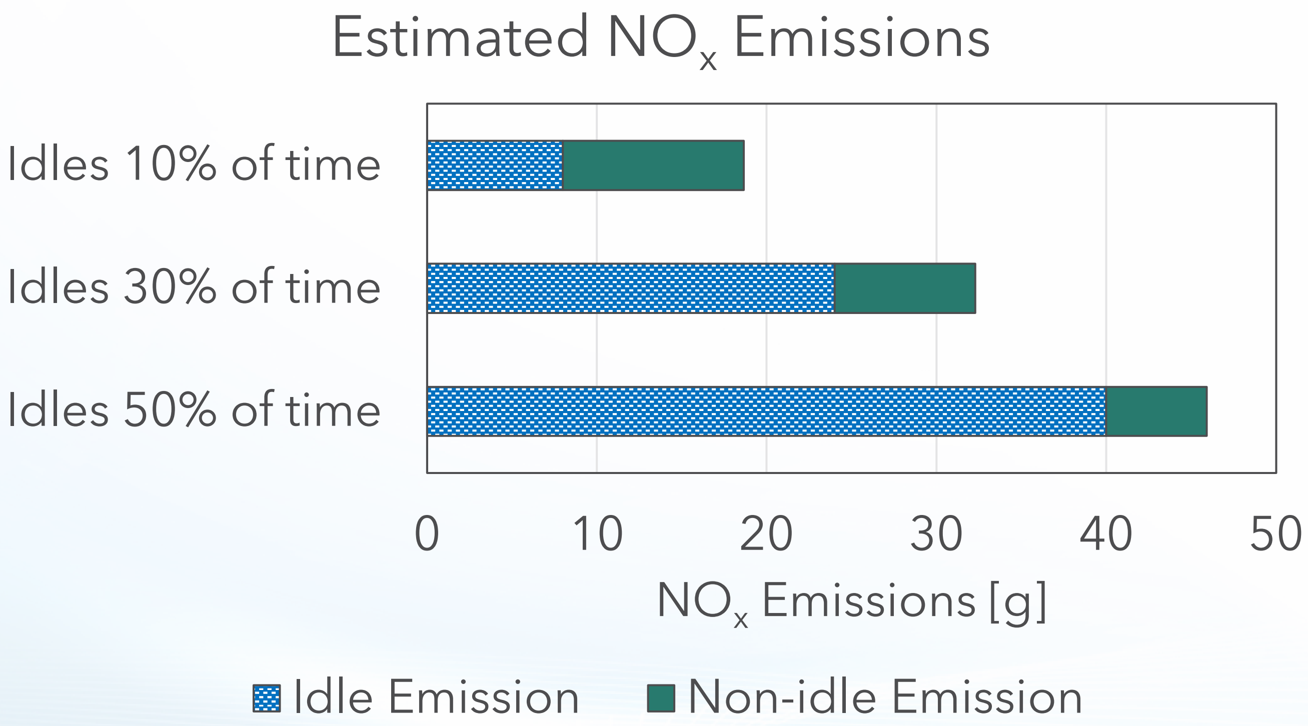
Importance of Controlling Idling NO_x Emissions in Tier 5

- Idling is common for off-road equipment, potentially 30-50% of time* is spent in idle
- Staff's current off-road emission inventory does not isolate emissions from idle because it uses average load factors for the entire operation
- Idle emissions could potentially dominate the overall NO_x emissions if the idle emission rate is much greater than non-idle emissions

*Based on manufacturer data as well as CARB's 3 different datasets for construction equipment (2011; 2019) and cargo handling equipment (2021)

A Hypothetical Idle Example at Various Idle Fractions

- A 100-kW engine operating at ~37% load, equivalent to the NRTC, when not idling
- Idle emission rate: 10 g/hr
- Non-idle brake-specific emissions: 0.04 g/kW-hr NO_x
- Eight hours of operation



To ensure that idle emissions do not dominate overall emissions, staff proposes to control idle emissions.

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Initial Idle Reduction Concept Presented in the December 2022 Workgroup

Demonstrate compliance with one of the following two options:

1. Use a non-programmable engine shutdown system that automatically shuts down the engine after five minutes of continuous idling operation, or
2. Comply with the NO_x idle standard

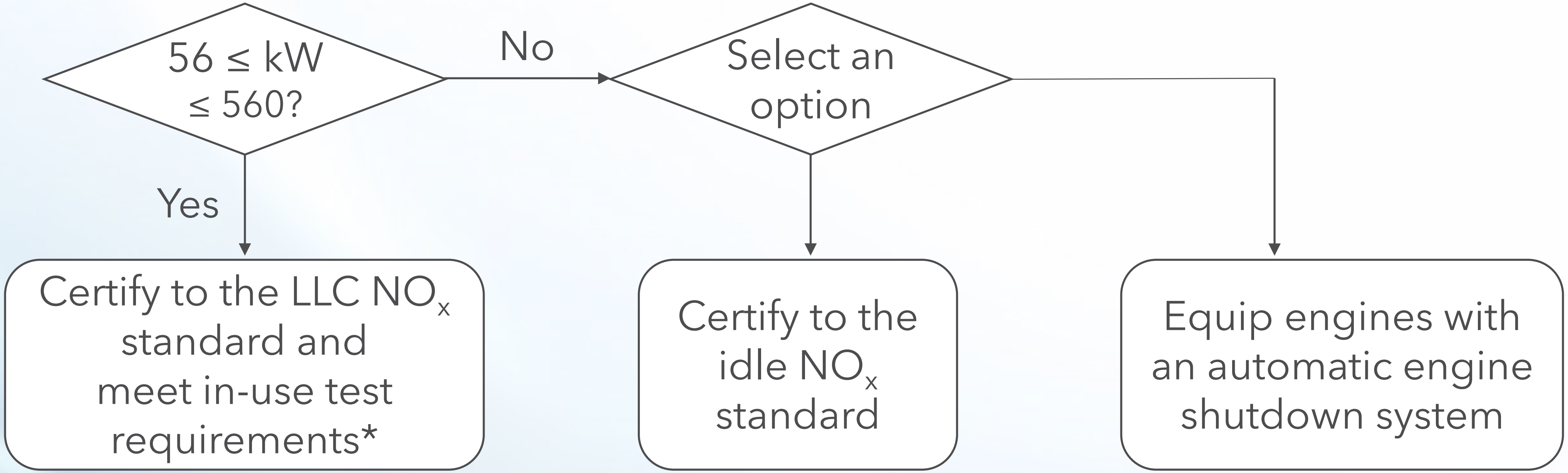
Industry Feedback from the December 2022 Workgroup

- Engine shutdown system
  - Idling is necessary in many cases (e.g., for safety, warm up)
  - The definition of idling must be clarified
- Idle standard
  - Align with the federal on-road standard (Clean Trucks Plan NO_x rule, 10 g/hr)

LLC Test Cycle Ensures Clean Idle

- The LLC is required for certifying engines 56 ≤ kW ≤ 560
- The LLC includes an extended idle period
- Staff's analysis of LLC parameters (average load, cycle duration, idle length) shows that if an engine family is certified with LLC, idle emissions would be low enough to pass the idle standard
- Therefore, to reduce certification burden, staff proposes to allow an engine family to automatically meet the idle certification requirement if it meets the LLC standard
  - The idle standard continues to apply for in-use testing [screening and portable emissions measurement system (PEMS) testing]

Idle NO_x Reduction Requirements



* Meet Bin A (Idle Bin) standard of in-use NO_x screening program and off-cycle testing with PEMS

Proposed Idle NO_x Standards

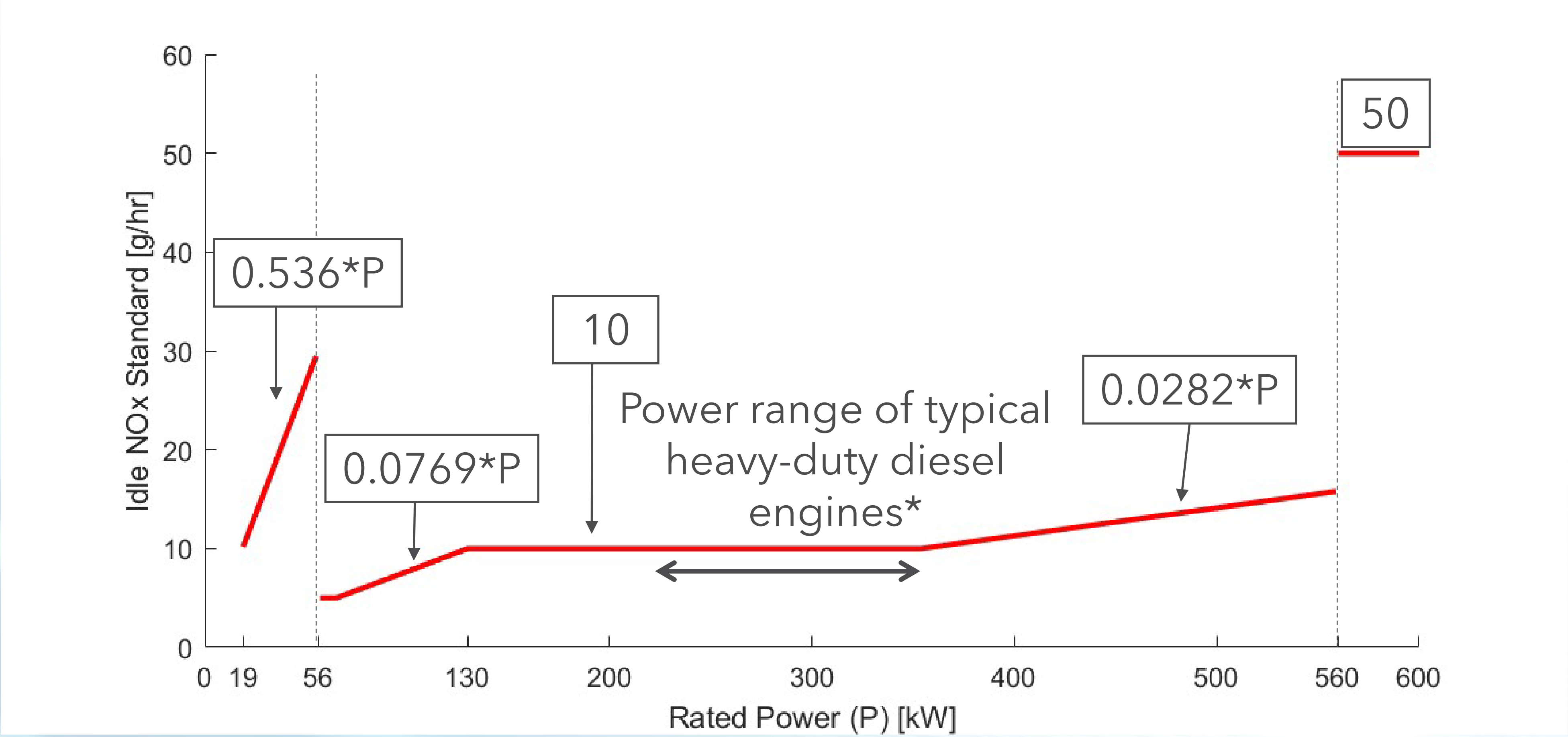
- Staff proposes linearly scaling the idle standard by the engine power:
  - Staff proposes aligning with the federal idle standard, 10 g/hr, at the power range similar to on-road heavy-duty engines
  - Staff proposes higher idle standards for engines < 56 kW and > 560 kW because they tend to have less sophisticated emission control systems than 56 ≤ kW ≤ 560
- Engines exclusively designed for constant speed applications, such as generator sets, transport refrigeration units, pumps, and welders, are exempted

Proposed Tier 5 Idle NO_x Standards

Power Category	Application	Idling NO_x Standard (g/hr)	Idling NO_x Standard Range (g/hr)	Note
19 ≤ kW < 56 (25 ≤ HP < 75)	All	0.536*Power (P)	10 - 30	Slope = [30 g/hr]/[56 kW]
56 ≤ kW < 130 (75 ≤ HP < 175)	All	5 or 0.0769*P, whichever is greater	5 - 10	Slope = [10 g/hr]/[130 kW]
130 ≤ kW < 560 (175 ≤ HP < 750)	All	10 or 0.0282*P, whichever is greater	10 - 15.8	Slope = [10 g/hr]/[354 kW]*
> 560 kW (> 750 HP)	Gen Sets	-	-	-
> 560 kW (> 750 HP)	Mobile Machines	50	50	-

* Assumed a typical power rating of a Heavy Heavy-Duty Engine is 475 hp (=354 kW). https://www.nrel.gov/docs/fy20osti/76571.pdf.

Proposed Tier 5 Idle NO_x Standards



* A typical power rating of a Light Heavy-Duty Diesel Engine is ~300 hp (224 kW) and a Heavy Heavy-Duty Diesel Engine is ~475 hp (354 kW). https://www.nrel.gov/docs/fy20osti/76571.pdf.

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Idle Test Procedure

- Warm up the engine (operate the engine over the NRTC/RMC or other appropriate method)
- Bring down the engine to the warm idle speed and apply 3.5% of rated power
- Start measuring NO_x emissions after achieving temperature stability
- Stop emissions sampling after 30 minutes

Optional Engine Shutdown System Automatic Override

The engine shutdown system may be overridden automatically under the following conditions:

- The engine coolant temperature is below 60 °F (15.6 °C)[a,b]
- The exhaust emission control device is regenerating[a]
- Idling is necessary for engine protection

a: Based on the current California test procedure for heavy-duty diesel engines, §86.xxx-11.B.6.1.2
b: The low temperature override is intended to protect the health and safety of drivers during severe winter conditions.

Optional Engine Shutdown System Definition of Idling

The engine must be programmed to shut down after 300 seconds of continuous idling operation

- Idle speed: manufacturer-declared warm idle speed
- Idle load: ≤ 3.5% of rated power

Optional Engine Shutdown System Manual Override (1 of 2)

- The engine shutdown system may be overridden for idling operations allowed in 13 CCR § 2449 (d)(2)(A):
  1. idling when queuing,
  2. idling to verify that the vehicle is in safe operating condition,
  3. idling for testing, servicing, repairing or diagnostic purposes,
  4. idling necessary to accomplish work for which the vehicle was designed (such as operating a crane),
  5. idling required to bring the machine system to operating temperature, and
  6. idling necessary to ensure safe operation of the vehicle

Optional Engine Shutdown System Manual Override (2 of 2)

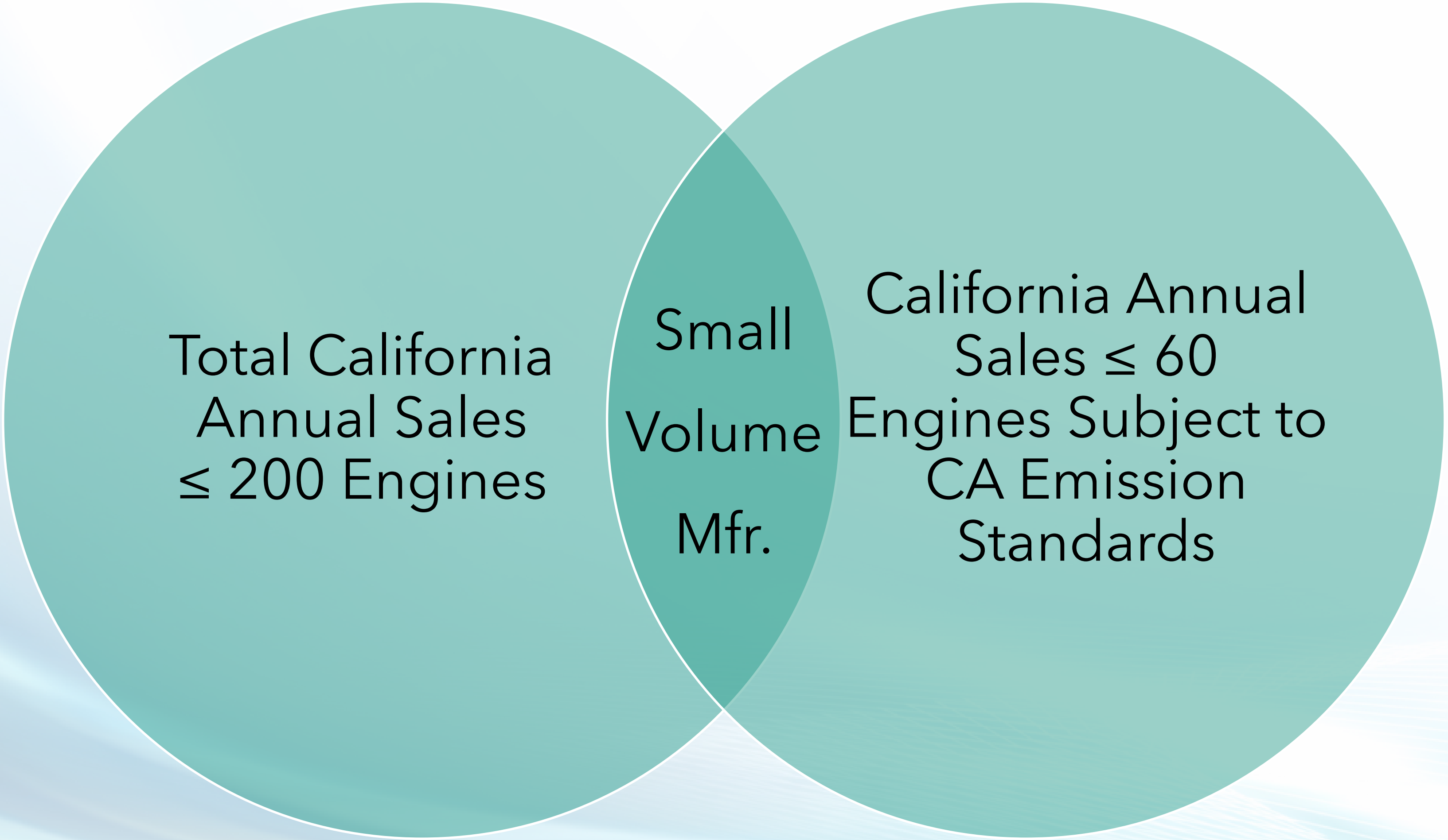
- The operator may reset the 300 second timer by momentarily changing the position of the accelerator
- The engine shutdown system may temporarily be deactivated by a designated button for up to one hour
- At the end of the set deactivation period, the engine's electronic control module shall restart the engine shutdown system sequence

California Small-Volume Manufacturer Provisions

Need for Small-Volume Manufacturer Allowances

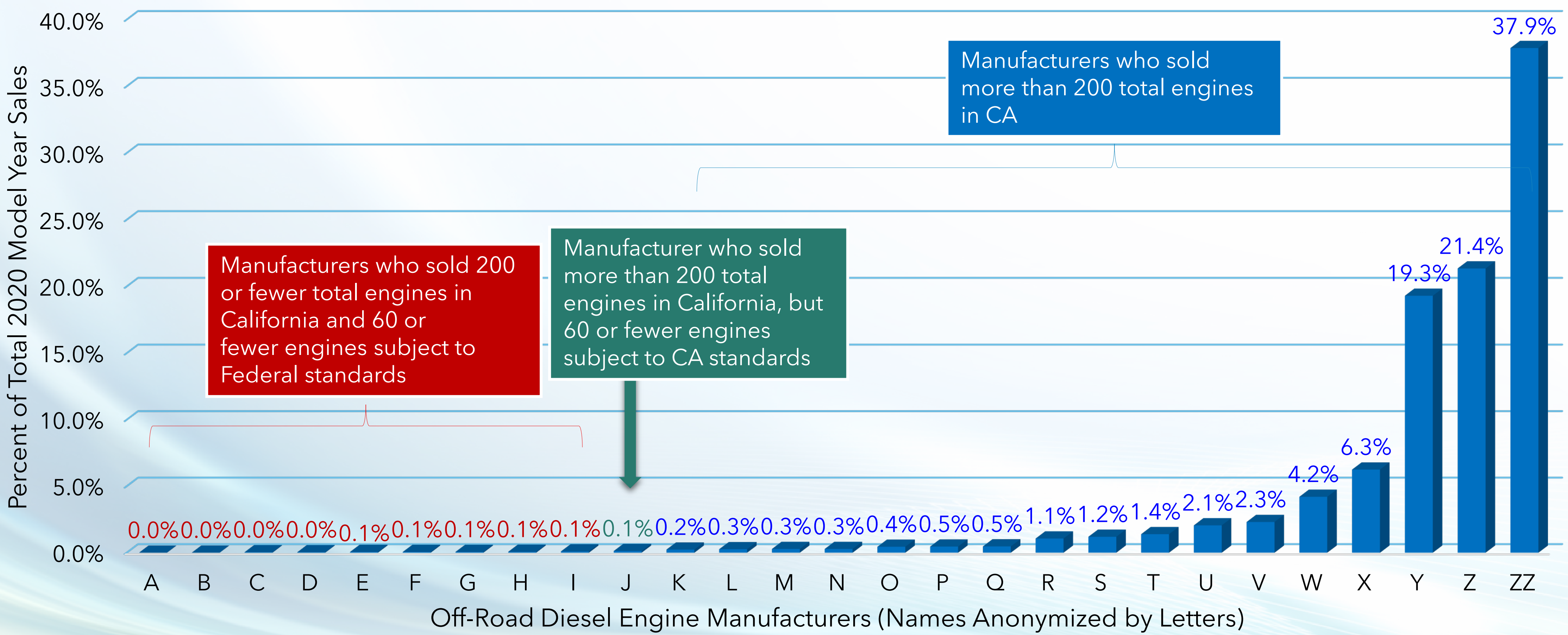
- Small-volume manufacturers may have insufficient engineering resources to develop Tier 5 engines just for California
- Small-volume manufacturers may have insufficient compliance resources to certify Tier 5 engines just for California
- Manufacturers who sell few engines in California may not be able to recoup their Tier 5 investments in the absence of federal alignment due to economies of scale
- Alternative provisions for small-volume engine manufacturers would be necessary to protect California businesses, employees, and clients who depend on the availability of their engines and the equipment they power for livelihood and infrastructure

Definition of a California Small-Volume Engine Manufacturer



Small-Volume Manufacturers represent approximately 0.5% of total annual off-road diesel engine sales in California

Distribution of California Off-Road Diesel Engine Manufacturers by Percentage of Engine Sales



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CA Small-Volume Manufacturer Provisions

- Delayed Implementation:
  - May certify to the Tier 4 final standards for an additional 2 years after the start of Tier 5 final
  - Useful Life
    - No changes for small-volume manufacturers
  - Test Cycles
    - Certification on the LLC or idle cycle would not be required for small-volume manufacturers
  - In-Use Program
    - Engines certified under the small-volume manufacturer provisions would not be subject to the manufacturer-run Tier 5 in-use provisions
  - On-Board Diagnostics and Monitoring (OBD/OBM)
    - Engines certified under the small-volume manufacturer provisions would not be subject to OBD/OBM

CA Small-Volume Manufacturers (Standards)

Tier 5 Final vs. Small-Volume Manufacturer Standards (g/kW-hr)
2-Year Allowance

POLLUTANT	19 ≤ kW < 56		56 ≤ kW ≤ 560		> 560 kW	
	TIER 5 FINAL	SMALL (T4F)	TIER 5 FINAL	SMALL (T4F)	TIER 5 FINAL	SMALL (T4F)
NO_x	2.5	4.7*	0.040	0.40	0.35 / 3.0**	0.67 / 3.5**
PM	0.008	0.03	0.005	0.02	0.008 / 0.040**	0.03 / 0.04**
NMHC	0.19	n/a	0.080[1]	0.19	0.080[1] / 0.19**	0.19
CO	5.0	5.0	5.0 / 3.5***	5.0 / 3.5***	3.5	3.5
CO_2	1054 (capping std)	n/a	773-691****	n/a	732 (capping std)	n/a

* $NMHC + NO_x$ ** Gen Sets / Mobile Machines *** The CO standard is 5.0 g/kW-hr for 56-130 kW engines and 3.5 g/kW-hr for 130-560 kW engines **** The CO_2 reducing standard is calculated from the equation (94% of baseline for 6% reduction): CO_2 = 677.5 + 2976*[Kilowatts]^(-0.8535) [1] The NMHC standard for lean-burn NG engine families remains at 0.19 g/kW-hr

Introduction of Next Agenda Item

Backup Slide

Proposed Consolidated Tier 5 Exhaust Standards (g/kW-hr)

Nonroad Transient Test Cycle (NRTC) and Steady-State/Ramped Modal Cycles (RMC)

Power Category	Implementation Period	NO_x Interim Standard	NO_x Final Standard	PM Interim Standard	PM Final Standard	CO_2 Capping Standard	CO_2 Reducing Standard	N_2O Capping Standard	CH_4 Capping Standard	NMHC Final Standard	CO
< 8 kW (< 11 HP)	2031-2033	6.0*	-	0.3	-	-	-	-	-	-	8.0
	2034 +	-	5.0*	-	0.2						
8 ≤ kW < 19 (11 ≤ HP < 25)	2031-2033	5.5*	-	0.2	-	-	-	-	-	-	6.6
	2034 +	-	4.0*	-	0.1						
19 ≤ kW < 56 (25 ≤ HP < 75)	2031-2033	3.7	-	0.015	-	1054	-	0.150	0.130	0.19	5.0
	2034 +	-	2.5	-	0.008						
56 ≤ kW < 130 (75 ≤ HP < 175)	2031-2033	0.22	-	0.005		-	-	0.150	0.130	0.080[1]	5.0
	2034 +	-	0.040	0.005		-	773-724**				
130 ≤ kW ≤ 560 (175 ≤ HP ≤ 750)	2029-2032	0.22	-	0.005		-	-	0.150	0.130	0.080[1]	3.5
	2033 +	-	0.040	0.005		-	724-691**				
> 560 kW (Gen Sets) (> 750 HP)	2030-2033	0.50	-	0.015	-	732	-	0.150	0.130	0.080[1]	3.5
	2034 +	-	0.35	-	0.008						
> 560 kW (Mobile Machines) (> 750 HP)	2030-2033	3.5	-	0.040		732	-	0.150	0.130	0.19	3.5
	2034 +	-	3.0								

* NMHC + NO_x
** Calculated using the CO_2 reducing standard equation: CO_2 STD = 677.5 + 2976*[Kilowatts]^(-0.8535)
\- Not applicable
1 The NMHC standard for lean-burn NG engine families would be 0.19 g/kW-hr

CARB