Appendix E

Emissions Inventory Methods and Results for the Proposed Amendments

Date of release: September 23, 2025
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This appendix provides further details on the emissions inventory methods and results for the Proposed Amendments.

I. Overview

This appendix summarizes methods used to estimate oxides of nitrogen (NOx) emissions benefits for the Proposed Amendments and presents the results of this analysis. California Air Resources Board's (CARB) on-road mobile source emissions inventory model, Emission FACtors (EMFAC) 2021 (CARB, 2025a), was used to perform the analysis. EMFAC incorporates the latest available information on vehicle emission rates, population, and vehicle miles traveled at the time of rulemaking development. This model was used to estimate emissions with the Proposed Amendments and two alternative scenarios.

CARB staff adjusted EMFAC2021 emissions outputs for recently adopted regulations, including the Clean Truck Check Program (CARB, 2025b), State and Local Government fleet requirements as part of Advanced Clean Fleets (CARB, 2025c), and 100% zero-emission heavy-duty (HD) and medium-duty (MD) vehicle sales starting in 2036 per the Clean Truck Partnership (CTP) agreement (CARB, 2023).

II. Emissions Inventory Methods

In emissions inventories, emissions are calculated as the product of a pollutant emission rate (e.g., grams of pollutant per mile) per unit of activity (e.g., miles driven) multiplied by the corresponding activity and population. Details on vehicle activity, emission rates, and populations can be found in the *EMFAC2021 technical documentation* (CARB, 2021). Within this analysis, staff considered three different scenarios below:

1. **Proposed Amendments** – update existing Omnibus requirements to align with the proposed requirements.
2. **Alternative 1 (Baseline)** – retain existing Omnibus requirements that are more stringent than the Proposed Amendments. This scenario represents baseline emissions.
3. **Alternative 2** – maintain the 2024 model year (MY) Omnibus requirements for 2027 and later MYs that are less stringent than the Proposed Amendments.

Requirements for the three scenarios are listed in Table 1. Please note that the table below only lists program components that were incorporated as part of emissions modeling and is not intended to be comprehensive.

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Table 1. Requirements for the Proposed Amendments, Alternative 1 (Baseline), and Alternative 2

Standards, Test Procedures, and Elements	Units[3]	Proposed Amendments: MY 2027+	Alternative 1: MY 2027-2030	Alternative 1: MY 2031+	Alternative 2: MY 2027+
Federal Test Procedure (FTP)	mg/hp·hr NOx	35	20	20	50
Low Load Cycle (LLC)	mg/hp·hr NOx	50	50	50	200
Idle	g/hr NOx	See off-cycle requirements Table 2	5	5	10
In-Use Limits	mg/hp·hr NOx	See off-cycle requirements Table 2	Binned Moving Average Window (MAW) 2.0x Standards	Binned MAW 1.5x Standards	Binned MAW 2.0x Standards
Warranty[1,2]	1,000 Miles	321/221/189/148	308/172/135/104	400/221/189/148	289/139/103/50
Useful Life[1]	1,000 Miles	650/350/270/200	600/270/190/155	800/350/270/200	435/185/110/110

[1]: The mileages shown for useful life and warranty are listed in the form of Heavy HDE/Medium HDE/Light HDE/SI HDE, as defined by the primary intended service class:

- Heavy HDE: heavy heavy-duty engine, gross vehicle weight rating (GVWR) >33,000 lb. (Class 8);
- Medium HDE: medium heavy-duty engine, 19,500 < GVWR ≤ 33,000 lb. (Class 6-7);
- Light HDE: light heavy-duty engine, 14,000 lb. < GVWR ≤ 19,500 lb. (Class 4-5);
- SI HDE: spark-ignition heavy-duty engine, GVWR >14,000 lb. (Class 4 and above);

[2]: Represents the average miles covered when considering the miles, years, and hours provisions within the proposed requirements.

[3]: Units used in Table 1: mg/hp·hr: milligrams per horsepower-hour; g/hr: grams/hour

The in-use standards in Alternatives 1 and 2 use a 3-Bin MAW methodology consistent with the original Omnibus Regulation. This approach evaluates emissions data from heavy-duty engines (HDE) and medium-duty engines (MDE) in different time segments that are classified as idle, low load and medium/high load, ensuring they meet the in-use limits in Table 1 for idle, LLC, and FTP, respectively. Tables 2 and 3 list the off-cycle or in-use standards for the Proposed Amendments scenario for MYs 2027-2030 and 2031-2034, respectively. Please note that in-use standards beyond MY 2034 are not listed because all California-certified

heavy-duty vehicles (HDV) and medium-duty vehicles (MDV) with engine MY 2035 and newer (that have a 2036 chassis and newer MYs) will be zero-emission per the CTP agreement. The in-use standards for the amended regulation combine the low load bin and medium/high load bin, i.e., Bin 2, and represent a weighted combination of FTP and LLC. In addition, unlike Alternatives 1 and 2, the in-use or off-cycle standards in the Proposed Amendments depend on the ambient temperature, with higher limits established for lower temperatures.

Table 2. Proposed Amendments – In-Use or Off-Cycle Standards for Engine MYs 2027-2030

Primary Intended Service Class	Units	Bin*	NOx Standard at 20 °C	NOx Standard at 5 °C
All	g/hr	1	10.4	15.4
Light HDE & MDEs	mg/hp·hr	2	63	107
Medium HDE and Heavy HDE	mg/hp·hr	2	78	122

* Bins 1 and 2 represent idle and non-idle operations, respectively.

Table 3. Proposed Amendments – In-Use or Off-Cycle Standards for Engine MYs 2031-2034

Primary Intended Service Class	Units	Bin**	NOx Standard at 5 - 20°C
All	g/hr	1	10.4
Light HDE & MDEs	mg/hp·hr	2	63
Medium HDE and Heavy HDE	mg/hp·hr	2	78

** Bins 1 and 2 represent idle and non-idle operations, respectively.

CARB staff used similar methods to those used to reflect the emissions benefits of Omnibus in EMFAC2021 to account for the impact of all three scenarios on emission rates. This analysis used the in-use or off-cycle requirements to account for real-world emissions, which are less stringent than certification standards. Please see Section 4.6.4 of the *EMFAC2021 Technical Documentation* for more details.

To estimate the temperature-dependent in-use limits for off-cycle standards in the Proposed Amendments, CARB staff first calculated the annual average ambient temperature in EMFAC, weighted by HDV or MDV miles traveled, to be 18.03 °C. The off-cycle standards listed in Tables 2 and 3 were then interpolated to this average temperature. The interpolated value for Bin 2 is the weighted average of the FTP and LLC operation, i.e., 0.75*FTP+0.25*LLC (U.S. EPA, 2023). Staff calculated the ratio of the off-cycle standard in Bin 2 at 18.03 °C divided by the weighted average of the FTP and LLC certification standards (38.75 mg/hp·hr NOx). For example, the Bin 2 ratio for medium HDEs and heavy HDEs for 2027-2030 is 83.77/38.75 = 2.2. This ratio was used to adjust the EMFAC base emission rates (at FTP average speed) from the certification standard to the off-cycle emission rate limits for California-certified MDVs and HDVs with engine MYs 2027 and newer.

Under the Proposed Amendments, there is a production volume allowance for a percentage of legacy engines to be certified 200 mg/hp·hr NOx for MY 2027-2029 engines. This amount is equal to 5% of the average sales volume of 2023-2025 engines, which staff estimates to be around 7% of MY 2027-2029 engines. The emissions results for the Proposed Amendments account for this portion of legacy engines.

For each scenario, staff modified underlying assumptions for California-certified MY 2027 and newer engine emission rates in EMFAC2021 (adjusted to account for adopted regulations) and then completed model runs at the Statewide level to obtain emissions results.

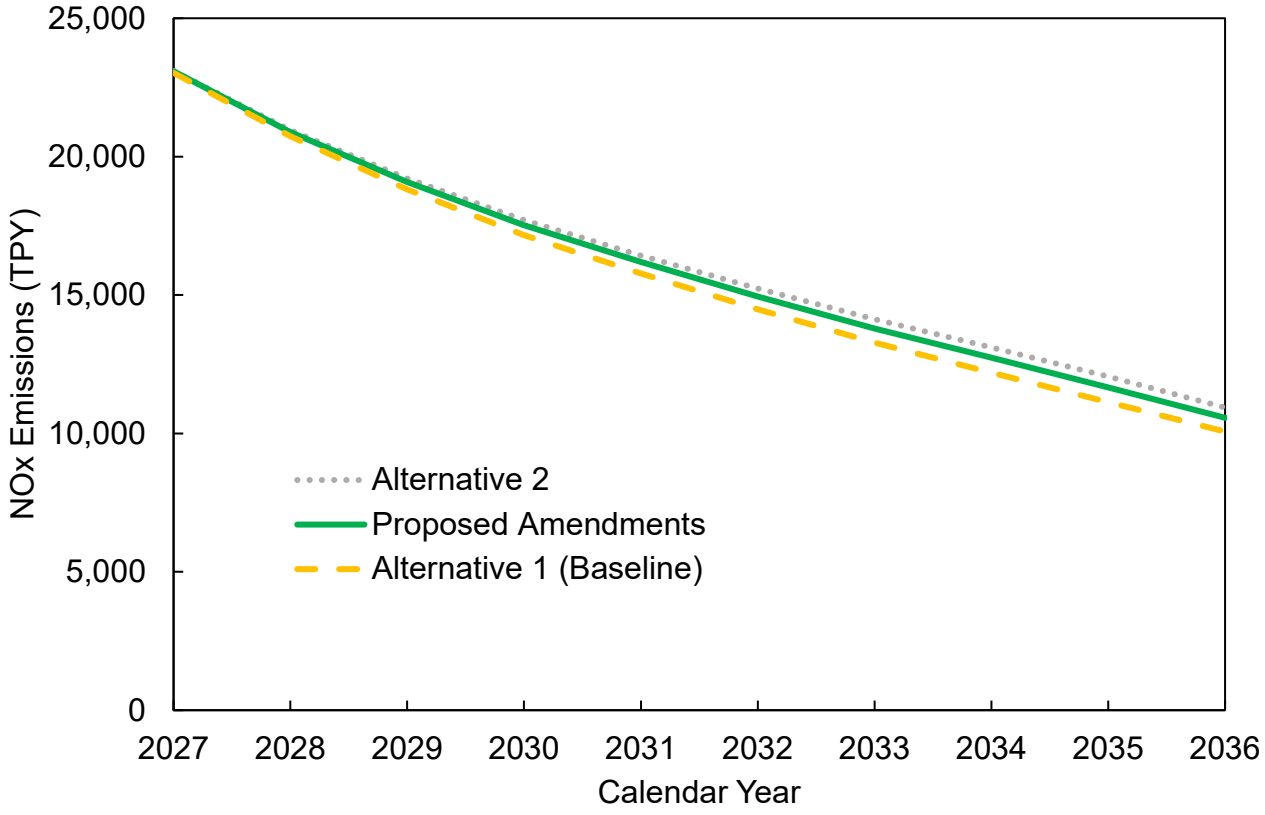
III. Results

Table 4 and Figure 1 show NOx emissions projections from the entire HD and MD fleets for all three scenarios in each calendar year. Although the Proposed Amendments' NOx emissions are larger than Alternative 1 (Baseline), primarily due to less stringent in-use standards, the impact is relatively minor, resulting in an approximately 2% cumulative increase (calendar years 2027-2036) from Alternative 1 (Baseline). Relative to Alternative 2, which has the least stringent in-use requirements, the Proposed amendments have lower NOx emissions.

Table 4. Projected NOx Emissions in Tons per Year (TPY) for All Three Scenarios

Calendar Year	Alternative 1 (Baseline)	Proposed Amendments	Alternative 2
2027	23,028.44	23,085.28	23,098.48
2028	20,732.81	20,891.17	20,956.85
2029	18,818.88	19,087.84	19,213.04
2030	17,170.02	17,523.22	17,703.39
2031	15,773.67	16,192.51	16,428.15
2032	14,479.69	14,949.76	15,238.07
2033	13,283.54	13,793.83	14,128.50
2034	12,191.97	12,736.89	13,111.88
2035	11,126.14	11,663.44	12,052.84
2036	10,066.14	10,564.74	10,933.78

Figure 1: Projected NOx Emissions from MDEs and HDEs in TPY for All Three Scenarios



IV. References

1. (CARB, 2021) *EMFAC2021 Volume III Technical Document*, California Air Resources Board, March 31, 2021.
2. (CARB, 2023) *Clean Truck Partnership Agreement*, California Air Resources Board, July 5, 2023.
3. (CARB, 2025a) *EMFAC2021*, California Air Resources Board, (Accessed June 17, 2025).
4. (CARB, 2025b) *Clean Truck Check (HD I/M)*, California Air Resources Board, (Accessed June 17, 2025).
5. (CARB, 2025c) *Advanced Clean Fleets*, California Air Resources Board, (Accessed June 17, 2025).
6. (U.S. EPA, 2023) Final Rule: *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards*, United States Environmental Protection Agency, Federal Register Vol. 88, No. 15, January 24, 2023.