

Appendix F

Emissions Inventory and Results

Advanced Clean Fleets Regulation

California Air Resources Board

Date of Release: August 30, 2022
Date of Hearing: October 27, 2022

I. Overview of Emissions Inventory

This appendix presents the methodology and results of the emissions inventory analysis for vehicles operated in California that would be affected under the proposed Advanced Clean Fleets (ACF) regulation. California Air Resources Board (CARB) staff used the latest available data and methods to estimate vehicle activity, and in-use emissions to assess the impacts of the proposed ACF regulation on both criteria (oxides of nitrogen, or NO_x and fine particulate matter, or PM_{2.5}) and greenhouse gas (GHG) emissions. The emissions inventory analysis results presented in this document consider medium and heavy-duty trucks and buses with gross vehicle weight rating (GVWR) greater than 8,500 pounds (Class 2b - 8). Because this modification will not increase light-duty zero emission vehicle (ZEV) sales beyond the requirements already set by the Advanced Clean Cars (ACC) regulation, this modification is not projected to have any direct costs on the state. The proposed ACF regulation is expected to provide 5.6 tons per day (tpd) and 4.6 tpd NO_x emissions reductions in the South Coast (SC) and San Joaquin Valley (SJV) air basins, respectively, along with a statewide NO_x emissions reduction of 20 tpd in 2031. In 2037, the proposed regulation is expected to lead to 14.4 tpd NO_x emissions reduction in SC, 12.7 tpd in SJV, and a total of 52 tpd statewide. With full implementation in 2042, the proposed regulation is expected to achieve approximately 80 tpd NO_x reduction statewide, with 21.6 and 20.3 tpd in SC and SJV, respectively.

II. Introduction and Background

Under the Governor's Executive Order N-79-20,¹ CARB is mandated to develop and propose strategies to achieve 100 percent zero-emissions from medium and heavy-duty on-road vehicles in the state by 2045 where feasible and by 2035 from drayage trucks.² The proposed ACF regulation is one of the ongoing efforts that CARB is developing to meet zero-emission goals through establishing targeted fleet purchase requirements. The proposed ACF regulation follows a recently adopted Advanced Clean Trucks (ACT) regulation that requires manufacturers of heavy-duty vehicles to transition sales of diesel trucks and vans to electric zero-emission trucks beginning in

¹ Executive Department, State of California, [Executive Order N-79-20, 2020](https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf) (web link <https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf>, last accessed August 2020)

² California Air Resources Board (CARB), [Zero-Emission On-Road Medium-and Heavy-Duty Strategies](https://ww2.arb.ca.gov/resources/documents/zero-emission-road-medium-and-heavy-duty-strategies), April 2021 (weblink: <https://ww2.arb.ca.gov/resources/documents/zero-emission-road-medium-and-heavy-duty-strategies>, last accessed August 2020)

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2024.³ ACT will require that by 2035 and in future years, manufacturer sales of zero-emission trucks in California must be 55 percent for Class 2b - 3 vehicles, 75 percent for Class 4 - 8 vocational vehicles, and 40 percent for Class 7 - 8 tractors.

The proposed ACF regulation aims to direct the ZEV market and additionally accelerate the deployment of zero-emission medium and heavy-duty trucks and buses with GVWR greater than 8,500 pounds (Class 2b – 8) and light-duty package delivery vehicles that are either owned, or dispatched, by the following entities:

- **State and local government fleets:** The proposed State and local government fleet requirement would apply to cities, counties, public utilities, special districts, and the State fleet, but excludes federal agencies. For a public agency whose jurisdiction is not solely in a designated low population county, starting January 1, 2024, 50 percent of the total number of vehicles added to the California fleet in each calendar year must be ZEVs. Starting January 1, 2027, 100 percent of the total number of vehicles added to the California fleet in each calendar year must be ZEVs for all fleets.
- **Drayage fleets:** Drayage trucks are on-road, heavy-duty vehicles that transport containerized, bulk or break-bulk goods, empty containers, and chassis to and from seaports and intermodal railyards. Beginning January 1, 2024, all drayage trucks registering for the first time in the CARB Online System must be ZEVs. The CARB Online Reporting System would be used by seaports and intermodal rail yards to check compliance of drayage trucks before entering facilities. A legacy drayage truck must visit a regulated seaport or intermodal railyard at least once each calendar year, and trucks that have not met their annual visit requirement will be excluded from the CARB Online System and considered as noncompliant. Beginning January 1, 2025, existing legacy drayage trucks with internal combustion engines (ICE) will be excluded from the CARB Online Reporting System and considered as noncompliant after they exceed the minimum useful life provided in statute by Senate Bill (SB) 1,⁴ which is the later of the time periods specified below:

³ California Air Resources Board (CARB), [Advanced Clean Trucks Regulation](https://ww2.arb.ca.gov/rulemaking/2019/advancedcleantrucks), March 2021 (weblink: <https://ww2.arb.ca.gov/rulemaking/2019/advancedcleantrucks>, last accessed August 2020)

⁴ SB 1 (Beall, Stats. 2017, ch. 5). Govt. Code: repeal Sections 63048.66, 63048.67, 63048.7, 63048.75, 63048.8, 63048.65, and 63048.85; add new sections 14033, 14110, 14526.7, 14556.41, 14460, 14461, 14526.7, 14556.41, 16321, and 63048.65; amend section 14526.5; Health & Saf. Code add Section 43021; Public Utilities Code: amend Section 99312.1, and add Sections 99312.3, 99312.4, and 99314.9; Revenue & Taxation Code amend Sections 6051.8, 6201.8, 7360, 8352.4, 8352.5, 8352.6, and 60050; to add Sections 7361.2, 7653.2, 60050.2, and 60201.4 to, and to add Chapter 6 (commencing with

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(a) Thirteen years from the model year that the original engine and emissions control system of that drayage truck was first certified for use by CARB or U.S. Environmental Protection Agency (U.S. EPA), or

(b) The date that the drayage truck exceeded 800,000 vehicle miles traveled (VMT) or 18 years from the model year that the original engine and emissions control system of that drayage truck was first certified for use by CARB or U.S. EPA (whichever comes earlier).

In addition, beginning January 1, 2035, all drayage trucks registered in the CARB Online Reporting System must be ZEVs.

- **High priority and federal fleets:** High priority and federal fleets requirements are applicable to any entity that owns, operates, or directs one or more vehicles in California on or after January 1, 2024, and that meets any of the following criteria:
 - (A) Is an entity with \$50 million or more in total gross annual revenue in the prior year.
 - (B) Is a fleet owner that owns, operates, or directs 50 or more vehicles, excluding light duty package delivery vehicles.
 - (C) Is a fleet owner or controlling party whose fleet in combination with other fleets operated under common ownership and control totals 50 or more vehicles, excluding light duty package delivery vehicles; or
 - (D) Is any federal government agency.

High priority and federal fleets would be required to follow a compliance pathway such that existing ICE vehicles would be guaranteed their full useful life, as defined by SB 1, while all vehicles added to the California fleet must be ZEVs beginning in 2024. Alternatively, the fleets may opt-in to a ZEV milestone schedule and phase in medium- and heavy-duty ZEVs as percentage of the total fleet that operates in California based on vehicle body type (**Table 1**).

Section 11050) to Part 5 of Division 2 of, the Revenue and Taxation Code; Streets and Highways Code: amend Sections 2104, 2105, 2106, and 2107, add Sections 2103.1 and 2192.4, add Article 2.5 (commencing with Section 800) to Chapter 4 of Division 1 of, and to add Chapter 2 (commencing with Section 2030) and Chapter 8.5 (commencing with Section 2390) to Division 3 of, the Streets and Highways Code; Vehicle Code: amend Section 4156, add Sections 4000.15 and 9250.6.

Table 1. High Priority and Federal Fleet ZEV Phase-In Schedule

Group	Percentage of Fleet that Must be ZEV	10%	25%	50%	75%	100%
1	Box trucks, vans, two-axle buses, yard trucks, light-duty delivery vehicles	2025	2028	2031	2033	2035
2	Work trucks, day cab tractors, three-axle buses	2027	2030	2033	2036	2039
3	Sleeper cab tractors and specialty vehicles	2030	2033	2036	2039	2042

In addition, the proposed ACF regulation also requires that 100 percent of medium- and heavy-duty vehicle sales into California must be ZEVs starting in 2040. The methodology and results of the emissions inventory analysis are summarized to examine the effects of the proposed ACF regulation on NO_x exhaust (including running, start, and idling exhaust) emissions, PM_{2.5} exhaust and brake wear emissions, and carbon dioxide (CO₂) exhaust emissions from Class 2b – 8 trucks and buses in California. The emissions impact of light-duty package delivery vehicles was excluded from this analysis because the proposed regulation is complementary to the Advanced Clean Cars Program⁵ with no net increase in ZEV sales.

III. Emissions Inventory Methods

Staff has developed emissions inventories of the business as usual (BAU) baseline and three ACF regulation scenarios by running the EMFAC2021 model v1.0.2.⁶ EMFAC2021 is the latest emissions inventory model that CARB uses to assess emissions from on-road motor vehicles including cars, trucks, and buses in California, which reflects CARB's current understanding of statewide and regional vehicle activities and emissions. The EMFAC2021 inventory is based on population and vehicle miles traveled data from 2019 and more details on the activity forecasting and emissions estimates for medium and heavy-duty vehicles can be found in the

⁵ California Air Resources Board (CARB), *Advanced Clean Cars Program*, June 2022 (weblink: <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program>, last accessed August 2020)

⁶ California Air Resources Board (CARB), *EMFAC2021*, May 2022 (weblink: <https://arb.ca.gov/emfac/>, last accessed August 2020)

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EMFAC2021 technical support documentation.⁷ The latest version of EMFAC2021 has already incorporated recently adopted regulations such as ACT and Heavy-Duty Omnibus (HD Omnibus).⁸ As the Heavy-Duty Inspection and Maintenance (HD I/M)⁹ regulation is pending approval from the Office of Administrative Law (OAL) at the time of ACF development, two sets of baselines and corresponding ACF regulation scenarios are considered in the emissions inventory analysis. One baseline is generated directly using the publicly available EMFAC2021 v1.0.2 inventory (referred to as the “Legal Baseline”), while the other accounts for the pending HD I/M regulation, as indicated in the HD I/M Staff Report¹⁰ (referred to as the “modified baseline”). Only NO_x and particulate matter (PM) exhaust emissions are affected under the modified baseline because HD I/M is expected to have minimal impact on PM brake wear and GHG emissions. The emission inventory (both in the baselines and regulated scenarios) excludes urban transit buses (referred to in EMFAC2021 as ‘UBUS’) that have already been regulated under the Innovative Clean Transit (ICT)¹¹ regulation, school buses (SBUS), as well as yard trucks operated at the ports and intermodal rail yards that are subject to the Cargo Handling Equipment (CHE) requirements.¹²

In addition to the scenarios for the baseline and proposed ACF regulation, CARB staff also considered two regulatory alternatives. The four sets of emissions scenarios outlined below were calculated using both the Legal and Modified Baselines, to account for the impact of the HD I/M regulation that has been approved by the Board but not yet finalized by OAL:

- **BAU Baseline:** A business as usual scenario with all adopted regulations without the proposed ACF regulation.

⁷ California Air Resources Board (CARB), *EMFAC2021 Volume III Technical Document*, April 2021 (weblink: https://ww2.arb.ca.gov/sites/default/files/2021-03/emfac2021_volume_3_technical_document.pdf, last accessed August 2020)

⁸The Omnibus regulation is comprised of Cal. Code Regs., title 13, sections 1900, 1956.8, 1961.2, 1965, 1968.2, 1971.1, 1971.5, 2035, 2036, 2111 through 2119, 2121, 2123, 2125 through 2131, 2133, 2137, 2139, 2139.5, 2140 through 2149, 2166, 2166.1, 2167 through 2170, 2423, and 2485; and Cal. Code Regs., tit. 17 sections 95662 and 95663.

⁹The rulemaking action for the HD I/M regulation has not yet been completed; the proposed HD I/M regulation is comprised of Cal. Code Regs., tit. 13, sections 2193, 2195, 2195.6, 2196 through 2196.8, 2197 through 2197.3, and 2198 through 2199.1.

¹⁰ California Air Resources Board (CARB), *Public Hearing to Consider the Proposed Heavy-Duty Inspection and Maintenance Regulation*, Oct 2021 (weblink: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/hdim2021/isor.pdf>, last accessed August 2020)

¹¹ The ICT regulation is comprised of Cal. Code Regs., tit. 13, sections 2023 to 2023.11.

¹² The CHE regulation is comprised of Cal. Code Regs., tit. 13, section 2479.

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- **Proposed Regulation:** A scenario with the proposed ACF regulation that requires affected State and local government, drayage, and high priority and federal fleet operations to phase in medium- and heavy-duty ZEVs over time, and all new vehicle sales in California to be ZEVs starting in 2040.
- **Alternative 1:** A scenario with similar required elements as proposed ACF regulation, but with less stringent ZEV purchase requirements. Regulated fleets would have the option to meet compliance requirements by purchasing a combination of ZEVs or engines certified to the engine standards established by the HD Omnibus⁸ regulation. In this alternative, starting in 2024, State and local government fleets and high priority fleets would be required to purchase either ZEVs or engines certified to the California Omnibus engine standards.¹³ For drayage fleets, legacy trucks (pre-2024 MY) would be removed from the CARB drayage online reporting system at the end of their useful life and all vehicles added in the online reporting system would be either ZEVs or engines certified to the California Omnibus engine standards.
- **Alternative 2:** A scenario with more stringent ZEV purchase requirements for high priority and federal fleets, while the requirement for State and local government and drayage fleets remains the same as the proposed ACF regulation. Applicability for high priority and federal fleets would be expanded to any fleet which has either 50 or more vehicles, or any fleet which has 10 tractors or more. The requirements for high priority and federal fleets would be accelerated by requiring vehicles in Group 2 to meet the deadlines of Group 1 and sleeper cab tractors in Group 3 to meet the deadlines of Group 2. The 100 percent manufacturer ZEV sales requirement would be accelerated to begin in 2036.

A. Inventory development for State and local government fleets

The inventory for State and local government fleet includes Class 4-8 heavy-duty trucks under the EMFAC public categories, as well as Class 2b-3 medium-duty vehicles, buses, and Class 8 solid waste collection vehicles (SWCV) with exempted license plates as registered in California Department of Motor Vehicles (DMV) vehicle registration database. Around 74,800 Class 2b-3 and 63,800 Class 4-8 Vocational vehicles have been identified to be operated by public entities based on the latest available registration information from calendar year 2019. Vehicle population and characteristics of the exempted vehicles from the designated low population counties

¹³ California Air Resources Board (CARB), *On-Road New Vehicle & Engine Certification Program*, June 2021 (weblink: <https://www.arb.ca.gov/msprog/onroad/cert/cert.php>, last accessed August 2020)

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are determined based on vehicle DMV registration addresses. Staff determined that around 4 percent of Class 2b-3 and 6 percent of Class 4-8 State and local government fleets who operate in the designated counties would be exempted from the ZEVs purchase requirement until 2027. Vehicle survival rates and model year distributions of State and local government fleets were updated on top and in addition to EMFAC2021 assumptions based on the Large Entity Fleet Reporting, a one-time reporting requirement under ACT for government fleets and large entities.¹⁴ Staff assumed that 50 percent of model year (MY) 2024-2026 vehicles that are not operated in the designated low population counties, and 100 percent of MY 2027 and newer vehicles in the inventory are ZEVs. ZEVs expected to be deployed as a result of Assembly Bill (AB) 739¹⁵ have been considered as part of the baseline, and thus the associated emissions benefits are not included in the ACF State and local government fleet inventory under the proposed ACF regulation.

B. Inventory development for drayage fleets

Staff estimated approximately 33,500 drayage trucks visit California's seaports and intermodal railyards annually, of which 28,700 are considered active, or frequent visitor drayage trucks (**Table 2**). Only in-state Class 8 active drayage trucks were included in the ACF drayage inventory since they are more representative of average drayage daily activities and emissions. Information on individual trucks visiting the Port of Los Angeles/Long Beach (POLA) and Port of Oakland (POAK) in calendar year 2019 were provided by those ports directly, while the inventory for other seaports was estimated based on past survey data. The drayage inventory for trucks serving California's seaports has already been established in EMFAC2021 (referred to in EMFAC2021 as 'T7 POAK Class 8', 'T7 POLA Class 8', and 'T7 Other Ports Class 8') and was used directly for ACF drayage fleets modeling. The drayage inventory for trucks serving intermodal railyards was estimated based on aggregated information provided by Union Pacific Railroad and Burlington Northern and Santa Fe Railway.

¹⁴ California Air Resources Board (CARB), *Large Entity Fleet Reporting*, February 2022 (weblink: https://ww2.arb.ca.gov/sites/default/files/2022-02/Large_Entity_Reporting_Aggregated_Data_ADA.pdf, last accessed August 2020)

¹⁵AB 739 (Chau, Stats. 2017, ch. 639); Public Resources Code section 25722.11.

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Table 2. Drayage truck inventory in calendar year 2019 (non-gasoline only)*

Vehicle Category	POAK	POLA	Other Seaports	Intermodal Railyards	Total
In-state Class 8 Active** Trucks	4,200	14,000	1,500	9,000	28,700
In-state Class 8 Inactive Trucks	n/a	2,800	n/a	n/a	2,800
In-state POAK Class 8 already in POLA	140	n/a	n/a	n/a	140
Class 4-7	20	180	n/a	n/a	200
Out-of-State	820	850	n/a	n/a	1,670
Total	5,180	17,830	1,500	9,000	33,510

* In-state Class 8 active and inactive trucks were rounded to the nearest 100, and the others to the nearest 10.

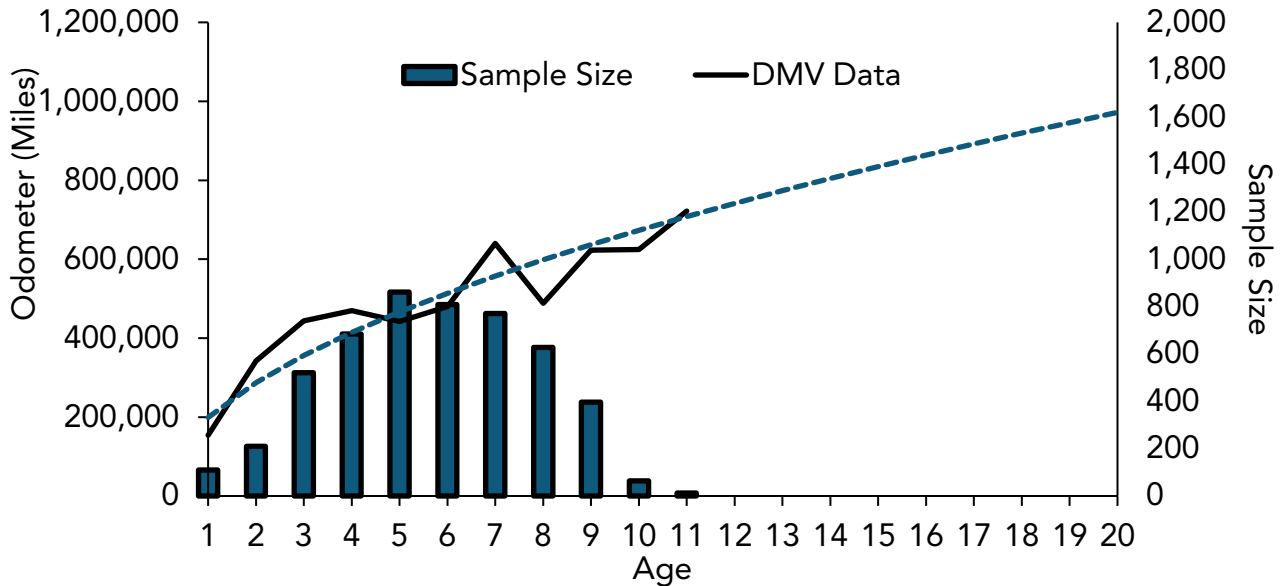
** POLA trucks with more than an average 2 visits/week or 112 visits/year are considered as active trucks. The 112 visit/year was determined based on POLA monthly active truck counts. POAK did not provide monthly visit data and therefore all POAK Class 8 in-state trucks were considered active.

To model the useful life requirement of drayage fleets, it was estimated that the average age by which a typical drayage truck accrues 800,000 miles is approximately 15 years old, as determined from DMV registration and California Vehicle Inventory and Use Survey (CA-VIUS)¹⁶ data (**Figure 1**). To model the control scenarios of the ACF regulation, staff assumed that any truck that is 15 years or older would be removed from the drayage inventory.

Around three thousand legacy drayage trucks would have to be removed from drayage service by 2035, regardless of their vehicle age, to meet the 100 percent ZEV requirement.

¹⁶ California Department of Transportation (Caltrans), California Vehicle Inventory and Use Survey Final Report, Volume I Truck Survey, April 2018.

Figure 1. Drayage truck odometer readings from 2019 DMV registration



C. Inventory development for high priority and federal fleets

Unlike State and local government or drayage fleets that already have established inventories in EMFAC2021 or readily accessible fleet information, high priority fleets required additional efforts to estimate the total number of affected vehicles under the proposed ACF requirements. Staff first acquired a list of 115 thousand companies with more than \$50 million revenue from Dun & Bradstreet®¹⁷ using California addresses. A unique identification number, Duns Number, was recorded for each business on the list and cross-compared with businesses who registered at least one medium- or heavy-duty vehicle in DMV. Staff then used the 2019 DMV and California International Registration Plan (IRP) registration databases to identify businesses or fleet owners with 50 or more vehicles registered under the same name or address. All the California registered (DMV and IRP with California registrations, or CAIRP) vehicles with unique vehicle identification numbers (VIN) who satisfy the above criteria were flagged as vehicles owned by high priority fleets. Out-of-state (OOS) fleets with 50 or more vehicles registered were identified by flagging those operated in California with non-California registrations in the IRP database. The fraction of Class 4-7 OOS vehicles subject to proposed ACF fleet requirements was determined using the ratio of VMT from identified fleet owners to the total VMT from all vehicles that travelled in California.

¹⁷ Dun & Bradstreet®, acquired from internal communication with CARB’s Mobile Source Control Division (MSCD). For more information please see: <https://www.dnb.com/>.

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Class 8 OOS high priority fleets were further split into neighboring (NOOS) and non-neighboring (NNOOS) jurisdictions based on registration locations. NOOS include British Columbia (BC), Washington (WA), Oregon (OR), Idaho (ID), Nevada (NV), and Arizona (AZ). The off-road yard truck activity and emissions inventory were developed using information collected through the Off-Road Diesel Online Reporting System (DOORS).¹⁸ Among 1,300 off-road yard trucks that were identified through DOORS, staff estimated 71 percent are owned or operated by high priority fleets based on the ACT Large Entity Fleet Reporting data.

Table 3. Affected California-registered population under ACF high priority fleet requirements.

Vehicle Category	Registration Only	Subhauler Included
Class 2b – 3	60,000	72,000
Class 4 – 8 Vocational	144,000	170,000
Class 7 – 8 Tractor	49,000	58,000

Table 4. Affected OOS population under ACF high priority fleet requirements.

Vehicle Category	Population*
Class 4 – 8 Vocational	600
Class 7 – 8 Tractor	50,000

* Population shown in this table represents both registered vehicles and subhaulers.

Staff further estimated the subhauler vehicles that are operated on behalf of high priority fleets or under the motor carrier authorities of high priority fleets in California using the ACT Large Entity Fleet Reporting data. The reporting data suggested the ratio of subhauler population to that of direct ownership is approximately 1 to 5, and thus 20 percent more vehicles were included in the affected population to account for in-state subhauler vehicles, except for refuse, utility, and off-road yard tractor fleet operators as they are unlikely to dispatch subhauler vehicles. In summary, staff estimated that approximately 300 thousand California registered vehicles, including both direct and subhauler operation, and 50 thousand OOS vehicles would be subject to the proposed ACF high priority fleets requirements, as shown in **Table 3** and **Table 4**. With the lower tractor fleet size (≥ 10) requirement applied, approximately 50 thousand more tractors would be regulated under Alternative 2.

¹⁸ California Air Resources Board (CARB), *Offroad Zone*, 2022 (weblink: <https://ww2.arb.ca.gov/sites/default/files/offroadzone/landing/doorsresources.html>, last accessed August 2020)

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Vehicle body type phase-in groups for high priority non-tractor vehicles were determined using VIN level information, as verified and adjusted based on information collected through Large Entity Fleet Reporting. Body type groupings of Class 8 tractors followed the same assumptions as used in EMFAC2021, such that the ratio of day cab to sleeper cab is 1 to 9 for California in-state (DMV registered only) tractors, and 9 to 1 for California interstate (CAIRP) and OOS tractors. As shown in **Table 5**, most non-tractors are expected to follow the Group 1 and Group 2 phase-in schedule, while more than half of the tractor fleets are expected to meet the Group 3 ZEV milestone requirements.

Table 5. Population under different high priority body type groups.

Vehicle Category	Group 1	Group 2	Group 3
Class 2b – 3	41,000	31,000	-
Class 4 – 8 Vocational	89,000	74,000	6,700
Class 7 – 8 Tractor	1,100	42,000	65,000
Total	131,000	147,000	72,000

Vehicle body type phase-in groups for high priority non-tractor vehicles were determined using VIN level information, as verified and adjusted based on information collected through Large Entity Fleet Reporting. Body type groupings of Class 8 tractors followed the same assumptions as used in EMFAC2021, such that the ratio of day cab to sleeper cab is 1 to 9 for California instate (DMV registered only) tractors, and 9 to 1 for California interstate (CAIRP) and OOS tractors. As shown in **Table 5**, most non-tractors are in Group 1 and Group 2, while more than half of the tractors belong to Group 3 based on their body type classifications.

Based on current business model and fleet turnover patterns, staff assumed that 50 percent of Group 1 fleets and 25 percent of Group 2 fleets would comply by retiring their vehicles at the end of their useful life as defined by SB 1, while the rest follow the ZEV phase-in target requirements presented in **Table 1**. For high priority fleets following the model year schedule, non-tractors are modeled to be retired at 18 years old, and tractors at 15 years old. The tractor useful life for these high priority fleets is consistent with the useful life requirement assumption derived for drayage fleets. Slower vehicle turnover rates as compared to BAU assumptions in EMFAC2021 were considered for the SB 1 pathway to account for the delay in replacing legacy vehicles when they can remain in the fleet up to their guaranteed useful life. Based on information collected from the Truck Regulation Upload, Compliance, and Reporting

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System (TRUCRS),¹⁹ staff estimated that approximately 10 percent of vehicles exceeding the useful life age limits are low-use vehicles that travel less than 1,000 miles annually, which would be exempted from the high priority fleets ZEV turnover requirements. For fleets who opt-in to the ZEV milestone schedule, ZEV fractions between the phase-in target years were linearly interpolated within this analysis. Low-use exemptions were considered for vehicles of all ages as the useful life requirement no longer applies to them. Based on TRUCRS data, around one (1) percent of tractors, and four (4) percent of non-tractors were assumed to be exempted since they are considered low mileage under the milestone schedule, regardless of vehicle age. After subtracting the contribution of exempted trucks, projected ZEV populations were calculated based on the phase-in fractions by vehicle body types.

D. Inventory development summary

In summary, staff has identified that out of 1.8 million medium and heavy-duty vehicles (based on population in 2019), at least 518 thousand would belong to fleets that are subject to the proposed ACF regulation, as shown in **Table 6**. Statewide, this amounts to approximately 12 percent of Class 2b – 3 trucks and vans, 52 percent of Class 4 – 8 vocational vehicles, and 67 percent of Class 7 – 8 tractors. The fractions of affected vehicle population derived above using 2019 registration data and other latest available information were assumed to stay constant over the years. Staff applied inventory modeling methods to estimate the impact of the proposed ACF fleet purchase requirements only to the abovementioned fractions of the inventory.

Table 6. Vehicles by fleet grouping and weight classes in Calendar Year 2019*

Vehicle Group	Class 2b-3	Class 4-8 Vocational	Class 7-8 Tractor	Total Class 2b -8
Statewide Population	1,193,000	444,000	204,000	1,841,000
Number of Vehicles Subject to ACF Fleet Requirements	147,000	234,000	137,000	518,000
Number of State and Local Government Vehicles	75,000	64,000	-	139,000
Number of Drayage Vehicles	-	-	29,000	29,000
Number of High Priority Fleet Vehicles	72,000	170,000	108,000	350,000

* Population shown in this table only represent the number of vehicles that belong to the three regulated fleet sectors; detailed projected ZEVs would depend on the individual fleet

¹⁹ California Air Resources Board (CARB), *TRUCRS Reporting Information and Forms*, 2022 (weblink: <https://ww2.arb.ca.gov/our-work/programs/truck-bus-regulation/trucrs-reporting-information-and-forms>, last accessed August 2020)

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purchase requirements as well as the manufacturer sales requirement. The numbers presented here also do not include vehicles that would be affected under the 100% manufacturer sales requirement starting in 2040. Populations were rounded to the nearest 1,000.

In addition to the fleet purchase requirements, staff has also included 100 percent ZEV manufacturer sales in California starting with MY 2040 (or MY 2036 for Alternative 2) in the inventory. Note that this requirement only applies to vehicles that are originally sold in California (first sold), the fraction of which was assumed to be the same as that in ACT (**Table 7**).²⁰

Table 7. Average Percentages for First Sold in California by Vehicle Type

Age	Class 2b -3	Class 4-6 Vocational	Class 7 Vocational	Class 8 Vocational	Class 7 Tractor	Class 8 Tractor	OOS
-1	100%	90.97%	85.01%	89.78%	84.31%	89.00%	0%
0	100%	90.97%	85.01%	89.78%	84.31%	89.00%	0%
1	100%	88.38%	80.35%	85.80%	82.10%	86.61%	0%
2	100%	85.68%	76.22%	81.86%	76.91%	79.17%	0%
3	100%	83.07%	72.74%	78.34%	69.92%	68.61%	0%
4	100%	80.74%	70.02%	75.59%	62.30%	56.87%	0%
5	100%	78.90%	68.18%	74.00%	55.25%	45.87%	0%
6	100%	77.76%	67.35%	73.92%	49.92%	37.55%	0%
7+	100%	77.50%	67.35%	73.92%	47.51%	33.85%	0%

IV. Emissions Inventory Results

The projected inventory under the proposed ACF regulation, including both the fleet purchase and the manufacturer sales requirements, are aggregated by three vehicle weight groups: Class 2b – 3, Class 4 – 8 Vocational, and Class 7 – 8 Tractor. The vehicle technology distribution of each group under the control scenarios was compared against the baseline scenario.

²⁰ California Air Resources Board (CARB), *Advanced Clean Trucks Regulation Staff Report: Initial Statement of Reasons (ISOR), Appendix F: Emissions Inventory Methods and Results for the Proposed Advanced Clean Trucks Regulation*, October 2019 (weblink: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/appf.pdf>, last accessed August 2020)

A. Separating emission benefits of ACF versus previously adopted regulations

Emission benefits of the three vehicle groups were calculated considering solely the additional ZEVs (or Omnibus-certified ICEs in Alternative 1) required to be purchased to comply with the ACF regulatory scenarios, which is above and beyond the baseline. The baseline includes adopted regulations as of the release of this report, including the proposed ACT regulation that requires manufacturers of heavy-duty vehicles to sell increasing fractions of ZEVs. The proposed ACF regulation could result in approximately 840 thousand ZEVs operating on California roadways by 2040, which is fifty percent higher than the number of ZEVs achieved under ACT alone. Vehicle population and technology projections will not be affected by different baselines since HD I/M will not impact vehicle population and activity.

Staff assumed that no additional emission benefits from ZEV deployments would occur under ACF until the number of ZEVs deployed under fleet requirements was greater than the number of ZEVs sold under the ACT regulation. There is the possibility that some fleets not subject to the requirements of the proposed ACF regulation could purchase and use ZEVs due to other factors, such as due to specific business decisions or through local, State, and federal incentive programs. However, in this analysis, CARB staff only attributed additional benefits when the number of ZEVs under the proposed ACF regulation was greater than the minimum number of sales required of manufacturers under ACT.

B. Vehicle population and technology projection

Figure 2 – Figure 5 show the forecasted vehicle population under the proposed ACF regulation, as well as the ZEV population that will already be sold into the California market as a result of ACT and other existing measures (ACT ZEV as shown on the figures). Since almost all Class 2b – 3 vehicles that are operated in California are first sold in California or equipped with CA-certified engines, ACT would bring sufficient ZEVs that can be absorbed by the fleets which would be subject to the ACF fleet purchase requirements. Therefore, the benefits associated with Class 2b – 3 vehicles from the proposed ACF regulation would mainly come from the sales requirements starting in 2040.

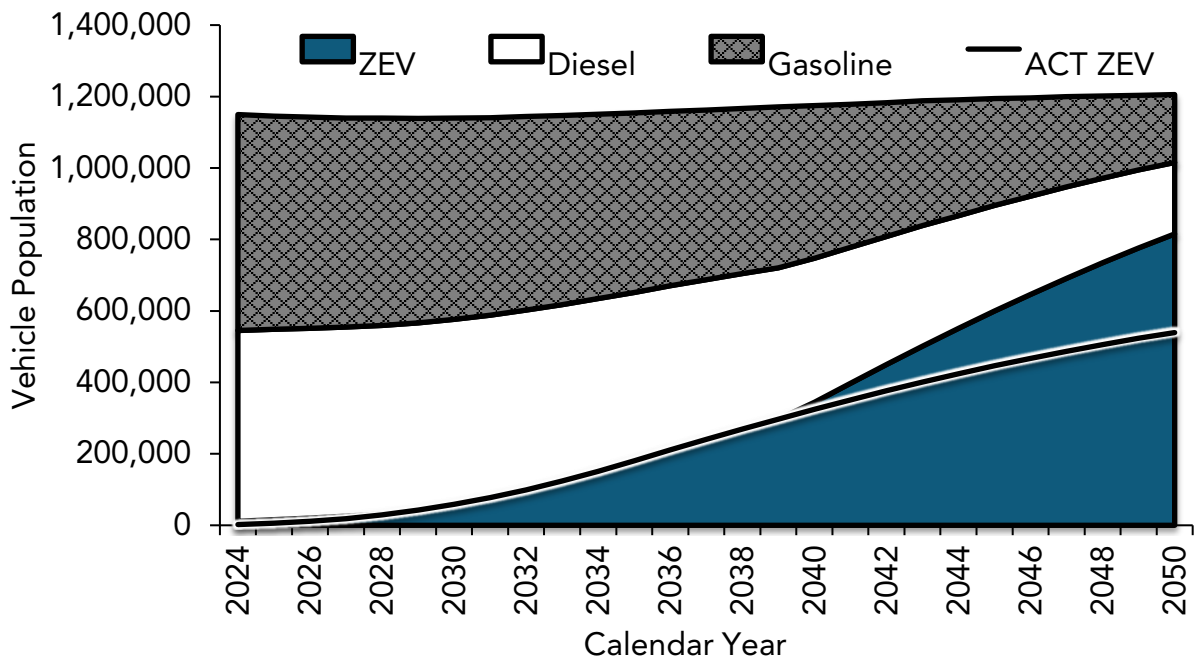
On the other hand, a considerable portion of Class 4 – 8 heavy-duty vehicles (including both Class 4 – 8 Vocational and Class 7 – 8 Tractor) are not first sold in California and would not have been covered by HD Omnibus or ACT. For example, the number of Class 7 – 8 ZE tractors brought by currently existing measures (dashed black line, or ACT ZEV on **Figure 4**) are relatively limited due to the large fraction of non-CA first sold engines and OOS trucks. Since these vehicles tend to be high emitters due to

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their having accrued significant miles and meeting less stringent emission standards, the impact of the proposed ACF regulation on them would be significant.

After the ACF fleet purchase requirements are fully phased-in by 2042, the addition of ZEVs would be mostly driven by the 100 percent manufacturer sales requirements of CA first sold engines. The addition of ICEs would still be expected due to the projected VMT growth, from both used purchases and new engines that do not comply with California manufacturer standards (i.e., not first sold in CA). By 2050, approximately 68 percent of Class 2b – 3 vehicles, 68 percent of Class 4 – 8 Vocational trucks and buses, and 66 percent of Class 7 – 8 tractors would be ZEVs.

Figure 2. Projected population for Class 2b-3 vehicles in California



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Figure 3. Projected population for Class 4 – 8 vocational vehicles in California

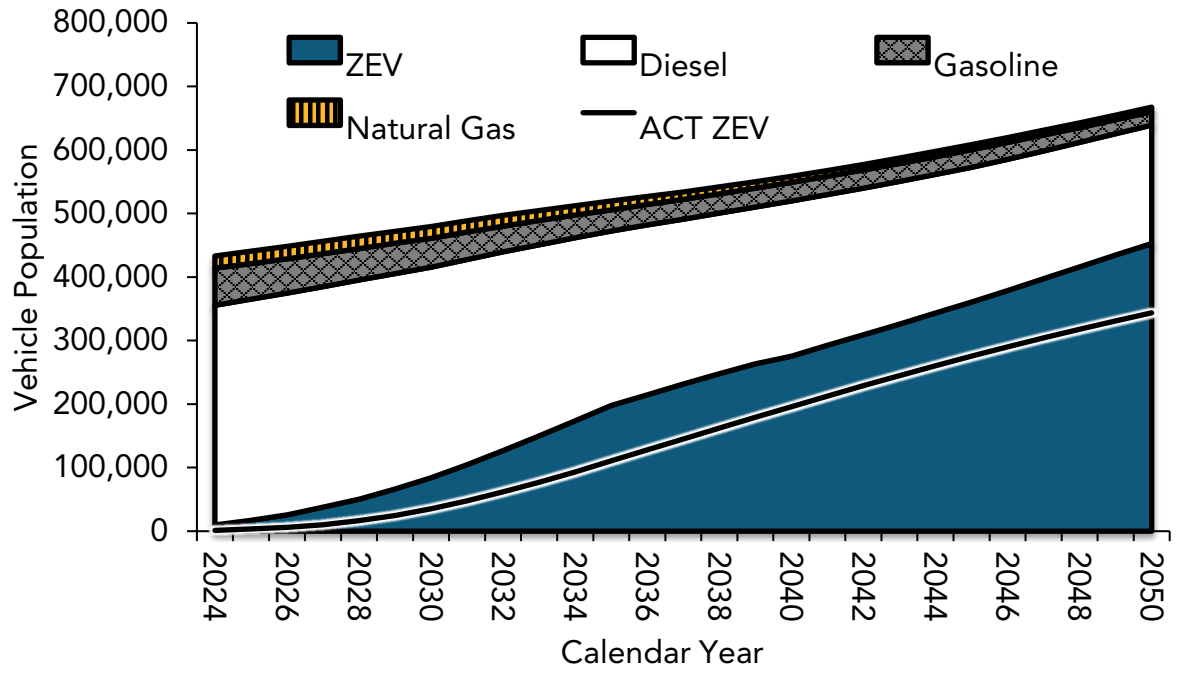


Figure 4. Projected population for Class 7 - 8 tractors in California

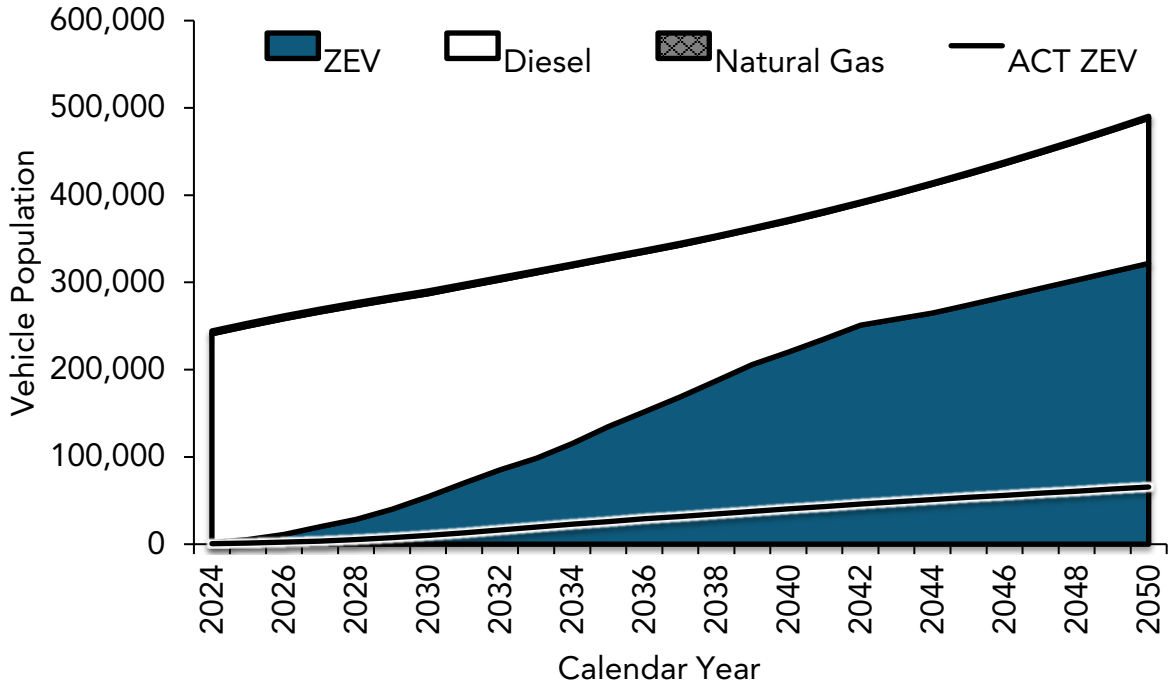
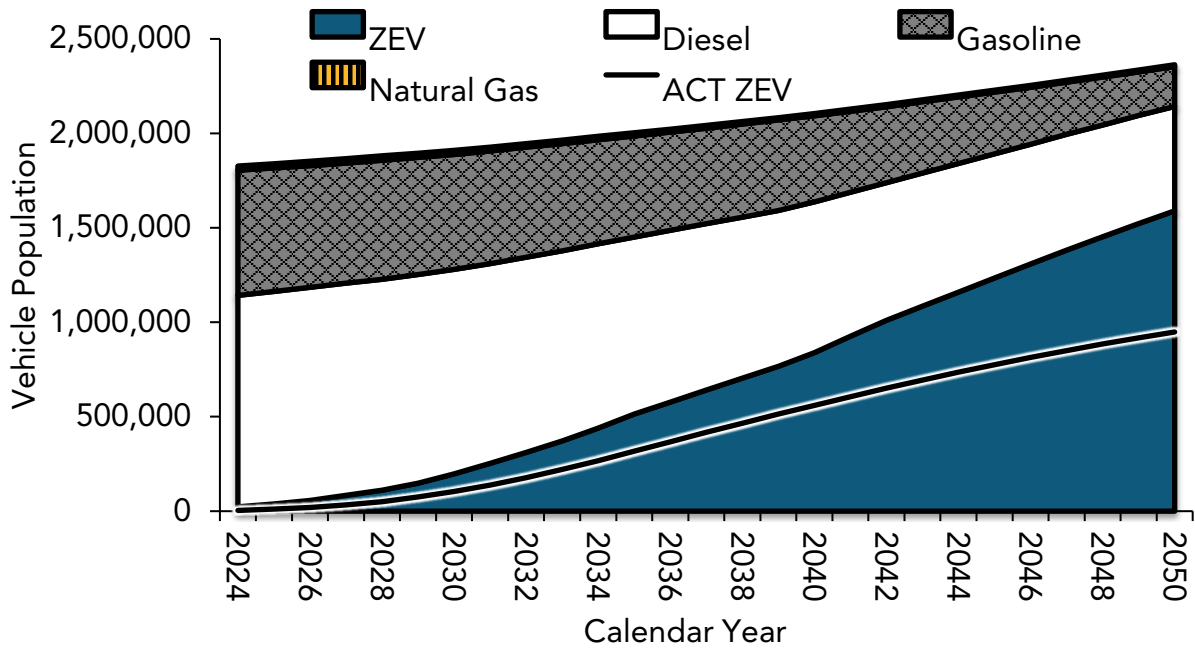


Figure 5. Projected population for Class 2b – 8 vehicles in California



C. Emission benefits results

Emission and deterioration rates within this analysis followed the same methodology as in EMFAC2021. Staff applied a 50 percent reduction of PM brake wear (PMBW) emissions for ZEVs due to regenerative braking capability.²¹ Tire wear emissions for ZEVs were assumed to be the same as ICE vehicles, and thus were not included in either the baseline or the control scenarios. Tank-to-wheel (TTW) GHG emissions were converted from CO₂ short tons to CO₂ million metric tons (MMT).

Figure 6 - Figure 8 show the statewide NO_x, PM_{2.5}, and TTW CO₂ emissions under various scenarios for all Class 2b – 8 vehicles (excluding UBUS and SBUS). Detailed emission benefits in SC and SJV at key State Implementation Plan (SIP) years with respect to the Legal Baseline are presented in **Table 8**. The presented emissions for all scenarios shown in the forementioned figures are relative to the Legal Baseline, and the numbers behind these figures are listed in **Table 9**. The proposed ACF regulation is expected to result in 4.6 tpd and 5.6 tpd NO_x emissions reductions in the SJV and SC air basins, respectively, along with a statewide NO_x emissions reduction of 20 tpd in 2031. In 2037, the proposed regulation is expected to lead to 12.7 tpd NO_x emissions reduction in SJV, 14.4 tpd in SC, and a total of 52 tpd statewide. By 2050, the total NO_x emission benefit in California resulting from ACF is expected to be 97 tpd. Statewide emissions relative to the modified baseline are given in **Table 10**.

²¹ National Renewable Energy Laboratory (NREL), *BAE/Orion Hybrid Electric Buses at New York City Transit, A Generational Comparison*, March 2008, (weblink: <https://afdc.energy.gov/files/pdfs/42217.pdf>, last accessed August 2020)

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Figure 6. Statewide NO_x emissions (ton/day, or tpd) under the Legal Baseline, proposed ACF regulation and alternatives.

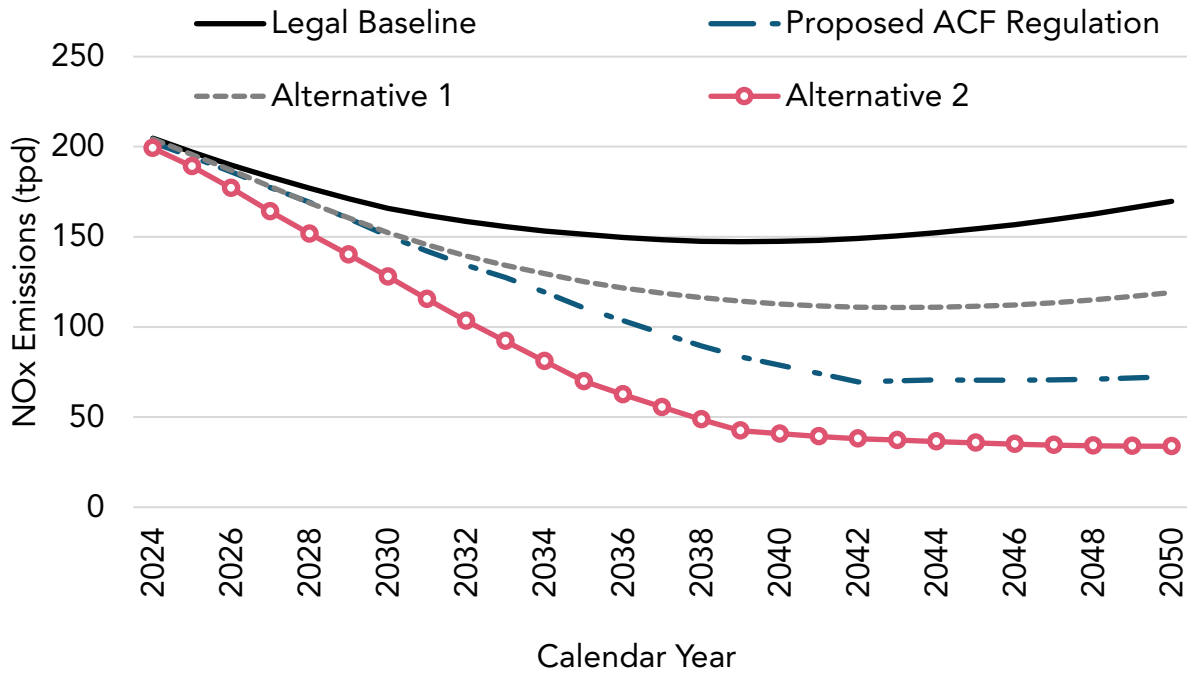
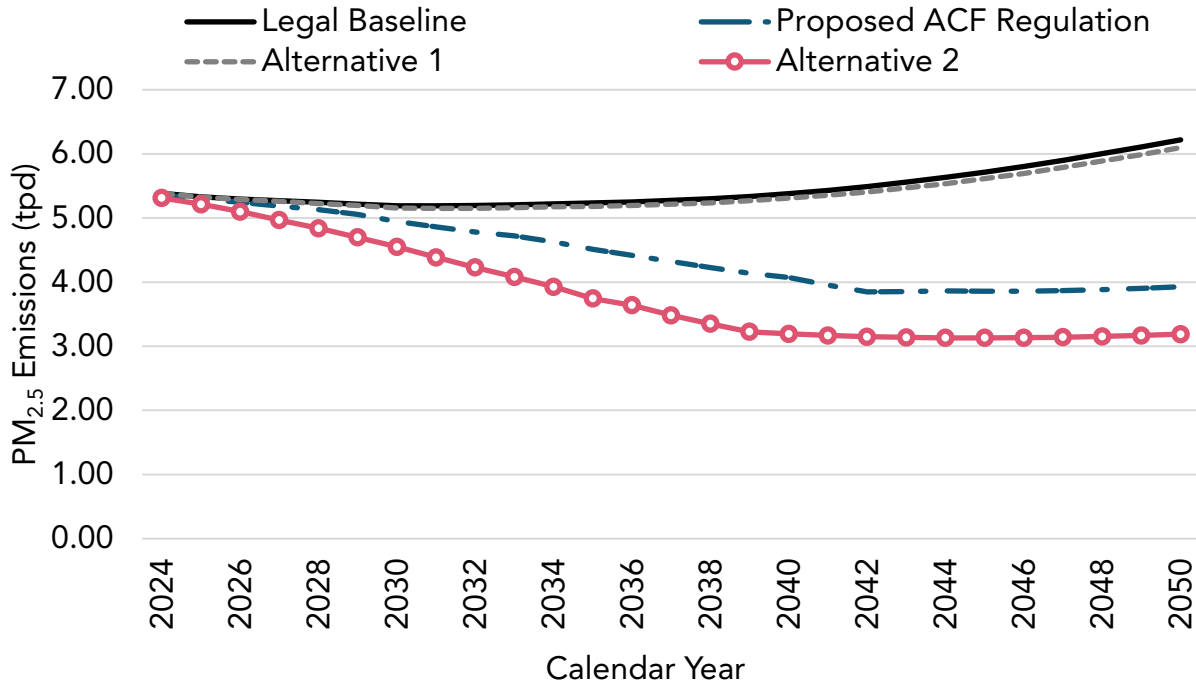


Figure 7. Statewide exhaust and brake wear PM_{2.5} emissions (ton/day, or tpd) under the Legal Baseline, proposed ACF regulation and alternatives.



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Figure 8. Statewide TTW CO₂ emissions (MMT/year) under the Legal Baseline, proposed ACF regulation and alternatives.

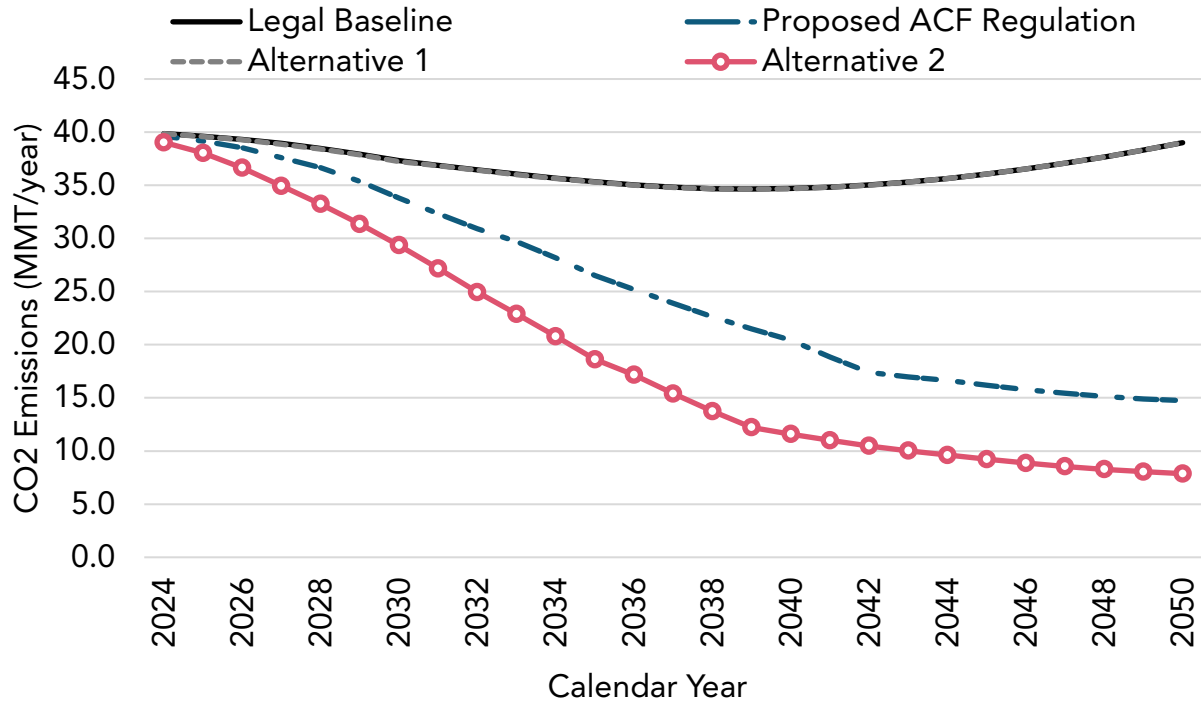


Table 8. Emission benefits under the proposed ACF regulation in key SIP years, relative to the Legal Baseline

Calendar Year	SC		SJV	
	NO _x (tpd)	PM _{2.5} (tpd)	NO _x (tpd)	PM _{2.5} (tpd)
2031	5.6	0.09	4.6	0.07
2037	14.4	0.27	12.7	0.21

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Table 9. Statewide NO_x, PM_{2.5} and GHG emissions under the Legal Baseline, proposed ACF regulation and alternatives.

Calendar Year	Legal Baseline			Proposed ACF			Alternative 1			Alternative 2		
	NO _x (tpd)	PM _{2.5} (tpd)	CO ₂ (MMT/year)	NO _x (tpd)	PM _{2.5} (tpd)	CO ₂ (MMT/year)	NO _x (tpd)	PM _{2.5} (tpd)	CO ₂ (MMT/year)	NO _x (tpd)	PM _{2.5} (tpd)	CO ₂ (MMT/year)
2024	205	5.39	39.9	202	5.35	39.6	204	5.39	39.9	199	5.31	39.0
2025	197	5.33	39.6	194	5.29	39.1	196	5.33	39.6	189	5.21	38.0
2026	190	5.30	39.3	186	5.24	38.5	187	5.29	39.3	177	5.10	36.6
2027	183	5.27	38.9	177	5.19	37.6	178	5.26	38.9	164	4.97	34.9
2028	177	5.24	38.5	169	5.13	36.7	169	5.23	38.4	152	4.84	33.2
2029	171	5.22	37.9	160	5.05	35.4	161	5.19	37.9	140	4.70	31.4
2030	166	5.19	37.3	151	4.95	33.8	152	5.16	37.2	128	4.55	29.4
2031	162	5.19	36.9	142	4.86	32.3	146	5.15	36.8	115	4.39	27.2
2032	159	5.20	36.5	134	4.78	30.9	139	5.15	36.4	103	4.23	24.9
2033	156	5.21	36.1	127	4.72	29.7	134	5.16	36.0	92.2	4.08	22.9
2034	153	5.22	35.7	119	4.63	28.2	130	5.18	35.6	81.0	3.93	20.8
2035	151	5.24	35.3	111	4.51	26.5	125	5.18	35.3	69.9	3.74	18.6
2036	150	5.25	35.0	103	4.42	25.2	122	5.20	35.0	62.5	3.64	17.2
2037	148	5.28	34.8	96.4	4.32	23.9	119	5.22	34.8	55.5	3.48	15.4
2038	148	5.30	34.7	89.4	4.23	22.6	116	5.24	34.7	48.7	3.35	13.7
2039	147	5.34	34.7	83.4	4.14	21.5	114	5.27	34.6	42.4	3.22	12.2
2040	147	5.38	34.7	78.9	4.07	20.4	113	5.31	34.7	40.7	3.19	11.6
2041	148	5.43	34.8	74.3	3.95	18.8	112	5.35	34.8	39.3	3.17	11.0
2042	149	5.49	35.0	69.5	3.85	17.4	111	5.41	35.0	38.1	3.15	10.5
2043	151	5.56	35.3	70.1	3.85	17.0	111	5.47	35.3	37.3	3.14	10.0
2044	152	5.63	35.7	70.6	3.86	16.6	111	5.54	35.7	36.4	3.13	9.61
2045	154	5.71	36.1	70.5	3.86	16.2	111	5.61	36.1	35.7	3.13	9.23
2046	157	5.80	36.5	70.5	3.86	15.8	112	5.70	36.5	35.0	3.13	8.86
2047	160	5.90	37.1	70.7	3.87	15.4	114	5.79	37.1	34.5	3.14	8.55
2048	163	6.00	37.7	71.0	3.88	15.1	115	5.89	37.7	34.1	3.15	8.28
2049	166	6.11	38.3	71.7	3.90	14.9	117	5.99	38.3	33.9	3.17	8.06
2050	170	6.22	39.0	72.5	3.93	14.7	119	6.10	39.0	33.8	3.19	7.87

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Table 10. Statewide NO_x and PM_{2.5} emissions under the modified baseline, proposed ACF regulation and alternatives.

Calendar Year	Modified Baseline		Proposed ACF		Alternative 1		Alternative 2	
	NO _x (tpd)	PM _{2.5} (tpd)	NO _x (tpd)	PM _{2.5} (tpd)	NO _x (tpd)	PM _{2.5} (tpd)	NO _x (tpd)	PM _{2.5} (tpd)
2024	174.0	5.07	171.6	5.04	173.6	5.07	169.0	5.00
2025	142.1	4.74	139.5	4.71	141.1	4.74	135.9	4.64
2026	130.1	4.68	127.0	4.63	128.4	4.67	121.1	4.51
2027	120.6	4.64	115.9	4.57	117.3	4.64	107.9	4.39
2028	112.4	4.61	106.4	4.52	107.4	4.60	96.4	4.29
2029	105.1	4.58	98.0	4.45	99.2	4.57	87.4	4.18
2030	98.6	4.55	89.9	4.37	91.8	4.54	78.5	4.07
2031	93.4	4.55	82.8	4.30	85.6	4.54	70.1	3.96
2032	88.8	4.55	76.6	4.24	80.1	4.53	62.5	3.84
2033	84.8	4.55	71.2	4.19	75.2	4.53	55.6	3.74
2034	81.4	4.56	65.6	4.12	70.9	4.54	49.2	3.63
2035	78.3	4.56	60.1	4.04	67.0	4.54	42.9	3.50
2036	75.7	4.57	55.4	3.97	63.7	4.55	38.5	3.42
2037	73.5	4.59	51.0	3.90	60.8	4.56	34.5	3.30
2038	71.8	4.60	46.9	3.84	58.4	4.57	30.7	3.20
2039	70.4	4.63	43.2	3.77	56.4	4.59	27.1	3.11
2040	69.4	4.66	40.2	3.72	54.7	4.62	25.3	3.07
2041	68.7	4.70	37.3	3.62	53.3	4.66	23.7	3.05
2042	68.3	4.75	34.5	3.54	52.3	4.70	22.4	3.03
2043	68.2	4.80	33.9	3.53	51.6	4.75	21.3	3.01
2044	68.2	4.86	33.2	3.53	51.0	4.81	20.2	3.00
2045	68.4	4.92	32.5	3.52	50.6	4.87	19.3	3.00
2046	68.8	4.99	31.8	3.52	50.4	4.93	18.3	3.00
2047	69.4	5.07	31.3	3.53	50.4	5.01	17.6	3.01
2048	70.2	5.15	30.9	3.54	50.6	5.08	17.0	3.02
2049	71.2	5.23	30.7	3.55	51.0	5.16	16.5	3.03
2050	70.8	5.30	30.1	3.57	50.4	5.24	15.8	3.04