Disclaimer

In Senate Bill (SB) 1, the Legislature required the California Air Resources Board (CARB) to, by January 1, 2025, evaluate the impact of the statute's limitations on requirements to retire, replace, retrofit, or repower motor vehicles on state and local clean air efforts to meet state and local clean air goals, including:

> (A) Compliance with the truck and bus rule (Section 2025 of Title 13 of the California Code of Regulations);
> (B) The benefits and impacts of measures enacted to improve local air quality impacts from stationary sources; and
> (C) State implementation plan compliance.
> (Cal. Health & Saf Code. § 43021, subd. (e).)

The statute also required CARB to make recommendations to the Legislature on additional or different mechanisms for achieving those goals while recognizing the financial investments made by the effected entities (sic).

The key finding of this report in fulfillment of the statute is that useful life limits in SB 1 have limited CARB in achieving emissions reductions from on-road heavy-duty vehicles in California. The report also identifies actions the California Legislature can take to mitigate the emissions impacts to strengthen the State's air quality control programs.

The analysis and recommendations in this report reflect information known to CARB as of March 2024. In January 2025, California withdrew its request for a waiver and authorization for the addition of some portions of the Advanced Clean Fleets (ACF) Regulation to the California state emissions control program. CARB staff have proposed that the Board repeal portions of the ACF Regulation that apply to high priority (Cal. Code Regs. tit. 13, § 2015) and drayage (Cal. Code Regs. tit. 13, § 2014) fleets. In addition, subsequent federal actions and litigation attacking California's authority to reduce air pollution from motor vehicles, specifically including heavy-duty vehicles, and proposals to prevent federal actions from also reducing pollution from motor vehicles could affect CARB's ability to achieve necessary emission reductions that are discussed in this report.

On June 12, 2025, Governor Newsom issued Executive Order N-27-25 that, in part, directed CARB, along with other State agencies to make recommendations to the Governor that would maintain momentum on zero-emissions vehicles. The recommendations in that report may expand, modify or supplant the recommendations in this SB 1 report.

Senate Bill 1 (Beall, Chapter 5, Statutes of 2017) Report to the Legislature to Evaluate the Impact of Provisions on State and Local Clean Air Efforts

DOCUMENT AVAILABILITY

This report can be viewed at: *https://ww2.arb.ca.gov/legislatively-mandated-reports*. To obtain a hard copy of this report, please contact David Ernest García, Ph.D. at *David.Garcia@arb.ca.gov*.

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Executive Summary

Background

Over the past 50 years, California has made remarkable progress in improving air quality. The State's mobile source programs have significantly reduced levels of smog-forming pollution, air toxics, and greenhouse gases (GHG) statewide. Enforcement of mobile source programs is crucial to their success. Senate Bill (SB) 1 (Beall, Chapter 5, Statutes of 2017), the Road Repair and Accountability Act of 2017, is a landmark investment in California's transportation systems. Among other provisions, it requires starting January 1, 2020, the California Department of Motor Vehicles (DMV) to withhold registration of diesel vehicles with Gross Vehicle Weight Rating (GVWR) greater than 14,000 that are not compliant with the California Air Resources Board's (CARB) Truck and Bus Regulation. This enables better enforcement of this key program and ensures that projected emissions benefits from this regulation are achieved. Another provision of SB 1 precludes the retirement, replacement, retrofit, or repower of commercial vehicles until they have reached a minimum useful life period of 13 years or until they reach 800,000 vehicle miles traveled (but no greater than 18 years old), whichever is later. This provision provides commercial vehicle owners with certainty about the useful life of engines certified by CARB and other applicable agencies to meet required environmental standards for sale in the State. Given California's ambitious air quality legal commitments and GHG reduction targets that need to be met over the next few decades, the useful life provision may limit what can be done to address these pollutants within traditional regulatory structures. These commitments include meeting National Ambient Air Quality Standards (NAAQS, or Standards), community emission reduction program objectives, and GHG emission reduction targets.

SB 1 established Health and Safety Code section 43021, which directed CARB by January 1, 2025, to hold at least one public workshop and report to the Legislature on:

- Compliance with the Truck and Bus Regulation (Section 2025 of Title 13 of the California Code of Regulations).
- The impact of the useful life provision on State and local clean air efforts, including State Implementation Plan (SIP) compliance for attaining and maintaining NAAQS.
- The benefits and impacts of measures enacted to improve local air quality impacts from stationary sources.
- Recommendations to the Legislature on additional or different mechanisms for achieving local and clean air efforts while recognizing the financial investments made by the affected entities.

Public Process and Approach

CARB fulfilled the public workshop requirement on August 11, 2022.[1] During the workshop, staff discussed the proposed approach to evaluate the impacts of SB 1, and presented preliminary analyses, including compliance statistics and emissions projections from the heavy-duty vehicle fleet. A total of 190 people attended the workshop.

In addition to the workshop, staff used registration databases to estimate compliance rates with Truck and Bus Regulation and performed an analysis based on emissions inventory data to estimate the impact of the useful life provision on heavy-duty truck emissions. In addition to in-house analysis of program compliance rates and impact, CARB staff entered into contract with the University of California, Berkeley to assess alternative policies beyond command-and-control approaches to accelerate the uptake of zero-emission vehicles. Staff also provided a summary of recent stationary source actions and their emissions benefits.

Findings

SB 1 Increased Compliance Rates

CARB's Truck and Bus Regulation requires that most commercial diesel vehicles meet engine model year 2010 standards. In 2022, California-registered vehicles were 99 percent compliant with the Truck and Bus Regulation. The success of enforcement efforts for California-registered vehicles is in large part due to the SB 1 registration holds, as well as outreach and streamlining enforcement efforts. The registration holds on California-registered vehicles allowed CARB to focus its enforcement efforts on out-of-State trucks operating in California, resulting in the compliance rate for these trucks with the Truck and Bus Regulation increasing from 70 percent in 2016 to 95 percent (as corroborated by vehicle data collection efforts) by 2022. By improving compliance rates, the SB 1 registration holds enabled CARB to achieve a greater fraction of the anticipated oxides of nitrogen (NOx) and diesel particulate matter (PM) benefits of the Truck and Bus Regulation.

Useful Life Limits Have Caused Air Quality Impacts

CARB staff assessed the emissions impacts of the useful life provision by evaluating two scenarios relative to a baseline:

- **Scenario A** – No SB 1 Useful Life Limits.
- **Scenario B** – With SB 1 Useful Life Limits.
- **Baseline** - All Adopted CARB Regulations as Limited by Useful Life.

[1] *Public Workshop in Fulfillment of Senate Bill (SB) 1 Requirements to Evaluate Emissions Reduction Needs from Commercial Motor Vehicles*. (2022).

CARB's regulatory programs for commercial vehicles could have achieved significantly more emissions reductions without the limitations imposed by the useful life provision. Table ES-1 summarizes the emissions impacts statewide and within air basins. Relative to Scenario B (With SB 1 Useful Life Limits), Scenario A (No SB 1 Useful Life Limits):

- Achieves 82,276 additional tons of NOx and 890 additional tons of diesel PM from 2024-2045.
- Avoids 1,288 premature deaths, 2,067 hospitalizations and emergency room visits, and other adverse health impacts, which translates to $16.5 billion in cost savings to the State.
- Results in 2.14 and 1.75 tons per day (tpd) of additional NOx benefits in South Coast and San Joaquin Valley Air Basins, respectively, in 2037. Through the SIP process, the limitations of the useful life provision required emission-reduction commitments from other sectors to demonstrate attaining the NAAQS.
- Achieves 55 percent more diesel PM reductions in Assembly Bill (AB) 617 (C. Garcia, Chapter 136, Statutes of 2017) communities in 2037.

Table ES-1. Summary of Emissions, Health, and Cost Impacts of the SB 1 Useful Life Provision

Cumulative Statewide NOx Emissions Increases (Tons; 2024-2045)	Cumulative Statewide Diesel PM Emissions Increases (Tons; 2024-2045)	Valuation of Health Impacts (Billion 2020 $)	South Coast NOx Increases in 2037 (tpd)	San Joaquin Valley NOx Increases in 2037 (tpd)
82,276	890	16.5	2.14	1.75

Alternative Regulatory Structures Present Opportunities to Further Reduce Emissions at Lower Cost

Moving forward, CARB has committed in a recent SIP[2] to develop a regulation to further reduce emissions from commercial vehicles, specifically heavy-duty diesel vehicles that were not regulated under CARB's Advanced Clean Fleet (ACF) regulation. This regulation is the Zero-Emission Truck (ZET) measure, which is planned for Board consideration in 2028 with first requirements taking effect in 2030. An external policy analysis performed by the University of California, Berkeley highlighted potential advantages of flexible regulatory structures for fleets not regulated by ACF, which are smaller fleets than those regulated by ACF as approved by the Board in April 2023. This analysis found that regulating commercial

[2] *2022 State SIP Strategy*. (2022).

vehicles using flexible policies, such as those that increase registration fees on higher-emitting vehicles, can provide fleets flexibility in managing their fleets. Overall, this flexibility saves costs for fleets while preserving the general trend of turning over the highest-emitting vehicles early, thereby still achieving the significant air quality benefits needed to meet air quality commitments.

Recommendations

In order to offset the emissions impacts of the useful life provisions and cost effectively regulate the commercial truck sector going forward, CARB staff recommends that the California Legislature consider the following measures:

- Directing CARB to implement a revenue neutral program that raises revenue with a fee on polluting commercial and heavy-duty vehicles operating in California and returns that revenue as an incentive to zero-emission trucks starting in 2030.
- Authorizing CARB to implement indirect source rule programs. CARB could use indirect source rules to hold facilities responsible for the emissions generated by mobile sources that are used at the facility or otherwise service the facility.
- Consider leveraging State, federal, and other funding to support $11 billion in incentive funding to offset the emissions impact of the SB 1 useful life provision through 2045. These funds could target either the on-road commercial vehicle sector or off-road sectors that were not addressed in the past due to technology limitations, such as zero-emission agriculture, construction, and aviation.
- Approving alternative sources of funding to upgrade the electric grid to support transportation electrification.
- Maintaining funding for infrastructure projects through programs like the Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE), focusing on projects that align with planned zero emission vehicle (ZEV) deployments by commercial and transit fleets.
- Adopting legislation to streamline permitting for battery electric vehicle chargers.

In addition, CARB staff recommends that the State explore the feasibility of implementing registration holds for any commercial vehicle, regardless of the vehicle's GVWR and regardless of fuel type, that is not meeting CARB regulations, as feasible.

Chapter 1: Introduction

Requirements of the SB 1 Report

Senate Bill (SB) 1 (Beall, Chapter 5, Statutes of 2017), the Road Repair and Accountability Act of 2017, was signed into law by Governor Edmund G. Brown Jr. on April 28, 2017.[3] It is a

[3] *SB-1 Transportation Funding*. (2017).

landmark transportation investment to rebuild California by fixing roads, freeways, and bridges in communities throughout California. SB 1 provided the first significant, stable, and ongoing increase in State transportation funding in over two decades. SB 1 invested $5.4 billion annually to fix roads, freeways, and bridges in California and dedicated more dollars toward transit and safety. It plays a major role in reducing traffic congestion and greenhouse gases (GHG), improving transportation options such as transit, rail, and active transportation, and improving goods movement, accessibility, and equity throughout the State.

Among other provisions, SB 1 states that as of January 1, 2020, the California Department of Motor Vehicles (DMV) must check that vehicles with a gross vehicle weight rating (GVWR) of more than 14,000 pounds, are compliant with, or exempt from, California Air Resources Board's (CARB) Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants From In-Use Heavy-Duty Diesel-Fueled Vehicles as set forth in title 13, California Code of Regulations 2025 (hereafter referred to as the Truck and Bus Regulation) prior to being registered to operate in California. Improved compliance rates with CARB's Truck and Bus Regulation provides a more level playing field for businesses operating in California and helps achieve the emissions benefits envisioned by the Truck and Bus Regulation. SB 1 also sets a useful life period for commercial vehicles, precluding CARB from requiring, via potential future regulations, commercial vehicle retirement, replacement, retrofit, or repower until 13 years or 800,000 miles with a maximum of 18 years from the model year the engine and emission control system are first certified. Under SB 1, all commercial vehicles are guaranteed this full useful life; based on the definition of commercial vehicle, this includes vehicles with a GVWR of 10,001 lb. or above as well as any vehicle transporting property for compensation with limited exceptions. Note that the definition of commercial vehicle includes vehicles owned by public agencies and private fleets, as well as out-of-State trucks operating within the State. This provision provides commercial vehicle owners with certainty about the useful life of engines certified by CARB and other applicable agencies to meet required environmental standards for sale in the State.

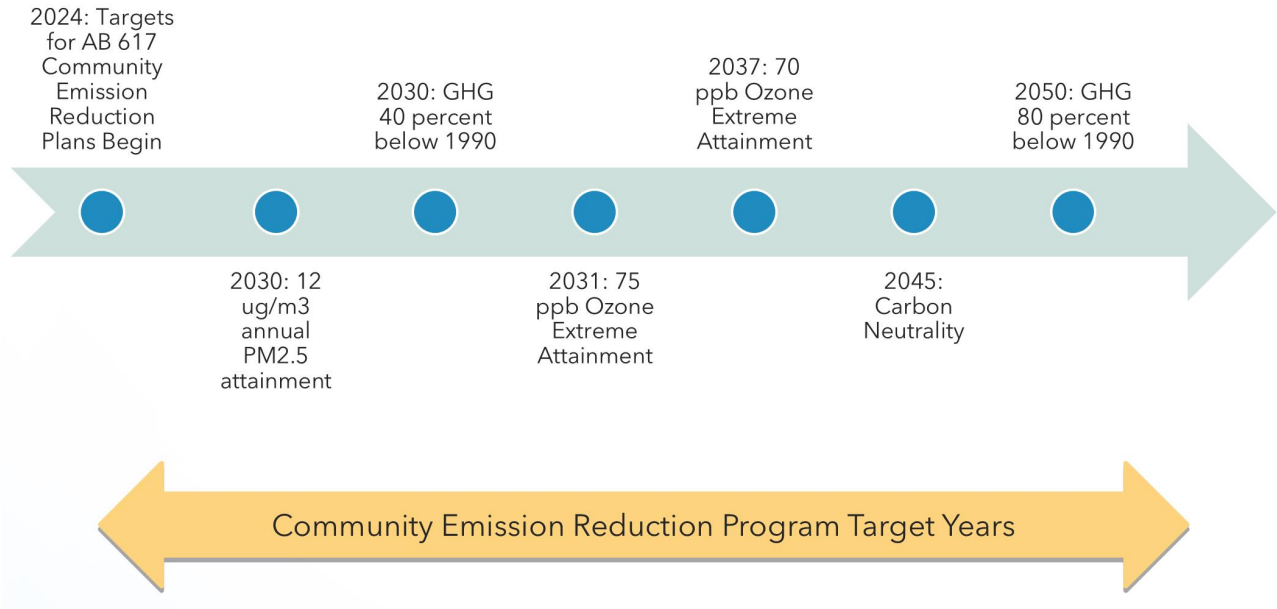
SB 1 directs CARB, by January 1, 2025, to report to the Legislature on the impact of the useful life provisions on efforts to meet State and local clean air efforts, make recommendations to the Legislature on additional or different mechanisms to clean air targets, and hold at least one public workshop prior to the completion of this report. SB 1 directs CARB to consider the report required in Section 38531 of the Health and Safety Code in developing the SB 1 report. The informational report required by Section 38531 is presented before the Joint Legislative Committee on Climate Change Policies and covers GHG, criteria and toxics emissions from all sectors covered by CARB's Scoping Plan, as well as a discussion of regulatory requirements, initiatives, and other programs that may

influence those trends.[4] In addition, SB 1 requires CARB to review compliance rates for CARB's Truck and Bus Regulation and summarize the benefits and impacts of measures enacted to improve local air quality impacts from stationary sources. CARB held a public workshop on the SB 1 report in August 2022,[5] thereby fulfilling the workshop requirement. This report addresses the remainder of CARB's obligations under SB 1, including the Truck and Bus Regulation compliance assessment, the impact of the useful life provisions on clean air efforts, and policy recommendations to achieve California's emission reduction targets.

California's Upcoming Clean Air and Climate Targets

Figure 1 presents a holistic picture of California's air quality and GHG reduction targets. Reducing heavy-duty vehicle emissions is crucial to achieving these targets, as this sector is responsible for 26 percent of statewide mobile source NOx[6] and 21 percent of statewide mobile source GHG emissions.[7]

Figure 1. California's Air Quality Targets and GHG Reduction Goals



[4] *Annual Update on Statewide Trends of Greenhouse Gas Emissions and an Overview of the 2022 Scoping Plan*. (2022).

[5] *Public Workshop in Fulfillment of Senate Bill (SB) 1 Requirements to Evaluate Emissions Reduction Needs from Commercial Motor Vehicles*. (2022).

[6] Source: CARB 2022 CEPAM v1.01; represents the current baseline emissions out to 100 nautical miles, with adopted CARB and district measures.

[7] Estimated based on Figure 4 in 2020 California GHG Emissions Report (*California Greenhouse Gas Emissions for 2000 to 2020 Trends of Emissions and Other Indicators*) and updated based on CO_2 emissions from *EMFAC2021 v.1.0.2*.

SB 1 requires CARB to assess the impact of the useful life provisions on California's ability to attain the National Ambient Air Quality Standards (NAAQS). NAAQS have legally obligated deadlines by which areas must attain as specified in the federal Clean Air Act (Act) and are established by the U.S. Environmental Protection Agency (EPA) each time a new standard is promulgated based on updated information showing health impacts at increasingly lower levels. California has the two areas with the most critical air quality challenges in the nation, the South Coast Air Basin and the San Joaquin Valley. The near-term deadlines for these areas are outlined in Table 1. Most recently, CARB released the 2022 State Strategy for the State Implementation Plan (SIP), which outlines the State's commitments to reducing emissions from mobile, stationary, and areawide sources to achieve attainment of the 70 parts per billion (ppb) 8-hour ozone standard.[8] These commitments are incorporated into a regional SIP for each nonattainment area that needs the reductions to attain by the attainment year. This strategy includes all adopted and under development heavy-duty programs that will be key for achieving this standard.

Table 1. Attainment Deadlines for the National Ambient Air Quality Standards

Attainment Year*	Standard
2030[9]	12 µg/m^3 annual $PM_{2.5}$**
2031	75 ppb 8-hour ozone
2037	70 ppb 8-hour ozone

* Represents attainment deadlines for South Coast and San Joaquin Valley Air Basins. Other areas have earlier attainment deadlines.
** PM2.5 is particulate matter 2.5 micrometers or less in diameter.

It is also important to evaluate the implications of the useful life provisions established in SB 1 at the community level, i.e., at a higher spatial resolution than the air basin or county level. Many communities in the State experience measurable harm in the form of negative health impacts from high cumulative exposure burdens for toxic air contaminants and criteria air pollutants. There is an immediate need to reduce emissions and exposure in these highly impacted, low-income and overburdened communities throughout the State, and specifically, communities identified by the Community Air Protection Program under Assembly Bill (AB) 617 (C. Garcia, Chapter 136, Statutes of 2017). Communities selected for Community Emission Reduction Plans (CERP) set five and ten-year targets to reduce community exposure; the targets for the first CERPs adopted by the Board are in 2024, and many of these plans include a focus on heavy-duty vehicle measures and reductions. Freight transport by trucks occurs at and nearby seaports, warehouses, rail yards, and other major freight hubs throughout California. As a result, nearby communities will be

[8] *2022 State SIP Strategy*. (2022).
[9] Pending U.S. EPA approval of a 5-year extension.

disproportionately burdened by the cumulative exposure to pollution from the heavy-duty truck traffic from these facilities.

The State also has a number of climate targets, including the mid-term target in 2030 for 40 percent GHG emissions reduction below 1990 levels, codified under Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), and longer-term targets for economy-wide carbon neutrality in 2045 as set in Executive Order B-55-18, and 80 percent GHG emissions reduction below 1990 levels by 2050 as directed by Executive Order S-3-05, a target that was reinforced by Governor Brown's Executive Order B-16-2012 that added an 80 percent reduction goal specific to the transportation sector. In recognition of the severity of the climate crisis and the need for immediate action, Governor Newsom signed Executive Order N-79-20 (hereafter referred to as the N-79-20) on September 23, 2020, which among other goals, set a goal to transition 100 percent of the drayage truck fleet to zero-emission by 2035, and the remainder of medium- and heavy-duty vehicles to zero-emission where feasible by 2045.

CARB's Long History of Reducing Emissions from the Heavy-Duty Fleet

California's air pollution control efforts have resulted in substantial improvements in air quality over the last 50 years. Nonetheless, the State still has more work to do to meet multiple NAAQS commitments and other health and climate stabilization targets in the next three decades. Given the significant contribution of the on-road heavy-duty fleet to air pollution in California, it is crucial that emissions from this sector be further reduced. This is necessary to not only meet NAAQS, but to minimize adverse health effects in the State's most impacted and disadvantaged communities, and to lessen the impacts of climate change.

CARB has a number of regulations either in place or recently adopted to reduce emissions from the on-road heavy-duty sector. Adopted in 2008, CARB's Truck and Bus Regulation required all fleets, registered in- and out-of-State, that operate in California to meet model year 2010 standards by 2023. More recently, CARB adopted technology-forcing regulations that have made significant strides in reducing both criteria and GHG pollutants from heavy-duty vehicles. Table 2 lists selected State and federal regulations adopted in 2018 and onward, as well as regulations that will be considered in the future.

Table 2. Recently Adopted and Under Development Heavy-Duty Vehicle Regulations

Regulation	State or Federal	Year Adopted	Implementation Year	Affected by SB 1 Useful Life Limits?
Heavy-Duty Warranty Phase 1	State	2018	2022	No

Regulation	State or Federal	Year Adopted	Implementation Year	Affected by SB 1 Useful Life Limits?
Periodic Smoke Inspection Program (PSIP) Amendments	State	2018	2019	No
U.S. EPA Phase 2 GHG	Federal	2018	2021	No
Innovative Clean Transit (ICT)	State	2019	2020	No
Zero-Emission Airport Shuttle Bus	State	2019	2022	No
Advanced Clean Trucks (ACT)	State	2020	2024	No
Heavy-Duty Omnibus	State	2020	2024	No
Heavy-Duty Inspection and Maintenance (HD I/M) Program	State	2021	2023	No
U.S. EPA Clean Trucks Plan (CTP) Oxides of Nitrogen (NOx) Final Rule	Federal	2022	2027	No
Advanced Clean Fleets (ACF)	State	2023	2024	Yes
U.S. EPA GHG/Phase 3	Federal	2024 (projected)	2027	No
Zero Emission Trucks (ZET) Measure	State	2028 (projected)	2030	Yes

Adopted Regulations Not Impacted by SB 1 Useful Life Limits

There are a number of California and federal requirements on manufacturers of vehicles and engines that reduce criteria pollutant and GHG emissions. Note that manufacturer requirements are not affected by the SB 1 useful life provisions since they do not necessitate the turnover of vehicles. To reduce NOx emissions from new on-road heavy-duty combustion vehicles, CARB adopted the Heavy-Duty Omnibus Regulation in 2020. These requirements ensure lower NOx emissions during the emission standard certification cycle, and additionally have more stringent provisions to maintain in-use control of emissions over a more comprehensive range of vehicle operation. This regulation also includes in-use performance requirements, such as more stringent in-use performance standards, lengthened engine useful life, warranty, and durability requirements. In December 2022,

U.S. EPA adopted the CTP NOx Rule, which sets more stringent standards for new model year 2027 and newer vehicles sold outside of California.[10]

In this report, CARB staff used an emissions inventory that reflects the CARB Heavy-Duty Omnibus Regulation and the U.S. EPA Clean Trucks Plan (CTP) NOx Rule, but does not reflect changes in response to the Clean Truck Partnership between CARB and the Engine Manufacturers Association (EMA) announced in July 2023.[11] The Clean Truck Partnership has two phases: (1) modify elements of the Heavy-Duty Omnibus Regulation for model year (MY) 2024 through 2026 engines, for which manufacturers will provide offsets as necessary to maintain California's emission targets, and (2) align with U.S. EPA's CTP NOx Rule for engines beginning in model year 2027 except for some provisions. Reflecting these changes would lead to higher baseline emissions, and therefore the emissions impact that CARB staff is reporting would be larger if these were reflected.

Even with more stringent NOx standards in the Heavy-Duty Omnibus Regulation, addressing California's air quality and climate targets requires reducing and eliminating emissions wherever feasible. In 2020, CARB adopted the Advanced Clean Truck (ACT) regulation that requires increasing sales of zero-emission heavy-duty vehicles. In April 2023, U.S. EPA released a notice of proposed rulemaking for the Heavy-Duty Phase 3 Greenhouse Gas program, which includes a stricter set of greenhouse gas standards for model year 2027 and newer vehicles that go beyond the current standards that apply under the heavy-duty Phase 2 Greenhouse Gas program. Manufacturers are expected to use zero emission vehicles (ZEV) as a cost-effective means to comply with the proposed federal emission standards, even in states that do not opt-in to California's emissions standards.

CARB has also adopted rules to ensure that heavy-duty emissions control systems are properly maintained. These rules do not require turnover and are therefore not impacted by the useful life provision of SB 1. The Periodic Smog Inspection Program (PSIP) and Heavy-Duty Inspection and Maintenance (HD I/M, or Clean Truck Check) are inspection and maintenance programs to ensure polluting, poorly maintained heavy-duty vehicles operating in California are quickly identified and repaired. PSIP requires fleet owners to conduct annual smoke opacity inspections of diesel vehicles over 6,000 pounds GVWR, and to repair those with excessive smoke emissions to ensure compliance. PSIP requirements carry forward at least through 2023 until periodic testing required by Clean Truck Check begins. Clean Truck Check requires owners of most non-gasoline powered trucks over 14,000 pounds GVWR that operate in California to perform periodic inspections to ensure trucks are operating as intended. Implementation began in January 2023 with periodic testing beginning in the 2024 timeframe. Until periodic testing begins, truck owners will still need to complete PSIP testing and keep records.

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[10] *Final Rule and Related Materials for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards.* EPA. (2023).

[11] *CARB and the Truck and Engine Manufacturers Agreement*. (2023).

To ensure that truck and bus fleets reduce and eliminate emissions wherever feasible, CARB has adopted several zero-emission fleet rules. Note that these fleet rules are distinct from ZEV manufacturer sales requirements in ACT, which does not require turnover. The Innovative Clean Transit (ICT) Regulation was adopted in December 2018, and requires transit agencies to gradually transition their bus fleets to zero-emission, either battery-electric or fuel cell fleet. Given that ICT fleets do not fit the commercial vehicle definition, they are excluded from this analysis. CARB also adopted the Zero-Emission Airport Shuttle Regulation in June 2019, which requires airport shuttle operators to meet a target of 100 percent zero-emission fleet by the end of 2035. Airport shuttle buses do not fit the commercial vehicle definition in SB 1 and are therefore not impacted by useful life limits.

Adopted Regulation Impacted by SB 1 Useful Life Limits: ACF

In April 2023, CARB adopted the ACF Regulation, which is the first-of-its-kind regulation to reduce and eliminate emissions wherever feasible from the on-road heavy-duty sector. The ACF Regulation has four components – a manufacturer sales requirement for 100 percent ZEV sales of medium- and heavy-duty vehicles by 2036, and three fleet requirements on High Priority Fleets, drayage trucks, and State and local government fleets. The drayage truck requirements apply to Class 7 and 8 trucks operating at the State's seaports and intermodal rail yards. Beginning in 2024, all newly registered trucks in the State's drayage truck registry must be zero-emission, and existing legacy combustion-powered trucks must be retired at the end of their useful life. By 2035, all drayage trucks must be zero-emission, which will deliver targeted benefits to nearby communities, many of which are overburdened.

High Priority Fleets in the ACF Regulation are defined as entities meeting one of the four following criteria: (1) own, operate, or direct 50 or more vehicles, (2) have $50 million or more in gross annual revenue, (3) have common ownership or control over multiple fleets totaling 50 or more vehicles, or (4) federal government agencies such as the United States Postal Service. Based on these thresholds, the High Priority Fleet requirements in the ACF Regulation affect larger fleets in the State and do not apply to smaller fleets. High Priority Fleets may comply with either a Model Year Schedule or ZEV Milestones Schedule. The Model Year Schedule requires all additions to the fleet to be ZEVs beginning January 1, 2024, and legacy combustion-powered vehicles must be retired at the end of their useful life. Alternatively, High Priority Fleets may opt into the ZEV Milestones option. Fleets using the ZEV Milestones option must ensure an increasing percentage of their fleets is composed of ZEVs beginning in 2025, and reach 100 percent zero-emission targets from 2035 to 2042 depending on the vehicle type. This pathway provides more flexibility to choose which vehicles to electrify and allows combustion-powered purchases if the fleet is meeting their ZEV phase-in percentage targets.

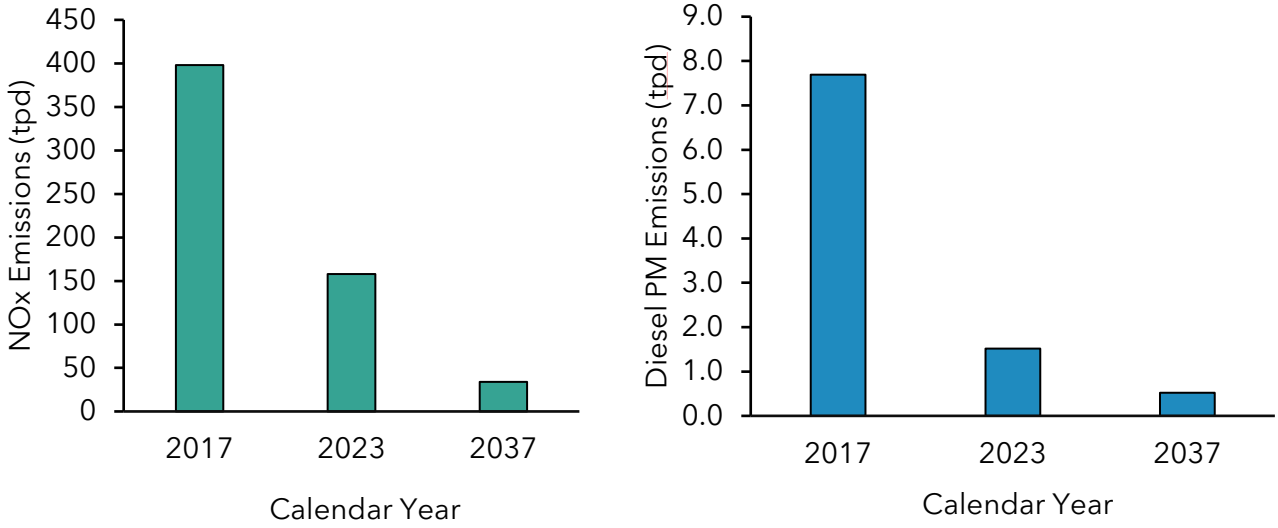
State and local government fleets in the ACF Regulation must follow a ZEV purchase requirement starting at 50 percent in 2024, ramping up to 100 percent in 2027. Government fleets located in designated low population counties or agencies with 10 or fewer vehicles are exempt until 2027. In addition, State and local government fleets may also opt into the ZEV Milestones option like High Priority Fleets.

Because SB 1 limited turnover of combustion-powered vehicles before the end of their useful life, and the Governor and Legislature established ambitious GHG reduction and zero-emission vehicle deployment goals, CARB staff had to limit the continued purchase of combustion-powered vehicles for drayage trucks and select High Priority Fleets in the ACF Regulation beginning on January 1, 2024. Otherwise, fleets could purchase new combustion vehicles and then use them for a minimum of 13 years and up to 18 years. During the development of the ACF Regulation, CARB staff identified that this type of lock-in may not be preferred by fleets. The ACF Regulation's ZEV Milestones option was available to High Priority Fleets and government fleets. As long as fleets meet their ZEV phase-in requirements, they have the flexibility to purchase and operate combustion vehicles. To meet the ZEV Milestones targets, fleets may need turn over their combustion vehicles before they reach the end of their useful life. As a result, for fleets to opt into this pathway, they must voluntarily waive their SB 1 useful life protections. Note, CARB was able to adhere to useful life limits in SB 1 when developing drayage truck requirements by only limiting combustion vehicle access to California seaports and intermodal rail yards. Drayage trucks will still be able to operate in non-drayage applications until the end of their useful life.

Emissions Impact of Adopted Programs

As a result of CARB's mobile source programs, significant progress has been made toward reducing emissions. Figure 2 shows a time series of heavy-duty NOx emissions, which is an important precursor for the formation of ozone and secondary particulate matter (PM), and diesel PM, which has been identified by CARB as a toxic air contaminant linked to increased cancer risk, respiratory and cardiac illnesses, and premature deaths. The decrease in emissions from 2017 to 2023 is mostly driven by the Truck and Bus Regulation. In the long-term, further reductions are achieved by cleaning up combustion trucks through regulations like Clean Truck Check and Heavy-Duty Omnibus, as well as zero-emission vehicle sales and fleet requirements through ACT and ACF, respectively. Note that this figure only includes adopted regulations and excludes regulatory actions that will be considered in the future. Despite the limits imposed by the useful life provision, NOx and diesel PM emissions from heavy-duty vehicles in California are projected to decrease by 79 percent and 66 percent, respectively, between 2023 and 2037.

Figure 2. Statewide Heavy-Duty NOx and Diesel PM Emissions with all Adopted Regulations as of July 2023



Future Regulation Impacted by SB 1 Useful Life Limits: Zero Emission Trucks (ZET) Measure

As a result of outreach and engagement efforts for developing the State SIP Strategy, staff added the ZET Measure. Under the ZET Measure, staff would implement regulatory strategies to reduce and eliminate emissions wherever feasible in fleets not covered by ACF using the following options:

A. Use market signals such as differentiated registration fees (DRF), restrictions or fees on vehicles entering low and zero emission zones (i.e., green zones), and/or indirect source rules to allow for a smoother and more equitable path to get to a 100 percent zero-emission California fleet. This combination of policies would help ensure that we are moving as quickly as possible to a zero-emission trucking future, everywhere feasible.
B. Require truck fleets of all sizes to scrap combustion (natural gas and diesel) vehicles when they reach the end of their useful lives and require that all purchases be zero-emission.

The ZET Measure would build on ACT and ACF, and potentially be considered by the Board in 2028 and begin implementation in 2030. This would be a significant step in the comprehensive strategy to achieve zero-emission heavy-duty vehicles everywhere feasible by 2045.

CARB's Approach to Meeting SB 1 Requirements

To address SB 1 requirements for CARB, staff:

- Held a public workshop in August 2022.
- Assessed the compliance rates of the Truck and Bus Regulation for in-State and out-of-State registered heavy-duty vehicles in calendar year 2022.
- Estimated the impact of the useful life provision on clean air efforts, including SIP compliance. This analysis includes key pollutants for SIP planning. This includes NOx and reactive organic gases (ROG), which are important precursors for ozone, and PM2.5. Staff also estimated the impacts of the useful life provision on diesel PM emissions.
- Entered into a contract with UC Berkeley to explore strategies that will reduce pollutant emissions from heavy-duty vehicles, including a qualitative assessment of policies to accelerate scrappage of old heavy-duty combustion and promote zero-emission heavy-duty vehicle uptake.
- Included a summary of recent stationary source actions and emissions benefits within this report.
- Presented recommended pathways for further reducing emissions from heavy-duty trucks necessary to improve California's air quality and public health.

Chapter 2: Truck and Bus Regulation Compliance Rates

CARB's Truck and Bus Regulation was adopted in 2008 and requires heavy-duty diesel vehicles (GVWR more than 14,000 pounds) operating in California to be equipped with modern emissions control systems to control NOx and PM emissions. Heavy-duty vehicles that meet these requirements have engine model years 2010 or newer. Unless exempt or not subject to the rule, pre-model year 2010 engine vehicles were required to be turned over according to the regulatory compliance schedules shown in Table 3. As of January 1, 2022, all heavy-duty diesel vehicles with engine model year 2006 and earlier engines were required to turn over to model year 2010 engines. Since January 1, 2023, all vehicles have been required to have model year 2010 or newer engines, unless using an exemption.

Table 3. Truck and Bus Regulation Model Year Schedule

LIGHTER VEHICLES (14,001-26,000 lbs. GVWR)	
Engine Model Year (Vehicle Model Year)	Replace or repower vehicle by*
2000 - 2003 (2001 - 2004)	January 1, 2020
2004 – 2006 (2005 - 2007)	January 1, 2021
2007 - 2009 (2008 - 2010)	January 1, 2023

HEAVIER VEHICLES (>26,000 lbs. GVWR)	
Engine Model Year (Vehicle Model Year)	Replace or repower vehicle by*
1996 - 1999 (1997 - 2000)	January 1, 2020
2000 - 2004 (2001 - 2005)	January 1, 2021
2005 - 2006 (2006 - 2007)	January 1, 2022
2007 - 2009 (2008 - 2010)	January 1, 2023

To assess compliance rates of heavy-duty vehicles subject to the Truck and Bus Regulation, CARB staff used two methods. The first was based on registration data and is used in CARB's annual enforcement reports. The second method used license plate data collected from Automated License Plate Reader (ALPR) systems. Both methods are described in detail below.

Compliance Assessment with Registration Data

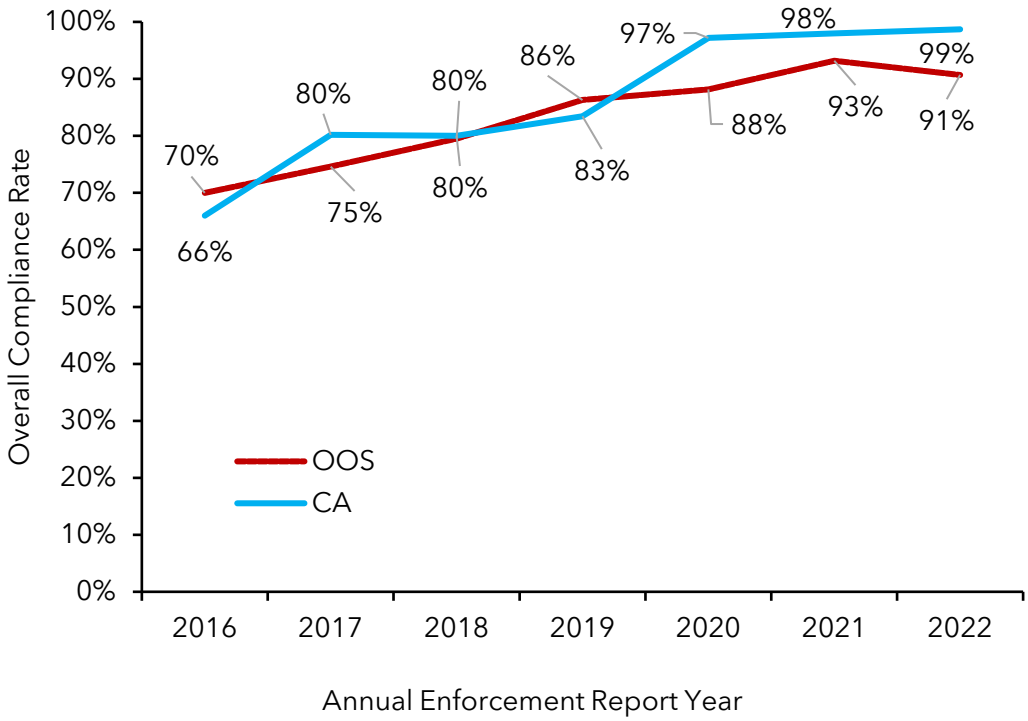
Since 1998, CARB's Enforcement Division has published summary statistics of enforcement activities on an annual basis.[12] Staff used California DMV for California-registered vehicles and the International Registration Plan (IRP) database for out-of-State vehicles. IRP is a registration reciprocity agreement between the contiguous United States and Canadian provinces and provides a listing of trucks in fleets reporting operation or mileage in California, but not the operation for individual trucks within these fleets. Vehicles with pre-2007 model year engines queried in DMV and IRP were cross-checked against the Truck Regulation Upload, Compliance and Reporting System (TRUCRS) for fleets using exemptions or a flexibility option. Further details about this methodology are provided through CARB's Enforcement Data Portal. The numbers presented in this section are consistent with these summary statistics.

Figure 3 shows that the overall compliance rates have improved significantly over time. For example, California-registered vehicle compliance rates increased from 66 percent in 2016

[12] *Enforcement Data - Truck and Bus Regulation Compliance. (2023).*

to 99 percent in 2022. Linking compliance to DMV registration was helpful for improving compliance rates. Historically, compliance for the Truck and Bus Regulation remained relatively low compared to other regulatory programs until the implementation of SB 1 in 2020, which required vehicles to be compliant with the Truck and Bus Regulation prior to registration. In the years leading up to the registration holds, enforcement staff developed new databases and tools to identify noncompliance and streamlined its practices to dramatically increase enforcement effectiveness. CARB staff in multiple divisions increased outreach and enforcement efforts to increase compliance rates prior to SB 1 requirements for DMV to withhold registration renewals began in January 2020. Since registration holds took effect in January 2020, compliance rates of California-registered trucks improved significantly from 83 percent in 2019 to 97 percent in 2020, 98 percent in 2021, and 99 percent in 2022. Compliance rates for out-of-State fleets are likely higher than reported because there is no method to distinguish which out-of-State registered vehicles in IRP never travel to California.

Figure 3. Overall Compliance Rates of Diesel CA-registered (CA) and Out-of-State (OOS) Vehicles with GVWR > 14,000 Pounds with the Truck and Bus Regulation



Most recently, CARB assessed Truck and Bus Regulation compliance rates in calendar year 2022. Table 4 lists the counts of all model year, pre-2007 engine model year, and non-compliant pre-2007 engine model year vehicles. The overall combined compliance rates with Truck and Bus Regulation are 99 percent for California-registered vehicles and 91 percent for out-of-State vehicles.

Table 4. Compliance Rates of Truck and Bus Regulation in Calendar Year 2022 for all Diesel Vehicles with GVWR > 14,000 pounds

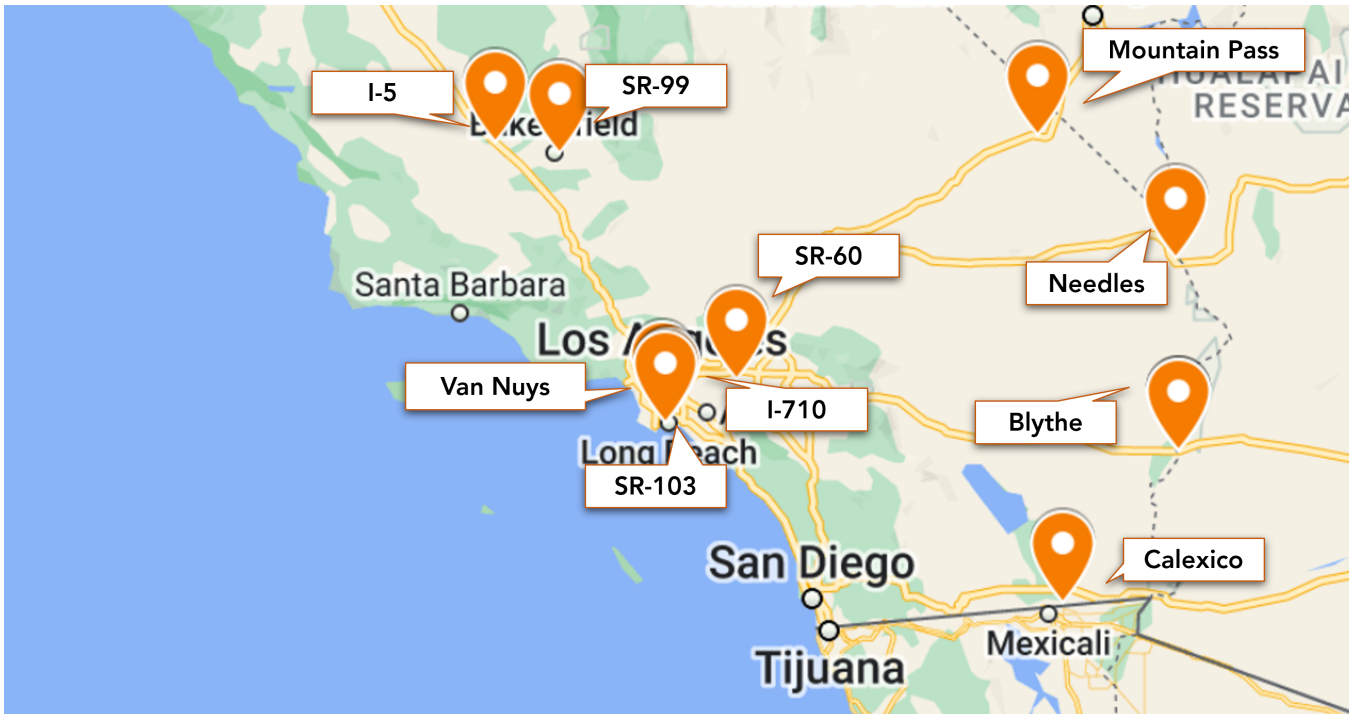
Registration Type	All Model Years	Pre-2007*	Pre-2007* Non-Compliant	Compliance Rate
Out-of-State	1,479,595	138,195	137,552	91%
California	427,211	18,935	5,711	99%
Total	1,906,806	157,130	143,263	92%

* Engine Model Year

Compliance Assessment with Automated License Plate Reader (ALPR) Data

ALPR systems record footage of vehicles operating on the road and digitize the alphanumeric characters of license plates and the jurisdiction or region of registration (e.g., California). CARB has deployed 10 ALPR systems through an extramural contract and internal efforts. Figure 4 shows the location of each ALPR system. License plates acquired through these systems can be matched to the California DMV and IRP registration databases to obtain vehicle weight class, fuel, and model year. Staff used these license plates to develop total counts of heavy-duty diesel vehicles detected by the ALPR systems, as well as counts of pre-2007 engine model year vehicles. Like the registration analysis, the potentially non-compliant pre-2007 engine model year vehicles were checked against the TRUCRS database for exemptions.

Figure 4. ALPR Systems Included in Compliance Assessment (January 1, 2022 to December 31, 2022)



Although the ALPR dataset is not comprehensive of all vehicles registered in California and out-of-State fleets that report mileage in the State, it provides real-world verification of compliance rates. As shown in Figure 4, this analysis was concentrated on vehicles operating in Southern California.

Table 5 lists compliance rates for the ALPR-based assessment. The compliance rate estimate was 99 percent for vehicles registered in California, which is consistent with the registration-based estimate. The out-of-State compliance rate of 95 percent based on ALPR is higher than the IRP registration-based analysis. This result suggests that, on average, out-of-State IRP fleets operate newer vehicles in California that have model year 2010 and newer engines.

Table 5. Truck and Bus Regulation Compliance Rates Based on ALPR Data in Calendar Year 2022*

Registration Type	All Model Years	Pre 2007**	Pre-2007** Non-Compliant	HD Compliance Rate
Out-of-State	483,608	23,637	23,444	95%
California	4,397,640	61,432	51,227	99%
Total	4,881,248	85,069	74,671	98%

*Vehicle counts correspond to plate reads and not necessarily unique vehicles.
**Engine Model Year

Summary

Implementation and enforcement of the Truck and Bus Regulation has resulted in significant NOx and PM emissions reductions from diesel trucks in California. CARB would have likely been unsuccessful in achieving much more emission reductions from California-registered fleets without SB 1 directing DMV to hold registration for non-compliant vehicles. Below are key results for the Truck and Bus Regulation assessment:

- **California Registered Vehicles:** Registration holds enabled through SB 1 starting in calendar year 2020 led to large improvements in compliance rates with the Truck and Bus Regulation. Compliance rates increased from a historical average of 66 percent up to 97 to 99 percent in 2020 to 2022.
- **Out-of-State Registered Vehicles:** Streamlining the enforcement of California-registered vehicles through SB 1 registration holds helped focus CARB enforcement efforts on out-of-State vehicles, which have improved significantly over time. The compliance rate was 91 percent in 2022 according to CARB's most recent enforcement data.
- Estimates through ALPR validated the compliance rates for both California and out-of-State Registered vehicles. ALPR-based methods suggest that the compliance rate of out-of-State vehicles could be up to 95 percent. Data gathered through ALPR will also assist in flagging non-compliant trucks for enforcement action.
- CARB and DMV will continue to place registration holds on diesel vehicles with GVWR more than 14,000 pounds that do not comply with California's regulations. SB 1 does not direct CARB or DMV to place registration holds on commercial vehicles with (1) non-diesel fuels and (2) GVWR less than 10,000 pounds. Both vehicle types are implicated by ACF. If enforcement of ACF (and other fleet rules) cannot be streamlined for all commercial vehicles through registration holds, then these regulations may result in lower emissions benefits than anticipated.

Chapter 3: Emissions Impacts of Useful Life Provision

We now turn our focus to the useful life provision and its air quality and climate implications, given that this provision constrains turnover of the combustion fleet through any heavy-duty fleet rules adopted after January 1, 2017.

Scenarios Analyzed

To explore the air quality impacts of the SB 1 useful life provision, staff ran two scenarios:

- **Scenario A** – Potential Reductions with No Useful Life Provision. Includes Planned ZET Measure (SIP commitment).
- **Scenario B** – Expected Reductions with Useful Life Provision in SB 1. Includes Planned ZET Measure.
- **Baseline** - All Adopted CARB Regulations as Limited by Useful Life. Excludes the Planned ZET Measure.

Scenario A provides a baseline regulatory option that CARB would likely have taken if not restricted by useful life starting in 2017. This scenario reflects the benefits CARB would have been able to achieve by structuring a new fleet rule similar to the Truck and Bus Regulation as applied to all fleets operating in California, both fleets not included in the ACF regulation (hereafter referred to as non-ACF fleets) and fleets that ultimately became subject to ACF. The schedule illustrates a scenario that is not constrained by the SB 1 useful life criteria by retiring vehicles before they reach 18 years of age or 800,000 miles and therefore demonstrates the range of emissions benefits that could be achieved without these restrictions. This scenario includes retirement of combustion vehicles at a specific age threshold and replacement with 75 percent zero-emission vehicles and 25 percent vehicles meeting the Heavy-Duty Omnibus standards (hereafter referred to as Omnibus Combustion) in the interim until 2035, then 100 percent zero-emission vehicles starting in 2036.

Table 6 and Table 7 list parameters for Scenario A as applied to ACF and non-ACF fleets, respectively.

Table 6. Scenario A Phase-In Schedule for Remaining Combustion Vehicles in ACF Fleets beginning in 2024

Calendar Year	Engine Model Year(s)	Forced Retirement Age	Technology Requiring Turnover to Zero-Emission
2024	2007 and older	17	0.2-certified* vehicles not equipped with OBD#
2025	2008	17	
2026	2009	17	
2027	2010-2012	15	
2028	2013	15	0.2-certified vehicles equipped with OBD
2029	2014-2015	14	
2030	2016	14	
2031	2017-2018	13	
2032	2019	13	
2033	2020	13	
2034	2021	13	
2035	2022	13	
2036	2023	13	
2037	2024	13	0.05-certified Omnibus vehicles **
2038	2025	13	
2039	2026	13	
2040	2027	13	0.02-certified Omnibus vehicles***
2041	2028	13	
2042	2029	13	
2043	2030	13	
2044	2031	13	
2045	All remaining (2032-2035)	10	

* 0.2-certified (model years 2010-2023): engines that are certified to the 0.2 g/bhp-hr NOx standard
** 0.05-certified (model years 2024-2026): engines that meet the 0.05 g/bhp-hr NOx Heavy-Duty Omnibus standard. Note that a portion of model year 2024-2026 trucks are federal-certified 0.2-certified are imported into the California fleet.
*** 0.02-certified (model years 2027+): engines that meet the 0.02 g/bhp-hr NOx Heavy-Duty Omnibus standard. Note that a portion of federal-certified model year 2027+ trucks certified to 0.035 g/bhp-hr may be imported into the California fleet.
# OBD: heavy-duty vehicles were equipped with on-board diagnostics (OBD) systems for model year 2013 and newer

Table 7. Scenario A Phase-In Schedule for Combustion Vehicles in Non-ACF Fleets covered by ZET starting in 2030.

Calendar Year	Engine Model Year(s)	Forced Retirement Age	Technology Requiring Turnover to Zero-Emission
2030	2013 and older	17	Includes 0.2-certified vehicles not equipped with OBD
2031	2014	17	Includes 0.2-certified vehicles equipped with OBD
2032	2015	17	
2033	2016-2018	15	
2034	2019	15	
2035	2020-2021	14	
2036	2022	14	
2037	2023-2024	13	
2038	2025	13	0.05-certified Omnibus vehicles
2039	2026	13	
2040	2027	13	0.02-certified Omnibus vehicles
2041	2028	13	
2042	2029	13	
2043	2030	13	
2044	2031	13	
2045	All remaining (2032-2035)	10	

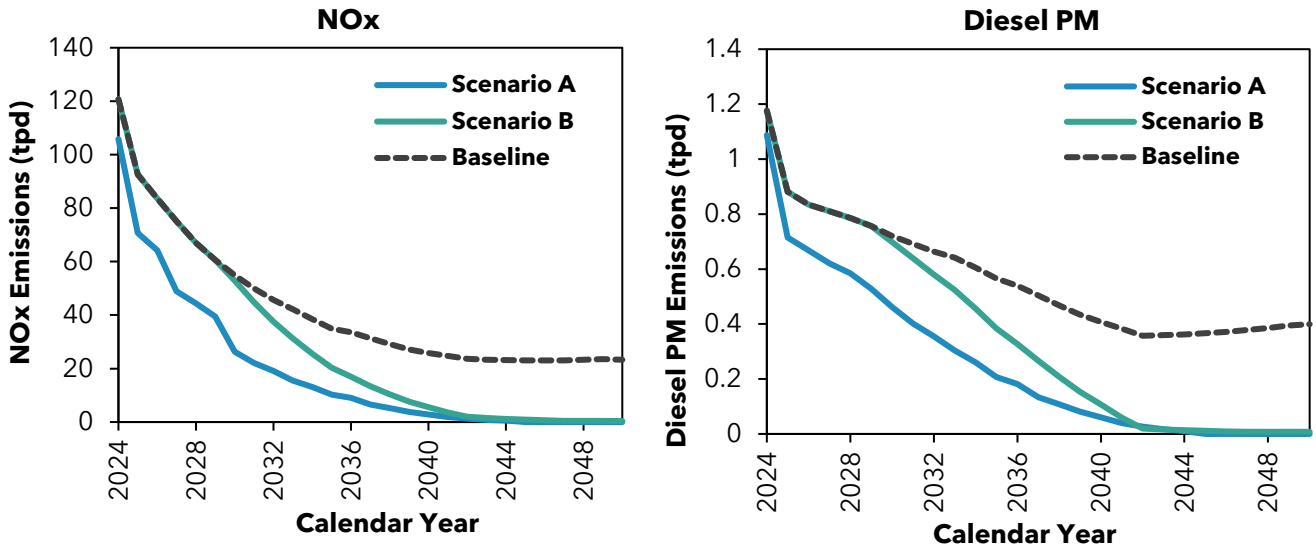
Scenario B represents CARB's current situation with all adopted and planned heavy-duty CARB regulations as limited by useful life, which includes all measures in the State SIP Strategy. This includes the ACF Regulation as adopted in April 2023, and the planned ZET Measure as CARB's commitment to reduce emissions from non-ACF fleets. As noted in Chapter 1, the ZET Measure is scheduled for Board consideration in 2028 with first implementation beginning in 2030. To quantify benefits from this measure, staff modeled the retirement of non-ACF fleets after the end of their useful life and replacement of combustion vehicles with zero-emission. Therefore, the emissions reductions from this scenario are a result of removing older combustion vehicles from the fleet and the displacement of new combustion with zero-emission vehicles.

The emissions results of Scenarios A and B are compared to the Baseline, which represents the implementation of adopted regulations and excludes the ZET Measure. In this analysis CARB staff is including all vehicles with GVWR greater than 14,000 pounds to quantify the impacts of the SB 1 useful life limits on commercial vehicles, with the exception of transit buses because they do not meet the definition of a commercial vehicle. Note that all emissions presented here are based on the latest version of CARB's on-road emissions inventory model EMFAC2021 (approved by U.S. EPA in 87 FR 68483, November 15, 2022),[13] which was adjusted for all regulatory programs adopted after its release, including ACF, HD I/M, and the federal CTP NOx Rule. As mentioned earlier, this emissions analysis does not reflect any modifications of the California heavy-duty engine standards established under the Omnibus Regulation in response to the Clean Truck Partnership announced in July 2023.[14]

Statewide Scenario Results

Figure 5 shows emissions after the implementation of the Baseline, Scenario A, and Scenario B. The area below the green line (Scenario B) and above the blue line (Scenario A) represents the lost emission benefits as a result of the useful life provision in SB 1.

Figure 5. NOx and Diesel PM Emissions as a Function of Calendar Year for the Baseline, Scenario A, and Scenario B



[13] *Emissions Inventory EMFAC*. (2023)

[14] *CARB and the Truck and Engine Manufacturers Agreement*. (2023).

Table 8 lists NOx and diesel PM emissions reductions for Scenarios A and B relative to the Baseline. In 2037, Scenario A would have achieved a 24.76 tons per day (tpd) NOx reduction (79 percent) and a 0.37 tpd diesel PM reduction (74 percent) relative to the Baseline. However, with the SB 1 useful life provision, CARB will only achieve reductions in Scenario B, which are 17.85 tpd NOx and 0.24 tpd diesel PM.

Scenario A also results in additional cumulative reductions of 82,276 tons NOx and 890 tons diesel PM relative to Scenario B from 2024-2045. Relative to Scenario B, Scenario A achieves 103 and 79 percent greater NOx and diesel PM cumulative reductions, respectively. Without the useful life limits, the State could have avoided 1,288 premature deaths, 2,067 hospitalizations and emergency room visits, and other adverse health impacts, which translates to $16.5 billion in cost savings. Note that these cost savings only represent differences in monetized health impacts and differ from a traditional cost benefit analysis completed as part of a rulemaking process. Appendix A provides more details on statewide Baseline and Scenario results.

Table 8. A Comparison of Emissions Reductions between Scenarios A and B, relative to the Baseline with Adopted Regulations

Scenario	NOx Reductions in 2037 (tpd)	Diesel PM Reductions in 2037 (tpd)	Cumulative NOx Reductions (tons; 2024-2045)	Cumulative Diesel PM Reductions (tons; 2024-2045)	Zero Emission Fleet % in 2037	Zero Emission Fleet % in 2045
A	24.76	0.37	162,203	2,014	84%	100%
B	17.85	0.24	79,927	1,124	80%	99%
A – B*	6.91	0.13	82,276	890	-	-

* Scenario A - B Represents Additional Reductions Possible Without the Useful Life Provision.

Air Basin Results

SB 1 requires CARB to assess the impact of useful life on SIP compliance, which necessitates emissions quantification at a regional or air basin level. SIP planning has become more challenging in part due to the large projected growth (and therefore emissions) of the heavy-duty truck sector over the coming decades. Staff performed this analysis in South Coast and San Joaquin Valley Air Basins (hereafter referred to as South Coast and San Joaquin Valley), because these two areas have some of the most critical air quality challenges. By 2031, both regions are required to meet the 75 ppb 8-hour ozone standard, and 70 ppb 8-hour ozone standard in 2037. The 5-year extension of the 12 µg/m3 annual PM2.5 standard to 2030 is still pending U.S. EPA approval in both South Coast and San Joaquin Valley and is therefore not assessed here. The overall strategies for attainment of the NAAQS are defined through the SIP process, which considers emission reduction strategies for the full range of sources including mobile, stationary, and areawide sources.

This assessment only covers the on-road heavy-duty sector and demonstrates additional emission benefits possible from the on-road heavy-duty sector in both air basins without the SB 1 useful life provision in key SIP years.

Figure 6 and Table 9 show that significant emission reductions are achieved by Scenario B and Scenario A in South Coast. Scenario A (No SB 1 Useful Life Limits) achieves 2.14 tpd additional NOx benefits in 2037 relative to Scenario B (With SB 1 Useful Life Limits). These additional reductions that were not possible due to the useful life provision needed to be fulfilled by reductions from other sources to meet NAAQS. The extra 2.14 tpd NOx reductions achieved from Scenario A is equivalent to 8 percent of 27.1 tpd NOx commitments from State actions for South Coast within other sectors (excluding on-road heavy-duty) in the State SIP Strategy. Scenario A also results in significant additional benefits for ROG and PM2.5 beyond current adopted regulations and Scenario B.

Figure 6. NOx, PM2.5 and ROG Emissions in South Coast Air Basin for the Baseline, Scenario A and Scenario B

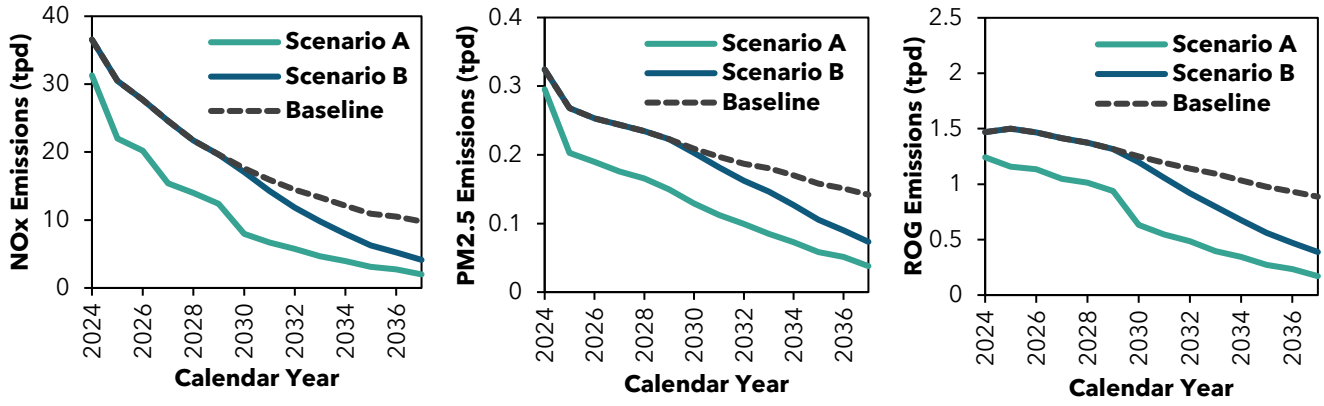


Table 9. Summary of Emissions Reductions in South Coast for Scenarios A and B Relative to the Baseline in Key SIP Years (EMFAC2021)

	2031 Emissions Reductions (tpd)			2037 Emissions Reductions (tpd)		
Scenario	**NOx**	**PM2.5**	**ROG**	**NOx**	**PM2.5**	**ROG**
Scenario A	9.21	0.08	0.65	7.79	0.10	0.72
Scenario B	1.63	0.01	0.14	5.65	0.06	0.50
Scenario A - B*	7.58	0.07	0.51	2.14	0.04	0.22

* Scenario A - B Represents Additional Reductions Possible Without the Useful Life Provision.

Figure 7 and Table 10 provide a summary of emissions benefits from Scenarios A (No SB 1 Useful Life Limits) and B (With SB 1 Useful Life Limits), which both achieve significant reductions in San Joaquin Valley. Relative to Scenario B, Scenario A results in 1.75 tpd more NOx reductions in 2037. This is equivalent to 10 percent of the 17.6 tpd commitments for State actions in San Joaquin Valley listed in the State SIP Strategy for all other sectors besides on-road heavy-duty. A more direct comparison to previous SIP commitments is discussed in the next section.

Figure 7. San Joaquin Valley NOx, PM2.5 and ROG Emissions in San Joaquin Valley Air Basin for the Baseline, Scenario A and Scenario B

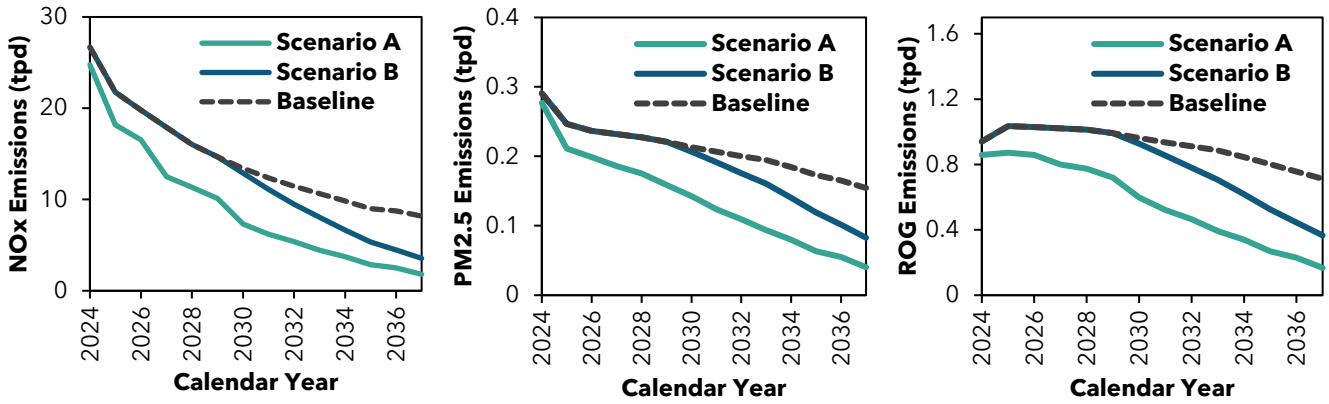


Table 10. Summary of Emissions Reductions in San Joaquin Valley for Scenarios A and B Relative to the Baseline in Key SIP Years (EMFAC2021)

	2031 Emissions Reductions (tpd)			2037 Emissions Reductions (tpd)		
Scenario	**NOx**	**PM2.5**	**ROG**	**NOx**	**PM2.5**	**ROG**
Scenario A	6.15	0.08	0.41	6.37	0.11	0.54
Scenario B	1.24	0.01	0.08	4.62	0.07	0.34
Scenario A - B*	4.91	0.07	0.33	1.75	0.04	0.20

* Scenario A - B Represents Additional Reductions Possible Without the Useful Life Provision.

Comparison to Previous SIP Commitments

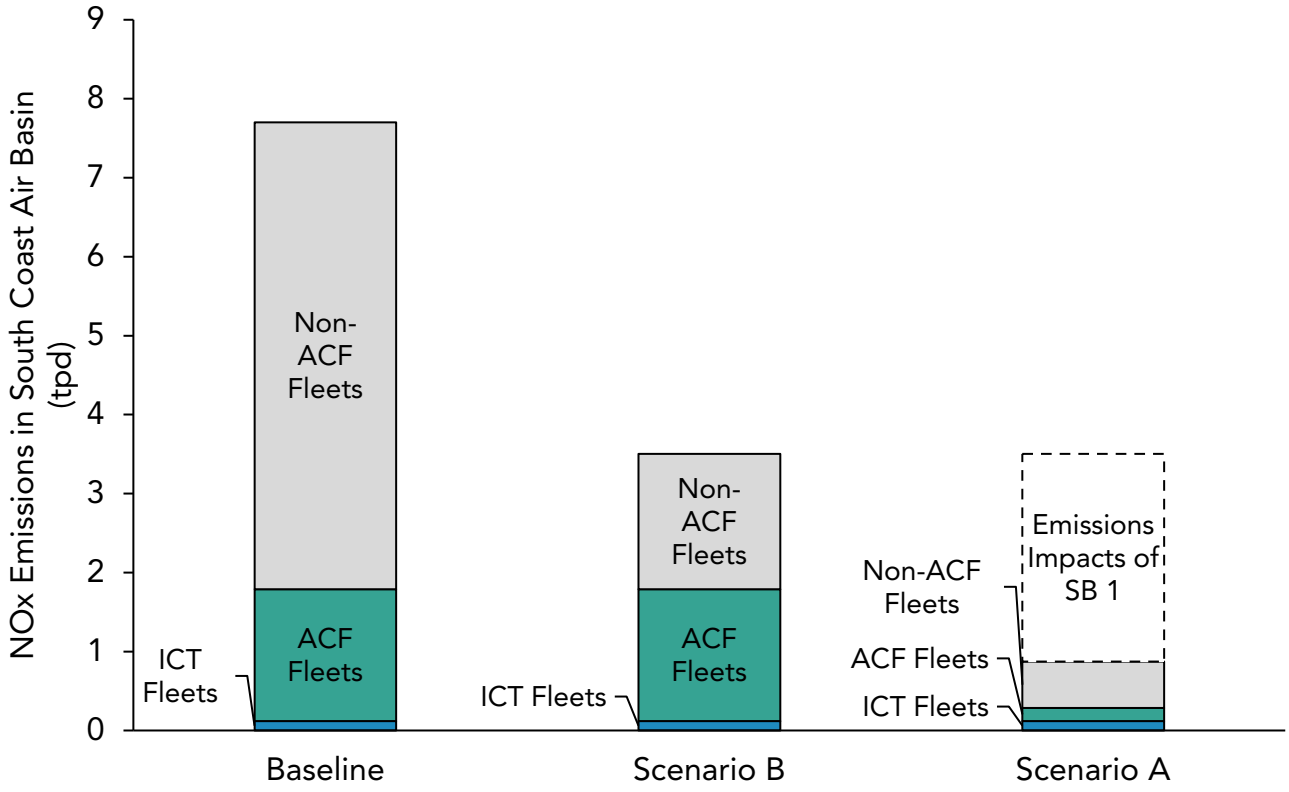
The 2022 State SIP Strategy detailed emissions reductions from mobile, stationary, and areawide measures needed for the 70 ppb 8-hour ozone standard in 2037. Here we compare emissions reductions in South Coast to measures included in the State SIP Strategy (Scenario B) and additional reductions that would be achievable without constraints

imposed by the useful life provision (Scenario A). Although the State SIP Strategy covered several air basins, this comparison focuses on South Coast; attainment in this area was very challenging and required reductions from the ZET Measure since the remaining reductions were assigned to federal measures as allowed under Section182(e)(5) of the Act. To compare directly to the State SIP Strategy emission reductions estimates, it was necessary to translate benefits achieved by Scenario B and Scenario A presented here to an earlier version of model (EMFAC2017), which was the latest version approved for use in SIP development when the State SIP Strategy was published.[15]

For the on-road heavy-duty sector, the State SIP Strategy reported total NOx reductions of 16.5 tpd in South Coast from CARB, local air district and federal measures. These reductions included reductions from ACF, the federal CTP NOx Rule, and the ZET Measure. After CARB published the State SIP Strategy, there were changes to ACF and the federal CTP NOx Rule once they were finalized. With these updates, heavy-duty measures are now estimated to reduce NOx emissions by 16.6 tpd. Scenario B represents the emissions benefits achieved by the ZET Measure, which specifically contributes 4.2 tpd of the total NOx emissions reductions in the State SIP Strategy. By turning over vehicles that are protected by the current useful life provision, Scenario A would have resulted in 2.6 tpd additional NOx emissions reductions compared to the current SIP commitments for this sector. Figure 8**Figure 8**
Figure 11 provides a summary of remaining emissions in the baseline, Scenario B (With SB 1 Useful Life Limits), and Scenario A (No SB 1 Useful Life Limits).

[15] Every version of EMFAC incorporated the most recent data on fleet mix, pollutant emission rates, and contains updates to forecasting methodologies. Therefore, the projected emissions will differ between EMFAC2021 and previous versions of EMFAC.

Figure 8. Heavy-Duty NOx Emissions Remaining in South Coast Air Basin After the Implementation of Adopted Programs and Scenarios in 2037



Scenario A demonstrates that extra emissions reductions beyond the original State SIP Strategy commitments for the heavy-duty sector could have been achieved by turning over combustion vehicles that became protected by the SB 1 useful life provision. Additional emissions reductions ensure that the on-road heavy-duty sector meets its SIP commitments, while providing additional reductions to cover other sectors if they do not achieve anticipated emissions benefits. Multiple CARB measures are still under development and may result in greater or lesser reductions once finalized. Moreover, many federal measures needed to demonstrate attainment in South Coast, which are allowed under Section 182(e)(5) of the Act, are not yet under development and may not achieve estimated emission reductions. More than half of mobile sources in California are primarily-federally regulated, which require unique strategies to regulate. Attainment of NAAQS will be more challenging if additional reductions cannot be achieved from heavy-duty vehicles.

Similarly, additional benefits without the useful life provision can also help support attainment of the near-term ozone standard in 2031, as well as measures for primarily-federally regulated sources allowed under Section 182(e)(5) of the Act.

Emissions Reductions in Communities

The impact of SB 1 on emissions at the air basin level also has significant implications at a more granular level within communities that are burdened by truck and other heavy -duty vehicle traffic. In this section, we focus on a few examples of AB 617[16] communities across California, including:

- International Border Community (San Diego Communities of San Ysidro and Otay Mesa)
- Richmond, North Richmond, San Pablo (Bay Area)
- Shafter (San Joaquin Valley)
- Stockton (San Joaquin Valley)
- Wilmington, Carson, West Long Beach (South Coast)

Figure 9 shows the locations of these AB 617 communities listed above and their corresponding air basins.

Figure 9. Selected AB 617 Communities Analyzed in the SB 1 Report

[16] *AB-617 Nonvehicular air pollution: criteria air pollutants and toxic air contaminants.* (2017).

AB 617 requires CARB to develop a Statewide Strategy to reduce emissions of toxic air contaminants and criteria air pollutants in communities affected by a high cumulative exposure burden and to update that strategy every five years. AB 617 requires CARB and air districts to develop and implement additional emissions reporting, monitoring, and plans to reduce exposures and emissions in the communities that are the most impacted by air pollution. CARB has selected 19 communities as of February 2023 for the development of a Community Air Monitoring Plan (CAMP) and/or a CERP.

The AB 617 communities selected for this analysis are required to develop both a CAMP and a CERP. In communities that were selected only for CAMPs, monitoring data will help better identify baseline air pollution levels and the emissions sources contributing to air pollution exposure. During the 2018 community selection process, the Board recommended prioritizing moving those communities that were previously selected only for a CAMP to work on the development of a CERP in subsequent years if the recommendation is supported by data and by the community steering committee. The CERPs developed by the community steering committees and the air districts provide a detailed analysis of emissions contributions from different air pollution sources in a community and identify strategies to reduce emissions and exposure in the community. There are currently CERPs for Stockton,[17] Wilmington, Carson, Long Beach,[18] and Shafter,[19] while CERPs for International Border Community and Richmond, North Richmond, San Pablo are presently under development. Many of these CERPs list heavy-duty trucks as one of the top community sources of concern and show that this source contributes significantly to NOx and PM2.5 in these communities. For example, heavy-duty trucks are responsible for 46 percent of NOx and 4.1 percent of total PM2.5 (including diesel PM, tire and brake wear, road dust, and other types of PM) in Shafter. The air basin-level emissions quantification above was translated to more granular community areas by applying reduction factors from Scenarios A and B relative to the Baseline. These inventories are highly detailed and built using emission rates (grams pollutant emitted per mile) from EMFAC2021 and vehicle miles traveled provided by metropolitan planning organizations (MPO).

Table 11 illustrates that Scenario A achieves significant diesel PM benefits in all communities beyond Scenario B. In 2037, Scenario A resulted in 73-74 percent reductions in diesel PM, while Scenario B resulted in 46-48 percent reductions in diesel PM. Scenario A achieves on average 55 percent greater diesel PM reductions compared to Scenario B in 2037. Note that only a few communities are included here for demonstration purposes, but it is expected that these results would be similar for other communities with heavy-duty truck traffic.

[17] *Community Emissions Reduction Plan - Stockton*. (2021).
[18] *Community Emissions Reductions Plan - Wilmington, Carson, West Long Beach*. (2019).
[19] *Community Emissions Reductions Plan – Shafter*. (2019).

Table 11. Scenario Emissions Diesel Particulate Matter Reductions (tpd) Compared to the Baseline in 2029

Community Area	2029: Scenario A	2029: Scenario B	2029: Scenario A - B*	2037: Scenario A	2037: Scenario B	2037: Scenario A - B*
International Border Community	0.04	0	0.04	0.07	0.04	0.03
Richmond, North Richmond, San Pablo	0.17	0	0.17	0.26	0.17	0.09
Shafter	0.40	0	0.40	0.75	0.47	0.28
Stockton	0.15	0	0.15	0.25	0.16	0.09
Wilmington, Carson, West Long Beach	0.72	0	0.72	1.00	0.66	0.34

* Scenario A - B Represents Additional Reductions Possible Without the Useful Life Provision.

The transition to cleaner heavy-duty vehicle technologies in communities is limited with the current useful life provision. Earlier and greater reductions of toxic pollutants are necessary for reducing exposure and improving public health in communities most impacted by air pollution.

Summary

- Staff assessed the emissions impact of the useful life provision by running a scenario that estimated potential reductions without the useful life limit (Scenario A) and a scenario with planned CARB regulations as limited by useful life (Scenario B).
- In 2037, Scenario A (No SB 1 Useful Life Limits) achieved 6.91 tpd more NOx and 0.13 tpd more diesel PM reductions than Scenario B (With SB 1 Useful Life Limits) in 2037 and resulted cumulatively in an additional 82,276 tons NOx and 890 tons diesel PM reductions from 2024-2045.
- The additional statewide emission reductions avoid 1,288 premature deaths, 2,067 hospitalizations and emergency room visits, and other adverse health impacts, which translates to $16.5 billion in cost savings to the State, without the SB 1 useful life provision.
- In 2037, Scenario A (No SB 1 Useful Life Limits) resulted in 2.14 tpd and 1.75 tpd NOx benefits compared to Scenario B (With SB 1 Useful Life Limits) in South Coast and San Joaquin Valley Air Basins, respectively. The limitations from the useful life provision required emission reductions commitments from other sectors to meet the NAAQS.

- At a more granular spatial scale, the useful life provision has limited CARB's ability to maximize emission reductions in AB 617 and other overburdened communities. In 2037, Scenario A (No SB 1 Useful Life Limits) achieved on average 55 percent more diesel PM reductions compared to Scenario B (With SB 1 Useful Life Limits). The extra emissions benefits achieved without the useful life provision would benefit people who live in communities with high cumulative air pollution exposure burden.

Chapter 4: Policies to Scrap Combustion Vehicles and Adopt Zero Emission

As required by SB 1, CARB explored different or additional mechanisms to achieve clean air goals. Since the provisions of the bill took effect in 2017, CARB adopted several additional regulations on commercial vehicle fleets in California (as listed in Table 2 and discussed in Chapter 1), ACF being the most recent and significant. ACF requires High Priority and federal fleets, State and local government fleets, and drayage fleets to meet zero-emission fleet targets. The majority of combustion vehicles remaining after the implementation of ACF will be in smaller fleets not subject to the ACF regulation, which requires a careful consideration of the economics of small businesses that are transitioning to zero-emission.

To inform this analysis, CARB entered into a contract with University of California, Berkeley (hereafter referred to as UC Berkeley). The contract assessed alternative policies beyond command-and-control approaches to promote the uptake of zero-emission vehicles. This policy assessment focused on fleets that are not covered by ACF. These fleets are anticipated to have unique economic and other challenges to zero-emission uptake and CARB staff is thinking creatively about how to push ZEVs in this space. The major findings of the UC Berkeley contract are summarized in this chapter. A full copy of the contract report can be found in Appendix B.

Key contract tasks included:

- An assessment of California's heavy-duty truck fleet purchase and retirement patterns today.
- An analysis of regulatory structures to (1) promote the retirement of heavy-duty diesel vehicles and (2) accelerate the uptake of ZEVs, including their efficiency, equity, efficacy, and interaction with other policies.

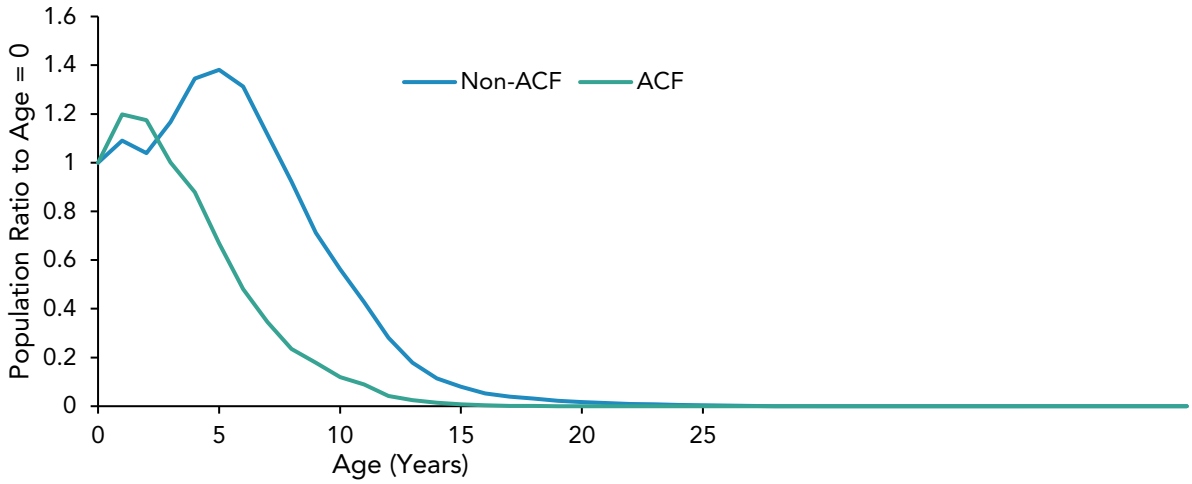
The policies considered here include a "command-and-control" approach and several flexible alternative regulatory structures. Command-and-control regulations generally prohibit purchase, registration or use of specific vehicle technologies and specify transition timelines for cleaner technologies (e.g., zero emission). On the other hand, more flexible approaches utilize a set of fees and subsidies to promote diesel vehicle turnover and the uptake of clean technology.

Findings on Command-and Control

UC Berkeley assessed the qualitative benefits and drawbacks of a command-and-control policy, focusing on non-ACF fleets in 2030. They considered a range of command-and-control policy scenarios that force the retirement of vehicles once they exceed their useful life. One scenario allows for used diesel purchases and the other would ban or restrict them. The qualitative assessment provided in this chapter focuses on the impacts of a policy that restricts the purchase of used diesel vehicles, because permitting used purchases will be ineffective at achieving policy goals. Although command-and-control structures have the advantage of greater certainty about progress toward zero-emission targets, UC Berkeley highlighted that this approach may result in several inefficiencies, which will be most pronounced for non-ACF fleets, which are smaller than fleets subject to ACF. These inefficiencies imply that the cost to industry and society will be larger for a command-and-control regulation compared with alternative strategies that use market signals. UC Berkeley pointed to three main sources of cost escalation that they found could arise from these inefficiencies.

- **Timing:** The lack of flexibility disrupts normal purchasing behaviors. From an assessment of the current truck market, it is common for fleets to import and sell used vehicles. This is especially true for the smaller, non-ACF fleets, which have limited access to capital. Therefore, a command-and-control regulation could present unique challenges for these fleets, which heavily rely on the purchase of used vehicles given their smaller upfront cost. Shown below in Figure 10 are scrappage curves for ACF and non-ACF fleets, which represent the populations in these fleet types relative to their populations at age 0. Values greater than 1 imply the import of used vehicles into the fleet. Currently, non-ACF fleets heavily rely on used vehicle sales that are 3-7 years old due to their lower upfront cost.

Figure 10. Scrappage Curves for ACF and Non-ACF Fleets



- **Unintended Consequences**: UC Berkeley pointed to a few potential unintended consequences of command-and-control regulations include pre-buying, lifetime extensions, and lock in, which would be more pronounced for smaller fleets that are more sensitive to the larger upfront cost of zero-emission vehicles and, at the same time, lessened by those small fleets with difficulty obtaining capital or credit to over-buy beyond their immediate needs. Pre-buying can occur when operators expand their inventory of older, higher-emitting vehicles ahead of a regulation being implemented. However, it is worth noting that a recent study by U.S. EPA found that pre-buy impacts were marginal and limited in duration.[20] Pre-buy is constrained by both individual fleet access to capital and the prevailing market conditions which tighten for used vehicles when industry-wide demand rises, or previous new purchases have experienced a low period. Lifetime extensions occur when operators expand the lifetime of their current older, higher-emitting vehicles because regulation makes their replacement cost higher. This effect can, however, be offset by the increased cost of maintaining older vehicles and the lost productivity during unscheduled repairs that can eliminate narrow margin profitability in a short time period. Lock-in occurs when operators keep vehicles in the California fleet instead of naturally cycling vehicles in and out of the California fleet to maintain the largest possible eligible fleet.
- **Incentive Alignment:** Efficiency requires that the trucks that have the lowest net value (the value to operators minus the monetized impacts of the pollution they contribute) are retired first. UC Berkeley indicated that command-and-control regulations align retirements based on age and mileage, not pollution damages and market value, and thus theoretically fail to maximize cost-effectiveness of zero-emission technology uptake. Flexible regulatory structures using cost signals can therefore improve the alignment and thus lower costs for smaller non-ACF fleets. It is worth noting that this loss in efficiency for command-and-control can be reduced by the increasing stringency of each subsequent emissions standard resulting in older vehicles having higher emissions even before considering deterioration and maintenance issues with older high mileage vehicles. It may also be infeasible to characterize in-use emissions of every truck periodically, which would require precise knowledge of the state of deterioration of each vehicle beyond what its internal on-board diagnostics (OBD) system can report.

CARB has and will continue to use command-and-control regulations that can minimize inefficiencies. For example, ACF has a ZEV Milestones option that provides flexibility to fleets and can reduce inefficiencies caused by market value. Programs like the CARB's Clean Truck Check that leverages the vehicle's internal OBD system in effect applies this flexible cost signaling via the naturally increasing frequency of repairs required to keep an aging vehicle in good standing.

[20] *Analysis of Heavy-Duty Vehicle Sales Impacts Due to New Regulation*. (2021).

Findings on Differentiated Registration Fees (DRF)

UC Berkeley assessed several types of flexible alternative regulatory structures to accelerate the transition to zero-emission technologies and retirement of diesel trucks. The most promising option is to impose annual registration fees that are differentiated by truck type, i.e., DRFs. While UC Berkeley considered vehicle registration as the implementation mechanism for an annual fee, other implementation options may be considered. To simultaneously encourage zero-emission uptake and scrappage of diesel vehicles, DRFs could raise annual registration fees for diesel vehicles and the revenue raised could subsidize zero-emission vehicles. The fees on diesel vehicles may follow a pollution-based scheme, which would impose larger fees on more polluting vehicles and these fees would be used to provide subsidies for zero-emission or supporting charging and fueling infrastructure. In general, older diesel would have the greatest fees because they have the largest pollutant emissions. Because heavier vehicles emit more pollution, heavy heavy-duty vehicles with GVWR greater than 33,000 pounds would have larger fees than medium heavy-duty vehicles with GVWR between 14,001 and 33,000 pounds. The magnitude of these fees may be based on environmental damages created per year translated to a dollar amount, which follows the economic principle of "pricing pollution." If these fees were implemented in California, the absolute magnitude of fees may be adjusted to target State goals, such as those directed by N-79-20, or by a specific zero-emission fleet percentage to achieve clean air targets.

According to UC Berkeley, benefits and drawbacks of DRFs include:

- If the fees are administered on an annual basis as a part of existing DMV registration requirements, there would be minimal new administrative costs required to implement the fees.
- Fees have the advantage of raising revenue. DRFs could be structured to be cost-neutral to the State by imposing fees on diesel vehicles and lowering or subsidizing registration fees for zero-emission vehicles and infrastructure as one example.
- These fees coupled with incentives may provide enough of a market signal for smaller fleets (i.e., non-ACF fleets) to transition to zero-emission vehicles.
- Such fees will need to be changed over time as the market evolves.
- An annual fee fails to take intensity of use (mileage) or driving location into account.
- A DRF that appropriately prices pollution would likely impose larger burdens on smaller operators who own older trucks, however this could be mitigated by using revenues to offset costs to transition these operators to zero-emission vehicles.

In summary, UC Berkeley found that DRFs can yield meaningful efficiency benefits as compared to a command-and-control regulation. The next section provides a quantitative assessment of these efficiency benefits.

Quantitative Assessment of DRFs

UC Berkeley assessed the effects of fees on shifting the heavy-duty diesel truck market in calendar year 2030 using a scenario based on fees calibrated to pollution damages. Note that this analysis only focused on diesel trucks but could be extended to other fuel types, such as natural gas. This scenario assumes a long-run equilibrium with fixed truck prices and a fee system are in place. Although some of the underlying assumptions of this analysis are uncertain, the results presented here demonstrate the plausible range of effects for fees of a given size paired with a rebate, or reduction in registration costs, to zero-emission vehicles in a revenue neutral structure. Appendix B contains more details on modeling assumptions.

Figure 11 and Figure 12 show the diesel fleet turnover for non-ACF fleets to zero-emission as a function of the annual benefit to an operator choosing zero-emission technology. The annual benefit represents the diesel truck fee plus the reduction in registration costs for a zero-emission vehicle in a revenue neutral structure. In other words, these charts demonstrate the fraction of registered diesel trucks that would be replaced with zero-emission in California at a given annual benefit. The revenue generated from diesel truck fees would be used to reduce annual registration costs for zero-emission vehicles. CARB staff estimated annual benefits using UC Berkeley's average fee per mile results and the average annual mileage accruals for medium and heavy heavy-duty vehicles from EMFAC.

Figure 11. Fraction of Medium Heavy-Duty Trucks Diesel Vehicle Miles Traveled (VMT) Converted to Zero-Emission as a Function of Fee and Rebate Level in 2030 According to a Revenue Neutral Structure

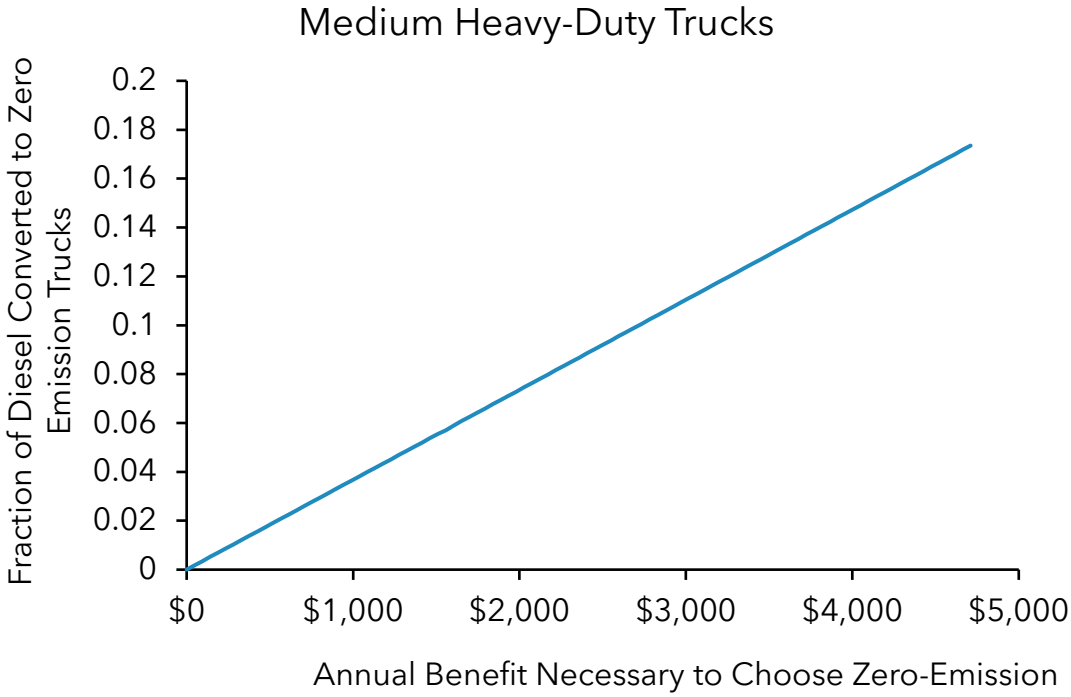
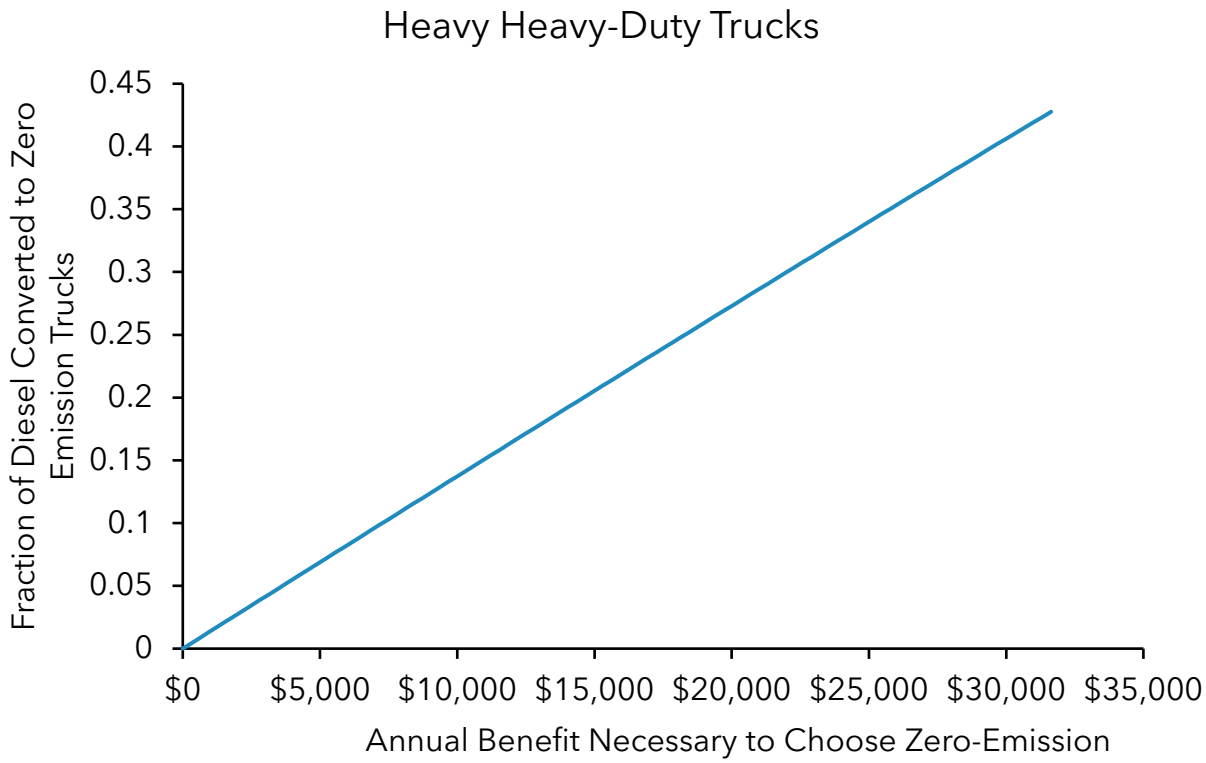


Figure 12. Fraction of Heavy Heavy-Duty Trucks Diesel VMT Converted to Zero-Emission as a Function of Fee and Rebate Level in 2030 According to a Revenue Neutral Structure



For comparison, CARB staff presented in Chapter 3 that Scenario B (With Useful Life Limits in SB 1) resulted in 5.7 percent conversion of medium heavy-duty diesel truck vehicle miles traveled (VMT) to zero-emission VMT in 2030. The results were similar for heavy heavy-duty trucks with 6.5 percent diesel VMT converted to zero-emission VMT. These zero-emission penetration targets of 5.7 and 6.5 percent would achieve the needed number of zero-emission vehicles on the road in calendar year 2030 to remain on track to meet longer-term zero-emission goals from the on-road heavy-duty sector.

CARB staff then compared these results to the potential turnover to zero-emission that could be incentivized by imposing DRFs on the non-ACF fleets. In UC Berkeley's modeling, the revenue generated from diesel fees was applied as a discount, or subsidy on annual registration for zero-emission trucks in the non-ACF fleets. CARB added the annual fee to the annual subsidy to estimate the annual benefit that would be necessary for an operator to choose zero-emission technology. Table 12 lists the estimated annual benefit necessary to achieve the same levels of turnover to zero-emission as achieved by Scenario B in 2030. An annual benefit of $4,728 would be needed to achieve this level of turnover. This annual benefit represents a fee neutral structure where fleets would pay $298 for each combustion truck and receive $4,430 for each zero-emission truck in 2030. The annual fee is about 10

percent of the current annual DMV registration cost of $3,000 per year on diesel vehicles. Sensitivity analysis indicates that the annual benefit could range from $4,728 up to $6,219. For the amount of turnover to zero-emission required in 2030 under CARB's Scenario B, this would equate to a total of $47 million in fees that would be collected in 2030 from operating diesel vehicles that would be redirected to zero-emission vehicles. This cost-neutrality and redirecting of fees is what results in the 5.7 and 6.5 percent turnover to zero-emission through DRFs.

Note that industry response to fee amounts will depend on zero-emission truck costs, infrastructure availability, equipment reliability, and many other factors that will likely evolve between now and 2030. Therefore, to support future regulatory development, CARB would need to revisit this economic evaluation and modeling to refine this quantitative assessment that presents current estimates for 2030, and since UC Berkeley's analysis was completed using the cost and operational values from the ACF regulation. This potential future analysis could also focus on refining fee levels necessary to move the truck fleet closer to 100 percent of the fleet to transition to zero-emission by 2045. This future analysis could also look at alternative incentive strategies, such as reducing upfront purchase costs for zero-emission trucks, as well as the need to reassess fees and corresponding incentives on some established interval to reflect market changes. In summary, this analysis suggests that DRFs provide a viable avenue for accelerating the turnover of older diesel trucks that would be replaced by zero-emission trucks. If CARB were to propose future regulations involving DRFs, more detailed and updated analysis of cost would be performed.

Table 12. Estimated Annual Benefit Necessary to Choose Medium Heavy-Duty (T6) and Heavy Heavy-Duty (T7) Zero-Emission Trucks

T6 Diesel VMT Converted to ZEV	T6 Estimated Annual Benefit	T7 Diesel VMT Converted to ZE	T7 Estimated Annual Benefit
5.7%	$1,157	6.5%	$4,728

UC Berkeley compared fleetwide costs of a fee-based system from the analysis described above to a command-and-control regulation. Note that the command-and-control cost estimates are only an approximation but are still grounded in economic theory. Table 13 lists the costs required in Scenario B. UC Berkeley's analysis concludes that the command-and-control structure is 14 times more costly than a DRF fee-based approach for non-ACF fleets to achieve the same targets in calendar year 2030. The larger costs of a command-and-control regulation are driven by the loss in efficiency resulting from heterogeneity between fleets. Where fee-based policies allow each firm to decide which truck type is most cost-effective, command-and-control-based policy can end up mandating very costly switches on some truck owners while also missing some very "cheap" switches. The relative difference between the two policy structures is smaller for larger zero-emission fleet turnover targets and converge to an equivalent cost at 100 percent turnover to zero-

emission. Table 14 shows the cost ratio for a variety of ZEV conversion targets in 2030. At 25, 35, and 50 percent turnover, the command-and-control approach is 3.8, 2.7, and 1.9 times more costly than the DRF approach, respectively. In the years preceding the 100 percent zero-emission target, the fee-based structure would result in cumulative cost savings relative to a command-and-control approach. If CARB is not able to implement more flexible regulatory structures, like DRFs, then CARB could implement a command-and-control regulation or some hybrid between the two approaches that offers more flexibility for smaller non-ACF fleets (e.g., by offering multiple pathways for compliance similar to the ZEV Milestones option for ACF fleets). This could minimize inefficiencies discussed for command-and-control regulations in the years leading up to the 100 percent zero-emission target.

Table 13. Cost Comparison Between Command-and-Control and Fee-Based Regulatory Structures for Non-ACF Fleets

Scenario	Diesel Conversion to ZEV in 2030	Policy Cost ($ Million)
Scenario B: Command-and-Control	6.3%	474.2
Scenario B: Fee-Based	6.3%	33

Table 14. Cost Ratios Between Command-and-Control and Fee-Based Regulatory Structures for a Variety of ZEV Conversion Targets for Non-ACF Fleets

Diesel Conversion to ZEV in 2030	Cost Ratio: Command-and-Control / Fee-Based
6.3% (Scenario B)	14.0
25%	3.8
35%	2.7
50%	1.9

Other Alternatives to Command-and-Control Structures

UC Berkeley assessed a range of other alternative policy structures that are described briefly in the sections below, which fall into two categories: (1) policies that promote retirement of combustion vehicles and (2) policies that promote the uptake of zero-emission vehicles. Note that only a subset of policies is summarized here. Other policies include fuel taxation, diesel buy out programs, and fuel subsidies. More details are provided in UC Berkeley's report in Appendix B.

Capital Subsidies – Promoting Retirement

Subsidies achieve some of the same benefits as DRFs, but they will be less efficient for two reasons. First, they require revenue, which must be raised from other public funds. DRFs raise funds through higher registration fees on heavy-duty combustion vehicles, thereby establishing a policy that can be revenue neutral. Subsidies are less efficient because they are harder to calibrate an optimal subsidy size across vehicles. The optimal subsidy to a particular ZEV depends on which type of vehicle (age, mileage, and vehicle class) is being replaced. In addition to making ZEVs cheaper to fleets, another benefit of subsidies is that they can also be used to support the buildout of heavy-duty zero emission infrastructure (e.g., chargers).

Mileage Fees – Promoting Retirement

Mileage fees could be assessed annually, but UC Berkeley distinguishes them from annual registration fees, which do not depend on the usage pattern of a specific vehicle and do not require new administrative systems or data. Mileage fees, in contrast, would require a new administrative system that collects mileage information. This policy has the benefit of incentivizing reduced usage of vehicles in accordance with true costs and benefits of operation. It would also have a fairness benefit in that it would charge more to those who pollute more, and vice versa, for different trucks within a class and vintage.

Tradable Quantity Systems – Promoting Retirement

A quantity-based policy could limit the number of registrations. UC Berkeley calls this a "license to register" system. In effect, CARB could issue a fixed number of licenses to register a truck in a given year. Without a license, an operator could not register a vehicle in the State. To enhance cost-effectiveness, the permits would be tradable between operators. They could be auctioned to stakeholders, or allocated for free based on past registration histories, but auctioning them has a number of benefits. Economic theory suggests that such a policy would deliver the cost effectiveness similar to a fee-based policy like DRFs, while creating greater certainty about the quantity of trucks and hence progress towards specific ZEV targets. Compared to DRFs, a tradable quantity system has less certainty about the cost of compliance, because permit markets can be volatile. Depending on how such a policy is implemented, it could require new data collection and expanded administrative capacity.

Green Zones – Promoting Retirement

One limitation of DRFs and subsidies is that they are of limited value in creating geographic differentiation. Green zones have the potential to address this limitation by restricting operation of more polluting trucks in a specific area. By targeting specific areas, this type of regulatory structure can also address the high levels of localized pollution experienced by communities burdened by truck traffic. The main downside of green zones compared to DRFs, or subsidies is they could be more complex and costly to administer. Another similar concept to green zones is expanded implementation of indirect source rules. Some air

districts have adopted indirect source rules to reduce facility-wide (e.g., warehouses) emissions, which includes truck traffic.

Infrastructure Fueling and Support – Promoting Uptake

Direct subsidies for equipment and installation aims to lower other costs by improving or subsidizing ZEV infrastructure. Infrastructure needed to fuel or charge heavy-duty trucks can have substantial up-front capital costs. Direct subsidies for private fleet infrastructure or public charging infrastructure along major travel corridors can thus be a direct and effective way of lowering barriers to zero-emission uptake. Current policies are setting the stage to accelerate development of necessary fueling infrastructure and additional policy actions can further accelerate this development. A deeper dive on California's infrastructure programs, as well as recommendations are provided in Chapter 5.

Summary

In summary, UC Berkeley's findings include:

- Command-and-control regulatory strategies can lead to several inefficiencies that elevate cost to operators, especially for small non-ACF fleets.
- DRFs can be a viable avenue for promoting the uptake ZEV trucks by non-ACF fleets. For Scenario B (With SB 1 Useful Life Limits), an estimated annual benefit of $4,728 (incentive of $4,430 for ZEV combined with an annual fee of $298 for combustion heavy heavy-duty trucks) should achieve the scenario zero-emission target (6.5 percent) in 2030.
- DRFs imposed on combustion vehicles could be implemented with minimal administrative burden, provide flexibility for smaller fleets, and could generate revenue to subsidize zero-emission.
- Compared to a command-and-control structure, DRFs provide a more cost-effective way to promote retirement of diesel trucks and adoption of zero-emission trucks. Specifically, a command-and-control regulation can be up to 14 times more costly to non-ACF fleets than a fee-based DRF structure in 2030.

Chapter 5: Infrastructure Needs and Recommendations

Meeting California's zero-emission targets for the heavy-duty sector requires new electric vehicle charging and hydrogen fueling infrastructure. CARB is working with utilities, local agencies, and other State agencies to ensure that vehicle rollout schedules associated with CARB regulations align with electric grid planning and ZEV charging and refueling infrastructure buildout. Heavy-duty zero-emission regulations include adopted regulations ACT, ICT, the Zero-Emission Airport Shuttle Regulation and ACF, as well as the under-development ZET Measure.

While CARB has taken a lead in establishing regulatory timeframes for this transition, the California Energy Commission (CEC) is the lead State agency for ZEV infrastructure funding and station planning. The California Public Utilities Commission (CPUC) oversees the State's investor-owned utility companies to ensure safe and reliable electric service, including for ZEV infrastructure, at reasonable and fair rates. Several State agencies are integral in funding, planning, and supporting the needed infrastructure for zero-emission vehicles. Key areas of collaboration include energy supply and grid planning, charging and fueling station infrastructure planning, and charging and fuel station development, which are described in the Zero-Emission Vehicle Infrastructure Joint Statement of Intent.[21] For example, as required by Senate Bill 671 (Gonzalez, Stats. 2021, Ch. 769), the California Transportation Commission (CTC), in coordination with CARB, CPUC, CEC and California's Governor's Office of Business and Economic Development (GO-Biz), prepared a Clean Freight Corridor Efficiency Assessment. This assessment provides high-level policy direction for the development of zero-emission freight infrastructure needed to support requirements established in Advanced Clean Trucks and Advanced Clean Fleets regulations. The assessment's goal is to identify freight corridors, zero-emission infrastructure needs, and barriers and solutions associated with the transition to zero-emission freight. The assessment was submitted to the relevant policy and fiscal committees of the California Legislature. As another example, Senate Bill 643 (Archuleta, Stats. 2021, Ch. 646) requires CEC, in consultation with CARB and CPUC, to prepare a statewide assessment of the fuel cell electric vehicle fueling infrastructure and fuel production needed to support the adoption of zero emission trucks, buses, and off-road vehicles. Assembly Bill 2127 (Ting, Stats. 2018, Ch. 365) requires CEC to assess the electric vehicle charging infrastructure needed to support California's zero-emission vehicle goals for both light-duty and medium- and heavy-duty vehicles. The first AB 2127 assessment was published in 2021, and the final version of the second AB 2127 assessment was published in early 2024.

Here, we focus on infrastructure needs to support the roll-out of heavy-duty zero-emission regulations and provide recommendations based on those needs. These recommendations were developed in collaboration with CEC and CPUC staff.

Electric Grid Upgrades

Transportation electrification charging infrastructure is expected to require electric grid upgrades over the next several years, especially to meet the needs from medium- and heavy-duty charging and light-duty fast charging.

A portion of charging infrastructure costs are passed onto ratepayers through electricity bills. Because of the need to accelerate these investments, they could have a significant impact on electricity rates if alternative sources of funding are not provided.

[21] *Zero-Emission Vehicle Infrastructure Joint Statement of Intent. (2023).*

To support electric grid upgrades and minimize the impact of upgrades on ratepayers, CARB staff, in collaboration with CPUC and CEC staff, recommends that the Legislature consider:

- Approving funding sources to fund, at least in part, the cost of distribution upgrades to prepare the grid to support electric vehicle charging station and hydrogen fuel cell vehicle refueling infrastructure. While funding should be directed primarily to support transportation electrification needs, due to the nature of the electric grid design, upgrades may benefit other types of loads such as business as usual service connections, building electrification, and other beneficial end-uses.

Reliable Funding for Infrastructure Projects

Each year, the Legislature appropriates funding from the Clean Transportation Program fund and, more recently, the General Fund and Greenhouse Gas Reduction Fund to CEC for zero-emission infrastructure, hydrogen production, and workforce development investments. In March 2022, CEC launched the Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE) program, as a streamlined mechanism for funding infrastructure projects. As of March 2023, the EnergIIZE program had awarded $171 million for public and private charging and hydrogen refueling infrastructure projects through several competitive and first-come, first-served funding opportunities. This program has been well received by project applicants with funding typically being oversubscribed after each release. Demand for EnergIIZE funding indicates progress by fleets and manufacturers to transition to zero-emission technology. However, ongoing funding is needed to alleviate the concerns by fleet and manufacturer stakeholders that funding allocated each year for zero-emission infrastructure may be insufficient. The recent extension of the CEC's Clean Transportation Program was an important step to help start addressing these concerns.

To support the State's infrastructure projects, CARB staff, in collaboration with CEC and CPUC staff, recommends that the Legislature consider:

- Maintaining funding for infrastructure projects through programs like the EnergIIZE program, focusing on projects that align with planned zero-emission deployments by commercial and transit fleets.
- Allowing flexibility so that the EnergIIZE program can allocate some of the funding to fill near-term temporary commercial infrastructure gaps.

Streamline Battery Electric Vehicle Charger Permitting

As battery electric vehicle sales increase and fleets electrify, demand for public fast charging is expected to grow. This will necessitate charging stations at properties where electric vehicle charging is intended as the sole or primary purpose for the parcel, rather than being an accessory (i.e., charging co-located with parking for a retail establishment). Local zoning

codes do not yet have "electric vehicle charging" as a defined use and existing codes for other types of vehicle refueling are incompatible with electric vehicle charging uses.

Incompatible zoning codes and lack of zoning codes specific to electric vehicle charging create both barriers and lengthy delays in gaining approvals and permits for a stand-alone charging project, which is essential to supporting the continued adoption of light-, medium- and heavy-duty on-road zero-emission vehicles. While some local jurisdictions are starting to contemplate this type of land use, identifying electric vehicle charging as a "land use case" in zoning ordinances at the State level would remove a key barrier to installing charging sites in multiple jurisdictions.

To support the roll-out of zero-emission infrastructure, CARB staff recommends that the Legislature consider the following measures to streamline permitting for battery electric vehicle chargers:

1. Define electric vehicle charging as its own use, including both a permitted primary use and accessory use and, where applicable, discontinue classifying electric vehicle charging under an existing use like parking and fueling stations.
2. Direct Authorities Having Jurisdiction (AHJ) to permit electric vehicle charging in all zoning districts and avoid limiting which zoning districts can be approved for primary use charging.
3. Direct Go-Biz to create a non-discretionary zoning approval pathway for primary use electric vehicle charging projects, and further codify streamlined permitting processes for electric vehicle charging by providing a checklist of permitting requirements for both accessory and primary use charging sites.
4. Direct AHJs to develop flexible, performance-based design standards for electric vehicle charging sites, in lieu of prescriptive parking design standards. The legislation should authorize AHJs to approve alternate design options in instances where compliance with guidelines as written is not possible.

Chapter 6: Stationary Source Actions and Benefits

As noted in the Introduction, SB 1 requires CARB to report on the benefits and impacts of measures enacted to improve local air quality impacts from stationary sources. There are a variety of recent control measures to reduce emissions from stationary sources, which are summarized in the South Coast Air Quality Management District (South Coast AQMD)'s 2022 Air Quality Management Plan[22] and the San Joaquin Valley Air Pollution Control District (San Joaquin Valley APCD)'s 2022 Plan for the 2015 8-Hour Ozone Standard.[23] The majority of South Coast AQMD and San Joaquin Valley APCD measures target stationary sources, which they are primarily responsible for regulating. South Coast AQMD's control measures are expected to reduce 22.1 tpd NOx emissions by 2037. These reductions are

[22] *South Coast AQMD 2022 Air Quality Management Plan*. (2022).
[23] *San Joaquin Valley Air Pollution Control District 2022 Plan for the 2015 8-hour Ozone Standard*. (2022).

achieved through targeting space and water heaters, cooking devices, and other residential and commercial appliances, as well as large combustion engine sources such as process heaters, turbines, refineries, incinerators, electricity generating facilities, and emergency combustion engines. In San Joaquin Valley, no additional reductions from stationary sources were needed to meet the 70 ppb ozone standard in 2037. The San Joaquin Valley APCD's current regulatory strategy is summarized in the 2022 Plan for the 2015 8-Hour Ozone Standard. In 2037, current rules reduce NOx by 62 percent from 2017 levels, which was achieved by regulating open burning, combustion engine use, and various types of boiler, heater, and furnace units.

Chapter 7: Conclusions and Recommendations

Through analysis of internal programs and leveraging expertise of UC Berkeley through a contract, CARB staff concludes the following:

- SB 1 significantly increased compliance rates of the Truck and Bus Regulation by enabling registration holds, which led to significant reductions in NOx and diesel PM.
- The SB 1 useful life provision has limited emissions reductions from adopted and planned heavy-duty regulations by a cumulative 82,276 tons of NOx and 890 tons of diesel PM starting in 2024 through 2045 statewide.
- In 2037, 2.14 tpd and 1.75 tpd additional NOx benefits could be achieved in South Coast and San Joaquin Valley Air Basins, respectively, without the useful life provision of SB 1. The limitations from the useful life provision will require emission reductions commitments from other sectors, such as stationary and federal sources, to meet the legally enforceable NAAQS.
- Without the useful life provision, diesel PM emission reductions in AB 617 communities could have been reduced by 55 percent relative to a scenario with the useful life provision in place.
- Alternative regulatory structures, such as DRFs, can provide small non-ACF fleets with the flexibility needed to make the shift from combustion to zero-emission vehicles and at a lower overall cost to fleets.

Recommendations

Based on the analysis provided within this report, staff provides the recommendations listed below to the Legislature for consideration. Together, these recommendations will be critical for CARB to continue achieving reductions from the commercial vehicle sector while maintaining the useful life provisions that provide certainty to fleet owners and operators as intended by SB 1.

Additionally, these actions support the State's ongoing efforts to reduce greenhouse gas, criteria, and toxics emissions from the transportation sector, which are summarized in the most recent informational report "Annual Update on Statewide Trends of Greenhouse Gas

Emissions and an Overview of the 2022 Scoping Plan" presented to the Joint Legislative Committee on Climate Change Policies.

Direct CARB to Implement Annual Fees, Such as Differentiated Registration Fees (DRF)

CARB recommends that the Legislature consider directing CARB to implement a revenue neutral program starting in 2030 that raises revenue with a fee on polluting commercial and heavy-duty vehicles operating in California and returns that revenue as an incentive to zero-emission trucks. Annual fees paired with an incentive provide an economic driver for fleets to transition to zero-emission as concluded by UC Berkeley's report. Additionally, a revenue neutral fee-based structure can generate equivalent emission reductions at a lower cost than traditional command-and-control regulations for the smaller fleets that would be affected.

Authorize CARB to Implement Statewide Indirect Source Rules

Indirect source rules place requirements on facilities related to mobile sources including warehouses, ports, rail yards, and other freight hubs. South Coast AQMD has developed an indirect source rule for warehouses,[24] which is currently being implemented. Such strategies at a statewide level may support the adoption of zero-emission trucks by ensuring facility owners are taking actions such as working with zero-emission vehicle operators and installing charging or hydrogen fueling infrastructure. Action by CARB at the State level rather than individual air districts can create a harmonized statewide program.

Support Additional Incentive Funding for Zero-Emission Vehicles

CARB staff recommends consideration of supporting additional State, federal, and other funding to leverage $11 billion (based on pollution damages of $100,000 per weighted ton[25]) of incentive funding to offset the emissions impact of the SB 1 useful life provision through 2045. The funds should focus on supporting projects that benefit communities that are most impacted by air pollution. These incentive funds could target the on-road commercial vehicle sector, as well as off-road sectors that were not addressed in the past due to technology limitations, such as zero-emission agriculture, construction, in-transit ocean going vessels and aviation. Incentive funding could help mitigate the excess emissions in overburdened and disadvantaged communities as a result of SB 1 and will help CARB meet the zero-emission mobile source targets as outlined in the N-79-20.

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[24] *Rule 2305 – Warehouse Actions and Investments to Reduce Emissions (WAIRE) Program*. (Adopted May 7, 2021)

[25] *Carl Moyer Program – Appendix C: Cost-Effectiveness Calculation Methodology*. (2021).

Zero-Emission Infrastructure Recommendations

To support the roll-out of zero-emission infrastructure, CARB staff recommends that the Legislature consider the following measures:

- Approve alternative sources of funding to upgrade the electric grid to support transportation electrification.
- Approve funding for infrastructure projects through programs like EnergIIZE, focusing on projects that align with planned ZEV deployments by commercial and transit fleets.
- Streamline permitting for battery electric vehicle chargers.

Registration Holds for Future Fleet Rules

SB 1 does not direct CARB to place registration holds on commercial vehicles with (1) non-diesel fuels and (2) GVWR less than 10,000 pounds. These are categories of vehicles that must comply with the ACF Regulation and any future measures for the non-ACF fleets (such as the ZET Measure). Without registration holds, it is possible that the ACF Regulation and future measures may not achieve the full extent of possible emissions reductions. CARB staff recommends that the state explore the feasibility of implementing registration holds for any commercial vehicle, as feasible, regardless of the vehicle's GVWR and regardless of fuel type, that is not meeting CARB regulations.

Appendix A: Detailed Baseline and Scenario Results

Baseline

Figure 13 shows NOx and diesel PM emissions for ACF and non-ACF and demonstrates the significant projected decrease in NOx and diesel PM levels in the ACF fleets from 2024-2042. After full implementation in 2042, most ACF fleets will be fully zero-emission, except for the small percentage of vehicles subject to ACF that have low mileage or other exemptions. If CARB takes no further action to regulate heavy-duty trucks, by the mid-2030s, non-ACF fleets will be responsible for the majority of heavy-duty on-road vehicle NOx and diesel PM emissions.

Figure 13. Baseline Statewide NOx and Diesel PM Emissions Split by ACF and Non-ACF Fleets After the Implementation of Adopted Regulations

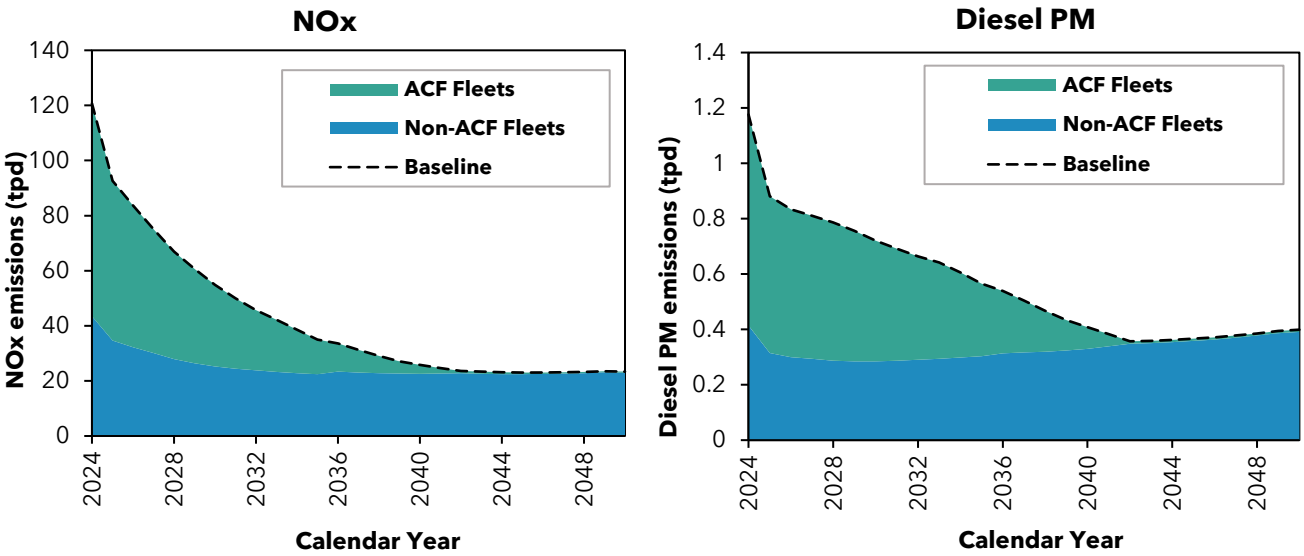

Figure 14 shows baseline fleet populations by technology with ACF implementation, including legacy combustion vehicles meeting model year 2010 engine standards, Omnibus combustion, and zero-emission. ACF converts a significant portion of the fleet to zero-emission. There are very ambitious schedules for specific types of ACF fleets, including 100 percent zero-emission drayage trucks by 2035. However, the N-79-20 target of 100 percent zero-emission trucks by 2045 will not be achieved by ACF alone, with only a 63 percent zero-emission fleet projected in this year.

Figure 14. Baseline Statewide Heavy-Duty Fleet Population by Technology and Zero Emission Vehicle (ZEV) Percentage

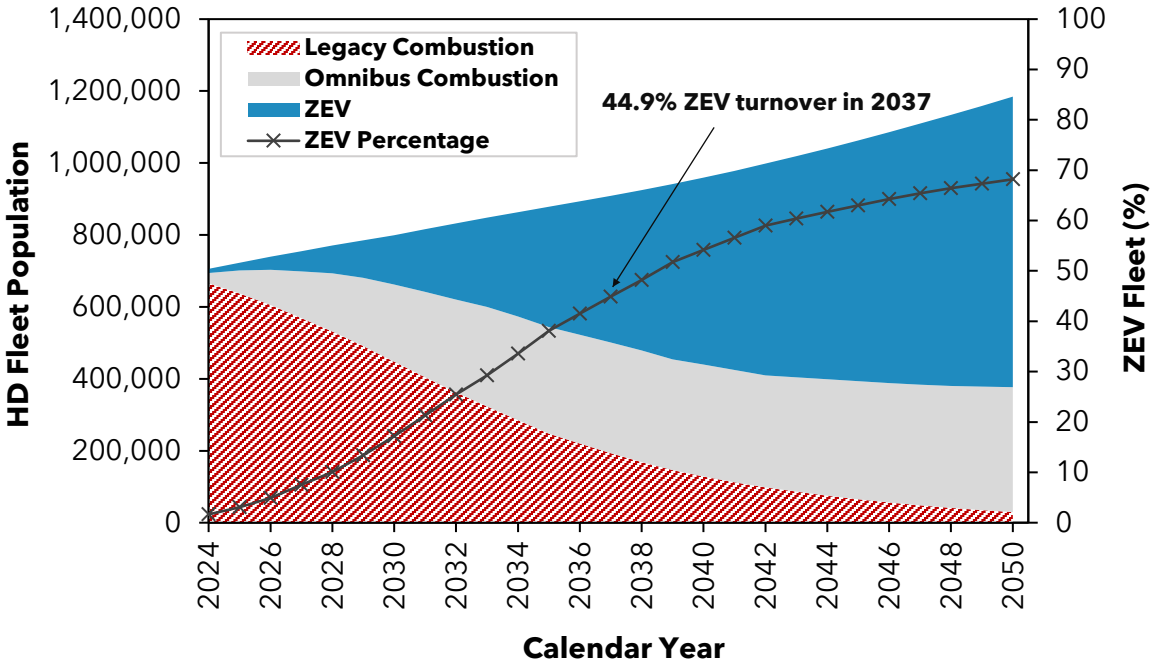

Table 15. Baseline Statewide Heavy-Duty Fleet Population Profile in 2037 and 2045

Fleet Type	Fleet Percentage in 2037	Fleet Percentage in 2045
Legacy Combustion	21.2%	6.2%
Omnibus Combustion	33.9%	30.8%
ZEV	44.9%	63.0%

Scenario A – No SB 1 Useful Life Limits

Figure 15 shows NOx and diesel PM emissions remaining after Scenario A. By retiring the oldest and most-polluting vehicles in ACF and non-ACF fleets first, Scenario A achieves cumulative benefits of 162,203 tons NOx and 2,014 tons diesel PM from 2024-2045.

Figure 15. Scenario A Statewide NOx and Diesel PM Emissions Split by ACF and non-ACF Fleets.

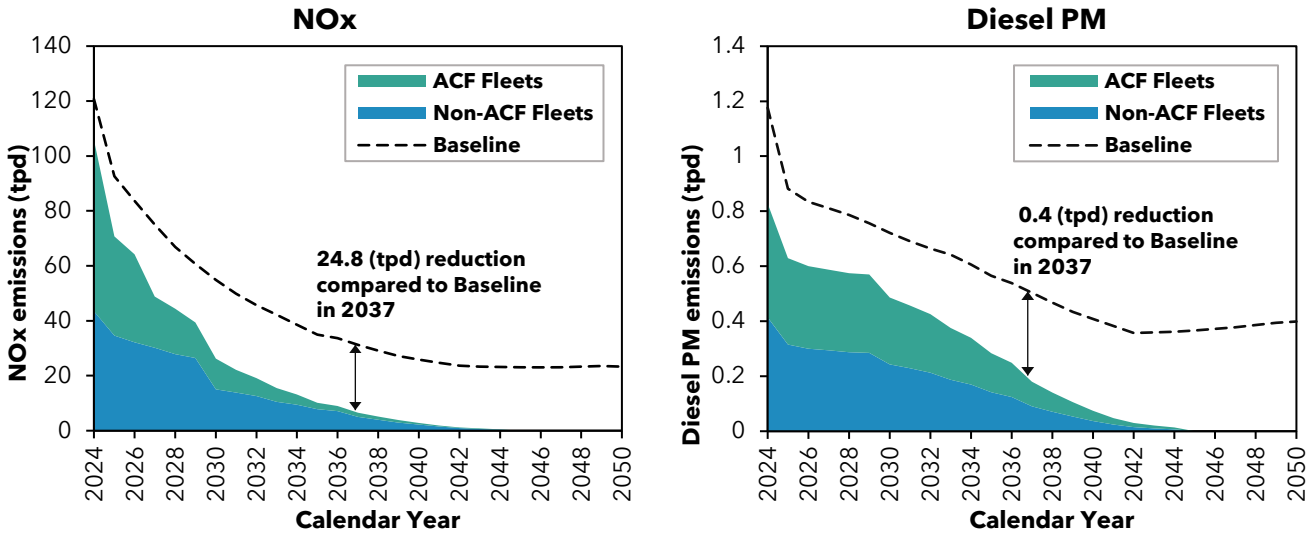

Figure 16 illustrates that Scenario A converts a large fraction of legacy combustion vehicles to Omnibus combustion and zero-emission. The entire heavy-duty fleet is projected to be 84 percent zero-emission in 2037 and achieves the N-79-20 target of 100 percent zero-emission in 2045.

Figure 16. Scenario A Statewide Heavy-Duty Fleet Population by Technology and Zero Emission Vehicle (ZEV) Fleet Turnover

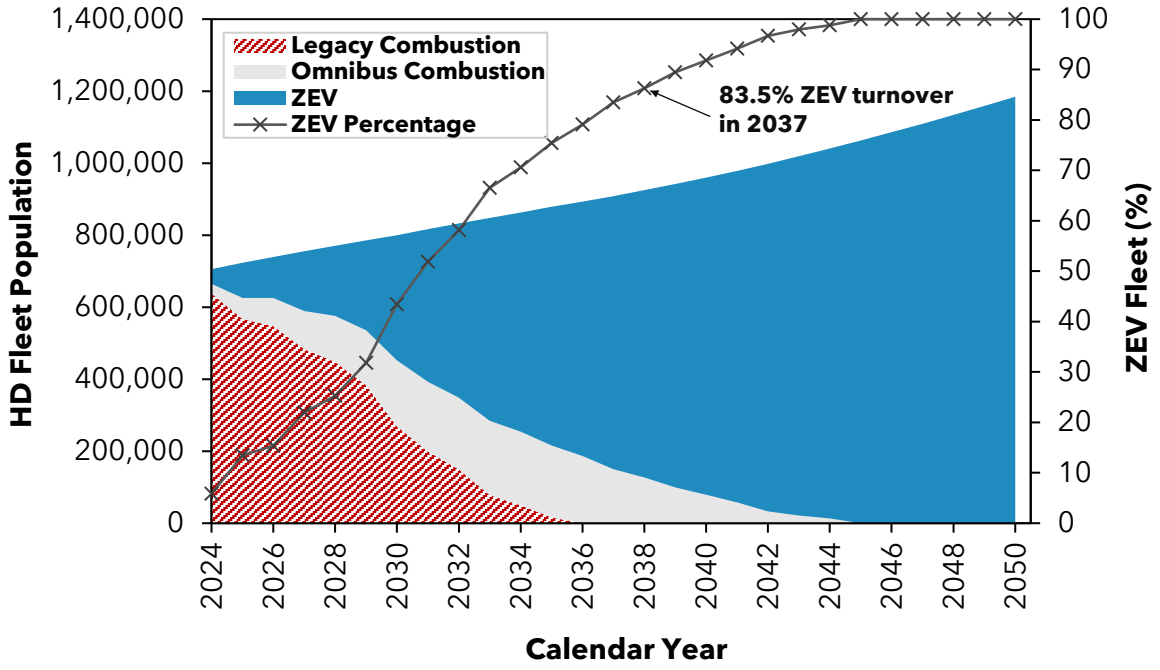

Table 16. Statewide Heavy-Duty Fleet Population Profile in 2037 and 2045 with Scenario A

Fleet Type	Fleet Percentage in 2037	Fleet Percentage in 2045
Legacy Combustion	0%	0%
Omnibus Combustion	16.5%	0%
ZEV	83.5%	100%

Scenario B – With SB 1 Useful Life Limits

As noted above, Scenario B represents planned regulations, including the ZET Measure, if limited by the useful life provision as specified in SB 1. Scenario B achieves large cumulative benefits of 79,927 tons NOx and 1,124 tons diesel PM, but 82,276 tons NOx and 890 tons diesel PM less than Scenario A.

Figure 17. Scenario B Statewide NOx and Diesel PM Emissions Split by ACF and Non-ACF Fleets

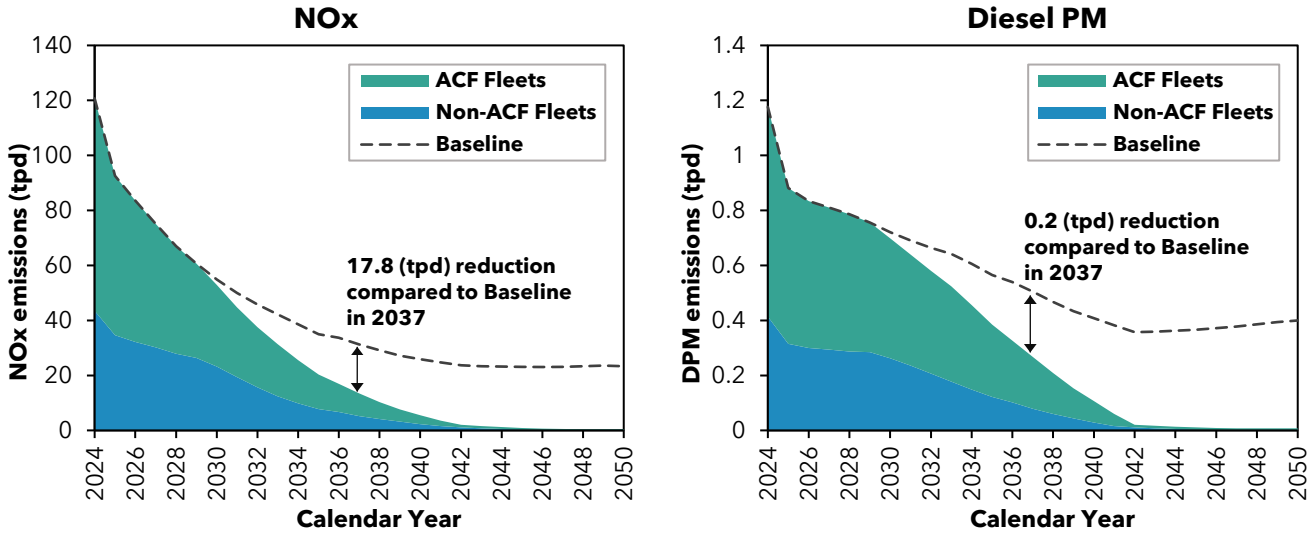

Figure 18 shows that Scenario B is expected to turnover 76 percent of the fleet to zero-emission by 2037, and 99 percent of the fleet to zero by 2045. These results illustrate the technology mix in the heavy-duty fleet after adopted and under development regulations are in place within the constraints of the useful life provision. In contrast to Scenario A (No SB 1 Useful Life Limits), there is less conversion of the legacy combustion fleet to zero-emission and Omnibus combustion in Scenario B (With SB 1 Useful Life Limits) in 2037.

Figure 18. Scenario B Statewide Heavy-Duty Fleet Population by Technology and Zero Emission Vehicle (ZEV) Fleet Percentage

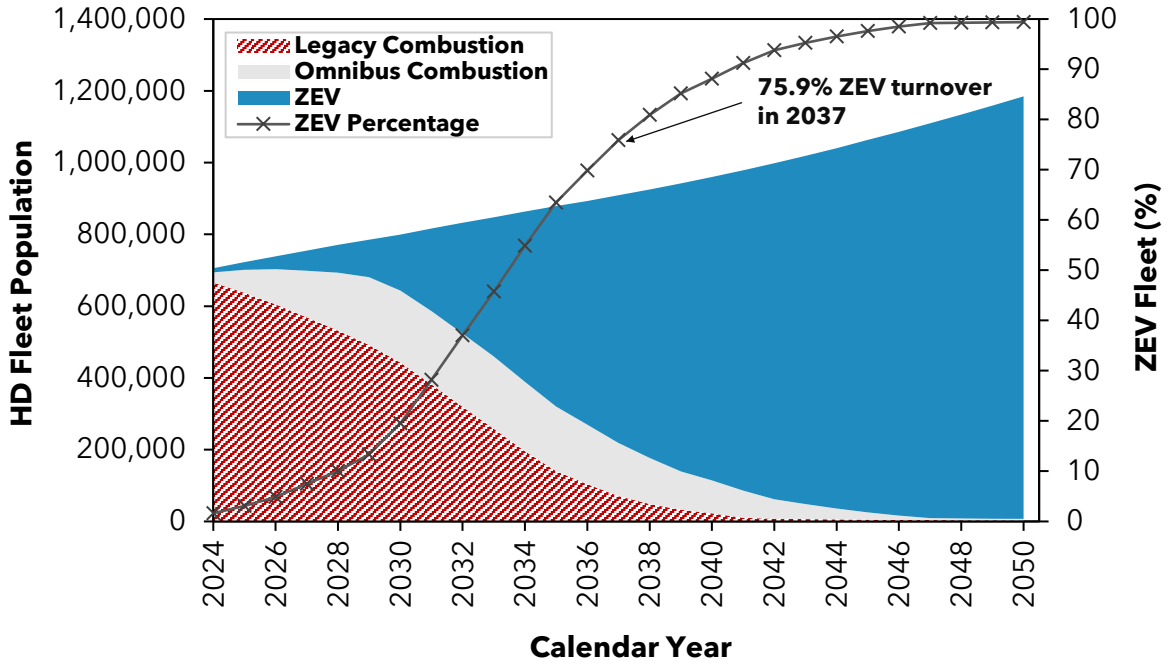

Table 17. Statewide Heavy-Duty Fleet Population Profile in 2037 and 2045 with Scenario B

Fleet Type	Fleet Percentage in 2037	Fleet Percentage in 2045
Legacy Combustion	7.8%	0.5%
Omnibus Combustion	16.3%	1.9%
ZEV	75.9%	97.6%

Link to Appendix B: *https://ww2.arb.ca.gov/sites/default/files/2025-08/UCB_ARB_ZET_Final.pdf*