State of California
Air Resources Board

Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation

Standardized Regulatory Impact Assessment (SRIA)

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1001 I Street
Sacramento, California 95814

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1 Introduction

Despite significant improvements in California's air quality over the past decades, major populated regions in California are still not in attainment with the federal particulate matter 2.5[1] (PM2.5) and ozone standards. Off-road vehicles are one of the larger sources of emissions today, as on-road vehicle emissions continue to be reduced by CARB regulations, and urgently warrant further control in light of pressing public health needs in communities across California. The Proposed Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation (Proposed Amendments) that this document preliminarily analyzes would require that fleets phase-out operation of their oldest and highest-emitting off-road diesel vehicles and put limits on what vehicles can be added to a fleet. The Proposed Amendments also include additional administrative requirements for prime contractors and public works awarding bodies with the goal of improving enforceability and compliance with the regulation.

Implementation of the Proposed Amendments, with requirements phased in from 2024 through 2036, would reduce emissions of oxides of nitrogen (NOx) from off-road diesel vehicles by as much as 24 percent and diesel particulate matter (PM) by as much as 42 percent, greatly decreasing health risks from air pollutants of off-road diesel vehicles operating in California. Table 1 provides a summary of the benefits expected from the full implementation to 2038 of the Proposed Amendments beyond what is expected over the same period from the current baseline regulation.

Table 1: Statewide Cumulative Benefits of Proposed Amendments by 2038

Benefit	Cumulative Benefit by 2038
NOx Reduction	31,218 tons
$PM_{2.5}$ Reduction	2,729 tons
Estimated Avoided Premature Deaths	574
Estimated Avoided Hospital Admissions	182
Estimated Avoided Emergency Room Visits for Asthma	278
Health Benefits Valuation (2020$)	$5.76 billion

The additional emissions reductions from the Proposed Amendments are expected to reduce the concentration of ozone and PM in the communities in which these vehicles operate, benefitting both local residents and the operators of the vehicles alike. Furthermore, the proposed administrative requirements will ensure that compliant fleets are not subject to unfair competition by fleets that have chosen not to comply through aiding enforcement of the regulation's provisions.

[1] PM2.5 is fine particulate matter that are 2.5 microns or less in diameter.

The Proposed Amendments address emissions from a wide variety of off-road diesel vehicles, regarding both size and function. Off-road vehicles range from small skid-steer loaders used in residential landscaping to very large mining trucks and include dozers, forklifts, cranes, and excavators. Section 7 (Appendix A) provides an overview of several different equipment types. The construction industry employs the highest use of off-road diesel vehicles in California, but these types of vehicles are also used by industries such as airlines, mining, equipment rental, oil and gas drilling, and the industrial sector. The industrial sector using these vehicles includes facilities, both wholesale and retail distribution points, throughout the State where forklifts, cranes and other tractors are used to facilitate manufacturing and to distribute raw materials and finished products. This sector includes a wide variety of business types, such as recycling facilities, landfills, refineries, power plants, retail and wholesale goods distribution, utility services, golf courses, ski resorts, sewage treatment plants, landscape materials, and factories. Government agencies also use these vehicles for road maintenance, lawn and tree care for recreational spaces, and other activities.

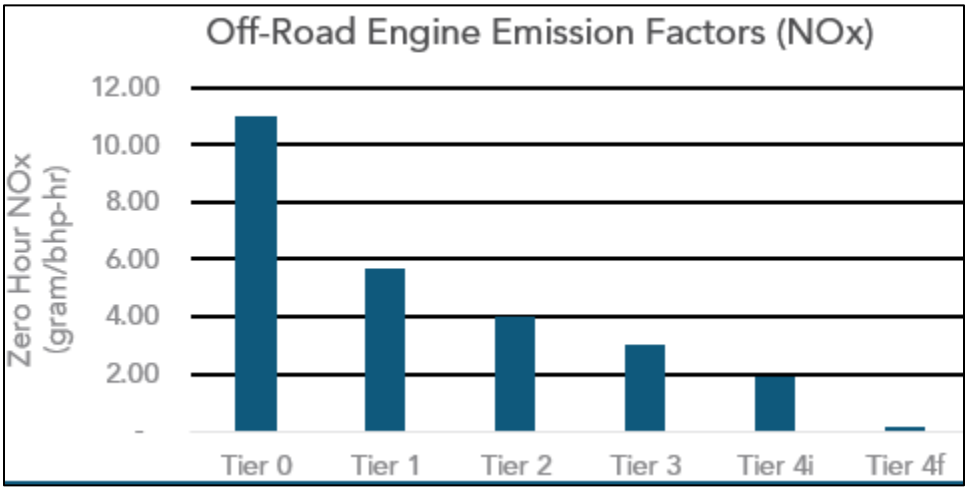
Achieving further PM and NOx reductions from the off-road sector is critically important to providing much needed public health protection for the millions of Californians who still breathe unhealthy air, to reducing community exposure to air toxics, and to helping meet current health based ambient air quality standards across California. Over the course of the fourteen-year implementation period, the Proposed Amendments' measures will lead to substantial PM and NOx reductions from one of the largest sources of emissions today and help avoid hundreds of premature deaths and pollution-related health impacts in communities across the state, with an overall health benefits valuation of over $5 billion.

1.1 Regulatory History

1.1.1 New Off-Road Engine Standards

Since the mid-1990s, new engine standards adopted by the United States Environmental Protection Agency (U.S. EPA) and the California Air Resources Board (CARB) have required new off-road compression-ignition engines to become progressively cleaner. In California, these standards, which are harmonized with U.S. EPA's, are contained in Title 13, California Code of Regulations (CCR), section 2423(b)(1) and reduce emissions of both oxides of nitrogen (NOx) and particulate matter (PM), among other pollutants, and apply to engine and equipment manufacturers. The emission standards are divided into four increasingly stringent levels, called Tiers. Until the mid-1990s, off-road diesel engines were not subject to any emission standards and are commonly known as Tier 0 or "uncontrolled". Tier 1 standards took effect starting 1996 through 2000, depending on engine size. Tier 2 engine standards followed, with all engine sizes subject to these standards by 2006. Between 2006 and 2008, Tier 3 standards took effect for some horsepower groups. Tier 4 standards are divided into two stages: Tier 4 interim, began between 2008 and 2012 for most engines, and Tier 4 final, became effective for all off-road engines by 2015. The Tier 4 final standards require the use of advanced exhaust after-treatment technologies to control both PM and NOx and result in diesel engines that emit 80 times less NOx than Tier 0 engines (100-175 horsepower) as seen in Figure 1 below.

Figure 1. Off-Road Emission Factors by Tier



1.1.2 In-Use Off-Road Diesel-Fueled Fleets Regulation

CARB approved the In-Use Off-Road Diesel-Fueled Fleets Regulation (Off-Road Regulation, CCR title 13, section 2449 et. seq.) in 2007 and formally adopted the regulation in 2008. The Off-Road Regulation was amended twice in 2009, and again in 2010. The purpose of this regulation is to reduce diesel PM, NOx, and other criteria air pollutants from in-use off-road heavy-duty vehicles in California. The Off-Road Regulation applies to owners of applicable vehicles operating within California and requires fleets to reduce their emissions by retiring older engines and replacing with newer engines, repowering, or installing verified diesel emission control strategies (VDECS); and restricts the adding of older vehicles to fleets. The regulation applies to owners of some specific on-road vehicles as well, such as workover rigs operating in the oil and gas industry, two-engine water-well drilling rigs, and other two-engine vehicles that are specially constructed. The Off-Road Regulation has been effective, but is in need of updates as technology continues to advance and California's air quality needs remain serious, as discussed further below.

The emission performance requirements of the Off-Road Regulation require fleets to meet declining fleet average targets that are phased in by fleet size. There are two ways to be compliant with the emission performance requirements of the Off-Road Regulation:

1. A fleet can either meet its fleet average target, calculated based on the fleet's equipment composition, or
2. Comply with the Best Available Control Technology (BACT) requirements (i.e., fleet must turn over a certain percent of total fleet horsepower or use accrued credits).

If a fleet meets the fleet target for a given year, it is not required to take further action. If a fleet does not meet its fleet target, it can comply by meeting the BACT requirement, which requires a fleet to turn over a certain percentage of the fleet's total horsepower (generally 10 percent) or use credits accrued by the fleet for actions taken in previous years. The phase in of the fleet average targets are described in Table 2. If a fleet does not meet its final fleet target by the final date shown in Table 2, the fleet is required to turn over 10 percent of its

total fleet horsepower each year until it meets that target. The Off-Road Regulation also has annual fleet reporting requirements, vehicle labeling requirements, and special provisions for vehicles that operate for less than 200 hours per year (low-use vehicles). The compliance dates and compliance requirements by fleet size are incorporated in CARB's baseline off-road emission inventory. For each year a fleet reports and submits a Responsible Official Affirmation of Reporting attesting to their compliance with the regulation, CARB issues a fleet Certificate of Reported Compliance.

Table 2. Fleet size, Phase-in Dates of Performance Requirements, and Number of Fleets and Vehicles

Fleet Size	Fleet Average Target or BACT Date (January 1)	Number of Fleets	Number of Vehicles (% of total)	Number of Fleets Meeting Final Target
Large (>5,000 total horsepower)	2014-2023	1,136	108,150 (55)	504
Medium (2,501 to 5000 total horsepower)	2017-2023	721	16,675 (9)	219
Small (≤2,500 total horsepower)	2019-2028	12,431	70,867 (36))	4,438
Ultra-small (optional) (< 500 total horsepower)	2019-2029	7,975 (subset of small)	18,403 (subset of small)	N/A[2]

As shown in Table 2, the Off-Road Regulation has been almost fully implemented for large and medium fleets. Small fleets and ultra-small fleets[3] are approximately halfway through implementation. Table 2 also shows the number of fleets that are already meeting their final fleet average target and have met full compliance of the emission performance requirements of Off-Road Regulation (January 1, 2023 targets for large and medium fleets and January 1, 2028 targets for small fleets). Note that these data are current as of April 2022 and do not reflect the number of fleets that will meet the fleet average target on January 1, 2023. As shown, 44 percent of large fleets, 30 percent of medium fleets, and 36 percent of small fleets have already met the full compliance of the Off-Road Regulation's emission performance requirements. The Proposed Amendments are designed to supplement the existing compliance of fleets.

1.1.3 Low Carbon Fuel Standard

CARB approved the Low Carbon Fuel Standard (LCFS) in 2009 and began implementation on January 1, 2011. Since 2009, the LCFS has been amended several times with the latest

[2] Ultra-small fleets are not required to meet a final fleet average target but instead are required to be comprised of 100 percent Tier 2 vehicles by January 1, 2029.

[3] Fleets with less than 500 total horsepower have the option of complying with the small fleet or ultra-small fleet requirements of the Off-Road Regulation. Fleets make this determination annually, so for most analytics and projections ultra-small fleets are assumed to be complying with small fleet provisions unless otherwise noted.

amendments approved in 2018. The LCFS is designed to decrease the carbon intensity (CI) of California's transportation fuel pool and provide an increasing range of low-carbon and renewable alternatives, which reduce petroleum dependency and achieve greenhouse gas and other air quality benefits. The LCFS sets annual CI standards, or benchmarks, which reduce over time, for gasoline, diesel, and the fuels that replace them. Fuels and fuel blendstocks with CIs below the benchmark generate credits which can be sold to offset the costs of the lower CI fuel to consumers; renewable diesel (R99) is generally one such fuel. The Proposed Amendments will require all fleets, with some exceptions, to use renewable diesel. Renewable diesel is currently available in volumes that would readily fulfill the fueling needs of vehicles subject to the Proposed Amendments. The LCFS will continue to drive production of renewable diesel and increase its availability in future years.

1.2 Proposed Amendments

The Proposed Amendments will further reduce criteria pollutant and toxic emissions from off-road diesel vehicles operating in California by phasing out the most polluting vehicles earlier or beyond what is required of fleets in the Off-Road Regulation. Reducing these emissions will provide much needed public health protection for the millions of Californians who still breathe unhealthy air, reduce community exposure to air toxics, and help to meet current health based ambient air quality standards across California. The importance of achieving further emissions reductions from the off-road sector is only getting more critical as the share of emissions from the on-road sector as a portion of total emissions continues to decline as a result of CARB's robust on-road regulatory and incentive policies.

The Proposed Amendments are designed to supplement the existing compliance of fleets, achieving further reductions from fleets that have fully implemented the Off-Road Regulation and, for fleets with further compliance obligations, it targets removal of the oldest and highest-emitting vehicles remaining in a fleet. The Proposed Amendments target the phased removal of the highly polluting and out-of-date Tier 0, 1, and 2 vehicles still currently in use by fleets and require the vehicles to be replaced with the cleanest available technology. The target of the Proposed Amendments aligns with the 2020 Mobile Source Strategy's (2020 MSS)[4] goal of reducing statewide NOx emissions from the construction and earth-moving sector by 7.5 tons per day by 2031 and full turnover of remaining Tier 0 through Tier 2 engines in the fleet between 2024 and 2033. The target of the Proposed Amendments also aligns with the measure in the Draft 2022 State Strategy for the State Implementation Plan (2022 State SIP Strategy)[5] to achieve reductions of 4.1 tons per day of NOx in 2037.

The Proposed Amendments achieve the necessary emission reductions through several key provisions that are described in more detail below:

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[4] California Air Resources Board's 2020 Mobile Source Strategy released October 28, 2021 (web link: *https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf*)

[5] Draft 2022 State Strategy for the State Implementation Plan, January 31, 2022. (web link: *https://ww2.arb.ca.gov/sites/default/files/2022-01/Draft_2022_State_SIP_Strategy.pdf*)

1. Phase out of the oldest and highest-emitting off-road engines (Tier 0, 1, or 2) from operation in California. This provision will be implemented by fleet size and engine Tier.
2. Extend existing provisions of the Off-Road Regulation that restrict the vehicle engine Tier a fleet can add to their fleet.
3. New requirements for public works awarding bodies and prime contractors that will require a review of a fleet's Certificate of Reported Compliance prior to awarding contract or hiring.
4. Mandate the use of R99 renewable diesel for all fleets, with some exceptions.
5. Voluntary compliance flexibility for fleets that adopt zero-emission technology.
6. Additional requirements to increase enforceability, provide clarity in implementation, and provide additional flexibility for permanent low-use vehicles.

1.2.1 Tier Phase-out

The Proposed Amendments will require that fleets no longer operate in California, vehicles with Tier 0, 1, or 2 off-road engines or a specified model year of on-road engine, phased-out over a schedule determined by fleet size in accordance with Table 3 below. Some exemptions apply, such as for vehicles used less than 200 hours per year (i.e., low-use).

Table 3. Tier and Model Year (MY) Phase-Out Dates by Fleet Size

Year (January 1)	Large Fleets	Medium Fleets	Small Fleets	Ultra-Small[6]
2024	Tier 0/MY 1994 or older on-road			
2026	Tier 1/MY 1999 or older on-road	Tier 0/MY 1994 or older on-road		
2028	Tier 2/MY 2003 or older on-road	Tier 1/MY 1999 or older on-road	Tier 0/MY 1994 or older on-road	
2030		Tier 2/MY 2003 or older on-road	Tier 1/MY 1999 or older on-road	
2032			Tier 2/MY 2003 or older on-road	
2036				Tier 2/MY 2003 or older on-road

In addition, for all fleet sizes, the Proposed Amendments will discontinue the low-use vehicle exemption for Tier 0 or model year 1994 or earlier on-road engines, requiring them to be required to be removed from the fleet's California operations by January 1, 2036. While the Tier phase-out is assumed to incur costs from purchasing new or used vehicles to replace the phased-out vehicles; the discontinuation of the low-use vehicle exemption for Tier 0 or model year 1994 or earlier on-road engines is assumed to have no cost because fleets will generally

[6] Ultra-small fleets are allowed to comply with the Off-Road Regulation using an optional compliance schedule which requires that they only operate Tier 2 or cleaner engines by January 1, 2029.

not directly replace these vehicles, which would be over 37 years old and would have been in low-use for a minimum of 8 years, by 2036.

These Tier phase-out and discontinuation of the low-use vehicle exemption for the oldest vehicles would greatly reduce operations of the oldest and highest-emitting vehicles in our communities throughout California. Even with low usage, these Tier 0 vehicles can contribute significant NOx and PM emissions compared to newer vehicles.

As mentioned previously, some fleets may still have further compliance obligations for the Off-Road Regulation when the compliance dates of the Proposed Amendments start. For example, currently 70 percent of medium and large fleets are complying with the Off-Road Regulation by meeting the annual fleet average targets. For the 30 percent of medium and large fleets that are complying with the Off-Road Regulation using BACT (i.e., 10 percent fleet turnover), the Proposed Amendments may result in a fleet needing to adjust its current compliance strategy to comply with Tier phase-out of the Proposed Amendments. However, the Proposed Amendments are designed so that any additional actions a fleet must take to comply with the Tier phase-out, can be used to comply with BACT.

1.2.2 Extension to the Adding Vehicles Requirements

The Proposed Amendments will extend an existing provision that already restricts the addition of Tier 0, 1, and 2 vehicles to fleets to further include a restriction on the addition of Tier 3 and Tier 4 interim (Tier 4i) vehicles, as well as model year 2006 or older on-road vehicles to fleets. The Proposed Amendments would disallow the addition of older technology engines into fleets based on a phased-in schedule determined by fleet size, in accordance with Table 4 below. This requirement would ensure that new vehicles added to a fleet would meet the cleanest standards.

Table 4. Compliance Dates for the Restrictions on Adding Vehicles

Year (January 1)	Large Fleets	Medium Fleets	Small and Ultra-Small Fleets
Adoption	Tier 3 or older	Tier 3 or older	Tier 3 or older
2024	Tier 4i/MY 2006 or older on-road	Tier 4i/MY 2006 or older on-road	
2028			Tier 4i/MY 2006 or older on-road

1.2.3 Public Works Requirements

Beginning January 1, 2024, the Proposed Amendments will impose new requirements for public works awarding bodies, which for the purpose of these Proposed Amendments, are considered to be any public agencies that award or enter into contracts for public works projects. These requirements are intended to enhance the enforceability of the Off-Road Regulation and do not have a direct emissions benefit, but will have an impact on the cost analysis. The requirements for public works awarding bodies are:

- To receive fleet Certificates of Reported Compliance from fleets prior to awarding public works contracts. These requirements will ensure that only compliant fleets are

being used on public works projects, reducing unfair competition and increasing enforceability of the regulation.
- To report to CARB basic information on public works projects that have been awarded, such as location, length of project, and information on all fleets working on the project known at the time of awarding the project.

1.2.4 Prime Contractor Requirements

Beginning June 1, 2024, the Proposed Amendments include new requirements for prime contractors which, for the purpose of these Proposed Amendments, is considered to be the entity that contracts directly with the project owner for any project involving the use of vehicles subject to this regulation. These requirements are included in the cost analysis but not expected to impact the benefits analysis. These requirements are intended to enhance the enforceability of the Off-Road Regulation and do not have a direct emissions benefit. The requirements for prime contractors are:

- To receive fleet Certificates of Reported Compliance from fleets prior to awarding contracts and to receive vehicle certificates of reported compliance once contracts have been awarded. Prime contractors will also be required to report any observed non-compliance with the Off-Road Regulation to CARB. These requirements will ensure prime contractors are only hiring compliant fleets, reducing unfair competition, and increasing enforceability of the regulation.

1.2.5 Renewable Diesel Requirements

Beginning January 1, 2024, the Proposed Amendments will require the use of R99 renewable diesel in certain fleets. This requirement will achieve significant near-term NOx and PM reductions in the benefits analysis but is not expected to have an impact on the cost analysis. CARB staff believe there will not be additional costs associated with these requirements, because renewable diesel prices in California[7] have historically been found to be similar to conventional diesel prices, generally due to credits generated through the LCFS. CARB staff also acknowledge that short-term forecasts for fuel prices can change abruptly, due to unexpected shocks in the economy. These shocks lead to fluctuations in diesel prices which make it difficult to predict future diesel prices, however, historical data also show that the price trends of both renewable diesel and conventional diesel generally move together[8] so that users of either fuel should experience similar impacts as a result of these price changes. The Proposed Amendments will not increase or decrease the volume of fuel used by the off-road vehicles that are impacted by the proposal.

The renewable diesel supply and distribution network is generally available throughout California due to LCFS. However, the fuel is used almost exclusively in the on-road sector.

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[7] Clean Cities Alternative Fuel Price Report released October 2021 (web link: *https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_october_2021.pdf*) .
[8] Clean Cities Alternative Fuel Price Reports October 2019 – October 2021 (web link: *https://afdc.energy.gov/publications/search/keyword/?q=alternative-fuel-price-report*).

On-road vehicles are significantly cleaner than older off-road vehicles due to the use of selective catalytic reduction and diesel particulate filters. Therefore, using renewable diesel in the older higher-emitting off-road vehicles will provide additional NOx and PM benefits. However, renewable diesel does not provide any additional NOx or PM benefits beyond its current use in on-road vehicles when used in the most advanced off-road vehicles (Tier 4 final). As such, CARB accounted for benefits of renewable diesel use in Tier 0 through Tier 4 interim engines, but not in Tier 4 final engines. The requirements pertaining to renewable diesel include the following:

- All fleets are required to use R99 renewable diesel fuel in all vehicles subject to the Proposed Amendments, with the exception of any fleet that is designated as solely operating in attainment areas (captive attainment area fleet) or a fleet that is comprised entirely of vehicles with Tier 4 final engines or model year 2007 or newer on-road engines.
- In each year that annual reporting is required under the Off-Road Regulation, a fleet shall submit to CARB an affirmation that the fleet complied with the renewable diesel use requirement.
- Fleets must document and retain records related to the use of renewable diesel or its lack of availability.

The reporting and records retention requirements are similar to existing requirements and would not result in additional administrative costs to fleets.

1.2.6 Additional Requirements

Additionally, the Proposed Amendments include the following changes that are not expected to impact the benefits and cost analyses:

Beginning January 1, 2024:

- Low-use provisions will be modified accordingly:
    - Provide additional flexibility to fleets for vehicles designated as permanent low-use by allowing fleets to average their vehicle use to less than 600 hours over 3 years to qualify as low-use (3-year rolling average),
    - Removing the year-by-year low-use definition and compliance options since the 3-year rolling average flexibility will be provided to permanent low-use vehicles, and
    - Providing for submittal to CARB of hour-meter documentation used to verify low-use vehicle hours of operation.

  These provisions would not require fleets to significantly change their current reporting and compliance requirements, and for this reason, are not expected to impact the benefit and cost analyses.

- To provide a regulatory incentive for the adoption of off-road zero-emission vehicles, a fleet may delay the phase-out of one vehicle with a Tier 1 or Tier 2 engine for two years for each zero-emission vehicle added, if all required conditions are met. Among

the conditions being considered are that the zero-emission vehicle should have a similar power output rating to the vehicle whose phase-out is being delayed. The use of this flexibility provision is voluntary and the degree to which it will be employed will depend on individual fleets' decisions and for this reason is not included in the benefit and cost analysis.

- Fleets shall not add a vehicle with a Tier 0 engine as a vehicle designated as a dedicated snow removal vehicle, a vehicle used for emergency operations, or a job corps vehicle. This will prohibit uncontrolled engines from being added to fleets to be used without operational constraints in these types of operations. In the last three reporting years (2019-2022), about forty Tier 0 vehicles were added to fleets for these operations. Fleets would still be allowed to add used vehicles with Tier 1 or newer engines to their fleet for these operations, so there would be no technical or availability challenges with compliance with this provision. Due to the limited scope of this provision, emission benefits were not included in the analysis. Cost impacts were also not included because of the limited scope and the compliance option to use vehicles with Tier 1 and newer engines.

Beginning January 1, 2028:

- Beginning January 1, 2028, a fleet may not add any model year 2028 or later engine or vehicle of any Tier to its fleet unless the engine is California-certified or certified to the California-equivalent emission standards applicable to model year 2028 and later equipment. This requirement also applies to model year 2028 and later replacement engines produced under the provisions of title 13 CCR, section 2423(j), and to federal replacement engines produced under the provisions of 40 Code of Federal Regulations, part 1068.240. Except as required or allowed by federal law, this requirement does not apply to new engines smaller than 175 horsepower that are used in construction equipment or vehicles, or used in farm equipment or vehicles. Currently, U.S. EPA and CARB off-road engine standards are aligned, therefore there is no additional cost or emissions benefit associated with this provision. This provision provides assurance that the cleanest engines continue to be used in California even if the off-road engine standards diverge at some point in the future. Costs and benefits associated with that change will be analyzed in full as part of that future regulatory effort.

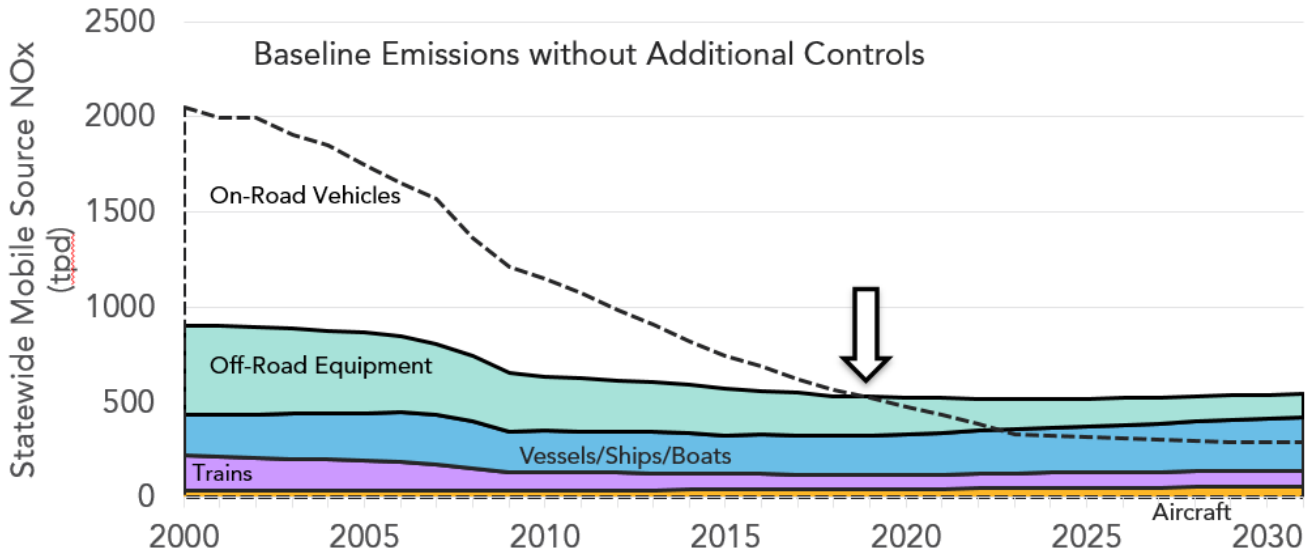
1.3 Statement of the Need of the Proposed Regulation

In the coming years, California needs to continue to build upon its successful efforts to meet critical health and environmental risk reduction goals as well as air quality goals. Achieving these goals will provide much needed public health protection for the millions of Californians who still breathe unhealthy air, reduce community exposure to air toxics, and help to meet current health based ambient air quality standards across California.

California has made significant improvements in its air quality over the past decade. However, despite these improvements, major populated regions in California are still not in attainment with the federal PM2.5 and ozone standards. In order to meet the federal air

quality standards and to improve public health, further PM and NOx emissions reductions are needed. These emissions reductions are especially needed from the off-road sector, as seen in Figure 2 below and presented to the Board as part of the 2020 Mobile Source Strategy[9]. The importance of achieving further emissions reductions from the off-road sector is only getting more critical as the share of emissions from the on-road sector as a portion of total emissions continues to decline as a result of CARB's robust on-road regulatory and incentive policies.

Figure 2. Statewide Emissions of NOx by Mobile Sector



The Legislature has granted CARB broad authority under the California Health and Safety Code (HSC) to adopt the Proposed Amendments. The California Legislature has designated CARB as the State agency that is "charged with coordinating efforts to attain and maintain ambient air quality standards, to conduct research into the causes of and solution to air pollution, and to systematically attack the serious problem caused by motor vehicles, which is the major source of air pollution in many areas of the State" (HSC 39003). The Legislature has authorized CARB to adopt standards, rules, and regulations needed to properly execute the powers and duties granted to and imposed on CARB by law (e.g., HSC 39601). It should also be noted that the federal Clean Air Act does generally preempt California from regulating emissions in certain ways from new farm and construction engines and equipment under 175 horsepower [section 209(e)(1)(A) of the federal Clean Air Act]. This provision does not apply to this concept because the Proposed Amendments do not include any new engine or equipment standards.

The Proposed Amendments will achieve PM and NOx emission reductions from restricting the addition of older off-road diesel-powered vehicles and accelerating the turnover of older,

[9] California Air Resources Board, 2020 Mobile Source Strategy Board Presentation, October 28, 2021. (web link: *https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2020/121020/20-13-6pres.pdf*)

higher-emitting vehicles, which are needed to meet these complementary goals. The Proposed Amendments will achieve NOx and PM emission reductions statewide, ensuring that fleets have consistent compliance obligations and that communities are protected from toxic emissions from off-road equipment in construction and other sector sources.

1.3.1 Need to Reduce NOx

Progress has been achieved in reducing NOx emissions from mobile sources statewide through the implementation of CARB's existing programs. These programs are expected to continue to provide further emission reductions, helping the State to meet air quality standards. However, challenges remain in meeting the federal ambient air quality standard for ozone for several areas throughout the State, and these areas are considered nonattainment areas. Ozone nonattainment areas are classified according to the severity of their air pollution problem. Nineteen areas in California are designated as nonattainment, and of those nineteen, ten areas are classified as Moderate and above for the 70 parts per billion (ppb) ozone standard[10]. These areas include California's large urban regions as well as rural downwind areas, and more than half (21 million out of nearly 40 million) of Californians live in areas that exceed the 70 ppb ozone standard. The South Coast Air Basin and San Joaquin Valley are the only two regions that are classified as Extreme in the nation. The near-term targets for these areas are a 2023 deadline for attainment of the 80 ppb 8-hour ozone standard, and the mid-term attainment years of 2031 and 2037 for the more recent 8-hour ozone standards of 75 ppb and 70 ppb, respectively[11]. Additional NOx reductions from the off-road sector, one of the largest sources of NOx emissions in the State, are essential to meeting these air quality standards.

1.3.2 Need to Reduce Particulate Matter (PM)

Challenges remain in meeting the PM2.5 ambient air quality standard, especially for the two areas of the State with extreme air quality issues: the South Coast Air Basin and San Joaquin Valley. The near-term targets for these areas are to meet the 35 microgram per cubic meter ($\mu g/m^3$) 24-hour PM2.5 standard by 2024, and the 12 $\mu g/m^3$ annual PM2.5 standard by 2025. It is also important to note that NOx is a precursor to secondary PM2.5 formation, so reductions in NOx emissions also provide benefits to help meet the PM2.5 standards. As a significant source of PM2.5, the off-road sector needs additional reductions to meet these air quality standards.

In addition to meeting the PM2.5 ambient air quality standard, California also needs to reduce diesel PM emissions in order to reduce its associated public health risks associated. Diesel PM has been identified as a toxic air contaminant (TAC) by CARB and poses a significant public health risk, especially at the local level. Action is needed to reduce diesel PM at a statewide level to reduce the health risk throughout California, especially in communities that experience disproportionate burdens from exposure to TACs. The

[10] Based on 2020 monitored ozone design values contoured over population by census tract.
[11] California Air Resources Board, 2020 Mobile Source Strategy, October 28, 2021. (web link: *https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf*)

Proposed Amendments would achieve PM reductions that are necessary to achieve PM2.5 federal attainment as well as reduce the public health risk from diesel PM emissions throughout California communities.

Black carbon is a component of PM2.5 and is identified as a short-lived climate pollutant, which CARB is working towards reducing in California. Because the Proposed Amendment would achieve PM reductions, the added co-benefit of reducing black carbon emissions in California would help California attain its short-lived climate pollutant reduction goals.

1.3.3 Need to Address State Policy and Plans Directing CARB to Achieve Further Emission Reductions from the Off-Road Diesel Sector

The Proposed Amendments are needed to achieve the State policies and plans directing CARB to obtain additional diesel emission reductions and are summarized below.

1.3.3.1 2020 Mobile Source Strategy

CARB released the 2020 Mobile Source Strategy (MSS) in October 2021[12]. The 2020 MSS was developed through a public process that included two virtual workshops and presentations at three Board meetings and is a top-down document outlining key emissions reductions needs to be further developed in specific regulatory processes. The strategy document looks at existing and emerging technologies to reduce emissions from California's transportation sector, including cars, trucks, trains, ships, and other on-road and off-road sources. It provides a top-down description of key needs, intended to be evaluated through subsequent public processes, including regulatory processes like this one. The strategies laid out in the MSS illustrate the technology mixes needed for the State to meet its various clean air goals, including federal ambient air quality standards, community risk reduction, and ambitious mid-and long-term climate change targets. The MSS includes a phase-out of Tier 0, 1, and 2 equipment in the off-road diesel sector between 2024 and 2033, as well as limiting the addition of Tier 3 and 4 interim equipment to fleets.

1.3.3.2 2022 State Strategy for the State Implementation Plan

The federal Clean Air Act requires areas that exceed the health-based national ambient air quality standards to develop State Implementation Plans (SIP) that demonstrate how they will attain the standards by specified dates. After an extensive public process including three public workshops and an informational update to the Board, in January 2022, CARB released the Draft 2022 State Strategy for the State Implementation Plan (2022 State SIP Strategy)[13], which outlines CARB's comprehensive strategy to reduce emissions from mobile sources to meet critical air quality and climate goals over the coming years. CARB anticipates taking the Proposed 2022 State SIP Strategy to the Board for consideration in Summer 2022. The State SIP Strategy includes statewide control measures CARB is committing to bring to the Board for adoption to achieve the NOx reductions needed for attainment. These Proposed

[12] See note 4

[13] See note 5

Amendments constitute one of the control measures that is committed in the Draft 2022 State SIP Strategy.

1.3.3.3 Executive Order N-79-20

In September 2020, Governor Newsom issued Executive Order (EO) N-79-20[14], which directed CARB, in coordination with other State agencies, U.S. EPA, and local air districts, to develop and propose strategies to achieve 100 percent zero-emission from off-road vehicles and equipment operations in the State by 2035 where technologically feasible and cost-effective. The Proposed Amendments support the directive of the EO by introducing a voluntary regulatory incentive that provides compliance flexibility for fleets that adopt zero-emission off-road technology which will encourage early adoption of the technology needed to meet the governor's directive.

1.3.3.4 Assembly Bill 617

The State of California placed additional emphasis on protecting local communities from the harmful effects of air pollution through the passage of Assembly Bill (AB) 617 (C. Garcia, Chapter 136, Statutes of 2017)[15]. AB 617 is a significant piece of air quality legislation that highlights the need for further emission reductions in communities with high exposure burdens. AB 617 requires CARB to pursue new community-focused and community-driven actions to reduce air pollution and improve public health in communities that experience disproportionate burdens from exposure to air pollutants. Under AB 617, selected communities were chosen to develop and adopt a Community Emission Reduction Plan (CERP). CERPs, such as those of South Coast[16], San Joaquin Valley[17], and Imperial County[18] recognize off-road diesel vehicles as major contributors and plan to work on mitigation measures. In addition, the South Central Fresno CERP[19] promotes the use of biodiesel/renewable diesel fuels. The Proposed Amendments are expected to reduce diesel off-road emissions and exposure statewide and will be of particular benefit in disadvantaged communities experiencing disproportionate burdens.

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[14] Executive Order N-79-20, State of California Executive Order signed by Governor Gavin Newsom, September 23, 2020. (web link: *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf*)

[15] California Health and Safety Code §§ 39607.1, 40920.6, 40920.8, 42400, 42402, 42411, 42705.5, 44391.2; Assembly Bill No. 617, Nonvehicular Air Pollution: Criteria Air Pollutants and Toxic Air Contaminants, July 26, 2017. (web link: *https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB617*)

[16] Community Emissions Reduction Plans, South Coast Air Quality Management District. (web link: *http://www.aqmd.gov/nav/about/initiatives/environmental-justice/ab617-134*)

[17] Community Emissions Reduction Program, San Joaquin Valley Air Pollution Control District. (web link: *https://community.valleyair.org/community-emission-reduction-programs*)

[18] Community Emissions Reduction Plan, Imperial County. (web link: *https://www.icab617community.org/_files/ugd/99eb03_080a305618f5453cb0c69272eb622946.pdf*)

[19] Community Emissions Reduction Program, South Central Fresno. (web link: *https://community.valleyair.org/media/1516/01finalscfresnocerp-9-19-19.pdf*)

1.3.3.5 Short-Lived Climate Pollutant Reduction Strategy

CARB's Short-Lived Climate Pollutant (SLCP) Reduction Strategy[20] developed a range of options intended to accelerate the reduction of emissions of SLCPs in California, which include black carbon (soot), methane (CH4), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs). The SLCP specifically calls out the need for further diesel PM2.5 emissions reductions in order to reduce black carbon and quantifies the amount of black carbon that will be reduced as a result of regulatory items moving forward under the SIP process which these Proposed Amendments are a part of. The Proposed Amendments do not directly quantify black carbon emission reductions, but reducing diesel PM2.5 has the co-benefit of reducing black carbon which is a key strategy outlined in the SLCP.

1.3.4 Need to Amend the In-Use Off-Road Diesel-Fueled Fleets Regulation

The existing In-Use Off-Road Diesel-Fueled Fleets Regulation requires that fleets meet an increasingly stringent set of fleet average targets, culminating in 2023 for large and medium fleets, and in 2028 for small fleets. The most stringent fleet average target generally corresponds to roughly a 2012 model year, or a Tier 3 average standard. While this regulation has resulted in significant emissions reductions from the sector, the regulation does allow Tier 0, 1, and 2 equipment to continue operating indefinitely with no activity restrictions (dependent on the mix of other equipment owned by the fleet). For comparison, a single Tier 0 off-road engine in the 100-175 hp bin has 80 times higher NOx emissions than a Tier 4 Final off-road engine. By 2031, this Tier 0 equipment will be 32 years old or more, Tier 1 will be 28 to 31 years old, and Tier 2 will be 24 to 27 years old. Significant emissions benefits can be achieved by targeting this older, high-polluting equipment.

The Proposed Amendments target the removal of the Tier 0, 1, and 2 vehicles currently in use and ensure that the vehicles will be replaced with the cleanest available technology. Without these amendments, CARB cannot achieve the necessary emissions reductions described in previous sections. This is especially critical in addressing the need to reduce diesel PM at the community level to reduce the public health risk of TACs because under the Proposed Amendments, the oldest and highest-emitting vehicles will no longer be allowed to operate in those communities.

CARB also set forth goals for the Proposed Amendments to increase the enforceability of the regulation and simplify what is required of fleets to improve the effectiveness of the regulation. The intent of these changes is to ensure a level playing field among the regulated community as well as to ensure that the projected emission reductions are being achieved.

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[20] Short Lived Climate Pollutant Reduction Strategy, March 2017. (web link: *https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf*)

1.4 Major Regulation Determination

Per Department of Finance regulations (title 1, CCR, sections 2000-2004), the Proposed Amendments are a major regulation requiring a SRIA because the economic impact of the regulation is projected to exceed $50 million in a 12-month period. The Proposed Amendments result in direct costs exceeding $50 million each year beginning in 2023. Staff estimates that the Proposed Amendments will become effective in 2023 and be fully implemented by January 1, 2036. The SRIA analyzes costs to comply with the Proposed Amendments from 2023 through 2038.

1.5 Baseline Information

For this SRIA, the economic and emissions impacts of the Proposed Amendments are evaluated against a baseline scenario each year for the analysis period spanning 2023 through 2038, two years after all the requirements of the Proposed Amendments take effect. The "modeled" baseline reflects implementation and full compliance with existing federal and state emission standards for off-road diesel engines and diesel fuel, as well as with the current Off-Road Regulation amended in 2010, as described in Section 1.1.2. This baseline uses the 2022 Statewide In-Use Off-Road Emissions Inventory model to estimate emissions for the baseline, as well as to forecast the number of in-use equipment each year from 2023 through 2038 for which there are direct costs or benefits associated with the Proposed Amendments. The Proposed Amendments will introduce requirements that would alter the age composition of the fleet through its phase-out requirements and vehicle addition restrictions. The composition of the baseline fleet is shown in Table 5.

Table 5. Composition of the Baseline Statewide Off-Road Diesel Vehicle Population by Tier and by Calendar Year.

Year	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4 Interim	Tier 4 Final
2023	17,300	13,500	19,800	11,200	19,700	111,100
2024	16,300	11,600	17,800	10,200	18,400	118,300
2025	15,400	10,000	15,800	9,200	17,100	125,100
2026	14,500	8,700	13,900	8,300	15,800	131,400
2027	13,800	7,700	12,000	7,300	14,500	137,300
2028	13,000	6,900	10,300	6,400	13,200	142,700
2029	12,100	6,400	8,800	5,600	11,900	147,700
2030	11,400	6,200	7,600	4,900	10,800	151,800
2031	10,500	6,000	6,500	4,300	9,600	155,600
2032	9,700	5,900	5,700	3,700	8,500	159,000
2033	8,900	5,900	5,100	3,100	7,500	162,100
2034	8,100	5,900	4,700	2,700	6,500	164,700
2035	7,200	5,800	4,500	2,400	5,600	167,000
2036	6,500	5,700	4,400	2,100	4,900	169,100
2037	5,800	5,500	4,300	1,900	4,200	170,800
2038	5,200	5,200	4,300	1,800	3,700	172,400

CARB's previous in-use off-road inventory model was released in 2010. The 2022 updates are being implemented to support the new regulatory amendment efforts, including emissions and cost analyses. An overview of the updates to the inventory and the proposed methodology was discussed and public comments were received at the December 14, 2021 workshop for the Proposed Amendments. In addition, CARB staff conducted several meetings with stakeholders to discuss the inventory directly. An updated inventory methodology document will be released for public comment prior to the CARB Board hearing as part of the Initial Statement of Reasons (ISOR) and will contain detailed information on the data sources and methodology used in the 2022 Statewide In-Use Off-Road Emissions Inventory model. More details on the 2022 Statewide In-Use Off-Road Emissions Inventory model can be found in Section 2.1.1.

As discussed in the Introduction, the Proposed Amendments address emissions from a wide variety of off-road diesel vehicles operating in several different industries. Table 6 displays the industries and associated North American Industry Classification System (NAICS)[21] code impacted by the Proposed Amendments as well as each industry's share of the percentage of

[21] U.S. Census. North American Industry Classification System, 2022. Available at: *https://www.census.gov/naics/*

the total vehicle population[22]. The Off-Road Regulation does not require fleets to report the industry that they operate in, so CARB staff assumes these industries are represented the same among the different fleet sizes.

Table 6. Industries Impacted by the Proposed Amendments

Industry	NAICS Code	Percent of Vehicle Population
Mining, quarrying, and oil and gas extraction	21	10%
Construction	23	53%
Air transportation	481	3%
Commercial and industrial machinery and equipment rental and leasing	5324	15%
Waste management and remediation services	562	4%
Services to buildings and dwellings	5617	5%
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	8113	5%
State Government	N/A	1%
Local Government	N/A	3%
Federal Civilian	N/A	1%
Total		100%

1.6 Public Outreach and Input

CARB staff conducted 2 virtual public workshops, 3 workgroup meetings, and over 20 individual meetings with stakeholders upon request to gather additional information and feedback during the development of the Proposed Amendments. Attendees of these meetings included impacted community members, industry stakeholders, local air districts, consultants, construction companies, off-road vehicle operators, and vehicle manufacturers. Staff established the Proposed Amendments email, ordamendments@arb.ca.gov, so that the public may reach out to CARB staff at any time. In addition, in August 2021, CARB sent a postcard announcing multiple regulatory efforts, including the Proposed Amendments, to about 273,000 recipients who own class 3-8 non-gasoline vehicles in California.

[22] See Table V-1 (page 45) in the CARB document, Technical Support Document: Proposed Regulation for In-Use Off-Road Diesel Vehicles, for vehicle population breakdown. Available at: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2007/ordiesl07/tsd.pdf*.

CARB staff published two posts on CARB's Environmental Justice Blog[23] to encourage feedback from underserved community groups in California that may be impacted by emissions from off-road vehicles or by the Off-Road Regulation. The first post was published on September 15, 2021 and the second post was published on November 30, 2021. Both posts included information about the current regulation and the potential amendments along with links to register for public meetings.

1.6.1 Public Workshops

CARB staff conducted 2 workshops to discuss the amendment concept and solicit feedback from stakeholders. Staff notified stakeholders of the first workshop by posting notices to CARB's website for the Off-Road Regulation[24] and also by distributing the notice to several public Govdelivery topic lists, such as the Agricultural Activities, Zero-Emission Forklifts, Off-Road Equipment (In-Use) Control Measure, Mobile Source Emission Inventory, State Implementation Plan, Workshops Sponsored by CARB, Enforcement Activities, and Environmental Justice Stakeholders Group lists. Combined, these lists have over 40,000 subscribers. In addition, all off-road diesel fleets with accounts in DOORS[25], the reporting tool for the Off-Road Regulation, were sent an email announcing the first workshop. The second workshop was posted to the Off-Road Equipment (In-Use) Control Measure topic list, which has more than 7,000 subscribers. The workshops were open to all members of the public. Staff posted meeting materials, including agendas, slide presentations, and amendment concept language on CARB's Proposed Amendment webpage prior to the workshops.

The first workshop was held virtually on May 6, 2021 using GoToWebinar. CARB staff presented a background on the existing Off-Road Regulation and a status update on fleet compliance and implementation. CARB staff also presented the need for amendments to the existing regulation to achieve additional emission reductions and established a goal to simplify the requirements for regulated parties. CARB provided a conceptual proposal of how the amendments could be structured to achieve the emission reductions needed in alignment with the 2020 Mobile Source Strategy and to simplify regulatory requirements. In addition, staff went over next steps and the amendment timeline. Attendees included local air districts, consultants, construction companies, off-road vehicle operators, and industry stakeholders. CARB staff solicited alternatives to the conceptual proposal presented at this workshop. The workshop included 550 attendees. The workshop was not recorded.

The second workshop was held virtually on December 14, 2021 using GoToWebinar. CARB staff presented a more refined and comprehensive concept of the potential amendments to the Off-Road Regulation that built upon the concepts presented at the kick-off workshop on May 6th. These included: a phase-out of the oldest and highest-emitting vehicles in the fleet

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[23] California Air Resources Board, Environmental Justice Blog (web link: *https://carbej.blogspot.com/*)

[24] California Air Resources Board, In-Use Off-Road Diesel-Fueled Fleets Regulation website (web link: *https://ww2.arb.ca.gov/our-work/programs/use-road-diesel-fueled-fleets-regulation*)

[25] California Air Resources Board, DOORS. (web link: *https://ssl.arb.ca.gov/ssldoors/doors_reporting/doors_login.html*).

(Tier 0-2 vehicles), an extension to the restrictions on adding vehicles to a fleet to include Tier 3 and Tier 4 interim vehicles, and the elimination of the year-by-year low-use option. In addition, staff discussed renewable diesel requirements and reporting requirements for prime contractors and public works awarding bodies, and voluntary flexibility provisions for the addition of zero-emission vehicles to a fleet. The second half of this workshop focused on the off-road inventory and covered data sources and methodology for the emission inventory, including population, activity, and emission rates. CARB staff solicited alternatives to the proposed concept discussed at this workshop, which had an attendance of 263. The workshop was recorded and posted on CARB's website for the Off-Road Regulation under Workshops and Meetings.

1.6.2 Public Workgroup Meetings

CARB staff conducted three virtual workgroup meetings on GoToWebinar to solicit stakeholder feedback and discussed potential renewable diesel requirements, prime contractor and public works requirements, and costs and incentives associated with the potential amendments. The notice and information to register for the workgroups was posted to CARB's website for the Off-Road Regulation. In addition, the notice was distributed to the Off-Road Equipment (In-Use) Control Measure topic list before each workgroup. The workgroup meetings were open to all members of the public. Staff posted slide presentations prior to the workgroups on CARB's website for the Off-Road Regulation.

Staff held the first workgroup virtually on September 10, 2021 to discuss the use of renewable diesel in the off-road sector. Staff assessed the potential benefits and emission reductions of renewable diesel, and during the meeting, staff discussed the potential requirements and exemptions for utilizing renewable diesel. The workgroup solicited stakeholder feedback on fuel contracting cycles and costs to switch from conventional diesel to renewable diesel. The workgroup meeting was comprised of 101 attendees. The workgroup was not recorded.

Staff held the second workgroup virtually on September 21, 2021 to discuss proposed requirements for contractors and public works awarding bodies. Staff did additional public outreach for this workgroup to reach a broader audience by publishing an industry bulletin[26] through the Contractors State Licensing Board to invite licensees to participate in the workgroup. Additionally, staff distributed the notice for this workgroup to the Fleet Rule for Public Agencies and Utilities and the Environmental Justice Stakeholders Group topic lists, which have a combined 9,800 subscribers. Staff went over the potential applicability, vehicle certificates, and record keeping requirements for public works awarding bodies. This workgroup solicited stakeholder feedback on vehicle certificate requirements and discussed the potential implications and costs of the additional requirements. The workgroup meeting was comprised of 124 attendees. The workgroup was recorded and posted on CARB's website for the Off-Road Regulation under Workshops and Meetings.

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[26] Contractors State Licensing Board Industry Bulletin (web link: *https://www.cslb.ca.gov/Resources/IndustryBulletins/2021/21-16_CARB_Workgroup.pdf*)

Staff held the third workgroup virtually on October 15, 2021 to discuss the development of the cost analysis and availability of incentive funds for clean construction equipment. The first part of this workgroup centered around a discussion of the cost analysis and methodology, which included topics such as data sources and data gathering. The second part of this workgroup focused on the availability of incentive programs and how the programs might overlay with the proposed amendments for the off-road construction industry. The workgroup meeting was comprised of 73 attendees. The workgroup was recorded and posted on CARB's website for the Off-Road Regulation under Workshops and Meetings.

1.6.3 Stakeholder Meetings

CARB staff has conducted more than 20 informal virtual meetings and attended 1 site visit since March 2021 with a variety of stakeholders, as of April 2022. These meetings have been held with representatives from various groups including fleet managers (both private and governmental), regulated fleets, public works awarding bodies, vehicle and engine manufacturers, rental companies, biodiesel representatives, and consultants and company officials that represent large, medium, and small fleets subject to the Off-Road Regulation. Various topics were discussed based on the needs of the stakeholder group. These topics primarily focused on the new provisions of the proposed amendments and included: challenges with renewable diesel and its availability, new requirements for prime contractors and public works awarding bodies, challenges with the proposed Tier phase-out and early dates for Tier 0, the proposed extension on the restriction on adding Tier 3 and Tier 4 interim vehicles to a fleet, and the removal of the year-by-year low-use provisions.

2 Benefits

The Off-Road Regulation reduces emissions of NOx and PM by requiring that fleets meet declining fleet emission targets through replacing or retiring older vehicles, replacing older engines in vehicles, or installing Verified Diesel Emission Control Strategies. The Proposed Amendments will further reduce emissions of NOx and PM by introducing a mandatory Tier phase-out on uncontrolled Tier 0 engines, and engines certified to Tier 1 and Tier 2 standards, requiring the use of renewable diesel, and prohibiting the addition of engines certified to a standard older than Tier 4 final standards. Finally, the Proposed Amendments will improve reporting and enforceability to achieve a more level playing field among the regulated community and ensure the projected emission reductions are being achieved.

NOx is a precursor to ozone and secondary particulate matter formation. Exposure to ozone and to PM2.5 is associated with increases in premature death, hospitalizations, visits to doctors, use of medication, and emergency room visits due to exacerbation of chronic heart and lung diseases and other adverse health conditions. California's South Coast air basin has the highest ozone pollution levels in the nation. The San Joaquin Valley has some of the highest levels of PM2.5 in the nation. Reducing this pollution would benefit Californians by reducing emergency room and doctor's office visits for asthma, hospitalizations for worsened heart diseases, and premature deaths. This in turn would result in reduced asthma-related school absences, reduced sick days off from work, reduced health care costs and increased economic productivity. Furthermore, the Proposed Amendments are expected to reduce

diesel off-road emissions statewide which will provide a particular benefit in disadvantaged communities that may bear a disproportionate health burden due to projects in their vicinity.

Cumulatively, from 2024 through 2038[27], corresponding to the first set of requirements and the second year after the final set of requirements take effect, the Proposed Amendments are expected to reduce statewide emissions from off-road diesel-fueled vehicles by approximately 31,218 tons of NOx and 2,729 tons of PM beyond the reductions expected from the base regulation. The total statewide valuation of avoided health outcomes of the Proposed Amendments from 2024 through 2038 is approximately $5.76 billion. The additional emissions reductions from the Proposed Amendments are expected to reduce the concentration of ozone and PM in the communities in which these vehicles operate, benefitting both local residents and the operators of the vehicles alike.

The Proposed Amendments will also introduce additional requirements to reporting, specifically for prime contractors and public works awarding bodies. These changes are intended to enhance enforcement of the regulation to better assure that the emissions reductions expected from the Off-Road Regulation and the Proposed Amendments will be realized, as well as to ensure that compliant fleets are not subject to unfair competition by fleets that have chosen not to comply.

2.1 Emission Benefits

2.1.1 Inventory Methodology

For the SRIA, CARB staff used the 2022 Statewide In-Use Off-Road Emissions Inventory Model to estimate emissions for the baseline, as well as to forecast the number of in-use equipment each year from 2023 through 2038 for which there are direct costs or benefits associated with the Proposed Amendments. CARB's previous in-use off-road inventory model was released in 2010. The 2022 updates are being implemented to support the new regulatory amendment efforts, including emissions and cost analyses. An overview of the updates to the inventory and the proposed methodology was discussed and public comments were received at the December 14, 2021 workshop for the Proposed Amendments. In addition, CARB staff conducted several meetings with stakeholders to discuss the inventory directly. An updated inventory methodology document will be released for public comment prior to the Board hearing as part of the Initial Statement of Reasons (ISOR) and will contain detailed information on the data sources and methodology used in the 2022 Statewide In-Use Off-Road Emissions Inventory Model.

The updates incorporate the most recent information available, including the following:

- Vehicle and engine data from the DOORS online reporting system as of 2020.

[27] Note that costs are analyzed starting in 2023 to account for the actions that fleets will need to take to comply with the January 1, 2024 requirements. Benefits are analyzed starting 2024 to reflect the first full year of implementation of those January 1, 2024 requirements.

- Activity hours profiles created from the results of the 2020 Off-Road Activity Survey, an optional survey conducted via the DOORS online reporting system.
- Yearly fuel used adjustment, created using information from the U.S. Energy Information Administration (EIA) and the California State Board of Equalization (BoE) fuel reports.
- Survival and purchasing curves developed from the age distribution of equipment reported in DOORS.
- Emission factors[28] developed in 2017 for the Mobile Source Emissions Inventory[29].

The inventory used in this analysis is based on a 2020 baseline and forecasts emissions for future years for each equipment category and pollutant. The emissions for any given year are a function of the population, hours of engine activity, engine horsepower, load factors, emission factors, and fuel correction factors, as shown in the following equation:

$$\text{Emissions} = \text{Population} \times \text{Activity} \times \text{Hp} \times \text{LF} \times \text{EF} \times \text{FCF}$$

Where:

Population = Count of equipment

Activity = Time the engine is running in hours

Hp = Maximum brake horsepower of the engine

LF = Load factor (Average fraction of max power rating of engine during normal operations)

EF = Emission Factor (grams per horsepower-hour) specific to horsepower, engine build year, and the specific pollutant. Includes a deterioration factor.

FCF = fuel correction factor, based on calendar year

2.1.2 Anticipated Emission Benefits

The Proposed Amendments are expected to reduce NOx and PM from off-road diesel-fueled vehicles operating in California beyond what would be achieved under the current Off-Road Diesel-Fueled Fleets Regulation[30]. The first emission reductions are expected to occur upon

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[28] Emission factors are based on manufacturer information which has gone through extensive public process as part of several other CARB rulemakings (Portable Engine Air Toxics Control Measure, Cargo Handling Equipment Regulation to name a few), the agricultural inventory update and the December 2021 workshop on the Proposed Amendments.

[29] CARB Mobile Source Emission Inventory Documentation Off-Road Diesel Equipment (web link: *https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road*)

[30] As the engines impacted by the requirements of this regulation are not subject to greenhouse gas certification standards, no GHG analysis was completed for the replacement of these engines. CARB staff did

adoption when the prohibition on adding Tier 3 engines takes effect, followed by requirements in 2024, when the requirement to use renewable diesel fuel, the Tier phase-out for uncontrolled Tier 0 engines in large fleets, and the prohibition on adding Tier 4 interim engines in large and medium fleets begin. After successive phases, the regulation culminates with all fleets of any size subject to the phase-out of Tier 2 and older engines, the continuation of the renewable diesel requirement, the prohibition on adding engines certified to a tier lower than Tier 4 Final, and the retirement of all remaining Tier 0 engines, including those in low-use, by 2036.

Emissions reductions estimates from the amendments were performed based on the 2022 Statewide In-Use Off-Road Inventory Model. Staff estimated the reductions from the Tier phase-out provisions to be realized from a combination of retiring the older vehicle or placing the older vehicle into low-use as well as a combination of purchasing a new or used vehicle to replace the older vehicle, or simply downsizing the fleet. The likelihood of each option, and the average age of used vehicles purchased, were determined based on responses to a survey, conducted at the suggestion of stakeholders, after the October 2021 workgroup meeting. Benefits from the use of renewable diesel were estimated to be a 10 percent reduction in NOx and a 30 percent reduction in PM emitted from engines that are Tier 4 Interim and older.[31] Finally, in estimating the emissions reductions from the 2036 Tier 0 low-use phase-out, because vehicles with Tier 0 engines would be at least 37 years old by 2036, and because they would have already been placed into low-use a minimum of 8 years, staff assumed that generally, they would not be replaced.

Staff estimate that from 2024 through 2038, the Proposed Amendments would reduce cumulative statewide emissions by approximately 31,218 tons of NOx and 2,729 tons of PM beyond expected emissions reductions from the base regulation. Table 7 shows the estimated annual emission reductions that would result from the Proposed Amendments from 2024 through 2038; Figure 3 and Figure 4 show the difference in emissions between the baseline scenario and the Proposed Amendments for NOx and PM, respectively.

Table 7. Estimated Annual NOx and PM Emission Reductions Resulting from the Proposed Amendments from 2024 through 2038 Beyond the Baseline Emission Reductions

Year	NOx (tons)	PM (tons)
2024	2,592	276
2025	2,334	249
2026	2,678	250
2027	2,387	224
2028	2,911	243

not analyze a potential GHG benefit from the voluntary zero-emission compliance flexibility provision as the degree to which it will be employed will depend on individual fleets' decisions. Furthermore, any GHG benefit derived from the use of renewable diesel is already accounted for in the LCFS and is not evaluated here.

[31] CalEPA, Staff Report: Multimedia Evaluation of Renewable Diesel (weblink: *https://ww3.arb.ca.gov/fuels/multimedia/meetings/renewabledieselstaffreport_nov2013.pdf*)

Year	NOx (tons)	PM (tons)
2029	2,537	214
2030	2,488	202
2031	2,181	178
2032	2,000	162
2033	1,747	142
2034	1,529	124
2035	1,344	109
2036	1,671	133
2037	1,489	119
2038	1,331	106
Total	**31,218**	**2,729**

Note: Values have been rounded

Figure 3. Statewide NOx Emissions from Off-Road Diesel Vehicles under the Baseline and Proposed Amendments from 2022 through 2038

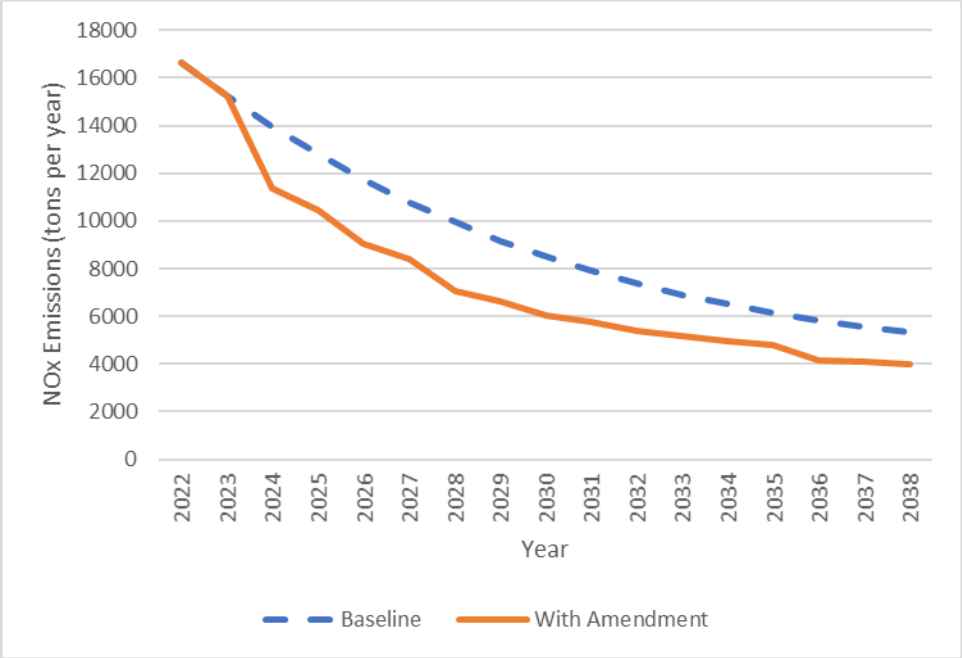
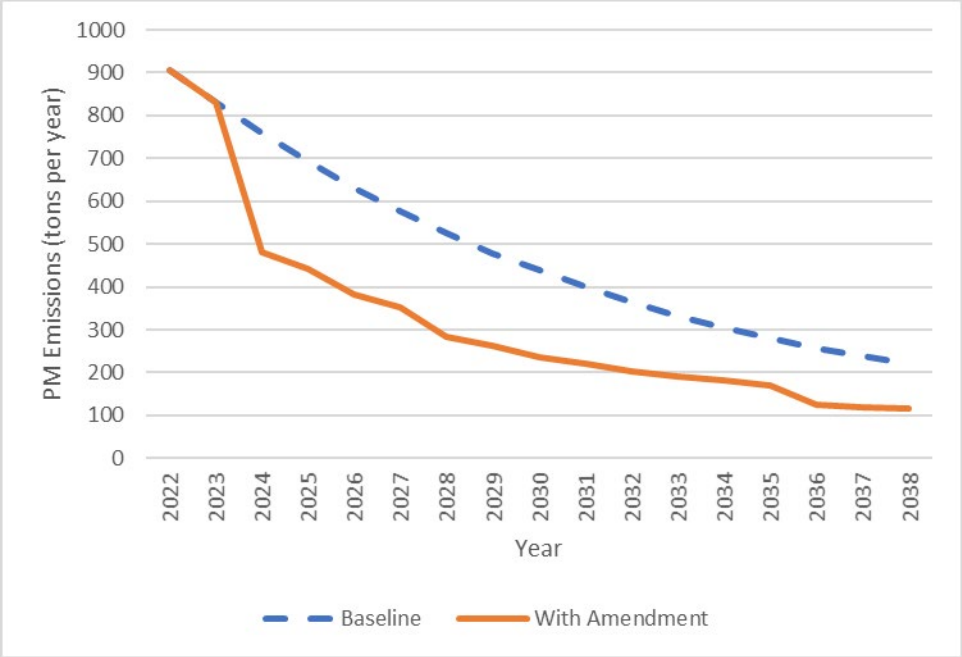


Figure 4. Statewide PM Emissions from Off-Road Diesel Vehicles under the Baseline and Proposed Amendments from 2022 through 2038



2.2 Benefits to Typical Businesses

The Proposed Amendments will provide air quality benefits that will benefit the health of not only people residing or working near where off-road diesel vehicles are operated, but will also benefit the employees of the companies using these vehicles as they are the ones most exposed to the emissions associated with operating these vehicles. These health benefits for their employees would translate into reduced healthcare costs and reduced lost productivity from sickness associated with exposure to diesel emissions.

The increased demand for newer vehicles due to the Tier phase-out requirements would also increase sales of off-road diesel vehicles, resulting in additional income for businesses involved in the manufacture and distribution of off-road diesel vehicles, including vehicle and parts manufacturers, dealers, financial institutions, as well as consultant companies that advise companies on compliance with the regulation's changes.

Often fleets see increased efficiencies from the use of newer off-road vehicles. Some vehicles have increased versatility due to the numerous attachments available, increasing the type of work a single machine can be used for. Newer off-road vehicles often incorporate advancements that increase worker comfort, have more precise operations that decrease fuel use (e.g., telematics and electronic throttles for precision control), and newer engines that may reduce fuel consumption through optional modes that reduce engine speed without reducing power, as examples.

Finally, businesses using off-road diesel vehicles would be provided with a more level playing field through the enhanced enforcement and reporting provisions of the Proposed

Amendments, which would ensure that compliant fleets would not be subjected to unfair competition by fleets that have chosen not to comply.

2.3 Benefits to Small Businesses

Certain businesses mentioned in the previous section, Benefits to Typical Businesses, may also be small businesses, primarily among vehicle dealers and consultants. These businesses serve an important function in providing access to the vehicles that operators need to run their businesses and to provide guidance in understanding the regulation across the state and will most likely see benefits similar to those described for typical businesses as a result of the Proposed Amendments.

2.4 Benefits to Individuals

The Proposed Amendments will benefit California residents by lowering cancer risks and cardiopulmonary illnesses and other non-cancer health impacts through reducing exposure to both primary PM generated from diesel combustion in off-road vehicles, as well as to ozone and PM2.5 formed in secondary reactions with NOx. While these benefits would apply to individuals in large swathes of the state, especially in non-attainment regions where facilities and job sites utilizing off-road diesel vehicles operate, residents of communities directly adjacent to where the equipment are being used, as well as those directly employed in these facilities and job sites and who operate the equipment, would see the largest impacts, as they are nearest to the equipment's operations for the longest duration of time. Staff estimated the statewide value of health benefits from reduced PM and NOx emissions, as described below.

2.4.1 Health Benefits

CARB staff conducted a mortality and illness analysis based on the statewide emission reductions of PM2.5 and NOx that would be achieved by the Proposed Amendments. This section provides a summary of the mortality and illness impacts, which include premature death from cardiopulmonary disease, hospital admissions, and emergency room visits.

2.4.1.1 PM2.5 Mortality and Illness Overview

The Proposed Amendments would reduce NOx and PM2.5 emissions, resulting in health benefits for individuals in California. CARB analyzed four health outcomes in the Proposed Amendments: cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness, and emergency room (ER) visits for asthma. These health outcomes and others have been identified by U.S. EPA as having a causal or likely causal relationship with exposure to PM2.5 based on a substantial body of evidence[32].

[32] U.S. EPA. (2019). Integrated Science Assessment for Particulate Matter (December 2019) (EPA/600/R-19/188). Retrieved March 15, 2022 from: *https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534#tab-3*

U.S. EPA has determined that both long-term and short-term exposure to PM2.5 play a causal role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between PM2.5 exposure and increased risk of mortality. This relationship persists even when other risk factors such as smoking, poverty and other factors are considered[33].

U.S. EPA has also determined a causal relationship between nonfatal cardiovascular effects and short- and long-term exposure to PM2.5 and a likely causal relationship between non-mortality respiratory effects and short- and long-term PM2.5 exposures[34]. These outcomes lead to hospitalizations and ER visits and are included in this analysis.

CARB staff evaluated a limited number of statewide non-cancer health benefits associated with reductions in exposure to PM2.5 and NOx emissions resulting from the Proposed Amendments. NOx includes nitrogen dioxide, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled[35]. However, the most serious quantifiable impacts of NOx emissions occur through the conversion of NOx to fine particles of ammonium nitrate aerosol through chemical processes in the atmosphere. PM2.5 formed in this manner is termed secondary PM2.5. Both directly emitted (primary) PM2.5 and secondary PM2.5 are associated with adverse health outcomes, such as cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and ER visits for asthma. As a result, reductions in PM2.5 and NOx emissions are associated with reductions in these adverse health outcomes.

2.4.1.1.1 Incidence-per-Ton Methodology

CARB uses the incidence-per-ton (IPT) methodology to quantify the health benefits of emission reductions in cases where air quality modeling results are not available. A description of this method is included on CARB's Methodology for Estimating the Health Effects of Air Pollution webpage[36]. CARB's IPT methodology is based on a methodology developed by U.S. EPA[37] [38] [39].

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[33] See note32.

[34] See note 32.

[35] U.S. EPA. (2016). *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (January 2016)* (EPA/600/R-15/068). Retrieved March 22, 2022 from: *http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=526855*

[36] CARB. CARB's Methodology for Estimating the Health Effects of Air Pollution. Retrieved March 22, 2022, from: *https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution*

[37] Fann N, Fulcher CM, Hubbell BJ., The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution, Air Quality, Atmosphere & Health, 2:169-176, 2009. Retrieved March 22, 2022 from: *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/*

[38] Fann N, Baker KR, Fulcher CM., Characterizing the PM2.5-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S. Environ Int.; 49:141-51, November 15, 2012. Retrieved March 22, 2022 from: *https://www.sciencedirect.com/science/article/pii/S0160412012001985*

[39] Fann N, Baker K, Chan E, Eyth A, Macpherson A, Miller E, Snyder J., Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025, Environ. Sci. Technol. 52 (15), pp 8095–8103, 2018. Retrieved March 22, 2022 from: *https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050*

The IPT methodology assumes that changes in emissions are approximately proportional to changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to PM2.5 concentrations for a baseline scenario and dividing by the emissions of PM2.5 or a precursor. The calculation is performed separately for each air basin using the following equation:

$$IPT = \frac{number\ of\ health\ outcomes\ in\ air\ basin}{annual\ emissions\ in\ air\ basin}$$

Multiplying the emission reductions from the Proposed Amendments in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the Proposed Amendments. For future years, the number of outcomes is adjusted to account for population growth. CARB's current IPT factors are based on a 2014-2016 baseline scenario, which represents the most recent data available at the time the current IPT factors were computed. IPT factors are computed for the two types of PM2.5: primary PM2.5 and secondary PM2.5 of ammonium nitrate aerosol formed from precursors.

2.4.1.1.2 Reduction in Adverse Health Impacts

CARB staff estimated the reduction in adverse health outcomes associated with reduced emissions of PM2.5 and NOx due to the Proposed Amendments. These health outcomes include cardiopulmonary mortality, hospital admissions for cardiovascular and respiratory illnesses, and ER visits for asthma. Based on the analysis, staff estimates that the total reduction in the number of cases statewide due to the implementation of the Proposed Amendments from 2024 to 2038 would be as follows:

- 574 fewer premature deaths (448 to 702, 95 percent confidence interval (CI))
- 83 fewer hospital admissions for cardiovascular illnesses (0 to 162, 95 percent CI)
- 99 fewer hospital admissions for respiratory illnesses (23 to 174, 95 percent CI)
- 278 fewer emergency room visits for asthma (176 to 381, 95 percent CI)

Table 8 shows the estimated reductions and 95 percent confidence intervals in adverse health outcomes resulting from the Proposed Amendments by air basin from 2024 through 2038. The biggest health benefits are expected to occur in the South Coast, San Joaquin Valley, and San Francisco Bay Area air basins.

Table 8. Total Reductions in Health Outcomes as a Result of the Proposed Amendments (2024 through 2038)

Air Basin[40]	Cardiopulmonary Mortality	Cardiovascular Hospital Admissions	Respiratory Hospital Admissions	Asthma Emergency Room Visits
Mojave Desert	13 (10 - 16)	2 (0 - 4)	2 (1 - 4)	5 (3 - 7)
Mountain Counties	3 (3 - 4)	0 (0 - 1)	0 (0 - 1)	1 (1 - 2)
North Central Coast	2 (1 - 2)	0 (0 - 1)	0 (0 - 1)	1 (1 - 1)
North Coast	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	25 (20 - 31)	3 (0 - 5)	3 (1 - 6)	10 (6 - 13)
Salton Sea	1 (1 - 2)	0 (0 - 0)	0 (0 - 0)	1 (0 - 1)
San Diego County	29 (23 - 36)	4 (0 - 7)	4 (1 - 8)	12 (8 - 17)
San Francisco Bay Area	51 (40 - 63)	8 (0 - 15)	9 (2 - 16)	29 (18 - 39)
San Joaquin Valley	83 (65 - 102)	9 (0 - 17)	11 (2 - 19)	31 (19 - 42)
South Central Coast	6 (5 - 8)	1 (0 - 2)	1 (0 - 2)	3 (2 - 4)
South Coast	357 (279 - 437)	56 (0 - 110)	67 (16 - 118)	185 (117 - 253)
Total	**574 (448 - 702)**	**83 (0 - 162)**	**99 (23 - 174)**	**278 (176 - 381)**

2.4.1.1.3 Uncertainties Associated with the Mortality and Illness Analysis

Although the estimated health outcome presented in this report are based on a well-established methodology, they are subject to uncertainty. Uncertainty is reflected in the 95 percent confidence intervals included with the central estimates in Table 8. These confidence intervals take into account uncertainties in translating air quality changes into health outcomes.

Other sources of uncertainty include the following:

- The relationship between changes in pollutant concentrations and changes in pollutant or precursor emissions is assumed to be proportional, although this is an approximation.
- Emissions are reported at an air basin resolution, and do not capture local variations.
- Future population estimates are subject to increasing uncertainty as they are projected further into the future.
- Baseline incidence rates can experience year-to-year variation.

[40] Air Basins not listed have no quantifiable reductions in health outcomes as a result of the Proposed Amendments.

2.4.1.2 Monetization of Health Impacts

In accordance with U.S. EPA practice, CARB staff monetized health outcomes by multiplying the number of incidences by a standard value derived from economic studies[41]. Table 9 shows the valuation per incident avoided health outcome in 2020 U.S. Dollars (2020$). The valuation for avoided premature mortality is based on willingness to pay[42]. This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risk of dying in a year, such that one death would be avoided in the year across the population. This is not an estimate of how much any single individual would be willing to pay to prevent a certain death of any particular person[43], nor does it consider any specific costs associated with mortality, such as hospital expenditures.

Unlike premature mortality valuation, the valuation for avoided hospitalizations and emergency room visits is based on a combination of typical costs associated with hospitalization and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, lost earnings for both individuals and family members, lost recreation value, and lost household protection (e.g., valuation of time losses from inability to maintain the household or provide childcare). These costs are most closely associated with specific cost savings to individuals and costs to the healthcare system.

Table 9. Valuation per Incident Avoided Health Outcomes (2020$)

Outcome	Valuation per Incident
Avoided Premature Deaths	$10,030,076
Avoided Hospital Admissions for Cardiovascular Illnesses	$59,247
Avoided Hospital Admissions for Respiratory Illnesses	$51,678
Avoided Emergency Room Visits for Asthma	$848

The statewide valuation of health benefits is calculated by multiplying the number of avoided adverse health outcomes by valuation per incident. Staff quantified the annual and total statewide valuation of avoided adverse health outcomes from 2024 through 2038, as shown in Table 10 and Table 11, respectively. The statewide distribution of these benefits follows the distribution of emission reductions and avoided adverse health outcomes; therefore,

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[41] National Center for Environmental Economics et al., Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses (EPA 240-R-10-001), Retrieved December 2010 from: *https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-22.pdf*

[42] U.S. EPA Science Advisory Board (U.S. EPA-SAB), An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (EPA-SAB-EEAC-00-013), Retrieved July 2000 from: *http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf*

[43] U.S. EPA, Mortality Risk Valuation – What does it mean the place a value on a life? Retrieved March 2, 2021 from: *https://www.epa.gov/environmental-economics/mortality-risk-valuation#means*

most benefits to individuals will occur in the South Coast, San Joaquin Valley, and San Francisco Bay Area air basins.

Table 10. Annual Statewide Avoided Adverse Health Outcomes and Valuation as a Result of the Proposed Amendments from 2024 through 2038

Year	Avoided Premature Deaths	Avoided Hospitalizations	Avoided Emergency Room Visits	Valuation (million 2020$)
2024	50	14	25	$500.1
2025	45	13	22	$456.3
2026	49	14	24	$490.6
2027	44	13	22	$444.3
2028	51	16	25	$513.5
2029	45	14	22	$456.0
2030	44	14	21	$443.2
2031	39	13	19	$394.3
2032	36	12	17	$363.7
2033	32	11	15	$321.9
2034	28	10	14	$284.9
2035	25	9	12	$252.9
2036	31	11	15	$311.0
2037	28	10	13	$279.3
2038	25	9	12	$251.7
Total	50	14	25	$5,763.8

Table 11. Total Statewide Valuation of Avoided Adverse Health Outcomes as a Result of the Proposed Amendments from 2024 through 2038

Outcome	Valuation (million 2020$)
Avoided Premature Deaths	$5,753.6
Avoided Hospital Admissions for Cardiovascular Illnesses	$4.9
Avoided Hospital Admissions for Respiratory Illnesses	$5.1
Avoided Emergency Room Visits for Asthma	$0.2
Total	$5,763.8

2.4.1.3 Potential Future Evaluation of Additional Health Benefits

The proposed regulation will result in additional health benefits beyond what CARB staff has quantified. CARB's current PM2.5 mortality and illness evaluation focuses on select air pollutants and health outcomes, and therefore captures only a portion of the health benefits of the Proposed Amendments. For example, while the current analysis considers the impact of NOx on the formation of secondary PM2.5 particles, NOx can also react with other compounds to form ozone, which can cause respiratory problems. The Proposed Amendments would also result in a decrease of toxic air contaminants emitted from diesel engines, which can cause cancer and other adverse health effects. In California, about 70

percent of known cancer risks from TACs are from diesel engine emissions.[44,45] In addition to the health benefits that are quantified, the Proposed Amendments would reduce additional cardio and respiratory illnesses, nonfatal and fatal cancers, and lost workdays, particularly for those who live and work around areas with high off-road diesel activity. Expanding CARB's health evaluation to include any of the above additional health outcomes would allow the public to reach a better understanding of the benefits from reducing air pollution and staff are updating methodologies that will allow these additional benefits to be quantified in the future.

3 Direct Costs

The Proposed Amendments will result in direct cost impacts to owners of off-road diesel vehicles, as well as public works awarding bodies and prime contractors. This cost is estimated to be approximately $1.92 billion from years 2023 through 2038. The direct costs include capital costs for new Tier 4 final off-road diesel vehicles, used Tier 4 final off-road diesel vehicles, annual cost for maintenance of Tier 4 final vehicles, and administrative costs for reporting of public works awarding bodies and prime contractors provisions. The direct costs in this section include costs to federal, State, and local governments, which are also quantified separately in the Fiscal Impacts, Section 4. The assumptions underlying the direct costs are detailed in the sections below. All estimated costs are in 2020 dollars (2020$), unless otherwise specified.

CARB staff acknowledges that current international events can result in unexpected short-term shocks to the economy and impact supply chains and prices. These shocks can potentially have medium- and long-term impacts as well. However, the timeframe and extent of the impact is very uncertain and cannot be predicted. Therefore, this analysis assumes that there will be no impacts to the availability or price of off-road vehicles during the implementation timeframe from 2023-2036. Further discussion on regulatory compliance flexibilities available to fleet in the Off-Road Regulation along with the impact of those flexibilities can be found in Section 3.1.2.

CARB staff also acknowledge that the value of the U.S. dollar varies from year to year. The U.S. Consumer Price Index for all Urban Consumers (CPI-U) rose 8.5 percent for the 12 months ending in March 2022, the largest 12-month increase since the period ending December 1981.[46] In this study, all costs and cost-savings are converted to constant 2020

[44] CARB. Overview: Diesel Exhaust & Health | California Air Resources Board. Retrieved March 22, 2022 from: https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health

[45] Propper, R., P. Wong, S. Bui, J. Austin, W. Vance, Á. Alvarado, B. Croes and D. Luo (2015). "Ambient and Emission Trends of Toxic Air Contaminants in California." Environmental Science & Technology 49(19): 11329-11339.

[46] U.S. Bureau of Labor Statistics, Economic News Release: Consumer Price Index Summary. April 12, 2022. Accessed April 20, 2022. *https://www.bls.gov/news.release/cpi.nr0.htm#*

dollars by using the annual valuations for California CPI-U.[47] When converted to a different dollar year, the numerical value of estimated costs and cost-savings would scale proportionately with the Consumer Price Index.

3.1 Direct Cost Inputs

3.1.1 Fleet Cost and Compliance Survey

In October 2021, staff developed a survey to help CARB better understand how off-road vehicles are purchased and other costs that stakeholders may incur as a result of the potential amendments to the Off-Road Regulation. The survey was developed at the request of stakeholders. The survey was distributed directly to all registrants from the October 15 workgroup via email and a notice of availability was distributed to the Off-Road Equipment (In-Use) Control Measure list serve. The survey consisted of two parts:

1. Questionnaire Worksheet that included questions regarding vehicle purchasing behavior, vehicle purchasing mechanisms, fuel use, selling of old vehicles, and other questions to better understand how the proposed concept would impact fleets.
2. Purchasing Data Worksheet that requested detailed cost information on recent vehicle acquisitions.

CARB staff was particularly interested in cost data for all equipment types greater than 600 hp (new and used), data for aerial lifts, paving equipment, sweeper/scrubbers, drill rigs, rubber-tired dozers, trenchers, workover rigs and railcar movers. The goal was to receive the most relevant cost data for Tier 4 vehicles both new and used from fleets firsthand. Staff received 19 responses from a mix of large, small fleets, and 1 medium fleet, and received cost information for 440 off-road vehicles.

Based on the responses from the survey, CARB staff identified six compliance pathways used to analyze direct costs for vehicle owners:

1. Retiring off-road diesel vehicles and replacing them with new Tier 4 final vehicles,
2. Retiring off-road diesel vehicles and replacing with used Tier 4 final vehicles (5-year-old),
3. Retiring off-road diesel vehicles and not replacing,
4. Designating off-road diesel vehicles as low-use and purchasing new Tier 4 final vehicles,
5. Designating off-road diesel vehicles as low-use and purchasing used Tier 4 final vehicles (5-year-old), and
6. Designating off-road diesel vehicles as low-use and not replacing.

CARB staff believes that while the response rate of the survey was relatively low, responses generally trended similar to fleet compliance in response to the Off-Road Regulation when

[47] State of California, Department of Industrial Relations, California Consumer Price Index (1955-2022). Accessed April 202, 2022. *https://www.dir.ca.gov/OPRL/CPI/EntireCCPI.PDF*

replacing vehicles, by fleet size. For example, larger fleets are more likely to replace with new equipment, while medium and small fleets replace with used equipment or simply downsize their fleet at a higher rate than large fleets. While the rates at which small and ultra-small fleets replace with used equipment are likely to be higher than that of medium fleets, combining these three fleet size categories together as an average number is reasonable given the relatively small number of responses received per fleet size category. It is possible that this may lead to a slight underrepresentation of used vehicle purchases among the small and ultra-small fleets, and thus a slightly higher cost estimate for the Proposed Amendments. In the sample fleet analyses presented later in Section 3.2.3 and Section 3.3.1, CARB staff introduced additional assumptions that are more specific to small and ultra-small fleets. For the total costs presented in the next section, however, CARB staff took a higher level approach and did not apply these more limited assumptions in the calculations for the overall cost of the Proposed Amendments.

Results of the survey were presented at the December 2021 workshop[48] for further public comment. No further comments were received regarding the six compliance pathways presented. Comment was received to review and incorporate new vehicle cost data previously provided to CARB staff by the Construction Industry Air Quality Coalition (CIAQC). This data was incorporated and is discussed in more detail below.

3.1.2 Off-Road Diesel Vehicle Costs to Owners

The Proposed Amendments' requirements and associated costs to vehicle owners are phased in based on fleet size. As described in Section 2.1.1, all estimates for annual off-road diesel vehicle populations are from the 2022 Statewide In-Use Off-Road Emissions Inventory Model, excluding vehicles designated as low-use. CARB staff analyzed the affected off-road diesel vehicle population using the three different fleet sizes (small, medium, and large) as established in the off-road inventory. Two sets of probabilities, one for large fleets, and one for medium and small fleets, were created for each of the six compliance pathways based on responses to CARB's Fleet Cost and Compliance Survey. CARB staff assigned a single set of probabilities for small and medium fleets because only one medium fleet responded to the survey, and because CARB staff believe that medium fleets are more similar to small fleets than to large fleets since medium fleets represent a narrow range of total horsepower, but large fleets, with no upward limit on size, can be much bigger.

To establish costs for the vehicles, CARB staff divided off-road vehicles into eight different horsepower groups. These groups were established based on the phase-in of the Tier standards by horsepower. The cost for new Tier 4 final off-road diesel vehicles was estimated based on stakeholder survey input, data gathered from grants for new Tier 4 final vehicles funded by the Carl Moyer Memorial Air Quality Standards Attainment Program between the

[48] CARB December 14, 2021 workshop on Potential Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation presentation (web link: *https://ww2.arb.ca.gov/sites/default/files/2021-12/Final_ORDA_Second_Workshop_Presentation.pdf*)

years of 2015 through 2021, and cost data provided by CIAQC in 2018 as shown in Table 12 converted to 2020 dollars.

Based on responses to the October 2021 survey, Staff determined that on average, fleet stakeholders who add used vehicles to their fleets typically purchase vehicles that are five years old. While fleets may purchase newer or older used vehicles as replacements, provided that the older vehicles still meet the Tier restrictions on adding vehicles, Staff decided to use the average age of five years as a representative age for purposes of cost and emissions calculations for this SRIA. The cost for used five-year-old Tier 4 final off-road diesel vehicles was estimated based on vehicle auction[49] data from years 2019-2021. Table 13 displays the estimated cost of vehicles by horsepower group used in the cost analysis.

Table 12. New Vehicle Cost Data by Source

Engine hp Group Number	Minimum hp	Maximum hp	Average Survey Cost Data	Average Carl Moyer Cost Data	CIAQC Cost Data
1	25	49	$61,172	$49,179	$57,584
2	50	74	$75,496	$80,829	$104,699
3	75	99	$105,618	$120,427	$130,874
4	100	174	$175,380	$183,853	$167,518
5	175	299	$288,315	$358,619	$314,097
6	300	599	$659,153	$771,161	$785,242
7	600	749	$912,670	$1,738,621	$1,046,989
8	750	9999	$1,529,102	$1,613,170	$1,884,580

Table 13. Engine Horsepower (hp) Groups and New and Used Tier 4 final Vehicle Costs

Engine hp Group Number	Minimum hp	Maximum hp	Average New Tier 4 final cost	Used Tier 4 final cost
1	25	49	$55,978	$16,828
2	50	74	$87,008	$32,823
3	75	99	$118,973	$37,788
4	100	174	$175,583	$62,173
5	175	299	$320,343	$128,175
6	300	599	$738,519	$124,538
7	600	749	$1,232,760	$168,222
8	750	9999	$1,675,618	$869,249

[49] Data CARB staff collected by recording sale prices at vehicle auctions located in Southern and Northern California.

Recent worldwide events have resulted in uncertainty around the availability and the pricing of new and used vehicles. The Off-Road Regulation includes compliance flexibilities for delays in availability of Tier 3 or Tier 4 vehicles or for equipment manufacturer delays. These compliance flexibilities allow fleets (individually or as a group) to request that the CARB Executive Officer issue a compliance extension that would allow for fleets to continue to operate their current vehicles until the replacement vehicles become available. If current availability volatility continues, these provisions would apply to the requirements of the Proposed Amendments. To date, these provisions have been used sparingly[50] and have not resulted in significant impacts to the emission reductions of the Off-Road Regulation. It is expected that use of these provisions will continue to be minimal, or only necessary for a short period of time, and will not have a significant negative impact on the estimated benefits of Proposed Amendments. However, if these compliance flexibilities are used extensively, they could result in a delay of achieving the estimated emission benefits. There would be minimal impact to the estimated costs of the Proposed Amendments since use of these provisions require fleets to have a purchase agreement for a replacement vehicle or a plan to achieve compliance which could have the effect of delaying some costs of the proposal.

The costs of new and used Tier 4 final vehicles are based on the best available data provided directly by fleets, industry, and through the State's grant program. Recent pricing volatility is not necessarily reflected due to the delays in data gathering. It can be assumed that there will be some premium on vehicle costs in the short-term as a result of the recent price increases, this would impact both the baseline costs as well as the costs of the Proposed Amendments.

As described in Section 3.1.1, CARB staff identified six likely compliance pathways used to analyze direct costs for vehicle owners. Based on responses to the survey, each compliance pathway was assigned a fraction based on the likelihood of it being chosen by a fleet of a specific size. Table 14 displays the fraction allocated to each compliance pathway.

Table 14. Compliance Pathways with Probability Fractions by Fleet Size

Fleet Size	Retired /Replaced with new Tier 4 final	Retired /Replaced with used Tier 4 final	Retired /Not replaced	Low-use /Replaced with new Tier 4 final	Low-use /Replaced with used Tier 4 final	Low-use /Not replaced
Large	0.779	0.051	0.047	0.058	0.004	0.062
Medium and Small	0.537	0.102	0.120	0.101	0.019	0.120

For each year of the analysis, staff calculated the number of vehicles that would be removed from operation (vehicle turnover population) in California for both the baseline and the Proposed Amendments. The baseline turnover accounts for the vehicles that would be

[50] As of April 2022, one fleet has requested a compliance flexibility for delay in availability of Tier 3 or Tier 4 vehicles as defined in section 2449(e)(9) and no fleet has requested a compliance extension for equipment manufacturer or installer delays as defined in section 2449(e)(6).

removed from the fleet due to the Off-Road Regulation as well as natural attrition. These vehicle turnover populations were calculated for each fleet size and engine hp group identified in Table 13 and are found in Section 8 (Appendix B). The analysis for costs begins in calendar year 2023 since the first compliance date for the Proposed Amendments is January 1, 2024 and fleets would need to be taking actions to comply in 2023. The resulting vehicle population was then multiplied by the compliance path fraction in Table 14 and the new or used vehicle cost in Table 13.

The baseline vehicle capital cost was then subtracted from the Proposed Amendments' vehicle capital cost and then sales tax was applied on this difference to obtain the incremental vehicle capital cost. The incremental vehicle capital costs inclusive of sales tax are shown in Table 15. Sales tax is further discussed in Section 3.1.3. The incremental vehicle capital cost is positive in years where the cost of the Proposed Amendments is larger compared to the baseline, and negative in years where the baseline has larger capital cost. Incremental vehicle capital costs are amortized over five years at 5 percent interest. The unamortized costs show a pattern of positive and negative costs which primarily reflect the implementation of the Tier phase-out. The baseline has larger capital costs in years where some portion of the baseline turnover population was turned over in a previous year due to implementation of the Proposed Amendments. For example, a Tier 0 in a large fleet may be turned over in 2024 under the baseline scenario, but the Proposed Amendments would require that vehicle be turned over in 2023. Finally, while fleets would most likely be able to recoup some costs by selling the retired or replaced vehicle on the used market, and while CARB staff does have data on resale values from past auctions, CARB staff decided to omit these possible recouped costs from this analysis due to the amount of uncertainty arising from the numerous factors that would impact the amount that could be recouped, including the effect of the Tier phase-out, transportation costs, and condition of the vehicle, among other factors, that may deteriorate the value of the vehicle in the future. The costs in Table 15 are, therefore, a high-end estimate on vehicle capital costs and account for the full replacement costs associated with the Proposed Amendments.

Table 15. Incremental Vehicle Capital Cost, Inclusive of Sales Tax

Year	Vehicle Capital Cost (unamortized)	Vehicle Capital Cost (amortized)
2023	$1,732,369,434	$400,133,680
2024	-$115,425,230	$373,473,361
2025	$546,780,838	$499,765,955
2026	-$173,267,760	$459,745,469
2027	$914,066,616	$670,871,821
2028	-$308,469,320	$199,489,502
2029	$84,591,133	$245,688,241
2030	-$271,761,357	$56,625,623
2031	-$31,002,142	$89,485,395
2032	-$248,650,893	-$179,073,047
2033	-$216,357,278	-$157,797,487
2034	-$191,030,541	-$221,459,147

Year	Vehicle Capital Cost (unamortized)	Vehicle Capital Cost (amortized)
2035	-$173,498,124	-$198,762,817
2036	-$147,794,025	-$225,738,799
2037	-$125,910,016	-$197,388,749
2038	-$108,650,368	-$172,511,167
Total	**$1,165,990,967**	**$1,642,547,834**

3.1.3 Sales Tax

Sales tax is an additional cost levied on the purchase of an off-road diesel vehicle. Since sales tax is based on the purchase price of an off-road diesel vehicle, they are higher for units that would be purchased to comply with the Proposed Amendments due to their higher capital costs. Off-road diesel vehicles purchased in California incur a sales tax on top of the purchase price. The sales tax varies across the state from a minimum of 7.25 percent up to 10.5 percent in some municipalities. For this analysis, staff used a value of 8.6 percent, which is a weighted average based on county-level output.[51,52] Staff applied the additional sales tax cost to the capital cost for off-road diesel vehicles based in California. This results in higher costs for California-based off-road diesel vehicle owners and higher revenue for local and State government (discussed in Section 4.1 and 4.2).

3.1.4 Maintenance Costs

Typical off-road vehicles require annual maintenance. While most engine Tiers have similar maintenance costs, Tier 4 final engines have additional emission controls that require ongoing maintenance on top of the maintenance already required for the other engine Tiers. To achieve the Tier 4 final emission standards, engine manufacturers introduced diesel particulate filters (DPF) on about 50 percent of the engines certified by CARB, and selective catalytic reduction, which requires the use of diesel exhaust fluid (DEF). The amount of DEF consumed is, on average, between 2 to 3 percent of the diesel fuel consumed. CARB staff assumed a 3 percent consumption rate at an average price of $4.00 per gallon for DEF. The percentage and price were then multiplied by the average fuel used (in gallons) per vehicle multiplied by the projected population of Tier 4 final vehicles in each hp group for each year. Diesel particulate filters require annual cleanings at an average cost of $475 per unit. To calculate the cost of DPF cleanings, 50 percent of the Tier 4 final population in each hp group per year was multiplied by the average cleaning cost. This analysis was completed for both the baseline and the Proposed Amendments. The baseline represents the Tier 4 final vehicles that would have been added to fleets in the absence of the Proposed Amendments.

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[51] County-level output derived from Regional Economic Models, Inc. (REMI) Policy Insight Plus. Output is defined as the amount of production, including all intermediate goods purchased as well as value added (compensation and profit). Can also be thought of as sales or supply. The components of Output are Self Supply and Exports (Multiregions, Rest of Nation, and Rest of World).

[52] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, January 2022. (web link: *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm*)

The difference of the baseline costs subtracted from the Proposed Amendments, resulting in incremental costs, for both DEF purchases and DPF cleaning, are displayed in Table 16.

Table 16. Incremental Off-Road Diesel Vehicle Tier 4 Maintenance Cost of Proposed Amendments over Baseline

Year	Maintenance DPF Cost	Maintenance DEF Cost
2023	$0	$0
2024	$816,288	$1,100,245
2025	$816,288	$1,100,245
2026	$1,338,313	$1,564,834
2027	$1,338,313	$1,564,834
2028	$2,509,188	$2,348,679
2029	$2,509,188	$2,348,679
2030	$3,020,288	$2,610,979
2031	$3,020,288	$2,610,979
2032	$3,454,200	$2,781,864
2033	$3,454,200	$2,781,864
2034	$3,454,200	$2,781,864
2035	$3,454,200	$2,781,864
2036	$3,454,200	$2,781,864
2037	$3,454,200	$2,781,864
2038	$3,454,200	$2,781,864
Total	**$39,547,550**	**$34,722,523**

3.1.5 Administrative Costs

Off-road diesel vehicle fleet owners are currently required to complete mandatory reporting to CARB. The Proposed Amendments require some additional reporting to CARB, however the additional reporting will be completed as part of the annual reporting already required under the baseline so no additional reporting costs will be incurred by the vehicle owners. This additional reporting includes attesting to the use of renewable diesel during annual reporting and submittal of records already required to be kept by fleets for the Off-Road Regulation for low-use vehicles during annual reporting. The Proposed Amendments include new requirements for public works awarding bodies and prime contractors, which will result in new administrative costs for these entities. These costs are discussed in detail in the following sections.

3.1.5.1 Public Works Awarding Bodies Reporting Costs

The Proposed Amendments include new requirements for public works awarding bodies that require the awarding bodies to verify that all fleets being used on a public works contract are in compliance with the Off-Road Regulation and the Proposed Amendments, and for the awarding bodies to report active public works projects to CARB (see Section 1.2.3 for more information on the reporting requirement provisions). The awarding bodies would incur new costs for additional administrative reporting and for verifying fleet level compliance at the

time of awarding a public contract. In order to estimate the potential costs to public works awarding bodies as a result of these new requirements, CARB staff analyzed three key factors: 1) the number of contracted public works projects in California that utilize off-road diesel vehicles and therefore would need to be reported to CARB under the provision, 2) the number of hours needed by a public works awarding body staff person to report the information, and 3) the job classification and labor rate of the public works awarding body staff person who would most likely be reporting the information.

To analyze the potential number of public works projects occurring annually in California, CARB staff reviewed several cities' Capital Improvement Plans[53] [54] [55] [56] [57] [58] [59] to understand how many public works projects cities typically initiate annually that would require the use of off-road diesel machinery. After looking at several plans it became clear that cities with larger populations had a larger number of projects, so CARB staff categorized cities into large cities (population greater than 400,000) and small cities, then averaged the number of capital improvement projects for each category to get an estimate of annual projects. Small cities had an average of 14 projects per year and large cities had an average of 100 projects per year. Taking the total number of cities in California to be 482 (9 of which are large under CARB staff's assumptions) resulted in an estimated 7,522 capital improvement projects from all cities annually.

Many projects implemented by cities are maintenance or on-call type projects that are not included in Capital Improvement Plans. CARB staff could not find data showing the number of these types of projects, so CARB staff assumed the number of these projects would be much greater than what is included in the Capital Improvement Plans and assumed these types of projects were triple that of capital improvement projects. The total number of maintenance projects by cities was estimated to be 22,566 projects which results in cities assumed to have a total of 30,088 projects annually.

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[53] Capital Improvement Program Project List – March 2022, The City of San Diego. (San Diego, 2022) (web link: *https://cipapp.sandiego.gov/cipdistrictnav.aspx*)

[54] Department of Public Works Project Status Report – February 2022, The City of Temecula. (Temecula, 2022) (web link: *https://temeculaca.gov/DocumentCenter/View/5081/Infrastructure-Projects*)

[55] Capital Improvement Project List – March 2022, The City of Santa Rosa. (Santa Rosa, 2022) (web link: *http://cippublic.srcity.org/ciplist.html*)

[56] Capital and Technology Improvement Program 2021-22 to 2025-26, The City of Los Angeles. (Los Angeles, 2021) (web link: *https://cao.lacity.org/capital/Five-Year%20Capital%20and%20Technology%20Improvement%20Program%20(CTIP)%20-%202021-22%20to%202025-26.pdf*)

[57] Capital Improvement Program 2021-22, The City of South San Francisco. (South San Francisco, 2021) (web link: *https://www.ssf.net/home/showpublisheddocument/24189/637632507801070000*)

[58] 2016-2021 Approved Capital Improvement Program – 2016, The City of Sacramento. (Sacramento, 2016) (web link: *https://www.cityofsacramento.org/-/media/Corporate/Files/Finance/Budget/2016-2021CIP/A015-Index-L-Projects-Receiving-New-Funding-by-Funding-Source.pdf?la=en*)

[59] 2021-23 Capital Improvement Program, July 2021, The City of Oakland. (Oakland, 2021) (web link: *https://cao-94612.s3.amazonaws.com/documents/FY-21-23-Adopted-CIP-Book-9.29.21.pdf*)

In addition to cities, other governmental bodies, including counties, transportation districts, school districts, and state agencies, also play the role of public works awarding bodies, but CARB staff were not able to find data that show the number of annual projects for these entities. To determine the number of projects these governmental bodies initiate each year, CARB staff compared each of these other types of public agencies to cities in terms of agency size, number of such entities, area of jurisdiction, and typical construction activity. CARB staff projected the number of projects of these other government bodies as a factor of the number of projects of a city. Table 17 depicts the results of Staff's projection. These results are based on the best available data and on broad assumptions, and are intended to be on the high end to ensure costs are not underestimated.

Table 17. Estimated Number of Public Works Projects Initiated in California Each Year

Type of Entity	Number of Projects Each Year
Cities	30,088
Counties	5,800
Special Districts	62,820
UC Campus	150
Cal State Campus	345
State Agencies	942
Total	**100,145**

Next CARB staff analyzed the amount of labor required for a public works awarding body to report the requested information to CARB. Because the project information requested in the proposed amendments is very similar to the project information already reported to the Department of Industrial Relations and with similar deadline requirements, CARB staff assumed public works awarding bodies would already have the information available to them without needing to perform additional work. The labor required to report this already available information would take on average 45 minutes.

Finally, CARB assumed an office and administrative support staff person would perform the reporting for public works awarding bodies, and using the U.S. Bureau of Labor Statistics data[60], CARB assigned a labor rate of $30.16 an hour, which is adjusted for total compensation rate.

Taking an estimate of 100,145 projects initiated in California by public works awarding bodies each year, an average of 45 minutes to report information to CARB, and a labor rate of $30.16 per hour, the total potential annual cost to all public works awarding bodies across the state is estimated to be $2,265,280.

[60] State Occupational Employment and Wage Estimates – May 2020, U.S Bureau of Labor Statistics. (US BLS, 2020) (web link: *https://www.bls.gov/oes/2020/may/oes_ca.htm*)

3.1.5.2 Prime Contractors

The Proposed Amendments include new requirements to ensure that prime contractors only hire compliant fleets and maintain appropriate records, and would cause prime contractors to incur an additional administrative cost. To estimate these potential costs to prime contractors, CARB staff analyzed three key factors: the number of projects in California that would include a prime contractor, the number of hours needed by a prime contractor staff person to verify compliance and to maintain records, and the job classification and labor rate of the prime contractor staff person who would most likely be performing this work.

To estimate the number of projects that would involve a prime contractor, CARB staff first used the California Department of Finance's Annual Data of Residential Units and Valuation[61] and found that in 2019, California had 111,284 new residential units under construction. Approximately half of these units were part of multi-family housing projects (as seen in the Department of Finance data). CARB staff assumed that multi-family housing projects would include multiple units constructed under a single project and involve only a single prime contractor. CARB staff assumed that on average a project includes 5 units[62], so the total number of projects from this analysis was 66,770 projects (55,642 single unit construction projects and 11,128 multi-unit construction projects with an average of 5 units each, so that single-family and multi-family projects each account for half of the 111,284 new residential units).

In additional to residential projects, there are nonresidential construction projects and public works projects. Public works projects, which would also involve a prime contractor and would also be subject to these additional requirements, were analyzed in Section 3.1.5.1 above and determined to add approximately 100,000 projects[63] to this analysis. For nonresidential non-public works projects, CARB staff used the California Department of Finance's California Department of Finance's Annual Data of Residential Units and Valuation[64] and Annual Data of Nonresidential Valuation[65] and determined that the valuation of residential to nonresidential construction in California is approximately a 1:1 ratio. Because nonresidential projects are expected to be more expensive than residential projects, the number of nonresidential projects were expected to be lower than the number of residential units. For this reason, CARB staff assumed that the number of nonresidential projects would be approximately half

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[61] Annual Data of Residential Units and Valuation – June 2020, California Department of Finance. (CA DOF, 2020) (web link: *https://dof.ca.gov/forecasting/economics/economic-indicators-2/construction-permits/*)

[62] CARB was unable to find data on the average number of units for a multi-unit dwelling per prime contractor. CARB staff assumed some projects would be a small number of units and other projects would include a large number of units. CARB staff landed on 5 units as a conservative estimate.

[63] The number of public works projects estimated in section 3.1.5.1 was rounded due to the uncertainty in the development of that estimate.

[64] See note 61

[65] Annual Data of Nonresidential Valuation – June 2020, California Department of Finance. (CA DOF, 2020) (web link: *https://dof.ca.gov/forecasting/economics/economic-indicators-2/construction-permits/*)

that of the residential units determined above, and added a further 33,386 projects to the analysis from nonresidential projects.

Adding the 66,770 residential projects, 100,000 public works projects, and 33,386 nonresidential projects together, CARB staff estimates that there are 200,156 projects subject to the Proposed Amendments' reporting provision occurring in California each year. As with the estimate developed for the number of public works projects, this analysis included many broad assumptions. The CARB staff estimate is an attempt to quantify the number of projects affected by the reporting requirements and similar caveats should apply.

Next CARB staff analyzed the amount of labor required for a prime contractor to comply with the new requirements. The number of labor hours required to implement these provisions varies greatly based on the size of the project. For a small project, a prime contractor may only need to verify the compliance for 1 or 2 fleets and maintain records of a handful of vehicles, estimated to take somewhere between 15-30 minutes. For a large project, however; a prime contractor may need to check the compliance of a large number of fleets, receive a large number of documents from various entities, and then maintain those records throughout the project, tasks that could take several hours. Based on this understanding, CARB staff decided to use 1 hour as the average amount of time needed to comply with these requirements, recognizing that an individual prime contractor could require quite a bit more or less time to comply with the requirements.

Finally, CARB assumed a first line supervisor for construction trades and extraction workers would be the most likely staff person to implement these requirements for the prime contractor, and using the U.S. Bureau of Labor Statistics data[66], CARB determined the labor rate to be $56.17 an hour, adjusted for total compensation rate.

Taking an estimate of 200,156 construction projects initiated in California each year, an average of one hour to comply with the requirements, and a labor rate of $56.17 per hour, the total potential annual cost to all prime contractors across the State is estimated to be $11,242,740. A majority of this cost is expected to be attributed specifically to the construction industry, the industry within which most Prime Contractors conduct business, with a small amount also attributed to the mining industry, to the extent that they conduct business as a Prime Contractor, so CARB assumed a cost split of 90 percent to the construction industry and 10 percent to the mining industry.

3.1.6 Total Direct Costs

Table 18 shows the total direct incremental costs of the Proposed Amendments from 2023 through 2038. Direct incremental costs include vehicle capital costs (amortized), off-road diesel vehicle Tier 4 final maintenance costs, and administrative costs for reporting and review of fleet certificates associated with the public works awarding bodies and prime contractors provisions. As shown in Table 18, costs to fleet are higher in the earlier years of the Proposed Amendments and reduced in later years. Starting in 2032, amortized capital

[66] See note 60

costs due to the Proposed Amendments decrease as a result of fleets having already purchased newer vehicles in prior years to comply with the accelerated turnover mandated by the Proposed Amendments, and, for those years, are no longer subject to the capital costs required as part of natural turnover in the baseline.

Table 18. Annual Direct Incremental Costs of the Proposed Amendments

Year	Annual Vehicle Capital Costs (amortized, with tax)	Tier 4 final Maintenance Costs	Administrative Costs Public Works Awarding Bodies	Administrative Costs Prime Contractors	Total
2023	$400,133,680	$0	$0	$0	$400,133,680
2024	$373,473,361	$1,916,532	$2,265,280	$11,242,740	$388,897,913
2025	$499,765,955	$1,916,532	$2,265,280	$11,242,740	$515,190,507
2026	$459,745,469	$2,903,146	$2,265,280	$11,242,740	$476,156,635
2027	$670,871,821	$2,903,146	$2,265,280	$11,242,740	$687,282,987
2028	$199,489,502	$4,857,867	$2,265,280	$11,242,740	$217,855,389
2029	$245,688,241	$4,857,867	$2,265,280	$11,242,740	$264,054,128
2030	$56,625,623	$5,631,267	$2,265,280	$11,242,740	$75,764,909
2031	$89,485,395	$5,631,267	$2,265,280	$11,242,740	$108,624,682
2032	-$179,073,047	$6,236,064	$2,265,280	$11,242,740	-$159,328,963
2033	-$157,797,487	$6,236,064	$2,265,280	$11,242,740	-$138,053,403
2034	-$221,459,147	$6,236,064	$2,265,280	$11,242,740	-$201,715,063
2035	-$198,762,817	$6,236,064	$2,265,280	$11,242,740	-$179,018,733
2036	-$225,738,799	$6,236,064	$2,265,280	$11,242,740	-$205,994,714
2037	-$197,388,749	$6,236,064	$2,265,280	$11,242,740	-$177,644,665
2038	-$172,511,167	$6,236,064	$2,265,280	$11,242,740	-$152,767,083
Total	**$1,642,547,834**	**$74,270,072**	**$33,979,199**	**$168,641,101**	**$1,919,438,206**

3.2 Direct Costs on Typical Businesses

For the purpose of the Proposed Amendments, typical businesses are defined as all affected off-road diesel vehicle fleets in the State that are small, medium, or large in size. CARB staff conducted a case study to illustrate a typical fleet in each fleet size based on the fleets reported to CARB in DOORS. To select a representative fleet, CARB staff first calculated the average total horsepower and age of equipment statewide for each fleet size from all fleets compliant with the Off-Road Regulation. CARB staff then identified fleets that were similar in average horsepower and vehicle age to the statewide calculations for each fleet size. Lastly, staff reviewed the fleets to select one that had a range of vehicle types and horsepower. This analysis and the fleet attributes provided below reflect the composition of fleets as of February 2022.

For all fleet sizes, CARB staff conducted the same analysis to estimate the costs of the Proposed Amendments to a typical business. For the baseline, CARB staff developed a compliance plan for the fleet to achieve the final requirements of the Off-Road Regulation

using CARB's compliance planning tool[67]. Because the baseline Off-Road Regulation itself drives accelerated turnover, CARB staff assumed that, in the baseline scenario, after the final compliance date of the Off-Road Regulation, fleets would not take additional actions, such as replacing a vehicle with a new or used vehicle, until the average age of the vehicles in the fleet was the same as the average age of the vehicles in the fleet in calendar year 2013, a year in which all existing fleets should have been reported to CARB and prior to the start of the turnover requirements of the Off-Road Regulation. At that point, the analysis assumed the fleet would take actions to maintain that average age through 2038. CARB staff then applied the same inputs and methodology as described in Section 3.1.2 to calculate vehicle capital costs for the baseline. After calculating the baseline, CARB staff used the same compliance planning tool to develop a compliance plan for the Proposed Amendments. The same assumptions were made for the Proposed Amendments as the baseline regarding average age of the vehicles in the fleet through 2038. CARB staff applied the same inputs and methodology as described in Section 3.1.2 to calculate vehicle capital costs for the Proposed Amendments. The baseline vehicle capital cost was then subtracted from the Proposed Amendments vehicle capital cost and then sales tax was applied on the difference.

To assess DEF and DPF maintenance costs, staff calculated the number of Tier 4 final vehicles in the fleet for each analysis year under the baseline and Proposed Amendments. CARB staff then applied the methodology described in Section 3.1.4 to assess costs for maintenance under the baseline and Proposed Amendments. The baseline vehicle maintenance cost was then subtracted from the Proposed Amendments vehicle maintenance cost to get the incremental maintenance cost due to the Proposed Amendments.

Fleets with off-road equipment are eligible to participate in incentive programs that offset costs associated with the purchase of new vehicles prior to compliance dates. CARB staff did not include the availability of incentive programs in this analysis. These programs are generally available to fleets that are in full compliance with the Off-Road Regulation and are choosing to take the actions required by the Proposed Amendments prior to the required compliance dates.

3.2.1 Large Fleet Owner

Using the methodology described above, CARB staff selected a representative large fleet to analyze the incremental costs to a typical large business. Attributes of the fleet selected are shown in Table 19. The fleet is currently complying with the Off-Road Regulation using BACT and is therefore required to turnover 10 percent of the fleet's total horsepower each year until it meets the final fleet average target. CARB staff assumed that, to comply with the baseline regulation, the fleet would turn over the oldest vehicles first to comply with BACT,

[67] CARB's Fleet Average Calculator tools were developed by staff to assist with compliance planning. This tool allows a fleet to import their fleet of vehicles along with the necessary information needed to calculate the fleets emissions. The tool allows for a fleet to select different compliance actions (replace, retire, retrofit, designate as low-use, etc.) by vehicle in each year of the regulation. This tool allows fleets to visualize the benefits and impacts of taking different compliance actions. This tool allowed for fleets to complete long-term planning. Web link: *https://ww2.arb.ca.gov/resources/documents/road-fleet-average-calculators*

resulting in all Tier 0 and Tier 1 vehicles being removed from the fleet in 2023 and 2024. This fleet achieved the fleet average target as required under the Off-Road Regulation by December 31, 2024. Due to the actions already required by the Off-Road Regulation, this typical large fleet would then not have to take further actions to comply with the Tier 0 and Tier 1 phase-out requirements of the Proposed Amendments. This fleet will need to comply with the Tier 2 phase-out beginning January 1, 2028.

Table 19. Typical Large Fleet Attributes

Vehicle Tier	Number of Vehicles and Combined hp
Tier 0	2 vehicles, 259 hp
Tier 1	12 vehicles, 1,793 hp
Tier 2	6 vehicles, 1,055 hp
Tier 3	17 vehicles, 4,066 hp
Tier 4 interim	10 vehicles, 1,761 hp
Tier 4 final	21 vehicles, 6,074 hp
Total	**68 vehicles, 14,997 hp**

Using the methodology described in Section 3.2, CARB staff estimated the annual vehicle capital costs (amortized, with tax) and vehicle maintenance costs, which together comprise the incremental costs due to the Proposed Amendments, and the results are shown in Table 20. This typical large fleet would see increased total costs starting in 2027 to comply with the Tier 2 phase-out requirement on January 1, 2028. This typical large fleet would see decreased costs 2033-2038. Overall, this fleet would see an increased cost of $332,160 from the Proposed Amendments during the analysis period from 2023-2038. Since the analyses for both the Proposed Amendments and the baseline incorporate business as usual to maintain an average fleet age into the future, the baseline scenario assumes that the fleet would start making these purchases in 2033. In the Proposed Amendments scenario, the fleet does not start making these purchases until 2035. Both fleets will have continued costs beyond the analysis period.

Table 20. Summary Incremental Costs due to the Proposed Amendments for a Typical Large Fleet

Year	Annual Vehicle Capital Costs (amortized, with tax)	Maintenance DPF Cost	Maintenance DEF Cost	Total
2023	$0	$0	$0	$0
2024	$0	$0	$0	$0
2025	$0	$0	$0	$0
2026	$0	$0	$0	$0
2027	$207,672	$1,188	$816	$209,676
2028	$207,672	$1,188	$816	$209,676
2029	$207,672	$1,188	$816	$209,676
2030	$207,672	$1,188	$816	$209,676
2031	$207,672	$1,188	$816	$209,676

Year	Annual Vehicle Capital Costs (amortized, with tax)	Maintenance DPF Cost	Maintenance DEF Cost	Total
2032	$0	$1,188	$816	$2,004
2033	-$37,719	$950	$658	-$36,111
2034	-$106,736	$713	$398	-$105,626
2035	-$113,156	$475	$342	-$112,340
2036	-$113,156	$475	$342	-$112,340
2037	-$182,174	$238	$82	-$181,855
2038	-$169,953	$0	$0	-$169,953
Total	$315,466	$9,975	$6,720	$332,160

3.2.2 Medium Fleet Owner

Using the methodology described above, CARB staff selected a representative medium fleet to analyze the costs to a typical medium-sized business. Attributes of the fleet selected are shown in Table 21. The fleet is currently complying with the Off-Road Regulation using BACT and is therefore required to turn over 10 percent of the fleet's total horsepower each year until it meets the final fleet average target. CARB staff assumed that, to comply with the baseline regulation, the fleet would turn-over the oldest vehicles first to comply with BACT, resulting in all Tier 0 and Tier 1 vehicles being removed from the fleet in 2023 and 2024. With a 10 percent fleet horsepower turnover each year, this fleet does not achieve the final fleet average target as required under the Off-Road Regulation until December 31, 2028, at which point the fleet would have turned over 8 of their 10 Tier 2 vehicles between January 1, 2025 and December 31, 2028. Due to these actions, taken to comply with the existing Off-Road Regulation, this typical medium fleet would then not have to take further actions to comply with the Tier 0 and Tier 1 phase-out requirements of the Proposed Amendments. This fleet will need to comply with the Tier 2 phase out beginning January 1, 2030. This fleet does not make additional purchases during the analysis period from 2023-2038 for the baseline or Proposed Amendments scenario to maintain the fleet's average vehicle age.

Table 21. Typical Medium Fleet Attributes

Vehicle Tier	Number of Vehicles and Combined hp
Tier 0	1 vehicle, 84 hp
Tier 1	3 vehicles, 493 hp
Tier 2	10 vehicles, 1,034 hp
Tier 3	2 vehicles, 403 hp
Tier 4 interim	5 vehicles, 539 hp
Tier 4 final	5 vehicles, 304 hp
Total	**26 vehicles, 2,857 hp**

Using the methodology described in Section 3.2, CARB staff estimated the annual vehicle capital costs (amortized, with tax) and vehicle maintenance costs, which together comprise

the incremental costs due to the Proposed Amendments, and the results are shown in Table 22. This typical medium fleet would see increased total costs starting in 2029 to comply with the Tier 2 phase-out requirement on January 1, 2030. Overall, this fleet would see an increased cost of $203,998 from the Proposed Amendments during the analysis period from 2023-2038.

Table 22. Summary Incremental Costs due to the Proposed Amendments for a Typical Medium Fleet

Year	Annual Vehicle Capital Costs (amortized, with tax)	Maintenance DPF Cost	Maintenance DEF Cost	Total
2023	$0	$0	$0	$0
2024	$0	$0	$0	$0
2025	$0	$0	$0	$0
2026	$0	$0	$0	$0
2027	$0	$0	$0	$0
2028	$0	$0	$0	$0
2029	$39,455	$475	$197	$40,127
2030	$39,455	$475	$197	$40,127
2031	$39,455	$475	$197	$40,127
2032	$39,455	$475	$197	$40,127
2033	$39,455	$475	$197	$40,127
2034	$0	$475	$197	$672
2035	$0	$475	$197	$672
2036	$0	$475	$197	$672
2037	$0	$475	$197	$672
2038	$0	$475	$197	$672
Total	$197,275	$4,750	$1,973	$203,998

3.2.3 Small Fleet Owner

Using the methodology described above, CARB staff selected a representative small fleet to analyze the costs to a typical small business. Some small fleets may have less than 500 hp (ultra-small fleet) and may benefit from some of the relaxed requirements provided to those fleets. An analysis of the impacts to an ultra-small fleet are discussed in Section 3.3. Attributes of the fleet selected are shown in Table 23. This fleet currently has five vehicles designated as low-use, four Tier 0 vehicles and one Tier 1 vehicle. Due to the small size of the fleet, CARB staff assumed that all vehicles would be replaced when required (the compliance scenario that a fleet would turnover a vehicle and not replace it was not assumed). The factors in Table 14 were not applied to the costs, and instead the new or used vehicle costs in Table 13 were used directly in the analysis. The fleet is currently complying with the Off-Road Regulation by meeting the fleet average target for 2022. CARB staff projects that this fleet will comply with the Off-Road Regulation beyond 2022 as follows:

This fleet will meet the fleet average target for 2023 with no further actions required. For compliance years 2024-2027, the fleet does not meet the fleet average target, but does have enough compliance credits to comply with the regulation using BACT, and is not required to take additional action until 2028 when the credits expire and the fleet must turn over 10 percent of the total fleet horsepower until it meets the final fleet average target. For compliance years 2028 through 2032, when the fleet meets its final fleet average target, the fleet turns over all non-low-use vehicles with a Tier 0, Tier 1, or Tier 2 engine, as well as one vehicle with a Tier 3 engine.

Due to these projected actions, taken to comply with the Off-Road Regulation, this typical small fleet would have no further requirements under the Proposed Amendments to comply with the Tier 0 and Tier 1 phase-out provision. However, this fleet will need to comply with the Tier 2 phase out for the remaining vehicles beginning January 1, 2032. Essentially, this means that the single Tier 2 vehicle that the fleet would have turned over in 2032 in the baseline would now need to be turned over in 2031 to comply with the Proposed Amendments. This fleet does not make additional purchases during the analysis period from 2023-2038 for the baseline or Proposed Amendments scenario to maintain the fleet's average vehicle age.

Table 23. Typical Small Fleet Attributes

Vehicle Tier	Number of Vehicles and Combined hp
Tier 0	4 vehicles, 501 hp
Tier 1	3 vehicles, 281 hp
Tier 2	9 vehicles, 538 hp
Tier 3	3 vehicles, 334 hp
Tier 4 interim	1 vehicle, 46 hp
Tier 4 final	6 vehicles, 329 hp
Total	**26 vehicles, 2,029 hp**

Under the Proposed Amendments, the four Tier 0 low-use vehicles would need to be phased out in 2036, while under the Off-Road Regulation, these vehicles could continue to operate indefinitely. CARB staff did not analyze costs associated with the phase out of these Tier 0 low-use vehicles as it is assumed that these vehicles would not be replaced by the fleet, given their age and low usage. In 2036, these vehicles would be 61, 56, 40, and 40 years old, and would have been operating at less than 200 hours per year for 14 to 18 years. Since the analysis assumed that all of the other vehicles would be replaced, as discussed previously, CARB staff assumed the fleet would have sufficient horsepower remaining in the rest of the fleet to cover the work done by these Tier 0 low-use vehicles and consequently not need to replace them.

Using the methodology described in Section 3.2, CARB staff estimated the annual vehicle capital costs (amortized, with tax) and vehicle maintenance costs, which together comprise the incremental costs due to the Proposed Amendments, and the results are shown in Table 24. This typical small fleet would see increased total costs in 2031 to comply with the Tier 2 phase-out requirement on January 1, 2032. This typical small fleet would see no changes in

costs 2032-2036. Overall, this fleet would see an increased cost of $553 from the Proposed Amendments during the analysis period from 2023-2038. To maintain the fleet's average vehicle age, CARB staff projects that this fleet will not make any additional vehicle purchases during the analysis period from 2023-2038 for both the baseline and Proposed Amendments scenarios.

Table 24. Summary Incremental Costs due to the Proposed Amendments for a Typical Small Fleet

Year	Annual Vehicle Capital Costs (amortized, with tax)	Maintenance DPF Cost	Maintenance DEF Cost	Total
2023	$0	$0	$0	$0
2024	$0	$0	$0	$0
2025	$0	$0	$0	$0
2026	$0	$0	$0	$0
2027	$0	$0	$0	$0
2028	$0	$0	$0	$0
2029	$0	$0	$0	$0
2030	$0	$0	$0	$0
2031	$28,085	$475	$78	$28,638
2032	$0	$0	$0	$0
2033	$0	$0	$0	$0
2034	$0	$0	$0	$0
2035	$0	$0	$0	$0
2036	-$28,085	$0	$0	-$28,085
2037	$0	$0	$0	$0
2038	$0	$0	$0	$0
Total	**$0**	**$475**	**$78**	**$553**

3.3 Direct Costs on Small Businesses

For the purposes of this cost analysis, a small business may be the off-road diesel vehicle fleets with less than 500 total horsepower (ultra-small fleets) operating in California. Fleets meeting the ultra-small fleet definition have the option of complying with the small fleet requirements or with the less stringent ultra-small fleet requirements of the Proposed Amendments. It is likely that some fleets not categorized as an ultra-small fleet may be considered a small business, especially fleets that fall into the small or medium fleet definition of the Off-Road Regulation. Impacts to a typical business under the definition of a small or medium fleet can be found in Section 3.2.

3.3.1 Ultra-Small Fleet Owner

Ultra-small fleets typically operate only a few small or medium horsepower vehicles, and generally do not operate high horsepower equipment. Vehicles owned by these fleets tend to be older than those owned by large and medium fleets, and are usually purchased as used vehicles. Using the methodology described in Section 3.2, CARB staff selected a representative ultra-small fleet to analyze the costs to a typical small business. Attributes of the fleet selected are shown in Table 25. The fleet is currently complying with the Off-Road Regulation by using BACT, and will have enough compliance credits to comply with the regulation until 2028 when the credits expire and the fleet must begin turning over 10 percent of the total fleet horsepower each year until it meets the final fleet average target, or the fleet complies with the optional compliance strategy for ultra-small fleets by January 1, 2029. In this scenario, CARB staff project that this fleet will replace the Tier 0 vehicle in 2028, making this fleet 100 percent Tier 2 or cleaner and thus fully compliant with the optional compliance strategy for ultra-small fleets of Off-Road Regulation.

Due to these projected actions, taken to comply with the Off-Road Regulation, this typical ultra-small fleet would have no further requirements under the Proposed Amendments to comply with the Tier 0 and Tier 1 phase-out provision. However, this fleet will need to comply with the Tier 2 phase-out beginning January 1, 2036, so the single Tier 2 vehicle that remains would need to be turned over in 2035. To maintain the fleet's average vehicle age, this fleet is not projected to make any additional purchases during the analysis period from 2023-2038 for either the baseline or Proposed Amendments scenarios.

Table 25. Typical Ultra-Small Fleet Attributes

Vehicle Tier	Number of Vehicles and Combined hp
Tier 0	1 vehicles, 88.5 hp
Tier 1	0 vehicle, 0 hp
Tier 2	1 vehicle, 71 hp
Tier 3	0 vehicles, 0 hp
Tier 4 interim	0 vehicles, 0 hp
Tier 4 final	0 vehicles, 0 hp
Total	**2 vehicles, 159.5 hp**

Using the methodology described in Section 3.2, CARB staff estimated the annual vehicle capital costs (amortized, with tax) and vehicle maintenance costs, which together comprise the incremental costs due to the Proposed Amendments, and the results are shown in Table 26. CARB staff made a change to the methodology in Section 3.2 and assumed that the vehicles purchased by the fleet would all be 5-year-old used vehicles, and applied the cost from Table 13. This typical ultra-small fleet would see increased costs beginning in 2035 and to comply with the Tier 2 phase-out requirement on January 1, 2036. Overall, this fleet would see an increased incremental cost of $34,109 from the Proposed Amendments during the analysis period from 2023-2038.

Table 26. Summary Incremental Costs due to the Proposed Amendments for a Typical Ultra-Small Fleet

Year	Annual Vehicle Capital Costs (amortized, with tax)	Maintenance DPF Cost	Maintenance DEF Cost	Total
2023	$0	$0	$0	$0
2024	$0	$0	$0	$0
2025	$0	$0	$0	$0
2026	$0	$0	$0	$0
2027	$0	$0	$0	$0
2028	$0	$0	$0	$0
2029	$0	$0	$0	$0
2030	$0	$0	$0	$0
2031	$0	$0	$0	$0
2032	$0	$0	$0	$0
2033	$0	$0	$0	$0
2034	$0	$0	$0	$0
2035	$8,234	$238	$56	$8,527
2036	$8,234	$238	$56	$8,527
2037	$8,234	$238	$56	$8,527
2038	$8,234	$238	$56	$8,527
Total	$32,935	$950	$224	$34,109

As illustrated above, the costs to a typical fleet will vary based on the fleet size, the type of equipment the fleet currently owns, and the types of actions taken to comply with the Proposed Amendments. In the examples, maximum annual amortized cost to comply with the Proposed Amendments was estimated to be approximately $210 thousand, $40 thousand, $29 thousand, and $10 thousand for the large, medium, small, and ultra-small fleets, respectively. In other years, these fleets may experience cost savings relative to the baseline, as they would no longer need to purchase vehicles in the later years of the analysis.

To illustrate the feasibility of compliance for these typical businesses, staff compared the maximum amortized annual cost with the average revenues of businesses in impacted industries.[68] Table 27 illustrates the average revenues per firm for the impacted industries. For firms with greater than 100 employees, the average revenue varies between $19.8 million to $331.4 million. Firms with fewer than 100 employees have lower annual revenues, which are shown to vary between $0.6 to $5.9 million. While fleet and firm size are not directly linked, the maximum amortized cost for a large fleet would represent less than 1 percent of

[68] U.S. Census Bureau, 2017 Statistics of U.S. Businesses Annual Dataset by Establishment and Industry. Accessed May, 5, 2022. *https://www2.census.gov/programs-surveys/susb/datasets/2017/us_state_6digitnaics_2017.txt*

average annual revenues for firms with 100 employees or greater and the maximum amortized cost for an ultra-small fleet would represent between 0.2 to 1.7 percent of average annual revenues for firms with fewer than 100 employees.

Table 27. Average Revenues per Firm in Impacted Industries

Industry	NAICS Code	Average Revenues per Firm (millions, firms with greater than 100 employees)	Average Revenues per Firm (millions, firms with fewer than 100 employees)
Mining, quarrying, and oil and gas extraction	21	$117.9	$2.7
Construction	23	$112.5	$1.4
Air transportation	481	$331.4	$5.9
Commercial and industrial machinery and equipment rental and leasing	5324	$93.4	$2.7
Waste management and remediation services	562	$100.1	$2.1
Services to buildings and dwellings	5617	$30.4	$0.6
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	8113	$19.8	$1.1

3.4 Direct Costs on Individuals

The Proposed Amendments would not result in any direct costs on individuals. CARB staff anticipates that the Proposed Amendments could result in indirect costs to individuals to the extent that compliance costs are passed through to consumers of construction, mining, industrial, government, and other industries. However, CARB staff also believes that it is unlikely that indirect costs would be passed on to residents of new residential housing, as discussed below. CARB staff analyzed the potential impact to new residential construction on a per unit basis based on forecasted production of new residential units and the needed units to meet California's housing needs identified in the 2022 Statewide Housing Plan[69]. It is important to consider the housing needs established in the Statewide Housing Plan as these inform legal obligations through the Regional Housing Needs Assessment (RHNA), which dictates how much housing local governments must plan to accommodate. The results and methodology for CARB's analysis is found in Section 9 (Appendix C).

Governor Newsom has prioritized tackling California's housing crisis though a comprehensive housing vision focusing on 4 key areas: streamlining the building of new homes, breaking

[69] A Home for Every Californian: 2022 Statewide Housing Plan, California Department of Housing and Community Development (web link: *https://storymaps.arcgis.com/stories/94729ab1648d43b1811c1698a748c136*)

down barriers to build more affordable housing, addressing systemic bias by elevating fair housing principles, and holding local governments accountable to do their job. To achieve this, the Governor signed a 31-bill housing package in 2021 that touches on all 4 key areas, which will result in local governments needing to plan for the creation of more than 2.5 million units statewide – more than doubling their obligation under the previous RHNA cycle. This suite of legislation is complemented by a $22 billion investment in housing as part of the California Comeback Plan. CARB's analysis is projecting potential impacts based on today's conditions; however, this robust package of legislation and funding provide a basis for extensive growth in the residential housing sector through the next decade.

Developing residential housing in California is complex, with multiple facets combining that add to the cost of development. These include land acquisition, hard construction costs, development fees, permitting and development timelines, financing, and regulations. Hard construction costs are those directly related to construction and are a significant percentage of total development costs. These costs are primarily driven by labor (prevailing wages) and materials (e.g., wood, concrete, plastics, composites, steel, etc.)[70]; vehicles, such as those subject to the Proposed Amendments, are not generally factored into cost drivers of residential housing in California.

CARB estimates that there could potentially be a one-time cost per unit (calculated based on forecasted units) of $236 to $1,042, which represents 0.04 to 0.3 percent of the cost of a typical new residential unit, or a one-time cost per unit (calculated based on housing needs) of $117 to $487, which represents 0.02 to 0.1 percent of the cost of a typical new residential unit. If these costs were fully passed along to consumers of newly-constructed, for-sale housing, this could potentially add $1 to $5 a month to a 30-year mortgage at a 4 percent interest rate for some households purchasing newly-constructed housing after the year 2023. For residents of new rental housing constructed after the year 2023, if estimated costs were fully passed along to consumers, the potential additional cost would likely be less than that for consumers of for-sale housing and would likely be lower on a per-unit basis. This is because construction costs for these units are likely to be financed over a longer period time, and because of economies of scale in multi-family housing construction, which is the form of housing in which the majority of rental housing is likely to be produced. Importantly, for residents of deed-restricted low- and moderate-income affordable housing, any potential costs passed through to residential construction projects would not impact out-of-pocket expenses (i.e. monthly rent) to residents because these units are subject to rent restrictions based on area median incomes as established by the federal government.

Further discussion on the anticipated benefits to individuals can be found in Section 2.4 and change in real personal income can be found in Section 5.3.4.

[70] The Hard Costs of Construction: Recent Trends in Labor and Materials Costs for Apartment Buildings in California, March 2020, Terner Center for Housing Innovation U.C. Berkley (web link: https://ternercenter.berkeley.edu/research-and-policy/hard-construction-costs-apartments-california/)

4 Fiscal Impacts

This section describes costs and benefits that would be incurred by local, State, and federal government agencies due to the Proposed Amendments. Local government agencies that own off-road diesel vehicle fleets would be subject to the same direct costs and benefits outlined in Section 3, as well as experience changes in revenue from diesel fuel taxes and local sales taxes. State government agencies that own off-road diesel vehicle fleets would also be subject to the same direct costs and benefits in Section 3, as well as experience changes in revenue from diesel fuel taxes, and State sales taxes. In addition, State and local agencies that act as public works awarding bodies would incur the administrative costs associated with the reporting and fleet certificate review. Costs to CARB would include staffing and resources needed to implement and enforce the Proposed Amendments. CARB does not own any off-road diesel vehicles. Federal government agencies that own off-road diesel vehicles would also be subject to the same direct costs and benefits outlined in Section 3. In addition, the Proposed Amendments would result in health benefits to individuals in California. These benefits may translate to cost savings for local and State healthcare providers.

4.1 Local governments

4.1.1 Off-Road Diesel Vehicle Costs to Owners

Local governments own and operate vehicles subject to the Tier phase-out and additional vehicle restrictions of the Proposed Amendments. Almost any local government could own and operate a vehicle subject to the Proposed Amendments, such as a forklift operating in a warehouse or other facility. However, the local agencies that will be most impacted are those that are involved in public works, waste management and sanitation, flood control and water agencies, parks and recreation districts, fire departments, and transportation agencies.

Using February 2022 data from DOORS[71], CARB staff determined that the number of vehicles owned by local governments to be three percent of the total number of vehicles reported. Staff applied this number to the total vehicle direct costs in Table 15 to estimate the costs incurred by local government off-road diesel vehicle owners. The assumptions underlying the direct capital costs of vehicles to local government agencies are identical to those identified in Section 3.1.2 of the SRIA.

4.1.2 Maintenance Costs

Local governments own and operate vehicles subject to the Tier phase-out and adding vehicle restrictions of the Proposed Amendments. As local governments comply with these requirements, many of the affected vehicles will be replaced with vehicles with Tier 4 final engines. As described in Section 3.1.4, Tier 4 final engines employ technologies that require

[71] California Air Resources Board, DOORS. (web link: *https://ssl.arb.ca.gov/ssldoors/doors_reporting/doors_login.html*, last accessed February 2022)

additional maintenance costs beyond what is required by older engines. CARB staff determined that the number of vehicles owned by local governments to be three percent of the total number of vehicles reported. Staff applied this number to the total maintenance costs in Table 16 to estimate the costs incurred by local governments. The underlying assumptions for calculating the direct costs of maintenance to local government agencies are identical to those identified in Section 3.1.4.

4.1.3 Local Sales Tax

Sales tax is levied in California to fund a variety of programs at the local and State levels. The Proposed Amendments would result in the sale of more expensive off-road diesel vehicles in California, which would result in a direct increase in sales tax revenue collected by local governments. However, overall, local sales tax revenue may increase less than the direct increase from off-road diesel vehicle sales if overall business spending does not increase. For this analysis, CARB staff used a combined State and local sales tax rate of 8.6 percent, which is a weighted average based on county-level output, with 3.94 percent[72] going towards State sales tax and 4.67 percent[73] going towards local sales tax.

4.1.4 Reporting and Fleet Review by Public Works Awarding Bodies

The Proposed Amendments require that public works awarding bodies verify fleet compliance by obtaining and reviewing the Certificate of Reported Compliance from all known fleets bidding on a contract, only enter a contract with fleets compliant with the regulation, and report the public works projects to CARB. These requirements have administrative and reporting costs that affect the direct costs on local governments. Using the assumptions and cost analysis described in section 3.1.5.1, CARB staff determined that 99 percent of the projects that would be subject to these requirements would be happening at the local level.

4.1.5 Fiscal Impacts on Local Governments

Table 28 shows the estimated incremental fiscal impacts to local governments due to the Proposed Amendments, based on the fiscal aspect explained above. Costs (expenditures) to local governments are shown as a positive number, and cost savings are shown as a negative number. Local sales tax revenue is shown as a positive number when there is an increase in revenue, and a negative number when there is a decrease in revenue. The total fiscal impact, defined as the change in revenue minus the change in costs, to local government is estimated to be a net benefit of about $50 million over the first three years of the regulation due to increased sales tax revenue, and a net cost of about $35 million over the regulatory horizon.

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[72] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate. (web link: *https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm*, last accessed March 11, 2022)

[73] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, March 2021. (web link: *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm*)

Table 28. Estimated Incremental Fiscal Impacts to Local Governments from 2023 through 2038 (2020$)

Year	Vehicle Cost (amortized)	DPF Maintenance Cost	DEF Maintenance Cost	Administrative Costs for Public Works Awarding Bodies	Local Sales Tax Revenue	Total = Revenue – Sum of Costs
2023	$12,004,010	$0	$0	$0	$74,487,336	$62,483,325
2024	$11,204,201	$24,489	$33,007	$2,242,627	-$4,962,982	-$18,467,306
2025	$14,992,979	$24,489	$33,007	$2,242,627	$23,510,140	$6,217,038
2026	$13,792,364	$40,149	$46,945	$2,242,627	-$7,450,059	-$23,572,144
2027	$20,126,155	$40,149	$46,945	$2,242,627	$39,302,464	$16,846,588
2028	$5,984,685	$75,276	$70,460	$2,242,627	-$13,263,371	-$21,636,419
2029	$7,370,647	$75,276	$70,460	$2,242,627	$3,637,197	-$6,121,814
2030	$1,698,769	$90,609	$78,329	$2,242,627	-$11,685,025	-$15,795,358
2031	$2,684,562	$90,609	$78,329	$2,242,627	-$1,333,011	-$6,429,138
2032	-$5,372,191	$103,626	$83,456	$2,242,627	-$10,691,335	-$7,748,853
2033	-$4,733,925	$103,626	$83,456	$2,242,627	-$9,302,795	-$6,998,579
2034	-$6,643,774	$103,626	$83,456	$2,242,627	-$8,213,812	-$3,999,746
2035	-$5,962,885	$103,626	$83,456	$2,242,627	-$7,459,964	-$3,926,788
2036	-$6,772,164	$103,626	$83,456	$2,242,627	-$6,354,755	-$2,012,300
2037	-$5,921,662	$103,626	$83,456	$2,242,627	-$5,413,800	-$1,921,846
2038	-$5,175,335	$103,626	$83,456	$2,242,627	-$4,671,680	-$1,926,054
Total	**$49,276,435**	**$1,186,427**	**$1,041,676**	**$33,639,405**	**$50,134,549**	**-$35,009,393**

4.2 State Government

4.2.1 Off-Road Diesel Vehicle Costs to Owners

The State government owns and operates vehicles subject to the Tier phase-out and adding vehicle restrictions of the Proposed Amendments. Using February 2022 data from DOORS, CARB staff determined that the number of vehicles owned by the State government to be one percent of the total number of vehicles reported. Staff applied this number to the total vehicle direct costs in Table 15 to estimate the costs incurred by State government off-road diesel vehicle owners. The assumptions underlying the direct capital costs of vehicles to State government agencies are identical to those identified in Section 3.1.2 of the SRIA.

4.2.2 Maintenance Costs

The State government owns and operates vehicles subject to the Tier phase-out and additional vehicle restrictions of the Proposed Amendments. As the State government complies with these requirements, many of these vehicles will be replaced with vehicles with Tier 4 final engines. As described in Section 3.1.4, Tier 4 final engines employ technologies that require additional maintenance costs beyond what is required by older engines. CARB staff determined that the number of vehicles owned by the State government to be one

percent of the total number of vehicles reported. CARB staff applied this number to the total maintenance costs in Table 16 to estimate the costs incurred by the State government. The assumptions underlying the direct costs of maintenance to State government agencies are identical to those identified in Section 3.1.4.

4.2.3 State Sales Tax

Sales tax is levied in California to fund a variety of programs at the local and State levels. The Proposed Amendments would result in the sale of more expensive off-road diesel vehicles in California, which would result in a direct increase in sales tax revenue collected by the State. However, overall, State sales tax revenue may increase less than the direct increase from off-road diesel vehicle sales if overall business spending does not increase. For this analysis, staff used a combined State and local sales tax rate of 8.6 percent, which is a weighted average based on county-level output, with 3.94 percent[74] going towards State sales tax and 4.67 percent[75] going towards local sales tax.

4.2.4 Reporting and Fleet Review by Public Works Awarding Bodies

The Proposed Amendments require that public works awarding bodies verify fleet compliance by obtaining and reviewing the Certificate of Reported Compliance from all known fleets bidding on a contract, only enter a contract with fleets compliant with the regulation, and report the public works projects to CARB. These requirements have administrative and reporting costs that affect the direct costs on the State government. Using the assumptions and cost analysis described in section 3.1.5.1, CARB staff determined that one percent of the projects that would be subject to these requirements would be occurring at the State level.

4.2.5 Cost to CARB

4.2.5.1 Additional Staffing

Table 29 displays the additional permanent, full-time CARB staff that are needed to successfully implement and enforce the Proposed Amendments. The Proposed Amendments will increase the number of enforcement referrals that CARB receives, resulting in increased fleet audits. Additional staff are also needed for outreach and compliance assistance to newly regulated prime contractors and public works awarding bodies, development and maintenance of compliance assistance tools, and increased enforcement activity resulting from the new requirements to prime contractors and public works awarding bodies.

[74] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate. (web link: *https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm*, last accessed March 11, 2022)
[75] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, March 2021. (web link: *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm*)

Table 29. Number of Additional CARB Positions Required and Costs in 2024

Position	Number of Positions	Initial Budget Year Cost (Annual Salary plus Benefits per Position)	Ongoing Cost (Annual Salary plus Benefits per Position)
Air Pollution Specialist	3	$211,000	$210,000
Air Resources Technician II	4	$105,000	$104,000

Table 30 shows the estimated staffing costs expected to be incurred by CARB from 2023 through 2038.

Table 30. Estimated Additional Annual Staffing Costs Incurred by CARB from 2023 through 2038

Year	Annual CARB Staffing Cost
2023	$0
2024	$1,053,000
2025	$1,046,000
2026	$1,046,000
2027	$1,046,000
2028	$1,046,000
2029	$1,046,000
2030	$1,046,000
2031	$1,046,000
2032	$1,046,000
2033	$1,046,000
2034	$1,046,000
2035	$1,046,000
2036	$1,046,000
2037	$1,046,000
2038	$1,046,000
Total	**$15,697,000**

4.2.6 Fiscal Impacts on State Government

Table 31 shows the estimated incremental fiscal impacts to the State government due to the Proposed Amendments, based on the fiscal aspect explained above. Costs (expenditures) to the State government are shown as a positive number, and cost savings are shown as a negative number. State sales tax revenue is shown as a positive number when there is an increase in revenue, and a negative number when there is a decrease in revenue. The total fiscal impact, defined as the change in revenue minus the change in costs, to the State government is estimated to be a net increase of about $63.5 million over the first three years of the regulation due to increased sales tax revenue and a net increase of about $9 million over the regulatory horizon. The vehicle and maintenance costs will not be spread across all State government agencies. Based on data reported in DOORS, the California Department of

Transportation owns and operates about 40 percent of all the State-owned vehicles and, along with the California Department of General Services, does the most public works contracting that would be subject to the Proposed Amendments. Other agencies that will be impacted by the Proposed Amendments include, but are not limited to, the California Department of Forestry and Fire Protection and the California Department of Parks and Recreation both with approximately 7 percent of reported State-owned vehicles and the California Department of Fish and Wildlife with approximately 6 percent of reported State-owned vehicles.

Table 31. Estimated Incremental Fiscal Impact to State Government from 2023 through 2038 (2020$)

Year	Vehicle Cost (amortized)	DPF Maintenance Cost	DEF Maintenance Cost	Administrative Costs for Public Works Awarding Bodies	State Sales Tax Revenue	CARB Personnel Cost	Total = Revenue – Sum of Costs
2023	$4,001,337	$0	$0	$0	$62,801,513	$0	$58,800,176
2024	$3,734,734	$8,163	$11,002	$22,653	-$4,184,373	$1,053,000	-$9,013,924
2025	$4,997,660	$8,163	$11,002	$22,653	$19,821,790	$1,046,000	$13,736,313
2026	$4,597,455	$13,383	$15,648	$22,653	-$6,281,268	$1,046,000	-$11,976,408
2027	$6,708,718	$13,383	$15,648	$22,653	$33,136,562	$1,046,000	$25,330,159
2028	$1,994,895	$25,092	$23,487	$22,653	-$11,182,569	$1,046,000	-$14,294,695
2029	$2,456,882	$25,092	$23,487	$22,653	$3,066,581	$1,046,000	-$507,533
2030	$566,256	$30,203	$26,110	$22,653	-$9,851,839	$1,046,000	-$11,543,061
2031	$894,854	$30,203	$26,110	$22,653	-$1,123,883	$1,046,000	-$3,143,703
2032	-$1,790,730	$34,542	$27,819	$22,653	-$9,014,043	$1,046,000	-$8,354,326
2033	-$1,577,975	$34,542	$27,819	$22,653	-$7,843,341	$1,046,000	-$7,396,380
2034	-$2,214,591	$34,542	$27,819	$22,653	-$6,925,201	$1,046,000	-$5,841,623
2035	-$1,987,628	$34,542	$27,819	$22,653	-$6,289,620	$1,046,000	-$5,433,005
2036	-$2,257,388	$34,542	$27,819	$22,653	-$5,357,800	$1,046,000	-$4,231,425
2037	-$1,973,887	$34,542	$27,819	$22,653	-$4,564,465	$1,046,000	-$3,721,591
2038	-$1,725,112	$34,542	$27,819	$22,653	-$3,938,772	$1,046,000	-$3,344,674
Total	**$16,425,480**	**$395,476**	**$347,227**	**$339,795**	**$42,269,272**	**$15,697,000**	**$9,064,300**

4.3 Federal Government

4.3.1 Off-Road Diesel Vehicle Costs to Owners

The Federal government owns and operates vehicles subject to the Tier phase-out and additional vehicle restrictions of the Proposed Amendments. Using February 2022 data from DOORS, CARB staff determined that the number of vehicles owned by the Federal government to be one percent of the total number of vehicles reported. Staff applied this number to the total vehicle direct costs in Table 15 to estimate the costs incurred by Federal government off-road diesel vehicle owners. The underlying assumptions for calculating the direct capital costs of vehicles owned by Federal government agencies are identical to those identified in Section 3.1.2 of the SRIA.

4.3.2 Maintenance Costs

The Federal government owns and operates vehicles subject to the Tier phase-out and adding vehicle restrictions of the Proposed Amendments. As the Federal government complies with these requirements, many of the affected vehicles will be replaced with vehicles with Tier 4 final engines. As described in Section 3.1.4, Tier 4 final engines employ technologies that require additional maintenance costs beyond what is required by older engines. CARB staff determined that the number of vehicles owned by the Federal government to be one percent of the total number of vehicles reported. Staff applied this number to the total maintenance costs in Table 16 to estimate the costs incurred by the Federal government. The underlying assumptions for calculating the direct costs of maintenance to Federal government agencies are identical to those identified in Section 3.1.4.

4.3.3 Fiscal Impacts on Federal Government

Table 32 shows the estimated incremental fiscal impacts to the Federal government due to the Proposed Amendments, based on the fiscal aspect explained above. CARB staff did not attribute administrative costs from the requirements for Federal government public works awarding bodies because projects under complete and direct control of the Federal government will not be required to comply with those requirements. Costs (expenditures) to the Federal government are shown as positive numbers and savings to the Federal government are shown as negative numbers. The total fiscal impact, defined as the change in revenue minus the change in costs, to the Federal government is estimated to be about $12.7 million in costs over the first three years of the regulation due to vehicle purchase costs and a cumulative cost of about $17.2 million over the regulatory horizon.

Table 32. Estimated Incremental Fiscal Impact to the Federal Government from 2023 through 2038 (2020$)

Year	Vehicle Cost (amortized)	DPF Maintenance Cost	DEF Maintenance Cost	Total
2023	$4,001,337	$0	$0	$4,001,337
2024	$3,734,734	$8,163	$11,002	$3,753,899

Year	Vehicle Cost (amortized)	DPF Maintenance Cost	DEF Maintenance Cost	Total
2025	$4,997,660	$8,163	$11,002	$5,016,825
2026	$4,597,455	$13,383	$15,648	$4,626,486
2027	$6,708,718	$13,383	$15,648	$6,737,750
2028	$1,994,895	$25,092	$23,487	$2,043,474
2029	$2,456,882	$25,092	$23,487	$2,505,461
2030	$566,256	$30,203	$26,110	$622,569
2031	$894,854	$30,203	$26,110	$951,167
2032	-$1,790,730	$34,542	$27,819	-$1,728,370
2033	-$1,577,975	$34,542	$27,819	-$1,515,614
2034	-$2,214,591	$34,542	$27,819	-$2,152,231
2035	-$1,987,628	$34,542	$27,819	-$1,925,268
2036	-$2,257,388	$34,542	$27,819	-$2,195,027
2037	-$1,973,887	$34,542	$27,819	-$1,911,527
2038	-$1,725,112	$34,542	$27,819	-$1,662,751
Total	**$16,425,478**	**$395,476**	**$347,225**	**$17,168,179**

5 Macroeconomic Impacts

5.1 Methods for determining economic impacts

This section describes the estimated total impact of the Proposed Amendments on the California economy. The Proposed Amendments will accelerate the replacement or retirement of those vehicles with older engine tiers and will result in incremental costs and cost-savings for businesses and governments through the early retirement of vehicles and purchase of lower-emitting new and used vehicles. These changes in expenditures will indirectly affect employment, output, and investment in sectors that supply goods and provide services to the affected businesses. A summary of the results is provided in Section 5.4.

The direct impacts of the Proposed Amendments would lead to additional indirect and induced effects, such as changes in personal income that affect consumer expenditures across other spending categories. The incremental total economic impacts of the Proposed Amendments are simulated relative to the baseline using cost data described in Section 3 of the SRIA. The analysis focuses on incremental change in major macroeconomic indicators from 2023 to 2038 on employment, output growth, and Gross State Product (GSP). The years of the analysis are used to simulate the Proposed Amendments through two years beyond full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 2.5.0 is used to estimate the macroeconomic impacts of the Proposed Amendments on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output,

computable general equilibrium, econometric and economic geography methodologies.[76] REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the Proposed Amendments, pursuant to the requirements of SB 617 and the California Department of Finance. Staff used the REMI single region, 160 sector model with the model reference case adjusted to reflect California Department of Finance's most current publicly available economic and demographic projections.[77,78]

Specifically, the REMI model's National and Regional Control was updated to conform to the most recent California Department of Finance economic forecasts which include U.S. Real Gross Domestic Product, income, and employment, as well as California civilian employment by industry, released with the Governor's Budget on January 10, 2022 and Department of Finance demographic forecasts for California population forecasts, last updated in July 2021.[79,80,81,82] After the Department of Finance economic forecasts end in 2025, CARB staff made assumptions that post-2025, economic variables would continue to grow at the same rate projected in the REMI baseline forecasts.

5.2 Inputs and assumptions of the assessment

The estimated economic impact of the Proposed Amendments is sensitive to modeling assumptions. This section provides a summary of the assumptions and inputs used to determine the suite of policy variables that best reflect the macroeconomic impacts of the Proposed Amendments. The direct costs and savings estimated in Section 3 and the non-mortality related health benefits estimated in Section 2 are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[83]

The direct costs and cost-savings of the Proposed Amendments, as described in Section 3, include changes in upfront costs to businesses and governments that purchase off-road diesel vehicles, changes in annual maintenance costs, and additional annual reporting requirements for public works awarding bodies and prime contractors.

Vehicle capital costs, maintenance costs, and reporting costs for applicable fleets are input into the economic model as a change in production costs in the following industries, each followed by its respective North American Industry Classification System (NAICS) code in

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[76] For further information and model documentation see: *https://www.remi.com/model/pi*
[77] California Legislature, Senate Bill 617. October 2011.
[78] California Department of Finance, Chapter 1: Standardized Regulatory Impact Analysis for Major Regulations - Order of Adoption. December 2013.
[79] California Department of Finance. Economic Research Unit. National Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.
[80] California Department of Finance. Economic Research Unit. California Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.
[81] California Department of Finance. Economic Research Unit. National Deflators: Calendar Year averages: from 1929, April 2021. Sacramento: California. January 2022.
[82] California Department of Finance. Demographic Research Unit. Report P-3: Population Projections, California, 2010-2060 (Baseline 2019 Population Projections; Vintage 2020 Release). Sacramento: California. July 2021.
[83] Refer to the Macroeconomic Appendix for a full list of REMI inputs for this analysis.

parenthesis: mining, quarrying, and oil and gas extraction (NAICS 21), construction (NAICS 23), air transportation (NAICS 481), commercial and industrial machinery and equipment rental and leasing (NAICS 5324), waste management and remediation services (NAICS 562), services to buildings and dwellings (NAICS 5617), and commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (NAICS 8113). For government fleets, these costs are input into the model as local and State government spending, which are fiscal impacts to the governments. The costs allocated to each of the industries are based on each industry's share of the total vehicle population, as shown in Table 6.

Costs and savings incurred by the applicable fleets would result in corresponding changes in final demand for industries supplying those particular services or vehicles. Change in demand for vehicles is input into the model as an exogenous change in demand to the following industries: agriculture, construction, and mining machinery manufacturing (NAICS 3331), industrial machinery manufacturing (NAICS 3332), other general purpose machinery manufacturing (NAICS 3339), and motor vehicle manufacturing (NAICS 3361). The costs allocated to each of the supplier industries are based on each industry's share of the total vehicle population, as shown in Table 33.[84]

Table 33. Percentage of Vehicle Population in Vehicle Supplier Industries

Industry of Suppliers	NAICS Code	Percentage
Agriculture, construction, and mining machinery manufacturing	3331	83%
Industrial machinery manufacturing	3332	1.5%
Other general purpose machinery manufacturing	3339	13.5%
Motor vehicle manufacturing	3361	2%
Total		**100%**

Changes in demand for DPFs are input into the model as an exogenous change in demand to the motor vehicle parts manufacturing industry (NAICS 3363), and changes in demand in DEF are input into the model as an exogenous change in demand to the basic chemical manufacturing industry (NAICS 3251). The reporting cost incurred by prime contractors is modeled as increased demand in the office administrative services and facilities support services industry (NAICS 5611, 5612). The reporting cost incurred by public works awarding bodies is modeled as decreased government spending to reflect the opportunity costs of spending, assuming the cost is not offset elsewhere.

Table 34 illustrates the sources of changes in production costs for applicable fleets and corresponding changes in final demand by industry as described above.

[84] The percentage of vehicle population in vehicle supplier industries is based on the percentage of vehicle types reported in the CARB reporting tool, DOORS.

Table 34. Source of Changes in Production Cost and Final Demand by Industry

Source of Costs	Industries with Change in Production Costs (NAICS)[85]	Industries with Changes in Final Demand (NAICS)
Vehicle purchase price	Applicable fleets	Other general purpose machinery manufacturing (3339), industrial machinery manufacturing (3332), motor vehicle manufacturing (3361)
Vehicle maintenance (diesel particulate filter (DPF) and diesel exhaust fluid (DEF))	Applicable fleets	Motor vehicle parts manufacturing (3363), basic chemical manufacturing (3251)
Reporting	Prime contractors	Office administrative services; facilities support services (5611, 5612)

In addition to these changes in production costs and final demand for businesses, there would also be economic impacts as a result of the fiscal effects. The Proposed Amendments would result in changes in government spending for off-road diesel vehicle purchases and maintenance, expenditures for the reporting requirements by public works awarding bodies, and sales tax revenues. The changes in government revenue and spending are modeled as changes in state and local government spending, assuming that these changes in revenue and spending are not offset elsewhere. The additional CARB staff needed to implement the Proposed Amendments is modeled as an increase in government employment.

The health benefits resulting from the emission reductions of the Proposed Amendments, on average, reduce healthcare costs for individuals. This reduction in healthcare cost is modeled as a decrease in spending for hospitals, with a reallocation of this spending towards other goods and increased savings.

5.3 Results of the assessment

The results from the REMI model provide estimates of the impact of the Proposed Amendments on the California economy. These results represent the annual incremental change from the implementation of the Proposed Amendments relative to the baseline scenario. Negative impacts reported here should be interpreted as a slowing of growth, and positive impacts represent an acceleration of growth resulting from the Proposed Amendments. The results are reported here in tables for every year from 2023 through 2038.

[85] Applicable fleets include businesses in the following industries: mining, quarrying, and oil and gas extraction (21), construction (23), air transportation (481), commercial and industrial machinery and equipment rental and leasing (5324), waste management and remediation services (562), services to buildings and dwellings (5617), and commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113). Prime contractors include businesses in mining (21) and construction (23) industries.

5.3.1 California Employment Impacts

Table 35 presents the impact of the Proposed Amendments on total employment in California across all industries. Employment comprises estimates of the number of jobs, full-time and part-time, by place of work for all industries. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included. The employment impacts represent the net change in employment, which consist of positive impacts for some industries and negative impacts for others. The Proposed Amendments are estimated to have a negative impact on statewide employment from 2023 to 2031, and then a positive impact on statewide employment afterward. The results suggest that the estimated negative employment impact for the initial years is primarily from increased production costs due to increases in vehicle purchase costs, maintenance costs, and reporting costs as a result of the Proposed Amendments in the industries described in Table 6. This is caused by the Proposed Amendments' requirement to accelerate the replacement or retirement of vehicles with older engine Tiers between 2023 and 2031, which displaces natural turnover that would have happened after 2031. The decrease in vehicle capital investment and production costs after 2031 results from the vehicle purchases and replacement that has happened in earlier years in the time period between 2023 to 2038. The changes in statewide employment represent, at most, a 0.04 percent decrease relative to baseline California employment.

Table 35. Total California Employment Impacts

Year	California Employment	Change in Total Jobs	% Change
2023	25,128,917	-2,046	-0.01%
2024	25,572,136	-7,964	-0.03%
2025	25,885,512	-8,636	-0.03%
2026	25,944,659	-10,461	-0.04%
2027	25,960,205	-10,865	-0.04%
2028	25,958,031	-7,308	-0.03%
2029	26,005,176	-5,580	-0.02%
2030	25,985,331	-2,906	-0.01%
2031	26,004,578	-1,813	-0.01%
2032	26,070,820	1,872	0.01%
2033	26,141,024	2,524	0.01%
2034	26,219,252	3,769	0.01%
2035	26,302,684	3,664	0.01%
2036	26,397,399	3,967	0.02%
2037	26,502,258	3,508	0.01%
2038	26,623,712	2,983	0.01%

The total employment impacts shown above are net changes at the industry level. The overall trend in employment changes by major sector are illustrated in Figure 5. The construction and services sectors are estimated to make up the largest proportion of job increases and decreases. Because the construction sector represents more than 50 percent of the total off-road diesel vehicle population under the Proposed Amendments (Table 6), this sector has

large impacts on the employment change. The services sector, which also sees large job impacts, includes the following industries that are directly affected by the Proposed Amendment: services to buildings and dwellings, waste management and remediation services, commercial and industrial machinery and equipment repair and maintenance, and office administrative services and facilities support services.

Figure 5. Changes in Employment by Major Sector

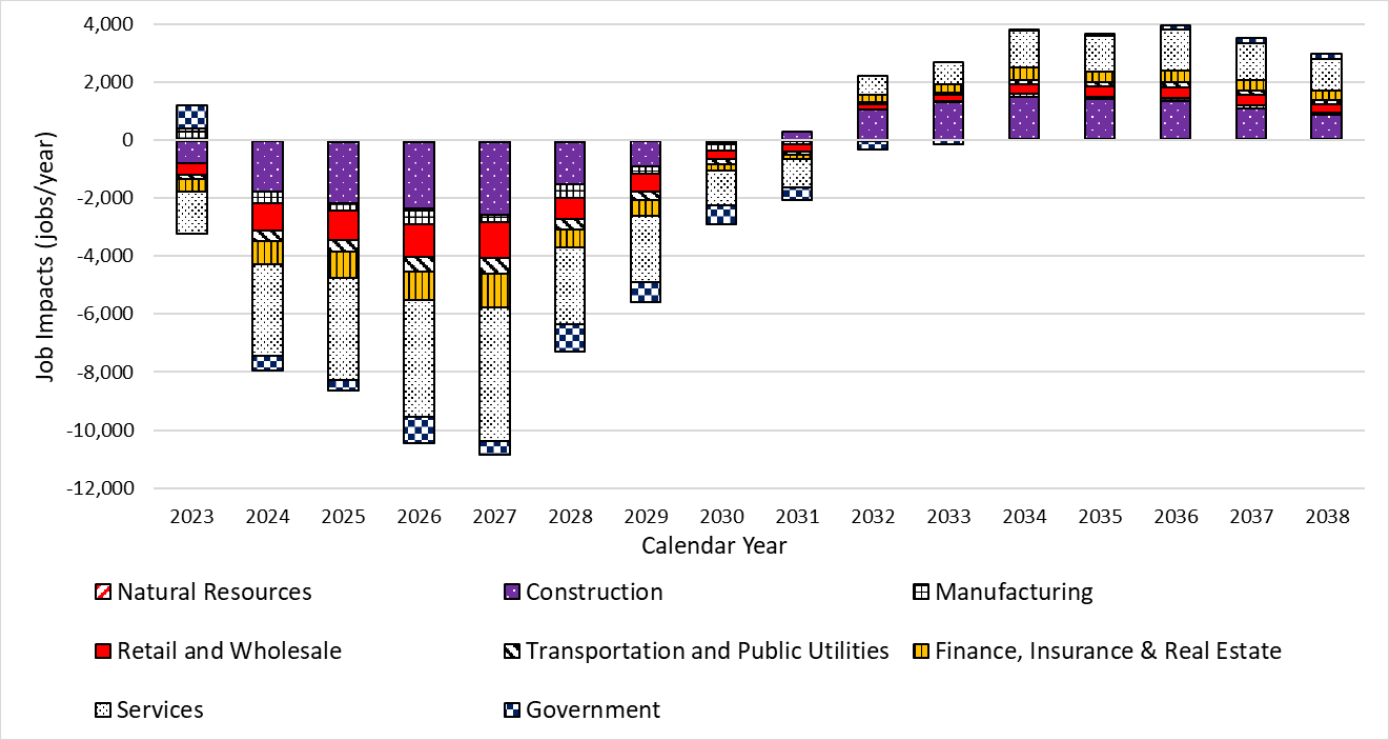


Table 36 shows the changes in employment by industries that are directly-impacted by the Proposed Amendments. Of these directly-impacted industries, mining, construction, and commercial and industrial machinery and equipment rental and leasing are estimated to see the greatest impacts to employment, with an approximately 0.2 percent decrease in baseline employment in 2027.

Table 36. Employment Impacts by Primary and Secondary Industries

	Mining (21)		Construction (23)		Air transportation (481)		Commercial and industrial machinery and equipment rental and leasing (5324)	
Year	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change
2023	-24	-0.07%	-791	-0.06%	-24	-0.04%	-17	-0.05%
2024	-45	-0.13%	-1744	-0.13%	-37	-0.06%	-32	-0.10%
2025	-58	-0.17%	-2111	-0.16%	-49	-0.07%	-44	-0.13%
2026	-66	-0.19%	-2286	-0.17%	-52	-0.07%	-52	-0.15%
2027	-78	-0.22%	-2481	-0.18%	-66	-0.09%	-65	-0.19%
2028	-59	-0.17%	-1473	-0.11%	-33	-0.05%	-54	-0.16%
2029	-49	-0.14%	-856	-0.06%	-31	-0.04%	-50	-0.14%
2030	-32	-0.09%	-83	-0.01%	-15	-0.02%	-38	-0.11%
2031	-23	-0.07%	272	0.02%	-14	-0.02%	-32	-0.09%
2032	-3	-0.01%	1065	0.08%	9	0.01%	-16	-0.04%
2033	7	0.02%	1299	0.10%	10	0.01%	-7	-0.02%
2034	17	0.05%	1482	0.11%	17	0.02%	3	0.01%
2035	21	0.06%	1383	0.10%	17	0.02%	9	0.02%
2036	25	0.07%	1295	0.10%	20	0.03%	14	0.04%
2037	25	0.07%	1075	0.08%	18	0.02%	17	0.04%
2038	23	0.07%	829	0.06%	16	0.02%	18	0.05%

	Services to buildings and dwellings (5617)		Waste management and remediation services (562)		Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)		State and Local Government	
Year	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change
2023	-75	-0.02%	-6	-0.01%	-13	-0.04%	775	0.03%
2024	-172	-0.04%	-23	-0.04%	-30	-0.08%	-540	-0.02%
2025	-195	-0.04%	-26	-0.04%	-41	-0.11%	-366	-0.02%
2026	-225	-0.05%	-33	-0.05%	-51	-0.14%	-906	-0.04%
2027	-256	-0.06%	-36	-0.06%	-61	-0.16%	-488	-0.02%
2028	-162	-0.04%	-27	-0.04%	-53	-0.14%	-952	-0.04%
2029	-137	-0.03%	-23	-0.04%	-49	-0.13%	-668	-0.03%
2030	-76	-0.02%	-16	-0.03%	-39	-0.10%	-668	-0.03%
2031	-59	-0.01%	-12	-0.02%	-33	-0.08%	-443	-0.02%
2032	28	0.01%	-1	0.00%	-17	-0.04%	-289	-0.01%
2033	42	0.01%	2	0.00%	-8	-0.02%	-150	-0.01%
2034	72	0.02%	7	0.01%	1	0.00%	1	0.00%
2035	73	0.02%	9	0.01%	7	0.02%	71	0.00%
2036	84	0.02%	11	0.02%	13	0.03%	148	0.01%
2037	77	0.02%	11	0.02%	15	0.04%	173	0.01%

	Services to buildings and dwellings (5617)		Waste management and remediation services (562)		Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)		State and Local Government	
Year	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change
2038	68	0.01%	11	0.02%	17	0.04%	176	0.01%

5.3.2 California Business Impacts

Gross output is used as a measure for business impacts because it represents an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output growth is the sum of output in each private industry and State and local government as it contributes to the state's gross domestic product (GDP), and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth.

As illustrated in Table 37, the Proposed Amendments are estimated to result in a decrease in statewide output from 2023 to 2031. From 2032, the Proposed Amendments are estimated to lead to a slight increase in statewide output. The largest impact years show a decrease in output of $2.5 billion in 2027 and an increase of $864 million in 2036. The changes in statewide output are no larger than 0.04 percent of baseline levels.

Table 37. Change in California Output Growth

Year	Output (2020M$)	Change (2020M$)	% Change
2023	5,428,787	-249	-0.01%
2024	5,610,471	-1,731	-0.03%
2025	5,769,927	-1,873	-0.03%
2026	5,841,046	-2,409	-0.04%
2027	5,910,287	-2,452	-0.04%
2028	5,982,628	-1,876	-0.03%
2029	6,065,833	-1,471	-0.02%
2030	6,133,166	-922	-0.02%
2031	6,211,463	-642	-0.01%
2032	6,297,591	195	0.00%
2033	6,387,015	393	0.01%
2034	6,481,547	728	0.01%
2035	6,581,224	750	0.01%
2036	6,688,052	864	0.01%
2037	6,802,423	794	0.01%
2038	6,928,156	699	0.01%

The trend in output changes is illustrated by major sector in Figure 6. Similar to the employment impacts, sectors and industries that are anticipated to face production cost increases are anticipated to have corresponding decreases in output. The construction, services, and finance, insurance and real estate sectors are estimated to have the largest proportion of both increases and decreases in output. As noted in Section 5.3.1, the largest proportion of the off-road diesel vehicle population is in the construction sector. The services, and the financial, insurance and real estate are the next two largest sectors that use off-road diesel vehicles. The commercial and industrial machinery and equipment rental and leasing industry, under the finance, insurance and real estate sector, has a similar proportion of the vehicle population as the services sector. Table 38 shows the changes in output by industries that are directly impacted by the Proposed Amendments. Of the directly-impacted industries, mining, construction, and commercial and industrial machinery and equipment rental and leasing are estimated to see the greatest impacts to output with an approximately 0.2 percent decrease compared with the baseline in 2027.

Figure 6. Change in Output in California by Major Sector

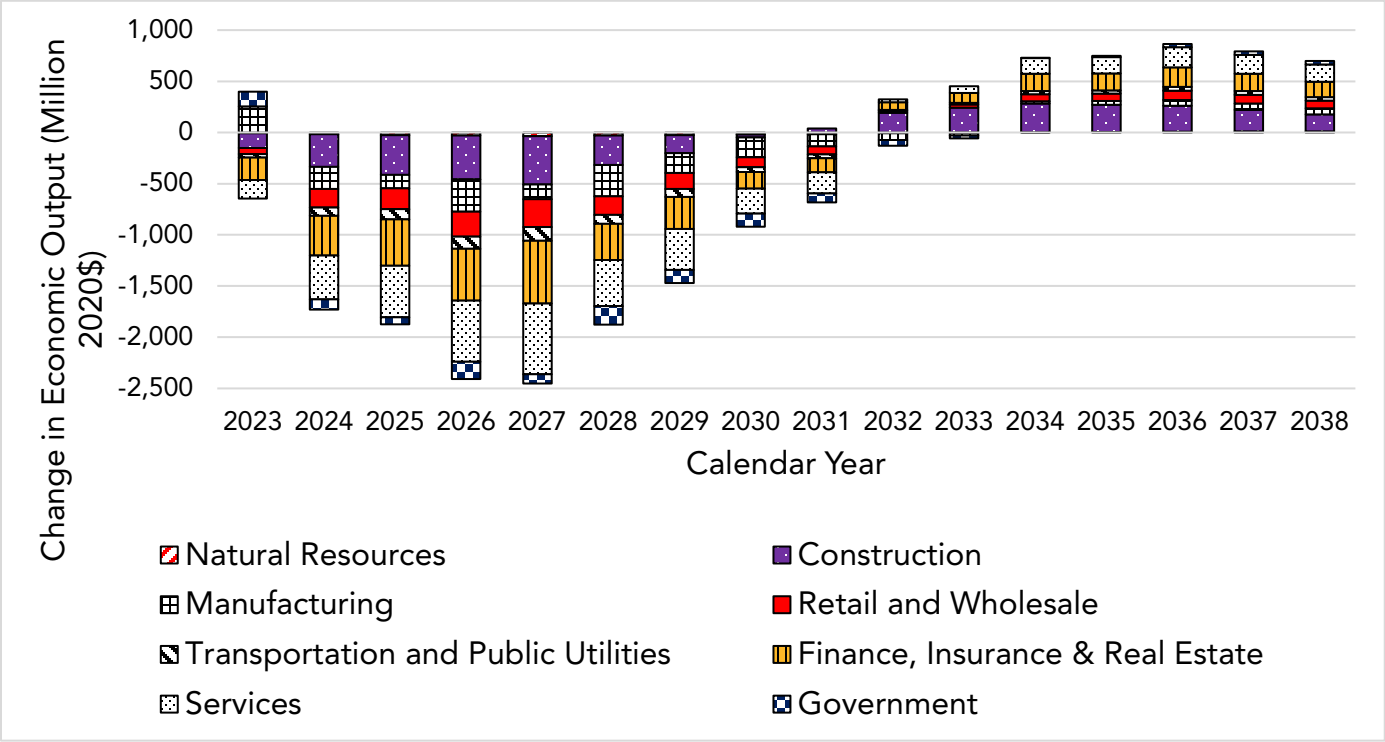


Table 38. Change in California Output Growth by Industry

	Mining (21)		Construction (23)		Air transportation (481)		Commercial and industrial machinery and equipment rental and leasing (5324)	
Year	Change (2020M$)	% Change	Change (2020M$)	% Change	Change (2020M$)	% Change	Change (2020M$)	% Change
2023	-9	-0.05%	-141	-0.06%	-13	-0.04%	-6	-0.05%
2024	-18	-0.10%	-317	-0.13%	-20	-0.06%	-11	-0.10%
2025	-24	-0.13%	-390	-0.16%	-27	-0.07%	-16	-0.13%
2026	-28	-0.16%	-428	-0.17%	-29	-0.08%	-19	-0.15%
2027	-35	-0.19%	-470	-0.19%	-37	-0.09%	-24	-0.19%
2028	-29	-0.15%	-287	-0.12%	-19	-0.05%	-20	-0.16%
2029	-26	-0.13%	-174	-0.07%	-19	-0.05%	-19	-0.14%
2030	-20	-0.10%	-28	-0.01%	-10	-0.02%	-15	-0.11%
2031	-17	-0.08%	40	0.02%	-9	-0.02%	-12	-0.09%
2032	-7	-0.04%	193	0.08%	4	0.01%	-6	-0.05%
2033	-2	-0.01%	241	0.10%	5	0.01%	-3	-0.02%
2034	3	0.01%	281	0.11%	9	0.02%	1	0.01%
2035	6	0.03%	265	0.10%	9	0.02%	3	0.02%
2036	9	0.04%	252	0.10%	11	0.03%	5	0.04%
2037	10	0.04%	212	0.08%	10	0.02%	6	0.04%
2038	10	0.04%	166	0.06%	9	0.02%	7	0.05%

	Services to buildings and dwellings (5617)		Waste management and remediation services (562)		Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)		State and Local Government	
Year	Change (2020M$)	% Change	Change (2020M$)	% Change	Change (2020M$)	% Change	Change (2020M$)	% Change
2023	-5	-0.02%	-2	-0.01%	-2	-0.04%	142	0.03%
2024	-12	-0.04%	-5	-0.04%	-4	-0.09%	-100	-0.02%
2025	-14	-0.05%	-7	-0.05%	-6	-0.11%	-69	-0.02%
2026	-17	-0.05%	-8	-0.06%	-7	-0.14%	-171	-0.04%
2027	-20	-0.06%	-9	-0.06%	-9	-0.17%	-93	-0.02%
2028	-13	-0.04%	-7	-0.05%	-8	-0.15%	-182	-0.04%
2029	-11	-0.03%	-6	-0.04%	-7	-0.13%	-128	-0.03%
2030	-7	-0.02%	-5	-0.03%	-6	-0.11%	-129	-0.03%
2031	-5	-0.02%	-4	-0.02%	-5	-0.09%	-86	-0.02%
2032	1	0.00%	-1	-0.01%	-3	-0.05%	-56	-0.01%
2033	2	0.01%	0	0.00%	-1	-0.03%	-29	-0.01%
2034	5	0.01%	1	0.01%	0	0.00%	0	0.00%
2035	5	0.01%	2	0.01%	1	0.02%	14	0.00%
2036	6	0.02%	3	0.02%	2	0.03%	29	0.01%
2037	6	0.02%	3	0.02%	2	0.04%	34	0.01%

	Services to buildings and dwellings (5617)		Waste management and remediation services (562)		Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)		State and Local Government	
Year	Change (2020M$)	% Change	Change (2020M$)	% Change	Change (2020M$)	% Change	Change (2020M$)	% Change
2038	5	0.01%	3	0.02%	3	0.04%	35	0.01%

5.3.3 Impacts on Investments in California

Private domestic investment consists of purchases of residential and nonresidential structures and of equipment and software by private businesses and nonprofit institutions. It is used as a proxy for impacts on investments in California because it provides an indicator of the future productive capacity of the economy.

The relative changes to growth in private investment due to the Proposed Amendments are shown in Table 39 and shows the highest decrease of private investment of about $787 million in 2027, which is followed by a positive trend resulting in an increase of $248 million in 2038. In any given year this represents changes of less than 0.15 percent of baseline investment.

Table 39. Change in Gross Domestic Investment

Year	Private Investment (2020M$)	Change (2020M$)	% Change
2023	469,637	-249	-0.05%
2024	498,037	-476	-0.10%
2025	519,683	-618	-0.12%
2026	526,960	-678	-0.13%
2027	534,477	-787	-0.15%
2028	540,900	-514	-0.10%
2029	549,614	-364	-0.07%
2030	556,127	-146	-0.03%
2031	562,688	-47	-0.01%
2032	570,646	189	0.03%
2033	579,052	277	0.05%
2034	587,995	351	0.06%
2035	597,275	348	0.06%
2036	606,778	345	0.06%
2037	616,678	302	0.05%
2038	627,337	248	0.04%

5.3.4 Impacts on Individuals in California

As modeled, the Proposed Amendments do not impose direct costs on individuals in California. However, the costs incurred by affected businesses and the public sector would cascade through the economy and affect individuals.

One measure of this impact is the change in real personal income, which is income received from all sources, including compensation of employees and government and business transfer activity, adjusted for inflation. This is an aggregate statewide measure of personal income change, representing a net of income lost from jobs foregone in some sectors and jobs gained in other sectors.

Table 40 shows the annual change in real personal income across all individuals in California. Total personal income decreases by $694 million in 2023, then continues a downward trend until 2031, with the highest decrease of $1.79 billion in 2027. Personal income increases after 2031. The change in personal income can also be divided by the California population to show the average or per capita impact on personal income. Personal income initially decreases by $16 per person in 2023 and decreases by about $27 per person in 2027, which is the year with the greatest impact.

Table 40. Change in Personal Income

Year	Personal Income (2020M$)	Change (2020M$)	% Change	Personal Income Per Capita (2020$)	Change (2020$)	% Change
2023	2,759,340	-694	-0.03%	68,380	-16	-0.02%
2024	2,862,139	-1,145	-0.04%	70,546	-23	-0.03%
2025	2,957,646	-1,315	-0.04%	72,486	-23	-0.03%
2026	3,013,168	-1,448	-0.05%	73,453	-23	-0.03%
2027	3,072,164	-1,787	-0.06%	74,502	-27	-0.04%
2028	3,148,627	-880	-0.03%	75,967	-5	-0.01%
2029	3,199,683	-871	-0.03%	76,820	-5	-0.01%
2030	3,276,140	-415	-0.01%	78,278	5	0.01%
2031	3,353,897	-411	-0.01%	79,771	3	0.00%
2032	3,413,981	300	0.01%	80,849	17	0.02%
2033	3,475,379	287	0.01%	81,967	13	0.02%
2034	3,539,589	508	0.01%	83,160	15	0.02%
2035	3,605,563	470	0.01%	84,404	12	0.01%
2036	3,673,513	565	0.02%	85,704	12	0.01%
2037	3,744,548	497	0.01%	87,083	9	0.01%
2038	3,819,490	437	0.01%	88,562	7	0.01%

5.3.5 Impacts on Gross State Product (GSP)

Gross State Product (GSP) is the market value of all goods and services produced in California and is one of the primary indicators of economic growth. It is calculated as the sum of the dollar value of consumption, investment, net exports, and government spending.

Table 41 shows the estimated annual change in GSP as a result of the Proposed Amendments. Under the Proposed Amendments, GSP is anticipated to decrease from 2023 to 2031. It then starts to increase from 2032 onwards. At the point of greatest impact, in 2027, GSP is estimated to be $1.5 billion lower than the baseline levels, a 0.04 percent decrease. This metric summarizes impacts discussed above, including consumer spending, investment, and government spending. These changes do not exceed 0.04 percent of baseline GSP.

Table 41. Change in Gross State Product

Year	GSP (2020M$)	Change (2020M$)	% Change
2023	3,230,419	-224	-0.01%
2024	3,341,272	-1,016	-0.03%
2025	3,438,475	-1,126	-0.03%
2026	3,483,979	-1,411	-0.04%
2027	3,531,308	-1,487	-0.04%
2028	3,581,885	-1,087	-0.03%
2029	3,640,315	-871	-0.02%
2030	3,692,779	-530	-0.01%
2031	3,750,999	-379	-0.01%
2032	3,813,455	133	0.00%
2033	3,877,229	246	0.01%
2034	3,943,107	445	0.01%
2035	4,010,519	455	0.01%
2036	4,080,408	523	0.01%
2037	4,152,695	479	0.01%
2038	4,229,364	420	0.01%

5.3.6 Creation or Elimination of Businesses

The Proposed Amendments do not directly result in business creation or elimination, and the REMI model cannot directly estimate the creation or elimination of businesses. However, changes in the number of jobs and output in the California economy can be used to understand some of the potential impacts. The overall jobs and output impacts are small relative to the total California economy. The largest employment and output decreases in the State are estimated to be about 0.04 percent in 2026 and 2027. However, impacts in some sectors are proportionately larger or occur at different times, as described in previous sections. For example, the directly-impacted industries, including mining, construction, and commercial and industrial machinery and equipment rental and leasing, are estimated to have the largest employment and output decrease of around 0.2 percent in 2027. Some other directly-impacted industries, including services to buildings and dwellings, and waste management and remediation services, only have an employment and output decrease of 0.06 percent in 2027. In addition, the impacts to typical businesses vary depending on the fleet size. As discussed in Section 3.2 and Section 3.3, the Proposed Amendment will result in increased costs of about $330,000 and $200,000 for typical large and medium fleets respectively, and a slight cost increase of around $550 for a typical small fleet during the analysis period from 2023 to 2038. A typical ultra-small fleet would see a total cost increase of less than $35,000 from the Proposed Amendments during the same analysis period.

Reductions in output could indicate the elimination of businesses. Conversely, increased output within an industry could signal the potential for additional business creation if existing businesses cannot accommodate all future demand. There is no threshold that identifies the creation or elimination of business.

5.3.7 Incentives for Innovation

The Proposed Amendments will further reduce emissions from off-road diesel equipment operating in California by phasing out the use of the most polluting vehicles. The Proposed Amendments target the removal of vehicles with Tier 0, 1, and 2 engines and require the vehicles to be replaced with the cleanest available technology. The Tier 4 final engine standard has been in use since the late 2010's. Hence, the Proposed Amendments' requirements can be met with existing technology and will not be driving innovation in terms of engine standards. However, the Proposed Amendments include an optional flexibility provision for fleets that want to incorporate zero-emission technology into their fleets. CARB staff does not assume any benefits or costs associated with this provision, as it is optional. The Proposed Amendments provide the opportunities for the development and deployment of zero-emission technologies and could provide much needed compliance flexibility for fleets wanting to participate in the beachhead innovation of off-road zero-emission technology. The compliance flexibility offered in the Proposed Amendments could create a staging ground for fleets to initiate and improve their experience with zero-emission technology. While this provision provides opportunities, the degree to which it will be employed will depend on individual fleets' decisions and are not quantified.

5.3.8 Competitive Advantage or Disadvantage

Staff do not anticipate impacts to the competitive advantage or disadvantage of businesses currently doing business in the State. The Proposed Amendments impose requirements equally on all fleets that operate off-road diesel vehicles in California, whether the business that owns or operates them is based in-state or out-of-state. If an out-of-state business wants to operate vehicles subject to the Off-Road Diesel-Fueled Fleets Regulation, it would need to comply with all requirements of the regulation, just as an in-state business would. In addition, the work performed by these off-road diesel vehicles is bound to the job site, and requires large infrastructure investments, such as mining and construction activities. Therefore, it is unlikely the directly-impacted businesses will move out of the State.

5.4 Summary and Agency Interpretation of the Assessment Results

The results of the macroeconomic analysis of the Proposed Amendments are summarized in Table 42. As analyzed here, CARB estimates the Proposed Amendments are unlikely to have a significant impact on the California economy. Overall, the change in the growth of jobs, State GDP, and output is projected to not exceed 0.04 percent of the baseline.

Table 42. Summary of Macroeconomic Impacts of the Proposed Amendments

	GSP		Personal Income		Employment		Output		Private Investment	
Year	Change (2020$M)	% Change	Change (2020$M)	% Change	Change in jobs	% Change	Change (2020$M)	% Change	Change (2020$M)	% Change
2023	-224	-0.01%	-694	-0.03%	-2,046	-0.01%	-249	-0.01%	-249	-0.05%
2024	-1,016	-0.03%	-1,145	-0.04%	-7,964	-0.03%	-1,731	-0.03%	-476	-0.10%
2025	-1,126	-0.03%	-1,315	-0.04%	-8,636	-0.03%	-1,873	-0.03%	-618	-0.12%
2026	-1,411	-0.04%	-1,448	-0.05%	-10,461	-0.04%	-2,409	-0.04%	-678	-0.13%
2027	-1,487	-0.04%	-1,787	-0.06%	-10,865	-0.04%	-2,452	-0.04%	-787	-0.15%
2028	-1,087	-0.03%	-880	-0.03%	-7,308	-0.03%	-1,876	-0.03%	-514	-0.10%
2029	-871	-0.02%	-871	-0.03%	-5,580	-0.02%	-1,471	-0.02%	-364	-0.07%
2030	-530	-0.01%	-415	-0.01%	-2,906	-0.01%	-922	-0.02%	-146	-0.03%
2031	-379	-0.01%	-411	-0.01%	-1,813	-0.01%	-642	-0.01%	-47	-0.01%
2032	133	0.00%	300	0.01%	1,872	0.01%	195	0.00%	189	0.03%
2033	246	0.01%	287	0.01%	2,524	0.01%	393	0.01%	277	0.05%
2034	445	0.01%	508	0.01%	3,769	0.01%	728	0.01%	351	0.06%
2035	455	0.01%	470	0.01%	3,664	0.01%	750	0.01%	348	0.06%
2036	523	0.01%	565	0.02%	3,967	0.02%	864	0.01%	345	0.06%
2037	479	0.01%	497	0.01%	3,508	0.01%	794	0.01%	302	0.05%
2038	420	0.01%	437	0.01%	2,983	0.01%	699	0.01%	248	0.04%

6 Alternatives

Alternatives were solicited from the staff and the public throughout the process for developing the Proposed Amendments, and most explicitly at the May 2021 and December 2021 workshops. These alternatives are analyzed relative to the same baseline presented in Section 1.5 and the results are then compared to the Proposed Amendments along with the reason(s) for rejection of the alternatives. Alternatives are required to consider one case that achieves benefits beyond those of the proposed regulation (more stringent), and one that achieves the same level of benefits but is less likely or more costly to achieve those benefits. The two alternatives focus on adjusting the Tier phase-out requirements because this has the largest impact on costs and benefits.

6.1 Alternative 1 - Less Stringent

Alternative 1 is a less stringent requirement for fleets that own and operate the vehicles subject to the Proposed Amendments. Alternative 1 adjusts the Proposed Amendments by delaying the phase-out of vehicles with Tier 0, 1, and 2 engines by 2 years. Additionally, Alternative 1 does not implement a phase-out of Tier 2 engines for small and ultra-small (<500 HP) fleets. Alternative 1 also delays the restrictions on adding Tier 3 and Tier 4 interim vehicles to a fleet by two years when compared to the Proposed Amendment. Alternative 1 does not require fleets to transition to R99 renewable diesel. This alternative would not make changes to the requirements for prime contractors or public works awarding bodies. Key elements of Alternative 1 include the following:

- Requirements for the Tier phase-out are adjusted based on the schedule in Table 43. Some exemptions apply, such as using a vehicle less than 200 hours per year (i.e., low-use). For all fleet sizes, low-use vehicles with Tier 0 or a model year 1994 or earlier on-road engines would be required to be phased-out by January 1, 2036.

Table 43. Tier and Model Year Phase-out Dates by Fleet Size for Alternative 1

Year (January 1)	Large Fleets	Medium Fleets	Small Fleets[86]
2026	Tier 0/MY 1994 or older on-road		
2028	Tier 1/MY 1999 or older on-road	Tier 0/MY 1994 or older on-road	
2030	Tier 2/MY 2003 or older on-road	Tier 1/MY 1999 or older on-road	Tier 0/MY 1994 or older on-road
2032		Tier 2/MY 2003 or older on-road	Tier 1/MY 1999 or older on-road

[86] Ultra-small fleets would not have additional phase-out requirements under Alternative 1.

- Requirements for the restrictions on the addition of a Tier 3 or Tier 4 interim (Tier 4i) vehicle or a model year (MY) 2006 or older on-road vehicle to a fleet are adjusted based on the schedule in Table 44.

Table 44. Compliance Dates for the Restrictions on Adding Vehicles for Alternative 1

Year (January 1)	Large Fleets	Medium Fleets	Small and Ultra-Small Fleets
2024	Tier 3		
2026	Tier 4i/MY 2006 or older on-road	Tier 3	
2028		Tier 4i/MY 2006 or older on-road	Tier 3
2030			Tier 4i/MY 2006 or older on-road

This alternative aligns with proposals and comments made by stakeholders advocating for delayed implementation of several key elements to the Proposed Amendments and to not require renewable diesel usage as part of the Proposed Amendments.

6.1.1 Costs

CARB staff developed cost estimates for Alternative 1 according to the methodology described in Section 3.1. Table 45 provides the summary results of the incremental costs associated with Alternative 1. For simplicity, included are the amortized vehicle capital costs, Tier 4 final maintenance costs, and the costs for public works awarding bodies and prime contractors (which are the same as in the Proposed Regulation).

Table 45. Summary of Incremental Costs Due to Alternative 1

Year	Annual Vehicle Capital Costs (amortized, with tax)	Tier 4 final Maintenance Costs	Administrative Costs Public Works Awarding Bodies	Administrative Costs Prime Contractors	Total
2023	$0	$0	$0.0	$0.0	$0
2024	$0	$0	$2,265,280	$11,242,740	$13,508,020
2025	$347,911,868	$0	$2,265,280	$11,242,740	$361,419,888
2026	$323,967,974	$1,669,374	$2,265,280	$11,242,740	$339,145,368
2027	$426,350,837	$1,669,374	$2,265,280	$11,242,740	$441,528,231
2028	$392,088,839	$2,672,415	$2,265,280	$11,242,740	$408,269,274
2029	$540,997,696	$2,672,415	$2,265,280	$11,242,740	$557,178,131
2030	$135,470,277	$4,109,815	$2,265,280	$11,242,740	$153,088,112
2031	$173,240,000	$4,109,815	$2,265,280	$11,242,740	$190,857,835
2032	$20,133,210	$4,796,242	$2,265,280	$11,242,740	$38,437,472
2033	$8,145,990	$4,796,242	$2,265,280	$11,242,740	$26,450,252
2034	-$183,275,900	$4,796,242	$2,265,280	$11,242,740	-$164,971,638
2035	-$165,246,301	$4,796,242	$2,265,280	$11,242,740	-$146,942,039
2036	-$213,129,916	$4,796,242	$2,265,280	$11,242,740	-$194,825,654
2037	-$191,418,081	$4,796,242	$2,265,280	$11,242,740	-$173,113,819

Year	Annual Vehicle Capital Costs (amortized, with tax)	Tier 4 final Maintenance Costs	Administrative Costs Public Works Awarding Bodies	Administrative Costs Prime Contractors	Total
2038	-$170,099,621	$4,796,242	$2,265,280	$11,242,740	-$151,795,359
Total	**$1,445,136,873**	**$50,476,901**	**$33,979,199**	**$168,641,101**	**$1,698,234,073**

6.1.2 Benefits

CARB staff developed emission reduction estimates for Alternative 1 according to the methodology described in Section 2.1. Alternative 1 would result in fewer NOx and PM emission reductions than the Proposed Amendments. From 2023 through 2038, Alternative 1 results in emission reductions of 18,254 tons of NOx and 1,256 tons of PM2.5 compared with the baseline. Figure 7 and Figure 8 show the NOx and PM emissions under the Baseline, Proposed Amendments, and Alternative 1. For additional clarity, Table 46 and Table 47 show the data that correspond to Figure 7 and Figure 8, respectively.

Figure 7. Projected NOx Emissions under the Baseline, Proposed Amendments, and Alternative 1

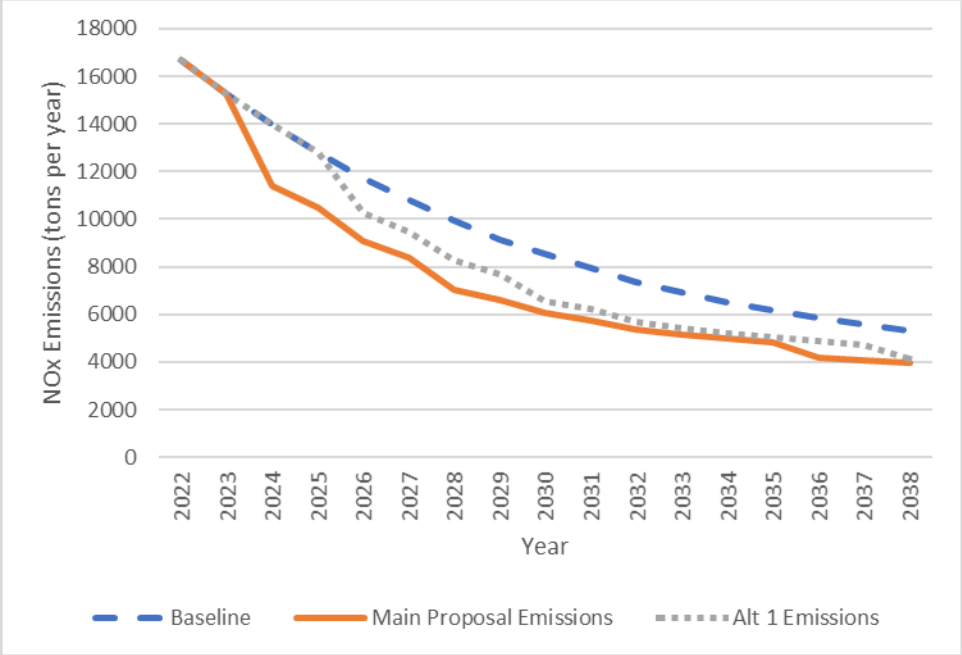


Table 46. Projected NOx emissions under the Baseline, Proposed Amendments, and Alternative 1, in tons per year

Year	Baseline	Proposal	Alternative 1
2023	15,257	15,257	15,257
2024	13,967	11,374	13,967
2025	12,800	10,465	12,800
2026	11,742	9,065	10,295
2027	10,790	8,403	9,487
2028	9,946	7,036	8,259
2029	9,162	6,625	7,666
2030	8,530	6,043	6,562
2031	7,935	5,754	6,224
2032	7,387	5,387	5,680
2033	6,918	5,171	5,429
2034	6,508	4,980	5,212
2035	6,155	4,812	5,026
2036	5,837	4,166	4,859
2037	5,562	4,073	4,713
2038	5,320	3,989	4,126
Total	143,816	112,600	125,562

Figure 8. Projected PM Emissions under the Baseline, Proposed Amendments, and Alternative 1

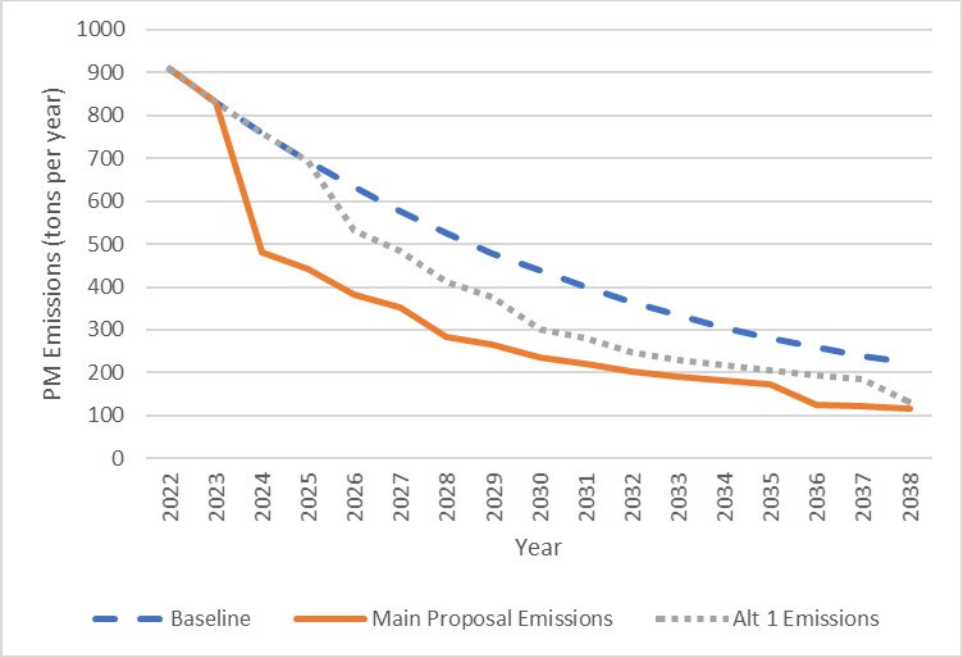


Table 47. Projected PM emissions under the Baseline, Proposed Amendments, and Alternative 1, in tons per year

Year	Baseline	Proposal	Alternative 1
2023	830	830	830
2024	758	482	758
2025	692	443	692
2026	632	382	530
2027	577	353	485
2028	526	284	413
2029	478	264	377
2030	438	236	301
2031	400	222	280
2032	364	203	247
2033	333	191	231
2034	305	181	217
2035	280	171	205
2036	258	125	194
2037	239	121	184
2038	222	116	132
Total	7,332	4,604	6,076

Staff used the estimation methodologies described in Section 2.4.1 to quantify avoided cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and emergency room visits for respiratory illness and asthma that would be expected from Alternative 1. Table 48 shows the statewide valuation of avoided health outcomes for Alternative 1, which generates a lower valuation of health benefits at $3.03 billion compared to the Proposed Amendments at $5.76 billion.

Table 48. Statewide Valuation of Avoided Health Outcomes for Alternative 1 from 2023 to 2038

Outcome	Avoided Incidents	Valuation (million 2020$)[87]
Cardiopulmonary mortality	301	$3,023.7
Hospitalizations for cardiovascular illness	45	$2.6
Hospitalizations for respiratory illness	53	$2.8
Emergency room visits	145	$0.1
Total		**$3,029.3**

[87] Note: Numbers may not add up exactly due to rounding.

6.1.3 Economic Impacts

Alternative 1 imposes a less stringent vehicle phase-out requirement compared to the Proposed Amendments by delaying the phase-out of vehicles with Tier 0, 1, and 2 engines, and delaying the restrictions on adding Tier 3 and Tier 4i vehicles to a fleet by two years, among other requirements. The macroeconomic impact analysis results for Alternative 1 are qualitatively similar to the results of the Proposed Amendments, but the impacts are delayed by two years compared to the Proposed Amendments. The largest decreases in GSP, personal income, employment, output, and private investment are seen in 2029 in Alternative 1 versus 2027 in the Proposed Amendments. In Alternative 1, these economic indicators are estimated to increase slightly relative to the baseline starting from 2034. The magnitude of the impacts for Alternative 1 is slightly less than that of the Proposed Amendments. The changes in statewide output and employment represent, at most, a 0.03 percent decrease relative to the baseline. The macroeconomic impact analysis results for Alternative 1 are shown in Table 49. Figure 9 and Figure 10 show the job and economic impact changes of Alternative 1, respectively.

Table 49. Summary of Economic Impacts of Alternative 1

	GSP		Personal Income		Employment		Output		Private Investment	
Year	Change (2020$M)	% Change	Change (2020$M)	% Change	Change in jobs	% Change	Change (2020$M)	% Change	Change (2020$M)	% Change
2023	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
2024	-20	0.00%	-33	0.00%	-126	0.00%	-32	0.00%	-12	0.00%
2025	-206	-0.01%	-630	-0.02%	-1,784	-0.01%	-230	0.00%	-224	-0.04%
2026	-881	-0.03%	-1,003	-0.03%	-6,672	-0.03%	-1,497	-0.03%	-405	-0.08%
2027	-970	-0.03%	-1,143	-0.04%	-7,198	-0.03%	-1,608	-0.03%	-520	-0.10%
2028	-1,204	-0.03%	-1,257	-0.04%	-8,638	-0.03%	-2,046	-0.03%	-570	-0.11%
2029	-1,265	-0.04%	-1,500	-0.05%	-8,910	-0.03%	-2,086	-0.03%	-648	-0.12%
2030	-846	-0.02%	-661	-0.02%	-5,426	-0.02%	-1,454	-0.02%	-399	-0.07%
2031	-663	-0.02%	-667	-0.02%	-4,016	-0.02%	-1,115	-0.02%	-267	-0.05%
2032	-375	-0.01%	-281	-0.01%	-1,846	-0.01%	-651	-0.01%	-88	-0.02%
2033	-231	-0.01%	-205	-0.01%	-830	0.00%	-403	-0.01%	13	0.00%
2034	216	0.01%	351	0.01%	2,248	0.01%	340	0.01%	202	0.03%
2035	297	0.01%	331	0.01%	2,669	0.01%	482	0.01%	267	0.05%
2036	451	0.01%	503	0.01%	3,579	0.01%	740	0.01%	320	0.05%
2037	453	0.01%	465	0.01%	3,434	0.01%	748	0.01%	311	0.05%
2038	420	0.01%	423	0.01%	3,079	0.01%	698	0.01%	274	0.04%

Figure 9. Employment Impacts by Major Sector of Alternative 1

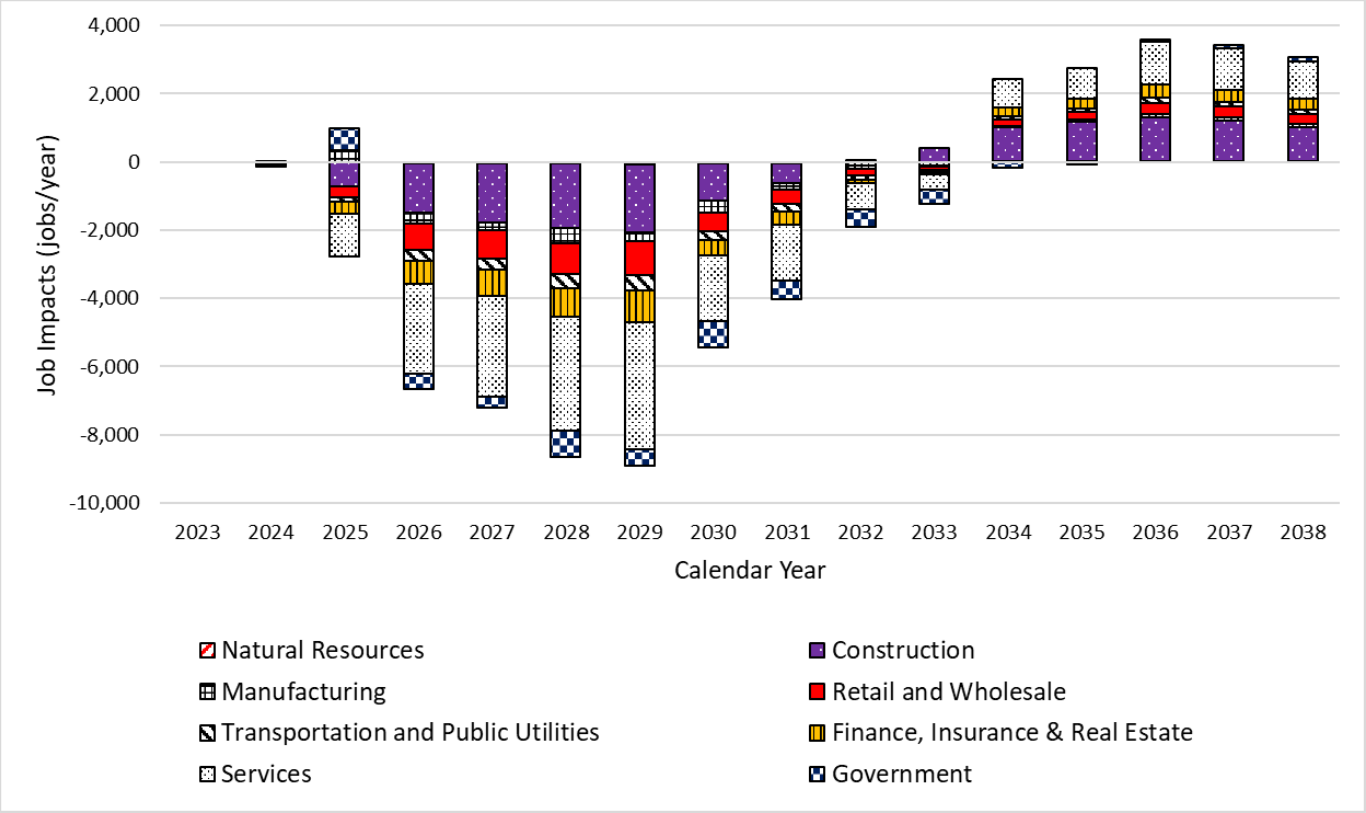
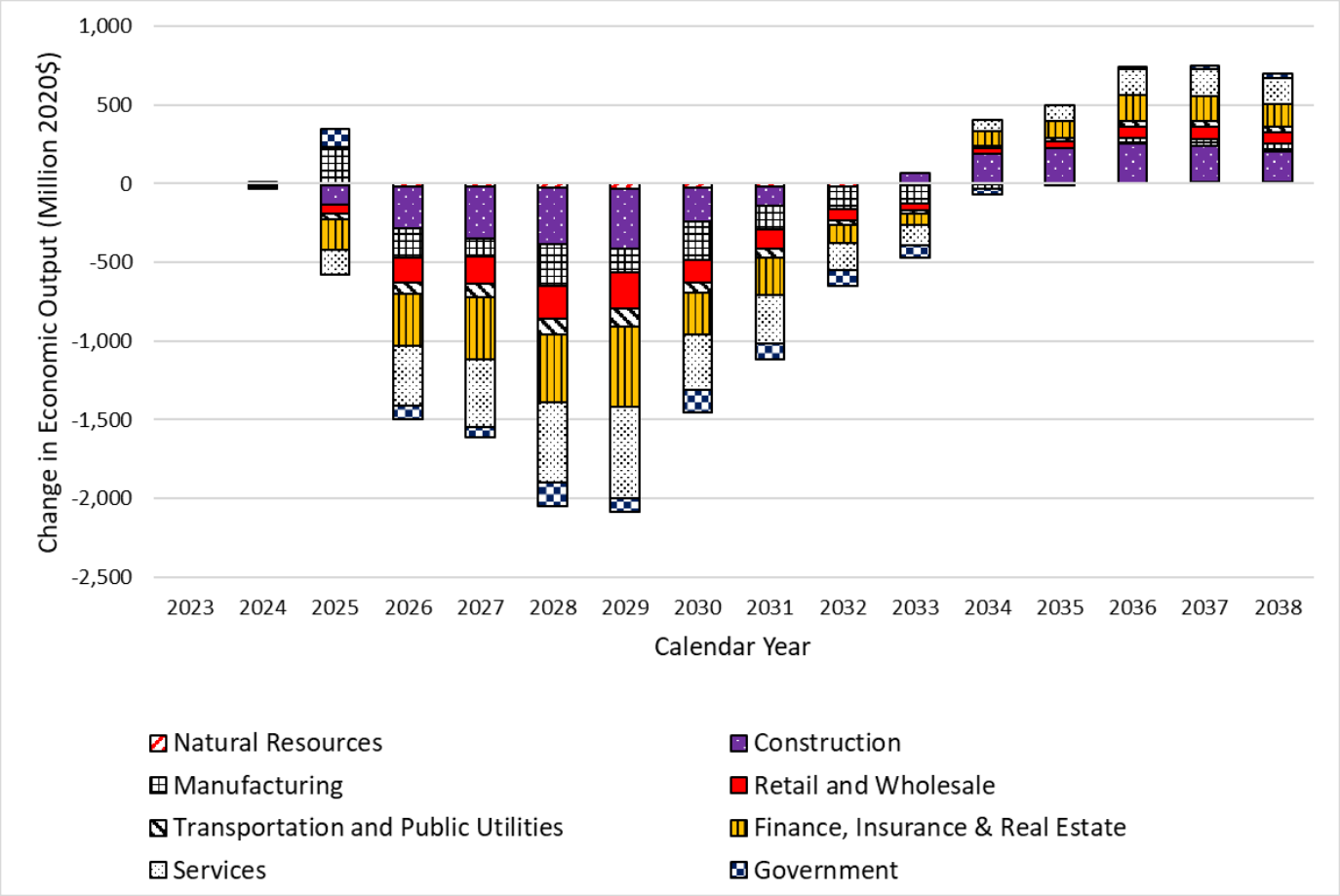


Figure 10. Change in Output in California by Major Sector of Alternative 1



6.1.4 Cost-Effectiveness

Cost-effectiveness is a measure of the cost of a regulation per ton of expected emission reduction. There are multiple approaches to calculating cost-effectiveness. Staff calculated the cost-effectiveness of Alternative 1 (in $/weighted ton) using the cost-effectiveness method provided in Appendix C of the Carl Moyer Program Guidelines, which divides the cost over a period of time by the weighted emission reductions (in tons per year) over that time period[88]. Table 50 displays the cost-effectiveness of the Proposed Amendments compared to Alternative 1. CARB staff estimates that Alternative 1 is less cost-effective than the Proposed Amendments due to the reduced emission reductions from the delay in the Tier phase-out and the lack of a requirement for fleets to use renewable diesel.

[88] California Air Resources Board, Carl Moyer Program Guidelines, Appendix C, April 27, 2017. (web link: *https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2017/2017_cmpgl.pdf*)

Table 50. Cost-Effectiveness of the Proposed Amendments and Alternative 1

Proposal	Carl Moyer Program Cost-Effectiveness per Weighted Ton
Proposed Amendments	$22,369
Alternative 1	$39,121
Difference	$16,751

6.1.5 Reason for Rejecting

CARB staff rejected Alternative 1 because it is less cost-effective and would achieve fewer NOx and PM reductions than the Proposed Amendments. Alternative 1 delays the Tier phase-out for Tier 0, Tier 1, and Tier 2 vehicles in all fleet sizes, allowing the oldest equipment to continue to operate for several additional years. The delay in the Tier phase-out along with the delay in the restrictions on adding vehicles would result in fleets being able to add Tier 3 as replacements for their Tier 0 vehicles, therefore increasing NOx emissions and causing significant delays to achieving PM reductions in impacted communities throughout the state. To the extent the vehicles impacted by the Proposed Amendments are domiciled at a facility, Alternative 1 does not provide much needed localized reductions in toxic diesel PM. Alternative 1 does not align with the 2020 MSS goal of reducing statewide NOx emissions by 7.5 tons per day by 2031 and full turnover of remaining Tier 0 through Tier 2 engines in the fleet between 2024 and 2033. The Alternative also does not align with the measure in the 2022 State SIP Strategy to achieve reductions of 4.1 tons per day of NOx in 2037. Additionally, Alternative 1 does not include the requirement for fleets to use renewable diesel which achieves significant near-term NOx reductions which are needed to help meet the federal ambient air quality standards for ozone and achieve additional PM reductions in communities throughout the state.

6.2 Alternative 2 – More Stringent

Alternative 2 is a more stringent requirement for fleets who own and operate the vehicles subject to the Proposed Amendments. Alternative 2 adjusts the Proposed Amendment by implementing the phase-out of vehicles with Tier 0, 1, and 2 engines earlier than the Proposed Amendments. Alternative 2 also imposes a phase-out of Tier 3 vehicles for all fleet sizes that is not required under the Proposed Amendments. Additionally, Alternative 2 implements the restrictions on adding Tier 3 and Tier 4i vehicles to large and medium fleets upon adoption of the proposal. For small fleets, Alternative 2 implements the restriction on adding Tier 3 vehicles upon adoption and Tier 4 interim vehicles two years earlier than the Proposed Amendments. This alternative would maintain the requirements for renewable diesel, prime contractors and public works awarding bodies, as in the Proposed Amendments. Key elements of Alternative 2 include the following:

- Requirements for the Tier phase-out are adjusted based on the schedule in Table 51. Some exemptions apply, such as using a vehicle less than 200 hours per year (i.e.,

low-use). For all fleet sizes, low-use vehicles with a Tier 0 engine or a model year 1994 or earlier on-road engine would be required to be phased-out by January 1, 2036.

Table 51. Tier and Model Year Phase-out Dates by Fleet Size for Alternative 2

Year (January 1)	Large Fleets	Medium Fleets	Small Fleets	Ultra-Small[89]
Upon adoption	Tier 0/MY 1994 or older on-road			
2024		Tier 0/MY1994 or older on-road		
2025	Tier 1/MY1999 or older on-road			
2026		Tier 1/MY 1999 or older on-road	Tier 0/MY 1994 or older on-road	
2027	Tier 2/MY 2003 or older on-road			
2028		Tier 2/MY 2003 or older on-road	Tier 1/MY 1999 or older on-road	
2029	Tier 3			
2030		Tier 3	Tier 2/MY 2003 or older on-road	
2032			Tier 3	
2036				Tier 2/MY 2003 or older on-road

- Requirements for the restrictions on the addition of a Tier 3 or Tier 4 interim (Tier 4i) vehicle or a model year 2006 or older on-road vehicle to a fleet are adjusted based on the schedule in Table 52.

Table 52. Compliance Dates for the Restrictions on Adding Vehicles for Alternative 2

Year	Large Fleets	Medium Fleets	Small and Ultra-Small Fleets
Adoption	Tier 4i/MY 2006 or older on-road	Tier 4i/MY 2006 or older on-road	Tier 3 or older
2026			Tier 4i/MY 2006 or older on-road

This alternative aligns with proposals and comments made by stakeholders advocating to achieve additional emission reductions from this sector as quickly as possible and to require the phase-out of Tier 3 engines in California.

6.2.1 Costs

CARB staff developed cost estimates for Alternative 2 according to the methodology described in Section 3.1. Table 53 provides the summary results of the incremental costs

[89] Ultra-small fleets are required to have 100 percent of their fleet Tier 2 or cleaner by January 1, 2029 under the Off-Road Regulation.

associated with Alternative 2. For simplicity, included are the amortized vehicle capital costs, Tier 4 final maintenance costs, and the costs for public works awarding bodies and prime contractors (which are the same as in the Proposed Regulation).

Table 53. Summary Incremental Costs Due to Alternative 2

Year	Annual Vehicle Capital Costs (amortized, with tax)	Tier 4 final Maintenance Costs	Administrative Costs Public Works Awarding Bodies	Administrative Costs Prime Contractors	Total
2023	$459,778,687	$514,139	$0.0	$0.0	$460,292,826
2024	$547,793,640	$910,167	$2,265,280	$11,242,740	$562,211,827
2025	$664,766,126	$1,692,842	$2,265,280	$11,242,740	$679,966,988
2026	$746,483,499	$3,130,589	$2,265,280	$11,242,740	$763,122,108
2027	$766,561,286	$4,087,801	$2,265,280	$11,242,740	$784,157,107
2028	$379,346,036	$5,031,786	$2,265,280	$11,242,740	$397,885,842
2029	$310,318,378	$5,938,060	$2,265,280	$11,242,740	$329,764,458
2030	$91,992,621	$7,061,049	$2,265,280	$11,242,740	$112,561,690
2031	-$30,609,306	$7,061,049	$2,265,280	$11,242,740	-$10,040,237
2032	-$134,854,862	$7,475,261	$2,265,280	$11,242,740	-$113,871,581
2033	-$278,655,968	$7,475,261	$2,265,280	$11,242,740	-$257,672,687
2034	-$357,707,309	$7,475,261	$2,265,280	$11,242,740	-$336,724,028
2035	-$307,812,941	$7,475,261	$2,265,280	$11,242,740	-$286,829,660
2036	-$308,351,548	$7,475,261	$2,265,280	$11,242,740	-$287,368,267
2037	-$257,771,805	$7,475,261	$2,265,280	$11,242,740	-$236,788,524
2038	-$214,260,995	$7,475,261	$2,265,280	$11,242,740	-$193,277,714
Total	**$2,077,015,538**	**$87,754,307**	**$33,979,199**	**$168,641,101**	**$2,367,390,145**

6.2.2 Benefits

Staff developed emission reduction estimates for Alternative 2 according to the methodology described in Section 2.1. Alternative 2 would result in slightly greater emission reductions than the Proposed Amendments. From 2023 through 2038, Alternative 2 results in emission reductions of 38,403 tons of NOx and 3,127 tons of PM2.5 compared with the baseline. Figure 11 and Figure 12 show the NOx and PM emissions under the Baseline, Proposed Amendments, and Alternative 2. For additional clarity, Table 54 and Table 55 show the data that correspond to Figure 11 and Figure 12, respectively.

Figure 11. Projected NOx Emissions under the Baseline, Proposed Amendments, and Alternative 2

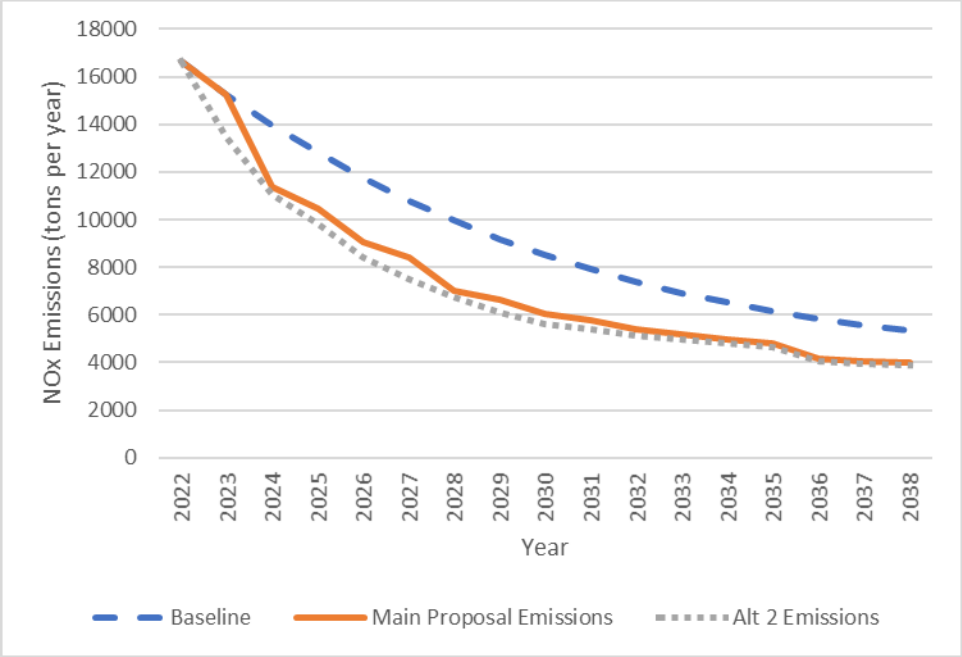


Table 54. Projected NOx emissions under the Baseline, Proposed Amendments, and Alternative 2, in tons per year

Year	Baseline	Proposal	Alternative 2
2023	15,257	15,257	13,494
2024	13,967	11,374	11,031
2025	12,800	10,465	9,792
2026	11,742	9,065	8,388
2027	10,790	8,403	7,489
2028	9,946	7,036	6,723
2029	9,162	6,625	6,110
2030	8,530	6,043	5,608
2031	7,935	5,754	5,397
2032	7,387	5,387	5,121
2033	6,918	5,171	4,952
2034	6,508	4,980	4,797
2035	6,155	4,812	4,656
2036	5,837	4,166	4,030
2037	5,562	4,073	3,950
2038	5,320	3,989	3,875
Total	143,816	112,600	105,413

Figure 12. Projected PM Emissions under the Baseline, Proposed Amendments, and Alternative 2

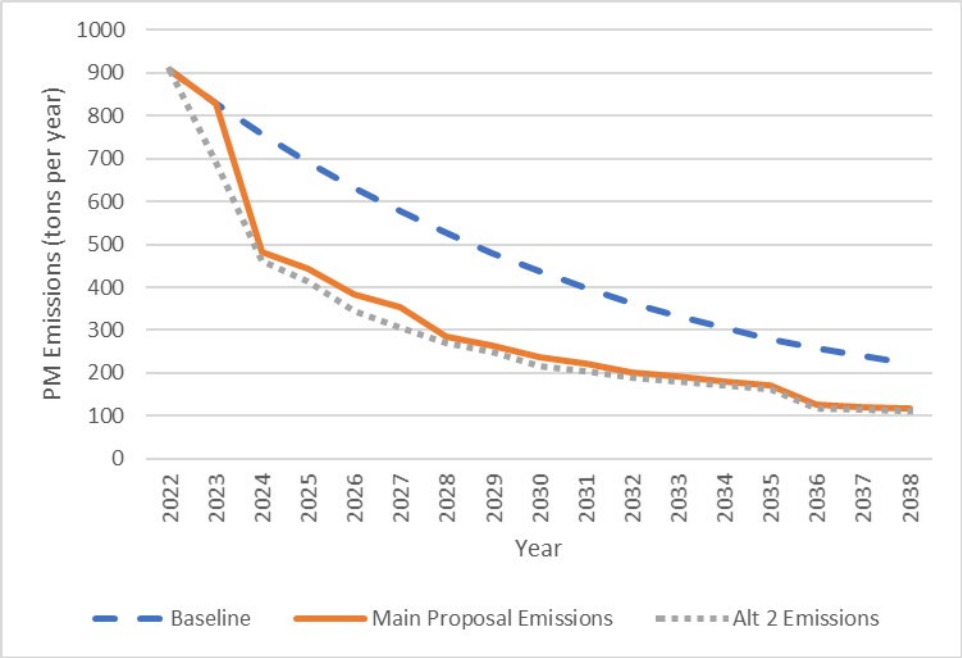


Table 55. Projected PM emissions under the Baseline, Proposed Amendments, and Alternative 2, in tons per year

Year	Baseline	Proposal	Alternative 2
2023	830	830	692
2024	758	482	462
2025	692	443	414
2026	632	382	344
2027	577	353	307
2028	526	284	271
2029	478	264	250
2030	438	236	215
2031	400	222	204
2032	364	203	189
2033	333	191	180
2034	305	181	171
2035	280	171	163
2036	258	125	118
2037	239	121	114
2038	222	116	111
Total	7,332	4,604	4,205

Staff used the estimation methodologies described in Section 2.4.1 to quantify avoided cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and emergency room visits for respiratory illness and asthma that would be expected to result from Alternative 2. Staff calculated the health benefits for Alternative 2 using the methodology described in Section 2.4.1. Table 56 shows the statewide valuation of avoided health outcomes for Alternative 2. Alternative 2 results in a higher valuation of health benefits at $6.58 billion compared to the Proposed Amendments at $5.76 billion.

Table 56. Statewide Valuation of Avoided Health Outcomes for Alternative 2 from 2023 to 2038

Outcome	Avoided Incidents	Valuation (million 2020$)[90]
Cardiopulmonary mortality	654	$6,563.8
Hospitalizations for cardiovascular illness	94	$5.6
Hospitalizations for respiratory illness	112	$5.8
Emergency room visits	317	$0.3

[90] Note that numbers may not add up exactly due to rounding.

Outcome	Avoided Incidents	Valuation (million 2020$)[90]
Total		$6,575.4

6.2.3 Economic Impacts

Alternative 2 is more stringent compared to the Proposed Amendments. Alternative 2 imposes an earlier phase-out schedule for vehicles with Tier 0, 1, and 2 engines than the Proposed Amendments, imposes a phase-out of Tier 3 vehicles for all fleet sizes, and implements the restrictions on adding Tier 3 and Tier 4i vehicles. The schedule of these restrictions varies depending on the fleet size, but they are implemented earlier than the Proposed Amendments. The macroeconomic impact analysis results for Alternative 2 are qualitatively similar to the results of the Proposed Amendments, but of a greater magnitude. The largest decreases in GSP, personal income, employment, output, and private investment for Alternative 2 are seen in 2027, which is the same year as for the Proposed Amendments. Similar to the Proposed Amendments, these economic indicators start to increase after 2031. The changes in statewide output and employment for Alternative 2 represent, at most, a 0.06 percent decrease relative to the baseline. The macroeconomic impact analysis results for Alternative 2 are shown in Table 57. Figure 13 and Figure 14 show the job and economic impact changes of Alternative 2, respectively.

Table 57. Summary of Economic Impacts of Alternative 2

	GSP		Personal Income		Employment		Output		Private Investment	
Year	Change (2020$M)	% Change	Change (2020$M)	% Change	Change in jobs	% Change	Change (2020$M)	% Change	Change (2020$M)	% Change
2023	-258	-0.01%	-799	-0.03%	-2,357	-0.01%	-287	-0.01%	-286	-0.06%
2024	-1,226	-0.04%	-1,512	-0.05%	-9,693	-0.04%	-2,048	-0.04%	-616	-0.12%
2025	-1,569	-0.05%	-1,796	-0.06%	-12,041	-0.05%	-2,628	-0.05%	-829	-0.16%
2026	-1,933	-0.06%	-2,133	-0.07%	-14,448	-0.06%	-3,256	-0.06%	-978	-0.19%
2027	-2,163	-0.06%	-2,300	-0.08%	-15,721	-0.06%	-3,663	-0.06%	-1,044	-0.20%
2028	-1,389	-0.04%	-1,275	-0.04%	-9,393	-0.04%	-2,347	-0.04%	-720	-0.13%
2029	-1,173	-0.03%	-1,144	-0.04%	-7,516	-0.03%	-1,987	-0.03%	-493	-0.09%
2030	-762	-0.02%	-604	-0.02%	-4,267	-0.02%	-1,328	-0.02%	-209	-0.04%
2031	-253	-0.01%	-154	-0.01%	-575	0.00%	-450	-0.01%	47	0.01%
2032	40	0.00%	136	0.00%	1,466	0.01%	34	0.00%	233	0.04%
2033	465	0.01%	597	0.02%	4,316	0.02%	748	0.01%	417	0.07%
2034	751	0.02%	863	0.02%	6,075	0.02%	1,231	0.02%	541	0.09%
2035	751	0.02%	775	0.02%	5,806	0.02%	1,240	0.02%	533	0.09%
2036	776	0.02%	810	0.02%	5,736	0.02%	1,284	0.02%	500	0.08%
2037	677	0.02%	685	0.02%	4,847	0.02%	1,125	0.02%	419	0.07%
2038	563	0.01%	571	0.02%	3,908	0.02%	938	0.01%	325	0.05%

Figure 13. Employment Impacts by Major Sector of Alternative 2

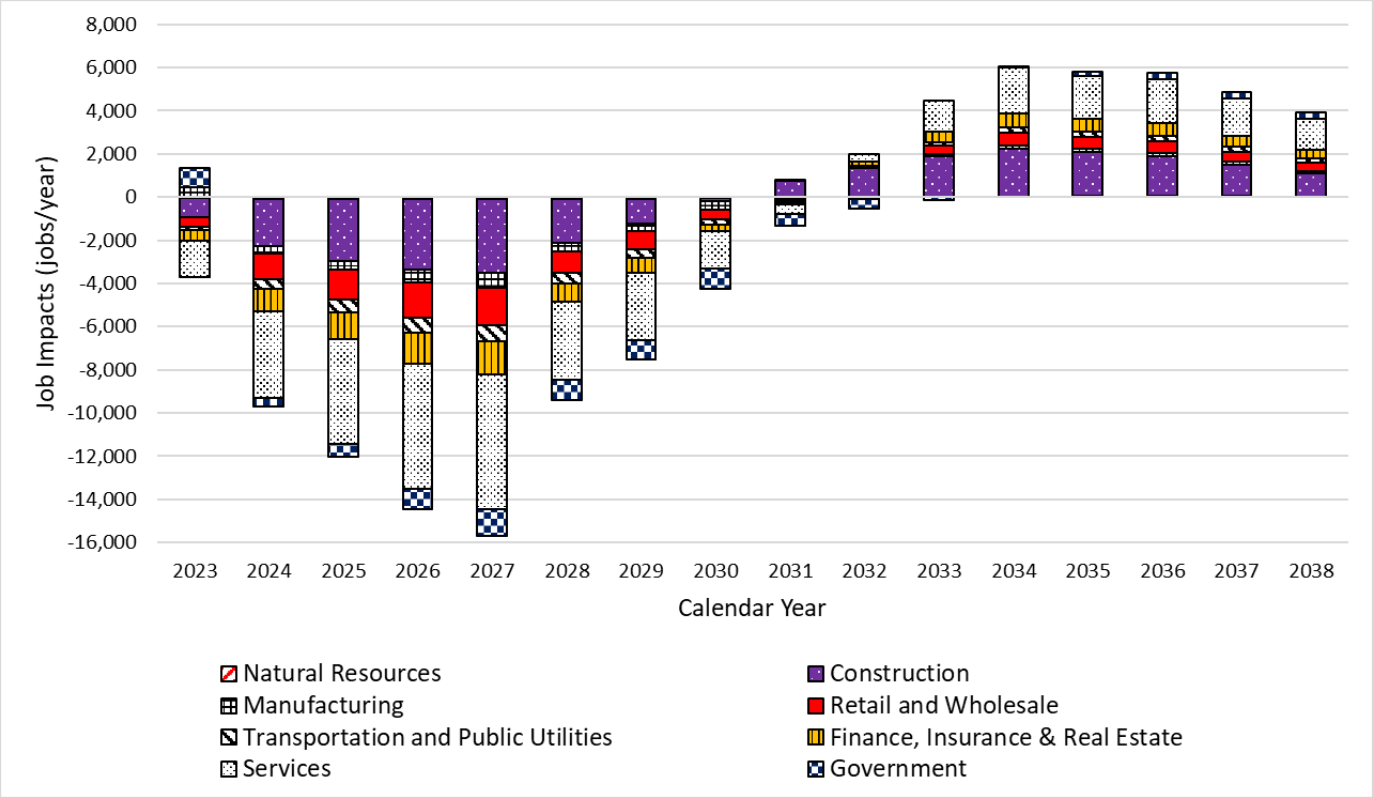
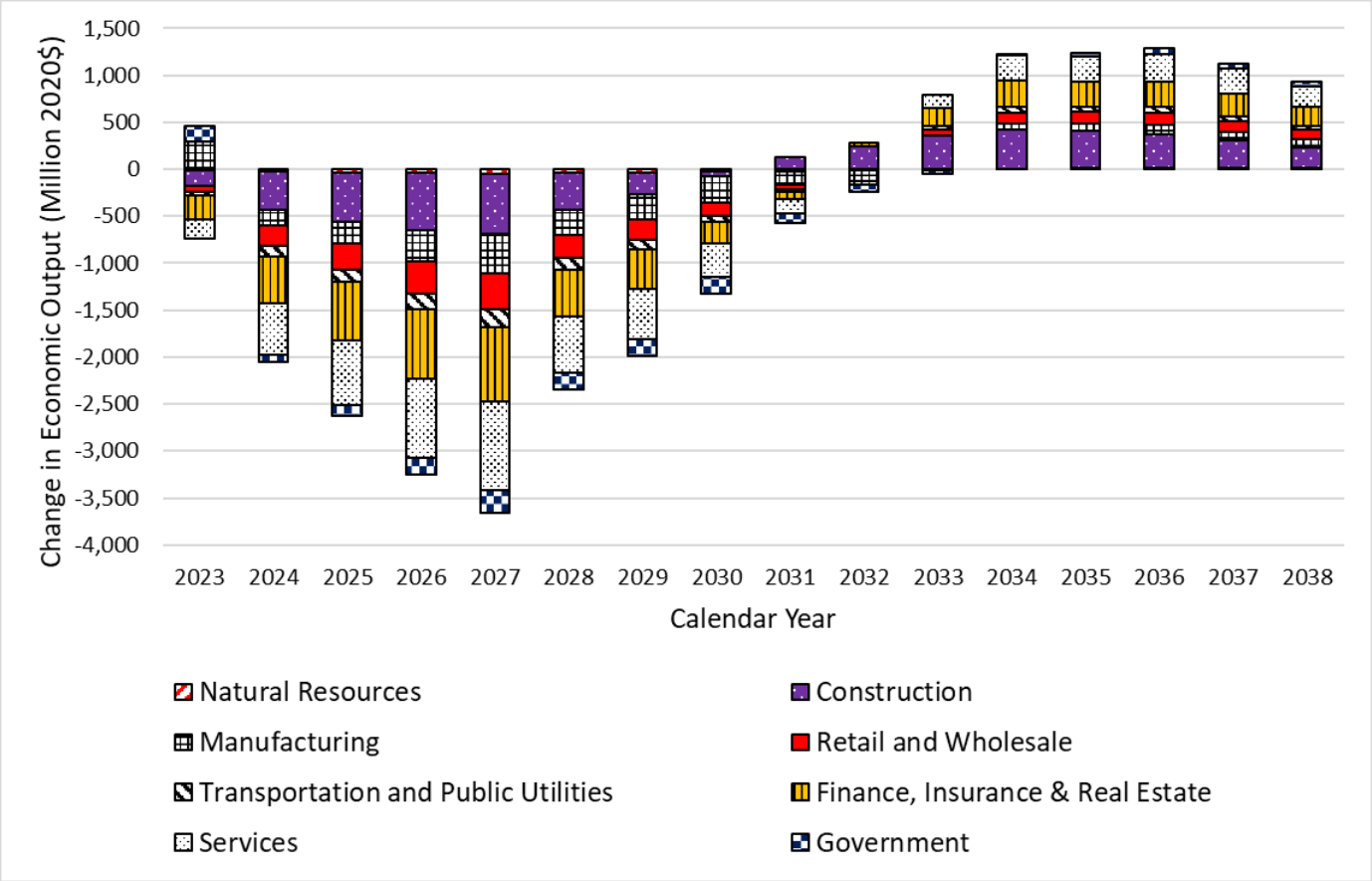


Figure 14. Change in Output in California by Major Sector of Alternative 2



6.2.4 Cost-Effectiveness

Cost-effectiveness is a measure of the cost of a regulation per ton of expected emission reduction. There are multiple approaches to calculating cost-effectiveness. Staff calculated the cost-effectiveness of Alternative 2 (in $/weighted ton) using the cost-effectiveness method provided in Appendix C of the Carl Moyer Program Guidelines, which divides the cost over a period of time by the weighted emission reductions (in tons per year) over that time period[91]. Table 58 displays the cost-effectiveness of the Proposed Amendments compared to Alternative 2. CARB staff estimates that Alternative 2 is less cost-effective than the Proposed Amendments due to the increased costs associated with the implementation of the Tier phase-out on an accelerated timeframe along with the addition of the Tier 3 phase-out.

[91] See note 88

Table 58. Cost-Effectiveness of the Proposed Amendments and Alternative 2

Proposal	Carl Moyer Program Cost-Effectiveness per Weighted Ton
Proposed Amendments	$22,369
Alternative 2	$24,257
Difference	$1,888

6.2.5 Reason for Rejecting

Alternative 2 was rejected because it imposes higher costs and low additional emission reductions; therefore, it would be less cost-effective to implement than the Proposed Amendments. Although Alternative 2 achieves greater emissions benefits in the early years of implementation primarily due to the accelerated timeline of the Tier phase out, this adjusted timeframe would pose a challenge for fleets to comply due to the immediate need for action. The Proposed Amendments attempt to balance the need for additional NOx and PM reductions with the cost impacts. The accelerated timeline under Alternative 2 creates significant additional costs in the near-term which could put fleets at risk of non-compliance or inability to continue their business at current levels. Additionally, due to the additional near-term vehicle turnover that will be required, vehicle costs may increase due to increased demand and there could be a lack of availability of vehicles to meet the near-term need. This alternative therefore may not be more effective at achieving emission benefits than the Proposed Amendments due to the potential lack of availability of vehicles and the compliance flexibility in the Off-Road Regulation that allows for delayed compliance if compliant vehicles are unavailable.

7 Appendix A – Overview of Off-Road Diesel Vehicles

Heavy-duty off-road diesel-powered vehicles are a diverse group. These vehicles are used in industries such as construction, mining, landscaping, airlines, equipment rental, ski, oil and gas drilling, manufacturing, retail and wholesale distribution, recycling, utilities, telephone and cable, and many others. Government agencies engaged in road maintenance and other activities also utilize affected vehicles. There are hundreds of manufactures of off-road diesel vehicles. Some vehicle manufacturers also manufacture engines for their equipment, but most vehicle manufacturers design vehicles to accept engines manufactured by other companies. Some off-road engine manufacturers also supply engines for multiple vehicle manufacturers. Off-road vehicles range from small skid-steer loaders used in residential landscaping to very large mining trucks. Common vehicle types are described below.

Dozer

Figure 15. Photo of a Dozer

The term dozer (or bulldozer) refers to an off-road tractor, either tracked or wheeled, equipped with a blade. In the emissions inventory, dozers are called "crawler tractors." A ripper, which is a claw-like device, may be attached to the back of a larger dozer (typically greater than 200 horsepower (hp)). The ripper is useful in loosening up the ground so that the blade will be able to penetrate and fill quickly. Dozers are used in a wide variety of industries such as construction and mining for earthwork and grading to move piles of dirt or for demolition, and industrial settings to position bulk cargo.

Loader

Figure 16. Photo of a Loader

The term "loader" is generic and can be any type of off-road tractor that uses a bucket on the end of movable arms to lift materials into trucks, and move material such as dirt, debris,

building materials, bulk goods, heavy objects, or snow. Loaders are used widely in construction, mining, industrial sectors and road maintenance. There are many different types of loaders, including but not limited to, front end, skid steer, backhoe, rubber tired, and crawler.

Loaders are manufactured in a wide range of sizes, from 25 hp (for small, skid steer loaders) to over 1,000 hp (for large, rubber-tired loaders), with most being between 200 hp and 750 hp. Small loaders may have bucket capacities of 1 cubic yard or less, while the large rubber-tired loaders can have a bucket capacity over 45 cubic yards.

Forklift

Figure 17. Photo of a Mast Forklift

Forklifts are industrial trucks used to hoist and transport materials by means of one or more steel forks inserted under the load. Forklifts are extremely diverse in both their size and custom cargo handling abilities. Forklift engines can be powered by internal combustion engines, such as compression ignition (i.e., diesel or natural gas) or spark ignition (i.e., gasoline or propane) engines, or electric motors. Compression ignition forklifts are usually designed for higher lift capacity than their electric or spark-ignited counterparts. Diesel forklifts tend to have lift capacities of over 6,000 pounds, are usually used outdoors, and have pneumatic tires. Forklifts are used in a variety of applications, including, but not limited to, manufacturing, construction, retail, meat and poultry processing, lumber and building supplies, trades, agriculture, and a variety of warehouse operations.

Motor Grader

Figure 18. Photo of a Motor Grader

Motor graders are used to establish a rough or finish grade, spread material for building paved roads, build and maintain unpaved roads, such as rural or mine haul roads, and clear snow from roads. Motor graders contain engines with hp typically between 125 to 500 hp, and blade widths range from 12 to 24 feet.

Crane

Figure 19. Photo of a Crane

There are a wide variety of cranes that range in size, weight and function. Cranes are used to lift and lower materials, and to move them horizontally. Large cranes are commonly used in the construction of buildings, bridges, and in manufacturing. Smaller cranes are used in a variety of applications across many sectors. Cranes may have telescoping, lattice or articulating (folding) booms. The capacity rating is in tons that the crane can safely lift. The smaller cranes may have engines with less than 25 hp, while some contain engines over 500 hp. Some of the largest cranes have 2 engines, an upper and lower engine. In these cranes, the lower engine propels the vehicle to position itself and the upper engine provides the power for performing the lifting or dragging function once in position. Smaller cranes only have one engine, which is used to both propel the vehicle and to provide the lifting power.

Scraper

Figure 20. Photo of a Scraper

A scraper is a large machine used for earthmoving and mining. The rear section has a vertically moveable hopper with a sharp horizontal front edge. The hopper can be hydraulically lowered and raised. When the hopper is lowered, the front edge cuts into the soil and fills the hopper. The engines have hp ranging from 175 to over 500 hp. The heavier scraper types have two engines (tandem powered).

Excavator

Figure 21. Photo of Excavator

An excavator is a machine made for digging out earth with its bucket to create trenches, holes and foundations. The bucket may sometimes be swapped out with other attachments to perform other tasks. Excavators generally come in three sizes. The largest being standard excavators used for bulk earthmoving and heavy lifting. Midi excavators are used when a jobsite is in a confined area and has more power than a mini excavator. A mini excavator is the smallest machine and used when a small footprint is needed, or jobsite space is tight.

8 Appendix B – Statewide Vehicle Populations Used to Analyze Direct Costs

The tables in Appendix B represent the statewide vehicle populations that were assumed to be removed (or turned over) from the statewide fleet as described in Section 3.1.2. The tables are presented by fleet size. Each table displays the vehicle turnover population in each year during the analysis timeframe and by hp group. The vehicle turnover populations exclude all vehicles designated as low-use. Table 59 through Table 61 represent the baseline scenario derived directly from the 2022 Statewide In-Use Off-Road Emissions Inventory Model. Table 62through Table 64 represent Proposed Amendments and have been modified from the baseline to reflect the phase-out requirements in Table 3.

Table 59. Baseline Statewide Large Fleet Vehicle Turnover Populations

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2023	1,470	2,477	1,431	2,232	1,197	1,219	102	76
2024	1,481	2,502	1,419	2,235	1,193	1,222	100	76
2025	1,492	2,528	1,409	2,240	1,186	1,223	99	75
2026	1,504	2,556	1,401	2,247	1,181	1,219	100	75
2027	1,515	2,583	1,395	2,255	1,176	1,212	102	75
2028	1,508	2,578	1,374	2,241	1,170	1,220	107	75
2029	1,408	2,416	1,273	2,091	1,086	1,121	105	70
2030	1,398	2,405	1,256	2,075	1,079	1,123	113	70
2031	1,393	2,400	1,247	2,067	1,075	1,122	118	70
2032	1,393	2,410	1,244	2,070	1,073	1,117	120	71
2033	1,318	2,286	1,172	1,961	1,013	1,053	115	68
2034	1,254	2,182	1,113	1,870	967	1,005	109	66
2035	1,257	2,192	1,116	1,877	969	1,004	106	66
2036	1,264	2,206	1,117	1,885	973	1,001	104	66
2037	1,270	2,221	1,120	1,900	974	997	102	65
2038	1,275	2,231	1,128	1,909	978	994	99	65

Table 60. Baseline Statewide Medium Fleet Vehicle Turnover Populations

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2023	102	129	165	204	145	92	4	3
2024	104	136	163	199	142	92	4	3
2025	108	144	165	201	138	90	4	4
2026	109	149	164	203	136	89	4	4
2027	110	153	162	202	134	90	4	4
2028	111	157	160	202	133	88	4	5
2029	111	160	157	200	132	89	4	5

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2030	110	161	153	201	131	89	4	5
2031	107	160	147	199	131	91	4	6
2032	87	132	118	165	104	71	4	4
2033	86	133	117	161	109	70	4	4
2034	79	124	107	151	98	65	3	4
2035	79	123	106	150	99	65	3	4
2036	80	125	105	154	97	65	3	4
2037	80	126	104	153	98	64	3	4
2038	80	127	103	155	97	64	3	4

Table 61. Baseline Statewide Small Fleet Vehicle Turnover Populations

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2023	928	857	1,039	878	352	180	7	3
2024	949	850	1,079	862	350	178	7	3
2025	969	852	1,109	849	348	174	7	3
2026	984	858	1,120	833	346	175	7	4
2027	994	866	1,116	818	348	176	7	4
2028	992	867	1,081	805	350	180	7	5
2029	831	735	872	668	294	151	7	5
2030	844	758	842	670	294	150	7	5
2031	857	792	808	672	294	149	7	5
2032	870	839	773	680	293	144	7	6
2033	873	884	733	695	293	139	7	6
2034	877	927	704	709	289	135	6	6
2035	871	960	679	718	285	135	6	6
2036	797	917	619	675	257	122	5	6
2037	792	934	617	682	252	122	5	6
2038	786	944	622	683	250	122	5	5

Table 62. Proposed Amendments Statewide Large Fleet Vehicle Turnover Populations

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2023	1,655	2,779	1,782	2,808	1,903	2,612	393	126
2024	1,469	2,488	1,403	2,205	1,147	1,095	96	73
2025	1,609	2,744	1,806	2,560	1,452	1,315	138	94
2026	1,476	2,511	1,329	2,180	1,107	1,086	89	71
2027	1,810	2,873	1,889	2,608	1,323	1,358	112	108
2028	1,434	2,493	1,237	2,127	1,077	1,053	86	65

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2029	1,353	2,351	1,171	2,005	1,014	998	82	62
2030	1,353	2,351	1,174	2,003	1,012	1,001	83	63
2031	1,355	2,356	1,179	2,005	1,012	1,006	85	63
2032	1,364	2,372	1,189	2,017	1,018	1,016	87	64
2033	1,296	2,254	1,130	1,914	965	968	84	61
2034	1,237	2,154	1,080	1,827	920	926	82	59
2035	1,243	2,167	1,085	1,835	922	932	84	60
2036	1,251	2,183	1,093	1,846	928	941	86	61
2037	1,260	2,202	1,101	1,860	937	951	88	62
2038	1,265	2,213	1,106	1,869	943	960	89	62

Table 63. Proposed Amendments Statewide Medium Fleet Vehicle Turnover Populations

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2023	102	129	165	204	145	92	4	3
2024	104	136	163	199	142	92	4	3
2025	165	233	253	459	349	288	9	7
2026	104	143	157	184	121	72	4	4
2027	173	235	286	329	210	99	5	6
2028	96	138	133	163	106	69	4	4
2029	229	281	424	326	181	118	6	11
2030	79	125	89	146	98	63	4	4
2031	80	128	92	149	99	63	4	4
2032	68	109	80	127	84	54	3	3
2033	71	113	84	133	86	56	3	3
2034	68	108	81	127	82	53	3	3
2035	70	111	84	131	84	54	3	3
2036	72	115	88	135	86	55	3	3
2037	74	119	92	140	88	57	3	4
2038	76	122	95	143	90	58	3	4

Table 64. Proposed Amendments Statewide Small Fleet Vehicle Turnover Populations

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2023	928	857	1,039	878	352	180	7	3
2024	949	850	1,079	862	350	178	7	3
2025	969	852	1,109	849	348	174	7	3
2026	984	858	1,120	833	346	175	7	4
2027	1,644	1,538	1,699	1,653	778	464	16	6

Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-749 hp	750-9999 hp
2028	943	796	1,026	715	295	136	7	7
2029	1,150	1,075	1,351	1,041	425	178	9	5
2030	782	692	781	587	247	116	6	4
2031	1,448	1,222	1,552	954	333	170	8	8
2032	724	720	613	569	246	115	6	5
2033	758	785	613	590	246	115	6	5
2034	789	851	613	616	248	115	6	6
2035	800	896	603	629	245	113	6	6
2036	741	859	549	592	225	105	5	6
2037	730	871	540	596	222	104	5	5
2038	720	875	539	601	220	105	4	5

9 Appendix C – Methodology for Estimating Impacts to Residential Housing

As discussed in Section 3.4, there is the potential that the Proposed Amendments could impact the cost of residential housing in the event that compliance costs to fleets are indirectly passed along to individuals. This Appendix describes the methodology CARB staff used to determine the value that could be passed on to individuals.

CARB staff estimates that 53 percent of the affected vehicles belong to the construction industry (Table 6). Therefore, it is assumed that 53 percent of the direct costs discussed in Section 3 and provided in Table 18 would apply to the construction industry, inclusive of both residential and non-residential construction. CARB staff used historical construction permit estimates (2015-2019) for residential[92] and non-residential[93] construction to calculate an allocation for residential and non-residential construction projects based on their weighted percentage of the total construction estimates for each year. Residential construction represented an average 53 percent of the total valuation from 2015 through 2019. CARB staff applied that percent to the direct costs allocated to the construction industry to estimate the direct costs to the construction industry operating in residential construction.

California Department of Finance's (DOF) California Economic Forecast[94] provides forecasts on the number and valuation of single-family and multi-family residential permits for years 2023, 2024, and 2025. However, these forecasts do not meet the total housing need described in the 2022 Statewide Housing Plan[95]. California must plan for more than 2.5 million homes over the next eight years, and no less than one million of those homes must meet the needs of lower-income households. In order to achieve this, upwards of 300,000 housing units per year will need to be constructed. The 2022 Statewide Housing Plan describes a suite of measures – both recently implemented and in progress - that are intended to significantly spur production of new housing in the coming years. Thus it is likely that actual housing production numbers in the coming years may fall somewhere in between DOF's forecast and total housing production need. Table 65 displays the estimated direct costs of the Proposed Amendments to the residential construction industry as well as the valuation of the forecasted building permits, the percent of the estimated direct costs to the permit valuation, and the number of forecasted units.

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[92] California Department of Finance, annual data for residential construction permits. (web link: *https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/Annual_Construction_Residential.xlsx*)

[93] California Department of Finance, annual data for non-residential construction permits. (web link: *https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/Annual_Construction_Nonresidential.xlsx*)

[94] California Department of Finance, California Economic Forecast- Annual & Quarterly (web link: *https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/California-Economic-Forecast-GB-2022-23.xlsx*)

[95] See note 69

Table 65. Estimated Direct Costs to the Residential Construction Industry and Valuation and Number of Forecasted Residential Building Permits

Year	Forecasted Building Permit Valuation	Total Estimated Added Cost of Compliance - Dollars	Total Estimated Added Cost of Compliance – Percent of Total Valuation	Forecasted Number of Units	Housing Need (Units)
2023	$32,924,134,674	$112,397,551	0.3	132,337	300,000
2024	$35,942,159,121	$110,809,808	0.3	139,866	300,000
2025	$39,286,530,608	$146,285,398	0.3	149,160	300,000

To estimate the impacts of these costs on a per unit basis, CARB staff divided the estimated direct costs to residential construction by the forecasted total number of residential units authorized by permits and the housing need identified in the 2022 State Housing Plan. From the cost analysis earlier, the years for which the forecast is available, 2023 through 2025, are some of the highest cost years of the Proposed Amendments, with most years costing significantly less. CARB also calculated an average cost per year from ($35.2M) and an annual number of forecasted units (140,000) to provide a range of costs. CARB staff also calculated the percent of that direct cost to the cost of construction for new residential construction which is estimated at $350,000 to $570,000 per unit. Table 66 displays the potential impact to residential housing on a per unit basis.

Table 66. Estimated Direct Costs, Forecasted and Needed Units, and the Percent of Direct Costs to New Construction Costs

Year	Estimated Direct Costs (Millions)	Total Forecasted Permits	Potential One-time Cost per Unit (Forecast)	Percent of New per Unit Construction Costs (Forecast)	Total Needed Units	Potential One-time Cost per Unit (Need)	Percent of New per Unit Construction Costs (Need)
2023	$35.2- $112.4	132,337-140,455	$251-$849	0.04-0.2	300,000	$117-$374	0.02-0.1
2024	$35.2- $110.8	139,867-140,455	$251-$792	0.04-0.2	300,000	$117-$369	0.02-0.1
2025	$35.2-$146.3	140,455-149,160	$236-$1,042	0.04-0.3	300,000	$117-$487	0.02-0.1

10 Appendix D – Macroeconomic Inputs for REMI Analysis (Million 2020$)

REMI Policy Variables	Industry	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Production Cost	Lagged Market Share Response: Mining (21)	40.0	37.3	50.0	46.0	67.1	19.9	24.6	5.7	8.9	-17.9	-15.8	-22.1	-19.9	-22.6	-19.7	-17.3
Production Cost	Lagged Market Share Response: Construction (23)	212.1	197.9	264.9	243.7	355.6	105.7	130.2	30.0	47.4	-94.9	-83.6	-117.4	-105.3	-119.6	-104.6	-91.4
Production Cost	Lagged Market Share Response: Air transportation (481)	12.0	11.2	15.0	13.8	20.1	6.0	7.4	1.7	2.7	-5.4	-4.7	-6.6	-6.0	-6.8	-5.9	-5.2
Production Cost	Lagged Market Share Response: Commercial and industrial machinery and equipment rental and leasing (5324)	60.0	56.0	75.0	69.0	100.6	29.9	36.9	8.5	13.4	-26.9	-23.7	-33.2	-29.8	-33.9	-29.6	-25.9
Production Cost	Lagged Market Share Response: Waste management and remediation services (562)	16.0	14.9	20.0	18.4	26.8	8.0	9.8	2.3	3.6	-7.2	-6.3	-8.9	-8.0	-9.0	-7.9	-6.9
Production Cost	Lagged Market Share Response: Services to buildings and dwellings (5617)	20.0	18.7	25.0	23.0	33.5	10.0	12.3	2.8	4.5	-9.0	-7.9	-11.1	-9.9	-11.3	-9.9	-8.6

REMI Policy Variables	Industry	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Production Cost	Lagged Market Share Response: Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)	20.0	18.7	25.0	23.0	33.5	10.0	12.3	2.8	4.5	-9.0	-7.9	-11.1	-9.9	-11.3	-9.9	-8.6
Production Cost	Lagged Market Share Response: Mining (21)	0.0	0.2	0.2	0.3	0.3	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Production Cost	Lagged Market Share Response: Construction (23)	0.0	1.0	1.0	1.5	1.5	2.6	2.6	3.0	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Production Cost	Lagged Market Share Response: Air transportation (481)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Production Cost	Lagged Market Share Response: Commercial and industrial machinery and equipment rental and leasing (5324)	0.0	0.3	0.3	0.4	0.4	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Production Cost	Lagged Market Share Response: Waste management and remediation services (562)	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Production Cost	Lagged Market Share Response: Services to buildings and dwellings (5617	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

REMI Policy Variables	Industry	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Production Cost	Lagged Market Share Response: Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Production Cost	Lagged Market Share Response: Mining (21)	0.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Production Cost	Lagged Market Share Response: Construction (23)	0.0	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
Exogenous Final Demand	Agriculture, construction, and mining machinery manufacturing (3331)	1323.9	-88.2	417.9	-132.4	698.6	-235.7	64.6	-207.7	-23.7	-190.0	-165.3	-146.0	-132.6	-112.9	-96.2	-83.0
Exogenous Final Demand	Industrial machinery manufacturing (3332)	23.9	-1.6	7.6	-2.4	12.6	-4.3	1.2	-3.8	-0.4	-3.4	-3.0	-2.6	-2.4	-2.0	-1.7	-1.5
Exogenous Final Demand	Other general purpose machinery manufacturing (3339)	215.3	-14.3	68.0	-21.5	113.6	-38.3	10.5	-33.8	-3.9	-30.9	-26.9	-23.7	-21.6	-18.4	-15.7	-13.5
Exogenous Final Demand	Motor vehicle manufacturing (3361)	31.9	-2.1	10.1	-3.2	16.8	-5.7	1.6	-5.0	-0.6	-4.6	-4.0	-3.5	-3.2	-2.7	-2.3	-2.0
Exogenous Final Demand	Motor vehicle parts manufacturing (3363)	0.0	0.8	0.8	1.3	1.3	2.5	2.5	3.0	3.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5

REMI Policy Variables	Industry	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Exogenous Final Demand	Basic chemical manufacturing (3251)	0.0	1.1	1.1	1.6	1.6	2.3	2.3	2.6	2.6	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Exogenous Final Demand	Office administrative services; facilities support services (5611, 5612)	0.0	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
State and Local Government Spending	State Government	58.8	-9.0	13.7	-12.0	25.3	-14.3	-0.5	-11.5	-3.1	-8.4	-7.4	-5.8	-5.4	-4.2	-3.7	-3.3
State and Local Government Spending	Local Government	62.5	-18.5	6.2	-23.6	16.8	-21.6	-6.1	-15.8	-6.4	-7.7	-7.0	-4.0	-3.9	-2.0	-1.9	-1.9
Consumer Spending	Reallocate Consumption: Hospitals	0.0	-0.8	-0.7	-0.8	-0.8	-0.9	-0.8	-0.8	-0.7	-0.7	-0.6	-0.5	-0.5	-0.6	-0.5	-0.5
State and Local Government Employment	State Government (no. of job change)	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7