Appendix C-1

Original Standard Regulatory Impact Assessment Submitted to Department of Finance

Advanced Clean Fleets Regulation

California Air Resources Board

Date of Release: August 30, 2022
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Appendix C-1

State of California
Air Resources Board

Advanced Clean Fleets Regulation

Standardized Regulatory Impact Assessment

Date of Release: May 18, 2022

California Air Resources Board
1001 I Street

Sacramento, California 95814

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LIST OF ACRONYMS AND ABBREVIATIONS

AB	Assembly Bill
ACC II	Advanced Clean Cars II
ACF	Advanced Clean Fleets
ACT	Advanced Clean Trucks
APS	Air Pollution Specialist
ARE	Air Resources Engineer
ARS	Air Resources Supervisor
ART	Air Resources Technician
ASB	Airport Shuttle Bus
BAU	Business as Usual
BEV	Battery-Electric Vehicle
CARB or Board	California Air Resources Board
CEC	California Energy Commission
CI	Confidence Interval
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalents
CPUC	California Public Utilities Commission
DEF	Diesel Exhaust Fluid
DMV	Department of Motor Vehicles
DOF	Department of Finance
EER	Energy Efficiency Ratio
EIA	Energy Information Administration
EMFAC	Emission Factor Inventory Model
EPA	Environmental Protection Agency
ER	Emergency Room
EVSE	Electric Vehicle Supply Equipment
FCEV	Fuel Cell Electric Vehicle
FY	Fiscal Year
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GO-Biz	Governor’s Office of Business and Economic Development
GSP	Gross State Product
GVWR	Gross Vehicle Weight Rating
HDIM	Heavy-Duty Inspection and Maintenance
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE	Internal Combustion Engine
ICT	Innovative Clean Transit
IPT	Incidence-per-Ton
IRS	Internal Revenue Service
IWG	Interagency Working Group
kWh	Kilowatt-Hour
LCFS	Low Carbon Fuel Standard

MACRS	Modified Accelerated Cost Recovery System
MMT	Million Metric Tons
MY	Model Year
NOx	Oxides of Nitrogen
NZEV	Near-Zero-Emission Vehicle
OAL	Office of Administrative Law
OBD	On-Board Diagnostics
PG&E	Pacific Gas and Electric
PHEV	Plug-In Hybrid Electric Vehicle
PM	Particulate Matter
$PM_{2.5}$	Fine Particulate Matter
ppb	Parts Per Billion
SB	Senate Bill
$SC\text{-}CO_2$	Social Cost of Carbon
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SIP	State Implementation Plan
SLCP	Short-Lived Climate Pollutant
SRIA	Standardized Regulatory Impact Assessment
SWCV	Solid Waste Collection Vehicle
tpd	Tons Per Day
TTW	Tank-to-Wheel
VMT	Vehicle Miles Traveled
WTT	Well-to-Tank
WTW	Well-to-Wheel
ZE	Zero-Emission
ZEB	Zero-Emission Bus
ZEV	Zero-Emission Vehicle

1 Introduction

This document details an economic analysis of CARB staff's developing proposal to reduce emissions from Class 2b and larger medium- and heavy-duty vehicles that operate in California. Class 2b-8 vehicles have a manufacturer's gross vehicle weight rating (GVWR) greater than 8,500 lbs. Mobile sources and the fossil fuels that power them are the largest contributors to the formation of ozone, greenhouse gas (GHG) emissions, fine particulate matter ($PM_{2.5}$), and toxic diesel particulate matter. In California, the transportation sector alone accounts for 41 percent of total GHG emissions (50 percent when upstream emissions from fuel are included) and is a major contributor to ground level ozone and particulate matter ($PM_{2.5}$). Statewide, about 12 million Californians live in 19 areas where levels of ozone and $PM_{2.5}$ exceed the national ambient air quality standards (NAAQS) for ozone and $PM_{2.5,}$(nonattainment areas). Exposure to $PM_{2.5}$ and ozone is associated with increased risk of premature mortality, which has been estimated to contribute to 7,500 premature deaths each year in California.[1] The South Coast and the San Joaquin Valley air basins have the most critical air quality challenges. These regions experience some of the nation's highest PM levels and are the only 2 areas in the nation with an "extreme" classification for non-attainment with the federal ozone standard. In addition, 7 other areas in California are in serious or severe non-attainment with the federal ozone standard. Achieving federal air quality standards in these regions, as well as across California, will provide essential public health protection by reducing hospitalizations for heart and lung related causes, decreasing emergency room (ER) visits, and reducing incidences of asthma.

In California, climate change is contributing to an escalation of serious problems, including raging wildfires, coastal erosion, disruption of water supply, threats to agriculture, spread of insect-borne diseases, and continuing health threats from air pollution. Reducing GHG emissions will help put California on a trajectory to avoid the worst impacts of climate change; support a clean energy economy, which provides more opportunities for all Californians; and provide a more equitable future with good jobs and less pollution for all communities.

In addition to regional air pollutant levels, many communities in the state experience measurable harm in the form of negative health impacts from high levels of localized pollution. There is an immediate need to reduce emissions and exposure in these highly impacted, low-income, and disadvantaged communities throughout the state. Heavy-duty vehicle activity is often concentrated in and near these communities.

Zero-emission vehicle (ZEV) technologies eliminate all tailpipe emissions from the operation of the vehicle, which positively affects our air quality and climate challenge. The proposed Advanced Clean Fleets (ACF) regulation, in concert with existing state regulatory and incentive programs, seeks to accelerate the market transition to zero-emission (ZE) trucks and

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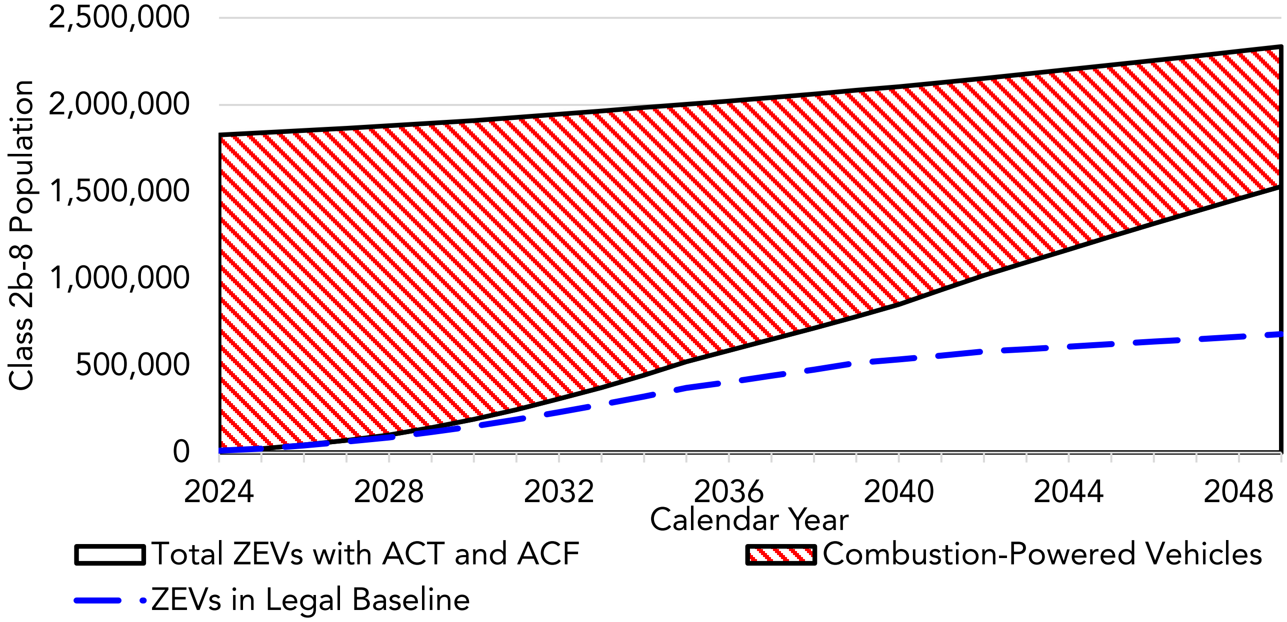
[1] California Air Resources Board, *Revised Proposed 2016 State Strategy for the State Implementation Plan*, 2017 (web link: https://ww3.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf, last accessed January 2022).

buses with a particular focus on particular fleets that pose acute health risks or which are particularly well positioned for electrification, contribute towards achieving the California Air Resources Board's (CARB or Board) emissions reductions goals for attaining federal health-based air quality standards, and reduce the local communities' exposure to air toxics and impacts of climate change. The proposed regulation would result in reductions in criteria pollutants, toxic air contaminants, and GHG emissions at the statewide, regional, and local levels. The proposed ACF regulation is one piece of California's holistic plan to address challenging federal air quality mandates, protect the public health of all Californians, and meet climate change goals. Table 1 enumerates the cumulative statewide benefits for emissions, cost savings, and avoided premature deaths expected from full implementation of the proposed regulation through calendar year 2050. Figure 1 shows the proposed regulation would be expected to increase the number of medium- and heavy-duty ZEVs beyond existing regulations from about 320,000 to about 520,000 by 2035 and from about 775,000 to about 1,250,000 ZEVs by 2045 with a growing number of ZEVs over time.

Table 1. Summary of Statewide Cumulative Benefits of Proposed ACF Regulation to 2050

Type of Benefit	**Cumulative Benefit by 2050**	**Section in SRIA**
NOx Reduction	444,000 tons	2.1.2
$PM_{2.5}$ Reduction	9,300 tons	2.1.2
GHG Reduction	267 MMT CO_2e	2.1.2
Estimated Avoided Cardiopulmonary Mortalities	5,888	2.4.1
Health Benefits	$61.7 billion	2.4.1
Social Cost of Carbon	$9.5-$37.4 billion	3.1.7
Net Cost Savings	$12.4 billion	3.1.7

Figure 1. Statewide Population Forecast with the Proposed Regulation



Medium- and heavy-duty ZEVs available today are already capable of meeting the average needs of local and regional trucking operations and a variety of vocational uses. They are expected to continue to improve over time. Several data sources show all truck types average less than 100 miles per day, except for semi-trucks where most average less than 200 miles per day.[2,3] Recent survey responses on daily mileage collected by CARB in 2021 as part of the Large Entity Reporting survey showed similar results for trucks that are owned by the respondents. Responses about broker-dispatched tractors showed a higher daily mileage. Today's medium- and heavy-duty ZEVs have energy storage systems that can meet most of these daily operational requirements. ZEVs also have unique advantages that will eventually lead to paradigm shifts in fleet operational behaviors. This includes quiet operations that enable later work shifts during times with less traffic and more efficient delivery schedules, improved safety on work sites, and less time spent on scheduled maintenance or out-of-service time due to the mechanical simplicity of ZEV systems. Over time, continued technology improvements, projected incremental cost reductions, and infrastructure growth will allow the ZEV market to continue expanding into all transportation service applications, including long-haul trucking.

Although medium- and heavy-duty ZEVs currently have higher upfront capital costs than vehicles powered by internal combustion engines, they have lower fuel and maintenance

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[2] United States Census Bureau, *2002 Vehicle Inventory and Use Survey, 2002* (web link: https://www2.census.gov/library/publications/economic-census/2002/vehicle-inventory-and-use-survey/ec02tv-us.pdf, last accessed January 2022).

[3] California Department of Transportation, *CalTrans Truck Survey, 2018* (web link: http://www.scag.ca.gov/committees/CommitteeDocLibrary/mtf012319_CAVIUS.pdf, last accessed January 2022).

costs that are expected to result in a positive total cost of ownership in most applications where they are suitable. Economic analyses by CARB and numerous third parties have found that medium- and heavy-duty ZEVs result in a lower total cost of ownership when compared to purchasing new gasoline or diesel counterparts in some applications today and in nearly all applications by 2030.[4,5,6,7,8,9,10,11]

Increasing public pressure to address our climate crisis is pushing governments and businesses to reduce California's carbon footprint through the development of sustainability plans and the adoption of carbon reducing incentive programs and regulations. As a result of such climate focused drivers and policies in California and other states, the medium- and heavy-duty ZEV market has developed rapidly over the past several years in the United States.

Today, there are over 100 Class 2b-8 ZEV models commercially available in North America from multiple manufacturers in every vehicle weight class category. As with heavy-duty combustion vehicles, many of these vehicles are manufactured as incomplete cab-and-chassis vehicles that can be equipped with a variety of body types to perform various functions. Currently, for the heaviest trucks in Class 8, there are 4 refuse models, 4 single-unit truck chassis, and 8 truck tractors that are commercially available. Another 4 on-road tractors are expected to be commercially available by 2023. In Class 6-7, there are 22 single-unit truck models and 9 van models that are commercially available. In Class 4-5, there are 19 single-unit truck models and 6 van models commercially available. In Class 2b-3, there are 7 van models and 1 pickup truck that are commercially available with 4 other pickup trucks and at

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[4] California Air Resources Board, *Draft Advanced Clean Trucks Total Cost of Ownership Discussion Document*, 2019 (web link: https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf, last accessed January 2022).

[5] Atlas Public Policy, *Assessing Financial Barriers to Adoption of Electric Trucks*, 2020 (web link: https://atlaspolicy.com/wp-content/uploads/2020/02/Assessing-Financial-Barriers-to-Adoption-of-Electric-Trucks.pdf, last accessed January 2022).

[6] Hydrogen Council, *Path to Hydrogen Competitiveness – A Cost Perspective*, 2020 (web link: https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf, last accessed January 2022).

[7] ICF International, *Comparison of Medium-Duty and Heavy-Duty Technologies in California*, 2019 (web link: https://caletc.aodesignsolutions.com/assets/files/ICF-Truck-Report_Final_December-2019.pdf, last accessed January 2022).

[8] North American Council for Fuel Efficiency, *Regional Haul*, 2019 (web link: https://nacfe.org/regional-haul/, last accessed January 2022).

[9] North American Council for Fuel Efficiency, *Viable Class 7/8 Electric, Hybrid, and Alternative Fuel Tractors*, 2019 (web link: https://nacfe.org/future-technology/viable-class-7-8/, last accessed January 2022).

[10] University of California Los Angeles, *Zero-Emission Drayage Trucks – Challenges and Opportunities for the San Pedro Bay Ports*, 2019. (web link: https://innovation.luskin.ucla.edu/wp-content/uploads/2019/10/Zero_Emission_Drayage_Trucks.pdf, last accessed January 2022)

[11] Union of Concerned Scientists, *Ready to Work – Now is the Time for Heavy-Duty Electric Vehicles*, 2019 (web link: https://www.ucsusa.org/sites/default/files/2019-12/ReadyforWorkFullReport.pdf, last accessed January 2022).

least 1 van model that are expected to be commercially available in 2022.[12] In addition, all major manufacturers have announced upcoming medium- and heavy-duty ZEV plans and all but 1 have ZEV models in development with plans to launch them commercially prior to 2024. End user companies like Amazon, DHL, and the United States Postal Service have commissioned or self-manufactured purpose-built ZEVs in quantity for their own delivery business use.[13,14,15] Finally, several companies including major truck parts suppliers have a variety of electric vehicle components and drivetrain solutions for vehicle manufacturers to use in their vehicles.

According to CALSTART's Zero-Emission Technology Inventory Analytics, it is estimated that there will be 594 ZE truck and bus models available internationally by the end 2022.[16] This shows that the ZEV market is rapidly expanding internationally, and that these same drivetrains or configurations could be made available in California with minimal additional engineering.

1.1 Regulatory History

CARB is responsible for protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change. Meeting these public health goals has resulted in a suite of regulations to control the harmful emissions of various air pollutants emitted from the operation of medium- and heavy-duty combustion engine vehicles. The following is a summary of key regulations that apply to fleets that would be affected by the proposed regulation including existing laws that will expand ZEV sales and continue to reduce emissions from new vehicles.

1.1.1 Public Agencies and Utilities Regulation

In 2005, the rule for On-Road Heavy-Duty Diesel-Fueled Public and Utility Fleets was approved by CARB to reduce diesel PM emissions from fleet vehicles operated by public agencies and utilities.[17] The rule required affected owners to equip their heavy-duty vehicles with Best Available Control Technology by December 31, 2012, with later requirements for

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[12] CALSTART, *Zero-emission Technology Inventory (ZETI) Analytics*, 2020 (web link: https://globaldrivetozero.org/tools/zeti-analytics/, last accessed January 2022).

[13] New York Times, *Can Anyone Satisfy Amazon's Craving for Electric Vans?*, 2022 (web link: https://www.nytimes.com/2022/01/18/technology/amazon-electric-vans.html, last accessed January 2022).

[14] Lightning eMotors, *DHL Express Deploys Nearly 100 New Lightning Electric Delivery Vans in U.S.*, 2021 (web link: https://lightningemotors.com/dhl-express-deploys-lightning-electric-vans-in-us/, last accessed January 2022).

[15] Reuters, *U.S. Postal chief commits to 10% of new delivery fleet as electric vehicles*, 2021 (web link: https://www.reuters.com/technology/us-postal-chief-commits-10-new-delivery-fleet-electric-vehicles-2021-02-24/ , last accessed January 2022

[16] CALSTART, *Zero-emission Technology Inventory (ZETI) Analytics*, 2020 (web link: https://globaldrivetozero.org/tools/zeti-analytics/, last accessed January 2022).

[17] California Air Resources Board, *Fleet Rule for Public Agencies and Utilities*, 2005 (web link: https://ww2.arb.ca.gov/our-work/programs/fleet-rule-public-agencies-and-utilities, last accessed January 2022).

designated low population counties. Many of the same parties are included in the proposed regulation.

1.1.2 Drayage Truck Regulation

In 2007, the Drayage Truck regulation was adopted as part of CARB's efforts to reduce PM and oxides of nitrogen (NOx) emissions from diesel-fueled engines and improve air quality associated with freight movement, as well as reduce near-source health risk from facilities where drayage trucks congregate.[18] Drayage trucks are on-road, heavy-duty trucks that transport containerized, bulk or break-bulk goods, empty containers, and chassis to and from seaports and intermodal railyards. The Drayage Truck regulation requires diesel emissions reductions as well as recordkeeping and reporting to help monitor compliance and enforcement efforts. Truck owners are required to register their trucks in the CARB Drayage Truck Registry to ensure their trucks meet emissions standards by the appropriate deadline dates. The Drayage Truck regulation will sunset at the end of 2022. At that time, the drayage fleet will be incorporated into the Truck and Bus regulation, which requires affected vehicles to meet or exceed 2010 or newer engine emissions standards. Drayage trucks are included in the proposed regulation.

1.1.3 Truck and Bus Regulation

In 2008, the Truck and Bus regulation was adopted by CARB as the final prong of the Diesel Risk Reduction Plan to reduce emissions of PM and NOx from heavy-duty trucks and buses over 14,000 lbs. GVWR.[19,20] This regulation affects all vehicles travelling in California that are owned or operated by private or federal entities. It requires retrofit, replacement, or repowering of older diesel vehicles, eventually ensuring that all affected vehicles meet or exceed 2010 or newer model year (MY) engine emissions by January 1, 2023. Federal fleets and a subset of private fleets are included in the proposed regulation.

1.1.4 Innovative Clean Transit Regulation

In December 2018, the Innovative Clean Transit (ICT) regulation was adopted by CARB. The ICT regulation was the first medium- and heavy-duty ZEV fleet rule of its kind and it replaced the existing fleet rule for transit agencies.[21] The regulation requires all public transit agencies to gradually transition to a 100 percent zero-emission bus (ZEB) fleet where most will be ZE by 2040. The regulation also encourages transit agencies to provide innovative first and last mile mobility for transit riders. This regulation includes various exemptions and compliance options to provide safeguards and flexibility for transit agencies through the transition. The

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[18] California Air Resources Board, *Drayage Trucks at Seaports & Railyards*, 2007 (web link: https://ww2.arb.ca.gov/our-work/programs/drayage-trucks-seaports-railyards, last accessed January 2022).
[19] California Air Resources Board, *Truck and Bus Regulation*, 2008 (web link: https://ww2.arb.ca.gov/our-work/programs/truck-and-bus-regulation, last accessed January 2022).
[20] California Air Resources Board, *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, 2000 (web link: https:/ww2.arb.ca.gov/sites/default/files/classic/diesel/documents/rrpfinal.pdf, last accessed January 2022).
[21] California Air Resources Board, *Innovative Clean Transit*, 2018 (web link: https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit, last accessed January 2022).

proposed regulation includes some of the same public agencies that are subject to the ICT regulation if they also operate vehicles that are not transit buses such as a city that provides road maintenance or waste hauling services. The proposed regulation builds upon the structure of the ICT purchase requirements for local and State government fleets.

1.1.5 Zero-Emission Airport Shuttle Bus Regulation

In June 2019, the Zero-Emission Airport Shuttle Bus (ASB) regulation was adopted by CARB. It promotes the development and use of ZE technologies in medium- and heavy-duty airport shuttles that operate on fixed routes at 13 California airports.[22] This regulation requires airport shuttle operators to transition their vehicles to ZEVs beginning in 2027, with a complete transition by the end of 2035. The regulation provides compliance extensions and other flexibilities to ensure service continuity as operators transition to ZE shuttles. The proposed regulation could include some fleet operators that are subject to the ASB regulation.

1.1.6 California and Federal Phase 2 GHG Regulation

CARB staff worked jointly with the U.S. Environmental Protection Agency (EPA) staff and with National Highway Traffic Safety Administration staff on the next phase of federal GHG emissions standards and fuel efficiency standards, respectively, for medium- and heavy-duty engines and vehicles.[23] The federal Phase 2 GHG emissions standards build on the Phase 1 GHG emissions standards, and represent a significant opportunity to achieve further GHG reductions for 2018 (2021 in California) and later MY heavy-duty vehicles . The Phase 2 GHG emissions standards are structured to provide a range of options to manufacturers to reduce emissions for medium- and heavy-duty vehicles using a wide range of technologies, including aerodynamics, more efficient engines, and other technologies. Additionally, the Phase 2 GHG emissions standards provide an opportunity to average, bank, and trade credits, as well as recognize advanced technologies that would apply to plug-in hybrid electric vehicles (PHEV), all-electric vehicles, and fuel cell electric vehicles (FCEV). In 2018, California adopted this federal Phase 2 program with minor changes.[24] There are some synergies in costs and emissions benefits between California Phase 2 GHG and the proposed regulation, because ZEVs could be used to comply with both regulations.

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[22] California Air Resources Board, *Zero-Emission Airport Shuttle*, 2019 (web link: https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle, last accessed January 2022).
[23] United States Environmental Protection Agency, *Final Rule for Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2*, 2016 (web link: https://www.gpo.gov/fdsys/pkg/FR-2016-10-25/pdf/2016-21203.pdf, last accessed January 2022).
[24] California Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking Proposed California Greenhouse Gas Emission Standards for Medium- and Heavy-Duty Engines and Vehicles and Proposed Amendments to the Tractor-Trailer GHG Regulation*, 2017 (web link: https://www.arb.ca.gov/regact/2018/phase2/isor.pdf, last accessed January 2022).

1.1.7 The Advanced Clean Trucks Regulation

In January 2021, the Advanced Clean Trucks (ACT) regulation was adopted by CARB. It is a key part of the holistic approach to accelerate a large-scale ZEV transition of medium- and heavy-duty trucks.[25] The regulation has two components including a manufacturer sales requirement and a One-Time Large Entity Reporting requirement:

- ZEV sales: Manufacturers who certify Class 2b–8 chassis or complete vehicles with combustion engines are required to sell medium- and heavy-duty ZEVs as an increasing percentage of their annual California sales from 2024 to 2035. By 2035, ZEV and chassis sales would need to be 55 percent of Class 2b–3 truck sales, 75 percent of Class 4–8 straight truck sales, and 40 percent of truck tractor sales.

- Fleet reporting: Large employers including retailers, manufacturers, brokers, and others were required to report information about vehicles they own, operate, or direct, and fleet owners with 50 or more trucks were required to report about their existing fleet operations by May 1, 2021.

The ZEV sales requirement establishes a supply of medium- and heavy-duty ZEVs, while the Large Entity Reporting requirement provides detailed information about fleets and how they use their vehicles. The ACT regulation includes flexibility for manufacturers to trade credits to meet compliance requirements and to decide which vehicles to sell as ZEVs. The proposed regulation would complement the ACT regulation by ensuring that fleets purchase the ZEVs that manufacturers produce and place them in service.

1.1.8 Heavy-Duty Omnibus Regulation

In September 2021, the Heavy-Duty Omnibus regulation was adopted by CARB. It requires manufacturers to comply with more stringent exhaust emissions standards, test procedures, and other emissions control requirements for 2024 MY and newer California certified heavy-duty engines.[26] The combined requirements will reduce real world in-use emissions. Fleets proposed to be included in the ACF regulation are the same that purchase combustion vehicles impacted by the Heavy-Duty Omnibus regulation. Key elements of the regulation include:

- Lowering NOx and PM emissions standards on existing regulatory cycles as well as a new NOx standard on a new low-load certification cycle. The NOx standards are about 75 percent below current standards beginning in 2024 and 90 percent below current standards in 2027.
- Revamping of the heavy-duty in-use testing program;

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[25] California Air Resources Board, *Advanced Clean Trucks*, 2020 (web link: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks, last accessed January 2022).
[26] California Air Resources Board, *Heavy-Duty Low-NOx Omnibus ISOR*, 2021 (web link: https://ww3.arb.ca.gov/regact/2020/hdomnibuslownox/isor.pdf, last accessed January 2022).

- Improving warranty, useful life, and emissions warranty information and reporting requirements;
- Strengthening the heavy-duty durability demonstration program;
- Improving the emissions averaging, banking, and trading program; and
- Creating powertrain certification test procedures for heavy-duty hybrid vehicles.

1.1.9 ZEV Purchases Required by AB 739

In October 2017, California's Governor signed Assembly Bill (AB) 739 (Chau, Chapter 744, Statutes of 2017), which requires heavy-duty ZEV purchases by State agencies. Beginning in 2025, at least 15 percent of new vehicle purchases with a GVWR of more than 19,000 lbs. must be ZEVs, and at least 30 percent of such purchases must be ZEVs beginning in 2030. These same agencies are proposed to be included in the ACF regulation; ZEVs purchased can be used to comply with both the proposed requirements and AB 739 requirements.

1.1.10 Zero-Emissions Powertrain Certification

In July 2019, CARB adopted the Zero-Emission Powertrain (ZEP) Certification procedures which established new, alternative certification procedures for heavy-duty battery-electric and fuel-cell vehicles and the zero-emission powertrains they use. ZEP Certification establishes a process that can be used to provide additional transparency, consistency, and stability in heavy-duty zero-emission market segments targeted by CARB's technology-forcing regulatory measures or incentives geared to deploying more-commercialized zero-emission vehicles. The Proposed ACF Regulation would make ZEP Certification mandatory for manufacturers subject to the 100 percent ZEV sales requirement.

1.2 Proposed Regulatory Action

The proposed regulation would build on the progress already made in the medium- and heavy-duty ZEV market, support existing policies and regulations through a phased-in fleet transition to ZEVs from 2024 through 2042, and would require all new vehicle sales to be ZEVs starting in 2040. This fleet focused strategy ensures that fleets begin to purchase and deploy medium- and heavy-duty ZEVs offered for sale by truck manufacturers in market segments that are suitable for electrification. The proposed regulation complements and supports the ZEV sales requirements of the ACT regulation by requiring affected public, drayage, and high priority and federal fleet operations to phase in medium- and heavy-duty ZEVs over time. Additionally, the proposed regulation sets a clear end date for combustion-powered new vehicle sales in California. The following is a summary of the proposed ACF requirements:

- State and local public fleets: Phased-in purchase requirement starting with 50 percent of medium- and heavy-duty ZEV purchases in 2024 and 100 percent in 2027. Municipalities in designated low population counties would be excluded until 2027.
- Drayage trucks: Phased-in registration requirements for newly added drayage trucks to be ZEVs starting in 2024, while allowing useful life for legacy trucks. All trucks conducting drayage operations must be ZEVs by 2035.

- High priority and federal fleets: Phased-in schedule with increasing ZEV targets as a percentage of the total vehicle fleet. High priority fleets are well-suited for electrification and include entities with more than $50 million in annual revenues, or those fleets that own, operate, or direct at least 50 trucks and buses under common ownership and control.
- Vehicle sales: 100 percent of medium- and heavy-duty vehicle sales into California must be ZE starting in 2040.

More detail on each element of the proposed regulation is provided below in the following sections. The precise form of these requirements will be further developed through the public process.

1.2.1 State and Local Public Fleets

The proposed public fleet requirement would apply to cities, counties, public utilities, special districts, and the State fleet, but excludes federal agencies. Federal agencies are included in the High Priority fleet group and not the Public fleet portion of the rule to align with the Clean Air Act Section 118 where federal fleet vehicles are to be treated the same as the general vehicle population. A purchase requirement was chosen to closely align with the normal purchase patterns of public fleets to ensure that a public fleet would not be out of compliance if budget fluctuations limited their ability to purchase replacement vehicles. These public entities would be required to make medium- and heavy-duty ZEV purchases starting at 50 percent of purchases in 2024 and 100 percent starting in 2027. However, public fleets based in designated low population counties would be exempt from ZEV purchases until 2027 because they tend to have fewer vehicles, more limited budgets, and they operate in remote areas that are expected to take longer for ZEV infrastructure and support networks to be developed.

The regulation includes flexibility to count early ZEV purchases towards future compliance and to purchase near-zero-emission vehicles (NZEV) if suitable ZEVs are not available. The regulation also includes limited exemptions to allow for internal combustion engine (ICE) vehicle purchases if ZEVs are not suitable to operate as emergency support vehicles outside their normal service territories, are not available to meet daily mileage needs, or if ZEVs and NZEVs are not commercially available in certain body configurations. Annual reporting would be required starting in 2024.

1.2.2 Drayage Trucks

The proposed regulation would require Class 7-8 drayage trucks operating at intermodal seaports and railyards to be ZEVs by 2035. The proposed regulation includes a phased-in approach for drayage trucks with the following requirements:

- All drayage trucks would be required to register in the CARB drayage online reporting system, starting in late 2023.

- Existing drayage trucks with ICEs, could remain in drayage service for a minimum useful life of either (a) 13 years from the MY that the engine and emissions control systems are first certified by CARB or the U.S. EPA or (b) when the vehicle reaches

800,000 vehicle miles traveled or 18 years from the MY that the engine and emissions control systems are first certified for use by, whichever is earlier.

- Trucks with MY engines of 12 years and greater would be required to report their mileage annually.
- Beginning in 2024, any truck added to the CARB drayage online reporting system must be a ZEV.
- All drayage trucks entering seaports and intermodal railyards must be ZEVs by 2035.
- All drayage trucks must visit a regulated seaport or railyard at least once each calendar year to remain in the CARB drayage online reporting system.
- All regulated intermodal seaports and railyards would be required to report drayage truck visits annually.

This approach would build on the structure of the existing drayage truck regulation and meet the goal of a complete transition of California's drayage fleet to ZE by 2035.

1.2.3 High Priority and Federal Fleets

High priority and federal fleets would be required to phase in medium- and heavy-duty ZEVs as percentage of the total fleet that operates in California. Affected California fleets would include all truck owners with an annual revenue greater than $50 million that operate at least 1 truck in California, or those who own, operate, or dispatch 50 or more trucks under common ownership and control and operate at least 1 truck in California. Controlling parties include the motor carrier, broker, or entity that dispatches, directs or otherwise manages the day-to-day operation of multiple fleets under common ownership or control to serve the customers or clients of the controlling party. Controlling parties must include all vehicles that are operated under common ownership or control in addition to their own vehicles that operate in California when determining compliance. All companies that hire or dispatch trucks must verify the fleets they hire comply with the regulation to maintain consistency with other existing fleet rules which have similar requirements.

High priority and federal fleets must phase-in ZEVs as a percentage of their total California fleet starting at 10 percent and increasing to 100 percent based on vehicle body type as shown in Table 2. Vehicles in Group 1 are commonly used for local and regional delivery or passenger transportation and are already suitable for electrification. With this proposed schedule, all covered delivery vans and box trucks that operate in urban areas and frequent warehouses and distribution centers would be ZEVs by 2035, except for the expected small percentage of vehicles using the alternative compliance path. Vehicles in Group 2 and Group 3 are expected to have higher daily mileage needs and more varied use cases. Fewer of these ZEV models are available today and they are given more time to make a complete transition to ZEVs. On these timelines, most tractors that go to warehouses and transport products throughout the state would be ZEVs by 2039 and all other vehicles by 2042. This would result in direct health benefits to communities most impacted by warehouses, distribution centers, and high traffic corridors.

Table 2. High Priority and Federal Fleet ZEV Phase-In Schedule

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

Fleets would have the flexibility to meet the ZEV target with any medium- or heavy-duty ZEV in their fleet regardless of body type. For example, a mixed fleet with 100 box trucks and 40 day cab tractors would need 10 ZEVs to comply in 2025. The number of ZEVs required to meet the 2025 target is calculated as 10 percent of the 100 box trucks in this example. The tractors are not counted in 2025 because there is no ZEV target for day cab tractors in that year. However, fleet owners have the flexibility to meet the 10 ZEV requirement with any combination of medium- and heavy-duty vehicles in the fleet. This means the fleet owner can meet the 2025 requirement with 10 ZEV tractors, 10 box trucks, or any combination that totals 10 ZEVs.

The regulation includes limited exemptions to operate or purchase ICE vehicles, such as situations where ZEVs or NZEVs are not commercially available in certain body configurations, available ZEVs would not meet a fleet's daily needs, and for backup vehicles that operate less than 1,000 total miles per year. Additionally, an exemption from making a complete conversion to ZEVs is included for certain essential service providers if ZEVs are not suitable to operate as emergency support vehicles outside their normal service territories. Additionally, the regulation provides an alternative compliance pathway such that existing internal combustion engine vehicles would be guaranteed their full useful life provided in statute by SB1.

1.2.4 100% ZEV Sales Requirement

Finally, the proposed regulation would include a new requirement on all vehicle manufacturers that 100 percent of all Class 2b-8 new vehicle sales in California must be ZE starting in 2040.

1.2.5 Reporting and Recordkeeping Requirements

Beginning in 2024, affected fleets would need to report and keep records on certain information about their company and all vehicles they operate in California, including vehicles that operate under common ownership and control. Reported vehicle information includes details such as: vehicle information number, body type, fuel type, and other identifying characteristics.

1.3 Statement of the Need for the Proposed Regulation

California needs to continue to build upon its successful efforts to meet critical risk reduction, air quality, and climate goals. Achieving these goals will provide much needed public health protection for the millions of Californians that still breathe unhealthy air, reduce exposure to air toxics, and help to meet current health-based National Ambient Air Quality Standards (NAAQS) across California.[27] Additional $PM_{2.5}$ and NOx reductions from all freight sources, including trucks, are essential to meeting these air quality standards as described in the recent Draft 2022 State Implementation Plan (SIP) Strategy.[28] Additionally, meeting California's GHG emissions reductions targets is needed to slow global warming and achieve climate stabilization. The proposed regulation would contribute to California's holistic strategy to reduce criteria pollutant emissions, reduce exposure to toxic air contaminants, achieve GHG emissions reductions goals, and cleaner technology targets, especially in heavily burdened communities. It would achieve PM, NOx, and GHG emissions reductions from trucks and increase the use of ZE technology which is needed to meet these complementary goals. CARB staff developed the 2020 Mobile Source Strategy (MSS) which lays out a high-level top-down description of the scale of the transition to cleaner mobile source technologies needed to achieve all of California's targets.[29] The MSS assumes its targets will be met through a portfolio of programs; this proposal is an important part of that portfolio.

The proposed regulation is needed to ensure the widespread adoption of ZEVs in the medium- and heavy-duty vehicle sector and to meet the Governor's and CARB's goals of early ZEV transitions in key market sectors. The deployment of medium- and heavy-duty ZEVs meets the goals identified in the 2016 ZEV Action Plan that support the Governor's Executive Orders B-16-12 and B-48-18, which calls for 1.5 million light-, medium-, and heavy-duty ZEVs in California by 2025 and establishes several milestones on the pathway toward this target. The proposed regulation contributes towards the goals established in the Governor's Executive Order N-79-20 and the Board's direction in Resolution 20-19 of making a complete transition of California's medium- and heavy-duty truck and bus fleet to ZE by 2045 with earlier targets for key segments including drayage and last mile delivery. Additionally, the proposed regulation supports the Memorandum of Understanding between states described in the Supporting Existing Policy Section to accelerate ZEV adoption.

The State of California placed additional emphasis on protecting local communities from the harmful effects of air pollution through the passage of AB 617 (C. Garcia, Chapter 136, Statutes of 2017). AB 617 requires CARB to pursue new community-identified actions to reduce air pollution and improve public health in communities that experience

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[27] U.S. EPA, *National Ambient Air Quality Standards*, February 10, 2021 (web link: *https://www.epa.gov/criteria-air-pollutants/naaqs-table*, last accessed January 2022).

[28] California Air Resources Board, *2022 State Strategy for the State Implementation Plan (2022 State SIP Strategy)*, 2022 (web link: https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy, last accessed January 2022).

[29] California Air Resources Board, *2020 Mobile Source Strategy*, 2020 (web link: https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy, last accessed January 2022).

disproportionate burdens from exposure to air pollutants. Despite statewide and regional scale improvements to air quality, disparities in community -scale air pollution and health inequities remain.[30,31,32,33] Community-level impacts from local emissions can be significant, even in areas that meet regional air quality standards. Apte et al. have shown that the top two sources of PM2.5 exposure in California are on-road vehicles and industrial activity, which also contribute most to PM2.5 concentration disparity by race/ethnicity. Despite regional reductions resulting from implementing CARB policies, low-income communities and communities of color still do not enjoy the same benefits because of their proximity to several concentrated emissions sources like ports, railyards, and highways. Similarly, historical land use practices of siting facilities in communities of color, along with residential redlining, have contributed to the exposure disparities that we see today.[34] The proposed regulation would reduce truck emissions and exposure statewide and would be of particular benefit in disadvantaged communities experiencing disproportionate burdens.

The proposed ACF regulation continues to build on earlier regulatory efforts to deploy ZEVs such as the ICT, ASB, and ACT regulations. The proposed regulation would increase the expected number of medium- and heavy-duty ZEVs beyond existing regulations from about 320,000 to about 520,000 by 2035 and from about 775,000 to about 1,250,000 ZEVs by 2045.

More details about how the proposed regulation addresses supporting policy needs can be found in the Supporting Existing Policy Chronology in Section 1.3.4.

1.3.1 Need to Reduce Risk to Communities

Many of the communities near facilities where trucks operate bear a disproportionate health burden due to their proximity to emissions from the combustion engines that power trucks. There are several occurrences across the state where communities contain "groups" or "clusters" of facilities where trucks operate. In many cases, these facilities are in or near communities classified as disadvantaged by the California EPA by using the California

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[30] Apte JS, Chambliss SE, Tessum CW, Marshall JD, *A method to prioritize sources for reducing high PM2.5 exposures in environmental justice communities in California*, CARB research contract number 17rd006, 2019 (web link: https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/17rd006.pdf, last accessed January 2022).

[31] Morello-Frosch R, Zuk M, Jerrett M, Shamasunder B, Kyle AD, *Understanding the cumulative impacts of inequalities in environmental health: Implications for policy*, Health affairs (Project Hope) 30:879-887, 2011 (web link: https://pubmed.ncbi.nlm.nih.gov/21555471/, last accessed January 2022).

[32] OEHHA, *Tracking and evaluation of benefits and impacts of greenhouse gas limits in disadvantaged communities: Initial report*, 2017 (web link: https://oehha.ca.gov/media/downloads/environmental-justice/report/oehhaab32report020217.pdf, last accessed January 2022).

[33] Propper R, Wong P, Bui S, Austin J, Vance W, Alvarado Á, et al., *Ambient and emission trends of toxic air contaminants in California*, Environmental Science & Technology 49:11329-11339, 2015 (web link: https://pubs.acs.org/doi/abs/10.1021/acs.est.5b02766, last accessed January 2022).

[34] Pastor M, Sadd J, Hipp J., *Which came first? Toxic facilities, minority move-in, and environmental justice*, Journal of urban affairs 23:1-1, 2001 (web link: https://www.tandfonline.com/doi/abs/10.1111/0735-2166.00072, last accessed January 2022).

Communities Environmental Health Screening Tool to rank California communities based on environmental pollution burden and socio-economic indicators.[35] Exposure to diesel PM is a main contributor to these metrics for many communities ranked in the top 10th percentile statewide.

1.3.2 Need to Reduce $PM_{2.5}$ and NOx Emissions

Progress has been achieved in reducing $PM_{2.5}$ and NOx emissions from mobile sources statewide through implementation of CARB's existing programs. These programs are expected to continue to provide further emissions reductions, helping the State to meet air quality standards. However, challenges remain in meeting the ambient air quality standards for ozone and $PM_{2.5}$; The South Coast and San Joaquin Valley air basins are designated as extreme non-attainment with the ozone NAAQS areas while 7 other areas are in serious or severe non-attainment with the ozone NAAQS. The near-term targets for these areas are a 2023 deadline for attainment of the 80 parts per billion (ppb) 8-hour ozone standard, 2024 for the 35 microgram per cubic meter ($\mu g/m^3$) 24-hour $PM_{2.5}$ standard, and 2025 for the 12 $\mu g/m^3$ annual $PM_{2.5}$ standard. There are also mid-term attainment years of 2031 and 2037 for the more recent 8-hour ozone standards of 75 ppb and 70 ppb, respectively. NOx is a precursor to both ozone and secondary $PM_{2.5}$ formation. Consequently, reductions in NOx emissions provide benefits to help meet both the ozone and the $PM_{2.5}$ standards. Additional $PM_{2.5}$ and NOx reductions from all freight sources, including trucks, are essential to meeting these air quality standards as described in the recent Draft 2022 State SIP Strategy.[36]

1.3.3 Need to Reduce GHG Emissions

To date, California has made significant progress towards meeting the goals of Senate Bill (SB) 32 (Pavley, Chapter 249, Statutes of 2016). SB 32 requires California to reduce GHG emissions to at least 40 percent below 1990 levels by 2030. Significant progress has been made, however more needs to be done.

Short-lived climate pollutants (SLCP) such as black carbon, methane, nitrous oxide, and others are emitted from transportation sources, including from burning fuels such as diesel or natural gas. These are powerful climate forcers that remain in the atmosphere for a much shorter period than longer-lived climate pollutants, such as carbon dioxide (CO_2), but are more potent when measured in terms of Global Warming Potential, which can be tens, hundreds, or even thousands of times greater than CO_2.

1.3.4 Supporting Existing Policy Chronology

CARB staff reviewed and considered air quality attainment goals established by the federal government, the laws passed by the California State Legislature, the State Implementation

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[35] Office of Environmental Health Hazard Assessment, *CalEnviroScreen 4.0*, October 20, 2021. (web link: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30, last accessed January 2022).

[36] California Air Resources Board, *2022 State Strategy for the State Implementation Plan (2022 State SIP Strategy)*, 2022 (web link: https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy, last accessed January 2022).

Plans (SIP), and the Executive Orders issued by the Governors of California to develop the regulation. The following is a chronological summary of key supporting and existing policies used to guide the development of the proposed regulation:

In 2006, California's Governor signed AB 32, the California Global Warming Solutions Act of 2006 (Núñez, Chapter 488, Statutes of 2006) to address global climate change. AB 32 directed CARB to develop a scoping plan identifying integrated and cost-effective regional, national, and international GHG reductions programs. CARB adopted the AB 32 Scoping Plan in 2008, with subsequent updates in 2013 and 2017, and is currently undertaking the public process to update it for 2022. California's 2017 Climate Change Scoping Plan outlines the State's strategy to achieve its 2030 GHG targets.

In March 2012, California's Governor issued Executive Order B-16-2012 directing California agencies to establish benchmarks for key milestones to help support and facilitate the ZEV market in California.[37] One of those milestones includes deploying over 1.5 million light-, medium-, and heavy-duty ZEVs and PHEVs on the road by 2025. As a result of this Order, multiple State agencies, including CARB, worked to develop and release the 2013 ZEV Action Plan.[38] The 2013 ZEV Action Plan identified over 100 strategies to meet the milestones of the Executive Order and included 4 broad goals to advance the overall light-, medium-, and heavy-duty ZEV market. These 4 goals are:

- Complete needed ZEV infrastructure and planning;
- Expand consumer awareness and demand of ZEVs;
- Transform fleets; and
- Grow jobs and investment in the private sector.

SB 605 (Lara, Chapter 523, Statutes of 2014)[39] required CARB to develop a plan to reduce emissions of SLCPs, and SB 1383 (Lara, Chapter 395, Statutes of 2016)[40] required the Board to approve and begin implementing the plan by January 1, 2018. SB 1383 also sets targets for statewide reductions in SLCP emissions of 40 percent below 2013 levels by 2030 for methane and hydrofluorocarbons, and 50 percent below 2013 levels by 2030 for black

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[37] Office of Governor Edmund G. (Jerry) Brown Jr., *Executive Order B-16-2012*, 2012 (web link: https://www.ca.gov/archive/gov39/2012/03/23/news17472/index.html, last accessed January 2022).
[38] Governor's Interagency Working Group on Zero-Emission Vehicles, *2013 ZEV Action Plan: A roadmap toward 1.5 million zero-emission vehicles on California roadways by 2025*, 2013 (web link: http://opr.ca.gov/docs/Governors_Office_ZEV_Action_Plan_(02-13).pdf, last accessed January 2022).
[39] California Health and Safety Code § 39730, Division 26, *Senate Bill No. 605, Short-lived climate pollutants*, September 21, 2014 (web link: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB605, last accessed January 2022).
[40] California Health and Safety Code § 39730, Division 30, *Senate Bill No. 1383, Short-lived climate pollutants: methane emissions: dairy and livestock: organic waste: landfills*, September 19, 2016 (web link: http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1383, last accessed January 2022).

carbon. Reductions in GHGs from trucks, including SLCPs like black carbon, are needed to achieve the State's multiple GHG emissions reductions targets and related climate goals.

In April 2015, CARB released the "Sustainable Freight Pathways to Zero and Near-Zero Discussion Document" in response to Board Resolution 14-2 which directed CARB to engage with stakeholders to identify and prioritize actions to move California toward a sustainable freight transport system.[41,42] The Discussion Document set out CARB's vision of a clean freight system and listed immediate and potential near-term CARB actions that staff would develop for future Board consideration. The near-term CARB measures identified in the Discussion Document included amending existing freight regulations, including the Cargo Handling Equipment, Locomotive, At-Berth, and Transport Refrigeration Unit regulations to achieve additional emissions reductions.

In July 2015, California's Governor signed Executive Order B-32-15 directing the California State Transportation Agency, CalEPA, and Natural Resources Agency to lead other relevant State departments in developing an integrated action plan by July 2016 that "establishes clear targets to improve freight efficiency, transition to ZE technologies, and increase competitiveness of California's freight system."[43] The 2016 California Sustainable Freight Action Plan included recommendations such as strengthening existing freight regulations as a State agency action to advance the objectives of the Executive Order.

In October 2015, California adopted SB 350 (De León, Chapter 547, Statutes of 2015), the Clean Energy and Pollution Reduction Act, which established GHG reductions targets and ordered the California Public Utilities Commission (CPUC) to direct the 6 investor-owned utilities in the state to "accelerate widespread transportation electrification." The resulting programs developed by the electric utilities, for which $701 million has been authorized, promote the deployment of medium- and heavy-duty ZEVs through incentivizing infrastructure upgrade projects that offset most or all the costs for electrical service upgrades.

In 2016, California's Governor signed SB 32 (Pavley, Chapter 249, Statutes of 2016) which requires CARB to ensure that California's GHG emissions are reduced to at least 40 percent below the 1990 GHG level by 2030.

In March 2017, CARB adopted the Revised Proposed 2016 State Strategies document as part of the SIP which identified several sectors that are key to launching ZE technologies in the on-road, heavy-duty sector: transit buses, delivery trucks, and airport shuttles. The proposed

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[41] California Air Resources Board, *Sustainable Freight Pathways to Zero and Near-Zero Emissions Discussion Document*, 2015 (web link: https://ww2.arb.ca.gov/sites/default/files/2020-09/Sustainable%20Freight%20Pathways%20to%20Zero%20and%20Near-Zero%20Emissions%20Discussion%20Document.pdf, last accessed January 2022).
[42] California Air Resources Board, *Board Resolution 14-2*, 2014 (web link: https://www.arb.ca.gov/board/res/2014/res14-2.pdf, last accessed January 2022).
[43] State of California Executive Order signed by Governor Edmund G. (Jerry) Brown Jr., *Executive Order B-32-15*, 2015 (web link: https://www.ca.gov/archive/gov39/2015/07/17/news19046/index.html, last accessed January 2022).

regulation continues implementation of these strategies to increase heavy-duty ZEV deployments.

In April 2017, SB 1 (Beall, Chapter 5, Statutes of 2017), also known as the Road Repair and Accountability Act of 2017 was signed into law, which provides specified commercial vehicles over 10,000 lbs. GVWR a "useful life" period before such vehicles can be retired, replaced, retrofitted, or repowered through new or amended regulations. The useful life period is specified as the later of either (a) 13 years from the MY that the engine and emissions control systems are first certified or (b) (when the vehicle travels reaches 800,000 vehicle miles traveled or 18 years from the MY that the engine and emissions control systems are first certified for use, whichever is earlier). SB 1 also empowered the California Department of Motor Vehicles (DMV) to enforce the Truck and Bus regulation through vehicle registrations.

In July 2017, AB 617 was signed into law. The bill requires new community-focused and community-driven action to reduce air pollution and improve public health in communities that experience disproportionate burdens from exposure to air pollutants. In response to AB 617, CARB established the Community Air Protection Program. The Program's focus is to reduce exposure in communities most impacted by air pollution. Communities around the state are working together to develop and implement new strategies to measure air pollution, develop plans, and reduce health impacts.

In January 2018, California's Governor issued Executive Order B-48-18 building on past efforts by increasing California's goal to introduce 5 million light-, medium-, and heavy-duty ZEVs on the road by 2030 and setting a target of 250,000 chargers by 2025.[44] Also in 2018, the Governor issued Executive Order B-55-18, which sets a target to achieve carbon neutrality in California no later than 2045 and achieve and maintain net negative emissions thereafter.[45] The proposed regulation directly supports achieving these goals through the required transition to medium- and heavy-duty ZEVs in California in local government, drayage, and high priority and federal transportation sector fleets.

In August 2018, California's Governor sent a letter to CARB directing the agency to pursue conversion of public and private fleets to ZEVs in categories including large employers, delivery vehicles, and transportation service fleets.[46] The proposed regulation addresses this direction by requiring medium- and heavy-duty ZEV purchases for public fleets, conversion of the drayage fleet to heavy-duty ZEVs, and upgrading to medium- and heavy-duty ZEVs in high priority and federal fleets.

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[44] Office of Governor Edmund G. (Jerry) Brown Jr., *Governor Brown Takes Action to Increase Zero-Emission Vehicles, Fund New Climate Investments*, 2018 (web link: https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html, last accessed January 2022).

[45] State of California Executive Order signed by Governor Edmund G. (Jerry) Brown Jr., *Executive Order B-55-18*, 2018 (web link: https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf, last accessed January 2022).

[46] Signed by Edmund G. (Jerry) Brown Jr., *Governor's Letter to Chair Nichols*, 2018 (web link: https://ww2.arb.ca.gov/sites/default/files/2020-06/zero_emission_fleet_letter_080118_ADA.pdf, last accessed January 2022).

In September 2019, Governor Newsom issued Executive Order N-19-19 which requires every aspect of State government to redouble efforts to reduce GHG emissions and mitigate the impacts of climate change while building a sustainable and inclusive economy.[47] The Executive Order specifically calls for CARB to propose new strategies to increase demand in the primary and secondary markets for ZEVs, and to consider strengthening existing regulations or adopting new regulations to achieve necessary GHG reductions in the transportation sector. The proposed regulation would support these goals by achieving GHG emissions reductions from the deployment of medium- and heavy-duty ZEVs. Additionally, ZEVs deployed early in the proposed regulatory timeline would be expected to be resold, thereby supporting a robust secondary market.

As part of adopting the ACT regulation in June 2020, the Board also approved Resolution 20-19. The resolution required staff to come back to the Board in 2021 with requirements ensuring fleets, businesses, and public entities purchase and operate medium- and heavy-duty ZEVs.[48] The resolution set goals for the fleet requirements to be implemented on a timeline consistent with the ACT regulation and to achieve a smooth transition of California's fleet to ZEVs by 2045 everywhere feasible. The resolution also directs staff to ensure these upcoming regulations emphasize emissions reductions within disadvantaged communities to the maximum extent feasible. The resolution set the following clear goals for transitioning sectors of California's transportation industry to medium- and heavy-duty ZEVs where feasible:

- 100 percent ZE drayage, last mile delivery, and government fleets by 2035;
- 100 percent ZE refuse trucks and local buses by 2040;
- 100 percent ZE-capable vehicles in utility fleets by 2040; and
- 100 percent ZE everywhere else, where feasible, by 2045.

Staff's proposal largely meets the overall goals laid out by the Board with implementation starting in 2024 to align with ACT as originally planned. It would achieve 100 percent ZE drayage trucks by 2035 and most regulated delivery vehicles by 2035 as well, although the proposal will be brought to the Board in 2022. This proposal is a part of a comprehensive strategy to transition all trucks to zero emissions where feasible.

After the ACT regulation was adopted by the Board, 16 states, the District of Columbia, and Province of Quebec signed a Memorandum of Understanding to work collaboratively to advance and accelerate the market for electric medium- and heavy-duty vehicles.[49] The states agreed to work together to set and meet medium- and heavy-duty ZEV sales targets and

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[47] State of California Executive Order signed by Governor Gavin Newsom, *Executive Order N-19-19*, 2019 (web link: https://catc.ca.gov/-/media/ctc-media/documents/ctc-codes/execorder-n-19-19-a11y.pdf, last accessed January 2022).
[48] California Air Resources Board, *Resolution 20-19*, 2020 (web link: https://ww3.arb.ca.gov/regact/2019/act2019/finalres20-19.pdf, last accessed January 2022).
[49] California Air Resources Board, *Press Release 20-18 15 states and the District of Columbia join forces to accelerate bus and truck electrification*, 2020 (web link: https://ww2.arb.ca.gov/news/15-states-and-district-columbia-join-forces-accelerate-bus-and-truck-electrification, last accessed January 2022).

develop action plans that accelerate vehicle electrification. As of January 2022, 5 states have adopted the ACT regulation, with more expected in this year.[50]

In September 2020, Governor Newsom signed Executive Order N-79-20 which establishes a goal that 100 percent of California sales of new passenger car and trucks be ZE by 2035.[51] In addition, the Governor's Order set a goal to transition all drayage trucks to ZEVs by 2035, all off-road equipment to ZE where feasible by 2035, and the remainder of medium- and heavy-duty vehicles to ZEVs where feasible by 2045. Under the Order, CARB is tasked to work with our State agency partners to develop regulations to achieve these goals considering technological feasibility and cost-effectiveness, which the proposed regulation seeks to fulfill.

In April 2021, CARB released the Revised Draft 2020 Mobile Source Strategy.[52] 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. These strategies illustrate the technology mixes needed for the State to meet its various clean air goals, including national ambient air quality standards, community risk reductions, and ambitious mid- and long-term climate change targets. To meet these goals, the Mobile Source Strategy found it is necessary for California's transportation sector to rapidly increase use of ZE technologies everywhere feasible.

In January 2022, CARB released the Draft 2022 State SIP Strategy for public comment. It will be considered by the Board in mid-2022. Given that the document indicates California will be short of needed tons of emissions reductions needed for attainment, there is a need to push for more ZEV deployments and avoid scaling back regulatory pressure on the market.

1.3.5 Supporting Incentive Programs

CARB's incentive and regulatory programs work together to accelerate the market for ZEVs. Incentives primarily support early commercialization and market development prior to regulatory requirements, early adopter purchase decisions by reducing incremental costs, and vehicle cost reductions over time by building manufacturer economies of scale. Historically, as regulatory requirements approach, the incentive strategy has shifted toward a focus on financial assistance for fleets that are challenged to qualify for traditional financing programs. Limited incentives may continue to be available for purchases that are made in advance of applicable regulatory schedules, or in addition to minimum purchase requirements. Incentive programs produce emissions reductions, and CARB is developing improved analyses of emissions benefits that result from incentive funding. SB 1403 (Lara, Chapter 370, Statutes of 2018) guides CARB's heavy-duty vehicle investments funded with Cap-and-Trade auction proceeds, and extended the California Clean Truck, Bus, and Off-

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[50] Washington, Oregon, New York, New Jersey, and Massachusetts have all adopted the ACT regulation.

[51] State of California Executive Order signed by Governor Gavin Newsom, *Executive Order N-79-20*, 2020 (web link: https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf, last accessed January 2022).

[52] California Air Resources Board, *Revised Draft 2020 Mobile Source Strategy*, April 23, 2021. (web link: https://ww2.arb.ca.gov/sites/default/files/2021-04/Revised_Draft_2020_Mobile_Source_Strategy.pdf, last accessed January 2022)

Road Vehicle and Equipment Technology Program created under SB 1204 (Lara, Chapter 524, Statutes of 2014). Funding allocations are subject to annual appropriations by the Legislature, and Board approval of the annual Funding Plan for Clean Transportation Incentives. Historically, most funding for medium- and heavy-duty ZEVs has been provided through the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), which began in 2009. Subject to funding availability, HVIP provides base vouchers of up to $120,000 for Class 8 battery-electric vehicle (BEV) trucks, with additional funding for trucks based in disadvantaged communities, and for drayage trucks purchased prior to January 1, 2022. In addition, the Volkswagen Environmental Mitigation Trust includes $90 million for ZE Class 8 freight and port drayage trucks with a maximum incentive of up to $200,000 per truck. The first statewide installment of $27 million has been allocated, and the remaining $63 million will be available beginning in 2022. Other incentive programs include the Carl Moyer Program, AB 617 Community Air Protection Program, the Air Quality Improvement Program, as well as infrastructure funding from utilities and the California Energy Commission (CEC). Financing assistance for small fleets is available through the Truck Loan Assistance Program.

1.4 Major Regulation Determination

Per Department of Finance (DOF) regulations (title 1, California Code of Regulations, Sections 2000-2004)[53], the proposed regulation has been determined to be a major regulation because the economic impact of the regulation in California is estimated to exceed $50 million in multiple years of the regulatory timeline extending from 2024 to 2050. The economic impact is estimated because of direct cost and cost-savings to the proposed regulated entities providing transportation services.

1.5 Baseline Information

The economic and emissions impacts of the proposed regulation are evaluated against the business as usual (BAU) scenario each year for the analysis period from 2024 to 2050. The BAU case for the economic and emissions analysis for the proposal is also referred to as the "Legal Baseline" and uses the same vehicle inventory for all analyses. The Legal Baseline reflects the implementation of all existing State and federal laws and regulations on the vehicles the proposed regulation would affect. The Heavy-Duty Inspection and Maintenance (HDIM) regulation was heard by the Board in December 2021 but was not included in the Legal Baseline because it was not approved by Office of Administrative Law (OAL) at the time this analysis was prepared.

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[53] California Code of Regulations § 2000-2004, Division 3, *Standardized Regulatory Impact Assessment for Major Regulations*. (web link: https://govt.westlaw.com/calregs/Document/IAA1C7210595511E3BFC8D5B3615C797F?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)&bhcp=1#co_anchor_IA8F81D2F7A734A449389719B2F838650, last accessed January 2022).

A second baseline analysis was also done to show how the analysis differs if the HDIM regulation is approved. This analysis is in the Modified Baseline Analysis Appendix and presents a scenario that anticipates the HDIM regulation being finalized prior to implementation of the proposed regulation.

Staff used CARB's Emission Factor Inventory Model (EMFAC) to assess the Legal Baseline vehicle inventory, including vehicle sales and population growth assumptions, for Class 2b and larger vehicles for all fuel types.[54] EMFAC includes the effects of CARB's ASB, ICT, Truck and Bus, Heavy-Duty Omnibus, ACT regulation, and Low Carbon Fuel Standard (LCFS) program compliance. It is important to note that the benefits of low carbon fuels such as renewable diesel and renewable natural gas that are part of the LCFS are already included in the Legal Baseline and all scenarios. Therefore, the economic and environmental impacts attributable to the ACF regulation are solely attributable to new actions beyond those already expected. This means only ZEV deployments required by the proposal that exceed the ZEV sales already expected from the ACT regulation will result in new emissions benefits and costs. When compared to the Legal Baseline, the proposed regulation would increase the expected number of medium- and heavy-duty ZEVs (beyond existing regulations) from about 320,000 to about 520,000 by 2035 and from about 776,000 to about 1,200,000 ZEVs by 2045. This increase in ZEVs is expected to be from Class 4-8 vehicles. Based on recent announcements and market developments, a portion of the ZEV sales expected in the Legal Baseline for Class 2b-3 will include vehicles, such as pickup trucks to individuals and small business, that are not in the scope of the proposed regulation.[55] Further discussion of vehicle population estimates is in Chapter "Direct Costs", Section "Vehicle Population." For the costs and emissions analysis, if the estimated ZEV sale can be attributed to the ACT regulation in the Legal Baseline, it will not be counted toward the proposed regulation.

Staff anticipates significant sales of medium- and heavy-duty ZEVs based on the number of preorders which have already been placed by customers. As shown in Table 3, these near-term commercial ZEV pre-orders number over 300,000 in the United States, indicating a clear demand for the vehicles such that individuals and entities that are not subject to the proposed regulation are expected to purchase them.[56] These early model sales are being counted towards compliance with the ACT regulation and would not be attributed to the proposed regulation.

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[54] California Air Resources Board, *EMFAC 2021 Database*, 2021 (web link: https://arb.ca.gov/emfac/, last accessed January 2022).

[55] M.J. Bradley & Associates, *Electric Vehicle Market Status Update, 2021* (https://www.mjbradley.com/sites/default/files/EDF_EV_Market_Report_January_2021_Update_0.pdf, last accessed January 2022)

[56] Electrek Co, *Tesla Cybertruck pre-orders rise to over 650,000, says new report* 2020 (https://electrek.co/2020/06/22/tesla-cybertruck-pre-orders-rose-over-650000-report/, last accessed January 2022)

Table 3. Existing Medium- and Heavy-Duty ZEV Orders in North America as of November 2021

Manufacturer	Order Status
Tesla	At least 252,000 on order (250,000 Cybertruck) [57,58]
Ford	At least 160,000 on order[59]
Rivian	At least 130,000 on order[60,61]
Lordstown	At least 100,000 on order[62]
Nikola	At least 16,500 on order[63,64]
Workhorse	At least 7,900 on order[65]
Arrival	At least 10,000 on order[66]
GMC	At least 10,000 on order[67]
Bollinger	At least 6,000 on order[68]

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[57] Trucks.com, *Everything We Know About the Tesla Semi Truck*, 2019 (https://www.trucks.com/2019/09/05/everything-we-know-about-the-tesla-semi-truck/, last accessed January 2022)

[58] CNBC, *Elon Musk suggests Tesla has received 250,000 pre-orders for its Cybertruck*, 2020 (https://www.cnbc.com/2019/11/27/elon-musk-suggests-tesla-received-250000-pre-orders-for-cybertruck.html, last accessed January 2022)

[59] Elektrek, *Ford F-150 Lightning reservations surpass 160,000 during pre-production*, 2021 (https://electrek.co/2021/11/03/ford-f-150-lightning-reservations-surpass160000-during-pre-production/, last accessed January 2022)

[60] The Verge, *Amazon will order 100,000 electric delivery vans from EV startup Rivian, Jeff Bezos says*, 2019 (https://www.theverge.com/2019/9/19/20873947/amazon-electric-delivery-van-rivian-jeff-bezos-order, last accessed January 2022).

[61] Inside EVs, *Reservation Numbers Reveal Rivian R1T Has 30,000 Buyers Waiting*, 2020 (https://insideevs.com/news/437341/rivian-r1t-30-thousand-reservations/, last accessed January 2022).

[62] Elektrek, *Lordstown claims more than 100,000 pre-orders for its electric pickup truck*, 2021 (https://electrek.co/2021/01/11/lordstown-over-100000-pre-orders-electric-pickup-truck/, last accessed January 2022)

[63] Bloomberg, *Nikola Founder Builds $7.4 Billion Fortune Off Free Truck Orders*, 2020 (https://www.bloomberg.com/news/articles/2020-06-12/nikola-founder-builds-7-4-billion-fortune-off-free-truck-orders, last accessed January 2022)

[64] Nikola, *Nikola Receives Landmark Order of 2500 Battery Electric Waste Trucks from Republic Services*, 2020 (https://nikolamotor.com/press_releases/nikola-receives-landmark-order-of-2500-battery-electric-waste-trucks-from-republic-services-91, last accessed January 2022)

[65] M.J. & Bradley, *EV Market Update January 2021*, 2021 (https://www.mjbradley.com/sites/default/files/EDF_EV_Market_Report_January_2021_Update_0.pdf, last accessed January 2022).

[66] Arrival, *UPS invests in Arrival and Orders 10,000 Generation 2 Electric Vehicles*, 2020 (https://arrival.com/news/ups-invests-in-arrival-and-orders-10000-generation-2-electric-vehicles, last accessed January 2022)

[67] Elektrek, *GMC Hummer EV receives surprising number of pre-orders, and GM is looking to increase production*, 2021 (https://electrek.co/2020/12/21/gmc-hummer-ev-surprising-number-pre-orders-increase-production/, last accessed January 2022)

[68] Biznes Alert, *Electric car for tough guys*, 2017 (https://translate.google.com/translate?sl=auto&tl=en&u=https://biznesalert.pl/bollinger-b1-samochod-elektryczny/, last accessed January 2022)

Manufacturer	Order Status
Lion	At least 300 delivered, 150 on order[69,70]
Motiv	At least 128 on order[71]
BYD	At least 100 delivered, 25 on order[72,73]
Lightning eMotors	At least 100 on order[74]
GreenPower	At least 100 on order[75]
Phoenix	At least 56 on order[76]
Volvo	At least 15 on order[77]

Although incentive funding is a key part of the overall State policy to develop and accelerate early markets, staff did not include assumptions about state, federal, or local grants, rebates, or other types of funding programs in the costs analysis. Part of the reasons for this are that annual funding appropriations for some existing programs are uncertain, and various approved funding allocations totaling more than a billion dollars in investments for medium- and heavy-duty ZEVs and infrastructure are expected to be used by a wide range of fleet owners that may not be within the scope of the proposed regulation. Clearly the significant vehicle and infrastructure incentives available would reduce costs for some impacted fleets. However, this approach shows the full cost of the proposed regulation and scenarios compared to the baseline without funding assistance.

1.6 Public Outreach and Input

In February 2020, CARB staff began informing the public of the proposed ACF regulation and development process. Staff offered engagement opportunities to receive feedback and solicit for alternatives from a variety of groups and stakeholders, including manufacturers, large fleet owners and single truck owners-operators, environmental advocacy organizations

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[69] Inside EVs. *Canadian National Railway Orders Lion Electric Trucks*, 2020 (https://insideevs.com/news/442185/canadian-national-railway-orders-lion-electric-trucks, last accessed January 2022)

[70] Inside EVs. *Lion Electric Scores Largest Truck Order to Date*, 2021 (https://insideevs.com/news/497182/lion-electric-largest-truck-order/, last accessed January 2022)

[71] Inside EVs, *Bimbo Orders More EV Trucks from Motiv After Successful Pilot*, 2020 (https://insideevs.com/news/453800/bimbo-orders-more-ev-trucks-motiv/, last accessed January 2022)

[72] BYD, *BYD Delivers 100th Battery Electric Truck in the United States,* 2020 (https://en.byd.com/news/byd-delivers-100th-battery-electric-truck-in-the-united-states/, last accessed January 2022)

[73] BYD, *Anheuser Busch Names BYD Sustainable Suppler of the Year*, 2020 (https://en.byd.com/news-posts/anheuser-busch-names-byd-sustainable-supplier-of-the-year, last accessed January 2022)

[74] Lightning eMotors, *Lightning eMotors Reports Financial Results for Second Quarter 2021*, 2021 (*https://lightningemotors.com/20120-2/*, last accessed January 2022)

[75] GreenPower, *GreenPower Receives Order for Additional 100 EV Stars from Green Commuter*, 2020 (https://greenpowermotor.com/10-100-ev-stars-green-commuter/, last accessed January 2022)

[76] Phoenix Motorcars, *Phoenix Motorcars Announces Order for 50 Zero-Emissions Utility Shuttles by LR Group of Companies*, 2016 (https://www.phoenixmotorcars.com/phoenix-motorcars-announces-order-for-50-zero-emissions-utility-shuttles-zeus-by-lr-group-of-companies/, last accessed January 2022)

[77] FleetOwner, *Volvo Trucks Lands Largest VNR Electric Order*, 2021 (https://www.fleetowner.com/running-green/press-release/21161426/volvo-trucks-lands-largest-vnr-electric-order, last accessed January 2022)

and the communities impacted most heavily by medium- and heavy-duty truck emissions. Numerous workshops, workgroup meetings, forums, and listening sessions were held via webcast and a full list of public meetings[78] related to this rulemaking is as follows:

- February 12, 2020: Workshop to Discuss a Potential Medium- and Heavy-Duty Zero-Emission Fleet Regulation
- September 18, 2020: Workshop to Discuss the Proposed Advanced Clean Fleets Regulation
- September 22, 2020: Workshop on Reporting Requirements for Large Entities and Fleets Under the Advanced Clean Truck Regulation
- December 9, 2020: Workgroup Meetings on Costs and Drayage Trucks
- March 2, 2021 and March 4, 2021: Workshop to Discuss the Proposed Advanced Clean Fleets Regulation
- June 2, 2021: Medium- and Heavy-Duty Zero-Emission Vehicle Fueling Infrastructure Forum
- June 8, 2021 and June 10, 2021: Freight Days Community Listening Session
- August 31, 2021: Truck Emissions Community Listening Session
- September 9, 2021: Workshop on Draft Regulatory Language and Updated Cost Assumptions for the Advanced Clean Fleets Regulation
- October 6, 2021: Workgroup to Discuss the Public Fleet Requirements of the Advanced Clean Fleets Regulation
- October 13, 2021: Workgroup to Discuss the High Priority Fleet Requirements of the Advanced Clean Fleets Regulation
- October 26, 2021: Workgroup to Discuss the Advanced Clean Fleets Regulation with Smaller Fleets
- November 17, 2021: Workgroup to Discuss the Emissions Inventory Associated with the Advanced Clean Fleets Regulation
- December 3, 2021: Medium- and Heavy-Duty Infrastructure Workgroup on Business Considerations
- December 16, 2021: Medium- and Heavy-Duty Infrastructure Workgroup on Hydrogen

[78] California Air Resources Board, *Advanced Clean Fleets Meetings and Events*, 2021 (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events, last accessed January 2022)

- January 12, 2022: Medium- and Heavy-Duty Infrastructure Workgroup on Electricity and the Grid (Part 1)
- February 11, 2022: Medium- and Heavy-Duty Infrastructure Workgroup on Cost and Funding
- March 10, 2022: Medium- and Heavy-Duty Infrastructure Workgroup on Electricity and the Grid (Part 2)
- May 2, 2022: Workshop on Draft Regulatory Language for the Advanced Clean Fleets Regulation - High-Priority and Federal Fleets
- May 4, 2022: Workshop on Draft Regulatory Language for the Advanced Clean Fleets Regulation - State and Local Government Fleets
- May 6, 2022: Public Workshop on Draft Regulatory Language for the Advanced Clean Fleets Regulation - Drayage Trucks

Beginning in 2020, workshops were held to discuss a variety of strategies on the potential framework for a ZE truck regulation. In 2021, several comprehensive workshops were held on the proposed regulation as a whole and in September of 2021 a workshop was held in line with a draft of the regulation language being released to the public. Some workshops were recorded and posted for reference on the ACF website; others were not recorded to allow for frank discussions. Most were held remotely due to the Coronavirus pandemic.

Smaller workgroups were held to better capture stakeholder input from similarly affected fleets.[79] These meetings focused on different topics including drayage fleets and costs, public fleets, high priority and federal fleets, and smaller fleets. This provided a dedicated space for smaller fleets to ask questions and comment about the proposed regulatory requirements and express how those requirements might affect them.[80] The small fleet workgroup meetings included both day and evening sessions to reach and receive input from the largest possible audience. A separate channel for live interpretation was provided once for Punjabi and twice for Spanish with one Spanish session recorded and posted on the ACF website. A workgroup was also held to discuss the emissions reductions associated with the proposed regulation. Staff were available throughout the meetings to answer questions. All workgroups were recorded and posted for reference on the ACF website.

Separate from the workgroups focused on the regulation proposal, CARB staff also hosted a four-part series of workgroup meetings in collaboration with the CEC, CPUC, and the California Governor's Office of Business Administrations and Economic Development (GO-Biz). Spanning from late 2021 to March 2022, these meetings focused on activities,

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[79] California Air Resources Board, Notice of Public Workshop Meeting to Discuss the Proposed Advanced Clean Fleets Regulation, 2021 (Notice of Public Workshop Meeting to Discuss the Proposed Advanced Clean Fleets Regulation, 2021 (https://ww2.arb.ca.gov/resources/documents/mailout-msc-21-2103, last accessed January 2022).

[80] California Air Resources Board, *Notice of Public Workshop to Discuss the Proposed Advanced Clean Fleets Regulation*, 2021 (https://content.govdelivery.com/accounts/CARB/bulletins/2f6a894)

challenges, and solutions surrounding the build-out of fueling infrastructure needed to support the fleet of ZE trucks and buses that the ACF regulation would bring about. The primary objective was to gain a collective understanding of the status in each topic area, the initiatives underway at each State agency, and the opportunities presented in meeting the demands of infrastructure scale-up. Workgroup meetings were held on four topics including Business Considerations, Hydrogen, Electricity and the Grid, and Costs and Funding.

Staff used notices to announce meeting events, documents, a public comment docket, translation resources, and other associated regulatory materials to encourage participation and attendance at the workgroups and workshops. This information was distributed to 10 public email distribution lists containing 80,372 recipients as well as 84,597 fleet contacts from the TRUCRS reporting database system. The program webpage housed all available information and documents that were made available for public comment.[81] These documents include staff presentations, the December 2020 Preliminary Draft Cost Data and Methodology Discussion updated and reposted with new September 2021 data, and the Draft ACF Regulation Language.[82] [83] Regulation text was written and organized in sections including requirements for high priority and federal fleets, public fleets, drayage truck fleets, and vehicle manufacturers and was posted publicly 2 weeks prior to the September 2021 workshop. Furthermore, the 30-day informal comment period following this posting was extended to allow ample and additional time for input, feedback, and alternatives to the proposed ACF regulation. Alternatives were also solicited at the March 2 and March 4, 2021 workshops. Table 4 list the number of recipients for each email list used by staff to announce public events.

Table 4. Distribution to CARB Email Lists

Public Email List	Number of Recipients
actruck	7,909
zevfleet	3,529
porttruck	6,244
onrdiesel	33,288
publicfleets	5,581
swcv	4,084
sfti	2,879
aqip	8,864
hvip	2,723
hdlownox	5,271

[81] California Air Resources Board, *Advanced Clean Fleets*, 2021 (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets, last accessed January 2022)
[82] California Air Resources Board, *Cost Data and Methodology Discussion Document, 2020 (https://ww2.arb.ca.gov/sites/default/files/2020-12/201207costdisc_ADA.pdf, last accessed January 2022).*
[83] California Air Resources Board, *Advanced Clean Fleets Draft Regulation and Comments*, 2021 (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-draft-regulation-and-comments, last accessed January 2022)

Public Email List	Number of Recipients
TRUCRS	84,597
Total	164,969

In addition to public workgroups and workshops, CARB staff reached out to many proposed regulatory parties throughout the regulatory development and conducted more than 273 group and individual meetings with more than 130 stakeholders including, but not limited to, the Truck and Engine Manufacturers Association, California Trucking Association, California Electric Transportation Coalition, Community Steering Committees, Amazon, UPS, Pepsi, Southern California Edison (SCE), Pacific Gas and Electric (PG&E), Ikea, Waste Management, LA Metro, Ports of Los Angeles, Long Beach, Oakland, and San Diego, American Trucking Association, South Coast Air Quality Management District, California Chamber of Commerce, California Environmental Associates, CALSTART, Harbor Trucking Association, California Cleaner Freight Coalition, Better World Group, Coalition for Clean Air, BlueGreen Alliance, Earth Justice, Warehouse Worker Resource Center, California Workforce Development Board, CEC, CPUC, California Department of Transportation, GO-Biz, Sierra Club, Union of Concerned Scientists, Center for Community Action and Environmental Justice, Port of Oakland Trucker Workgroup, Natural Resources Defense Council, California Association of Port Authorities, Los Angeles Business Council, and Owner-Operator Independent Driver Association amongst many other fleet representatives and nonprofit organizations.

Staff also worked to include input from the community beyond directly regulated stakeholders and environmental advocacy organizations. To do this, CARB hosted a community listening session focused on truck activities as well as a two-day listening session focused on freight activities. These events gave attendees a brief overview of CARB's work to reduce air pollution from California trucks and allowed interested community members the opportunity to provide their input and vision for what CARB's priorities should be going forward. In addition, staff directly reached out to over 50 environmental justice groups to offer information and time to discuss the proposed ACF regulation. This work resulted in several informational meetings and 3 webinar presentations for AB617 Community Steering Committees. Staff also published an article in the CARB Environmental Justice blog spot to reach a wider and more diverse audience of affected parties.[84] This post was highlighted in the November 2021 Environmental Justice newsletter.

Staff also explored several other avenues to inform and engage fleets who may not be tuned into CARB's workgroups or email lists. An informational postcard mailer was sent to over 273,000 fleets identified to be either directly or indirectly affected by the proposed ACF regulation. Staff has also reached out to 14 trade associations and 18 metropolitan planning organizations. Several rural areas were also engaged through our outreach efforts and meetings were held with the Otay Mesa Chamber of Commerce and the Imperial County Environmental Justice IVAN committee. Staff also reached out by email to the Rural Counties Representatives Council. To reach public fleets, staff reached out directly by email to the Metropolitan Planning Organizations, the SANDAG Freight Stakeholders Working Group,

[84] California Air Resources Board, *CARB Environmental Justice Blog*, 2021 (web link: http://carbej.blogspot.com/2021/10/new-zero-emission-truck-regulation-will.html, last accessed January 2022).

Clean Cities Coalitions and the Institute of Local Governments, who in turn included an overview in several affiliated newsletters and listservs. An overview of the rulemaking has also been incorporated into a new CARB training course that has hosted over 883 attendees in 5 separate sessions in addition to 586 attendees who received an ACF overview when CARB staff hosted the One-Stop Truck events that occurred October 2021 and January 2022.

Staff will continue to meet with stakeholders and explore ways to inform the public about the proposed regulation including utilizing radio broadcast partnerships to offer information to an even wider audience in the coming months. Beyond these plans, the program webpage and CARB's TruckStop website will be continually updated to offer information on opportunities to engage, existing and future regulations, and the resources that would aid fleets in their transition to ZE technologies.[85]

[85] California Air Resources Board, *CARB TruckStop Zero-Emission Vehicles*, 2021 (web link: http://ww2.arb.ca.gov/sites/default/files/truckstop/zev/zevinfo.html, last accessed January 2022).

2 Benefits

The proposed regulation supports the goals of the State SIP Strategy and reduces pollutants linked to multiple adverse health effects identified by California and federal ambient air quality standards.[86,87] These pollutants are NOx, key ingredients in the formation of several airborne toxic substances, and $PM_{2.5}$, which may deposit deep inside the lungs.[88] NOx is a precursor to both ozone and $PM_{2.5}$. Long-term exposure to $PM_{2.5}$ has been linked to premature death, particularly in people who have chronic heart or lung diseases, and reduced lung function and growth in children.[89] The proposed regulation would reduce GHG emissions, petroleum use, and ensure community health benefits in areas that need them most. The proposed ACF fleet purchase and turnover requirements would effectively accelerate benefits for all Californians.

The 2016 Mobile Source Strategy identified ZEVs as urgently important to address the localized risk of cancer and other adverse effects from combustion engine emissions at major freight hubs, and that fleet electrification must also play a growing role in reducing GHG emissions and petroleum use.[90] The 2020 Mobile Source Strategy continues to build upon the 2016 Mobile Source Strategy's plan for increasing medium- and heavy-duty ZEVs and the reduction of health impacts.[91] In January 2022, CARB released the Draft 2022 State SIP Strategy for public comment. It will be considered by the Board in mid-2022. Given that the document indicates California will be short of needed tons of emissions reductions needed for attainment, there is a need to push for more ZEV deployments and avoid scaling back regulatory pressure on the market. The proposed ACF regulation will significantly expand the number of ZEVs deployed statewide beyond existing measures, and more will be needed.

2.1 Emissions Benefits

2.1.1 Inventory Methodology

Staff used the EMFAC2021 model[92] to assess the emissions reductions that would be associated with the proposed regulation. EMFAC is California's official on-road (e.g., cars, trucks, and buses) mobile source inventory model that CARB uses for various clean air

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[86] California Air Resources Board, *2016 State Strategy for the State Implementation Plan*, 2017 (web link: https://ww3.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf, last accessed January 2022).
[87] California Air Resources Board, *California Ambient Air Quality Standards* (web link: https://ww2.arb.ca.gov/resources/california-ambient-air-quality-standards, last accessed January 2022).
[88] California Air Resources Board, *Nitrogen Dioxide and Health* (web link: https://ww2.arb.ca.gov/resources/nitrogen-dioxide-and-health, last accessed January 2022).
[89] California Air Resources Board, *Inhalable Particulate Matter (PM 2.5 and PM10)* (web link: https://ww3.arb.ca.gov/research/aaqs/common-pollutants/pm/pm.htm, last accessed January 2022).
[90] California Air Resources Board, *2016 Mobile Source Strategy*, 2016 (web link: https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf, last accessed January 2022).
[91] California Air Resources Board, *Draft 2020 Mobile Source Strategy*, 2020 (web link: https://ww2.arb.ca.gov/sites/default/files/2020-11/Draft_2020_Mobile_Source_Strategy.pdf, last accessed January 2022).
[92] California Air Resources Board, *EMFAC*, 2021 (web link: *https://arb.ca.gov/emfac/*, last accessed April 2022).

planning, policy development, and regulatory efforts. EMFAC2021 incorporates CARB's latest understanding of statewide and regional vehicle activity and emissions and reflects the Legal Baseline of adopted medium- and heavy-duty vehicle regulations including the ACT regulation. An alternative baseline is also presented in the "Baseline Information" Section to show how emissions compare if the HDIM regulation recently adopted by the Board is approved and finalized by OAL. The proposed regulation would require affected entities to upgrade their fleets to ZEVs, thereby eliminating NOx, PM, and GHG tailpipe emissions resulting from vehicle operations.

PM, NOx, and GHG emissions benefits are projected by assuming zero tailpipe emissions for the forecasted number of medium- and heavy-duty ZEVs operating in California with the proposed ACF requirements in place and assuming no change in total VMT, compared to the Legal Baseline. The PM emissions analysis also includes an estimated 50 percent reduction in PM associated with brake-wear for electric vehicles due to regenerative braking when compared to conventional vehicles.[93] Projections, including inventory assumptions, are further discussed in the Direct Costs Section of this SRIA. Staff used the latest available data on population, activity, and in-use emissions from medium- and heavy-duty truck fleets operating in California to estimate the Legal Baseline emissions.

This assessment is focused on the vehicle emissions, also known as tank-to-wheel (TTW) emissions, and does not include upstream emissions associated with producing and delivering the fuel or energy source to the vehicle that are addressed by other measures and policies to reduce those emissions. However, upstream emissions from medium and heavy-duty ZEVs are expected to show greater cumulative PM, NOx, and GHG reductions due to the much lower total energy use and the upstream emissions associated with electricity and hydrogen production compared to gasoline, diesel, natural gas, and other fuels.[94]

2.1.2 Anticipated Emissions Benefits

2.1.2.1 Criteria Pollutant Emissions Benefits

Medium- and heavy-duty trucks are the predominant means of distributing freight and services. These trucks can be seen along distribution centers, seaports, railyards, warehouses, and major roadways, which are commonly located around more densely populated urban areas, including in low-income and disadvantaged communities. ZEV deployment in low-income and disadvantaged communities will be an important part of the solution, not only for maximizing NOx and PM reductions needed to meet SIP requirements, but also for achieving

[93] National Renewable Energy Laboratory, *BAE/Orion Hybrid Electric Buses at New York City Transit* (web link: https://afdc.energy.gov/files/pdfs/42217.pdf, last accessed January 2022).
[94] California Air Resources Board, *Advanced Clean Cars II SRIA*, 2022 (web link: https://www.dof.ca.gov/forecasting/economics/major_regulations/major_regulations_table/documents/ACCII-SRIA.pdf, last accessed January 2022).

GHG emissions goals established in many statutes, or complementary to existing statutes including AB 32, SB 32, SB 350, and SB 375.[95]

The projected statewide emissions benefits of the proposed regulation from 2024 through 2050 are identified in Table 5 with respect to NOx, $PM_{2.5}$, and GHGs. The calendar years displayed in the table below represent targets for California to meet air quality standards and GHG goals. Years 2031 and 2037 are mid-term attainment deadlines for national ambient air quality standards, whereas years 2045 and 2050 are longer-term climate goals to achieve carbon neutrality and 80 percent GHG emissions reductions below 1990 levels, respectively.

Table 5. Statewide TTW NOx, $PM_{2.5}$, and GHG Benefits of the Proposed Regulation Relative to Legal Baseline

Calendar Year	NOx (tpd)	$PM_{2.5}$ (tpd)	CO_2 (MMT/year)
2024	0.29	0.01	0.11
2025	0.89	0.02	0.28
2026	2.73	0.05	0.70
2027	5.36	0.08	1.24
2028	7.53	0.12	1.72
2029	11.50	0.20	2.65
2030	15.69	0.28	3.62
2031	20.45	0.37	4.66
2032	25.21	0.46	5.71
2033	29.43	0.54	6.59
2034	35.62	0.65	7.83
2035	42.09	0.78	9.12
2036	48.01	0.90	10.18
2037	54.36	1.03	11.32
2038	61.08	1.16	12.53
2039	67.52	1.30	13.73

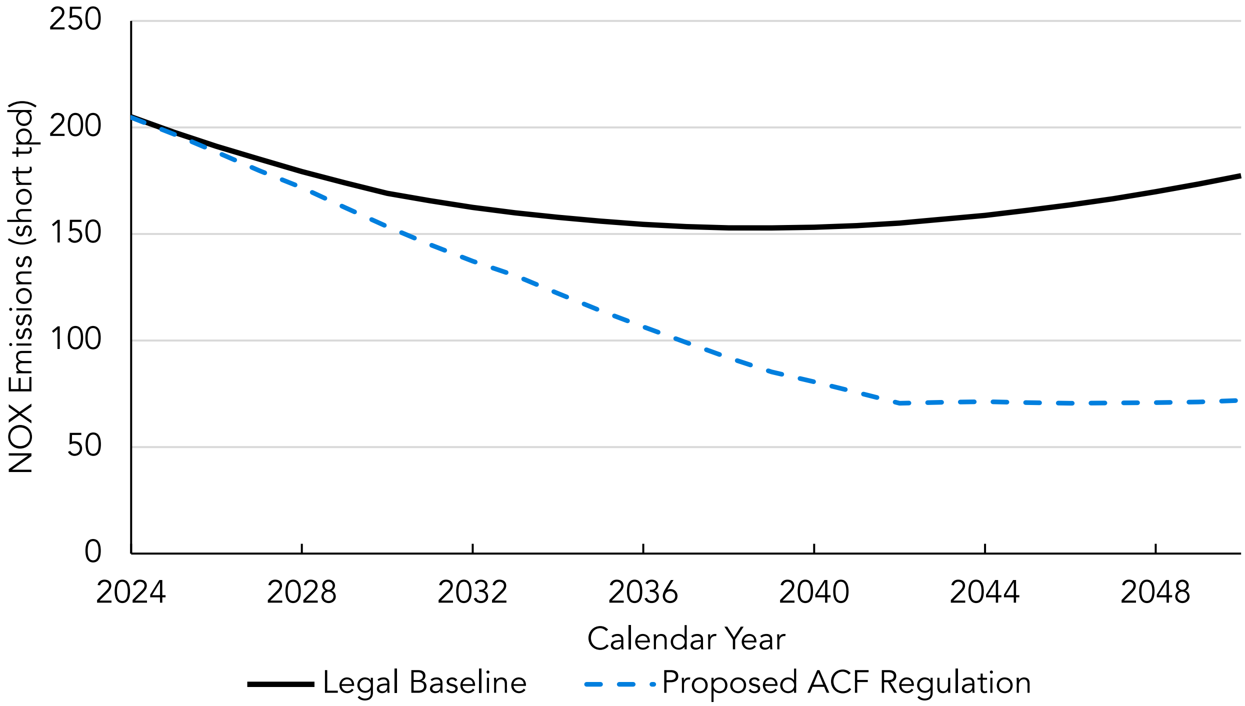
[95] The Sustainable Communities and Climate Protection Act of 2008 (SB 375) requires CARB to develop and set regional targets for GHG emissions reductions from passenger vehicles. CARB has set regional targets, indexed to years 2020 and 2035, to help achieve significant additional GHG emissions reductions from changed land use patterns and improved transportation in support of the State's climate goals, as well as in support of statewide public health and air quality objectives.

Calendar Year	NOx (tpd)	$PM_{2.5}$ (tpd)	CO_2 (MMT/year)
2040	72.59	1.45	15.06
2041	78.32	1.61	16.61
2042	84.59	1.77	18.20
2043	85.90	1.84	18.88
2044	87.47	1.91	19.58
2045	90.16	2.00	20.44
2046	93.01	2.09	21.32
2047	95.94	2.18	22.19
2048	99.07	2.27	23.07
2049	102.23	2.36	23.95
2050	105.40	2.45	24.81

Emissions benefits increase as the ZEV fleet requirements phase in and the population of medium- and heavy-duty ZEVs increases. The cumulative total emissions reductions from 2024 to 2050 is estimated to result in 443,799 tons reduction in NOx, 9,313 tons reduction in $PM_{2.5}$ and 316 million metric tons (MMT) reduction of GHG, relative to the Legal Baseline. Note that the emissions reductions presented are TTW and the conversion of NOx and $PM_{2.5}$ from tons per day into years assumes 312 operational days per year.

The statewide NOx and $PM_{2.5}$ emissions impacts of the proposed regulation are presented relative to the Legal Baseline in the following two figures and are shown in short tons per day (tpd). In the Legal Baseline, projected NOx emissions decrease significantly until 2023 when the Truck and Bus regulation achieves its goal of upgrading most diesel vehicles to 2010 MY and newer engines. Beginning in 2024, the Legal Baseline for NOx emissions continues to decline as cleaner engines and ZEVs are phased in, even as VMT continues to grow, due to the normal replacement of existing vehicles with cleaner vehicles and existing regulations. However, in later years, the Legal Baseline NOx emissions begin to increase with projected VMT growth.

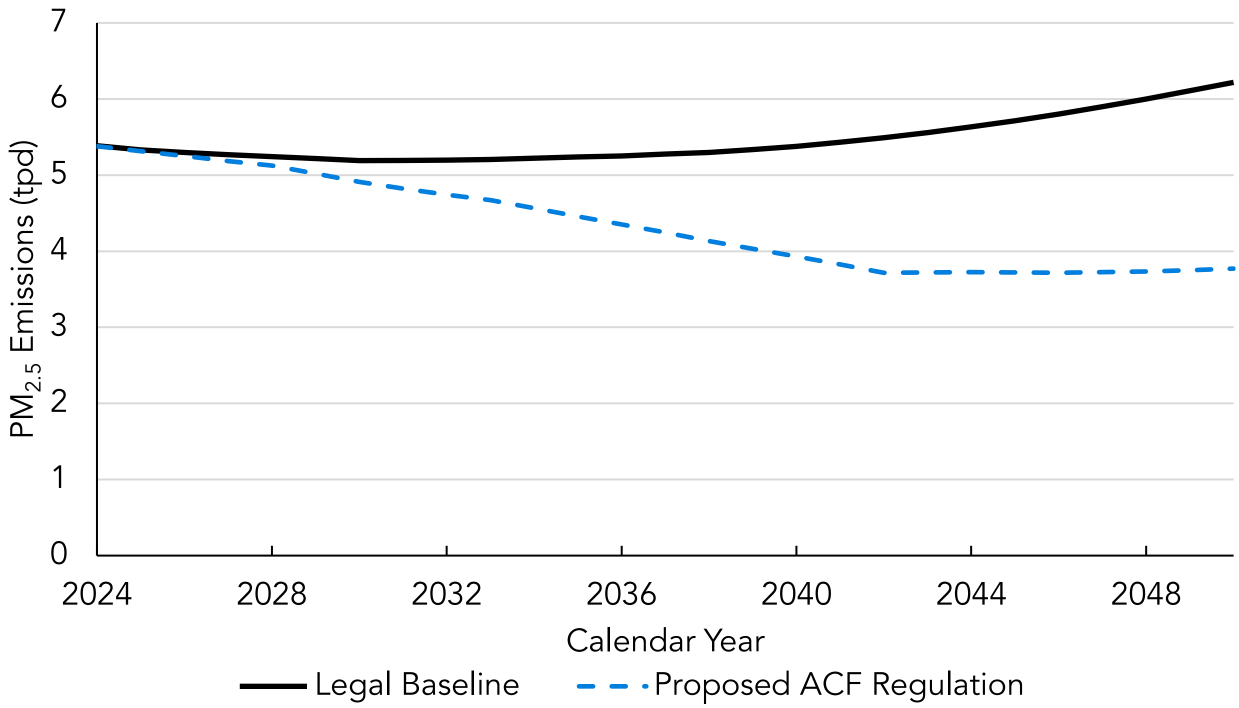
Figure 2. Projected Statewide NOx TTW Emissions, Legal Baseline and Proposed Regulation



In the Legal Baseline, NOx emissions are expected to decline from 205.0 tpd in 2024 to 177.3 tpd in 2050. With the proposed regulation, NOx emissions decline from 205.0 tpd in 2024 to 71.9 tpd in 2050. Although the regulated fleets will have fully converted to ZEVs by 2042, the new ZEV sales requirement will keep bringing extra emissions benefits despite the predicted VMT growth and emissions deterioration from remaining combustion vehicles.

For $PM_{2.5}$ emissions shown in Figure 3, the Legal Baseline is initially expected to remain relatively flat as most diesel trucks already have PM filters and only limited additional reductions are expected from newer engines. Then $PM_{2.5}$ emissions are expected to increase as projected VMT grows. With the proposed regulation, $PM_{2.5}$ emissions are expected to decline rapidly until about 2042 and then slow as more regulated fleets make a full conversion to ZEVs. Under the Legal Baseline, $PM_{2.5}$ emissions are expected to increase from 5.4 tpd in 2024 to 6.2 tpd in 2050. With the proposed regulation, $PM_{2.5}$ emissions are expected to decrease from 5.4 tpd in 2024 to 3.8 tpd in 2050. Remaining emissions are largely due to vehicles not covered by the rule and other non-exhaust sources such as brake or tire wear.

Figure 3. Projected Statewide $PM_{2.5}$ TTW Emissions, Legal Baseline and Proposed Regulation



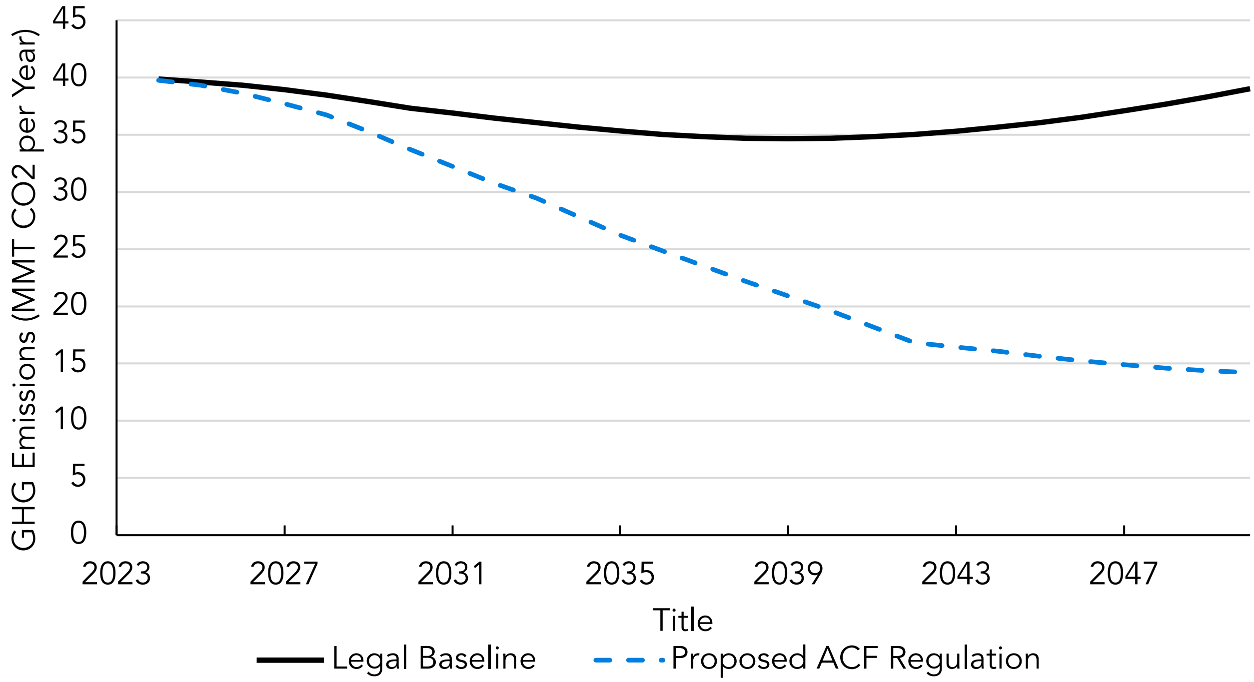
2.1.2.2 GHG Emissions Benefits

ZEV adoptions in low-income and disadvantaged communities will be an important part of the solution for improvement of air quality in these areas that are so heavily impacted by truck traffic, not only for maximizing NOx and PM reductions needed to meet SIP requirements, but also for achieving the State's GHG emissions reduction goals. Reducing GHG emissions will help stabilize the climate, which benefits all communities, including low-income and disadvantaged communities.

The proposed regulation would be expected to result in significant GHG emissions reductions, due to replacing ICE vehicles with ZEV technologies. ZEVs produce no tailpipe emissions and have lower upstream emissions. These emissions reductions contribute to keeping California on the GHG emissions reductions path set in the Climate Change Scoping Plan.

Figure 4 summarizes the estimated TTW GHG emissions from both the proposed regulation and the Legal Baseline, in units of MMT of CO_2 per year. The proposed regulation would be expected to reduce cumulative TTW GHG emissions by an estimated 316 MMT of CO_2 relative to the Legal Baseline from 2024 to 2050.

Figure 4. Projected Statewide TTW GHG Emissions of the Proposed Regulation



In the Legal Baseline, GHG emissions display a gradual overall decline from 2024 to 2039. The decline is the result of engine manufacturers meeting stricter emissions standards resulting in older models being replaced with more efficient models when normal replacements are made, the ACT regulation requiring manufacturers to build and sell a percentage of medium- and heavy-duty ZE trucks and buses. However, emissions begin to increase in about 2040, and by 2050, reach about the same annual emissions level as 2024. The GHG emissions increase is primarily due to the projected growth in medium- and heavy-duty truck VMT.

With the proposed regulation, GHG emissions demonstrate a rapid decline from 2024 to 2042, reducing the annual emissions by roughly half of the 2024 estimate. The decrease in GHG emissions in comparison to the Legal Baseline is attributed to an increase in the number of ZEVs and some early retirement of medium- and heavy-duty ICE vehicles that reach the end of their useful life. The benefits are from the fact ZEVs have no tailpipe emissions. From 2043 to 2050, GHG emissions continue to decline but at a much slower rate than in prior years.

The oil and gas and refining sector account for half of the industrial sector emissions in the State's annual GHG inventory, roughly 10 percent of the State's total GHGs.[96] The electricity sector currently accounts for approximately 14 percent of the State's total GHGs. As the

[96] California Air Resources Board, *California Greenhouse Gas Emissions for 2000 to 2019,* 2021 (web link: https://ww2.arb.ca.gov/sites/default/files/classic/cc/ca_ghg_inventory_trends_2000-2019.pdf, last accessed January 2022).

State moves away from fossil fuel combustion technology, there will be less dependence on petroleum, this could potentially result in a reduction in petroleum industry related GHG emissions. During the COVID-19 pandemic and the stay-at-home orders, there was a drastic reduction in demand for petroleum fuels as residents stayed home. As a result of that reduced demand, several refineries shutdown or announced the repurposing of those facilities to produce low carbon fuels.[97,98] It is reasonable to expect that as fleets turnover and transition away from petroleum fuel and demand is reduced, we may see resulting upstream reductions in petroleum industry activities which could translate into additional GHG reductions.

Moreover, the transition to a cleaner fleet may also see demand increase for electricity. And, while the electricity sector is still a source of GHG emissions, there are multiple efforts to drastically decarbonize the grid even while load grows. The 2017 Scoping Plan Update, SB 350 Integrated Resource Plans, and SB 100 Report lay out the decarbonization targets and goals for 2030 and 2045. [99,100,101] The 2017 Scoping Plan estimated a 51 to 72 percent reduction in GHG emissions relative to 1990 levels in the electricity sector while SB 100 requires planning for 100 percent zero-carbon electricity retail sales by 2045. In addition to these sector specific upstream efforts to reduce GHG emissions, the 2022 Scoping Plan is currently evaluating four scenarios for achieving carbon neutrality no later than 2045 which either eliminates or drastically reduces the dependence on fossil fuel sourced energy.[102]

The benefit of these GHG emissions reductions can be estimated using the social cost of carbon (SC-CO_2), which provides a dollar valuation of the damages caused by one ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future.

In the analysis of the SC-CO_2 for the proposed regulation, CARB utilizes the current Interagency Working Group (IWG) supported SC-CO_2 values to consider the social costs of actions taken to reduce GHG emissions. This is consistent with the approach presented in the Revised 2017 Climate Change Scoping Plan, is in line with U.S. Government Executive Orders

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[97] Phillips 66, *Phillips 66 Plans to Transform San Francisco Refinery into World's Largest Renewable Fuels Plant, 2020* (web link: https://investor.phillips66.com/financial-information/news-releases/news-release-details/2020/Phillips-66-Plans-to-Transform-San-Francisco-Refinery-into-Worlds-Largest-Renewable-Fuels-Plant/default.aspx, last accessed January 2022).

[98] BiodieselMagazine.com, *Marathon proceeds with renewables conversion at Martinez refinery,* 2021 (web link: https://biodieselmagazine.com/articles/2517427/marathon-proceeds-with-renewables-conversion-at-martinez-refinery, last accessed January 2022)

[99] California Air Resources Board, *California's 2017 Climate Change Scoping Plan,* 2017 (web link: https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf, last accessed January 2022)

[100] California Air Resources Board, *SB 350 Electricity Sector Greenhouse Gas Planning Targets | California Air Resources Board,* (web link: https://ww2.arb.ca.gov/our-work/programs/sb350, last accessed January 2022)

[101] California Energy Commission, *SB 100 Joint Agency Report* (web link: https://www.energy.ca.gov/sb100, last accessed January 2022)

[102] California Air Resources Board, *Pathways Scenario Modeling 2022 Scoping Plan Update,* 2021 (web link: https://ww2.arb.ca.gov/sites/default/files/2021-12/Revised_2022SP_ScenarioAssumptions_15Dec.pdf, last accessed January 2022)

including 13990 and the Office of Management and Budget's Circular A-4 of September 17, 2003 and reflects the best available science in the estimation of the socio-economic impacts of carbon.[103,104]

IWG describes the social costs of carbon as follows:

> The SC-CO_2 for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in CO_2 emissions into the atmosphere in that year or, equivalently, the benefits of reducing CO_2 emissions by the same amount in that year. The SC-CO_2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts from global climate change that result from an additional ton of CO_2.
>
> Those damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO_2 emissions today will affect economic outcomes throughout the next several centuries.[105]

The SC-CO_2 is year-specific and is highly sensitive to the discount rate used to discount the value of the damages in the future due to CO_2. The SC-CO_2 increases over time as systems become more stressed from the aggregate impacts of climate change and as future emissions cause incrementally larger damages. This discount rate accounts for the preference for current benefits and future costs over future benefits and current costs. A higher discount rate decreases the value today of future environmental damages. While the proposed regulation cost analysis does not account for any discount rate, this social cost analysis uses the IWG standardized range of discount rates from 2.5 to 5 percent to represent varying valuation of future damages. Table 6 shows the range of SC-CO_2 discount rates developed by the IWG which reflect the societal value of reducing carbon emissions by one metric ton.[106]

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[103] California Air Resources Board, *California's 2017 Climate Change Scoping Plan*, 2017 (web link: https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf, last accessed January 2022).

[104] Office of Management and Budgets, *Circular A-4*, 2003 (web link: https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf, last accessed January 2022).

[105] National Academies of Sciences, *Engineering, Medicine, Valuing Climate Damages: Updating Estimation of Carbon Dioxide*, 2017 (web link: http://www.nap.edu/24651, last accessed January 2022).

[106] Interagency Working Group on the Social Cost of Carbon, *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 13990*, 2021 (web link: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf, last accessed January 2022).

Table 6. SC-CO_2 Discount Rates (in 2021$ per Metric Ton of CO_2)

Year	5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2020	$16	$57	$85
2025	$19	$63	$93
2030	$22	$68	$100
2035	$25	$75	$107
2040	$29	$82	$115
2045	$31	$88	$122
2050	$36	$94	$130

The avoided SC-CO_2 from 2024 to 2050 is the sum of the annual TTW GHG emissions reductions multiplied by the SC-CO_2 in each year. The cumulative TTW GHG emissions reductions along with the estimated benefits from the proposed regulation are shown in Table 5. These benefits range from about $9.5 billion to $37.4 billion through 2050, depending on the chosen discount rate. In Table 7, staff calculated the avoided SC-CO_2 values (Million 2021$) by applying values in Table 6 (Million 2021$ per Metric Ton of CO_2) that were adjusted with a California consumer price index inflation adjustment factor.

Table 7. Avoided SC-CO_2 (Million 2021$)

Year	GHG Emissions Reductions (MMT)	Avoided SC-CO_2 5% Discount Rate	Avoided SC-CO_2 3% Discount Rate	Avoided SC-CO_2 2.5% Discount Rate
2024	0.1	$1.8	$6.2	$9.0
2025	0.3	$5.7	$18.9	$27.9
2026	0.7	$13.4	$45.0	$66.1
2027	1.2	$24.6	$78.8	$114.9
2028	1.7	$34.9	$113.9	$165.1
2029	2.7	$55.4	$180.9	$265.9
2030	3.6	$78.8	$246.2	$359.4
2031	4.7	$102.9	$327.8	$475.7
2032	5.7	$132.5	$405.4	$584.7
2033	6.6	$153.5	$478.4	$686.0
2034	7.8	$192.0	$576.1	$821.4
2035	9.1	$224.0	$684.5	$970.8

Year	GHG Emissions Reductions (MMT)	Avoided SC-CO_2 5% Discount Rate	Avoided SC-CO_2 3% Discount Rate	Avoided SC-CO_2 2.5% Discount Rate
2036	10.2	$265.1	$781.2	$1,102.1
2037	11.3	$293.6	$880.9	$1,251.9
2038	12.5	$341.9	$991.6	$1,401.9
2039	13.7	$374.8	$1,105.5	$1,555.2
2040	15.1	$433.7	$1,239.1	$1,734.8
2041	16.6	$476.8	$1,384.9	$1,929.8
2042	18.2	$547.6	$1,518.4	$2,140.7
2043	18.9	$568.7	$1,602.7	$2,248.9
2044	19.6	$616.6	$1,688.8	$2,359.0
2045	20.4	$641.7	$1,785.7	$2,483.2
2046	21.3	$699.2	$1,893.6	$2,621.9
2047	22.2	$728.7	$2,004.0	$2,793.4
2048	23.1	$789.8	$2,116.8	$2,938.2
2049	24.0	$820.6	$2,232.1	$3,085.5
2050	24.8	$881.9	$2,340.4	$3,222.3
Total	**316.1**	$9,500.2	$26,727.9	$37,415.8

It is important to note that the SC-CO_2, while intended to be a comprehensive estimate of the damage caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the SC-CO_2, including costs associated with changes in co-pollutants, the social cost of other GHGs including methane and nitrous oxide, and costs that cannot be included due to modeling and data limitations. The Intergovernmental Panel on Climate Change[107] has stated that the IWG SC-CO_2 estimates are likely underestimated due to the omission of significant impacts that cannot be accurately monetized including important physical, ecological, and economic impacts.[108]

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[107] Intergovernmental Panel on Climate Change, *IPCC webpage*, (weblink: https://www.ipcc.ch/, last accessed January 2022)
[108] Environmental Protection Agency, *Social Cost of Carbon Fact Sheet*, 2016, (weblink: https://www.epa.gov/sites/default/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf, last accessed January 2022)

2.2 Benefits to Typical Businesses

2.2.1 Truck and Bus Owners

Individual businesses may be able to lower their total cost of ownership by taking advantage of the operational cost-savings of ZEVs like battery-electric or hydrogen FCEVs. ZEV owners that also own their charging or hydrogen fueling stations can lower costs further by taking advantage of the LCFS program. Details can be found in the Direct Costs chapter of this SRIA in section 3.1.4.3.

Trucking companies and others that have ZEV fleets might choose to advertise themselves as being environmentally friendly and make partnerships or sign contracts with other companies that want to support the movement toward replacing fossil fuel-burning trucks and buses with those that produce no tailpipe emissions, resulting in better public health. Less vibration in the cab results in a reduced health impact to truck drivers, including a reduction in "driver's fatigue" which can lead to deadly accidents.[109, 110, 111] ZEVs reduce harmful emissions that contribute to air toxics hot spots at places such as truck mechanic shops, loading docks, and inside truck cabs, resulting in better quality air that truck drivers, including owner-operators, breathe.[112]

2.2.2 Electric Utility Providers

The proposed regulation would increase the number of medium- and heavy-duty ZEVs deployed which, in turn, would increase the amount of electricity supplied by electric utility providers, either directly or indirectly. In addition, since electric utilities also operate trucks, they would also see potential benefits like other truck owners.

The proposed regulation would also help the state's investor-owned utilities meet the goals of SB 350, which includes a requirement that the state's investor-owned utilities develop programs "to accelerate widespread transportation electrification." PG&E, SCE, and San Diego Gas and Electric (SDG&E) have active programs to install low-cost or free electric vehicle supply infrastructure on a customer's site, and they commonly offer a voucher for the charger itself.

All three of these investor-owned utilities have established new electricity rates for commercial ZEV deployments to better align with fleet needs and to ensure affordability, which includes a variety of approaches such as demand charge holidays or a subscription-based approach. Research and development of new rate strategies is ongoing. By ensuring that vehicles would be available to make use of these utility investments and rates, the

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[109] Institute of Transport Economics, *Experiences from Battery-Electric Truck Users in Norway* , 2020 (web link: https://www.mdpi.com/601754, last accessed January 2022).

[110] Bose Corporation, *The impact of different seats and whole-body vibration exposures on truck driver vigilance and discomfort*, 2017 (web link: https://doi.org/10.1080/00140139.2017.1372638, last accessed January 2022).

[111] RAND Corporation, *Evaluating the Impact of Whole-Body Vibration (WBV) on Fatigue and the Implications for Driver Safety*, 2015 (web link: www.rand.org/t/rr1057, last accessed January 2022).

[112] National Library of Medicine, *Potential air toxics hot spots in truck terminals and cabs*, 2012 (web link: https://pubmed.ncbi.nlm.nih.gov/23409510/, last accessed January 2022).

proposed regulation supports the utilities' programs, the goals of SB 350, and an increase in electricity demand. In addition, other electric service providers, such as publicly owned utilities and community choice aggregators, continue to develop and deploy new programs and policies and would similarly benefit from increased electricity deliveries.

2.2.3 Other California Businesses

The proposed regulation may result in benefits to ZEV manufacturers and component suppliers, electric vehicle supply equipment (EVSE) suppliers and installers, and hydrogen fuel station suppliers. Due to higher demand for medium- or heavy-duty ZEVs from the proposed regulation, production of ZEVs in California would be expected to rise, leading to increases in manufacturing and related jobs throughout the state. The increase in the production and usage of ZEVs would be expected to also benefit various businesses related to the ZEV component supply chain, including those involved with batteries, fuel cells, and electric drivetrains.

The proposed regulation may also benefit EVSE suppliers who would see an increase in charging equipment installation because of increased medium- and heavy-duty ZEV purchases. Most of these installations are expected to be in central depots or yards where trucks are parked overnight. Increased installation of charging infrastructure would benefit the EVSE suppliers, equipment installers, and electricians. EVSE installations would primarily in California (though, conceivably, some businesses might also choose to operate their ZEVs in other states, resulting in additional EVSE in those states), and some of the EVSE equipment may be manufactured in California. Increased purchase of medium- and heavy-duty ZEVs under the proposed regulation would also benefit various California businesses related to installing hydrogen fueling stations, supplying hydrogen, and providing associated maintenance.

Companies that contract with or use ZEV fleets would be able tout that they are either moving towards or currently operating with a carbon neutral or carbon optimal supply chain.[113] Choosing to focus on a more environmentally friendly shipping method and supply chain may help some companies in their move towards carbon neutrality by compensating for other aspects of their businesses from which it is more difficult to reduce GHG emissions.

2.3 Benefits to Small Businesses

The proposed regulation may result in benefits to small business due to higher demand for medium- and heavy-duty ZEVs, and associated infrastructure, which would likely lead to increases in manufacturing, distribution, infrastructure installation and maintenance, and other related jobs for small businesses throughout the state. Electricians, construction companies (including infrastructure installers), existing ZEV manufacturers, and fuel cell and electric drivetrain parts and components businesses may fall into the small business category and may see an increase in new sales or other business opportunities. Increased installation

[113] University of California at Los Angeles, *Carbon-Optimal and Carbon-Neutral Supply Chains*, 2011 (web link: https://escholarship.org/uc/item/3s01b6pg, last accessed January 2022).

of charging infrastructure would benefit EVSE suppliers, equipment installers, and electricians that could be small businesses. EVSE installations would be primarily in California (though, conceivably, some businesses might also choose to operate their ZEVs in other states, resulting in additional EVSE in those states), and some of the EVSE equipment may be manufactured in California. Increased purchase of medium- and heavy-duty ZEVs under the proposed regulation could also benefit various California small businesses related to installing hydrogen fueling stations, supplying hydrogen, and providing associated maintenance.

A shift in environmental conscientiousness and ZEV range availability may influence businesses to seek to fulfill their medium- and heavy-duty ZEV purchase and service needs with local companies, which may be small businesses, rather than ordering from businesses more distant from their communities. There may also be a decrease in shipping costs, due to the significantly lower fuel prices associated with purchasing from local businesses, which can be passed on to the customer or reinvested into the small business.

2.4 Benefits to Individuals

2.4.1 Health Benefits

The proposed regulation would reduce NOx and $PM_{2.5}$ emissions, resulting in health benefits for individuals in California. The value of health benefits calculated for this regulation is due to fewer instances of premature mortality and fewer hospital and ER visits. The evaluation method used in this analysis is the same as the one used for CARB's LCFS 2018 Amendments, Heavy-Duty Vehicle Inspection Program, and Periodic Smoke Inspection Program.

CARB analyzed the value associated with four health outcomes in the Legal Baseline, proposed regulation, and alternatives: cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness, and 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 $PM_{2.5}$ based on a substantial body of scientific evidence.[114] U.S. EPA has determined that both long-term and short-term exposure to $PM_{2.5}$ plays a causal role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between $PM_{2.5}$ exposure and increased risk of death. This relationship persists when other risk factors such as smoking rates, poverty, and other factors are taken into account. U.S. EPA has also determined a causal relationship between non-mortality cardiovascular effects and short- and long-term exposure to $PM_{2.5}$, and a likely causal relationship between non-mortality respiratory effects (including worsening asthma) and short- and long-term $PM_{2.5}$ exposure. These outcomes lead to hospitalizations and ER visits and are included in this analysis.

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[114] U.S. EPA, *Integrated Science Assessment for Particulate Matter (Issue EPA/600/R-19/188)*, 2019 (web link: https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534, last accessed January 2022).

CARB staff evaluated a limited number of statewide non-cancer health impacts associated with exposure to $PM_{2.5}$ and NOx emissions from medium- and heavy-duty vehicles. NOx includes nitrogen dioxide, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled.[115] However, the most serious quantifiable impacts of NOx emissions occur through the conversion of NOx to fine particles of ammonium nitrate aerosols through chemical processes in the atmosphere. $PM_{2.5}$ formed in this manner is termed secondary $PM_{2.5}$. Both directly emitted $PM_{2.5}$ and secondary $PM_{2.5}$ from medium- and heavy-duty vehicles 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 $PM_{2.5}$ and NOx emissions are associated with reductions in these health outcomes.

2.4.1.1 Incidence-Per-Ton Methodology

CARB uses the incidence-per-ton (IPT) methodology to quantify the health benefits of emissions reductions in cases where dispersion modeling results are not available. A description of this method is included on CARB's webpage.[116] CARB's IPT methodology is based on a methodology developed by U.S. EPA.[117,118,119]

Under the IPT methodology, 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 $PM_{2.5}$ for a baseline scenario using measured ambient concentrations and dividing by the emissions of $PM_{2.5}$ 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 emissions reductions from the proposed regulation in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the proposed regulation. For future years, the number of outcomes is adjusted to account for population

[115] United States Environmental Protection Agency, *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-15/068*, 2016 (web link: http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=526855, last accessed January 2022).
[116] California Air Resources Board, *CARB's Methodology for Estimating the Health Effects of Air Pollution* (web link: https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution, last accessed January 2022).
[117] 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 (web link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/, last accessed January 2022).
[118] 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, 2012 (web link: https://www.sciencedirect.com/science/article/pii/S0160412012001985118 , last accessed January 2022).
[119] 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 (web link: https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050, last accessed January 2022).

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 $PM_{2.5}$: primary $PM_{2.5}$ and secondary $PM_{2.5}$ of ammonium nitrate aerosol formed from precursors.

2.4.1.2 Reduction in Adverse Health Impacts

CARB staff evaluated the reduction in adverse health impacts including cardiopulmonary mortality, hospitalizations for cardiovascular and respiratory illness, and ER visits for asthma. The scale of emissions from short term construction of infrastructure is expected to be trivial in the context of the total emissions reductions expected from the regulation in the next two decades. For context, staff reviewed a sample of more than 20 CEQA notices for recent medium- and heavy-duty ZEV infrastructure projects funded by CARB and sister agencies and found all of the notices reviewed identified the projects as not having significant impacts on the environment. These ZEV deployments are expected to result in substantial emissions reductions. For instance, the Volvo Low Impact Green Highway Transportation Solutions pilot project description identified the project will deploy 23 Class 8 battery-electric tractors and was expected to result in 3.57 tons of criteria emission reductions and 3,020 metric tons of GHG reductions.[120] Staff estimates that the total number of cases statewide that would be reduced (from 2024 to 2050) from implementation of the proposed regulation are as follows:

- 5,888 cardiopulmonary deaths reduced (4,605 to 7,195, 95 percent confidence interval (CI));
- 932 hospital admissions for cardiovascular illness reduced (0 to 1,828, 95 percent CI);
- 1,113 hospital admissions for respiratory illness reduced (261 to 1,964, 95 percent CI); and
- 2,707 ER visits for asthma reduced (1,713 to 3,702, 95 percent CI).

Table 8 shows the estimated avoided cardiopulmonary mortality, hospitalizations, and ER visits because of the proposed regulation for 2024 through 2050 by California air basin, relative to the Legal Baseline. Note, the proposed regulation will result in additional health benefits beyond what CARB staff has quantified. CARB's current $PM_{2.5}$ 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 regulation. For example, while the current analysis considers the impact of NOx on the formation of secondary $PM_{2.5}$ particles, NOx can also react with other compounds to form ozone, which can cause respiratory problems. The proposed regulation would also result in a decrease of toxic air contaminants emitted from diesel engines, which can cause cancer and other adverse health effects. In addition to the health benefits that are quantified, the proposed regulation would reduce additional cardio and respiratory illnesses, nonfatal and fatal cancers, and lost workdays. Expanding CARB's health evaluation to include any of the above additional health outcomes would allow the

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[120] California Air Resources Board, *Fiscal Year 2017-18 Zero- and Near Zero-Emission Freight Facilities Project Solicitation - List of Applications Received and Project Summaries*, 2018 (web link: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low, last accessed April 2022)

public to reach a better understanding of the benefits from reducing air pollution by moving toward zero-emission technologies and Staff are updating methodologies that will allow these additional benefits to be quantified in the future.

While this analysis does not further quantify upstream emissions benefits of criteria pollutant reductions, to the degree reduced fuel demand from this rule results in reduced liquid fuel production at California refineries, further benefits would result from criteria pollutant reductions.[121] As noted above, during the COVID-19 pandemic and the stay-at-home orders, there was a drastic reduction in demand for petroleum fuels as residents stayed home. As a result of that reduced demand, several refineries shutdown or announced the repurposing of those facilities to produce low carbon fuels.[122,123] Just as GHG reductions from these sources might be expected to result from corresponding fuel demand reductions from this regulation, criteria and toxic pollution reduction from these sources could similarly occur, further expanding the benefits of these regulations. To be conservative, and in light of the many factors affecting upstream sector behavior, CARB has opted not to include specific reductions here – and even without them very significant health benefits are expected.

The results presented in Table 8 are estimated at a regional scale, at the air basin level. However, it is important to consider that the proposed regulation may decrease the occupational exposure to air pollution of California truck operators and other employees who work around truck traffic. These individuals are likely at higher risks of developing cardiovascular and respiratory issues as a result of medium- and heavy-duty vehicle PM emissions. Although CARB staff cannot quantify the potential effect on occupational exposure, the proposed regulation is expected to provide large health benefits for these types of workers.

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[121] CARB conducted a similar analysis, incorporated here by reference, in a recent SRIA document for the large fuel demand reductions associated with the proposed Advanced Clean Cars 2 Regulation. *See* California Air Resources Board, *Advanced Clean Cars II SRIA*, 2022 (web link: https://www.dof.ca.gov/forecasting/economics/major_regulations/major_regulations_table/documents/ACCII-SRIA.pdf, last accessed January 2022).
[122] Phillips 66, *Phillips 66 Plans to Transform San Francisco Refinery into World's Largest Renewable Fuels Plant, 2020* (web link: https://investor.phillips66.com/financial-information/news-releases/news-release-details/2020/Phillips-66-Plans-to-Transform-San-Francisco-Refinery-into-Worlds-Largest-Renewable-Fuels-Plant/default.aspx, last accessed January 2022).
[123] BiodieselMagazine.com, *Marathon proceeds with renewables conversion at Martinez refinery,* 2021 (web link: https://biodieselmagazine.com/articles/2517427/marathon-proceeds-with-renewables-conversion-at-martinez-refinery, last accessed January 2022)

Table 8. Regional and Statewide Avoided Mortality and Morbidity Incidents from 2024 to 2050 under the Proposed Regulation

Air Basin	Cardiopulmonary mortality	Hospitalizations for cardiovascular illness	Hospitalizations for respiratory illness	ER visits
Great Basin Valleys	3 (2 - 4)[‡]	0 (0 - 1)	0 (0 - 1)	1 (1 - 2)
Lake County	2 (2 - 3)	0 (0 - 0)	0 (0 - 0)	1 (1 - 1)
Lake Tahoe	1 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	100 (78 - 122)	15 (0 - 29)	18 (4 - 31)	38 (24 - 52)
Mountain Counties	49 (38 - 60)	5 (0 - 9)	6 (1 - 10)	16 (10 - 22)
North Central Coast	24 (19 - 30)	4 (0 - 8)	5 (1 - 9)	14 (9 - 19)
North Coast	9 (7 - 11)	1 (0 - 2)	1 (0 - 2)	3 (2 - 4)
Northeast Plateau	3 (2 - 3)	0 (0 - 1)	0 (0 - 1)	1 (1 - 2)
Sacramento Valley	258 (202 - 317)	33 (0 - 65)	40 (9 - 70)	96 (61 - 132)
Salton Sea	75 (59 - 92)	11 (0 - 22)	14 (3 - 24)	35 (22 - 48)
San Diego County	241 (188 - 295)	36 (0 - 71)	43 (10 - 77)	95 (60 - 130)
San Francisco Bay	447 (349 - 547)	72 (0 - 142)	86 (20 - 152)	240 (152 - 329)
San Joaquin Valley	1,180 (924 – 1,440)	150 (0 - 295)	180 (42 - 317)	418 (265 - 571)
South Central Coast	66 (52 - 81)	11 (0 - 21)	13 (3 - 22)	28 (18 - 39)
South Coast	3,429 (2,682 – 4,189)	592 (0 – 1,161)	707 (166 – 1,248)	1,721 (1,089 – 2,353)
Statewide*	5,888 (4,605 – 7,195)	932 (0 – 1,828)	1,113 (261 – 1,964)	2,707 (1,713 – 3,702)

*Note: Totals may differ due to rounding

[‡] Numbers in parentheses throughout this table represent the 95 percent CI.

2.4.1.3 Monetization of Health Impacts

In accordance with U.S. EPA practice, health outcomes are monetized by multiplying each incident by a standard value derived from economic studies.[124] The value per incident is shown in Table 9. The value for avoided premature mortality is based on willingness to pay, which 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 risks of dying in a year.[125] While the cost-savings associated with premature mortality is important to account for in the analysis, the valuation of avoided premature mortality does not correspond to changes in expenditures, and is not included in the macroeconomic modeling. As avoided hospitalizations and ER visits correspond to reductions in household expenditures on health care, these values are included in the macroeconomic modeling.

Unlike mortality valuation, the cost-savings for avoided hospitalizations and ER visits are 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 production (e.g., valuation of time-losses from inability to maintain the household or provide childcare).[126] These monetized benefits from avoided hospitalizations and ER visits are included in macroeconomic modeling.

Table 9. Valuation per Incident for Avoided Health Outcomes (2021$)

Outcome	Value per incident
Avoided Premature Mortality	$10,453,897
Avoided Cardiovascular Hospitalizations	$61,750
Avoided Acute Respiratory Hospitalizations	$53,862
Avoided ER Visits	$884

[124] U.S. EPA, *Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses (240-R-10-001)*, 2010 (web link: https://www.epa.gov/sites/default/files/2017-09/documents/ee-0568-22.pdf, last accessed January 2022).

[125] U.S. EPA, *An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (EPA-SAB-EEAC-00-013)*, 2000 (web link: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100JOK2.PDF?Dockey=P100JOK2.PDF, last accessed January 2022).

[126] Chestnut, L. G., Thayer, M. A., Lazo, J. K. and Van Den Eeden, S. K., *The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations*, Contemporary Economic Policy, 24: 127– 143, 2006 (web link: https://onlinelibrary.wiley.com/doi/abs/10.1093/cep/byj007, last accessed January 2022).

Statewide valuation of health benefits was calculated by multiplying the value per incident by the statewide total number of incidents for 2024-2050 as shown in Table 9. The total statewide health benefits derived from criteria emissions reductions is estimated to be $61.5 billion, with $61.4 billion resulting from reduced premature cardiopulmonary mortality and $0.1 billion resulting from reduced hospitalizations and ER visits. The spatial distribution of these benefits across the state follows the distribution of the health impacts by air basin as described in Table 10.

Table 10. Statewide Valuation from Avoided Health Outcomes (million 2021$)

Year	Avoided cardiopulmonary mortality valuation	Avoided hospitalizations for cardiovascular illness valuation	Avoided hospitalizations for respiratory illness valuation	Avoided ER visits valuation	Annual total valuation*
2024	1	0	0	1	$10.77
2025	3	0	0	2	$32.39
2026	9	1	1	5	$98.23
2027	18	3	3	9	$193.61
2028	26	4	4	13	$275.73
2029	41	6	7	20	$432.01
2030	57	8	10	28	$601.02
2031	76	11	13	36	$794.14
2032	94	14	17	45	$989.50
2033	112	17	20	53	$1,169.06
2034	137	21	25	65	$1,431.12
2035	163	25	30	77	$1,709.71
2036	188	29	35	88	$1,968.64
2037	215	33	40	100	$2,248.33
2038	243	38	45	113	$2,545.07
2039	271	43	51	126	$2,837.83
2040	295	47	56	136	$3,088.09
2041	322	51	61	148	$3,372.84
2042	351	56	67	161	$3,679.86
2043	360	57	68	165	$3,773.05
2044	370	59	70	169	$3,875.60
2045	384	62	73	175	$4,025.37
2046	399	64	77	181	$4,180.37
2047	414	67	80	188	$4,337.03
2048	430	70	83	195	$4,501.78
2049	446	73	87	202	$4,667.35
2050	461	75	90	208	$4,830.20
Total Benefit*	**$61,360.4**	**$57.6**	**$59.8**	**$2.4**	**$61,668.71**

*Note: Totals may differ due to rounding

2.4.2 Other Benefits

In addition to emissions reductions, ZEVs offer a number of other benefits to truck operators when compared to gasoline and diesel vehicles. ZEVs are quieter and have a smoother ride than ICE vehicles, and they reduce noise at the worksite as well as in the community where the vehicles operate.

3 Direct Costs

The proposed regulation would require fleets to replace their gasoline, diesel, natural gas, and other ICE vehicles with medium- and heavy-duty ZEVs. Staff assumes the costs to California includes the upfront capital costs for the ZEVs and their associated infrastructure, changes to operating expenses, and other cost elements associated with this technology transition. This approach shows the full estimated cost to California for deploying the number of ZEVs as required by the regulation.

3.1 Direct Cost Inputs

The estimated direct costs from the proposed regulation and the Legal Baseline scenario include upfront capital costs of the vehicles, infrastructure, and ongoing operating costs which include fueling, maintenance, and LCFS revenues where applicable. Compared to gasoline, diesel, or natural gas vehicles, ZEVs generally have higher upfront capital costs today but lower operating costs, which results in an overall savings in staff's analysis over the useful life of the vehicles.

Currently, there are a number of rebate and voucher programs in California that offset some or all of the incremental costs for ZEVs and supporting infrastructure; however, none of these incentives are included in the cost analysis due to uncertainty as to which fleets may utilize funding and uncertainty in ongoing funding. Separate from CARB's incentive programs, the LCFS regulation is a market-based regulatory program that allows some fleets that dispense low carbon fuels to generate credits and sell them on the open market to generate revenue. Because of the regulatory certainty associated with LCFS regulation, staff models credit revenue from the LCFS regulation for those who own and operate charging or hydrogen fueling stations. For retail stations, staff assumes a small portion of the LCFS credit value that reflects the difference in light-duty and heavy-duty credit value is passed through to the fleet. The assumptions underlying the direct costs are detailed in the following sections.

3.1.1 Vehicle Population

In this analysis, all estimates for annual California population and sales come from CARB's EMFAC 2021 inventory model.[127] The EMFAC model is developed and used by CARB to assess emissions from on-road vehicles including cars, trucks, and buses in California, and to support CARB's regulatory and air quality planning efforts to meet the Federal Highway Administration's transportation planning requirements. U.S. EPA approves EMFAC for use in SIP and transportation conformity analyses. It includes vehicle population growth, mileage accrual rates over time, vehicle fuel usage and associated emissions factors, and vehicle attrition over time.

Staff analyzed the impacts of COVID-19 on the trucking industry during development of EMFAC 2021 and as part of this analysis. Diesel fuel sales are a data surrogate to estimate

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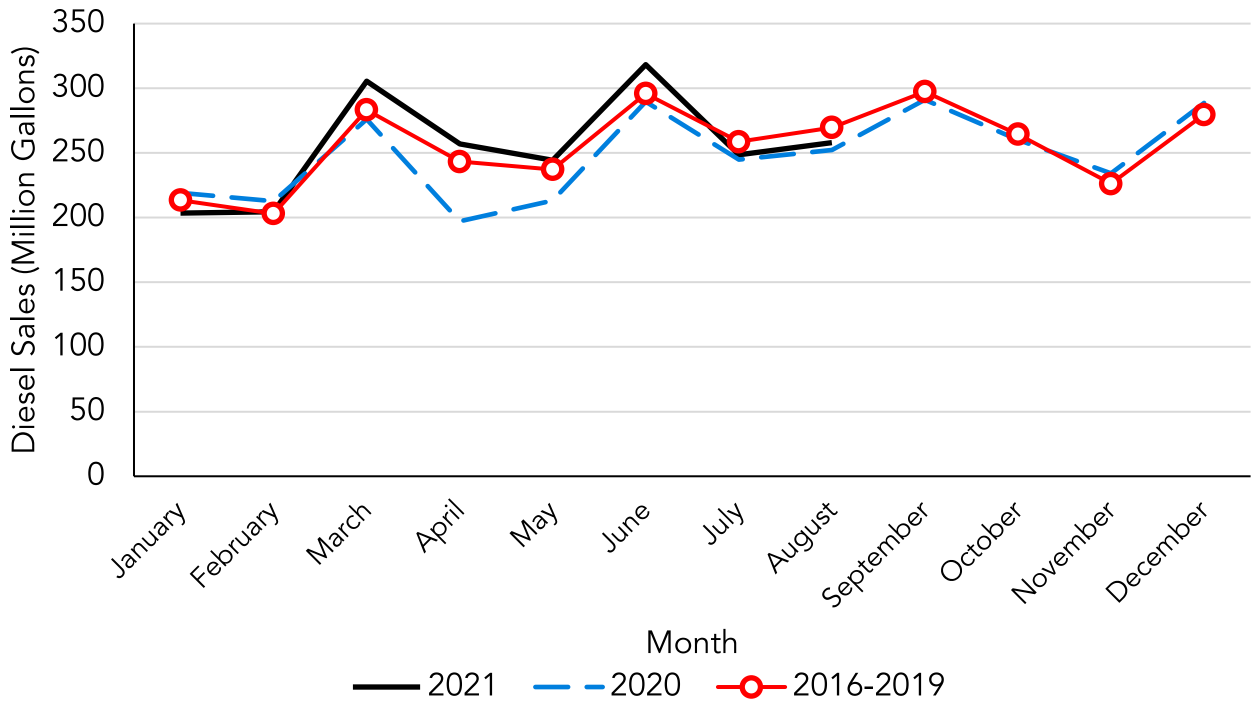
[127] California Air Resources Board, *EMFAC 2021 Web Database*, 2021 (web link: https://arb.ca.gov/emfac/emissions-inventory/, last accessed January 2022).

diesel VMT and illustrate the general trends present in the trucking market. Data from the California Department of Tax and Fee Administration is displayed in Figure 5.[128] It shows that diesel fuel sales dropped dramatically in April 2020 and remained depressed through the second quarter of 2020. Afterwards, diesel fuel sales rebounded and returned to normal trends by the end of the year. These trends indicate that diesel fuel sales and the trucking industry were not as impacted by the COVID-19 pandemic as other parts of the economy and the general trends forecasted within EMFAC 2021 remains appropriate for the purpose of this analysis.

Figure 5. Diesel Sales Data for 2021 and 2020 Versus 2016 Through 2019



The proposed regulation affects a subset of the total California Class 2b-8 vehicle population. Staff used data sources including CARB's EMFAC 2021 model, DMV registration data, the Drayage Truck Registry, and financial information from Dun and Bradstreet to determine which vehicles would be subject to the proposed regulation.

Public fleet population estimates are derived from DMV information. Vehicles registered in DMV with an exempt plate were assumed to be owned by public fleets. Staff estimates that roughly 128,000 trucks and buses would be subject to the proposed public fleet requirements by 2024.

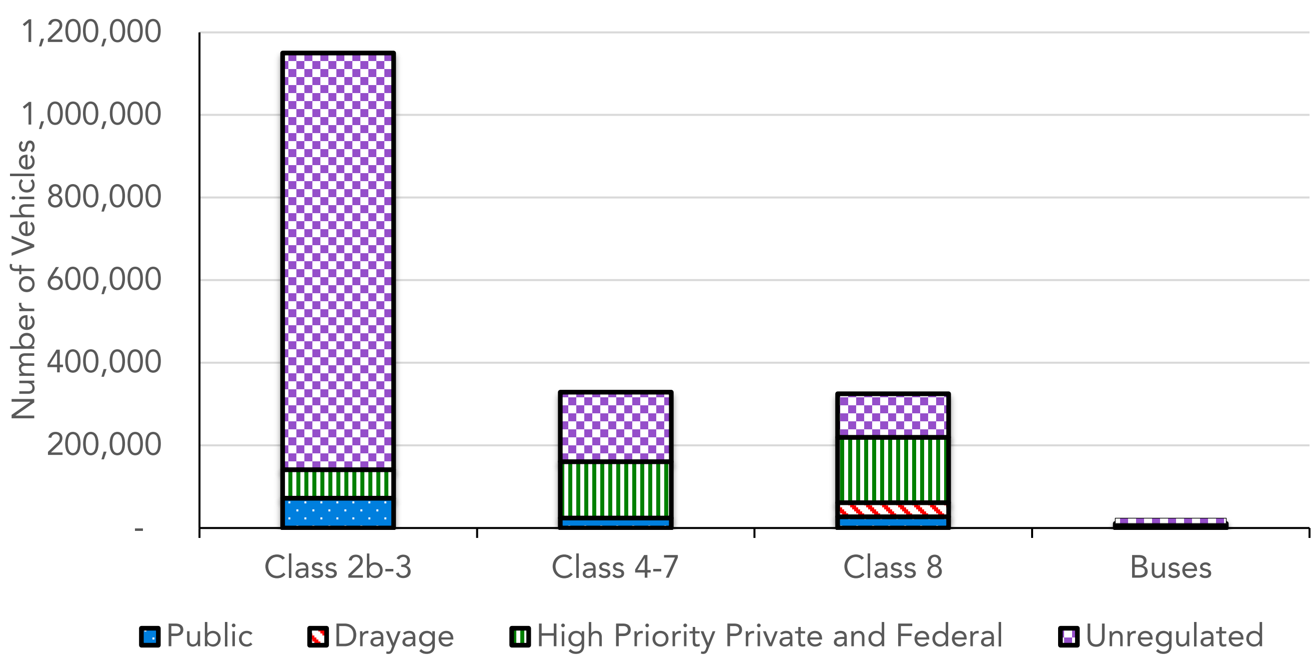
To estimate the number of vehicles subject to the drayage truck requirements, staff used the data from the CARB Drayage Truck Registry and the seaports and railyards to estimate the

[128] California Department of Tax and Fee Administration, *Taxable Diesel Gallons 10 Year Report*, 2021 (web link: https://www.cdtfa.ca.gov/taxes-and-fees/Diesel-10-Year-Report.xlsx, last accessed December 2021).

number of drayage trucks actively operating in California. Staff assumed a truck to be a part of the active fleet if they visited an average of 2 times per week. Staff estimates that approximately 34,000 trucks would be subject to the proposed drayage truck requirements by 2024.

To identify vehicles subject to the high priority and federal fleet requirement, staff first used DMV and International Registration Plan data to identify fleets with 50 or more vehicles. Staff then used Dun and Bradstreet data to determine California locations owned by businesses with greater than $50 million in annual revenue and, then used this data to match up locations owned by these businesses with vehicles registered at these locations in DMV. The data received from the ACT Large Entity Reporting requirement aligns with the results derived from this methodology. Staff estimated the number of vehicles under common ownership and control based on data collected in the ACT One-Time Large Entity Reporting survey to be an additional 20 percent of the high priority fleet. This data was applied to EMFAC population numbers to create projections for this analysis. Figure 6 summarizes the projected proportion of vehicles subject to the proposed regulation in four groups versus the total vehicle population in each group. Generally, vehicles in the Class 2b-3 group include pickup truck and vans that are owned by individuals and small businesses who would not be subject to the proposed regulation. Although the Class 2b-3 category has the highest number of vehicles, the proposed regulation would include the majority of heavier vehicles operating in California. These heavier Class 4-8 vehicles make up only 36 percent of the total medium- and heavy-duty fleet but produce 74 percent of NOx emissions and 75 percent of GHG emissions. Buses shown in the figure exclude transit buses.

Figure 6. Regulated Vehicles Versus Total Population in 2024



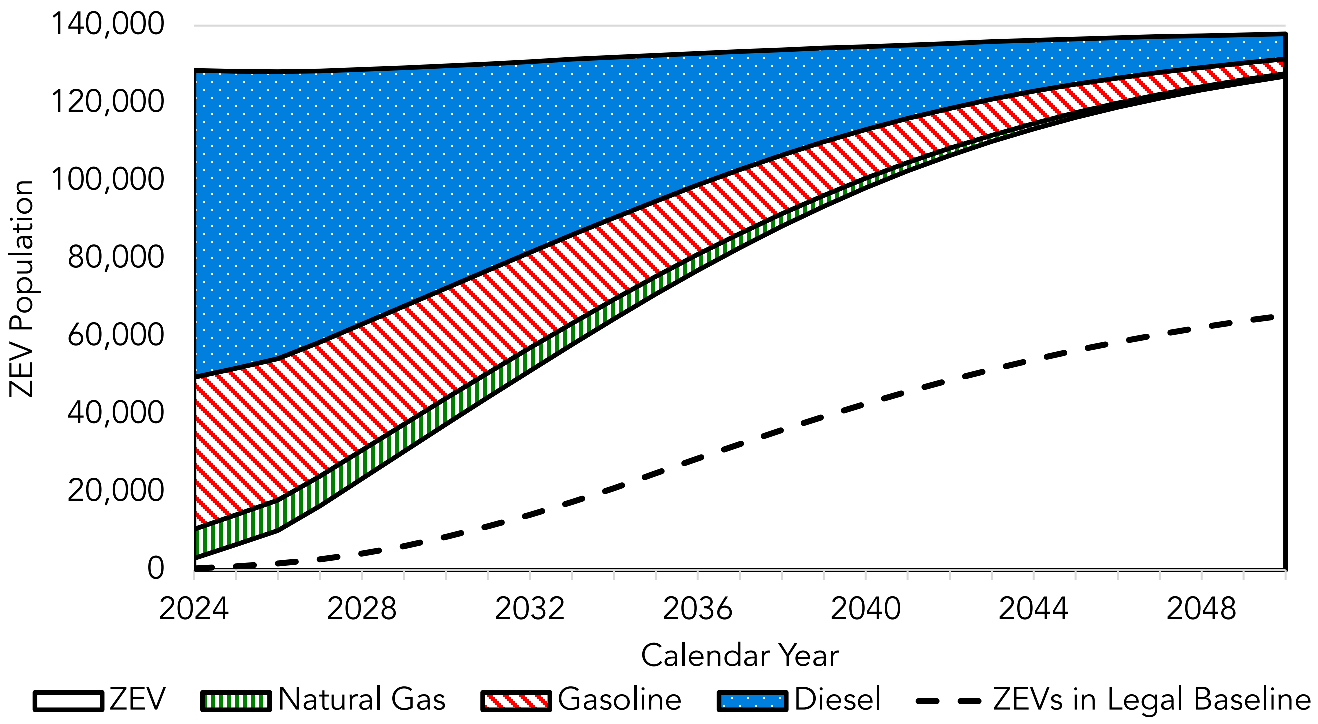
To calculate the public fleet technology mixture over time, the percentage schedules shown below in Table 11 are applied to the projected public fleet sales numbers to calculate the number of medium- and heavy-duty ZEVs purchased per year. Staff estimates that 3 percent of public fleets operate in the designated low population counties and 97 percent operate elsewhere.

Table 11. Public Fleets ZEV Purchase Schedule

Model Year	Designated Counties	All Other Counties
2024-2026	0	50%
2027+	100%	100%

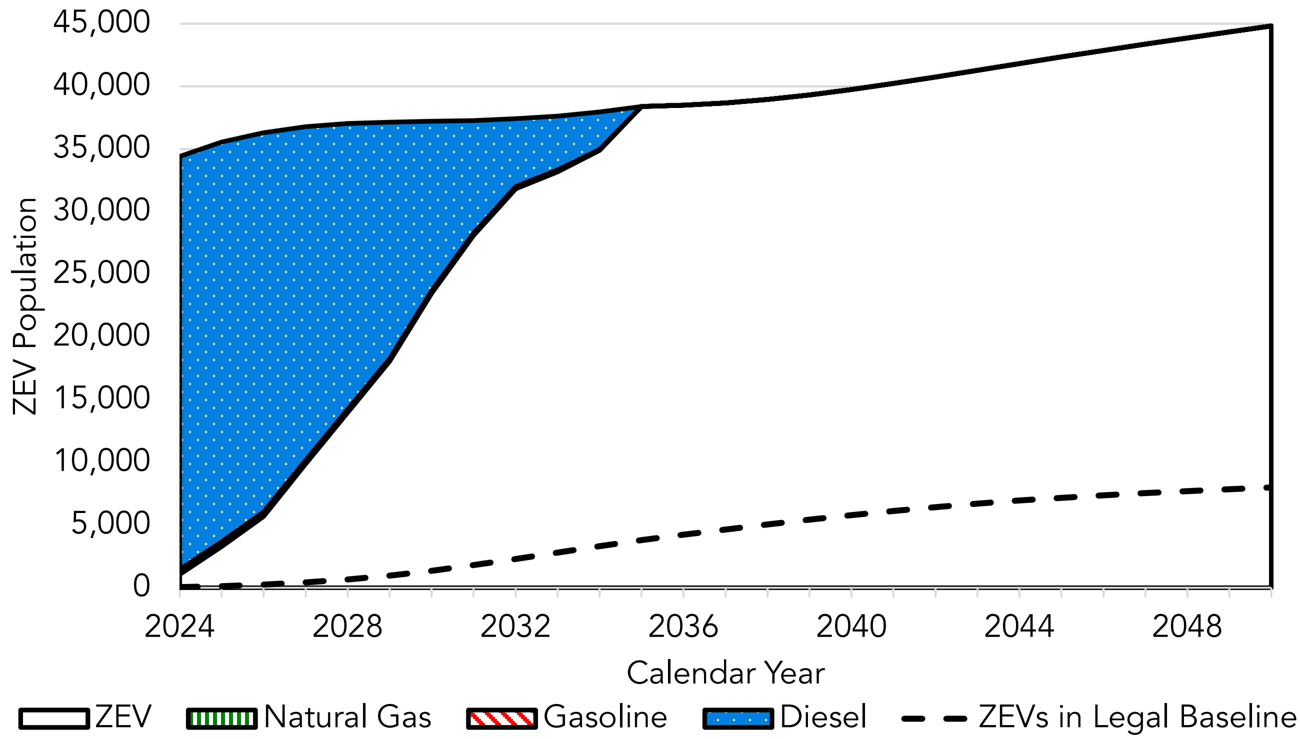
Figure 7 illustrates the projected public fleet population over time by technology type using these inputs versus the medium- and heavy-duty ZEV population in the Legal Baseline scenario.

Figure 7. Projected Public Fleet Population with the Proposed Regulation



To calculate the drayage truck technology mixture over time, staff assumed all additions to the drayage truck population beginning in 2024 would be ZEVs. Combustion-powered vehicles would leave the drayage truck inventory when they reach 800,000 miles which would typically be when the vehicle is 15-years-old based on mileage data. Figure 8 illustrates the projected drayage fleet population over time by technology type using these inputs versus the medium- and heavy-duty ZEV population in the Legal Baseline scenario. The natural gas population is under 300 vehicles in 2023 and is difficult to see on the figure. This figure includes drayage trucks operating at seaports as well as railyards.

Figure 8. Projected Drayage Truck Population with the Proposed Regulation



For the high priority and federal fleet requirements, vehicles would be subject to different phase-in schedules based on the vehicle body type. Table 12 outlines the medium- and heavy-duty ZEV percentage requirements for the three groups. Work trucks are single-unit trucks except for specialty vehicles and vehicles already included in Group 1. A specialty vehicle is a fairly uncommon Class 8 vocational vehicle that either: has a heavy front axle, has a unique custom-built chassis, or is designed to perform work while stationary with an auxiliary device which is integral to the vehicle's design (e.g. a boom truck or digger derrick). For the emissions and costs analysis, fleet ZEV percentages are interpolated in years between regulatory requirements. All high priority fleets are assumed to meet the phase-in schedule as the portion of fleets utilizing either the alternative compliance pathway or exemptions is expected to be negligible. Figure 9 illustrates the estimated 2023 population of vehicles in each vehicle category and vehicle group.

Table 12. High Priority and Federal Fleet Percentage Schedule

Group	**Vehicle Type**	**10%**	**25%**	**50%**	**75%**	**100%**
1	Box trucks, vans, two-axle buses, yard trucks	2025	2028	2031	2033	2035

Group	**Vehicle Type**	**10%**	**25%**	**50%**	**75%**	**100%**
2	Work trucks, day cab tractors, three-axle buses	2027	2030	2033	2036	2039
3	Sleeper cab tractors and specialty vehicles	2030	2033	2036	2039	2042

Figure 9. Estimated Number of Vehicles per Vehicle Category and High Priority and Federal Fleet Grouping in 2024

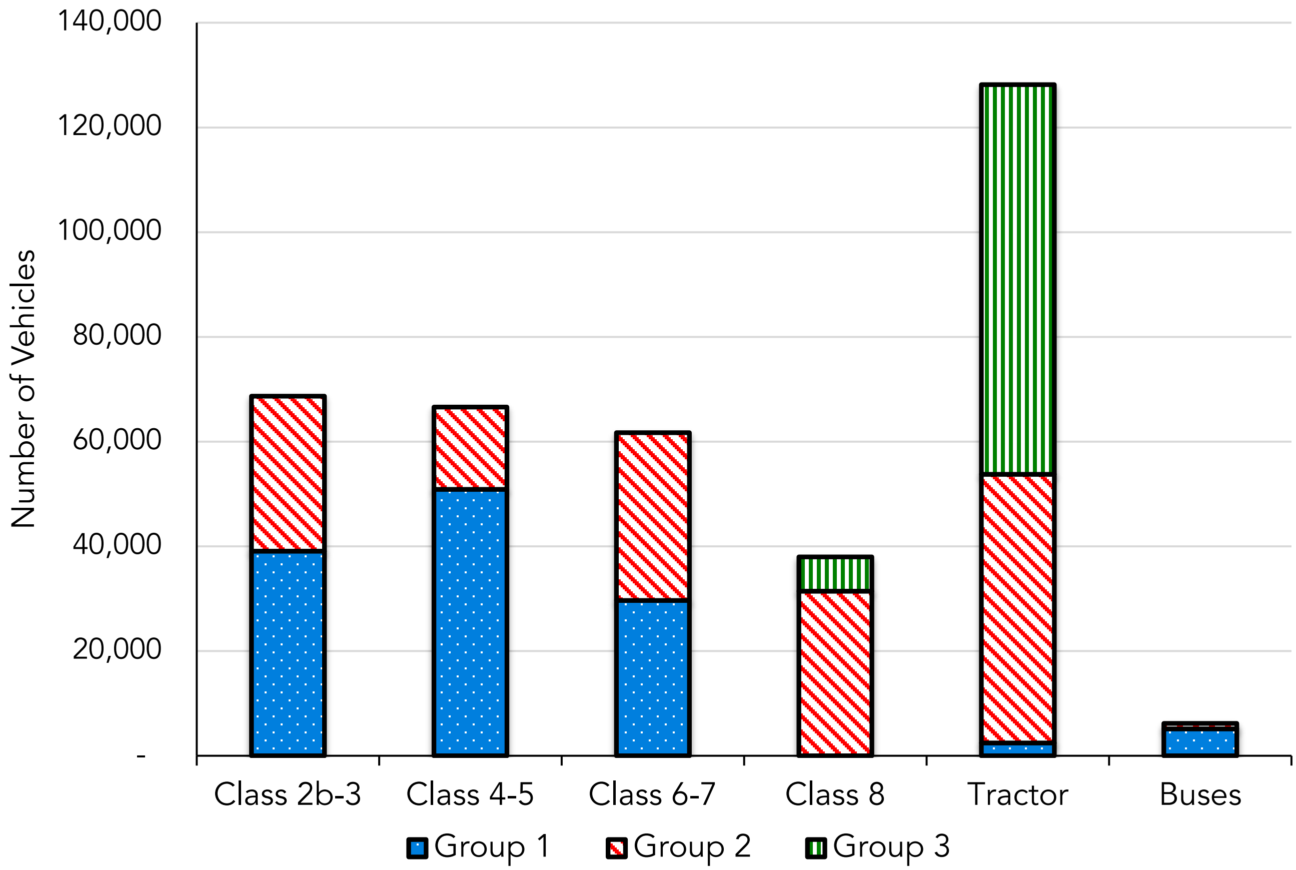
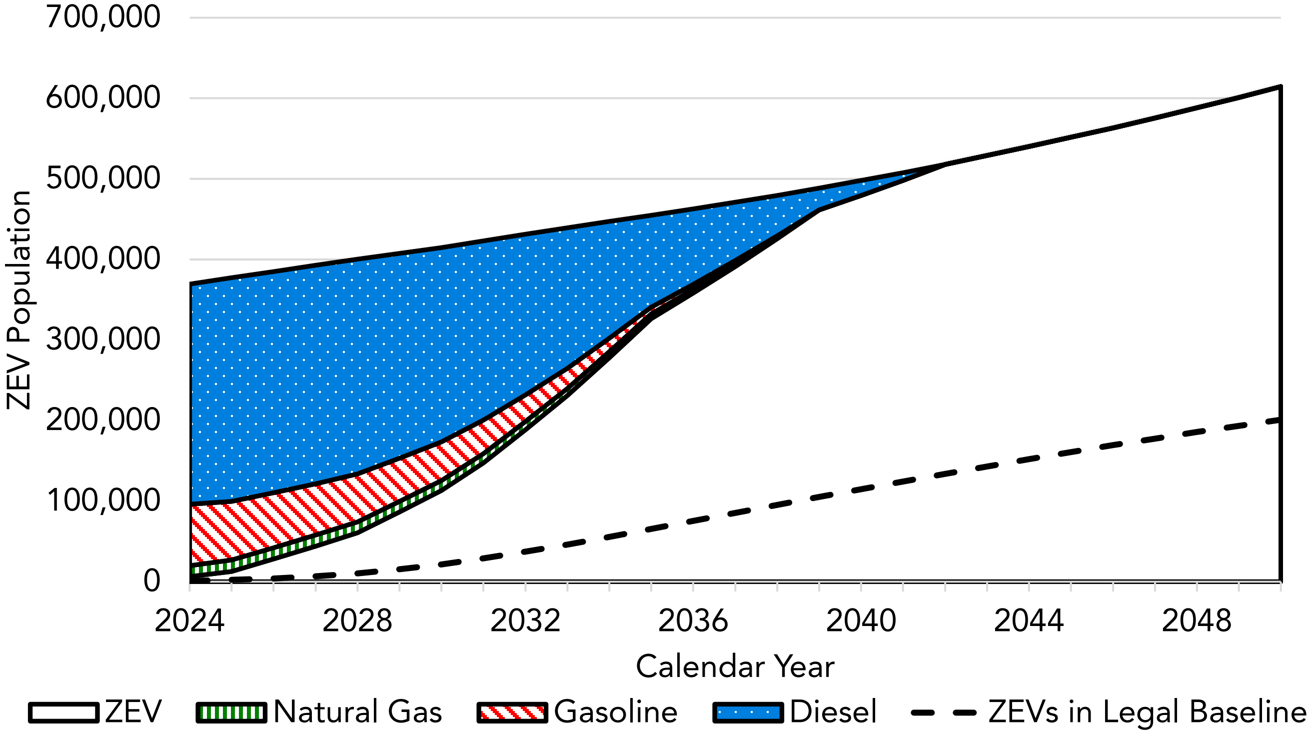


Figure 10 illustrates the projected high priority and federal fleet population over time by technology type using these inputs.

Figure 10. High Priority and Federal Fleet Population with the Proposed Regulation



All 2040 model year and newer vehicles are assumed to be ZEVs. Nearly all new vehicles operating within California are originally sold in California; however, staff modelled that more used vehicles originally sold outside California will begin entering the state and will be purchased by regulated fleets. Table 13 shows what portion of vehicles are assumed to be originally sold in California based on their age.[129] This data was gathered using first sold data from California DMV. Instate buses and Class 2b-3 vehicles are assumed to all be sold in California, while out-of-state tractors are assumed to have all been sold outside of California. Most other vehicles newly registered in California are assumed to be purchased in California, but this fraction drops over time showing that more used trucks are being newly registered in California. For example, in 2040, 89.0 percent of 2040 model year Class 8 tractors registered within California are assumed to have been sold in California. By 2045, this fraction drops to 45.87 percent of Class 8 tractors.

Table 13. Percentage of California Registered Vehicles Originally Sold in California

Age	Class 4-6 Vocational	Class 7 Vocational	Class 8 Vocational	Class 7 Tractor	Class 8 Tractor
-1 or 0	90.97%	85.01%	89.78%	84.31%	89.00%

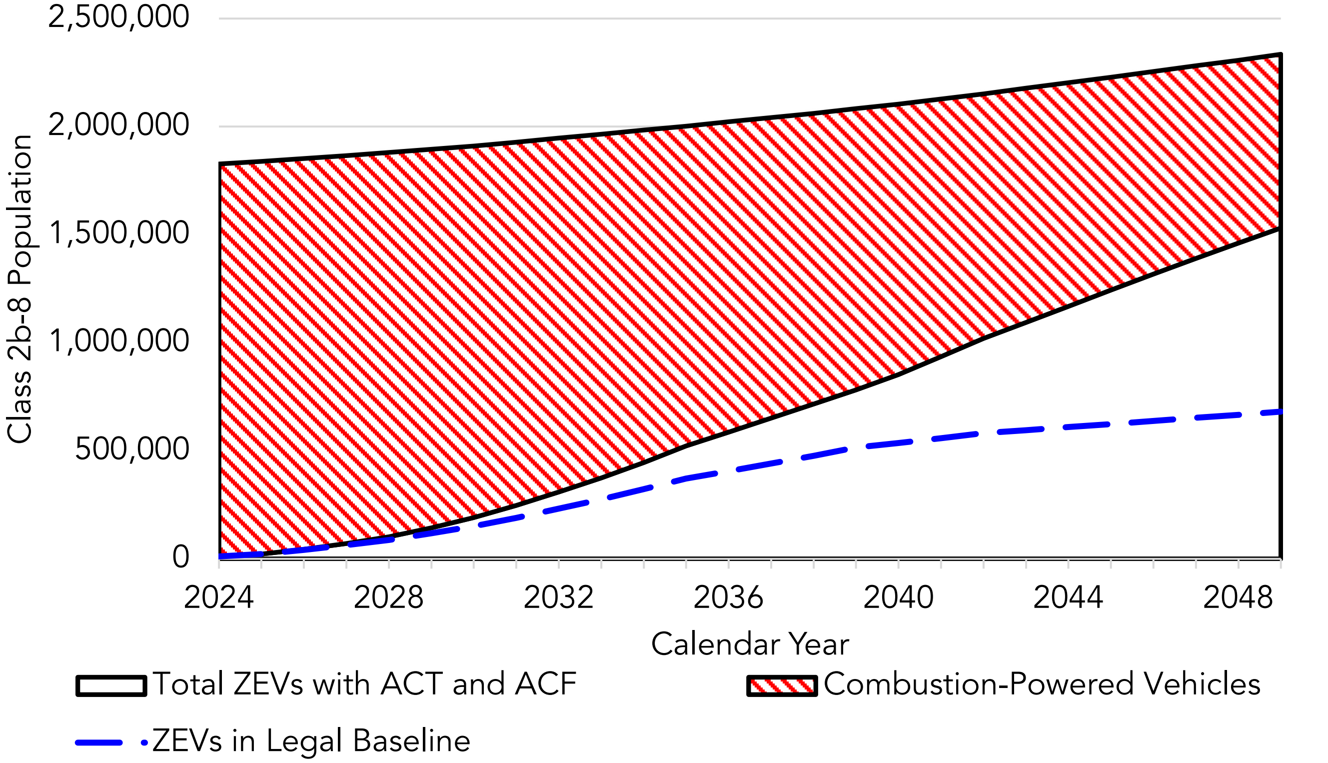
[129] California Air Resources Board, *Appendix F: Emissions Inventory Methods and Results for the Proposed Advanced Clean Trucks Regulation*, 2019 (web link: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/appf.pdf, last accessed January 2022).

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

Staff are not anticipating a prebuy situation beyond what is already expected with the Truck and Bus regulation. Most fleets that would be subject to the proposed regulation are already subject to the Truck and Bus regulation. The Truck and Bus regulation requires significant turnover to 2010 or newer diesel engines prior to 2023 and accelerates vehicle purchases beyond what would be expected without that regulation. The accelerated purchases due to the Truck and Bus regulation is expected to reduce medium- and heavy-duty diesel vehicle purchases in the following years as trucks in the fleet will be newer than is typical for some fleets. This shift in fleet behavior is included in the baseline EMFAC modelling assumptions. In addition, staff are also aware of the current worldwide supply chain delays that would also dampen any short-term prebuy effects due to limited production capability from manufacturers in the immediate future.

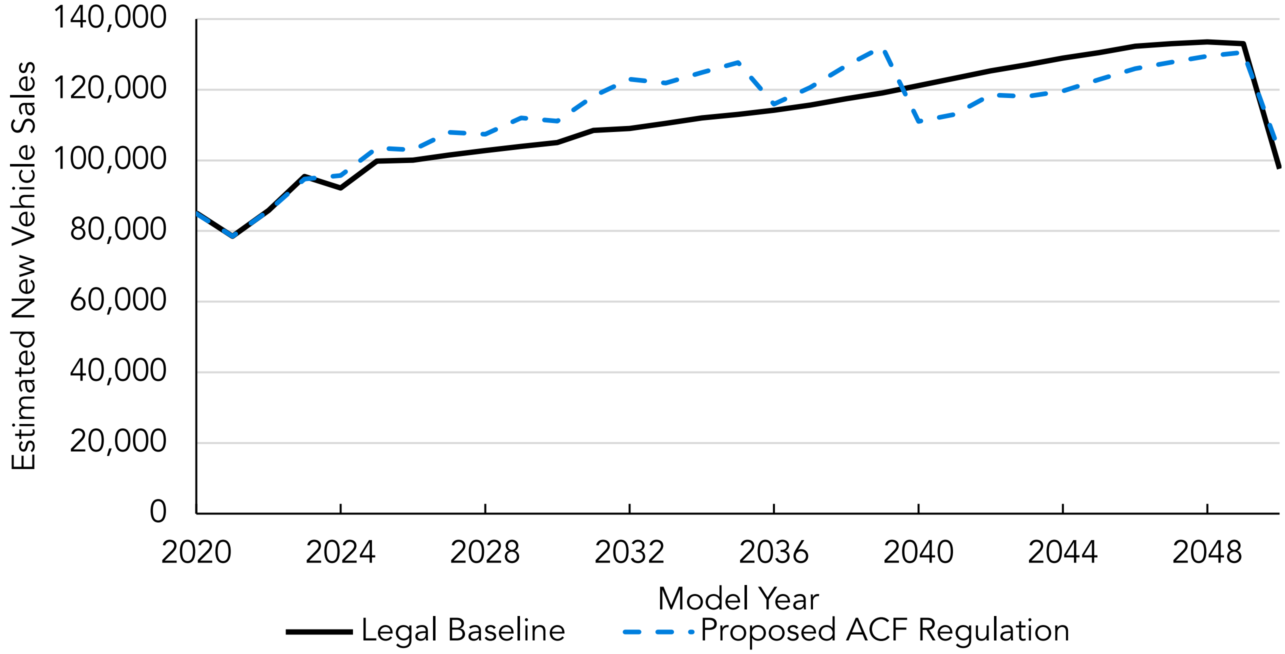
The proposed regulation is designed to complement the ACT regulation's requirement that manufacturers produce and sell increasing numbers of ZEVs in California. Figure 11 illustrates the net result of the 2 policies as well as the number of medium- and heavy-duty ZEVs each regulation would have achieved by itself. Generally, the proposed regulation by itself would be expected to result in more ZEVs deployed than the adopted ACT regulation. Because ZEV sales are not all expected to be purchased by the fleets regulated under the proposed regulation, the combination of the 2 would be expected to result in greater ZEV sales than each regulation achieves on its own. As a result, the proposed regulation would be expected to increase the number of medium- and heavy-duty ZEVs beyond existing regulations from about 320,000 to about 520,000 by 2035, from about 775,000 to about 1,250,000 ZEVs by 2045, and from about 950,000 to about 1,600,000 ZEVs by 2050.

Figure 11. Statewide Population Forecast with the Proposed Regulation



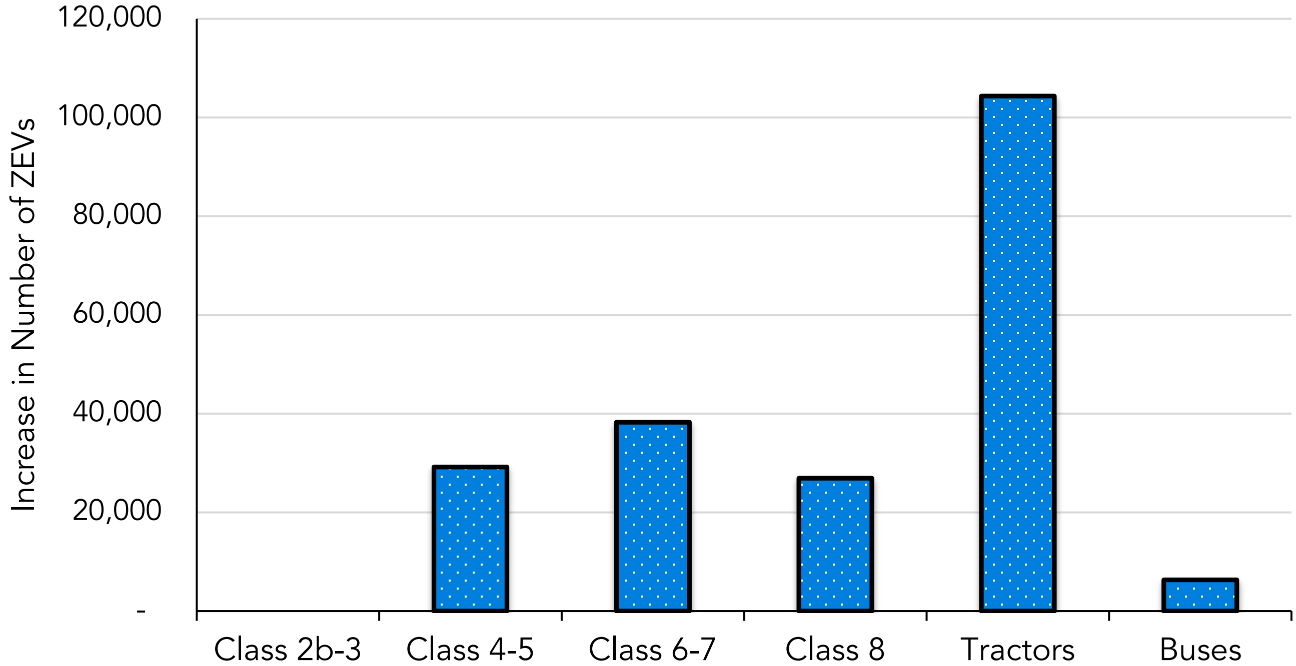
The proposed regulation will result in changes to vehicle purchasing behavior. Because ZEVs are a newly commercial technology, fleets will not be able to purchase used ZEVs for a significant period of time. The regulation will also require some fleets to purchase vehicles quicker than their baseline replacement rate to keep up with regulatory milestones. As a result, the proposed regulation is expected to increase new vehicle purchases by fleets. Figure 12 illustrates the projected sales per model year in the baseline and under the proposed regulation. The number of new vehicle sales increases from 2024 to 2039 due to implementation of the high priority and drayage requirements. New vehicle sales are projected decline after 2040 when the phase-in for Group 2 vehicles end before rebounding to their baseline value near 2050.

Figure 12. Estimated New Vehicle Sales per Model Year



The increase in ZEVs deployed varies depending on the type of vehicles. The ACT regulation is projected to result in the largest portion of ZEVs deployed in the Class 2b-3 vehicle group and relatively fewer tractors based on that regulation's requirements and estimated sales numbers. The proposed regulation generally places higher requirements on heavier vehicle classes, especially tractors, as noted previously in Figure 9. Figure 13 illustrates the expected increase in number of ZEVs by vehicle grouping in 2035.

Figure 13. Estimated Increase in ZEVs by Vehicle Category in 2035



Staff simplified the inventory analysis to use for cost modelling to better match inventory categories with cost information. The vehicle categories in EMFAC were grouped into the following vehicle categories:

- Class 2b-3 trucks (GVWR between 8,501 and 14,000 lbs.) representing heavy-duty pickup trucks, cargo vans, and passenger vans;
- Class 4-5 trucks (GVWR between 14,001 and 19,500 lbs.) representing lighter delivery vans and service trucks;
- Class 6-7 single-unit trucks (GVWR between 19,501 and 33,000 lbs.) representing heavier delivery vans, bucket trucks, and others;
- Class 8 single-unit trucks (GVWR above 33,001 lbs.) representing a wide variety of heavy-duty vehicles including dump trucks, construction equipment, and others;
- Solid waste collection vehicles (SWCV) refer to refuse trucks used for urban waste pickup and collection;
- Tractor-trailers representing day cab tractors typically used for drayage and short to regional haul operation as well as sleeper cab tractors used for long-haul trucking; and
- Buses representing primarily cutaway shuttles and motorcoaches.

For each component of the proposed regulation, staff assigned a representative vehicle for each vehicle category to calculate costs. Table 14, Table 15, and Table 16 display the different regulatory components and vehicle categories and what representative vehicle was used for that grouping.

Table 14. Public Fleet Vehicle Assumptions

Vehicle Category	Representative Vehicle
Class 2b-3	Class 3 Service Truck
Class 4-5	Class 5 Service Truck
Class 6-7	Class 6 Bucket Truck
Class 8	Class 8 Dump Truck
SWCV	Class 8 Refuse Packer
Buses	Class 5 Cutaway Shuttle

Table 15. Drayage Fleet Vehicle Assumptions

Vehicle Category	Representative Vehicle
Tractors	Class 8 Day Cab Tractor

Table 16. High Priority Fleet Vehicle Assumptions

Vehicle Category	Representative Vehicle
Group 1 - Class 2b-3	Class 2b Cargo Van
Group 1 - Class 4-5	Class 5 Walk-in Van
Group 1 - Class 6-7	Class 6 Box Truck
Group 1 - Buses	Class 5 Cutaway Shuttle
Group 1 – Yard Tractor	Class 8 Yard Tractor
Group 2 – Class 2b-3	Class 2b Pickup
Group 2 – Class 4-5	Class 5 Service Truck
Group 2 – Class 6-7	Class 6 Bucket Truck
Group 2 – Class 8	Class 8 Dump Truck
Group 2 – SWCV	Class 8 Refuse Packer
Group 2 – Buses	Class 8 Motorcoach
Group 2 – Tractors	Class 8 Day Cab Tractor
Group 3 – Tractors	Class 8 Sleeper Cab Tractor
Group 3 – Specialty	Class 8 Bucket Truck

Throughout the body of the document, staff will refer to the cost elements of sample vehicles from the list above rather than all vehicles for brevity. A list of all vehicle-specific cost elements used in this analysis is provided in Section 8 Vehicle Cost Attributes Appendix.

3.1.2 Technology Mix Projections

Fleets purchase trucks powered by a variety of fuels – most commonly gasoline or diesel, and relatively low volumes of compressed natural gas, liquid natural gas, propane, E85, and other fuels. In staff's assumed Legal Baseline conditions, for simplification, Class 2b-3 vehicles and buses are split between gasoline- and diesel-powered based on existing assumptions within the EMFAC database. Class 4-8 vehicles are generally treated as diesel-powered with the exception of refuse trucks and tractors where a small portion are modelled to be natural gas powered. Based on EMFAC data, roughly 10 percent of Class 4-8 vehicles use a fuel other than diesel, mainly gasoline.

Under the proposed regulation, fleets are anticipated to meet their medium- and heavy-duty ZEV requirements using a combination of BEVs and FCEVs. Additionally, the public fleet and high priority and federal fleet requirements can partly be met with NZEV technologies like PHEVs prior to 2035. It is somewhat challenging to predict which ZE technologies fleets would use for complying with the proposed regulation, especially as battery and fuel cell technologies have different characteristics and change as such technologies continue to advance, and costs continue to decline. Generally, FCEVs commonly have shorter refueling times and are expected to have less sensitivity to weight concerns in long range applications when compared to a battery-electric counterpart. BEVs can offer greater fuel cost-savings, especially for overnight charging, as electricity is generally a lower cost fuel compared to gasoline, diesel, natural gas, and hydrogen in a return to base duty cycle with sufficient dwell time to recharge the vehicles.

Based on expected manufacturer product availability and vehicle suitability analyses, staff assumes that fleets would comply with the proposed regulation with a combination of battery-electric and fuel cell technologies. Currently, a wide variety of battery-electric trucks in all weight classes and configurations are commercially available. There are several commercially available battery-electric tractors now and limited small-scale deployments of fuel cell electric tractors by several small and major truck manufacturers. Based on manufacturer announcements, the majority of tractors commercially launched within the immediate future will be battery-electric. Manufacturers are simultaneously making investments into fuel cell electric technologies leading to commercialization in the latter half of the decade. As a result, staff is assuming 10 percent of day cab tractors will be FCEV until 2027 and 25 percent afterwards.

For sleeper cab tractors, staff is assuming an even 50:50 split between BEVs and FCEVs as they are phased in to meet 2030 compliance requirements. Both technologies face similar issues where a network of publicly accessible infrastructure is necessary to enable long-distance transportation throughout California and outside the state. For all other vehicles, staff is assuming all purchases would be battery-electric until 2026, purchases starting in 2027 onward would be 90 percent BEV and 10 percent FCEV. Currently, there are a number of medium- and heavy-duty FCEVs being demonstrated but it remains somewhat uncertain on when manufacturers will commercially release FCEVs and in which market segments they would be preferred over other technologies. Staff foresees a portion would be fuel cell powered, but up to this point BEV technologies appear preferred for these segments which do not have high range or payload needs.

Although NZEVs are expected to have a lower upfront cost per vehicle than full ZEVs, they still require charging infrastructure and would not have as significant operational cost-savings as BEVs or FCEVs. They are not modeled in the analysis as they are expected to play a transitional role in limited use cases as existing BEVs already meet most fleet needs.

Table 17 outlines the technology assumptions for each vehicle group in the cost analysis. The Legal Baseline scenario and ACF Proposal scenario use the same technology distribution, but the number of ZEVs and combustion-powered vehicles will differ between the two scenarios.

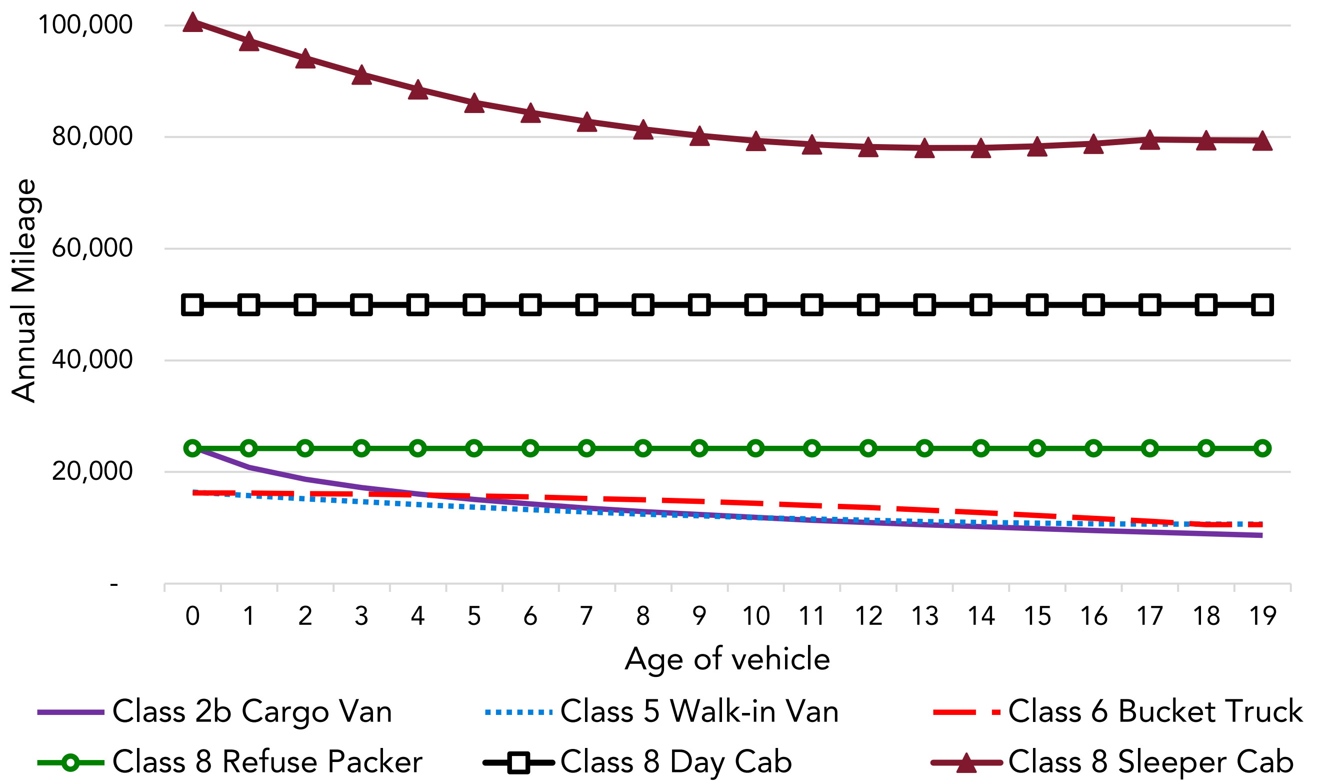
Table 17. Vehicle Groups and Technologies in the Cost Analysis

Vehicle Group	Technology Types
Class 2b-3	Diesel, Gasoline, BEV, FCEV
Class 4-5	Diesel, BEV, FCEV
Class 6-7	Diesel, BEV, FCEV
Class 8	Diesel, BEV, FCEV
SWCV	Diesel, Natural Gas, BEV, FCEV
Class 7-8 Tractor	Diesel, Natural Gas, BEV, FCEV
Buses	Diesel, Gasoline, BEV, FCEV

3.1.3 Annual Mileage

Annual mileage factors into a number of costs in this analysis including battery size, fuel costs, maintenance, and LCFS revenue. All annual mileage assumptions are based on EMFAC inventory estimates as representative of a typical vehicle within the category. For most vehicle categories, annual mileage is highest for newer vehicles and drops over time as the vehicle ages. EMFAC data was matched to the different representative vehicles. Figure 14 illustrates the accrual rates for a set of sample vehicles. Mileage accrual assumptions for all representative vehicles are listed in the Vehicle Attribute Appendix.

Figure 14. Sample Annual Mileage Accrual Rates by Vehicle and Age



Staff has modeled an additional power take off operation by the Class 8 specialty vehicles by assuming an effective 50 percent increase in annual mileage as a surrogate for fuel use during stationary operation. A corresponding increase in battery size is modeled and is discuss later.

Staff assumes ZEVs will travel the same distance as their combustion-powered counterparts. As shown in Figure 14, the majority of single-unit trucks such as walk-in vans and refuse trucks travel under 25,000 miles per year which represents 100 miles per day. Most medium- and heavy-duty ZEVs available today can achieve this threshold and future product launches advertise higher range options. For tractors, the majority of in-state tractors travel below 200 miles per day. Manufacturers including Freightliner, Volvo, Tesla, and others have announced ZE tractor launches in 2022-2023 which would be capable of meeting these needs. As technology improves and publicly available infrastructure is built, staff anticipates fleets would be able to manage their fleets and introduce ZEVs where they are suitable to meet their daily needs. This transition to ZEV technology would occur over the course of the next one to two decades which would provide sufficient time for all vehicle types to transition to ZEV technology and perform the same duty cycle.

3.1.4 Upfront Costs

Fleets are the regulated party in the proposed regulation and would need to make upfront investments in vehicles, infrastructure, and other costs in order to comply with the proposed regulation's requirements.

3.1.4.1 New and Used Vehicle Prices

This section covers the cost to the fleet of purchasing a vehicle. Today and for the foreseeable future, purchases of most BEVs and FCEVs will cost more than their combustion-powered counterparts. Declining battery and component costs in addition to economies of scale are expected to lower the incremental costs of ZEVs as the market expands.

Base gasoline and diesel new vehicle prices are based on averages of new 2020 model year prices from manufacturers' websites and online truck marketplaces collected in early 2021. [130] New natural gas vehicle prices are derived from sources which estimate the incremental cost of upfitting a gasoline or diesel-powered vehicle to run on natural gas. Table 18 displays sample new vehicle retail prices for a variety of applications and technology types.

Table 18. Sample New Combustion-Powered Vehicle Prices

Vehicle Group	Vehicle Price
Class 2b Cargo Van – Gasoline	$35,000
Class 2b Cargo Van – Diesel	$39,000
Class 5 Walk-in Van – Diesel	$87,000
Class 6 Bucket Truck – Diesel	$126,000
Class 8 Refuse Packer – Diesel	$226,000
Class 8 Refuse Packer – Natural Gas	$256,295
Class 8 Day Cab – Diesel	$130,000
Class 8 Day Cab – Natural Gas	$180,000
Class 8 Sleeper Cab – Diesel	$140,000
Class 8 Sleeper Cab – Natural Gas	$230,000

[130] California Air Resources Board, New Vehicle Cost Analysis, 2021.

The Federal and California Phase 2 GHG regulations require manufacturers to build trucks that have lower GHG emissions than existing models. These requirements start in 2021 MY and ramp up through the 2027 MY. U.S. EPA estimated the cost per vehicle to comply with the federal Phase 2 GHG regulation shown in Table 19.[131] These costs are added to the base cost of combustion-powered vehicles. Because ZEVs produce zero tailpipe emissions, they do not incur increased costs due to the Phase 2 GHG regulation.

Table 19. U.S. EPA Phase 2 GHG Incremental Compliance Costs

Phase 2 Category	2021-2023 MY	2024-2026 MY	2027+ MY
Class 2b-3 Pickup/Van	$524	$963	$1,364
Vocational Vehicles	$1,110	$2,022	$2,662
Tractors	$6,484	$10,101	$12,442

The Heavy-Duty Omnibus rulemaking is a multi-pronged, holistic approach to decrease emissions of new heavy-duty engines sold in California beginning in the 2024 MY. The regulation lowers NOx emissions by lowering tailpipe NOx standards, establishing a new low-load test cycle to ensure emissions reductions are occurring in all modes of operation, strengthening durability, lengthening warranty and useful life, and in-use testing provisions, along with other measures. The costs to a typical fleet purchasing combustion-powered vehicles based on the certification type and the MY is shown in Table 20.[132] These costs are added to the base cost of combustion-powered vehicles, but do not change the cost for ZEVs because they do not have combustion engines and have zero tailpipe emissions. The costs associated with the Heavy-Duty Omnibus regulation are included in the Legal Baseline.

Table 20. Heavy-Duty Omnibus Estimated Increase in Purchase Price

Vehicle Category	Corresponding Weight Class	2024-2026 MY	2027-2030 MY	2031+ MY
Medium-Duty Diesel	Class 3	$1,554	$3,916	$4,354
Medium-Duty Otto	Class 3	$412	$412	$412

[131] United States Environmental Protection Agency, *Final Rule for Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2*, 2016 (web link: https://www.govinfo.gov/content/pkg/FR-2016-10-25/pdf/2016-21203.pdf, last accessed January 2022).
[132] California Air Resources Board, *Public Hearing to Consider the Proposed Heavy-Duty Engine and Vehicle Omnibus Regulation and Associated Amendments – Staff Report: Initial Statement of Reasons*, 2020 (web link: https://ww3.arb.ca.gov/regact/2020/hdomnibuslownox/isor.pdf, , last accessed January 2022).

Vehicle Category	Corresponding Weight Class	2024-2026 MY	2027-2030 MY	2031+ MY
Heavy-Duty Otto	Class 4-8	$506	$821	$1,015
Light-Heavy-Duty Diesel	Class 4-5	$1,687	$4,741	$6,041
Medium-Heavy-Duty Diesel	Class 6-7	$2,469	$6,063	$6,923
Heavy-Heavy-Duty Diesel	Class 8/Tractors	$3,761	$7,423	$8,478

Staff estimated the cost of medium- and heavy-duty ZEVs for battery-electric and fuel cell powered vehicles by adding electric components costs, fuel cell component costs, energy storage costs, and body costs to a conventional glider vehicle, similar to CARB's approach used in the ACT regulation. Component costs are adjusted to account for the indirect costs associated with production volume and early market complexity. The indirect cost multipliers are derived from the 2019 Argonne National Laboratory Report "Fuel Economy and Cost Estimates for Medium- and Heavy-Duty Vehicles" and are displayed in Table 21 and are applied to the individual component costs. These multipliers are the highest in earliest years when volumes are lowest and new engineering is needed to launch electrified products. Over time, these multipliers decline as economies of scale emerge and ZEV production becomes normalized within the industry. Values for years in between are interpolated.[133] The final retail price of the ZEV is the sum of these individual total component costs. The calculated prices for BEVs are comparable to battery-electric trucks and vans that are available through the HVIP program today.

Table 21. Indirect Cost Multipliers Applied to ZEV Component Costs

Vehicle Category	2020 and Earlier	2025	2030	2035 and Later
Electric machine	1.95	1.55	1.29	1.20
Battery Packs	2.18	1.76	1.48	1.20
Fuel Cell System	2.18	1.76	1.48	1.20

[133] Argonne National Laboratory, *Fuel Economy and Cost Estimates for Medium- and Heavy-Duty Vehicles*, 2019 (web link: https://publications.anl.gov/anlpubs/2021/02/165815.pdf, last accessed December 2021).

Vehicle Category	2020 and Earlier	2025	2030	2035 and Later
Hydrogen Storage	2.18	1.76	1.48	1.20

Electric component costs including motors and electronic controllers are derived using assumptions from Argonne National Laboratory's 2021 Vehicle Technology Benefit Analysis for medium- and heavy-duty vehicles by averaging the low and high cases.[134] Hydrogen system component costs for the fuel cell stack and hydrogen storage are calculated using data from two Strategic Analysis reports prepared for the Department of Energy which estimated hydrogen fuel cell system costs for medium- and heavy-duty trucks.[135,136]

Generally, heavy-duty vehicles are manufactured in stages. A chassis manufacturer such as Ford or Freightliner installs a powertrain built by themselves or an outside supplier to produce a cab-and-chassis. This is then sent to a body manufacturer to install a body on the vehicle such as a box or bucket truck body. These body costs are modeled separately for ZEVs. The cost of a body can be estimated by measuring the difference between the price of a cab-and-chassis and the finished vehicle with a body. For this analysis, staff assumes bodies requiring power takeoff such as a bucket truck or refuse truck will cost 10 percent extra up until 2030 to account for additional costs of electrifying the power takeoff. No increased costs are modeled for bodies without power takeoff.

The cost of battery storage is the largest contributing factor associated with the price of BEVs. Battery pack costs have dropped nearly 90 percent since 2010 and are projected to continue declining. Battery pack cost for medium- and heavy-duty applications are currently higher than for light-duty cars due to smaller volumes and differing packaging requirements even though many use the same cells. For this analysis, staff estimate battery costs using a recent 2021 analysis from the National Academies of Sciences, Engineering, and Medicine and the indirect cost modifiers displayed in Table 21.[137] Figure 15 shows the historic battery price trend and the battery price projections used in this analysis. The projections used in this analysis are shown in bold.

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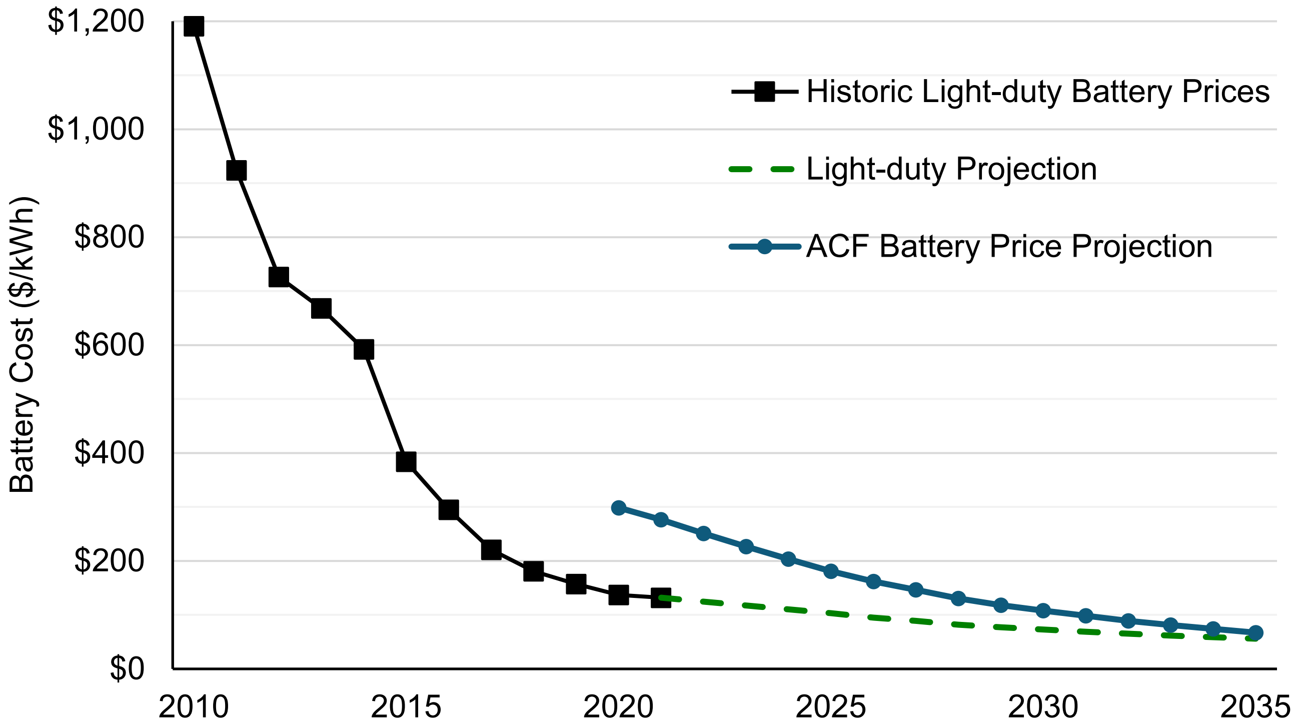
[134] Argonne National Laboratory, *2021 Vehicle Technology Benefit Analysis – Medium- and Heavy-Duty Vehicles - Assumptions*, 2021 (web link: https://anl.app.box.com/s/ml0vlag8merv5xb2jjt5f901cl6rbu38, last accessed December 2021).

[135] Strategic Analysis, *Fuel Cell Systems Analysis*, 2021 (web link: https://www.hydrogen.energy.gov/pdfs/review21/fc163_james_2021_o.pdf, last accessed December 2021).

[136] Strategic Analysis, *Hydrogen Storage Cost Analysis*, 2021 (web link: https://www.hydrogen.energy.gov/pdfs/review21/st100_james_2021_o.pdf, last accessed December 2021).

[137] National Academies of Sciences, Engineering, and Medicine, *Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025-2035*, 2021 (web link: https://www.nap.edu/read/26092/chapter/1, last accessed December 2021).

Figure 15. Historic Battery Price Trends and Battery Price Projections



Staff is not forecasting that this proposed regulation would affect commercial battery prices and ZEV technology significantly. The proposed regulation would affect a portion of California's medium- and heavy-duty trucking fleet, which is very small compared to the worldwide market for batteries in consumer electronics, light-duty vehicles, battery-storage, and other applications. To the extent that this rule increases economies of scale for general ZEV components, infrastructure, and battery production, there may be an accelerated reduction in component and vehicle prices as a result of the rule, but these effects are less certain and are not modelled. The proposed regulation, along with the ACT rule and similar efforts outside California, may cause the cost for battery packs and components specifically designed for medium- and heavy-duty ZEVs to decrease as economies of scale start to emerge in this new market.

The costs for BEVs are modelled using motors and electrical components in line with an existing diesel counterpart's power needs. Battery storage is estimated using the vehicle's average daily mileage based on EMFAC data and the energy efficiency of the electric vehicle in 2020. For vehicles which EMFAC models as driving below 100 miles per day, staff assumed the battery will have a minimum capability of driving 100 miles daily. Staff then modeled a 35 percent buffer to account for battery degradation and some operational variability. For Class 2b pickups, staff modeled they will require an additional 50 percent larger battery than would otherwise be calculated to account for the towing needs of these vehicles as well as their operational variability. Similarly, staff modeled that the Class 8 specialty vehicle will require a 50 percent larger battery to accommodate expanded power take off operation as discussed previously. Table 22 lists the specifications of sample BEV.

Table 22. Battery Size Calculation

Representative Vehicle	Daily Mileage	2020 Efficiency (kWh/mi)	Battery Size (kWh)
Class 2b Cargo Van	100	0.6	80
Class 5 Walk-in Van	100	1	135
Class 6 Bucket Truck	100	1.5	205
Class 8 Refuse Packer	100	3.0	405
Class 8 Day Cab	160	2.1	455
Class 8 Sleeper Cab	320	2.1	920

The costs for FCEVs are modeled using motors and electrical components in line with an existing diesel counterpart's power needs. The battery is assumed to be 10 kilowatt-hours (kWh). The fuel cell stack power output is assumed to be one half the vehicle's peak power needs. The amount of hydrogen storage depends on vehicles size with larger vehicles requiring more storage: 10 kg for Class 2b-3 vehicles, 20 kg for Class 4-7 vehicles, 40 kg for most Class 8 vehicles and 80 kg for Class 8 sleeper cab tractors.

The assumed vehicle prices for sample vehicles of all fuel types are shown Table 23. Based on these projections, ZEV costs are expected to be higher than diesel vehicle costs until at least 2030. After that point, some vocations may see lower cost for ZEVs versus their diesel-powered counterparts as costs for ZEVs continue declining while combustion-powered costs increase over time. All costs for all MYs are available in the Vehicle Cost Attributes Appendix.

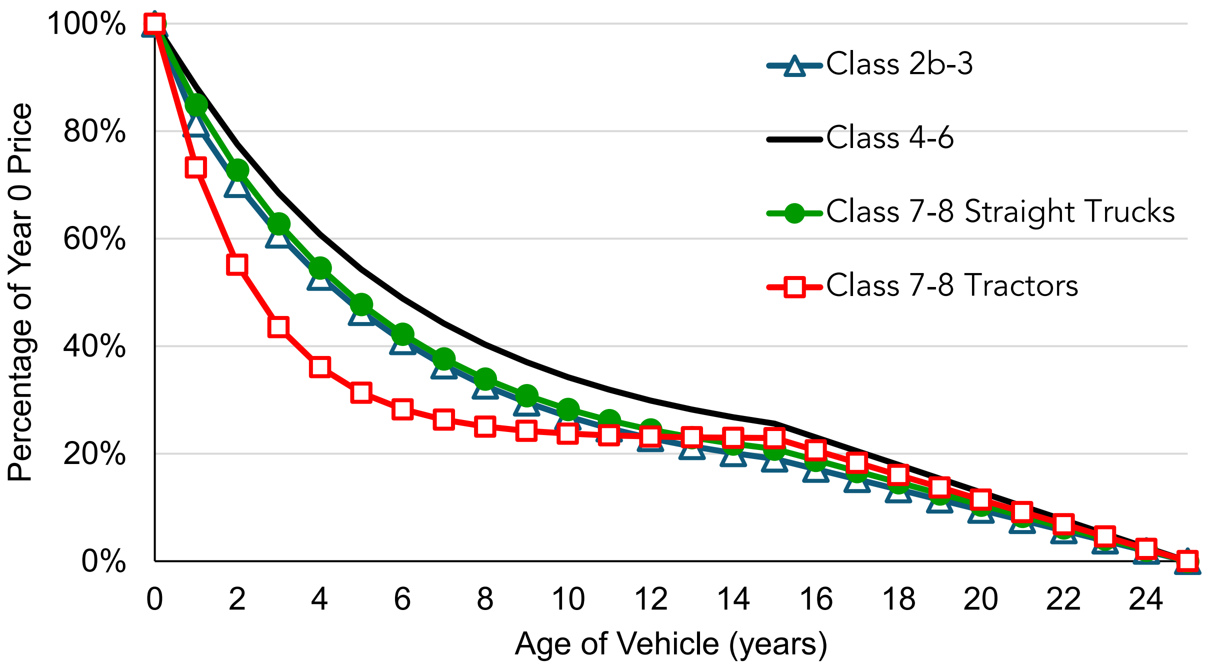
Table 23. New Vehicle Price Forecast

Vehicle Group	2025 MY	2030MY	2035 MY
Class 2b Cargo Van – Diesel	$40,137	$40,611	$40,611
Class 2b Cargo Van – Gasoline	$36,137	$36,611	$36,611
Class 2b Cargo Van – Battery-Electric	$54,835	$45,167	$40,361
Class 2b Cargo Van – Fuel Cell Electric	$89,469	$63,567	$48,115
Class 5 Walk-in Van – Diesel	$91,075	$94,884	$96,184

Vehicle Group	2025 MY	2030MY	2035 MY
Class 5 Walk-in Van – Battery-Electric	$107,074	$94,260	$87,552
Class 5 Walk-in Van – Fuel Cell Electric	$127,842	$106,944	$92,056
Class 6 Bucket Truck – Diesel	$130,857	$135,206	$136,066
Class 6 Bucket Truck – Battery-Electric	$165,527	$145,791	$142,076
Class 6 Bucket Truck – Fuel Cell Electric	$194,304	$161,337	$146,756
Class 8 Refuse Packer – Diesel	$232,149	$236,566	$237,621
Class 8 Refuse Packer – Natural Gas	$259,189	$260,259	$260,453
Class 8 Refuse Packer – Battery-Electric	$293,965	$257,685	$238,496
Class 8 Refuse Packer – Fuel Cell Electric	$319,852	$272,754	$240,265
Class 8 Day Cab – Diesel	$145,689	$152,115	$153,170
Class 8 Day Cab – Natural Gas	$192,434	$195,513	$195,707
Class 8 Day Cab – Battery-Electric	$204,579	$164,611	$143,371
Class 8 Day Cab – Fuel Cell Electric	$221,352	$174,254	$141,765
Class 8 Sleeper Cab – Diesel	$155,689	$162,115	$163,170
Class 8 Sleeper Cab – Natural Gas	$242,434	$245,513	$245,707
Class 8 Sleeper Cab – Battery-Electric	$295,597	$221,901	$181,883
Class 8 Sleeper Cab – Fuel Cell Electric	$254,774	$203,552	$160,833

The used vehicle prices for combustion-powered trucks are calculated using major online truck marketplaces such as TruckPaper and Commercial Truck Trader by measuring the price of a given body type over several MYs and weight classes. This analysis provided up to 2,000 data points per model year to calculate the long-term residual values for medium- and heavy-duty vehicles. The trend is calculated by grouping similar trucks, performing a weighted average, then calculating an exponential curve fit for the different groups. The residual value is assumed to linearly decline from its value at 15-years-old to a value of 0 at 25-years-old to reflect that most vehicles are out-of-service or scrapped at that point. Figure 16 displays the 4 residual value curves calculated for combustion-powered vehicles over a 25-year period. The residual value of ZEVs is assumed to decline at the same rate as combustion-powered trucks.

Figure 16. Residual Values by Vehicle Type and Age



For the purpose of this analysis, vehicles purchased by private fleets are assumed to be financed over a 5-year period while vehicles purchased by public fleets are assumed to be purchased outright. Staff assumes most fleets would be able to finance at a lower interest rate while some would have to finance for higher rates. Staff assumed that 80 percent of fleets finance at a 5 percent annual percentage rate and 20 percent of fleets finance at 15 percent to reflect costs on marginal operators affected by the regulation. These assumptions apply to both new and used vehicles.

3.1.4.2 Fueling Infrastructure Installation and Maintenance

Infrastructure is necessary to refuel or recharge vehicles. All vehicles need either dedicated refueling infrastructure onsite or publicly available retail stations in order to operate. There are numerous ways infrastructure expenses can be accounted for which would affect the cost to California businesses in different ways. Infrastructure expenses are generally an upfront capital investment needed prior to vehicles being deployed, but infrastructure can last multiple vehicle lifetimes and generally is amortized over its life.

For gasoline, diesel, and natural gas vehicles, staff assumes the fleet is either using existing infrastructure or publicly accessible stations and the infrastructure cost is already incorporated into the fuel cost. As a result, these infrastructure costs are not separately modeled.

For this analysis, staff assumes the BEVs would utilize both depot charging and recharging at publicly accessible medium- and heavy-duty retail stations and that it will vary by fleet. Staff estimated the portion of BEVs that would use depot charging versus retail refueling using data from the ACT Large Entity Reporting requirement.[138] Vehicles that travel under 200 miles per day and either fuel at base, park at their home base 8 or more hours per day, or return to base daily are assumed to be able to depot charge. Vehicles that cannot meet these criteria are assumed to require retail recharging, such as vehicles parked away from company grounds or owned by smaller operators without sufficient access to capital. Non-tractor trucks are assumed to solely depot charge until 2030 as the vast majority of these vehicles have ample opportunity to refuel at a home base during downtime. After 2030 as more vehicles transition to ZE, a portion of the non-tractor fleet is assumed to use retail charging to address more variable operations. Retail refueling assumptions are listed in Table 24. Staff acknowledges there are myriad ways fleets can choose to charge their vehicles and these assumptions are intended to be representative cost scenarios.

Table 24. Percentage of Retail Refueling for BEVs by Weight Class and Year

Vehicle Group	2023-2029	2030+
Class 2b-3	0%	15%
Class 4-5 Straight Truck	0%	15%
Class 6-7 Straight Truck	0%	15%
Class 8 Straight Truck	0%	15%
Class 7-8 Day Cab Tractor	25%	25%
Class 7-8 Sleeper Cab Tractor	75%	75%

Fleets owning BEVs that do not use retail charging would set up private, behind-the-fence facility-side infrastructure to recharge their vehicles. There are two main cost components of installing charging infrastructure: the cost of the charger itself and the cost of upgrading the site to deliver power to the charger.

Charger costs are derived from the International Council on Clean Transportation working paper, "Estimating Electric Vehicle Charging Infrastructure Costs Across Major U.S. Metropolitan Areas".[139] Generally, smaller trucks can use similar Level 2 chargers to what

[138] Advance Clean Trucks, *Large Entity Reporting Results* (web: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks/large-entity-reporting, last accessed January 2022)
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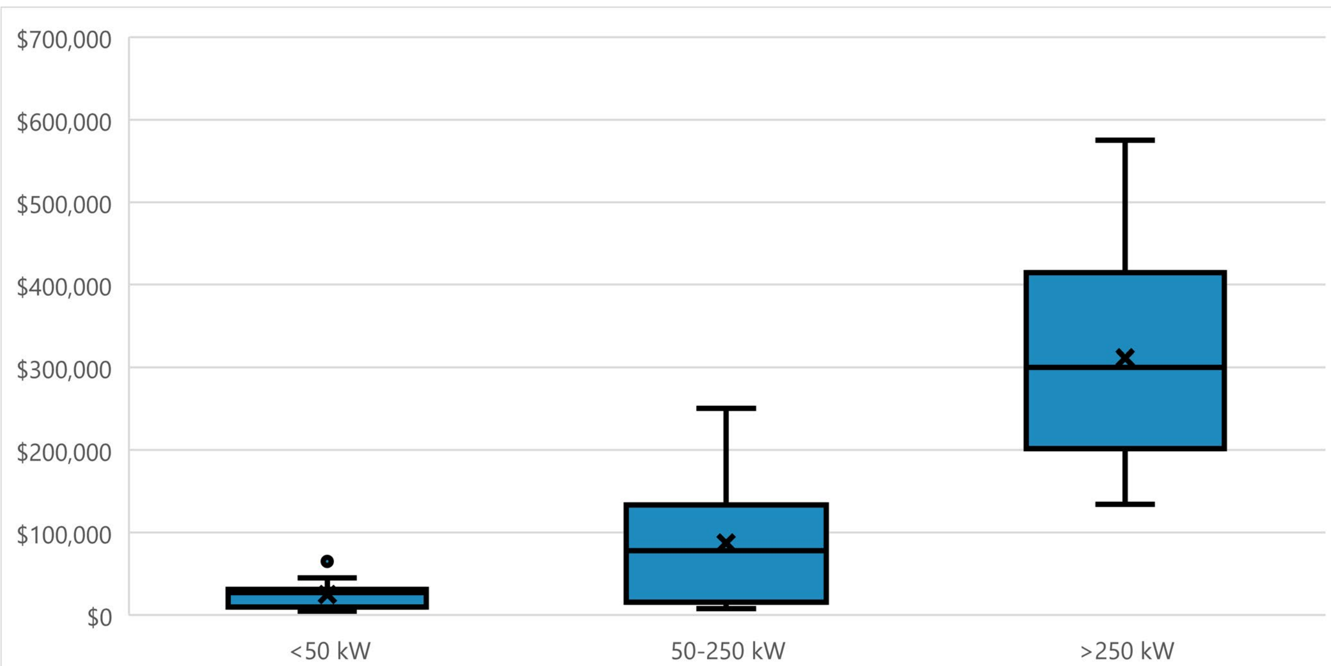
light-duty vehicles use. Class 6 and heavier vehicles are assumed to require higher power direct current chargers. Class 8 vehicles and Class 7-8 tractors are to use a 150 kW charger with 2 ports for each pair of BEVs.

Infrastructure upgrade costs represent costs on the customer side of the meter associated with setting up charging infrastructure at a facility and may include trenching, cabling, conduit, and panels as well as associated infrastructure costs. Staff anticipate that nearly all costs associated with utility-side upgrades are the responsibility of the utility as per requirements of AB 841. Soft costs including additional training costs and short-term implementation challenges, such as staff cycling vehicles between chargers, are captured within subsection "Transitional Costs and Workforce Development". Infrastructure costs are derived from an analysis of BEV deployments conducted by CARB. The data was analyzed to calculate the cost per port and results were broken into 3 groups: below 50 kW, between 50 and 250 kW, and above 250 kW. The results are shown in Figure 17 in a box-and-whisker plot. As depicted, infrastructure costs for fleets can be highly variable based on the layout of the site and the type of upgrades. The average cost is appropriate for a statewide analysis but the infrastructure cost to a given fleet may be higher or lower.

Figure 17. Infrastructure Upgrade Cost per Port and Power Level



International Council on Clean Transportation, *Estimating Electric Vehicle Charging Infrastructure Costs Across Major U.S. Metropolitan Areas*, 2019. (web link: https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf, last accessed January 2022).

Table 25 outlines the assumptions for charger power, charger cost, and infrastructure upgrade costs.

Table 25. Charger Power Ratings and Infrastructure Costs Per Vehicle

Vehicle Group	Charger Power (kW)	Charger Cost ($/vehicle)	Infrastructure Upgrade Cost ($/vehicle)
Class 2b-3	19	$5,000	$25,000
Class 4-5	19	$5,000	$25,000
Class 6-7	50	$25,000	$44,000
Class 8	150 kW for 2 vehicles	$37,500	$44,000
Class 7-8 Tractor	150 kW	$75,000	$88,000

Fleets are assumed to amortize their infrastructure costs over a 20-year period with an interest rate of 5 percent. The number of charger installations and infrastructure upgrades each year is based on the increase in ZEV population per year to avoid double-counting infrastructure costs in situations in later years where a ZEV is replacing another ZEV in the fleet. Fleets may be able to offset significant upgrade costs by participating in utility electrification incentives, however due to uncertain long-term availability and qualification criteria, we do not assume so in our analysis. Hydrogen infrastructure costs are incorporated into the hydrogen fuel costs and are not included here.

Depot and retail chargers for ZEVs require regular maintenance. The maintenance costs of depot chargers are estimated by considering costs for replacing charger heads, connectors, and other components, as well as labor costs for regular inspections. Charger maintenance costs are estimated at $400/year/charger.[140] Staff assume that the maintenance costs for other fueling infrastructures are reflected in the fuel price.

Backup power generation is not included in this analysis. Although some fleets may want backup generation on site, staff does not assume infrastructure costs for the use of on-site backup generation for a number of reasons. First, ZEVs would gradually enter the fleet over time and only a small portion of the fleet would be zero-emission. Second, power outages affect all fuel types as fuel pumps cannot work without electricity, so similar issues already exist today. Third, mobile fueling and other solutions are currently being developed and

[140] Alternative Fuels Data Center, *Charging Infrastructure Operation and Maintenance*, 2021 (web link: https://afdc.energy.gov/fuels/electricity_infrastructure_maintenance_and_operation.html, last accessed January 2022).

present a solution for fleets seeking additional reliability.[141] Some backup generation options such as onsite power storage, present the opportunity to offset some or all of the costs to store energy during off-peak periods to reduce peak demand charges, or by reselling the electricity onto the grid during peak times using vehicle-to-grid technology. [142]

3.1.4.3 Sales Tax and Federal Excise Tax

Taxes are additional costs levied on the purchase of a vehicle. Because they are based on the purchase price of the vehicle, they are higher for ZEVs due to their higher upfront costs.

Vehicles purchased in California must pay a sales tax on top of the vehicle's purchase price. The sales tax varies across the state from a minimum of 7.25 percent up to 10.50 percent in some municipalities; a value of 8.6 percent was used for staff's analysis based on a statewide average weighted by economic output.[143] This results in higher costs for fleets and higher revenue for State and local governments. Class 8 vehicles are subject to an additional federal excise tax which adds 12 percent to their purchase price.

3.1.4.4 Maintenance Bay Upgrades

Maintenance bays are facilities used to service vehicles. Services performed include inspections, routine maintenance, preventative maintenance, repairs, overhauls and more. Servicing electric vehicles requires separate safety equipment, diagnostic tools, and equipment which would incur costs to the facility.

Based on transit agency data, upgrading a 15 bus maintenance bay to handle battery-electric buses would cost $25,000, and upgrading to handle fuel cell electric buses would cost $750,000. For this analysis, staff assume the cost per maintenance bay is the same and a 15 bus maintenance bay could accommodate 25 trucks. Per vehicle, this works out to be $1,000 per battery-electric vehicle and $30,000 per fuel cell electric vehicle. The amount of maintenance bay upgrades each year is based on the increase in ZEV population per year to avoid double-counting in situations where a ZEV is replaced by a ZEV.

3.1.5 Operating and Maintenance Costs

The proposed regulation would require fleets to purchase medium- and heavy-duty ZEVs to meet the compliance requirements. The cost of ZEVs includes the cost of operating these vehicles in California for their lifetime. These operating costs include fueling, maintenance, and LCFS revenue where other costs are assumed to be the direct costs of the proposed regulation.

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[141] GM, *GM Plans to Broaden Electrification, Expanding Fuel Cells Beyond Vehicles*, 2022 (web link: https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2022/jan/0119-hydrotec.html, last accessed January 2022)

[142] EDF, *California Heavy-Duty Fleet Electrification Summary Report* , 2021 (web link: http://blogs.edf.org/energyexchange/files/2021/03/EDF-GNA-Final-March-2021.pdf, last accessed January 2022)

[143] Based on the *tax rate data* from California Department of Tax and Fee Administration: (https://cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm)

3.1.5.1 Gasoline, Diesel, Natural Gas, Electricity, and Hydrogen Fuel Cost

Fuel costs are calculated using total fuel consumed per year, and the cost of fuel per unit. The total fuel consumed per year is based on the vehicle population per calendar year, the annual mileage traveled by those vehicles, and the fuel economy/fuel efficiency of the vehicles. Population and mileage assumptions are discussed on Vehicle Population subsection on page 44. In general, ZEVs are two to five times as efficient as similar vehicles with ICE technologies. and significantly reduce petroleum and other fossil fuel consumption.

Fuel economy is measured in miles per gallon for gasoline and diesel, and miles per diesel gallon equivalent for natural gas. The energy efficiency of BEVs and FCEVs is measured in miles per kWh and miles per kg, respectively.[144] Gasoline, diesel, and natural gas fuel economy is derived from EMFAC inventory projections for each group. Generally, combustion-powered fuel economy is expected to increase until the 2027 MY and remain relatively constant afterwards.

BEV energy efficiency is derived from in-use data collected from a variety of vehicles.[145,146,147] For fuel cell vehicle efficiency, staff applied the LCFS program's Energy Efficiency Ratio (EER) of 1.9 to the diesel fuel economy to estimate the fuel cell fuel economy as there is limited information which measures the energy efficiency of medium- and heavy-duty FCEVs.

Staff modeled that for both BEVs and FCEVs, the efficiency will improve at the same rate the Phase 2 GHG regulation would require for combustion-powered vehicles until 2027 MY, then remain constant afterwards. This may be a conservative estimate as both technologies are less developed than ICE powertrains and reports have shown recent improvements in the technology.

Table 26 outlines the fuel economy and energy efficiency assumptions for a sample of vehicle groups and technology types over the course of the regulation. Full assumptions are in the Vehicle Attribute Appendix.

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[144] tiFuel economy, as defined in the Energy Policy and Conservation Act of 1975 (EPCA), does not apply to BEVs. *See* 49 U.S.C. §§ 32901(10 & 11) (defining "fuel" as gasoline, diesel oil, or other "liquid or gaseous fuel" that needs conserving and defining "fuel economy" as the average number of miles traveled by an automobile per gallon of gasoline or its equivalent). Moreover, note that medium- and heavy-duty on-highway vehicles are not ''automobiles'' as defined in 49 U.S.C. 32901(a)(3) (4-wheeled vehicles rated under 10,000 lb. GVWR, excluding work trucks (vehicles rated between 8,500 to 10,000 lb. GVWR and not medium-duty passenger vehicles as defined in 40 CFR section 86.1803-01).

[145] California Air Resources Board, *Battery Electric Truck and Bus Efficiency Compared to Diesel Vehicles* (web link: https://ww2.arb.ca.gov/sites/default/files/2018-11/180124hdbevefficiency.pdf, last accessed January 2022).

[146] Penn State LTI Bus Research and Testing Center, *Motor Coach Industries D45 CRTeLE*, 2020 (web link: http://apps.altoonabustest.psu.edu/buses/reports/522.pdf?1608733416, last accessed January 2022).

[147] Penn State LTI Bus Research and Testing Center, *GreenPower Motor Company EV Star*, 2020 (web link: http://apps.altoonabustest.psu.edu/buses/reports/515.pdf?1603821665, last accessed January 2022).

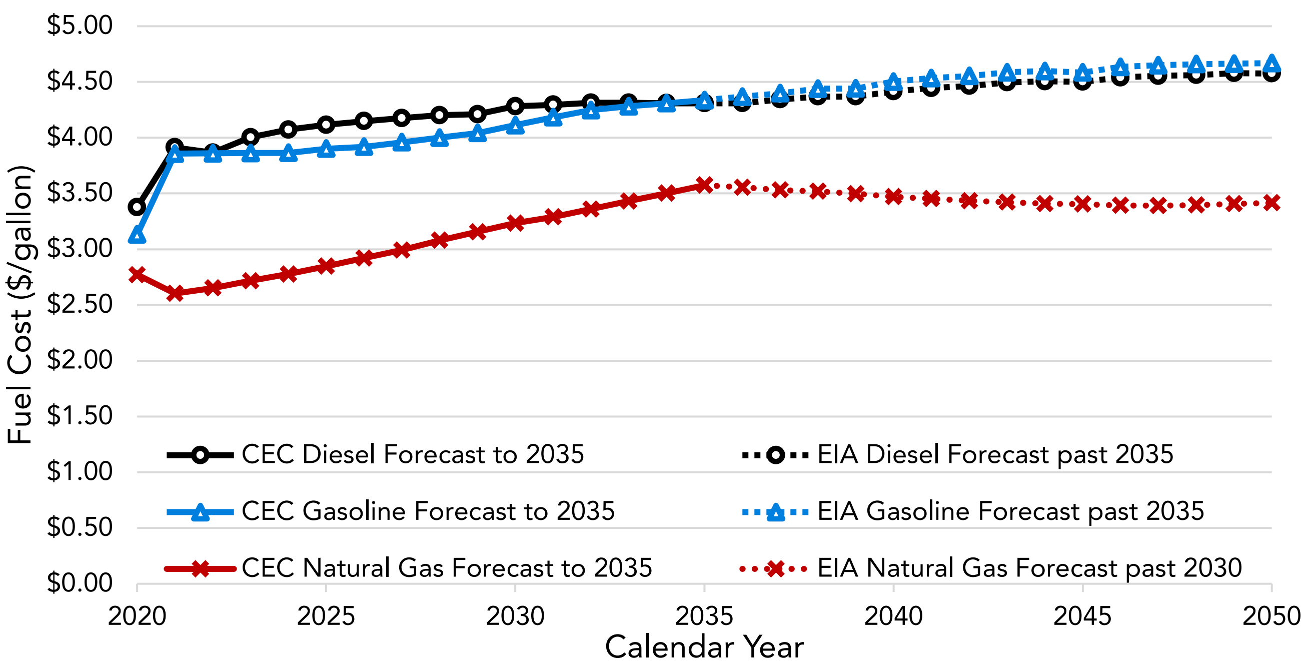
Table 26. Sample Vehicle Fuel Economy and Energy Efficiency

Vehicle Group	2024 MY	2027 MY	2031 MY	Unit
Class 2b Cargo Van – Diesel	19.4	19.4	19.3	mpg
Class 2b Cargo Van – Gasoline	14.1	14.1	14.0	mpg
Class 2b Cargo Van – Battery-Electric	1.9	2.0	2.0	mi./kWh
Class 2b Cargo Van – Fuel Cell Electric	42.5	42.4	42.4	mi./kg
Class 5 Walk-in Van – Diesel	9.4	9.5	9.6	mpg
Class 5 Walk-in Van – Battery-Electric	1.1	1.2	1.2	mi./kWh
Class 5 Walk-in Van – Fuel Cell Electric	16.1	17.0	17.0	mi./kg
Class 6 Bucket Truck – Diesel	8.9	9.0	9.1	mpg
Class 6 Bucket Truck – Battery-Electric	0.8	0.8	0.8	mi./kWh
Class 6 Bucket Truck – Fuel Cell Electric	15.1	15.9	15.9	mi./kg
Class 8 Refuse Packer – Diesel	3.2	3.2	3.3	mpg
Class 8 Refuse Packer – Natural Gas	6.5	6.5	6.6	mpg
Class 8 Refuse Packer – Battery-Electric	0.4	0.4	0.4	mi./kWh
Class 8 Refuse Packer – Fuel Cell Electric	5.2	5.5	5.5	mi./kg
Class 8 Day Cab – Diesel	6.9	7.0	7.0	mpg
Class 8 Day Cab – Natural Gas	6.7	6.8	6.9	mpg
Class 8 Day Cab – Battery-Electric	0.5	0.6	0.6	mi./kWh
Class 8 Day Cab – Fuel Cell Electric	10.9	11.6	11.6	mi./kg
Class 8 Sleeper Cab – Diesel	7.1	7.2	7.2	mpg

Vehicle Group	2024 MY	2027 MY	2031 MY	Unit
Class 8 Sleeper Cab – Natural Gas	6.5	6.5	6.5	mpg
Class 8 Sleeper Cab – Battery-Electric	0.5	0.6	0.6	mi./kWh
Class 8 Sleeper Cab – Fuel Cell Electric	11.0	11.6	11.6	mi./kg

Gasoline and diesel fuel prices to 2035 are taken from the "mid-demand" scenario from the CEC "Transportation Energy Demand Forecast."[148] Fuel prices past 2035 are calculated using the Energy Information Administration's (EIA) 2021 Annual Energy Outlook for the Pacific region.[149] The annual percentage change in EIA fuel prices past 2035 is applied to the 2035 CEC gasoline and diesel prices to estimate price changes past 2035. Figure 18 shows the projected prices of gasoline, diesel, and natural gas out to 2050.

Figure 18. Gasoline, Diesel, and Natural Gas Price Forecasts



Electricity costs for BEVs depend on the rate and on how they are charged and include energy costs, fixed fees, and demand fees. Vehicles charged at high power or during peak periods have higher electricity costs than if charging overnight or over an extended period.

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[148] California Energy Commission, *Transportation Energy Demand Forecast*, 2021 (web link: https://efiling.energy.ca.gov/GetDocument.aspx?tn=240934, last accessed January 2022).
[149] Energy Information Administration, *Annual Energy Outlook 2021*, 2021 (web link: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2021&region=1-9 , last accessed December 2021).

For this analysis, staff assumes the BEVs utilize both depot charging and recharging at publicly accessible medium- and heavy-duty retail stations using the same methodology as discussed previously in Section " Fueling Infrastructure Installation and Maintenance".

Electricity prices for depot charging are calculated using CARB's Battery-Electric Truck and Bus Charging Calculator and assumes a fleet of 20 vehicles using a managed charging strategy with the applicable rate schedule.[150] Tractors are assumed to be charged in a 4 hour shift at night with midday opportunity charging. All other trucks are assumed to charge overnight. Energy costs, monthly fees, demand rates, charger efficiency losses and local electricity taxes are incorporated into these numbers. The cost per kWh is calculated separately for each utility and a weighted average is used to determine the cost per kWh per vehicle in 2021.

Table 27 shows the depot charging electricity price per kWh for each vehicle group and major utility region as well as the weighted statewide average. In general, electricity costs are lower for larger vehicles because they tend to use more electricity which decreases the fixed costs per kWh and allows the use of lower cost rate schedules for larger utility customers. Note that SCE's newly introduced electric vehicle rates, EV-8 and EV-9, have no demand fees from 2019 to 2023 and phase them back over the following five years, with demand fees being fully reintroduced in 2029. However, to simplify the analysis, staff used the full cost of the SCE electricity rate including all demand charges from the beginning of the analysis period rather than discounting the price to reflect the transition period until the demand charges are fully reintroduced.[151]

Table 27. Depot Charging Electricity Cost Calculation for 2021 (2021$/kWh)

Utility Area	Class 2b-3	Class 4-5	Class 6-7	Class 8	Class 7-8 Tractor
Los Angeles Department of Water and Power	$0.11	$0.11	$0.13	$0.11	$0.17
Pacific Gas and Electric	$0.15	$0.15	$0.16	$0.15	$0.14
Sacramento Municipal Utility District	$0.17	$0.16	$0.16	$0.14	$0.14
San Diego Gas and Electric	$0.21	$0.20	$0.22	$0.20	$0.15
Southern California Edison*	$0.19	$0.15	$0.15	$0.14	$0.15

[150] California Air Resources Board, *Battery-Electric Truck and Bus Charging Calculator*, 2021 (web link: https://ww2.arb.ca.gov/resources/documents/battery-electric-truck-and-bus-charging-cost-calculator, last accessed December 2021).
[151] Southern California Edison, Communication via email with Alexander Echele in April 2019.

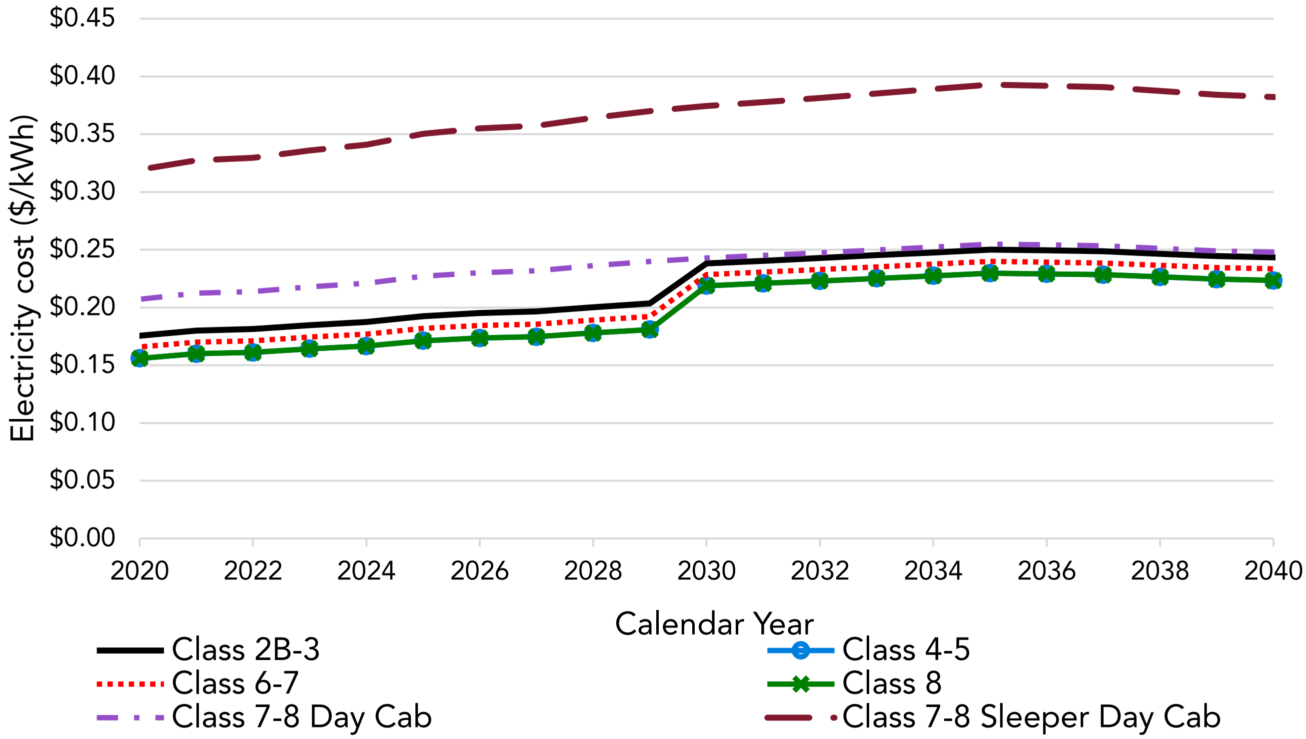
Utility Area	Class 2b-3	Class 4-5	Class 6-7	Class 8	Class 7-8 Tractor
Weighted Statewide Average	**$0.18**	**$0.16**	**$0.17**	**$0.16**	**$0.16**

For retail charging, staff assume the price for medium- and heavy-duty retail charging will be similar to current direct current fast charging costs for light-duty. Staff have used an average of charging costs offered today by Electrify America and EVgo to calculate a rate of $0.36/kWh in 2021.[152] The retail electricity charging prices have been adjusted to account for the higher LCFS credit value for heavy-duty vehicles as compared to light-duty vehicles. This adjustment is discussed further in the "Low Carbon Fuel Standard" Section.

Electricity rate changes over time are modelled using the CEC's "Transportation Energy Demand Forecast."[153] CEC's rate forecast includes current and escalating revenue requirements to support ongoing investments in transmission and distribution infrastructure. Fuel prices past 2035 are calculated using the EIA 2021 Annual Energy Outlook for the Pacific region.[154] The annual percentage change in EIA electricity prices past 2035 is applied to the 2035 CEC electricity to estimate future price changes. Results per vehicle type are shown in Figure 19.

[152] Electrify America, *Pricing and Plans for EV Charging*, 2021 (web link: https://www.electrifyamerica.com/pricing/, last accessed January 2022).
[153] California Energy Commission, *Transportation Energy Demand Forecast*, 2021 (web link: https://efiling.energy.ca.gov/GetDocument.aspx?tn=240934, last accessed January 2022).
[154] Energy Information Administration, *Annual Energy Outlook 2021*, 2021 (web link: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2021&region=1-9 , last accessed December 2021).

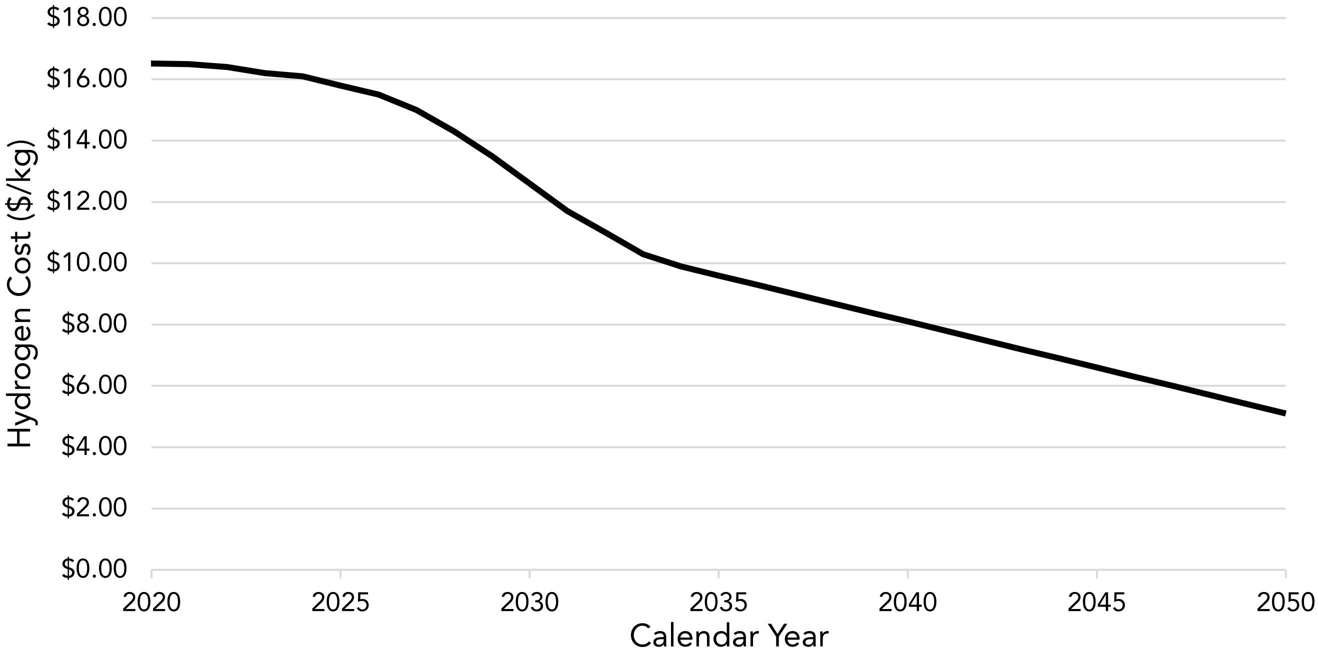
Figure 19. Electricity Price Forecasts



For this analysis, hydrogen stations are assumed to be available at strategic locations around seaports or major distribution hubs where the infrastructure costs are included in the hydrogen fuel price rather than reflecting costs for stations installed in a depot. This model is currently used for light-duty hydrogen stations and medium- and heavy-duty diesel sales and appears most appropriate for medium- and heavy-duty hydrogen fueling. Hydrogen fuel costs are modeled using the CEC's "Transportation Energy Demand Forecast".[155] Past 2035, the price of hydrogen continues to decline linearly. Hydrogen costs over time are shown in Figure 20.

[155] California Energy Commission, *Transportation Energy Demand Forecast*, 2021 (web link: https://efiling.energy.ca.gov/GetDocument.aspx?tn=240934, last accessed January 2022).

Figure 20. Hydrogen Price Forecasts



The cost of fuel displayed above includes fuel taxes. State and local taxes on fuel are listed below in Table 28.

Table 28. Local and State Taxes on Fuel

Fuel Type	Local Tax	State Tax
Gasoline	3.70% sales tax	$0.51/gal excise tax*
Diesel	4.5% sales tax	8.6% sales tax + $0.38/gal excise tax
Natural Gas	0	$0.887/gasoline gallon equivalent use tax
Electricity	3.53% utility user tax**	$0.0003/kWh
Hydrogen	0	0

*Local government portion is $0.22/gal and State government portion is $0.29/gal.
**Statewide population-weighted average

Staff acknowledge that both short-term and long-term forecasts for fuel and energy prices can change over time due to unexpected shocks in the economy. For example, The U.S. EIA's Short-Term Energy Outlook forecasts for Brent crude oil spot prices in 2022 have varied between $70 to $105 per barrel from the December 2021 to March 2022 forecast releases.[156,157] In the 2019, 2020, 2021, and 2022 releases of the U.S. EIA's Annual Energy Outlook, the predicted average annual real growth rate from 2021 through 2050 of transportation diesel fuel price varies from 1.0 percent, 1.5 percent, 1.5 percent, and 0.8 percent.[158] Similar patterns hold for the long-run projections on transportation gasoline prices and electricity prices, with relatively smaller adjustments for electricity prices. These different forecasts could result in changes in the cost and savings estimates for the proposed regulation and the alternatives. If the realized fuel prices differ from what is forecasted, there will be proportional changes in the fuel costs and cost savings.

3.1.5.2 Diesel Exhaust Fluid Consumption

Diesel-powered vehicles equipped with modern emissions control devices require diesel exhaust fluid (DEF) to break down NOx in the exhaust stream. Argonne National Laboratory estimates DEF consumption as being 2 percent of total fuel usage in their online 2020 AFLEET tool.[159] This assumption will be applied to the fuel economy discussed previously to estimate the DEF consumption per mile. DEF is assumed to cost $2.80 per gallon per Argonne.

3.1.5.3 Low Carbon Fuel Standard Revenue

The LCFS is a California regulation that creates a market mechanism incentivizing low carbon fuels and was recently amended in 2018 and 2019. These amendments 1) increased the EER for Class 4-8 trucks from 2.7 to 5.0, 2) reduced the carbon intensity target to 20 percent reduction by 2030, and 3) clarified how hydrogen station operators can receive credits. The regulation now requires the carbon intensity of California's transportation fuels to decrease by 20 percent through the 2030 timeframe and maintains the standard afterwards. Electricity and hydrogen are eligible to earn LCFS credits which can be sold and used to offset the costs of these fuels. Fossil gasoline and diesel are generally not eligible for LCFS credits.

Fleets who own and operate their infrastructure generate credits based on the amount of fuel or energy they dispense. Credit values for different fuel types are calculated using the LCFS Credit Price Calculator.[160] For this analysis, staff is projecting an LCFS credit price of $200 until 2030, then declining linearly to $25 in 2045 and remaining constant thereafter. An electric Class 2b-3 vehicle would earn $0.147/kWh in 2024 using grid electricity while an electric Class 4-8 vehicle would earn roughly $0.249/kWh in 2024 at this credit price. Staff

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[156] U.S Energy Information Administration, *Short-Term Energy Outlook December 2021*, 2021 (web link: https://www.eia.gov/outlooks/steo/archives/Dec21.pdf, last accessed April 2022).
[157] U.S. Energy Information Administration, *Short-Term Energy Outlook March 2022*, 2022 (web link: https://www.eia.gov/outlooks/steo/archives/Mar22.pdf, last accessed April 2022).
[158] U.S. Energy Information Administration, *Annual Energy Outlook 2019-2022, Table 3 Energy Prices by Sector and Sources, Pacific Region*, 2022 (web link: https://www.eia.gov/outlooks/aeo/, last accessed April 2022).
[159] Argonne National Laboratory, *Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool*. (https://greet.es.anl.gov/afleet, last accessed January 2022)
[160] California Air Resources Board, *LCFS Credit Price Calculator*, 2021(web link: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/dashboard/creditvaluecalculator.xlsx, last accessed January 2022).

assume hydrogen is produced from 33 percent renewable feedstock as required by SB 1505 (2006). This results in Class 4-8 vehicles earning $1.422/kg in 2024 at this credit price. LCFS credit revenue for a given fuel drops slightly over time as the program standards tighten and maintains upward pressure on the credit price.

For retail electricity refueling, staff conservatively assume that most LCFS credit revenue is not be passed on to fleets directly as the credit value is already incorporated into the retail price. As described previously, retail charging station costs are based off of what light-duty retail stations are charging today, which includes revenue they receive from the LCFS program. One key difference between light-duty and heavy-duty BEVs is that heavy-duty vehicles earn substantially more LCFS credits due to their higher EER value. To reflect this, staff applied this higher EER value to the retail electricity price by calculating the difference between light-duty and heavy-duty LCFS revenue and scaling the revenue by the credit value over time. This adjustment reduces the price of heavy-duty retail charging by $0.12/kWh by 2024 declining to $0.01/kWh by 2045. This adjustment is applied to the retail charging electricity cost.

This analysis reflects that the LCFS value associated with natural gas is already included in the retail price to the fleet owner. Fossil natural gas is expected to be a deficit generator in the LCFS program for the majority of this analysis and not generate revenue. While renewable natural gas does generate LCFS credits, the credits are typically claimed by the fuel producer and used to offset the higher cost of renewable natural gas. Therefore, the net cost to the fleet owner using renewable natural gas is essentially the same as fossil-based natural gas.

3.1.5.4 Maintenance Costs

Maintenance costs reflect the cost of labor and parts for routine maintenance, preventative maintenance, and repairing broken components, and does not include costs reflected in the next Section "Midlife Costs" where engine rebuilds, battery replacements, or fuel cell stack refurbishments are described. Maintenance costs for electric vehicles are generally assumed to be lower than for diesel in part due to their simpler design and fewer moving components.

Maintenance costs for combustion-powered vehicles are based on numerous studies published assessing maintenance costs for vehicles over a representative timeframe. The maintenance cost for the selected representative vehicles was calculated by identifying all sources where the maintenance cost appeared for the representative vehicles and averaging the values. All maintenance cost sources are listed in the Vehicle Attribute Appendix.

BEVs and FCEVs are assumed to have 40 percent lower vehicle maintenance costs compared to gasoline and diesel based on an aggregation of sources and data.[161] While numerous reports assume ZEVs can achieve maintenance costs of 50 percent or greater compared to

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[161] Argonne National Laboratory, *Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains* (web link: https://www.arb.ca.gov/regact/2018/ict2018/appg.pdfhttps://www.arb.ca.gov/msprog/bus/maintenance_cost.pdf, last accessed January 2022)

gasoline or diesel, the lack of long-term data on maintenance costs presents uncertainty for modelling purposes; therefore the staff analysis uses the more conservative estimate.

Table 29 illustrates the maintenance for a set of sample vehicles. Maintenance cost assumptions for all representative vehicles are listed in the Vehicle Attribute Appendix. All prices have been adjusted to 2021 dollars using a consumer price index.

Table 29. Sample Vehicle Maintenance Costs per Mile

Vehicle Group	Maintenance Cost ($/mi.)
Class 2b Cargo Van – Diesel	$0.337
Class 2b Cargo Van – Gasoline	$0.337
Class 2b Cargo Van – Battery-Electric	$0.202
Class 2b Cargo Van – Fuel Cell Electric	$0.202
Class 5 Walk-in Van – Diesel	$0.210
Class 5 Walk-in Van – Battery-Electric	$0.126
Class 5 Walk-in Van – Fuel Cell Electric	$0.126
Class 6 Bucket Truck – Diesel	$0.199
Class 6 Bucket Truck – Battery-Electric	$0.119
Class 6 Bucket Truck – Fuel Cell Electric	$0.119
Class 8 Refuse Packer – Diesel	$0.943
Class 8 Refuse Packer – Natural Gas	$0.943
Class 8 Refuse Packer – Battery-Electric	$0.566
Class 8 Refuse Packer – Fuel Cell Electric	$0.566
Class 8 Day Cab – Diesel	$0.198
Class 8 Day Cab – Natural Gas	$0.198
Class 8 Day Cab – Battery-Electric	$0.119
Class 8 Day Cab – Fuel Cell Electric	$0.119
Class 8 Sleeper Cab – Diesel	$0.159
Class 8 Sleeper Cab – Natural Gas	$0.159
Class 8 Sleeper Cab – Battery-Electric	$0.095
Class 8 Sleeper Cab – Fuel Cell Electric	$0.095

3.1.5.5 Midlife Costs

Midlife costs are the cost of rebuilding or replacing major propulsion components due to wear or deterioration. These costs do not include general maintenance on vehicles – these are included in the "Maintenance Costs" Section. The frequency and cost of a midlife rebuild varies across the different technologies. For combustion-powered vehicles, this would be a midlife rebuild, for BEVs this would be a battery replacement, and for a hydrogen FCEV this would be a fuel cell stack refurbishment.

The frequency of a diesel engine rebuild varies based on the vehicle's weight class. Table 30 shows the anticipated diesel engine useful life based on years or miles. The cost of an engine rebuild is estimated to be one quarter of the total price without a body.

Table 30. Useful Life of Diesel Engines

Vehicle/Engine Category	Useful Life (Years/Miles)
Class 4-5 (Light-Heavy-Duty)	15/270,000
Class 6-7 (Medium-Heavy-Duty)	12/350,000
Class 8 (Heavy-Heavy-Duty)	12/800,000

Data is limited for BEVs, but ZEV manufacturers are currently offering vehicles with warranties of 8 or more years and up to 500,000 miles on their products. [162,163,164,165,166] Staff estimates that the battery will be replaced every 500,000 miles and the cost of the replacement is assumed to be the size of the battery in kWh multiplied by the price per kWh at the time of the replacement.

For FCEVs, the consulting firm Ricardo has estimated that a fuel cell stack refurbishment is necessary every seven years and costs one third the cost of a new fuel cell stack at the time of refurbishment. [167]

Fleets generally do not rebuild older vehicles as there is poorer return on investment when the vehicle is approaching the end of its life. Staff does not model any rebuilds occurring after the vehicle is 20-years-old.

Based on the above assumptions, Table 31 shows when sample vehicles are assumed to incur midlife costs. This approach may overestimate the cost of ZEVs when compared with combustion vehicles. A table of when each representative vehicle is assumed to incur its midlife cost is shown in the Vehicle Attribute Appendix.

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[162] Department of Energy, *Batteries: 2020 Annual Progress Report*, 2020 (web link: https://www1.eere.energy.gov/vehiclesandfuels/downloads/VTO_2020_APR_Batteries_compliant_.pdf, last accessed December 2021).

[163] BYD, *The BYD K9*, 2019 (web link: https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets_k9-40_lr.pdf, last accessed January 2022)

[164] New Flyer, *Xcelsior Charge*, 2019 (web link: https://www.newflyer.com/site-content/uploads/2019/06/Xcelsior-CHARGE-web.pdf, last accessed January 2022)

[165] Proterra, *Catalyst: 40 Foot Bus – Performance Specifications*, 2019 (web link: https://mk0proterra6iwx7rkkj.kinstacdn.com/wp-content/uploads/2019/06/Proterra-Catalyst-40-ft-Spec-Sheet.pdf, last accessed January 2022)

[166] Steinbuch, *Tesla Model S Degradation Data*, 2015 (web link: https://steinbuch.wordpress.com/2015/01/24/tesla-model-s-battery-degradation-data/, last accessed January 2022)

[167] Ricardo, *Economics of Truck TCO and Hydrogen Refueling Stations*, 2016(web link: https://cafcp.org/sites/default/files/8_Economics-of-Hydrogen-Refueling-Stations-Ricardo_CaFCP-Bus-Team-meeting-Aug2016.pdf)

Table 31. Frequency of Midlife Rebuilds

Vehicle Group	Midlife Occurrence (year)
Class 2b Cargo Van – Gasoline	N/A
Class 2b Cargo Van – Diesel	N/A
Class 2b Cargo Van – Battery-Electric	N/A
Class 2b Cargo Van – Fuel Cell Electric	7, 14
Class 5 Walk-in Van – Diesel	15
Class 5 Walk-in Van – Battery-Electric	N/A
Class 5 Walk-in Van – Fuel Cell Electric	7, 14
Class 6 Bucket Truck – Diesel	12
Class 6 Bucket Truck – Battery-Electric	N/A
Class 6 Bucket Truck – Fuel Cell Electric	7, 14
Class 8 Refuse Packer – Diesel	12
Class 8 Refuse Packer – Natural Gas	12
Class 8 Refuse Packer – Battery-Electric	N/A
Class 8 Refuse Packer – Fuel Cell Electric	7, 14
Class 8 Day Cab – Diesel	12
Class 8 Day Cab – Natural Gas	12
Class 8 Day Cab – Battery-Electric	10
Class 8 Day Cab – Fuel Cell Electric	7, 14
Class 8 Sleeper Cab – Diesel	8, 19
Class 8 Sleeper Cab – Natural Gas	8, 19
Class 8 Sleeper Cab – Battery-Electric	5, 11, 17
Class 8 Sleeper Cab – Fuel Cell Electric	7, 14

For example, the midlife costs of a 2024 MY day cab tractor would be:

- Diesel, natural gas: midlife overhaul in 2036 at a cost of $32,500
- Battery-electric: battery replacement in 2034 at a cost of $33,717 in 2034
- Fuel cell electric: Fuel cell stack refurbishments in 2031 and 2038 at a cost of $10,460 in 2031 and $5,544 in 2038

3.1.5.6 Registration Fees

Vehicles operating and registered in California must pay an annual registration fee. The registration fee varies based on the vehicle's cost, age, and weight. These calculations are different for combustion-powered vehicles and ZEVs.

Combustion-powered vehicles and ZEVs are subject to the following fixed fees based on the DMV online calculator.[168] These are constant annual fees for every vehicle which are shown in Table 32 and Table 33.

[168] California Department of Motor Vehicles, *California New Vehicle Fees*, 2021 (web link: https://www.dmv.ca.gov/portal/dmv/detail/portal/feecalculatorweb, last accessed January 2022).

Table 32. Fixed Registration Fees for ICE Vehicles

Diesel Fee Name	Amount
Current Registration	$61
CVRA Registration Fee	$122
CVRA Service Authority for Freeway Emergencies Fee	$3
CVRA Fingerprint ID Fee	$3
CVRA Abandoned Vehicle Fee	$3
CVRA California Highway Patrol Fee	$46
Current Air Quality Management District	$6
Current Cargo Theft Interdiction Program Fee	$3
CVRA Weight Decal Fee	$3
Alt Fuel/Tech Registration Fee	$3
CVRA Auto Theft Deterrence/DUI Fee	$4
Reflectorized License Plate Fee	$1
Total	**$258**

Table 33. Fixed Registration Fees for ZEVs

ZEV Fee Name	Amount
Current Registration	$61
Current California Highway Patrol	$28
CVRA Service Authority for Freeway Emergencies Fee	$1
CVRA Fingerprint ID Fee	$1
CVRA Abandoned Vehicle Fee	$1
Current Air Quality Management District	$6
Alt Fuel/Tech Registration Fee	$3
CVRA Auto Theft Deterrence/DUI Fee	$2
Reflectorized License Plate Fee	$1

ZEV Fee Name	Amount
Road Improvement Fee	$100
Total	**$204**

All vehicles registered in California must pay a Transportation Improvement Fee based on the retail price of the vehicle. As of 2021, the fee is $171 for vehicles priced between $35,000 and $60,000, and $192 for vehicles priced above $60,000.

All registered vehicles are assessed a Vehicle License Fee which is equal to the vehicle price multiplied by 0.65 percent and a separate percentage schedule. This separate schedule is shown in Table 34.

Table 34. Vehicle License Fee Decline over Time

Year	1	2	3	4	5	6	7	8	9	10	11+
Percentage	100%	90%	80%	70%	60%	50%	40%	30%	25%	20%	15%

For commercial ICE vehicles, vehicle owners are assessed an annual weight fee based on the vehicle's potential maximum loaded weight. For electric vehicles, the weight fee is based on its unladen weight. The estimated weight fees are shown in Table 35.

Table 35. Weight Fees for ICE Vehicles and ZEVs

Weight Class	Diesel Weight Fee	ZEV Weight Fee
Class 2b-3	$210	$266
Class 4-5	$447	$358
Class 6-7	$546	$358
Class 8	$1,270	$358
Class 7-8 Tractor	$2,064	$358

Overall, ZEV's pay lower registration fees over the vehicle's life although it may be higher in the initial years of registration. This difference is greater for heavier vehicles due to the large difference in annual weight fees.

3.1.6 Other Costs

The fleet transition to medium- and heavy-duty ZEVs would cause shifts in other costs beyond upfront and general operating costs.

3.1.6.1 Residual Values

The residual value represents the value of the vehicle at the point where the initial purchaser sells the vehicle to another party. This value depends on numerous factors including the type of vehicle, its age, and the vehicle's propulsion technology and becomes more significant when modeling vehicle replacement cycles that are less than 12 years. The residual value for a vehicle is calculated using the same methodology described for used vehicles in subsection "New and Used Vehicle Prices" on page 66. For combustion-powered vehicles, this is the price of the used vehicle when it is sold out of state. This analysis reflects the net change to the California. New vehicle sales in California are expected to increase and as a result more used combustion-powered vehicles are sold out of the state. The residual value represents the increase in sales out of state.

Sales between California fleets are not reflected within this analysis as these do not represent a net change to the state – the two fleets are exchange cash for a vehicle asset which represents no net change.

3.1.6.2 Depreciation

Depreciation represents an asset's loss in value over time. This loss can be claimed as an expense and used to decrease a business's tax burden. Vehicles owned and used by businesses can have their depreciation quantified using values provided by the Internal Revenue Service (IRS) Publication 946 regarding property depreciation which may be recovered when itemizing deductions from taxes.[169] These deductions are referred to as the Modified Accelerated Cost Recovery System (MACRS) and are considered to be cost-savings.

The cost-savings from depreciation can be calculated by multiplying the vehicle's purchase price by the MACRS depreciation rate and the corporate tax rate. Per the IRS publication, most trucks follow a 5-year depreciation schedule while tractors follow a 3-year deprecation schedule. ZEVs and combustion-powered vehicles use the same depreciation rates. The amount of deprecation year-over-year is shown in Table 36.

Table 36. Depreciation Rate by Age

Age	0	1	2	3	4	5	6+
Truck	20.00%	32.00%	19.20%	11.52%	11.52%	5.76%	0%
Tractor	33.33%	44.45%	14.81%	7.41%	0%	0%	0%

The vehicle value depreciated per year is multiplied by the corporate tax rate to determine the amount of tax savings per year. The California corporate tax rate is 8.84 percent, and the

[169] Internal Revenue Service, *Publication 946 (2020), How To Depreciate Property*, 2020 (web link: https://www.irs.gov/pub/irs-pdf/p946.pdf, last accessed January 2022).

federal corporate tax rate is 21 percent.[170,171] Public fleets are not assumed to claim depreciation as they do not file State or federal income taxes.

3.1.6.3 Insurance

Fleets purchase insurance policies to protect against financial loss and a variety of unexpected events including damaging other property, damage to the vehicle, medical coverage in the event of an accident, and others. Because ZEVs are anticipated to cost more than their combustion-powered counterparts, vehicle coverage is anticipated to be more costly as well.

Table 37 shows the estimated cost of various insurance coverage components based on several sources staff identified.[172,173,174]

Table 37. Estimated Annual Semi-Truck Insurance Policy Costs

Types of Insurance Coverage	Policy Cost
Primary Liability	$6,000
General Liability	$550
Umbrella Policy	$600
Physical Damage	$2,000
Bobtail Insurance	$375
Uninsured/Underinsured Motorist	$75
Occupational Accident	$1,900

Physical damage is the only coverage element that depends on the cost of the vehicle being operated. The other coverage types are not dependent on the cost of the vehicle. For

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[170] Franchise Tax Board, *Business Tax Rates*, 2021 (web link: https://www.ftb.ca.gov/file/business/tax-rates.html, last accessed January 2022).
[171] Internal Revenue Service, *Publication 542, Corporation*, 2021 (web link: https://www.irs.gov/publications/p542, last accessed January 2022).
[172] Forerunner Insurance Group, *What does Average semi truck insurance costs for owner operators?*, 2018 (web link: https://www.forerunnerinsurance.com/what-does-average-semi-truck-insurance-costs-for-owner-operators/, last accessed January 2022).
[173] Commercial Truck Insurance HQ, *Average Semi Truck Insurance Cost*, 2019 (web link: https://www.commercialtruckinsurancehq.com/average-semi-truck-insurance-cost, last accessed January 2022).
[174] Strong Tie Insurance, *Why You Need a Commercial Semi Truck Insurance Coverage*, 2021 (web link: https://www.strongtieinsurance.com/semi-truck-insurance/, last accessed January 2022).

example, if truck were to crash into a signpost, the cost of the truck would not affect the cost of paying to replace the signpost.

The "Physical Damage" coverage costs 1/70th of the price of a new semi-truck; for the purpose of this analysis, staff assumes the "Physical Damage" insurance cost is proportional to 1/70th the cost of the vehicle when new. Insurance costs for a vehicle decline over time as the value of the vehicle decreases. Staff assumes the insurance costs decline at the same rate as shown in subsection "New and Used Vehicle Prices" on page 66.

3.1.6.4 Transitional Costs and Workforce Development

Transitioning to a new technology has inherent costs associated with its deployment, including shifts in operational and maintenance practices. These recurring costs include operator and technician trainings, purchasing and upgrading of software, securing additional spare parts, and others.

Limited information is available for this type of transitional cost, but discussions occurred on this topic during the development of the ICT regulation. Based on discussions with transit agencies, staff assumes that these "other costs" associated with ZEB deployments are equivalent to 2.5 percent of bus prices for all powertrains and should go down over time for ZEBs as they become more common.[175]

In the cost analysis for the proposed regulation, staff make similar assumptions that the workforce training and transitional costs are equal to 2.5 percent of the incremental cost difference between a baseline combustion vehicle and a ZEV given that the transitions transit agencies will be making are similar to changes made by trucking fleets. These costs continue until 2030 at which point the technology will have developed to a point where these transitional costs become BAU for trucking fleets.

3.1.6.5 Reporting Costs

Fleets subject to the proposed regulation would need to report information annually to demonstrate compliance. Reporting would include company contact information, vehicle registration information, and engine family numbers for tractors approaching the end of their useful life. Staff estimates that to report annually, a fleet of 50 vehicles would need an average of 12.5 hours, and would be proportionally longer based on the number of vehicles. Staff anticipates most fleets would already have the information requested available in databases. This time estimate includes collecting information from vehicles, placing the information into a spreadsheet, verifying the information, and reporting it into a CARB database. The hourly staffing cost is assumed to be $24.13 per hour for the employee assigned to pull the information.[176]

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[175] Transit Agency Subcommittee-Lifecycle Cost Modeling Subgroup, Report of Findings, 2017.

[176] U.S. Bureau of Labor Statistics, *Occupational Outlook Handbook – Diesel Service Technicians and Mechanics*, 2021 (web link: https://www.bls.gov/ooh/installation-maintenance-and-repair/diesel-service-technicians-and-mechanics.htm, last accessed January 2022).

3.1.6.6 Battery Recycling, Repurposing, and Disposal

The energy capacity of the batteries used in ZEVs will naturally degrade over their useful lives and require battery replacements. When battery capacity is not sufficient for meeting daily range needs for a truck or bus, it is expected that there will be a second life for the batteries. Used batteries can be repurposed into other applications such as stationary storage, then at the end of those battery lives can be recycled and non-recyclable materials can be disposed.

The cost for battery recycling at the end of battery life is not included here, because this cost could be offset by the residual value of the battery. The end of life may be a revenue source depending on whether the battery can be recycled and repurposed or could become a cost if it must be disposed of. Light-duty vehicle batteries are already being repurposed for second life applications including stationary storage.[177,178] Even today, some lithium-ion battery manufacturers provide an attractive residual value to customers upon the retirement of a battery. Therefore, staff believes that the residual value will offset the recycling cost and become a revenue source, but does not include a residual battery value in the economic analysis.

3.1.7 Total Costs

The proposed regulation would increase the number of medium- and heavy-duty ZEVs purchased in California relative to the Legal Baseline scenario. This means that all costs would be above and beyond the costs already expected with the ACT regulation. The increased ZEVs sales have higher upfront capital costs initially for the vehicle and infrastructure investments, but lower operating costs over time resulting in net savings for truck transportation in California. When assuming all costs are borne by fleets operating in California the proposed regulation results in a net cost of -$12.4 billion between 2020 and 2050 compared to the Legal Baseline scenario. This represents a substantial net decrease in costs and does not include indirect health cost-savings. Figure 21 and Table 39 illustrates the incremental difference in costs between the proposed regulation and the Legal Baseline scenario. Note that the incremental cost increases and decreases are mainly due to the number of ZEVs purchased in a given time frame, the actual incremental cost of ZEVs is declining steadily over this timeframe. In Figure 21, the cost components are grouped as shown Table 38.

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[177] Nissan Motor Corporation, *Nissan LEAF batteries to light up Japanese town*, 2018 (web link: https://newsroom.nissan-global.com/releases/180322-01-e?lang=en-US&la=1&downloadUrl=%2Freleases%2F180322-01-e%2Fdownload, last accessed January 2022).

[178] BMW Group, BMW Group, *Northvolt and Umicore join forces to develop sustainable life cycle loop for batteries* (web link: https://www.press.bmwgroup.com/global/article/detail/T0285924EN/bmw-group-northvolt-and-umicore-join-forces-to-develop-sustainable-life-cycle-loop-for-batteries, last accessed January 2022).

Table 38. Summarized Cost Items

Cost Category	Components
Vehicle Cost	Vehicle Cost, Sales Tax, Federal Excise Tax, Residual Values
Fuel Cost	Gasoline, Diesel, Electricity, Hydrogen Fuel Cost, Fuel Taxes
LCFS Revenue	LCFS Revenue
Infrastructure	Charger Costs, Infrastructure Upgrades, Charger Maintenance
Maintenance	Vehicle Maintenance Costs, Maintenance Bay Upgrades
Midlife	Midlife Costs
Other	DEF Consumption, Registration Fees, Depreciation, Insurance, Transitional Costs, Reporting Costs

Figure 21. Total Estimated Direct Costs of Proposed Regulation Relative to the Legal Baseline Scenario (million 2021$)

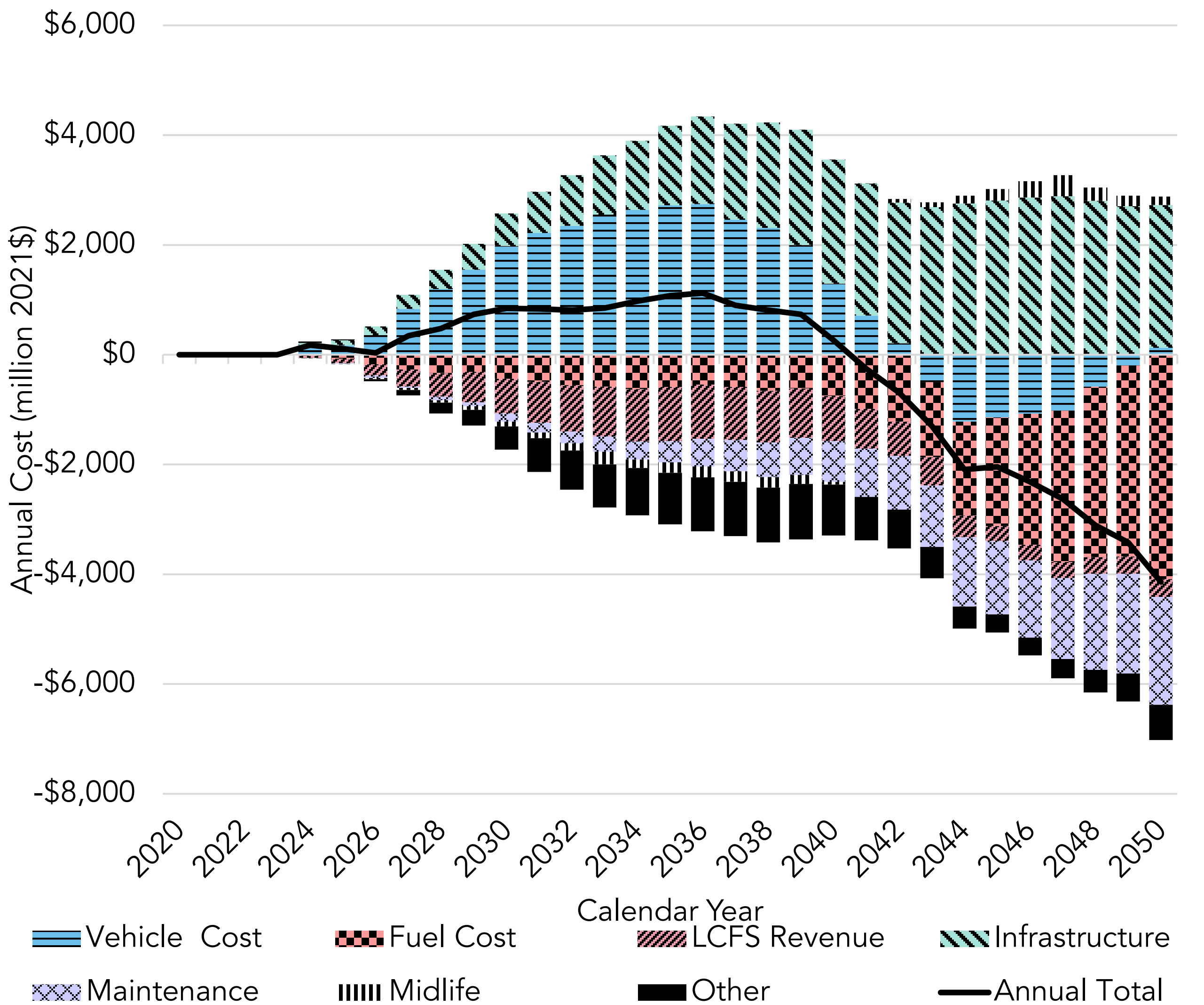

Table 39. Total Incremental Direct Costs of Proposed Regulation Relative to Legal Baseline Scenario (million 2021$)

Year	Vehicle Price	Sales and Excise Tax	EVSE & Infrastructure Installation	Maintenance Bay Upgrades	Fuel Cost	DEF Consumption	LCFS Revenue	Maintenance Cost	Midlife Costs	Registration Fees	Transitional Costs	Residual Values	Depreciation	Insurance Cost	Reporting Cost	Total Costs	Total Savings	Total*
2024	$152	$22	$39	$9	-$25	$0	-$34	-$9	-$2	$0	$26	$0	-$6	$3	$3	$254	-$76	**$178**
2025	$213	$47	$97	$13	-$72	-$1	-$79	-$25	-$5	-$2	$33	-$93	-$24	$7	$3	$413	-$301	**$112**
2026	$533	$226	$157	$13	-$178	-$4	-$198	-$62	-$19	-$8	$32	-$404	-$80	$19	$3	$983	-$953	**$30**
2027	$961	$299	$255	$78	-$269	-$8	-$310	-$102	-$35	-$17	$61	-$425	-$177	$34	$3	$1,691	-$1,343	**$348**
2028	$1,257	$244	$354	$75	-$335	-$11	-$425	-$139	-$47	-$24	$57	-$308	-$266	$42	$3	$2,032	-$1,555	**$477**
2029	$1,664	$379	$474	$121	-$312	-$17	-$555	-$193	-$66	-$35	$71	-$495	-$365	$57	$3	$2,769	-$2,038	**$731**
2030	$2,079	$392	$595	$117	-$442	-$23	-$635	-$264	-$87	-$52	$67	-$489	-$487	$67	$4	$3,321	-$2,479	**$842**
2031	$2,381	$484	$751	$159	-$500	-$30	-$748	-$333	-$109	-$72	$0	-$650	-$595	$81	$4	$3,860	-$3,037	**$823**
2032	$2,627	$461	$925	$180	-$561	-$37	-$851	-$398	-$130	-$90	$0	-$742	-$683	$92	$4	$4,289	-$3,492	**$797**
2033	$2,849	$368	$1,084	$168	-$588	-$43	-$917	-$451	-$228	-$108	$0	-$667	-$732	$95	$4	$4,568	-$3,734	**$834**
2034	$3,004	$469	$1,260	$209	-$640	-$51	-$969	-$537	-$152	-$136	$0	-$835	-$778	$102	$4	$5,048	-$4,098	**$950**
2035	$3,149	$455	$1,449	$235	-$603	-$59	-$1,010	-$615	-$193	-$164	$0	-$884	-$829	$107	$4	$5,399	-$4,357	**$1,042**
2036	$2,881	$344	$1,594	$187	-$569	-$67	-$1,008	-$691	-$199	-$193	$0	-$479	-$827	$101	$4	$5,111	-$4,033	**$1,078**
2037	$2,635	$372	$1,750	$206	-$617	-$75	-$992	-$775	-$195	-$226	$0	-$550	-$788	$98	$4	$5,065	-$4,218	**$847**
2038	$2,547	$397	$1,923	$229	-$694	-$84	-$968	-$859	-$190	-$259	$0	-$634	-$762	$98	$4	$5,198	-$4,450	**$748**
2039	$2,311	$366	$2,106	$247	-$659	-$92	-$930	-$919	-$169	-$286	$0	-$681	-$731	$94	$4	$5,128	-$4,467	**$661**
2040	$1,429	-$103	$2,262	$284	-$809	-$99	-$847	-$1,024	-$53	-$309	$0	-$31	-$584	$62	$4	$4,041	-$3,859	**$182**
2041	$923	-$49	$2,402	$285	-$1,055	-$107	-$751	-$1,162	$8	-$340	$0	-$160	-$385	$39	$4	$3,661	-$4,009	**-$348**
2042	$464	$16	$2,563	$315	-$1,293	-$116	-$650	-$1,294	$67	-$369	$0	-$271	-$254	$25	$4	$3,454	-$4,247	**-$793**
2043	-$351	-$264	$2,688	$228	-$1,446	-$119	-$536	-$1,348	$86	-$379	$0	$113	-$81	$2	$4	$3,121	-$4,524	**-$1,403**
2044	-$1,034	-$190	$2,756	$178	-$1,799	-$122	-$414	-$1,436	$140	-$394	$0	$7	$121	-$12	$4	$3,206	-$5,401	**-$2,195**
2045	-$950	-$103	$2,811	$191	-$2,068	-$126	-$289	-$1,525	$207	-$409	$0	-$92	$221	-$17	$4	$3,434	-$5,579	**-$2,145**
2046	-$877	-$48	$2,867	$199	-$2,482	-$131	-$296	-$1,606	$297	-$421	$0	-$150	$239	-$17	$4	$3,606	-$6,028	**-$2,422**
2047	-$830	$2	$2,889	$203	-$2,851	-$135	-$304	-$1,681	$379	-$431	$0	-$193	$225	-$14	$5	$3,703	-$6,439	**-$2,736**
2048	-$399	$59	$2,806	$0	-$3,205	-$140	-$314	-$1,751	$240	-$442	$0	-$241	$174	-$10	$5	$3,284	-$6,502	**-$3,218**
2049	-$27	$92	$2,704	$0	-$3,585	-$145	-$324	-$1,816	$195	-$451	$0	-$263	$85	-$4	$5	$3,081	-$6,615	**-$3,534**
2050	$285	$129	$2,598	$0	-$4,199	-$157	-$341	-$1,966	$154	-$483	$0	-$286	-$8	$2	$5	$3,173	-$7,440	**-$4,267**
Total*	**$29,878**	**$4,868**	**$44,159**	**$4,127**	**-$31,856**	**-$1,998**	**-$15,697**	**-$22,982**	**-$107**	**-$6,102**	**$347**	**-$9,904**	**-$8,378**	**$1,155**	**$106**	**$84,640**	**-$97,024**	**-$12,384**

*Note: Totals may differ due to rounding

Further detailed information on the costs of the different fleets subject to the proposed regulation versus the Legal Baseline are discussed in more detail in the Additional Cost Information Appendix.

Deploying more medium- and heavy-duty ZEVs due to the proposed regulation would result in a net decrease in costs to the California economy. Fleets would be expected to have higher vehicle costs and infrastructure expenses, but would also save money overall on fuel, LCFS revenue, maintenance savings, increased depreciation benefits, and other factors. Despite these potential savings, some fleets remain reluctant in shifting to ZEV technology.

The issues affecting decision-making regarding ZEVs are being analyzed in numerous reports by speaking with fleets.[179] Common themes identified include:

- **High vehicle upfront costs.** Today, a ZEV can range from 20 percent higher cost to as much as 2 to 3 times more than a similar conventional vehicle. While these costs are anticipated to decline, the higher upfront cost of ZEVs places a significant barrier in vehicle purchasing patterns. These costs are often a more significant barrier to smaller fleets with limited access to capital and higher borrowing costs. A combination of declining costs, incentives, and innovative financing models can defray these upfront investments and reduce the impact of these issues.
- **Inertia of combustion-powered vehicles**. Diesel and gasoline vehicles enjoy an inherent advantage versus newer technologies solely due to their established footprint in the market. Business models, duty cycles, agreements, and other core business practices are based on the established trends of fossil fuel powered vehicles. Fleets would need to spend additional time and resources planning for a transition to ZEV technologies that does not exist when staying with the status quo.
- **Uncertainty and lack of data.** Fleets have a wealth of information available about how their existing vehicles operate based on historical data which has been gathered for decades. However, this data currently does not exist for ZEVs. Information on medium- and heavy-duty ZEVs such as prices, residual values, battery deterioration, fuel economy, maintenance, and other factors are not as readily available for fleets. This information gap creates challenges in the decision-making process for fleets.
- **One-to-one Replacement.** Fleets have voiced concerns that a ZEV would not be able to perform the same work as an existing combustion-powered vehicle on a one-to-one basis due to payload, mileage, or other issues. Today, ZEVs cannot meet every duty cycle with a one-to-one replacement; however, ZEVs have shown that they can meet some duty cycles on a one-to-one basis today and as the technology continues to improve, more applications can transition to zero-emission with a one-to-one replacement.
- **Electricity rate structures.** Typical commercial and industrial rate structures are not always optimized for medium- and heavy-duty electrification. These rates have been traditionally designed for steady electricity usage with high fixed loads, not the

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[179] Electrification Coalition, *Electrifying Freight: Pathways to Accelerating the Transition*, 2020 (web link: https://www.electrificationcoalition.org/wp-content/uploads/2020/11/Electrifying-Freight-Pathways-to-Accelerating-the-Transition.pdf, last accessed January 2022).

intermittent usage associated with ZEV charging. This can result in higher electricity costs for fleets that are charging their vehicles in low-duration, high-power sessions if charger utilization is low. In response to these issues, the state's 3 largest investor-owned utilities, PG&E, SCE, and SDG&E, have all proposed commercial ZEV electricity rates. These new rates address issues that fleets are currently facing and will lower the cost of charging for ZEVs. This makes them a more competitive option versus their combustion counterparts. Further efforts are being made by the public utilities.

- **Stranded assets.** Fleets who have made investments in combustion-powered vehicles and infrastructure want to ensure they use their assets for their full useful life. The proposed regulation allows fleets to keep their vehicles for their full useful life as defined SB 1 which ensures existing vehicles and their supporting infrastructure can be used until the end of that asset's lifetime. Therefore, economic impacts of asset "stranding" are not likely to occur as no assets need be stranded. To the degree fleets opt to retire or replace vehicles early, they will be doing so because they view that course as the superior economic compliance choice.
- **Infrastructure planning and installation.** Switching from primarily diesel and gasoline to ZE technologies represents a paradigm shift for fleets. ZEVs require a completely different refueling strategy to fleets that can be a challenge with insufficient planning. Some issues identified include lead times for construction and interconnection, grid reliability, accommodating site layout and parking considerations, and site load management. However, numerous efforts are underway to address these issues. Under direction of SB 350, CPUC has approved applications from the state's investor-owned utilities for nearly $700 million over 5 years to support utility investments in medium-duty, heavy-duty, and off-road vehicle electrification. These programs will provide utility experience in delivering power to fleet's locations. The CEC has recently launched a $50 million program to fund medium-duty, heavy-duty, and off-road infrastructure titled EnergIIZE.[180] The program is a part of CEC's 2020-2023 investment plan to invest $129.8 million in medium- and heavy-duty ZEVs and infrastructure by 2023.[181] Private companies have also formed to streamline the process of fleet electrification by offering an all-in-one package to fleets. These programs are not included in the staff cost analysis and would lower the actual cost to fleets.

3.1.8 Cost-Effectiveness

Overall, the proposed regulation would result in significant emissions reductions but the net costs are lower than the Legal Baseline. For this reason, the costs and benefits are compared

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[180] California Energy Commission, *Energy Commission Announces Nation's First Incentive Project for Zero-Emission Truck and Bus Infrastructure*, 2021 (web link: https://www.energy.ca.gov/news/2021-04/energy-commission-announces-nations-first-incentive-project-zero-emission-truck, last accessed January 2022).

[181] California Energy Commission, *CEC Approves $384 Million Plan to Accelerate Zero-Emission Transportation*, 2020 (web link: https://www.energy.ca.gov/news/2020-10/cec-approves-384-million-plan-accelerate-zero-emission-transportation, last accessed January 2022).

as a benefit-cost ratio. Table 40 shows the estimated benefit-cost ratio for the proposed regulation.

Table 40. Benefit-Cost Ratio of the Proposed Regulation (billion $2021)

	Total Costs (TC)*	Cost-Savings (benefit)*	Health Benefits*	Tax and Fee Revenue	Total Benefit (TB)**	Net Benefit (TB – TC)	Benefit-Cost Ratio (TB ÷ TC)
Proposal	$84.6	$97.0	$61.7	-$36	$122.7	$38.1	1.5

*Total Costs and Cost-Savings are shown in Table 39 and Health Benefits in Table 10.
**Total Benefit = Cost-Savings + Health Benefits + Tax and Fee Revenue.

3.2 Direct Costs on Typical Businesses

Table 41 illustrates an example delivery fleet that owns 100 Class 5 walk-in vans and 100 Class 8 day cab tractors. This example can represent a fleet who moves goods to and from warehouses along freight corridors and to local distribution hubs. The costs from 2020-2050 are shown for a fleet in the Legal Baseline that only owns diesel vehicles purchased new in California, and under the ACF proposal scenario where the fleet would transition all their vehicles from diesel to battery-electric. In the baseline, the fleet operates their vehicles 10 years before replacing them and as a result buys 10 box trucks and 10 day cabs tractors per year. Under the proposed regulation, the fleet would meet the ZEV milestone targets set under the high priority fleet requirements and add ZEVs to the fleet. In the early years of the proposed regulation, the fleet can comply by ensuring a portion of their new purchases are ZEVs, but as the fleet approaches its 100 percent requirements it will need to accelerate replacement to ensure all diesel-powered vehicles leave the fleet and are replaced by ZEVs. This scenario assumes the fleet meets the minimum compliance requirements and assumes the fleet does not purchase any ZEVs early to avoid accelerated replacement. All other mileage and cost assumptions are the same as described previously in this section.

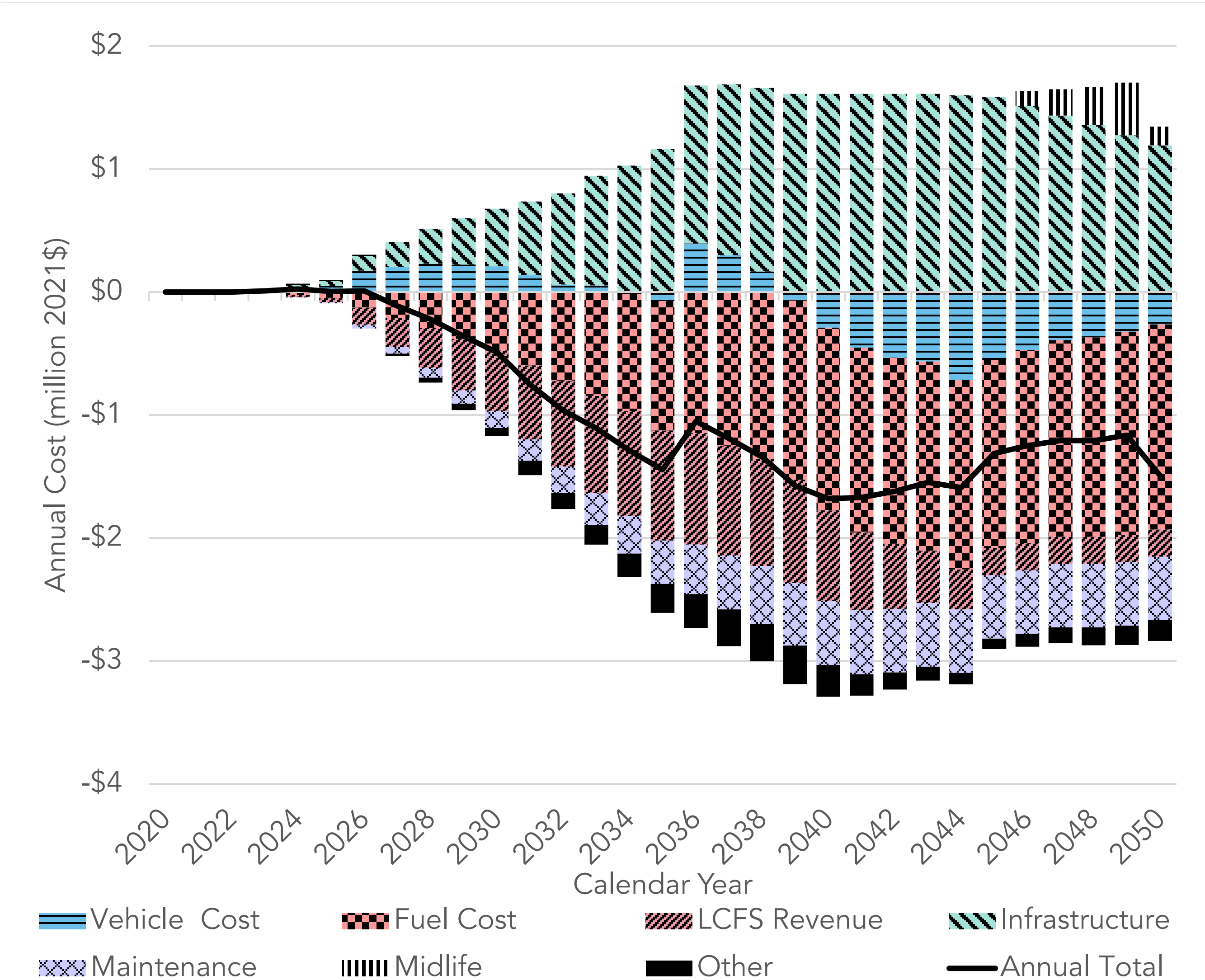
The costs over the analysis period are lower for the battery-electric fleet as compared to the diesel fleet (even with infrastructure costs included); however, the upfront capital expenses are higher initially but become lower after about 2035. Access to capital or financing will be critical for fleets to take advantage of the overall savings of medium- and heavy-duty ZEVs. Figure 22 shows the estimated costs for examples of a typical business.

Table 41. Typical Business Cumulative Cost Example 2024 to 2050 (2021$)

Cost line items	Legal Baseline 2030	ACF Proposal 2030	Legal Baseline 2040	ACF Proposal 2040	Legal Baseline 2050	ACF Proposal 2050	Difference 2050
Vehicle Price	$14,685,731	$15,642,581	$45,035,881	$47,818,215	$75,443,467	$73,298,665	-$2,144,802
Sales and Excise Tax	$2,698,173	$2,865,414	$6,655,722	$6,938,354	$10,613,271	$10,277,552	-$335,719

Cost line items	Legal Baseline 2030	ACF Proposal 2030	Legal Baseline 2040	ACF Proposal 2040	Legal Baseline 2050	ACF Proposal 2050	Difference 2050
EVSE & Infrastructure Costs	$0	$1,521,346	$0	$13,334,088	$0	$28,131,027	$28,131,027
Maintenance Bay Upgrades	$0	$48,274	$0	$219,195	$0	$230,975	$230,975
Fuel Cost	$31,129,984	$29,577,440	$68,629,847	$56,212,495	$107,407,314	$79,251,569	-$28,155,744
DEF Consumption	$420,289	$376,413	$904,788	$509,296	$1,384,947	$509,296	-$875,651
LCFS Revenue	$0	-$1,667,673	$0	-$9,745,633	$0	-$12,987,057	-$12,987,057
Maintenance Cost	$10,338,830	$9,849,816	$23,200,191	$18,928,186	$36,061,552	$26,624,399	-$9,437,153
Midlife Costs	$1,040,667	$1,040,667	$1,040,667	$1,040,667	$1,040,667	$2,263,707	$1,223,040
Registration Fees	$3,476,624	$3,345,371	$7,797,402	$6,338,450	$12,124,155	$8,639,178	-$3,484,977
Transitional Costs	$0	$214,835	$0	$214,835	$0	$214,835	$214,835
Residual Values	-$5,317,209	-$5,317,209	-$11,920,089	-$13,200,401	-$18,847,839	-$19,214,791	-$366,952
Depreciation	-$3,517,882	-$3,748,519	-$12,059,103	-$12,928,904	-$20,648,988	-$20,114,349	$534,639
Insurance Cost	$1,420,767	$1,463,448	$3,227,538	$3,296,439	$5,048,820	$4,898,627	-$150,193
Reporting Cost	$0	$9,652	$0	$21,717	$0	$33,782	$33,782
Total	**$56,375,973**	**$55,221,857**	**$132,512,843**	**$118,996,999**	**$209,627,367**	**$182,057,416**	**-$27,569,951**

Figure 22. Estimated Costs of Proposed Regulation to the Example Typical Business (million 2021$)



3.3 Direct Costs on Small Businesses

The example small business modeled is a drayage truck owner-operator subject to the drayage truck requirements. Drayage truck owners generally own 1 to 3 tractors and represent approximately 25 percent of drayage businesses. This percentage is based on vehicle identification numbers for tractors registered at the San Pedro Bay and Oakland seaports compared to California's DMV address registration data.

In the Legal Baseline scenario, the operator purchases a 2014 MY diesel day cab tractor in 2022 and operates it for 12 years. Following that, the operator would continue the pattern of purchasing an 8-year-old diesel day cab tractor and operating it for 12 years. In this example, the drayage operator purchases 8-year-old used tractors in 2034 and 2046.

Under this proposed regulation example, the operator owns a 2014 MY diesel day cab tractor purchased in 2022. The drayage operator would likely turn over their diesel tractor at the end of 2029 when the tractor is 15-years-old (average age or MY of tractors reaching 800,000 miles) and has exceeded the useful life and would replace it with a new 2030 MY battery-electric tractor which they would operate for 20 years.

Most assumptions are the same as previously described in this document; however, some modifications were made for this example to better illustrate the costs the small business would face:

- The drayage operator is assumed to finance their vehicles for 5 years at an interest rate of 15 percent;
- The drayage operator would not install infrastructure themselves and instead would rely solely on retail charging; and
- No transitional costs associated with maintenance or infrastructure planning are assumed as these are costs are associated with organizational shifts within a large business.

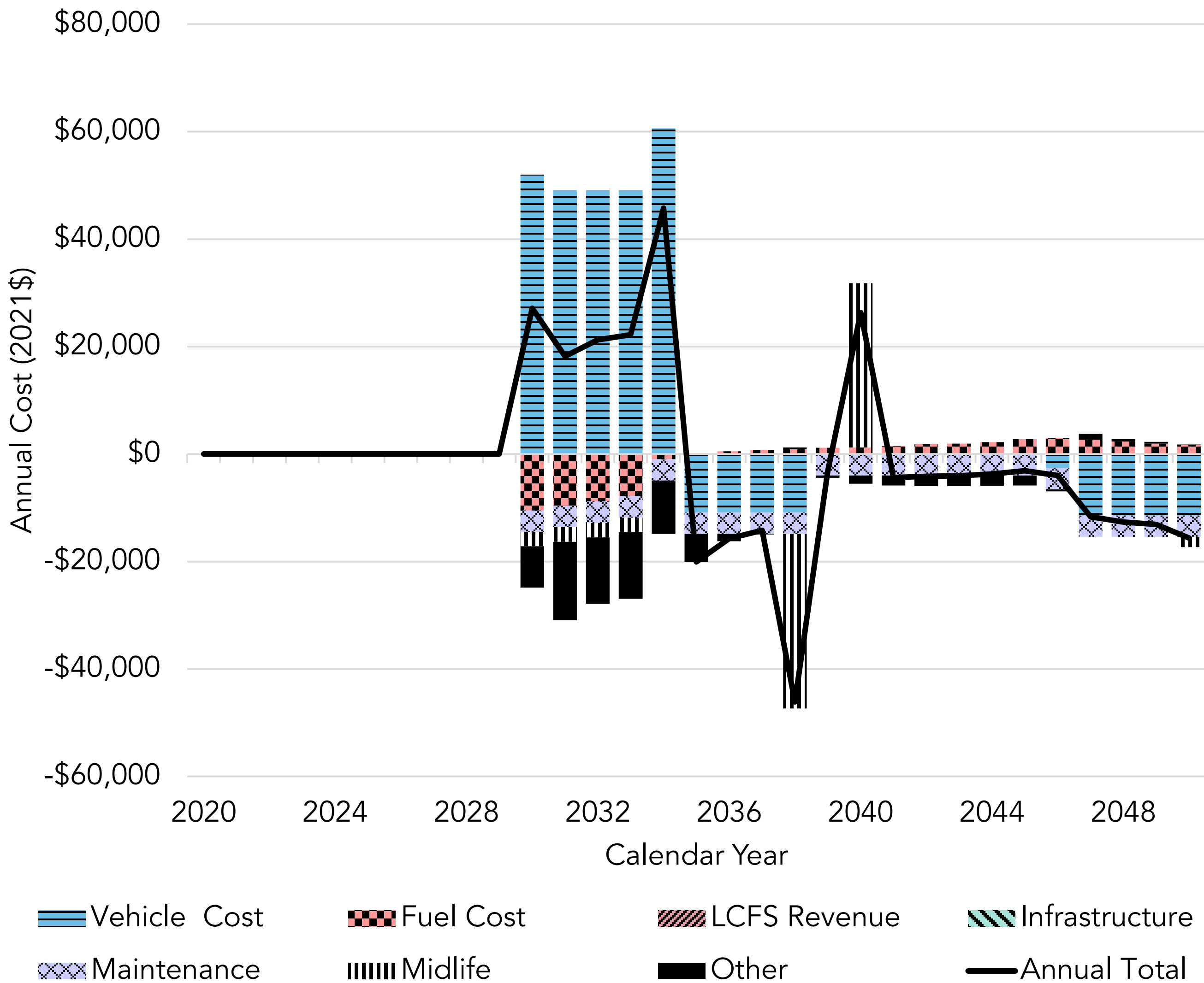
Table 42 and Figure 23 illustrate the costs for the example small business. The small business would see a net savings by 2040 and thereafter but would need to make significant upfront capital expenses in 2030 to purchase a new battery-electric tractor rather than buying another used diesel tractor. Incentives, financing assistance, and other programs offered will be helpful to support smaller operators with upfront capital expenses.

Table 42. Small Business Cumulative Cost Example 2024 to 2050

Cost line items	Legal Baseline 2030	ACF Proposal 2030	Legal Baseline 2040	ACF Proposal 2040	Legal Baseline 2050	ACF Proposal 2050	Difference 2050
Vehicle Price	$0	$49,106	$54,449	$245,531	$245,531	$245,531	$133,837
Sales and Excise Tax	$0	$33,745	$7,483	$33,745	$33,745	$33,745	$18,394
EVSE & Infrastructure Costs	$0	$0	$0	$0	$0	$0	$0
Maintenance Bay Upgrades	$0	$0	$0	$0	$0	$0	$0
Fuel Cost	$286,310	$275,812	$618,647	$585,387	$585,387	$932,196	-$11,466
DEF Consumption	$3,862	$3,380	$8,157	$3,380	$3,380	$3,380	-$8,803
LCFS Revenue	$0	$0	$0	$0	$0	$0	$0
Maintenance Cost	$79,265	$75,302	$178,347	$134,751	$134,751	$194,200	-$83,229
Midlife Costs	$21,667	$18,958	$62,292	$49,534	$49,534	$80,110	-$14,681
Registration Fees	$22,732	$21,915	$49,388	$34,591	$34,591	$43,736	-$32,399
Transitional Costs	$0	$0	$0	$0	$0	$0	$0

Cost line items	Legal Baseline 2030	ACF Proposal 2030	Legal Baseline 2040	ACF Proposal 2040	Legal Baseline 2050	ACF Proposal 2050	Difference 2050
Residual Values	$0	-$30,854	-$29,858	-$30,854	-$30,854	-$30,854	$15,693
Depreciation	$0	-$8,287	-$14,492	-$66,113	-$66,113	-$66,113	-$38,353
Insurance Cost	$4,431	$6,342	$9,172	$14,971	$14,971	$19,574	$5,876
Reporting Cost	$0	$48	$0	$109	$109	$169	$169
Total	$418,267	$445,466	$943,587	$1,005,031	$1,005,031	$1,455,672	-$14,961

Figure 23. Estimated Costs of Proposed Regulation to the Example Small Business (2021$)



3.4 Direct Costs on Individuals

There would be no direct costs on individuals as a result of this regulation. Individuals will realize health benefits, described in the Benefits Chapter, from statewide, regional, and local emissions benefits due to medium- and heavy-duty ZEVs displacing ICE vehicles. Manufacturers and fleets would see increased and decreased costs because of this rule which will indirectly impact individuals in the state. These indirect impacts are considered in the Macroeconomic Impacts Section.

4 Fiscal Impacts

The proposed regulation would impact State and local government expenditures through the purchase and operation of new vehicles and would impact revenues generated from a variety of State and local taxes and vehicle registration fee revenues that are collected.

These revenues, particularly those from State and local gasoline taxes and registration fees, are used to fund transportation projects across the state including road maintenance, construction of state highways and local streets, transit facilities and operation, and active transportation projects as described in Table 43 below. Thus, increases or decreases will impact funds available for these projects at the state, county, and local levels for use on road and transportation infrastructure improvements. We note that, though outside of this specific analysis, the transition towards zero emission vehicles and its impacts on some of these revenues, are the subject of continued policy development given the importance of the services funded. Thus, though this analysis does not assume the creation of new specific revenue-raising measures, such measures are not unlikely.

Table 43. Transportation Funding Source and Purpose

Revenue Source	Account/Program	Allocation Funding Purpose
Gasoline Excise Tax	State Highway Account (SHA)	highway projects and transportation maintenance and operational needs
	Road Maintenance & Rehabilitation Account (RMRA)	prioritized road maintenance and rehabilitation projects for state and local transportation systems
	Highway Users' Tax Account (HUTA)	local streets and roads projects
Diesel Excise Tax	Public Transportation Account (PTA)	transit and intercity and commuter rail operating programs and projects.
	RMRA	prioritized road maintenance and rehabilitation projects for the state and local transportation systems.
	SHA	highway projects and transportation maintenance and operational needs.
	Trade Corridors Enhancement Account (TCEA)	trade corridor projects

Revenue Source	Account/Program	Allocation Funding Purpose
State Sales Tax (diesel)	State Transit Assistance (STA)	transit purposes as outlined in the Transportation Development Act (TDA); local transit operation and capital purposes
	State Rail Assistance Program	intercity and commuter rail agencies for operation and capital purposes
Zero-Emission Vehicle Registration Fee	RMRA	basic road maintenance, rehabilitation, critical safety projects and other transportation initiatives, including complete street components for the state and local transportation systems
Motor Vehicle Registration Fees	California Highway Patrol (CHP) and Department of Motor Vehicles (DMV)	traffic law enforcement and regulations
Local Sales Tax Measures[182]	City/County Road Funds	Maintenance, new construction, engineering/administration, right of way, mass transit, and other
	Regional Transportation Planning Agencies (RTPAs)/Transit Operators	transit operations, transit planning

4.1 Local Government

4.1.1 Local Government Fleet Cost Pass-Through

The local government fleet is estimated to make up roughly 81 percent of California's public fleet based the total public fleet population and information from the Department of General Services. All local government fleets are subject to the proposed regulation with

[182] Counties can adopt a sales tax increase for transportation programs. The passage of a local sales tax measure requires 2/3 of local voter approval, generally lasting 20 to 30 years. Twenty-five counties have implemented sales tax measures for their transportation needs; and four transit authorities have approved permanent local tax measures.

requirements beginning for most fleets in 2024. Fleets located in designated counties would face their first requirements in 2027. A proportionate amount of the total costs outlined in Table 44 would be assumed to pass-through to local governments. Cost passthrough has been split into three categories – upfront costs, operating costs, and operating savings.

4.1.2 Utility User Taxes

Many cities and counties in California levy a Utility User Tax on electricity usage. This tax varies from city to city and ranges from no tax to 11 percent. A value of 3.53 percent was used in this analysis representing a population-weighted average.[183] By increasing the amount of electricity used, there would be an increase in the amount of the utility user tax revenue collected by cities and counties.

4.1.3 Gasoline and Diesel Fuel Taxes

Fuel taxes on gasoline and diesel fund transportation improvements at the state, county, and local levels. Displacing gasoline and diesel with electricity and hydrogen would decrease the total amount of gasoline and diesel dispensed in the state, resulting in a reduction in fuel tax revenue collected by local governments. Natural gas is not taxed by local governments and therefore is not included in this section. The local tax on fuel is listed in Table 28.

4.1.4 Local Sales Taxes

Sales taxes are levied in California to fund a variety of programs at the state and local level. The proposed regulation would require the sale of medium- and heavy-duty ZEVs in California resulting in a direct increase in sales tax revenue collected by local governments in the initial years of the regulation. Overall, local sales tax revenue may increase less than the direct increase from vehicle sales if overall business spending does not increase.

4.1.5 Fiscal Impacts on Local Government

Table 44 shows the estimated fiscal cost to local governments due to the proposed regulation relative to the Legal Baseline scenario. The fiscal impact to local government is estimated to be $288 million over the first 3 years of the regulation and $4.5 billion over the regulatory analysis period to 2050.

Table 44. Estimated Fiscal Impacts to Local Government (million 2021$)

Year	Local Government Fleet Upfront Cost Passthrough	Local Government Fleet Operational Cost Passthrough	Local Government Fleet Operational Saving Passthrough	Utility User Tax Revenue	Local Gasoline and Diesel Fuel Taxes	Local Sales Tax	Total Fiscal Impact*
2024	-$93	-$10	$27	$2	$97	$16	$40

[183] California State Controller's Office, *User Utility Tax Revenue and Rates*, 2017 (web page: https://sco.ca.gov/Files-ARD-Local/LocRep/2016-17 Cities UUT.pdf, last accessed January 2022).

Year	Local Government Fleet Upfront Cost Passthrough	Local Government Fleet Operational Cost Passthrough	Local Government Fleet Operational Saving Passthrough	Utility User Tax Revenue	Local Gasoline and Diesel Fuel Taxes	Local Sales Tax	Total Fiscal Impact*
2025	-$95	-$10	$56	$4	$90	$17	$63
2026	-$103	-$11	$83	$11	$79	$64	$123
2027	-$164	-$21	$128	$18	$66	$81	$107
2028	-$165	-$21	$170	$26	$54	$64	$128
2029	-$154	-$21	$206	$39	$35	$98	$203
2030	-$148	-$20	$216	$53	$14	$98	$213
2031	-$150	-$12	$237	$71	-$9	$123	$261
2032	-$148	-$14	$255	$91	-$32	$127	$279
2033	-$146	-$15	$267	$109	-$52	$105	$267
2034	-$145	-$17	$271	$132	-$78	$127	$290
2035	-$143	-$17	$274	$158	-$105	$125	$292
2036	-$146	-$18	$292	$181	-$130	$70	$248
2037	-$149	-$19	$293	$204	-$157	$79	$251
2038	-$152	-$19	$294	$228	-$185	$87	$254
2039	-$155	-$19	$313	$253	-$209	$81	$265
2040	-$158	-$19	$310	$276	-$241	-$44	$124
2041	-$160	-$18	$303	$300	-$276	-$27	$122
2042	-$161	-$18	$299	$325	-$312	-$9	$123
2043	-$163	-$18	$295	$339	-$331	-$69	$53
2044	-$152	-$19	$288	$346	-$348	-$49	$66
2045	-$143	-$19	$280	$360	-$367	-$28	$82
2046	-$136	-$20	$284	$370	-$391	-$13	$95
2047	-$118	-$21	$285	$381	-$412	$0	$115
2048	-$101	-$21	$289	$391	-$432	$13	$140
2049	-$88	-$21	$294	$402	-$453	$22	$155
2050	-$74	-$22	$298	$424	-$492	$32	$166
Total	**-$3,708**	**-$479**	**$6,607**	**$5,496**	**-$4,579**	**$1,187**	**$4,524**

*Note: Totals may differ due to rounding

4.2 State Government

4.2.1 CARB Staffing and Resources

To implement the proposed regulation, CARB would require permanent staffing resources. This would be met through a combination of new staffing resources and redirecting existing staffing resources. These resource needs are identified as follows:

- One new section consisting of one Air Resources Supervisor (ARS) I, two Air Resources Engineers (ARE), five Air Pollution Specialists (APS), and four Air Resources Technician (ART) II positions beginning in fiscal year (FY) 2023-2024 to implement the proposed regulation requirements on public and private fleets. Staff in this new section would provide compliance assistance to affected stakeholders, assist in outreach activities with business, public agencies, and fleet operators affected by the regulation to provided compliance assistance, and to support enforcement of the regulation. Staff would recognize ZEV fleets by posting compliant fleet information online and implement the ZEV Partner Program. Staff would develop program guidelines and applications, develop outreach materials, assist participants with inquiries, and audit information submitted by participants in the program.
- One ARE position beginning in FY 2023-2024 would be needed to develop and implement the database reporting system for the proposed regulation and provide ongoing support and maintenance.
- Two ART II, 0.25 ARS I, and 0.5 APS to assist drayage truck owners with CARB registration, verify annual compliance reporting requirements for the legacy fleet, provide technical assistance, answer calls and emails, analyze reported data sets, and develop and maintain an updated CARB online reporting system.
- Two APS, two ART II, and two ART I positions beginning in FY 2023-2024 would be used to conduct enforcement activities including data mining, reporting verification, inspections, audits, and other related activities. Table 45 shows the total number of additional positions and estimated cost per position.

Table 45. Estimated CARB Staffing Needs (million 2021$)

Position	Number of Positions	Initial Budget Year Cost ($/year per person)	Ongoing Cost ($/year per person)
Air Resources Supervisor	1.25	$238,000	$237,000
Air Resources Engineer	3	$206,000	$205,000
Air Pollution Specialist	7.5	$195,000	$194,000
Air Resources Technician I	2	$85,000	$84,000
Air Resources Technician II	8	$101,000	$100,000

In addition to staffing needs, the proposed regulation would require modifying an existing reporting system or developing a new system to handle the reporting. Staff is estimating contracting costs of $200,000 in FY 2023-2024 to set up or augment existing fleet reporting systems for this rule. The proposed regulation would also require contract funds for outreach related to the "Optional Certified ZEV Fleet and Partner Program"; however, staff estimates that current agency funds allocated towards outreach can cover these proposed costs, so no additional funding is necessary.

Six permanent intermittent personnel years would be redirected from the CARB Truck and Bus Call Center Team to primarily provide compliance assistance and respond to stakeholder inquiries via phone or email about all aspects of the proposed regulation.

4.2.2 State Fleet Cost Pass-Through

The State government fleet is estimated to make up 19 percent of California's public fleet based the total public fleet population and information from the Department of General Services. A proportionate amount of the total costs outlined in Table 46 would be assumed to pass-through the State governments. Cost passthrough has been split into three categories – upfront costs, operating costs, and operating savings.

4.2.3 Gasoline, Natural Gas, and Diesel Fuel Taxes

Fuel taxes on gasoline, natural gas, and diesel are used to fund transportation improvements at the state, county, and local levels. Displacing these combustion fuels with electricity and hydrogen would decrease the total amount of gasoline, natural gas, and diesel dispensed in the state. This would result in a reduction in revenue collected by the State for use in multiple levels of government. As noted above, though outside the scope of this analysis, State policy efforts continue to explore replacement revenue sources in light of the need for the zero-emission transition and the continuing need to fund vital services.

4.2.4 Energy Resources Fee

The Energy Resource Fee is a $0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities. The revenue collected is deposited into the Energy Resources Programs Account of the General Fund which is used for ongoing energy programs and projects deemed appropriate by the Legislature, including but not limited to, activities of the CEC.

4.2.5 Registration Fees

The State collects registration fees to fund transportation improvements at the state, county, and local levels. The fee structure for ZEVs is different from diesel vehicles with some fees such as the Vehicle License Fee being higher and others such as weight fees being lower. These differences result in lower registration fees for the ZEVs which would reduce revenue collected by the State for use in transportation services.

4.2.6 State Sales Tax

Sales taxes are levied in California to fund a variety of programs at the state and local level. This proposed regulation would require the sale of medium- and heavy-duty ZEVs in California resulting in higher sales tax collected by the State government in the initial years of the regulation.

4.2.7 Depreciation

In California, the State collects corporate income tax from businesses based on their net profit for the year at a rate of 8.84 percent. Depreciation can be treated as an expense and would reduce the tax burden for a fleet and decrease tax revenue for the State.

4.2.8 Fiscal Impacts on State Government

shows the estimated fiscal impacts to the State government due to the proposed regulation relative to Legal Baseline conditions. The fiscal impact to local government is estimated to be -$83 million over the first 3 years of the regulation and -$38.0 billion over the regulatory analysis period to 2050.

Table 46. Estimated Fiscal Impacts on State Government (million 2021$)

Year	CARB Staffing and Resources	State Government Fleet Upfront Cost Passthrough	State Government Fleet Operational Cost Passthrough	State Government Fleet Operational Saving Passthrough	State Fuel Taxes	Energy Resources Fees	Registration Fees	State Sales Taxes	Depreciation	Total Fiscal Impact*
2023	-$2	$0	$0	$0	$0	$0	$0	$0	$0	-$2
2024	-$3	-$22	-$2	$6	-$15	$0	$0	$14	-$6	-$28
2025	-$3	-$22	-$2	$13	-$27	$0	-$2	$14	-$24	-$53
2026	-$3	-$24	-$3	$19	-$59	$0	-$8	$54	-$80	-$104
2027	-$3	-$39	-$5	$30	-$100	$0	-$17	$68	-$177	-$242
2028	-$3	-$39	-$5	$40	-$138	$1	-$24	$54	-$266	-$380
2029	-$3	-$36	-$5	$48	-$208	$1	-$35	$83	-$365	-$520
2030	-$3	-$35	-$5	$51	-$285	$1	-$52	$83	-$487	-$732
2031	-$3	-$35	-$3	$56	-$369	$1	-$72	$104	-$595	-$917
2032	-$3	-$35	-$3	$60	-$453	$2	-$90	$107	-$683	-$1,099
2033	-$3	-$34	-$4	$63	-$523	$2	-$108	$88	-$732	-$1,252
2034	-$3	-$34	-$4	$64	-$621	$2	-$136	$107	-$778	-$1,404
2035	-$3	-$34	-$4	$64	-$724	$3	-$164	$106	-$829	-$1,585
2036	-$3	-$34	-$4	$68	-$816	$3	-$193	$59	-$827	-$1,747
2037	-$3	-$35	-$4	$69	-$917	$3	-$226	$66	-$788	-$1,836
2038	-$3	-$36	-$4	$69	-$1,025	$4	-$259	$73	-$762	-$1,943
2039	-$3	-$36	-$4	$73	-$1,120	$4	-$286	$69	-$731	-$2,035
2040	-$3	-$37	-$4	$73	-$1,218	$4	-$309	-$37	-$584	-$2,116
2041	-$3	-$37	-$4	$71	-$1,329	$5	-$340	-$23	-$385	-$2,045
2042	-$3	-$38	-$4	$70	-$1,445	$5	-$369	-$8	-$254	-$2,046
2043	-$3	-$38	-$4	$69	-$1,491	$5	-$379	-$58	-$81	-$1,980
2044	-$3	-$36	-$4	$68	-$1,535	$5	-$394	-$42	$121	-$1,821
2045	-$3	-$34	-$4	$66	-$1,594	$6	-$409	-$24	$221	-$1,776
2046	-$3	-$32	-$5	$67	-$1,662	$6	-$421	-$11	$239	-$1,823
2047	-$3	-$28	-$5	$67	-$1,726	$6	-$431	$0	$225	-$1,896
2048	-$3	-$24	-$5	$68	-$1,791	$6	-$442	$11	$174	-$2,006
2049	-$3	-$21	-$5	$69	-$1,858	$6	-$451	$18	$85	-$2,160
2050	-$3	-$17	-$5	$70	-$2,006	$7	-$483	$27	-$8	-$2,420
Total*	-$92	-$870	-$112	$1,550	-$25,056	$89	-$6,102	$1,004	-$8,378	-$37,968

*Note: Totals may differ due to rounding

5 Macroeconomic Impacts

5.1 Methods for determining economic impacts

This section describes the estimated total impact of the proposed regulation on the California economy. The proposed regulation would result in incremental cost and cost-savings for businesses to comply with the regulation. These costs would result in direct changes in expenditures in the economy and are passed on to businesses. These changes in expenditures by businesses would indirectly affect employment, output, and investment in sectors that move freight and provide services to affected businesses.

These direct and indirect effects would lead to induced effects, such as changes in personal income that affect consumer expenditures across other spending categories. The total economic impact is the sum of these effects and is presented in this section. The total economic impact of the proposed regulation is simulated relative to the baseline scenario using the cost estimates described in Section C. The analysis focuses on the changes in major macroeconomic indicators from 2022 to 2050, including employment, output, personal income, and gross state product (GSP). The years of the analysis are used to simulate the proposed regulations through more than 12 months post full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 2.5.0 is used to estimate the macroeconomic impacts of the Proposed Regulation 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.[184] REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the Proposed Regulation, 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.[185,186]

Specifically, 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

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[184] For further information and model documentation see: *https://www.remi.com/model/pi/*

[185] California Legislature, Senate Bill 617. October 2011.

[186] California Department of Finance, Chapter 1: Standardized Regulatory Impact Analysis for Major Regulations - Order of Adoption. December 2013.

2021.[187,188,189,190] 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 regulation 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 regulation. The direct costs and savings estimated in Section C and the non-mortality related health benefits estimated in Section B are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[191]

The direct costs of the proposed regulation, as described in Section C, would include changes in upfront costs to fleets for the increased purchase of ZEVs and decreased purchase of ICE vehicles. The net change in vehicle costs is input into the economic model as an increase in production costs for all industries in California that operate fleets anticipated to be affected by the proposed regulation (see Table 47). Fleets which use ZEVs would realize changes in production costs related to their change in fuel mix, operations costs, and maintenance and repair costs. Fleets would also need to make investments in infrastructure to support their use of the ZEVs, which would increase their production costs. Fleets that own ZEV infrastructure to charge their vehicles would be able to generate LCFS credits and receive a direct financial benefit. Fleets required to accelerate the retirement of their non-ZEVs may see an increased residual value from resale of the vehicles on the used market, as described in the Direct Costs Section of this report. This however is not expected to result in any statewide economic impact, as other fleets would also be purchasing the vehicles at the higher residual value, directly offsetting revenue received by the seller as an expenditure to the buyer. Finally, changes in fleets' vehicle purchases, fuel use, and other activities would reduce the amount paid in federal, State, and local taxes and fees. The total change in taxes and fees businesses pay are modeled as a reduction in production costs for the fleets.

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[187] California Department of Finance. Economic Research Unit. National Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.

[188] California Department of Finance. Economic Research Unit. California Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.

[189] California Department of Finance. Economic Research Unit. National Deflators: Calendar Year averages: from 1929, April 2021. Sacramento: California. January 2022.

[190] 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.

[191] Refer to the Macroeconomic Appendix for a full list of REMI inputs for this analysis.

Table 47. Share of Vehicles Owned and Operated by Fleets Affected by the High Priority and Federal Fleet Requirements of the Proposed Regulation

Major Sectors	NAICS	Share of Vehicles
Agriculture and Natural Resources	111-115, 21	5.12%
Construction	23	9.35%
Manufacturing	31-33	4.37%
Retail and Wholesale	42, 44-45	15.44%
Transportation and Public Utilities	22, 48, 492-493	50.40%
Finance, Insurance & Real Estate	52, 53	1.13%
Services	51, 54-56, 61, 62, 71, 72, 81	14.14%
Government (Public Administration)	92	0.05%

Costs and savings incurred by fleets would result in corresponding changes in final demand for industries supplying those particular goods or services as shown in Table 48. The term "fleets" in the table includes all of the industries with businesses operating affected vehicles as shown in Table 47. As fleets' purchase of vehicles are estimated to be primarily from out-of-state manufacturers, demand changes for the corresponding ZEV supply chain cannot be directly modeled as a change in final demand in California. In order to account for this, staff estimates the share of demand which may be fulfilled by California businesses, based on California's share of national output for the industry (electrical component mfg.).[192] All other changes in demand are included in this analysis. The infrastructure upgrades necessary for fleet use of ZEVs is assumed to be provided by businesses in the construction sector (NAICS 23). The EVSE and maintenance is assumed to be supplied by businesses in the Other Electrical Equipment and Component Manufacturing industry (NAICS 3359). The change in demand for vehicle maintenance and midlife rebuild is realized by the automotive repair and maintenance industry (NAICS 8111). The reduction in gasoline and diesel fuel demand is assumed to be incurred by the Petroleum and Coal Products manufacturing industry (NAICS 324), while the decrease in natural gas demand occurs for the Natural gas distribution industry (NAICS 2212). The increased demand for electricity and hydrogen fuel is assumed to be provided by the Electric power generation, transmission, and distribution industry (NAICS 2211) and Basic Chemical manufacturing industry (NAICS 3251), respectively. The reporting cost and the workforce training and development are assumed to be provided by the Office administrative services (NAICS 5611, 5612) and private education services industries (NAICS 61), respectively. The change in demand for gasoline stations (NAICS 4471) selling some of the products above, is estimated based on the retail margin for that industry and entered in

[192] Based on REMI Policy Insight Plus (v 2.4.1), California's share of national output is 2.3 percent for motor vehicle parts mfg. (3363) in 2019.

as change in final demand for the retail sector (NAICS 44-45).[193] Finally, the LCFS credits generated by fleets that install and use EVSE are assumed to be purchased by producers of fossil fuels, which pass those costs through in the price of fuel; this is modeled as an increase in fuel costs for individuals and businesses in California.

Table 48. Sources of Changes in Production Cost and Final Demand by Industry

Source of Cost or Savings for Fleets	Industries with Changes in Final Demand (NAICS)
Vehicle Prices	Upfront cost: Electrical Component Mfg.[a] (3363)
Infrastructure upgrades	Upfront cost: Construction (23)
Electric Vehicle Supply Equipment	Upfront cost: Other Electrical Equipment and Component Mfg. (3359)
EVSE maintenance	Upfront cost: Construction (23)
Vehicle maintenance and midlife rebuild	One-time and recurring cost: Automotive Repair and Maintenance (8111)
Gas and diesel fuel	Recurring cost: Petroleum and Coal Products Mfg. (324)
Natural gas	Recurring cost: Natural Gas Distribution (2212)
Hydrogen fuel	Recurring cost: Basic Chemical Manufacturing (3251)
Diesel Exhaust Fluid	Recurring cost: Agricultural Chemical mfg. (3253)
Workforce training and education	Recurring costs: Education Services; Private (61)

[193] A gross margin 10.5 percent is used, based on the average gross margin of small and medium gasoline stations (NAICS 4471) from *Bizminer* (https://www.bizminer.com/).

Source of Cost or Savings for Fleets	Industries with Changes in Final Demand (NAICS)
Reporting	One-time cost: Office Administrative Services; Facilities Support Services (5611, 5612)
LCFS credit generation	Recurring cost: Fuel prices[b]

[a] The Industry Sales policy variable is used here rather than Exogenous Final Demand.
[b] Individuals and each industry share of cost resulting from increasing fuel prices is based on data from REMI v2.5 (see the Macroeconomic Appendix for the distribution).

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, primarily from changes in fuel and sales tax revenue, depreciation, and registration fees, as described in Section D. The changes in fuel tax revenue would change the production costs for fleets and the corresponding change in government revenue is modeled as a change in State and local government spending, assuming this revenue reduction is not offset elsewhere. Additional CARB staff and resources in support of this regulation are modeled as changes in State government employment and spending. The change in federal excise tax revenue and depreciation is outside the scope of the economic model and not evaluated here.

The health benefits resulting from the emissions reductions of the proposed regulation would reduce healthcare costs for individuals on average. 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. The GHG emissions reductions benefits, as valued through the SC-CO_2, represent the avoided damage from climate change worldwide per metric ton of CO_2e. These benefits fall outside the scope of our economic model and are not evaluated here.

5.3 Results of the assessment

The results from the REMI model provide estimates of the impact of the proposed regulation on the California economy. These results represent the annual incremental change from the implementation of the proposed regulation relative to the baseline scenario. The California economy is forecasted to grow through 2050, therefore, negative statewide impacts reported here should be interpreted as a slowing of growth and positive impacts as an acceleration of growth resulting from the proposed regulation. The results are reported here in tables for every four years from 2022 through 2050.

5.3.1 California Employment Impacts

Table 49 presents the impact of the proposed regulation on total employment in California across all industries. Employment comprises estimates of the number of jobs, full-time plus 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 regulation is estimated to initially result in a slightly positive employment impact through about 2026 after which the trend reverses with a negative employment impact through rest of the regulatory horizon. The results are further described at the industry level in the following paragraph. These changes in employment do not exceed 0.2 percent of baseline California employment across the entire regulatory horizon.

Table 49. Total California Employment Impacts

Metric	2026	2030	2034	2038	2042	2046	2050
California Employment	25,955,120	25,988,237	26,215,483	26,620,729	27,193,545	27,865,042	28,673,835
% Change	0.00%	-0.07%	-0.13%	-0.16%	-0.13%	-0.09%	-0.15%
Change in Total Jobs	21	-18,835	-33,107	-43,138	-34,577	-25,572	-41,990

The total employment impacts shown above are net of changes at the industry level. The overall trend in employment changes by major sector are illustrated in Figure 24 and Table 50 shows the changes in employment by industries that would be directly impacted by the proposed regulation. As the requirements of the proposed regulation go into effect the industries generally realizing reductions in production cost or increases in final demand would see an increase in employment growth. This initially includes the construction sector as businesses install EVSE and make other facility upgrades, and the electric power sector due to increased demand. The directly affected fleets, which primarily operate in the transportation and warehousing sector, would initially see a decrease in employment due to higher vehicle costs, but as those vehicles are operated the operational savings build up over time, reducing production costs for the industry reducing the negative impact. The reduced spending on maintenance and repair costs for ZE trucks would result in a downward trend in employment for the industry. The largest decrease in employment results from the public sector, which is estimated to realize a decrease in fuel and sales tax revenue and registration fees. This foregone revenue may eventually be replaced by revenue from other sources, in which case these negative job impacts to State and local government would be diminished. However, this is outside the scope of the proposed regulation and not evaluated here. It is important to note that many of these negative job impacts represent a structural shift for these industries that directly correspond to substantial benefits to ZEV owners who would have much lower operational costs from the lower fuel expenses and reduced maintenance and repair of ZEVs.

Figure 24. Job Impacts by Major Sector

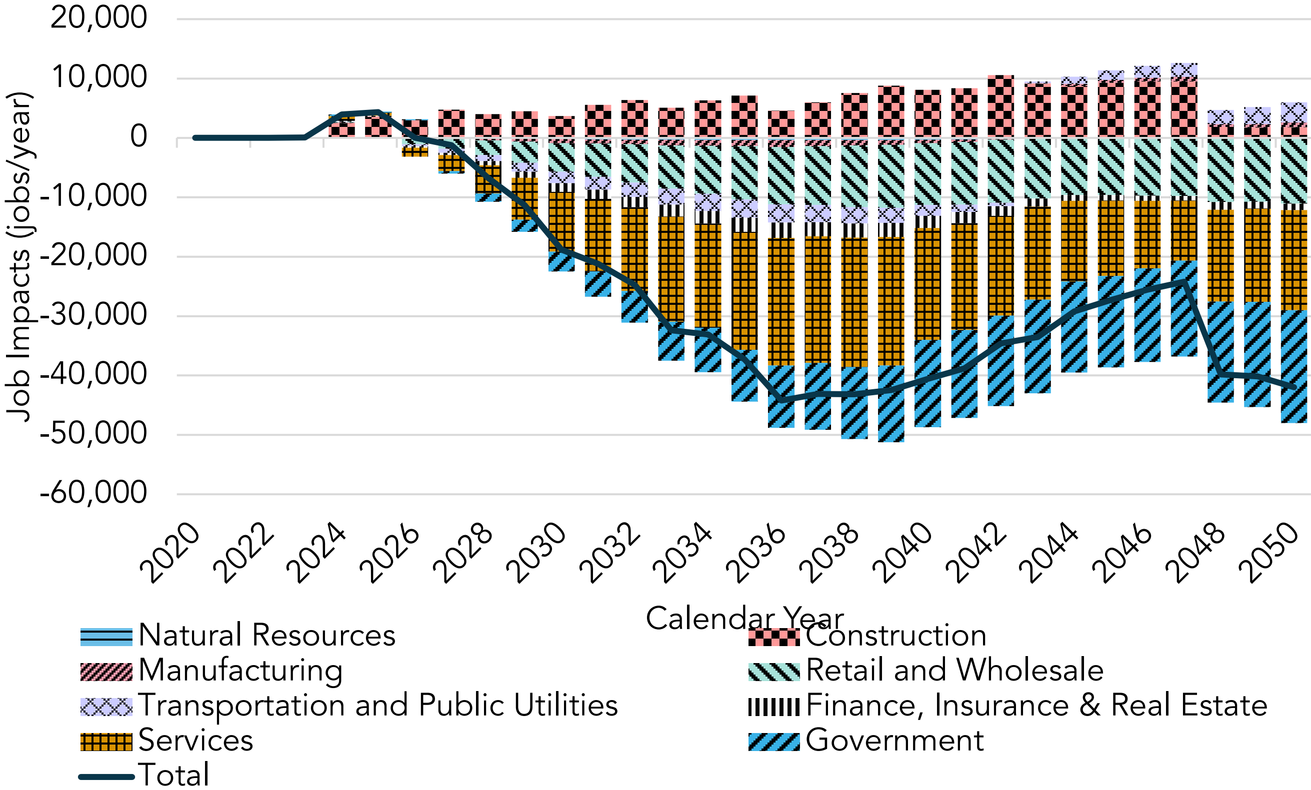


Table 50. Employment Impacts by Primary and Secondary Industries

Industry	Metric	2026	2030	2034	2038	2042	2046	2050
Transportation and Warehousing (48, 492-493)	% Change	0.00%	-0.12%	-0.22%	-0.26%	-0.14%	-0.01%	0.06%
	Change in Jobs	-70	-1,718	-3,238	-3,967	-2,229	-160	1,001
Electric power generation, transmission and distribution (2211)	% Change	0.20%	0.92%	2.30%	3.93%	5.73%	6.07%	6.66%
	Change in Jobs	75	332	791	1,302	1,819	1,882	2,013
Natural gas distribution (2212)	% Change	-0.07%	-0.35%	-0.66%	-0.95%	-1.12%	-1.15%	-1.30%
	Change in Jobs	-9	-43	-80	-112	-127	-128	-141
Construction (23)	% Change	0.22%	0.28%	0.48%	0.57%	0.67%	0.69%	0.11%
	Change in Jobs	3,009	3,660	6,327	7,573	9,124	9,468	1,610
Petroleum and coal products manufacturing (324)	% Change	-0.16%	-0.83%	-1.62%	-2.40%	-3.07%	-3.20%	-3.62%
	Change in Jobs	-20	-100	-189	-270	-333	-340	-376

Industry	Metric	2026	2030	2034	2038	2042	2046	2050
Retail trade (44-45)	% Change	-0.04%	-0.20%	-0.35%	-0.45%	-0.43%	-0.41%	-0.45%
	Change in Jobs	-829	-3,870	-6,605	-8,481	-8,438	-8,277	-9,437
Automotive repair and maintenance (8111)	% Change	-0.39%	-1.63%	-2.95%	-4.02%	-3.76%	-3.07%	-4.95%
	Change in Jobs	-903	-3,778	-6,834	-9,343	-8,750	-7,174	-11,634
State & Local Government	% Change	0.01%	-0.14%	-0.30%	-0.48%	-0.59%	-0.61%	-0.72%
	Change in Jobs	162	-3,375	-7,474	-12,132	-15,218	-15,747	-19,019

5.3.2 California Business Impacts

Gross output is used as a measure for business impacts as 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 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 would likely experience output growth.

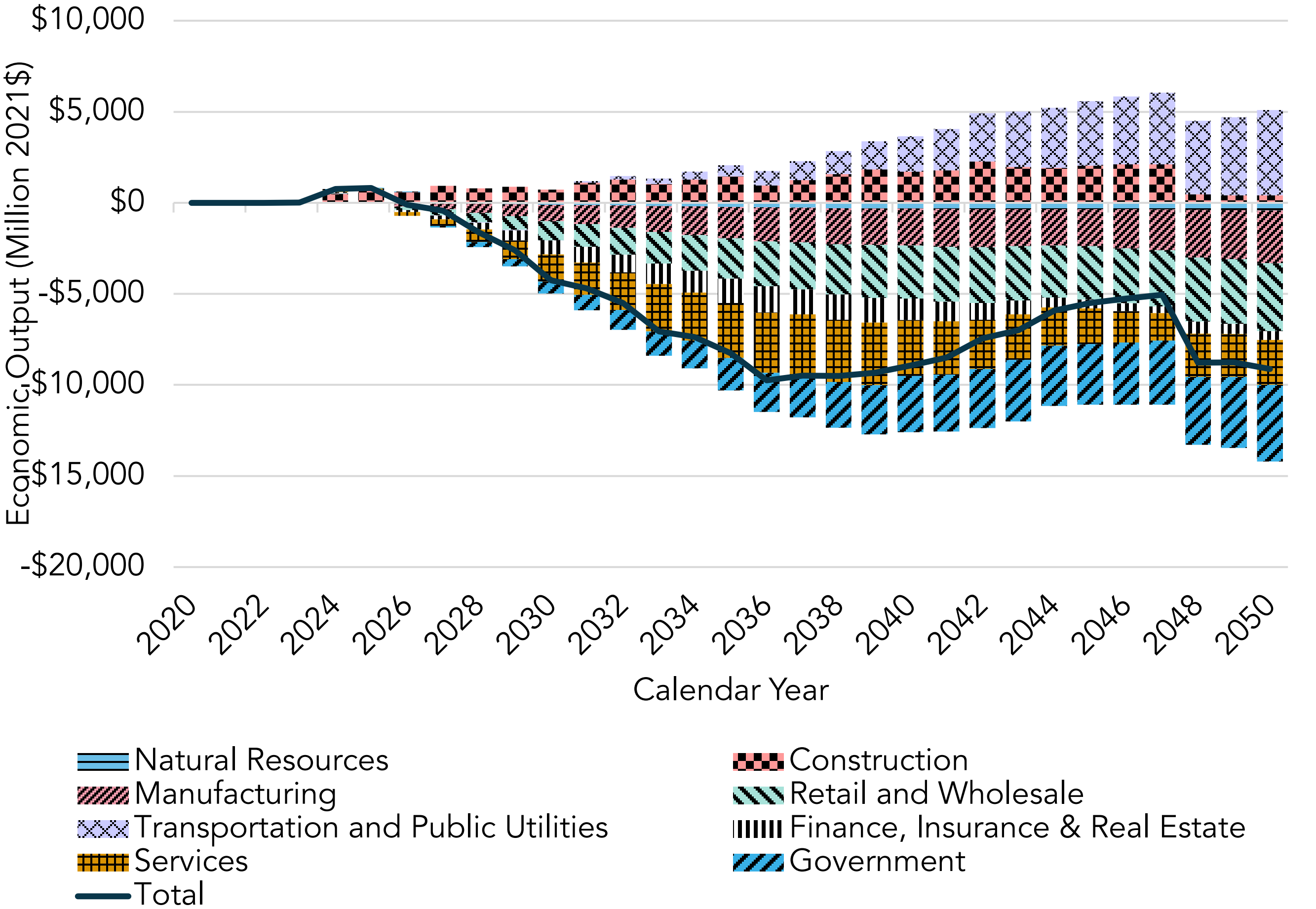
The results of the proposed regulation show a decrease in output of $99 million in 2030 and a decrease of $5.3 billion in 2050 as shown in Table 51. The trend in output changes is illustrated by major sector in Figure 25. Similar to the employment impacts, there would initially be positive impacts on output for construction and electric power sectors, which trend towards positive impacts over time as the operational savings accumulate, leading to output growth. There would be negative impacts on output in the oil and gas extraction, automotive repair and maintenance, and public sectors. The negative output impact on manufacturing is primarily driven by the petroleum and coal products manufacturing industry, which is estimated to see a relatively large decrease in final demand for diesel and gasoline.

Table 51. Change in Output Growth in California by Industry

Industry	Metric	2026	2030	2034	2038	2042	2046	2050
California Economy	Output (2021M$)	6,064,336	6,365,917	6,725,733	7,189,243	7,777,733	8,433,448	9,169,339
	% Change	0.00%	0.00%	-0.07%	-0.11%	-0.13%	-0.10%	-0.06%
	Change (2021M$)	0	-99	-4,256	-7,379	-9,506	-7,440	-5,253
Transportation and Warehousing (48, 492-493)	% Change	0.00%	-0.01%	-0.17%	-0.31%	-0.39%	-0.30%	-0.09%
	Change (2021M$)	0	-18	-351	-685	-905	-731	-226

Industry	Metric	2026	2030	2034	2038	2042	2046	2050
Electric power generation, transmission and distribution (2211)	% Change	0.00%	0.20%	0.93%	2.31%	3.96%	5.56%	6.13%
	Change (2021M$)	0	102	494	1,284	2,310	3,434	4,014
Natural gas distribution (2212)	% Change	0.00%	-0.07%	-0.35%	-0.67%	-0.96%	-1.14%	-1.15%
	Change (2021M$)	0	-7	-39	-76	-112	-138	-144
Construction (23)	% Change	0.00%	0.23%	0.28%	0.49%	0.58%	0.80%	0.71%
	Change (2021M$)	0	581	732	1,284	1,574	2,261	2,108
Petroleum and coal products manufacturing (324)	% Change	0.00%	-0.16%	-0.83%	-1.63%	-2.41%	-3.05%	-3.21%
	Change (2021M$)	0	-154	-855	-1,782	-2,800	-3,795	-4,288
Retail trade (44-45)	% Change	0.00%	-0.04%	-0.21%	-0.36%	-0.47%	-0.47%	-0.43%
	Change (2021M$)	0	-120	-624	-1,173	-1,665	-1,920	-1,985
Automotive repair and maintenance (8111)	% Change	0.00%	-0.39%	-1.66%	-3.02%	-4.13%	-3.75%	-3.20%
	Change (2021M$)	0	-103	-449	-844	-1,199	-1,133	-1,006
State & Local Government	% Change	0.00%	0.01%	-0.14%	-0.30%	-0.48%	-0.59%	-0.60%
	Change (2021M$)	0	32	-674	-1,519	-2,517	-3,237	-3,427

Figure 25. Change in Output in California by Major Sector



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 for the proposed regulation are shown in Table 52 and shows a decrease of private investment of about $1.0 billion in 2030 which trends towards an increase of $2.49 billion in 2050. These changes in investment do not exceed 0.4 percent baseline investment across the regulatory horizon.

Table 52. Change in Gross Domestic Private Investment Growth

Metric	2026	2030	2034	2038	2042	2046	2050
Private Investment (2021M$)	547,621	571,932	605,292	646,614	693,307	742,261	795,973
% Change	-0.03%	-0.18%	-0.19%	-0.07%	0.17%	0.33%	0.31%
Change (2021M$)	-172	-1,040	-1,141	-453	1,200	2,436	2,492

5.3.4 Impacts on Individuals in California

The proposed regulation would impose no 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 53 estimates annual change in real personal income across all individuals in California due to the proposed regulation. Total personal income growth decreases by about $3.86 billion in 2030 but the impact begins to diminish after 2040, resulting in a decrease of about $2.1 billion by 2050, not exceeding 0.2 percent of the baseline. The change in personal income estimated here can also be divided by the California population to show the average or per capita impact on personal income. The change in personal income growth is estimated to decrease $19 per person in 2030, which trends positive over time resulting in an increase of $68 per person in 2050.[194]

Table 53. Impacts on Individuals in California

Metric	2026	2030	2034	2038	2042	2046	2050
Personal Income (2021M$)	2,861,550	3,187,013	3,477,682	3,737,691	4,040,484	4,378,592	4,745,721
% Change	-0.02%	-0.11%	-0.17%	-0.18%	-0.11%	-0.05%	-0.04%
Change (2021M$)	-764	-3,855	-6,195	-7,140	-4,745	-2,180	-2,071

[194] The sign of the change in personal income per capita differs from overall personal income due to population growth changes estimated by the REMI model as a result of the proposed regulation.

Metric	2026	2030	2034	2038	2042	2046	2050
Personal Income per capita (2021$)	68,996	76,178	81,152	86,202	91,813	98,550	106,058
% Change	-0.02%	-0.08%	-0.08%	-0.05%	0.03%	0.06%	0.06%
Change (2021$)	-19	-64	-71	-44	25	62	68

5.3.5 Impacts on 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. Under the proposed regulation, GSP growth would be anticipated to decrease by about $2.42 billion in 2030 and by $4.28 billion in 2050 as shown in Table 54. These changes do not exceed 0.2 percent of baseline GSP. This metric summarizes impacts discussed above, including consumer spending, investment, and government spending. This is why the results trend negative, as the decrease in consumer and government spending in California would outweigh the increase in investment resulting from the proposed regulation.

Table 54. Change in Gross State Product

Metric	2026	2030	2034	2038	2042	2046	2050
GSP (2021M$)	3,666,219	3,893,045	4,161,493	4,471,810	4,822,161	5,207,097	5,630,591
% Change	0.00%	-0.06%	-0.10%	-0.12%	-0.08%	-0.04%	-0.08%
Change (2021M$)	-43	-2,420	-4,169	-5,276	-3,796	-2,293	-4,276

5.3.6 Creation or Elimination of Businesses

The REMI model cannot directly estimate the creation or elimination of businesses. However, changes in jobs and output for the California economy described above can be used to understand some potential impacts. The overall jobs and output impacts of the proposed regulation would be small relative to the total California economy, representing changes of no greater than 0.2 percent. However, impacts to specific industries are larger as described in previous sections. While there would initially be negative impacts on the transportation and warehousing sector, these diminish over time. The trend of increasing demand for the construction sector to provide services related to EV charging has the potential to lead to an expansion or creation of businesses over time. While the electric power sector similarly sees large increases in demand, its services are provided by public utilities, which would not directly impact business creation. The decreasing trend in demand for gasoline and diesel fuel following from this proposed regulation has the potential to result in the elimination of businesses in this industry and downstream industries, such as gasoline stations and vehicle repair businesses, if sustained over time.

5.3.7 Incentives for Innovation

The proposed regulation provides flexibility for fleets to purchase ZEVs ahead of their requirements. Private and public fleet owners that purchase ZEVs before they are required would be able to count them towards a future compliance requirement to gain flexibility when making future vehicle purchase. This may encourage fleets to make ZEV purchases early for vehicles that are well suited to their needs which could provide flexibility to purchase ICE vehicles in later years. High priority and federal fleets could purchase Group 1 ZEVs at any point prior to 2025, Group 2 ZEVs at any point prior to 2027, and Group 3 ZEVs at any point prior to 2030. Drayage fleets could add ZEVs to the drayage online reporting system at any point prior to turnover requirements or the 2035 ZEV deadline. Fleets that act early would be more likely to be eligible for incentive programs that may be available to finance costs or lower the upfront cost.

ZEVs are anticipated to lead to other unquantified benefits and operational efficiencies that may provide another incentive for fleets to use ZEVs to better serve customers. For example, ZEV may be able to make deliveries at night where noise ordinances limit deliveries, their quiet operation can also improve safety at a work site, and the ability to plug in power tools or export power at a job site or as back-up power may increase overall productivity.

Staff anticipates growth in industries who manufacture or support ZEVs including ZEV manufacturer and component suppliers, infrastructure installers, electrical vehicle technicians, and others. This growth would strengthen the ZEV supply chain, foster a ZE market, and promote technology growth sooner than would have otherwise occurred.

5.3.8 Competitive Advantage or Disadvantage

The proposed regulation has three primary regulatory components for different fleet types and each addresses competitive advantage or disadvantage differently.

The public fleet requirement would not be anticipated to create a competitive advantage or disadvantage. Public agencies do not compete against each other, and each agency would be able to identify the strategy which allows them to comply within their allocated budgets.

The drayage truck requirement would not be anticipated to create a competitive advantage or disadvantage. The proposal applies equally to all drayage trucks that enter seaports and railyards. It also applies equally to California companies as well as companies headquartered out-of-state.

The high priority and federal fleet requirement would not be anticipated to create a significant change in competitive advantage or disadvantage. First, federal agencies do not compete with other fleets and would not have a competitive advantage or disadvantage. For high priority fleets, the milestone requirements apply to all trucks that operate in California regardless of where the truck or company is headquartered and would be phased in by truck type. This ensures that all vehicles in these fleets would be subject to the same requirements.

Fleets that do not meet the fleet size or revenue threshold would not be regulated by this proposal, but the risk of creating a competitive advantage or disadvantage is mitigated as these fleets would become subject to the regulation if their revenue or fleet size increases above the thresholds established in the regulation. In addition, the fleet size for determining which fleet would be subject to the regulation includes all medium- and heavy-duty vehicles that are operated under common ownership and control. This ensures a level playing field between businesses that compete for the same work regardless of their business model.

5.4 Summary and Agency Interpretation of the Assessment Results

The results of the macroeconomic analysis of the proposed regulation are summarized in Table 55. As analyzed here, CARB estimates the proposed regulation would be 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 0.2 percent of the baseline. While the proposed regulation would initially result in decreased growth in the transportation and warehousing sector in California, it trends positively over time diminishing the negative impact. Both the construction and electric power sectors would see large positive growth by providing their services to affected fleets. The diesel and gasoline fuel savings for the fleets represent decreased demand for gasoline and diesel from the industry, implying a decrease in growth for the industry and downstream industries such as gasoline stations and vehicle repair. This analysis also shows the negative impact estimated for State and local government output and employment due to tax revenue decreases, without any offsetting revenues. This foregone revenue, which supports important programs in the state, may eventually be replaced by revenue from other sources, in which case these negative impacts to State and local government would be diminished.

Table 55. Summary of Macroeconomic Impacts of Proposed Regulation

Indicator	Metric	2026	2030	2034	2038	2042	2046	2050
GSP	% Change	0.00%	-0.06%	-0.10%	-0.12%	-0.08%	-0.04%	-0.08%
	Change (2021M$)	-43	-2,420	-4,169	-5,276	-3,796	-2,293	-4,276
Personal Income	% Change	-0.02%	-0.11%	-0.17%	-0.18%	-0.11%	-0.05%	-0.04%
	Change (2021M$)	-764	-3,855	-6,195	-7,140	-4,745	-2,180	-2,071
Employment	% Change	0.00%	-0.07%	-0.13%	-0.16%	-0.13%	-0.09%	-0.15%
	Change in Jobs	21	-18,835	-33,107	-43,138	-34,577	-25,572	-41,990
Output	% Change	0.00%	-0.07%	-0.11%	-0.13%	-0.10%	-0.06%	-0.10%
	Change (2021M$)	-99	-4,256	-7,379	-9,506	-7,440	-5,253	-9,117

Indicator	Metric	2026	2030	2034	2038	2042	2046	2050
Private Investment	% Change	-0.03%	-0.18%	-0.19%	-0.07%	0.17%	0.33%	0.31%
	Change (2021M$)	-172	-1,040	-1,141	-453	1,200	2,436	2,492

6 Alternatives

Pursuant to SB 617,[195] and HSC Sections 11346.2, 11346.3, 11346.5, 11346.9, 11347.3, 11349.1, 13401, 13402, 13403, 13404, 13405, 13406, 13407, 11342.548, 11346.36, and 11349.1.5, CARB staff solicited alternatives for the proposed regulation during workgroups, public workshops, and individual meetings with industry. CARB staff encouraged public input on alternative approaches that may yield the same or greater benefits compared to the proposed regulation or may achieve the goals at a lower cost. Based on comments received, two alternatives, one more stringent and one less stringent than the proposed regulation, are shown below. The analysis includes a comparison of costs, benefits, economic impacts, and cost-effectiveness.

6.1 Alternative 1

Alternative 1 is a less stringent alternative to the proposed regulation. This alternative is based on an alternative concept suggested by the California Council for Environmental and Economic Balance and applies to the same fleets as the proposed regulation. This alternative is structured as a cleaner combustion option that would count engines certified to the Heavy-Duty Omnibus regulation equivalent to a ZEV purchase for the same regulated fleets as the proposed regulation.[196]

Under this alternative, regulated fleets would have the option to meet compliance requirements by purchasing a combination of ZEVs or engines certified to the engine standards established by the Heavy-Duty Omnibus regulation. All medium- and heavy-duty engines sold in California need to be certified to this standard regardless of fuel type. Engines certified in California starting in 2024 are initially certified to standards 75 percent to 90 percent lower than U.S. EPA certified engines and have additional requirements that ensure real world emissions remain low for a longer period of time in all modes of operation through improved test procedures, lengthened warranty, strengthened durability demonstrations, and other emissions control requirements.[197] We expect real world NOx emissions to be about 90 percent lower during the life of the vehicle than existing engines starting in 2024.

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[195] Senate Bill 617, Calderon. State government: *Financial and administrative accountability*. October 6, 2011 (web link: http://dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Section%202000%20ISOR%201%20sb_617_bill_20111006_chaptered.pdf, last accessed January 2022).

[196] California Council for Economic and Environmental Balance, *Re:Comments on Advanced Clean Fleets Proposed Regulation and Alternatives for the Environmental Analysis*, 2021 (web link: https://www.arb.ca.gov/lists/com-attach/29-acf-comments-ws-UDNUMVUxUGZWMlcl.pdf, last accessed January 2022).

[197] California Air Resources Board, *Heavy-Duty Omnibus: Appendix D – Emissions Inventory and Results for the Proposed Amendments*, 2020 (web link: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hdomnibuslownox/appd.pdf, last accessed January 2021).

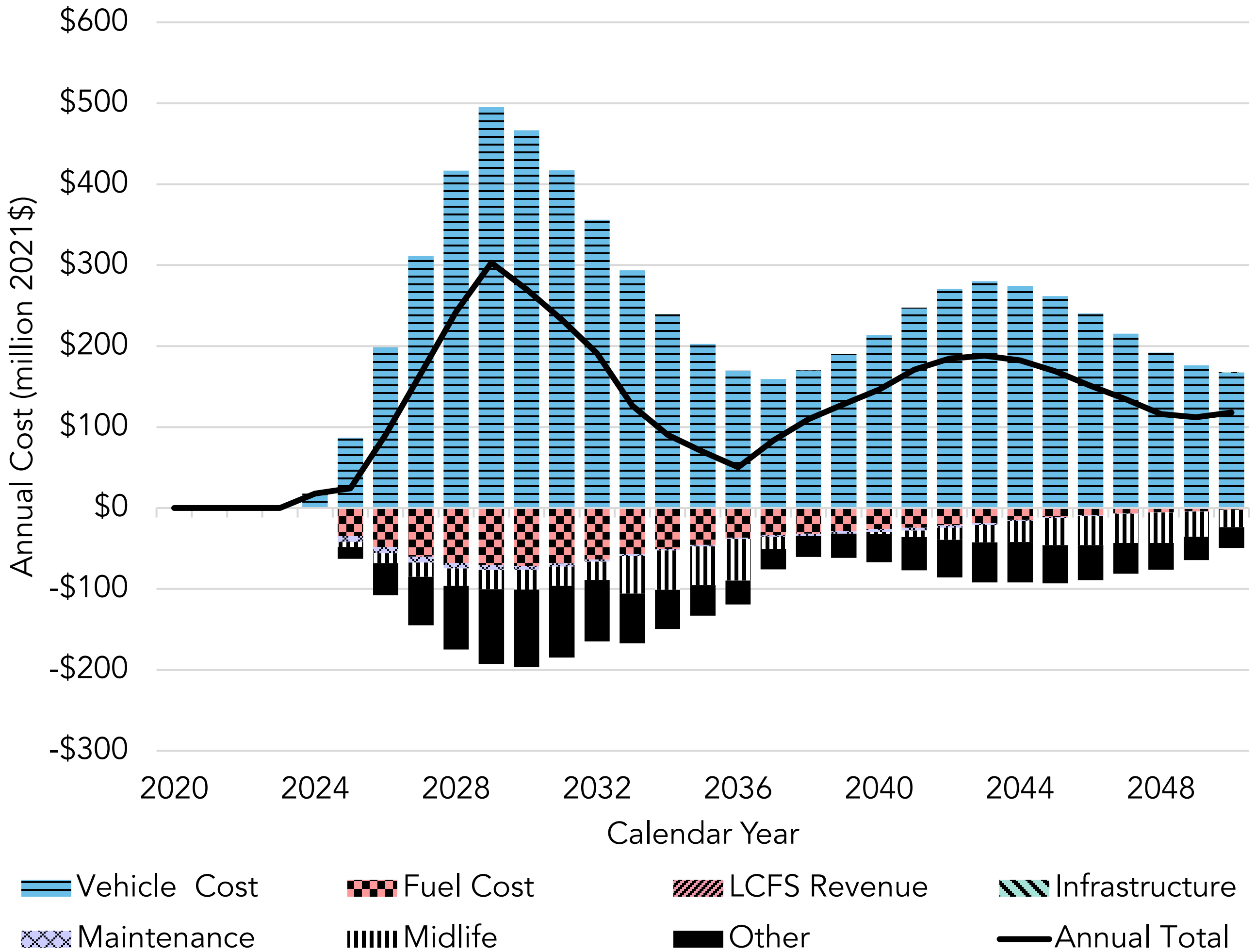
In this alternative, starting in 2024, public fleets and high priority fleets would be required to purchase either ZEVs or engines certified to the California Omnibus engine standards. For State and local government fleets, this alternative is not expected to result in any changes because they already buy California certified engines. For high priority and federal fleets, this would result in accelerated emissions benefits and increased costs as fleets that would have otherwise normally purchased used federally certified engines in the baseline, would now be required to purchase new California Omnibus certified engines. For drayage fleets, pre-2024 MY trucks would be removed from the CARB drayage online reporting system at the end of their useful life and all vehicles added in the online reporting system would be either a ZEV or 2024 MY or newer engine certified to the Heavy-Duty Omnibus requirements. Under this alternative, the number of ZEVs would not increase beyond what is expected from the ACT regulation already reflected in the Legal Baseline.

When compared to the proposed regulation, this alternative would result in fewer ZEVs, lower criteria emissions benefits, lower health benefits, and lower climate emissions reductions benefits as shown in the following sections.

6.1.1 Costs

Alternative 1 results in incremental costs of California certified engines versus federal certified engines which is partially offset by incremental savings associated with projected improved fuel economy of newer vehicles. The cost to the California economy when assuming all costs occur in California would be $3.8 billion between 2024 and 2050 in Alternative 1 versus the Legal Baseline. Figure 26 illustrates the incremental difference in cost between Alternative 1 and the Legal Baseline scenario.

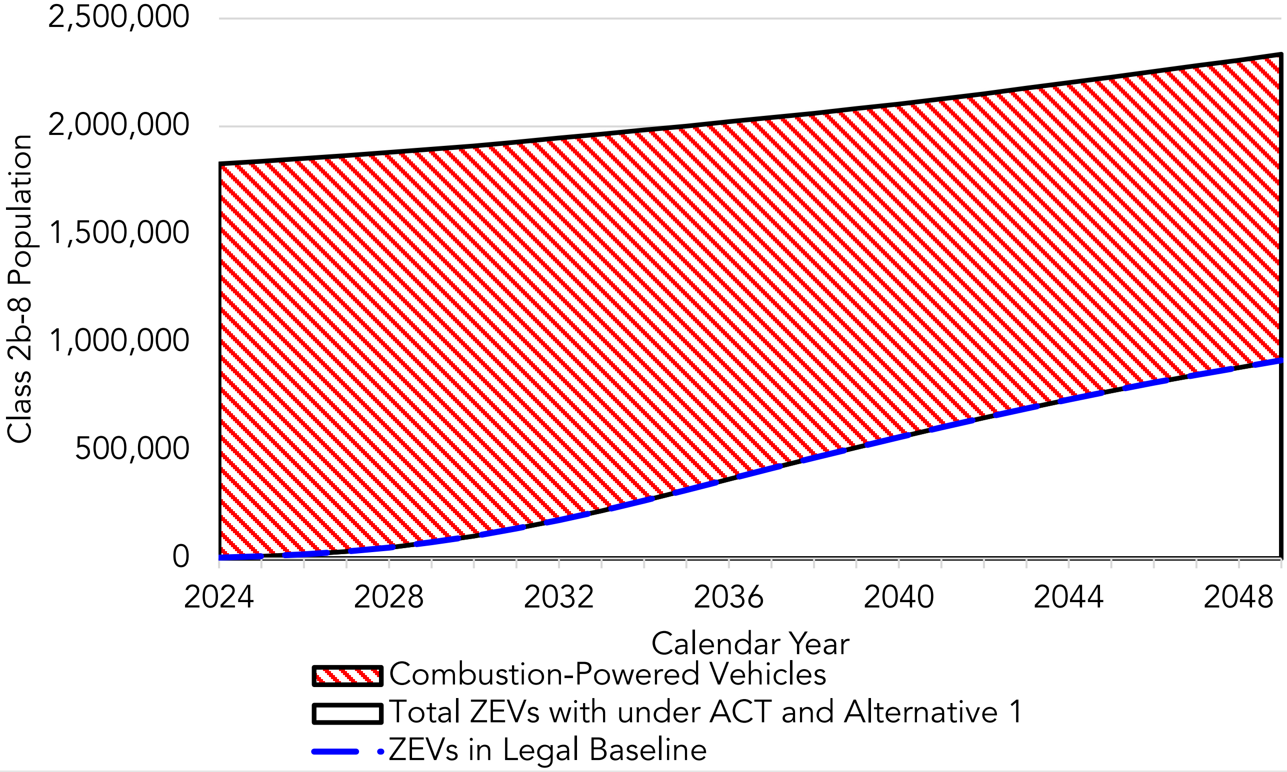
Figure 26. Total Estimated Direct Costs of Alternative 1 Relative to the Legal Baseline Scenario (million 2021$)



6.1.2 Benefits

Alternative 1 results in NOx emissions benefits relative to the Legal Baseline from the more stringent NOx standards of California certified engines compared to federal engine standards. Alternative 1 results in some $PM_{2.5}$ emissions benefits and negligible GHG benefits. Figure 27 illustrates the ZEV population over time under Alternative 1. Alternative 1 results in roughly 650,000 ZEVs by 2035 and 950,000 ZEVs by 2050, the same number as in the Legal Baseline. This represents 200,000 fewer ZEVs by 2035 and 650,000 fewer ZEVs by 2050 when compared to the proposed regulation. Because of the identical number of ZEVs between Alternative 1 and the Legal Baseline, the "ZEVs due to ACT" line overlaps with the "Total ZEVs" line.

Figure 27. Statewide Vehicle Population Forecast over Time under Alternative 1



6.1.2.1 Emissions Benefits

Alternative 1 results in lower NOx, $PM_{2.5}$, and GHG emissions compared to the Legal Baseline scenario. However, this alternative results in significantly fewer NOx, $PM_{2.5}$, and GHG benefits compared to the proposed regulation. Table 56 summarizes the expected annual NOx, $PM_{2.5}$, and CO_2 benefits of Alternative 1 from 2024 through 2050 when compared to the Legal Baseline. The alternative generates fewer criteria emissions reductions than the proposed regulation, is less effective at meeting our SIP obligations, and does not make progress towards meeting the State's GHG reduction targets. In addition, this alternative is not projected to result in any additional near-term emissions reductions compared to the proposed regulation.

Table 56. Alternative 1 NOx, $PM_{2.5}$, and GHG Benefits Relative to the Legal Baseline

Calendar Year	NOx (tpd)	$PM_{2.5}$ (tpd)	CO_2 (MMT/year)
2024	0.4	0.0002	0
2025	1.4	0.0048	0
2026	2.9	0.011	0
2027	5.2	0.020	0
2028	7.6	0.027	0
2029	9.9	0.034	0
2030	12.2	0.040	0
2031	14.4	0.042	0
2032	16.6	0.042	0
2033	18.6	0.043	0
2034	20.7	0.046	0
2035	22.6	0.050	0
2036	24.4	0.053	0
2037	26.1	0.057	0
2038	27.7	0.062	0
2039	29.3	0.067	0
2040	30.8	0.073	0
2041	32.2	0.078	0
2042	33.7	0.083	0
2043	35.1	0.088	0
2044	36.4	0.093	0
2045	37.8	0.097	0
2046	39.2	0.10	0
2047	40.6	0.11	0
2048	41.9	0.11	0
2049	43.3	0.11	0
2050	44.7	0.12	0

Figure 28, Figure 29, and Figure 30 show the difference in GHG, NOx, and $PM_{2.5}$ emissions between Alternative 1, the Legal Baseline, and the proposed regulation. The cumulative emissions benefits for this alternative accounts for a negligible CO_2 reduction, 204,500 tons of NOx, and 518 tons of $PM_{2.5}$ from 2024 to 2050. In comparison, the proposed regulation has total emissions benefits that are approximately 316 MMT CO_2, 443,800 tons of NOx, and 9,300 tons of $PM_{2.5}$ reductions during the same time period. GHG emissions of this alternative are about the same as the baseline.

Figure 28. Projected GHG Emissions under Legal Baseline, Proposed Regulation, and Alternative 1

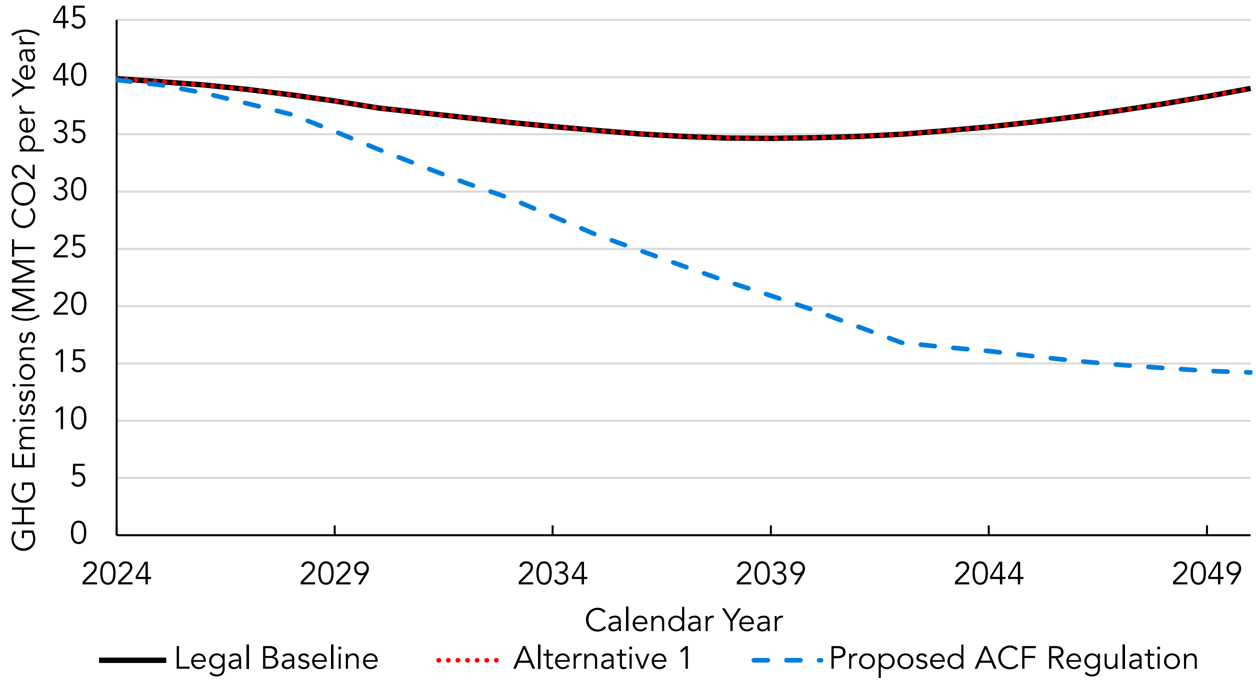


Figure 29. Projected NOx Emissions under Legal Baseline, Proposed Regulation, and Alternative 1

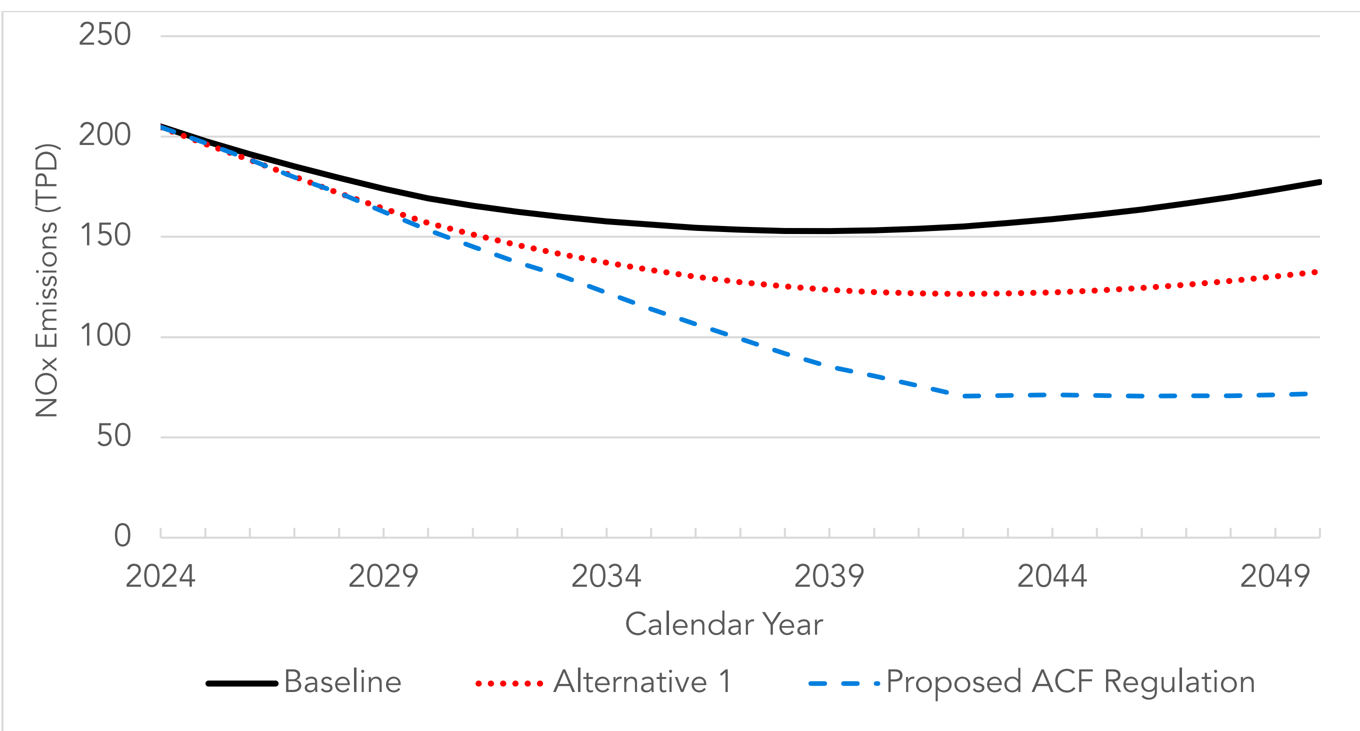
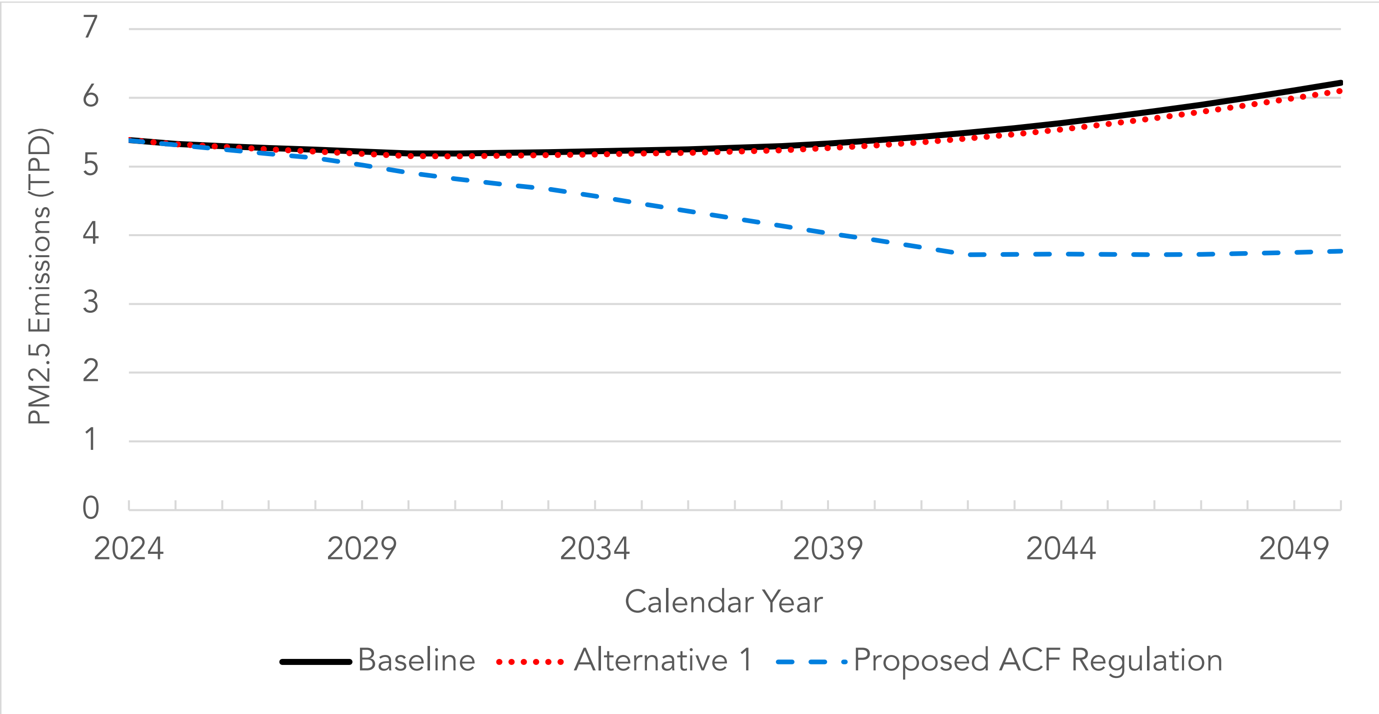


Figure 30. Projected $PM_{2.5}$ Emissions under Legal Baseline, Proposed Regulation, and Alternative 1



6.1.2.2 Health Benefits

Alternative 1 results in emissions reductions relative to the Legal Baseline leading to health benefits as shown in Table 57. The health benefits for Alternative 1 are less than those of the proposed ACF regulation due to less emissions reductions estimated. The total statewide valuation of health benefits of the less stringent alternative is estimated to be $22.7 billion as summarized in Table 57. Totals may not add up due to rounding.

Table 57. Statewide Valuation from Avoided Health Outcomes for Alternative 1 (Million 2021$)

Calendar Year	Avoided Cardiopulmonary Mortality	Avoided Hospitalizations for Cardiovascular Illness	Avoided Hospitalizations for Respiratory Illness	Avoided ER Visits	**Total Avoided Annual Valuation**
2024	1	0	0	1	**$10.5**
2025	4	1	1	2	**$41.9**
2026	8	1	1	4	**$83.8**
2027	15	2	3	7	**$157.1**
2028	23	3	4	11	**$240.9**
2029	30	4	5	14	**$314.1**
2030	37	5	6	18	**$387.4**

Calendar Year	Avoided Cardiopulmonary Mortality	Avoided Hospitalizations for Cardiovascular Illness	Avoided Hospitalizations for Respiratory Illness	Avoided ER Visits	**Total Avoided Annual Valuation**
2031	45	6	8	21	**$471.2**
2032	52	8	9	24	**$544.6**
2033	59	9	10	28	**$617.9**
2034	65	10	12	31	**$680.8**
2035	72	11	13	34	**$754.1**
2036	78	12	14	37	**$816.9**
2037	85	13	16	39	**$890.3**
2038	90	14	17	42	**$942.7**
2039	96	15	18	44	**$1,005.5**
2040	102	16	19	47	**$1,068.4**
2041	107	17	20	49	**$1,120.7**
2042	112	18	21	51	**$1,173.1**
2043	118	19	22	54	**$1,236.0**
2044	123	20	23	56	**$1,288.4**
2045	128	20	24	58	**$1,340.7**
2046	133	21	26	60	**$1,393.1**
2047	138	22	27	62	**$1,445.5**
2048	144	23	28	65	**$1,508.3**
2049	149	24	29	67	**$1,560.7**
2050	154	25	30	69	**$1,613.1**
Total Benefit*	**$22,664.0**	**$20.9**	**$21.9**	**$0.9**	**$22,707.7**

*Note: Totals may differ due to rounding

6.1.3 Economic Impacts

Alternative 1 imposes a less stringent ZEV purchase requirement in the near-term compared to the proposed regulation. This results in lower incremental vehicle cost as passed-through to fleets, but also results in fewer fuel costs savings and fewer total cost-savings during the analysis period. The macroeconomic impacts analysis indicates a very small change relative to the results of the proposed regulation, as shown in Table 58. Figure 31 and Figure 32 show the job impacts and output changes of Alternative 1, respectively.

Table 58. Change in Growth of Economic Indicators for Alternative 1

Indicator	Metric	2026	2030	2034	2038	2042	2046	2050
GSP	% Change	-0.01%	-0.02%	-0.01%	0.00%	-0.01%	-0.01%	0.00%
	Change (2021M$)	-291	-604	-312	-207	-382	-357	-250
Personal Income	% Change	-0.01%	-0.02%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
	Change (2021M$)	-318	-599	-280	-265	-430	-373	-281
Employment	% Change	-0.01%	-0.02%	-0.01%	0.00%	-0.01%	-0.01%	-0.01%
	Change in Jobs	-2,303	-4,427	-2,235	-1,288	-2,415	-2,233	-1,484
Output	% Change	-0.01%	-0.02%	-0.01%	0.00%	-0.01%	-0.01%	0.00%
	Change (2021M$)	-502	-1,037	-535	-352	-644	-605	-424
Private Investment	% Change	-0.02%	-0.04%	-0.01%	0.00%	-0.01%	-0.01%	-0.01%
	Change (2021M$)	-115	-233	-52	-19	-100	-86	-45

Figure 31. Job Impacts of Alternative 1 by Major Sector

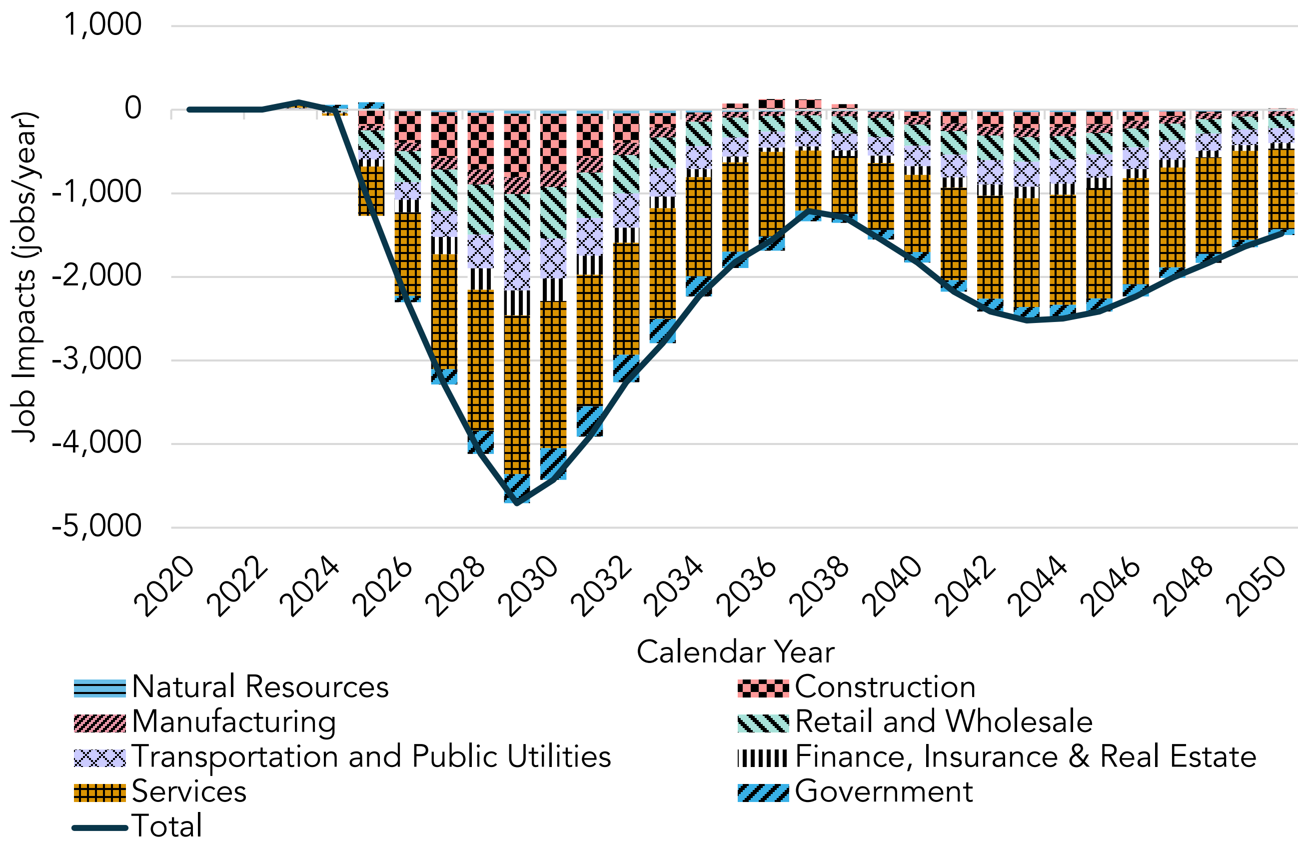
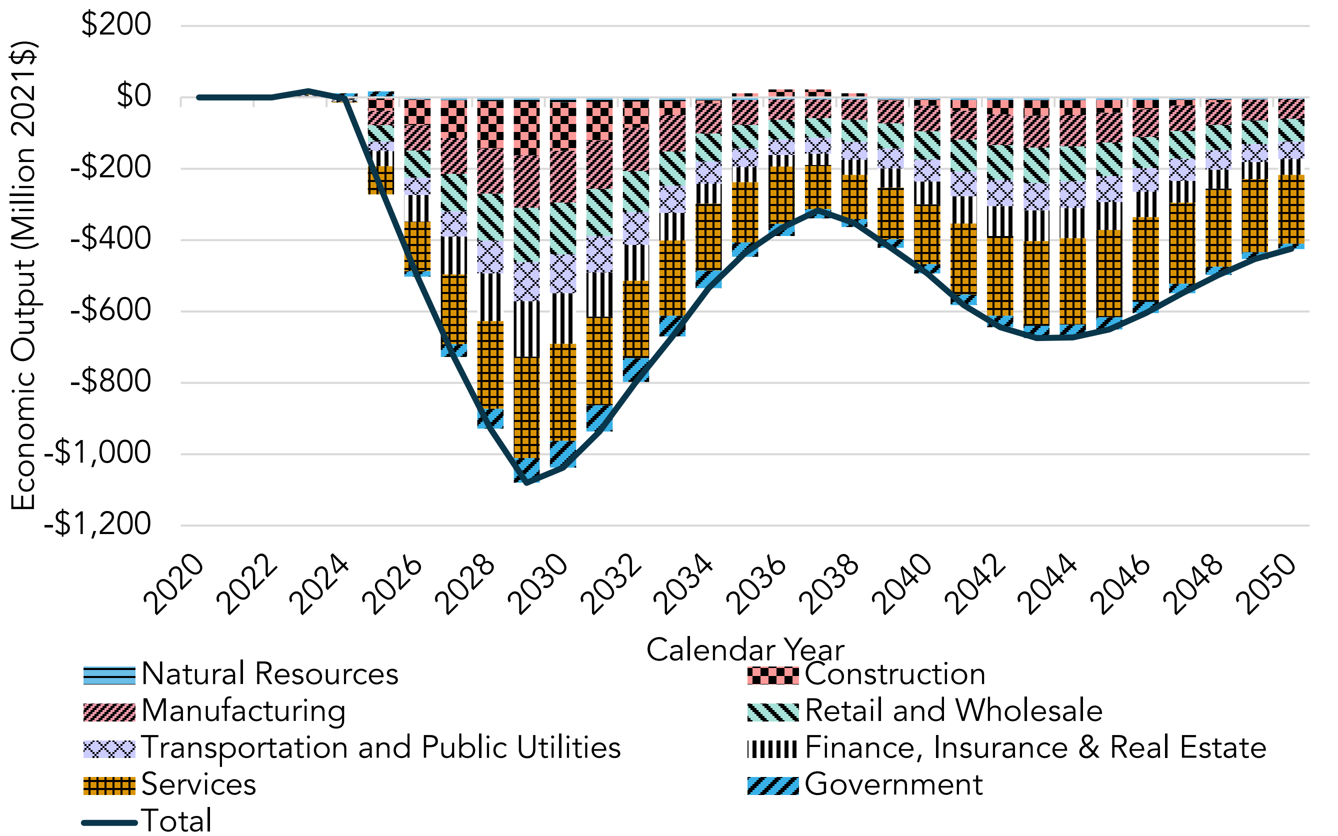


Figure 32. Changes in Output from Alternative 1 by Major Sector



6.1.4 Cost-Effectiveness

Cost-effectiveness is defined as the cost to achieve a ton of emissions reductions. However, like the proposed regulation, Alternative 1, has a lower net cost than the Legal Baseline and can be compared as a benefit-cost ratio. Table 59 shows the estimated benefit-cost ratio for Alternative 1. Alternative 1 has a benefit-cost ratio of 3.8 that is higher than the 1.5 benefit-cost ratio with the proposed regulation.

Table 59. Benefit-Cost Ratio of the Alternative 1 (billion $2021)

Alternative	Total Costs	Cost-Savings (benefit)	Health Benefits	Tax and Fee Revenue	Total Benefit	Net Benefit	Benefit-Cost Ratio
Alternative 1	$6.7	$2.9	$22.7	$0.0	$25.6	$18.8	3.8

6.1.5 Reason for Rejecting

Alternative 1 is rejected because it fails to adequately advance the adoption of medium- and heavy-duty ZEV technologies and is not as effective at reducing criteria emissions and achieving carbon neutrality goals. Alternative 1 achieves minimal $PM_{2.5}$ and GHG emissions reductions and is less effective at reducing NOx emissions. It is not as effective as the proposed regulation in meeting objectives to protect public health, achieve attainment, and to maximize benefits in disadvantage communities. Alternative 1 also does not effectively accelerate the deployment of ZEV deployments compared to the proposed regulation and is not consistent with the goals established by the Governor in multiple Executive Orders and by the Board. ZEV deployments are a key part of the State SIP Strategy, and the Climate Change Scoping Plan as a necessary component needed to improve California's air quality and achieve the State's climate protection goals. Therefore, this alternative is rejected because it would not advance CARB's Mobile Source Strategy, it would be less effective at meeting SIP targets, it would be less effective at reducing exposure to $PM_{2.5}$, and would be less effective at achieving California's carbon neutrality targets.

6.2 Alternative 2

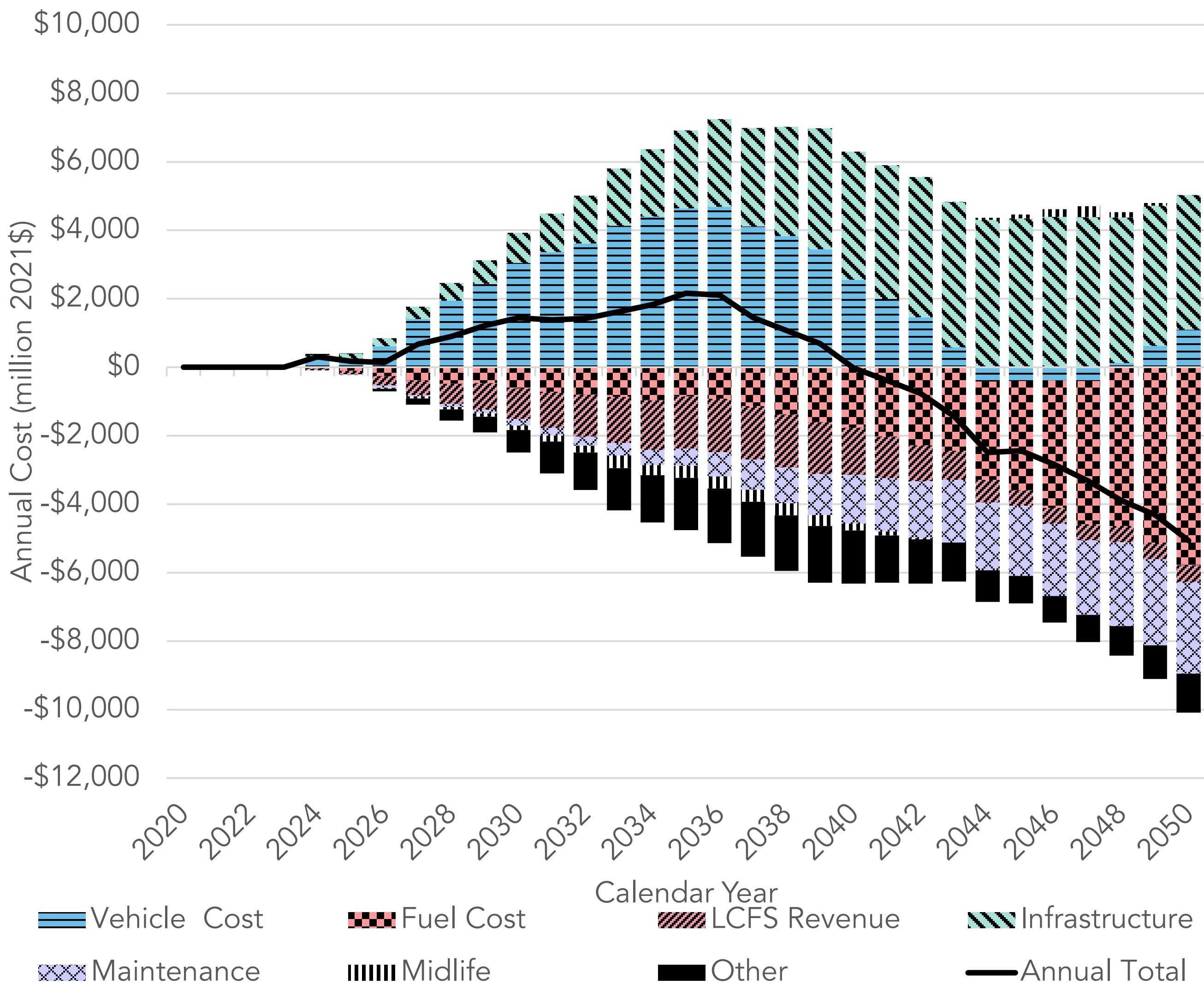
Alternative 2 is a more stringent medium- and heavy-duty ZEV purchase requirement than the proposed regulation. This alternative is based on a comment letter sent by the AMPLY, Los Angeles Cleantech Incubator, Itron, and PCS Energy. This alternative primarily recommends reducing the fleet size threshold for high priority and federal fleets to ten trucks and moves up the date for when all medium- and heavy-duty vehicle sales would need to be ZE.

This alternative is similar to the proposed regulation but includes modifications to the high priority and federal fleet requirements. In this alternative the fleet size threshold would be reduced from 50 vehicles to 10 vehicles. This alternative also includes a 100 percent sales requirement starting in 2036 rather than in 2040. Other aspects of the proposed regulation would stay the same. As such, the ZEV purchase requirement would apply to any entity that owns or controls 10 or more vehicles and to brokers that dispatch 10 or more vehicles per year. No changes would be made to the drayage truck requirement. Alternative 2 would increase the number of fleets affected and the number of medium- and heavy-duty ZEVs deployed.

6.2.1 Costs

Alternative 2 increases the number of medium- and heavy-duty ZEVs sold in California relative to the Legal Baseline. ZEV sales would also be higher than under the proposed regulation. This results in higher initial costs and lower net costs to California compared to the Legal Baseline. The cost to the California economy when assuming all costs occur in California would be -$8.5 billion between 2020 and 2050 in Alternative 2 versus the Legal Baseline scenario. In comparison, the cost of the proposed regulation is -$12.4 billion between 2020 and 2050 versus the Legal Baseline. The negative costs correspond to a net savings for the State. Figure 33 illustrates the incremental difference in cost between Alternative 2 and the Legal Baseline scenario.

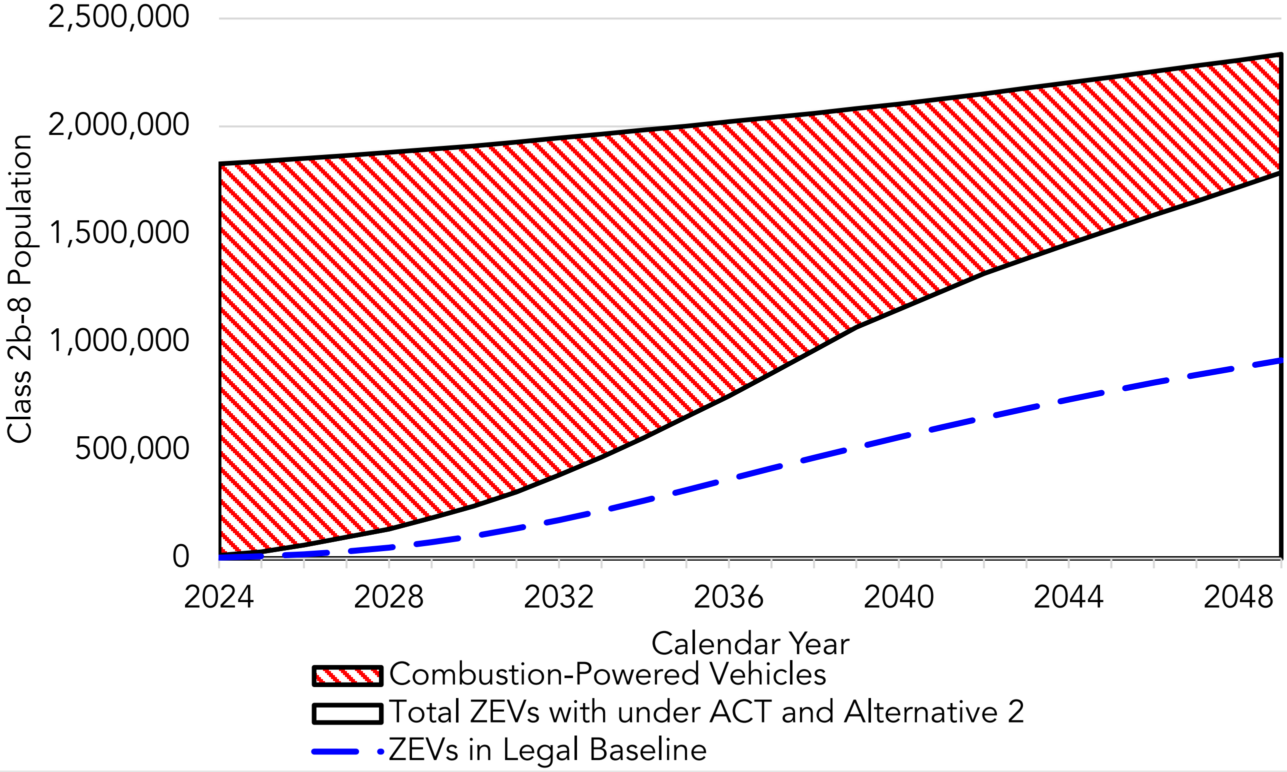
Figure 33. Total Estimated Direct Costs of Alternative 2 Relative to the Legal Baseline Scenario (million 2021$)



6.2.2 Benefits

Alternative 2 results in more medium- and heavy-duty ZEVs deployed than the Legal Baseline scenario and the proposed regulation and achieves more emissions benefits than the proposed regulation. Figure 34 illustrates the ZEV population over time under Alternative 2 in comparison to the proposed regulation. Alternative 2 results in roughly 520,000 ZEVs by 2035 and 1,260,000 ZEVs by 2050. This is an increase of 320,000 ZEVs by 2050 versus the Legal Baseline and 60,000 more ZEVs in 2050 than the proposed regulation.

Figure 34. Statewide Population Forecast over Time under Alternative 2



6.2.2.1 Emissions Benefits

Alternative 2 results in greater medium- and heavy-duty ZEV deployments compared to the Legal Baseline scenario and the proposed regulation. This Alternative provides more cumulative NOx, $PM_{2.5}$ and CO_2 benefits due to the more stringent ZEV purchase requirement for high priority fleets. The cumulative emissions benefits for the more stringent alternative relative to the Legal Baseline accounts for approximately 443 MMT of CO_2, 636,100 tons of NOx, and 12,800 tons of $PM_{2.5}$ from 2024 – 2050, whereas the proposed regulation relative to the Legal Baseline provides approximately 316 MMT CO_2, 443,800 tons of NOx, and 9,300 tons of $PM_{2.5}$ reductions during the same time period. Table 60 summarizes the expected annual NOx, $PM_{2.5}$, and CO_2 benefits in Alternative 2 from 2024 through 2050.

Table 60. Alternative 2 NOx, $PM_{2.5}$, and GHG Benefits Relative to the Legal Baseline

Calendar Year	NOx (tpd)	$PM_{2.5}$ (tpd)	CO_2 (MMT/year)
2024	0.5	0.009	0.2
2025	1.6	0.03	0.5
2026	4.6	0.08	1.2
2027	8.1	0.1	1.9
2028	11.1	0.2	2.6
2029	16.6	0.3	3.9
2030	22.1	0.4	5.0
2031	28.8	0.5	6.4
2032	35.6	0.6	7.9
2033	42.2	0.7	9.2
2034	51.3	0.9	11.1
2035	60.2	1.1	12.9
2036	68.7	1.2	14.8
2037	77.9	1.4	16.9
2038	87.7	1.7	19.0
2039	98.2	1.9	21.1
2040	105.8	2.1	22.8
2041	114.0	2.3	24.5
2042	122.9	2.5	26.3
2043	125.1	2.6	26.9
2044	127.5	2.7	27.6
2045	130.1	2.8	28.2
2046	133.0	2.8	28.9
2047	136.0	2.9	29.6
2048	139.5	3.0	30.4
2049	143.1	3.1	31.2
2050	146.8	3.2	32.0

Figure 35, Figure 36, and Figure 37 represent the difference in GHG, NOx, and $PM_{2.5}$ emissions between Legal Baseline and Alternative 2.

Figure 35. Projected GHG Emissions under Legal Baseline, Proposed Regulation, and Alternative 2

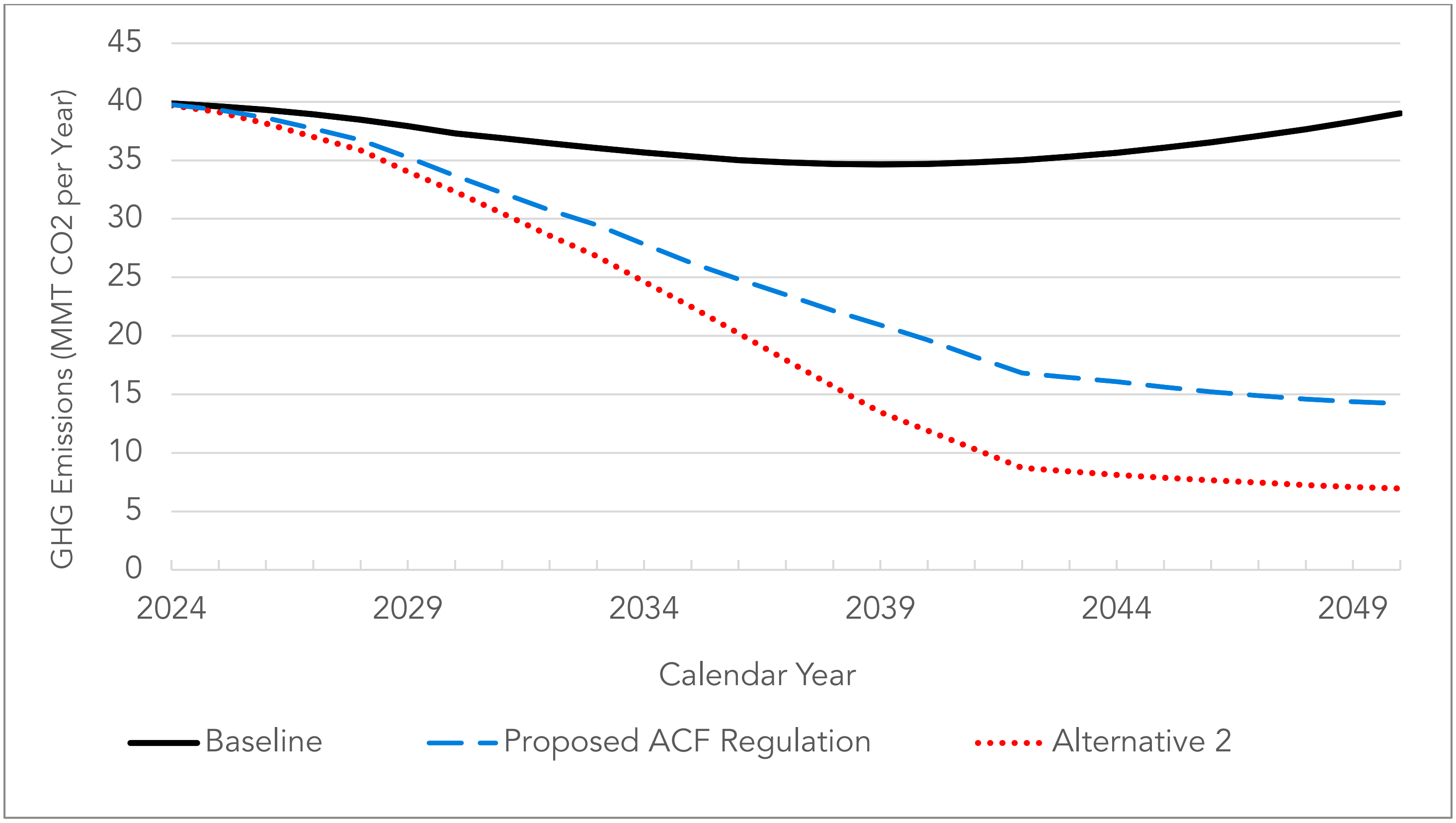


Figure 36. Projected NOx Emissions under Legal Baseline, Proposed Regulation, and Alternative 2

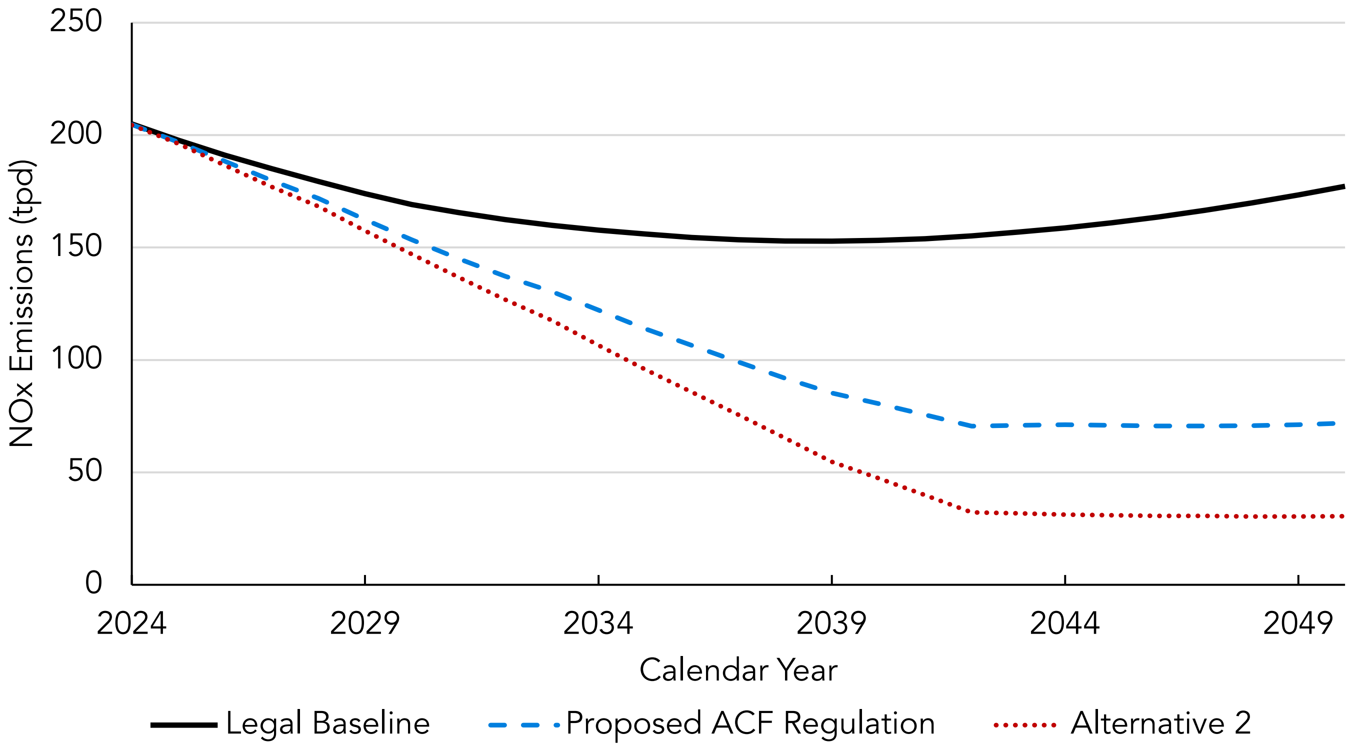
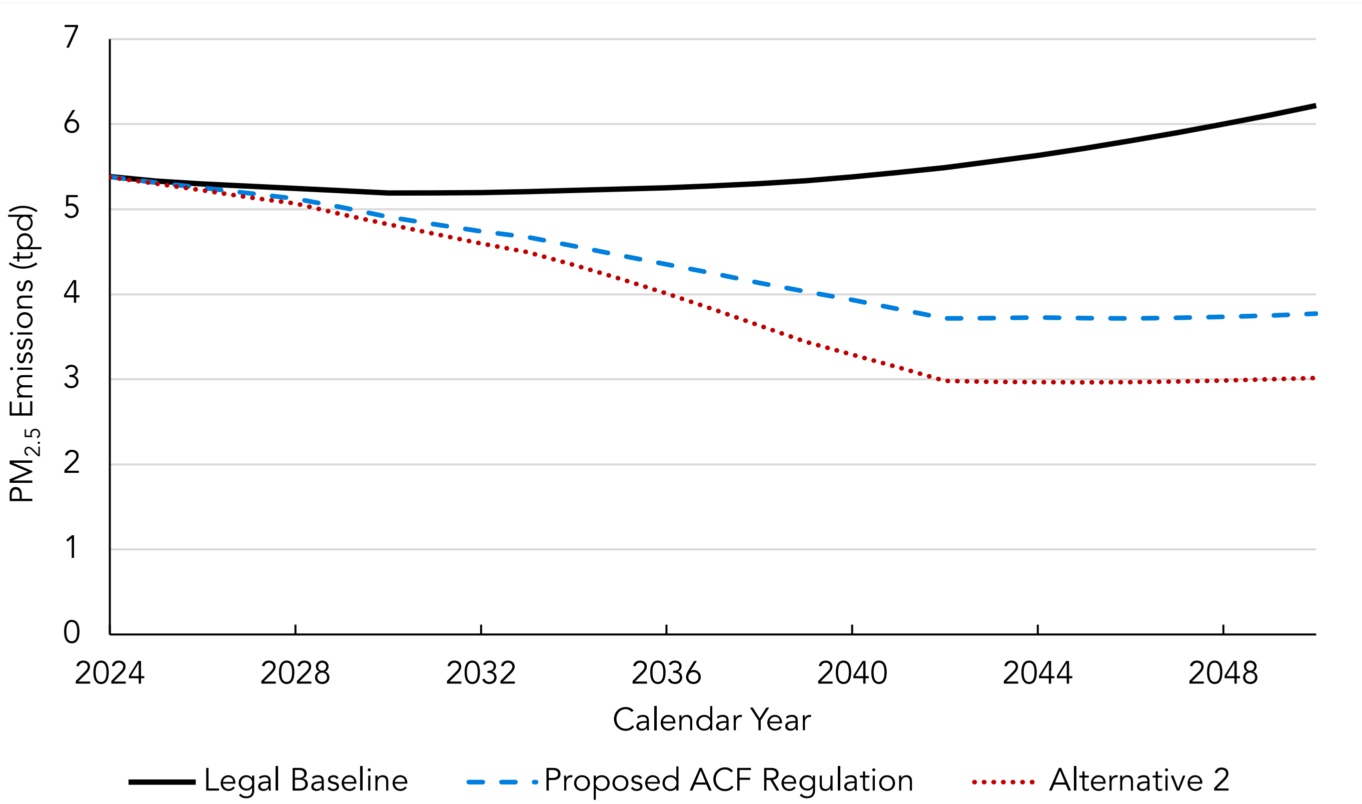


Figure 37. Projected $PM_{2.5}$ Emissions under Legal Baseline, Proposed Regulation, and Alternative 2



The cumulative GHG emissions reductions multiplied by the SC-CO_2 values gives a monetary estimate of the benefit of GHG emissions reductions from Alternative 2. These benefits range from about $13.5 billion to $54.4 billion through 2050, depending on the chosen discount rate.

6.2.2.2 Health Benefits

Alternative 2 results in emissions reductions relative to the Legal Baseline leading to health benefits as shown in Table 61. The health benefits for Alternative 2 are greater than those of the proposed regulation due to higher estimated emissions reductions. The total statewide valuation of health benefits of the more stringent alternative is estimated to be $87.6 billion.

Table 61. Statewide Valuation from Avoided Health Outcomes for Alternative 2 (million 2021$)

Calendar Year	Avoided Cardiopulmonary Mortality	Avoided Hospitalizations for Cardiovascular Illness	Avoided Hospitalizations for Respiratory Illness	Avoided ER Visits	Total Avoided Annual Valuation*
2024	2	0	0	1	**$20.9**

Calendar Year	Avoided Cardiopulmonary Mortality	Avoided Hospitalizations for Cardiovascular Illness	Avoided Hospitalizations for Respiratory Illness	Avoided ER Visits	Total Avoided Annual Valuation*
2025	6	1	1	3	**$62.8**
2026	16	2	3	8	**$167.6**
2027	28	4	5	14	**$293.2**
2028	39	5	6	19	**$408.4**
2029	59	8	10	28	**$617.8**
2030	80	11	14	38	**$837.8**
2031	105	15	18	50	**$1,099.6**
2032	132	19	23	63	**$1,382.4**
2033	158	24	28	75	**$1,654.8**
2034	194	29	35	92	**$2,031.8**
2035	231	35	42	109	**$2,419.4**
2036	267	41	49	125	**$2,796.5**
2037	307	48	57	143	**$3,215.5**
2038	349	55	65	162	**$3,655.5**
2039	394	62	74	183	**$4,126.8**
2040	429	68	81	198	**$4,493.5**
2041	467	74	88	215	**$4,891.5**
2042	507	80	96	233	**$5,310.4**
2043	520	83	99	238	**$5,446.7**
2044	534	85	102	244	**$5,593.3**
2045	549	88	105	250	**$5,750.5**
2046	564	91	108	256	**$5,907.7**
2047	579	94	112	263	**$6,064.9**
2048	597	97	116	270	**$6,253.5**
2049	614	100	119	278	**$6,431.5**
2050	633	103	123	286	**$6,630.6**
Total Benefit*	**$87,394.6**	**$81.6**	**$85.0**	**$3.4**	**$87,564.7**

*Note: Totals may differ due to rounding

6.2.3 Economic Impacts

Alternative 2 would impose a more stringent medium- and heavy-duty ZEVs sales requirement compared to the proposed regulation. This results in a greater incremental vehicle cost as passed-through to fleets, but also more Phase 2 GHG cost offsets and more fuel savings. The macroeconomic impacts analysis results show that this alternative would result in similar impacts to the proposal on employment and output but of a greater magnitude as displayed in Table 62.

Table 62. Change in Growth of Economic Indicators for Alternative 2

Indicator	Metric	2026	2030	2034	2038	2042	2046	2050
GSP	% Change	-0.01%	-0.09%	-0.16%	-0.18%	-0.17%	-0.11%	-0.13%
	Change (2021M$)	-300	-3,658	-6,738	-8,088	-7,964	-5,571	-7,538
Personal Income	% Change	-0.04%	-0.17%	-0.27%	-0.27%	-0.21%	-0.11%	-0.10%
	Change (2021M$)	-1,377	-5,763	-9,955	-10,840	-9,020	-5,302	-5,003
Employment	% Change	-0.01%	-0.11%	-0.20%	-0.25%	-0.25%	-0.19%	-0.24%
	Change in Jobs	-1,867	-28,367	-53,220	-66,612	-68,490	-52,800	-69,149
Output	% Change	-0.01%	-0.10%	-0.18%	-0.20%	-0.19%	-0.14%	-0.17%
	Change (2021M$)	-546	-6,404	-11,841	-14,590	-15,077	-11,483	-15,402
Private Investment	% Change	-0.06%	-0.28%	-0.32%	-0.11%	0.20%	0.42%	0.41%
	Change (2021M$)	-344	-1,594	-1,951	-706	1,364	3,124	3,260

Figure 38. Job Impacts of Alternative 2 by Major Sector

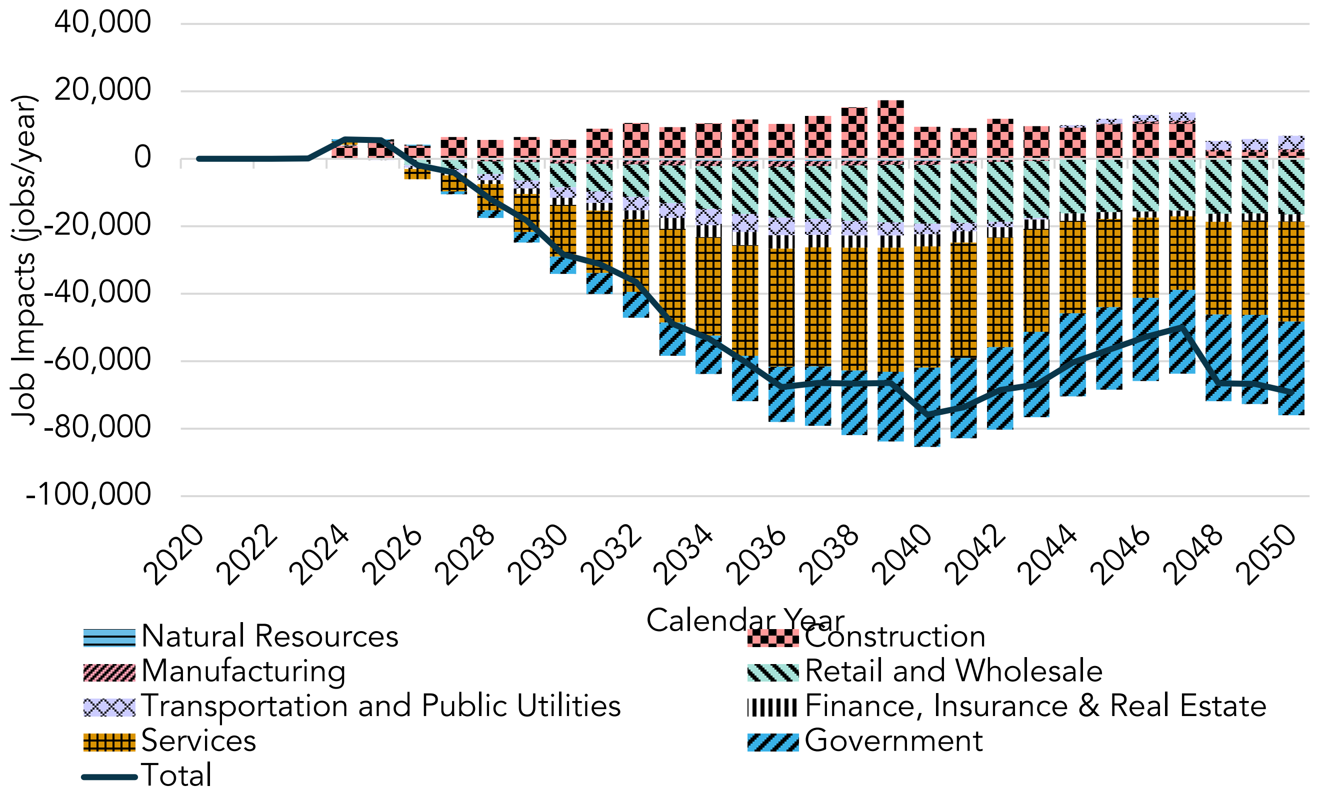
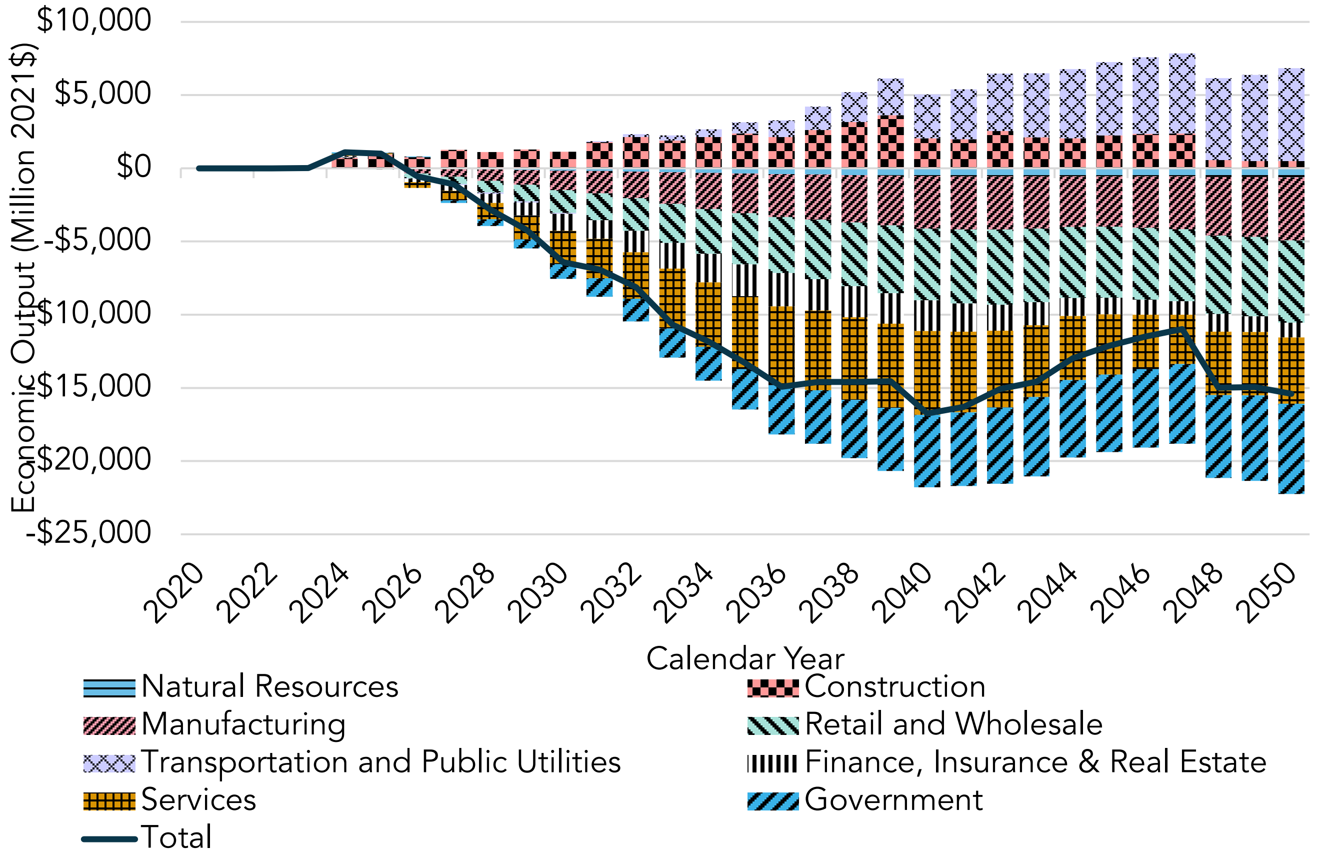


Figure 39. Changes in Output from Alternative 2 by Major Sector



6.2.4 Cost-Effectiveness

Cost-effectiveness is defined as the cost to achieve a ton of emissions reductions. However, like the proposed regulation, Alternative 2, has a lower net cost than the Legal Baseline and can be evaluated as a benefit-cost ratio.

For Alternative 2, the total cost from 2020 to 2050 results in higher initial costs due to the increase in ZEVs and a larger total net savings than the proposed regulation. Alternative 2 also achieves greater emissions reductions for criteria pollutants and GHG emissions. Table 63 illustrates the benefit-cost ratio of Alternative 2. Alternative 2 has a benefit-cost ratio of 1.3 that is lower than the 1.5 benefit-cost ratio with the proposed regulation.

Table 63. Benefit-Cost Ratio of the Alternative 2 (billion $2021)

Alternative	Total Costs	Cost-Savings (benefit)	Health Benefits	Tax and Fee Revenue	Total Benefit	Net Benefit	Benefit-Cost Ratio
Alternative 2	$124.9	$133.2	$87.6	-$59	$161.8	$36.9	1.3

6.2.5 Reason for Rejecting

Alternative 2 substantially increases the number of affected fleets and nearly doubles the number of medium- and heavy-duty ZEVs required. The increase in ZEVs is primarily in the Class 2b-3 and Class 7-8 tractor categories. Alternative 2 is rejected as the more aggressive timeframe raises questions about feasibility for certain fleets in the near-term while the ZEV market is still developing. Increasing the purchase requirements further by regulating more fleets would introduce potential market imbalances between required ZEV sales and purchases and more issues on the learning curve in deploying these new technologies in more fleets that could slow progress of the ZEV market in early implementation. This alternative would immediately bring in a wide range of smaller fleets operating statewide that may not operate in major transportation corridors where infrastructure is more likely to be sited in the early years. This alternative also proposes an earlier end date for combustion technologies which increases risks about feasibility for trucks with more challenging use cases, although the 2036 timeframe does provide time for zero-emission solutions to be identified.

With an accelerated timeframe, smaller fleets would not have the opportunity to learn from the experiences of early adopters and larger fleets. For a smooth transition to ZEV technologies, sufficient time is needed to build out maintenance, supply, and infrastructure networks to make a full transition to ZEVs. Smaller fleets are more likely to rely on publicly available charging infrastructure that is still in the process of being developed and may not be available where needed in all cases. Additionally, small fleets are more likely to purchase used vehicles, which may not be available as ZEVs due to the Alternative's accelerated timeframe. This could result in holding ICE vehicles longer as well as an administrative burden for fleets and CARB staff with potential increases in exemption requests as well as other unintended consequences.

Additionally, market forces need to be considered in expanding the early ZEV market. The ACT regulation guarantees a supply of ZEVs in the California market. However, Alternative 2 would result in a fast ramp-up of additional ZEV demand significantly above the expected supply of ZEVs, that may result put upward pressure on vehicle prices. Market dynamics concentrated in the hands of consumer fleets would help maintain downward price pressures and would bring ZEV costs in line with other technologies sooner.

Alternative 2 is rejected because it raises additional questions about timing, introduces additional uncertainty associated with the feasibility of successfully deploying ZEVs in the early market, and results in imbalanced market forces that could slow ZEV deployment. Alternative 2 has a lower cost-benefit ratio but greater emissions benefits and number of ZEVs deployed than the proposed regulation. Staff will continue to analyze the rapidly evolving technical progress of these categories to determine if additional stringency or future regulation is warranted.

7 Modified Baseline Analysis Appendix

As previously discussed, the Legal Baseline used for impact analysis did not include implementation of the HDIM regulation. Therefore, staff is including an additional analysis here that compares the proposed regulation to a Modified Baseline. The Modified Baseline accounts for the effects of the HDIM regulation, which was heard by the Board in December 2021 but has not yet been approved by OAL. The HDIM regulation would reduce statewide PM and NOx emissions from heavy-duty engines by ensuring that the emission control systems are operating as designed and are repaired in a timely manner if they malfunction. The HDIM regulation is anticipated to be fully approved into the California Code of Regulations by the time the proposed regulation would be implemented in 2023. In addition, the Modified Baseline accounts for the potential effects of the proposed Advanced Clean Cars II (ACC II) regulation that is expected to lower criteria emissions standards for Class 2b-3 vehicles that would be included in the proposed regulation. ACC II is anticipated to be presented to the Board in the summer of 2022. ACC II impacts on the proposed regulation's emissions benefits are negligible, accounting for less than 0.1 tons per day for vehicles over 8500 lbs. GVWR. In general, staff used the same benefit and cost impact analysis methodologies as described above for the Legal Baseline to analyze the scenario including the proposed HDIM and ACC II regulations in the baseline. Broadly, the Modified Baseline has lower criteria pollutant emissions and higher costs than the Legal Baseline which change both the costs and benefits of the proposed regulation. The Modified Baseline does not substantially change the alternatives analysis nor the conclusions drawn when using the Legal Baseline.

7.1 Benefits

7.1.1 Criteria Emissions Benefits

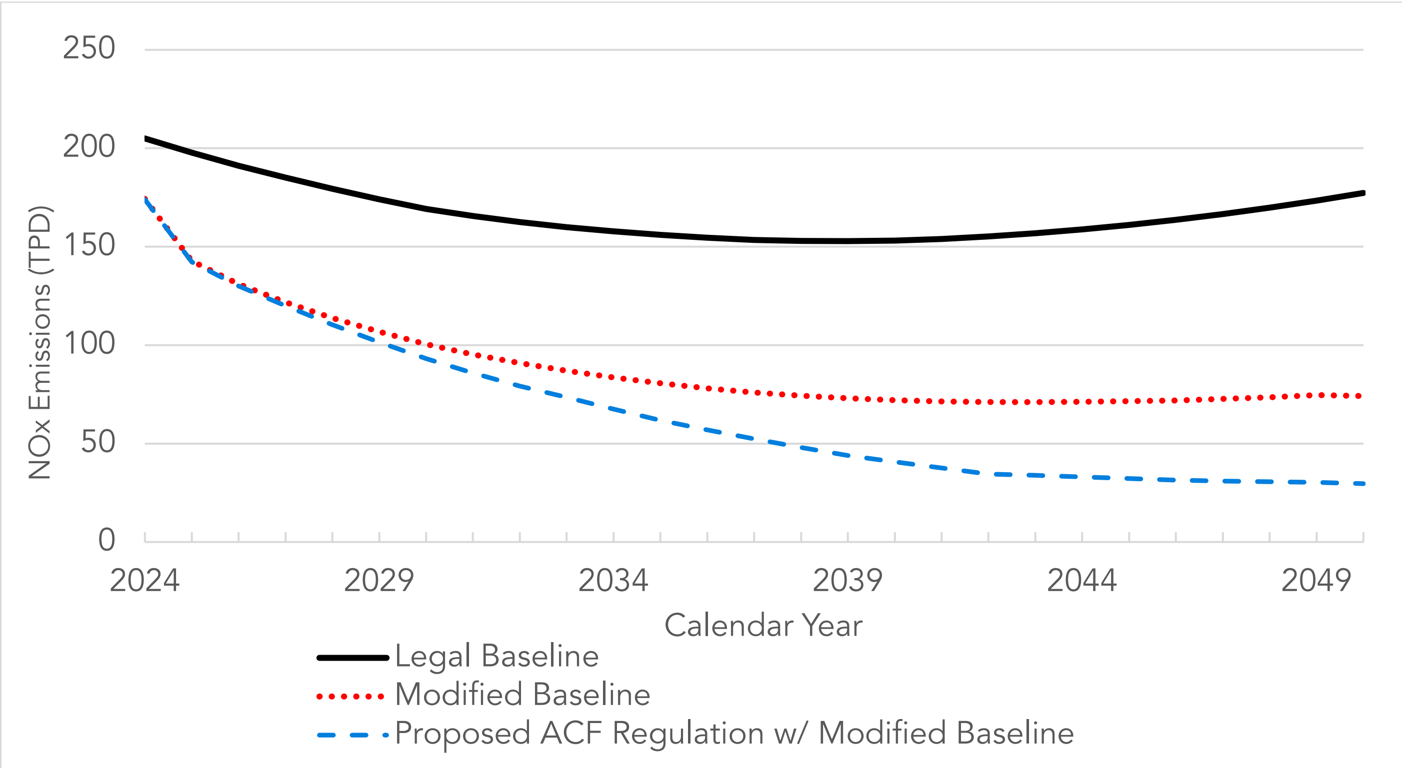
The emissions benefits for the proposed regulation with the Modified Baseline are shown in Table 64. The cumulative NOx and PM emissions benefits of the proposed regulation with Modified Baseline are projected to be about 55 percent and 25 percent lower respectively, compared to the analysis using the Legal Baseline because the HDIM program will ensure that heavy-duty engine emissions standards continue to be met throughout the vehicles' operating life through implementation of more comprehensive vehicle inspection and maintenance. This change lowers both the NOx and PM emissions benefits expected from the proposed regulation when a ZEV is purchased instead of an ICE vehicle.

Table 64. Projected Statewide TTW NOx and $PM_{2.5}$ Emissions Benefits of the Proposed Regulation with the Modified Baseline

Calendar Year	NOx (tpd)	$PM_{2.5}$ (tpd)
2024	0.3	0.0061
2025	0.4	0.011
2026	0.9	0.027
2027	1.9	0.049
2028	3.4	0.078
2029	5.3	0.14
2030	7.2	0.20
2031	9.5	0.27
2032	11.7	0.33
2033	13.5	0.39
2034	16.1	0.48
2035	18.8	0.57
2036	21.1	0.66
2037	23.6	0.75
2038	26.3	0.85
2039	29.1	0.96
2040	31.4	1.1
2041	33.9	1.20
2042	36.6	1.34
2043	37.3	1.40
2044	38.1	1.46
2045	39.3	1.53
2046	40.5	1.61
2047	41.7	1.67
2048	43.0	1.75
2049	44.3	1.82
2050	44.6	1.88

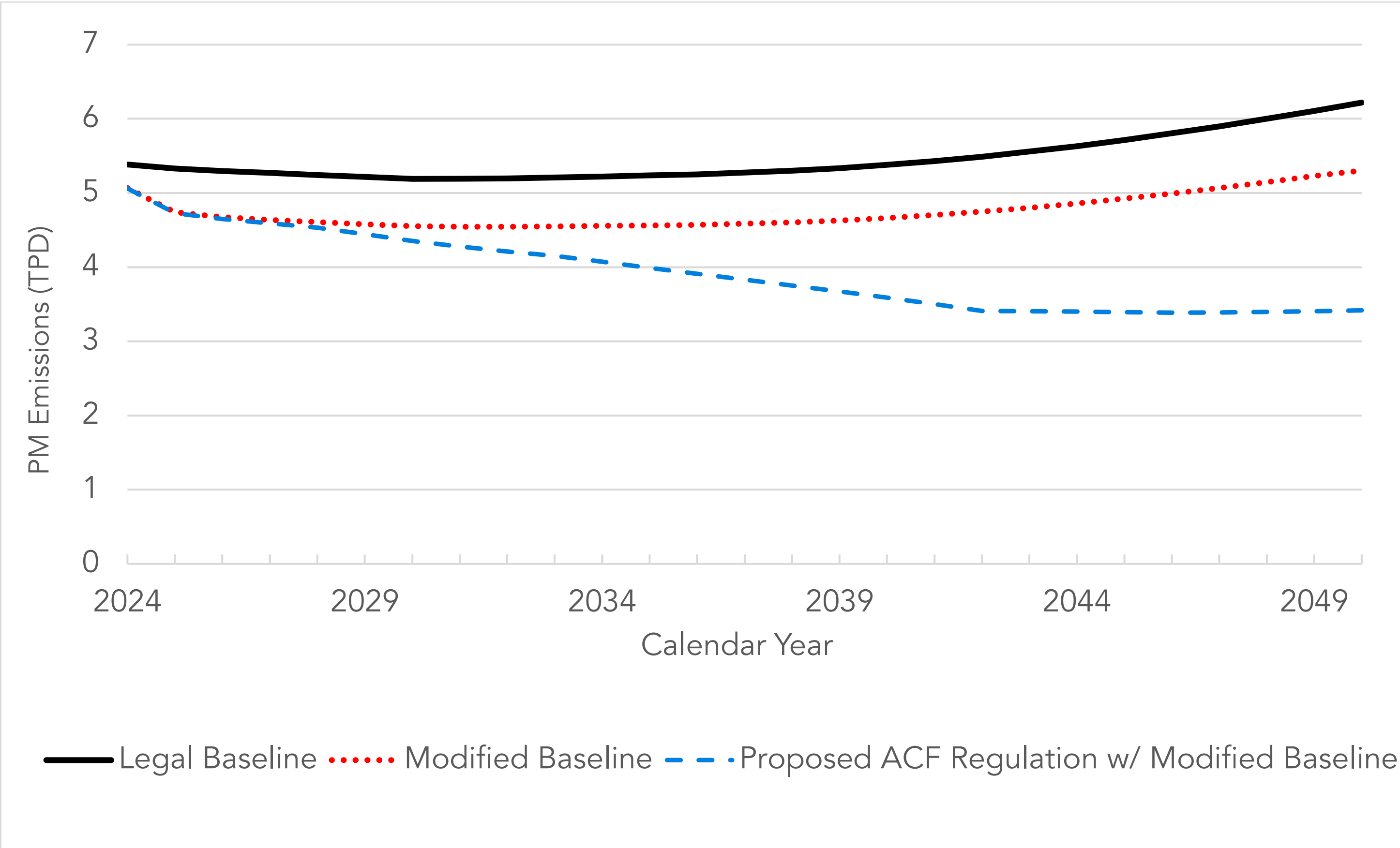
Figure 40 compares the NOx emissions for the proposed regulation with the Modified Baseline, the Legal Baseline, and the Proposed ACF Regulation with Modified Baseline scenarios. The cumulative NOx emissions benefits of the proposed regulation with the Modified Baseline compared to the Legal Baseline and Modified Baseline from 2024-2050 are approximately 843,800 tons and 193,400 tons, respectively.

Figure 40. Projected TTW NOx Emissions Benefits for the Proposed Regulation with Modified Baseline relative to the Legal Baseline and Modified Baseline (tpd)



Similarly, Figure 41 compares the PM emissions for the proposed regulation with the Modified Baseline, Legal Baseline, and Modified Baseline. The cumulative PM emissions benefits of the proposed regulation with the Modified Baseline compared to the Legal Baseline and Modified Baseline from 2024-2050 are approximately 12,900 tons and 7,000 tons, respectively.

Figure 41. Projected TTW PM Emissions Benefits for the Proposed Regulation with Modified Baseline relative to the Legal Baseline and Modified Baseline (tpd)



7.1.2 GHG Emissions Benefits

The HDIM regulation does not change the GHG emissions of heavy-duty vehicles, so there are no changes in the GHG emissions reductions or SC-CO_2 between the Modified Baseline and the Legal Baseline. All calculations from Chapter "2 Benefits", in Section "2.1 – Emissions Benefits" are identical between the two Baseline scenarios.

7.1.3 Health Benefits

Table 65 summarizes staff's estimated avoided statewide and regional premature mortality, hospitalizations, and ER visits associated with the proposed regulation relative to the Modified Baseline for 2024 through 2050.

Table 65. Regional and Statewide Avoided Mortality and Morbidity Incidents from 2024 to 2050 under the Proposed Regulation versus the Modified Baseline

Air Basin	Avoided Cardiopulmonary Deaths	Avoided Hospitalizations for cardiovascular illness	Avoided Hospitalizations for respiratory illness	Avoided ER visits for asthma
Great Basin Valleys	2 (2 - 2)	0 (0 - 0)	0 (0 - 1)	1 (0 - 1)
Lake County	2 (1 - 2)	0 (0 - 0)	0 (0 - 0)	1 (0 - 1)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	49 (39 - 61)	7 (0 - 15)	9 (2 - 16)	19 (12 - 26)
Mountain Counties	28 (21 - 34)	3 (0 - 5)	3 (1 - 5)	9 (6 - 12)
North Central Coast	13 (10 - 16)	2 (0 - 5)	3 (1 - 5)	7 (5 - 10)
North Coast	5 (4 - 7)	1 (0 - 1)	1 (0 - 1)	2 (1 - 3)
Northeast Plateau	2 (1 - 2)	0 (0 - 0)	0 (0 - 0)	1 (0 - 1)
Sacramento Valley	137 (107 - 168)	18 (0 - 35)	21 (5 - 37)	51 (32 - 70)
Salton Sea	37 (28 - 45)	6 (0 - 11)	7 (2 - 12)	17 (11 - 23)
San Diego County	135 (105 - 166)	20 (0 - 40)	24 (6 - 43)	53 (34 - 73)
San Francisco Bay	255 (199 - 312)	41 (0 - 81)	49 (11 - 87)	137 (86 - 187)
San Joaquin Valley	519 (406 - 633)	66 (0 - 130)	79 (18 - 139)	183 (116 - 250)
South Central Coast	37 (29 - 46)	6 (0 - 12)	7 (2 - 12)	16 (10 - 22)
South Coast	1807 (1413 - 2209)	312 (0 - 611)	372 (87 - 657)	906 (573 - 1239)
Statewide	3029 (2368 - 3703)	482 (0 - 945)	575 (135 - 1015)	1403 (888 - 1919)

The total statewide valuation of health benefits for the proposed regulation with the Modified Baseline are estimated to be $31.6 billion as summarized in Table 66. The health benefit valuation is about 48 percent lower relative to the analysis using the Legal Baseline, due to the lower projected NOx and PM emissions benefits.

Table 66. Statewide Valuation from Avoided Health Outcomes for the Proposed Regulation versus the Modified Baseline (million 2021$)

Year	Avoided cardiopulmonary mortality	Avoided hospitalizations for cardiovascular illness	Avoided hospitalizations for respiratory illness	Avoided ER visits for asthma	Avoided annual total valuation*
2024	1	0	0	0	**$10.5**
2025	2	0	0	1	**$20.9**
2026	4	0	1	2	**$41.9**
2027	7	1	1	4	**$73.3**
2028	13	2	2	6	**$136.1**
2029	21	3	4	10	**$219.9**
2030	30	4	5	14	**$314.1**
2031	40	6	7	19	**$418.9**

Year	Avoided cardiopulmonary mortality	Avoided hospitalizations for cardiovascular illness	Avoided hospitalizations for respiratory illness	Avoided ER visits for asthma	Avoided annual total valuation*
2032	49	7	9	24	$513.2
2033	58	9	10	28	$607.4
2034	70	11	13	33	$733.2
2035	83	13	15	39	$869.3
2036	95	15	18	45	$995.0
2037	108	17	20	51	$1,131.2
2038	121	19	23	57	$1,267.4
2039	136	21	26	63	$1,424.5
2040	149	24	28	69	$1,560.7
2041	164	26	31	76	$1,717.8
2042	180	29	34	83	$1,885.4
2043	186	30	35	86	$1,948.3
2044	192	31	37	89	$2,011.1
2045	200	32	38	92	$2,094.9
2046	208	34	40	95	$2,178.7
2047	216	35	42	99	$2,262.6
2048	225	37	44	103	$2,356.9
2049	233	38	45	106	$2,440.6
2050	237	39	46	108	$2,482.6
Total Benefit *	$31,654.4	$29.8	$30.9	$1.2	$31,716.4

*Note: Totals may differ due to rounding

7.2 Costs

7.2.1 Direct Costs

The Modified Baseline has higher costs than the Legal Baseline due to the costs associated with the HDIM regulation which affects non-gasoline Class 4-8 vehicles operating within California. ZEVs are not subject to many provisions of the HDIM regulation and as a result can avoid many of the costs associated with the regulation.[198] Costs associated with the HDIM regulation are derived from the Staff Report and are summarized in Table 67. These

[198] California Air Resources Board, *Proposed Heavy-Duty Inspection and Maintenance Regulation – Appendix F: Further Details on Costs and Economic Analysis*, 2021 (web link: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/hdim2021/appf.pdf, last accessed January 2022).

costs differ depending on whether the vehicle is based in-state or out-of-state, and whether the vehicle is equipped with on-board diagnostics (OBD).

Table 67. Annual Heavy-Duty Inspection and Maintenance Costs per Vehicle

Cost	Non-OBD In-State	Non-OBD Out-of-State	OBD In-State	OBD Out-of-State	ZEV
Inspection Result Reporting	$5.70	$5.70	$0	$0	$0
Periodic Testing and Follow-up Testing	$41	$401	$24	$24	$0
Repair Costs	$279	$211	$228	$172	$0

The cost of the proposed regulation, assuming all cost increases would be borne by fleets operating in California, is -$13.4 billion between 2020 and 2050 compared to the Modified Baseline. These savings are $0.9 billion greater than when the proposed regulation is compared to Legal Baseline. Figure 42 and Table 68 illustrate the incremental difference in cost between the proposed regulation and the Modified Baseline scenario. For simplicity, all costs which are identical to the legal baseline have been lumped together into one group, titled “Cost Versus Legal Baseline”, which are identical to the costs displayed in Table 39. The benefit-cost ratio of the proposed regulation versus the modified baseline is shown in Table 69.

Figure 42. Total Estimated Direct Costs of Proposed Regulation Relative to the Legal Baseline Scenario (million 2021$)

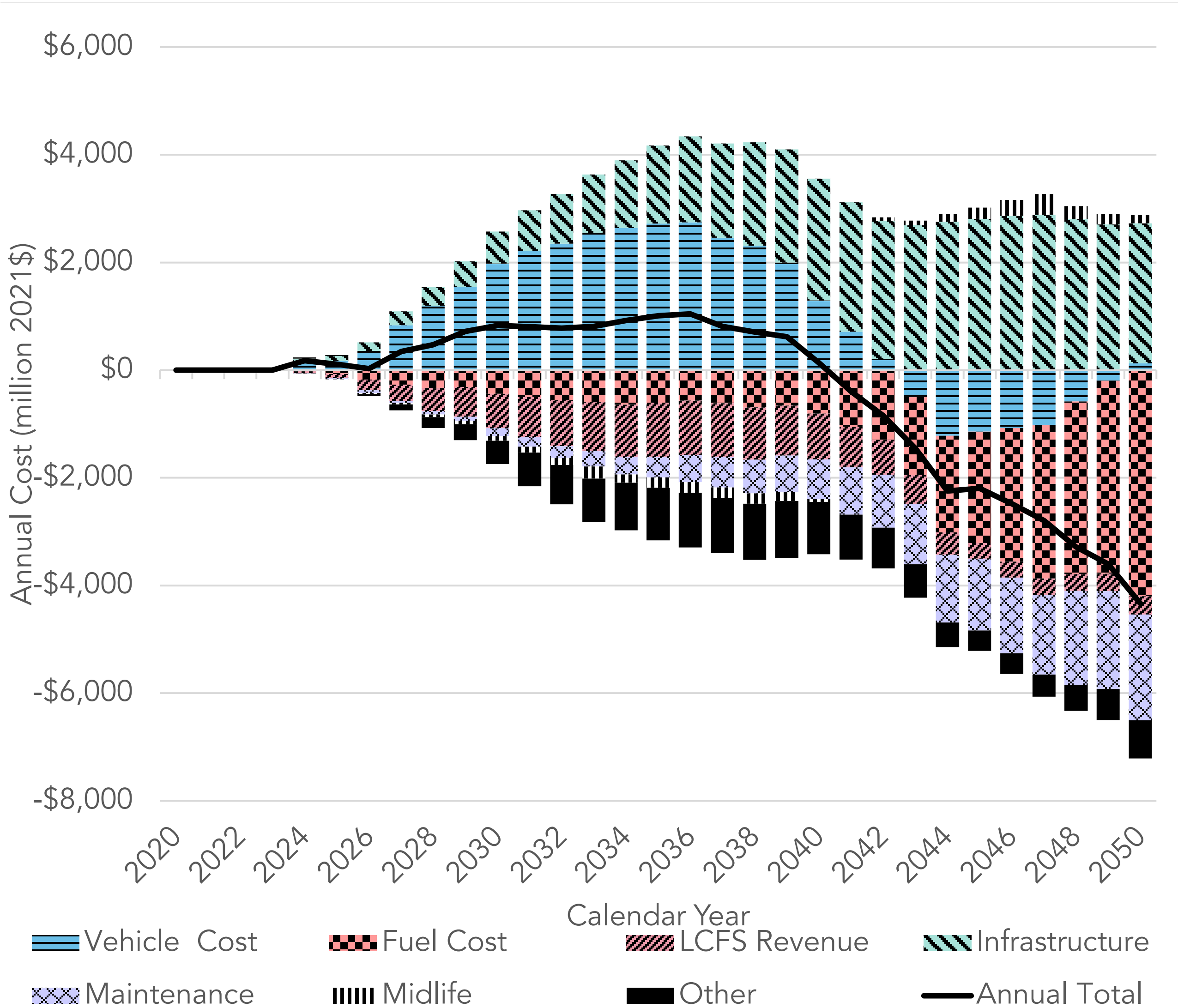


Table 68. Total Incremental Direct Costs of Proposed Regulation Relative to Modified Baseline Scenario (million 2021$)

Year	Cost Versus Legal Baseline	Heavy-Duty Inspection and Maintenance Program	Total *
2024	$174	-$1	$173
2025	$108	-$2	$106
2026	$28	-$3	$25
2027	$345	-$5	$340
2028	$475	-$7	$468
2029	$727	-$10	$717
2030	$837	-$12	$825
2031	$819	-$15	$803
2032	$795	-$19	$776
2033	$830	-$22	$808
2034	$945	-$26	$919
2035	$1,037	-$31	$1,006
2036	$1,074	-$34	$1,040
2037	$843	-$37	$806
2038	$744	-$40	$705
2039	$658	-$43	$615
2040	$179	-$45	$134
2041	-$352	-$47	-$399
2042	-$798	-$50	-$847
2043	-$1,407	-$51	-$1,458
2044	-$2,199	-$53	-$2,252
2045	-$2,148	-$54	-$2,203
2046	-$2,426	-$57	-$2,483
2047	-$2,742	-$59	-$2,801
2048	-$3,224	-$62	-$3,286
2049	-$3,541	-$64	-$3,605
2050	-$4,271	-$68	-$4,339
Total*	-$12,384	-$916	-$13,301

*Note: Totals may differ due to rounding

Table 69. Benefit-Cost Ratio of the Proposed Regulation Versus the Modified Baseline (billion $2021)

Category	Total Costs	Cost-Savings (benefit)	Health Benefits	Tax and Fee Revenue	Total Benefit	Net Benefit	Benefit-Cost Ratio
Proposal	$84.6	$107.5	$31.7	-$37	$102.2	-$16.5	1.2

7.2.2 Macroeconomics

Table 70, Table 71, Figure 43, and Figure 44 shows the impact of the proposed regulation relative to the Modified Baseline on select macroeconomic indicators in the economy. The macroeconomic analysis of the proposed regulation using the Modified Baseline shows that the major macroeconomic indicators would have a similar range of impact as using the Legal Baseline from 2024 to 2050, though they vary by year.

Table 70. Change in the Growth of Economic Indicators relative to the Modified Baseline

Indicator	Metric	2026	2030	2034	2038	2042	2046	2050
GSP	% Change	0.00%	-0.06%	-0.10%	-0.12%	-0.08%	-0.04%	-0.08%
	Change (2021M$)	-43	-2,420	-4,168	-5,276	-3,796	-2,293	-4,276
Personal Income	% Change	-0.02%	-0.11%	-0.17%	-0.18%	-0.11%	-0.05%	-0.04%
	Change (2021M$)	-764	-3,854	-6,195	-7,140	-4,744	-2,180	-2,070
Employment	% Change	0.00%	-0.07%	-0.13%	-0.16%	-0.13%	-0.09%	-0.15%
	Change in Jobs	21	-18,836	-33,107	-43,138	-34,578	-25,573	-41,992
Output	% Change	0.00%	-0.07%	-0.11%	-0.13%	-0.10%	-0.06%	-0.10%
	Change (2021M$)	-99	-4,256	-7,379	-9,506	-7,440	-5,253	-9,117
Private Investment	% Change	-0.03%	-0.18%	-0.19%	-0.07%	0.17%	0.33%	0.31%
	Change (2021M$)	-172	-1,040	-1,141	-453	1,200	2,437	2,492

Figure 43. Job Impacts by Major Sector relative to the Modified Baseline

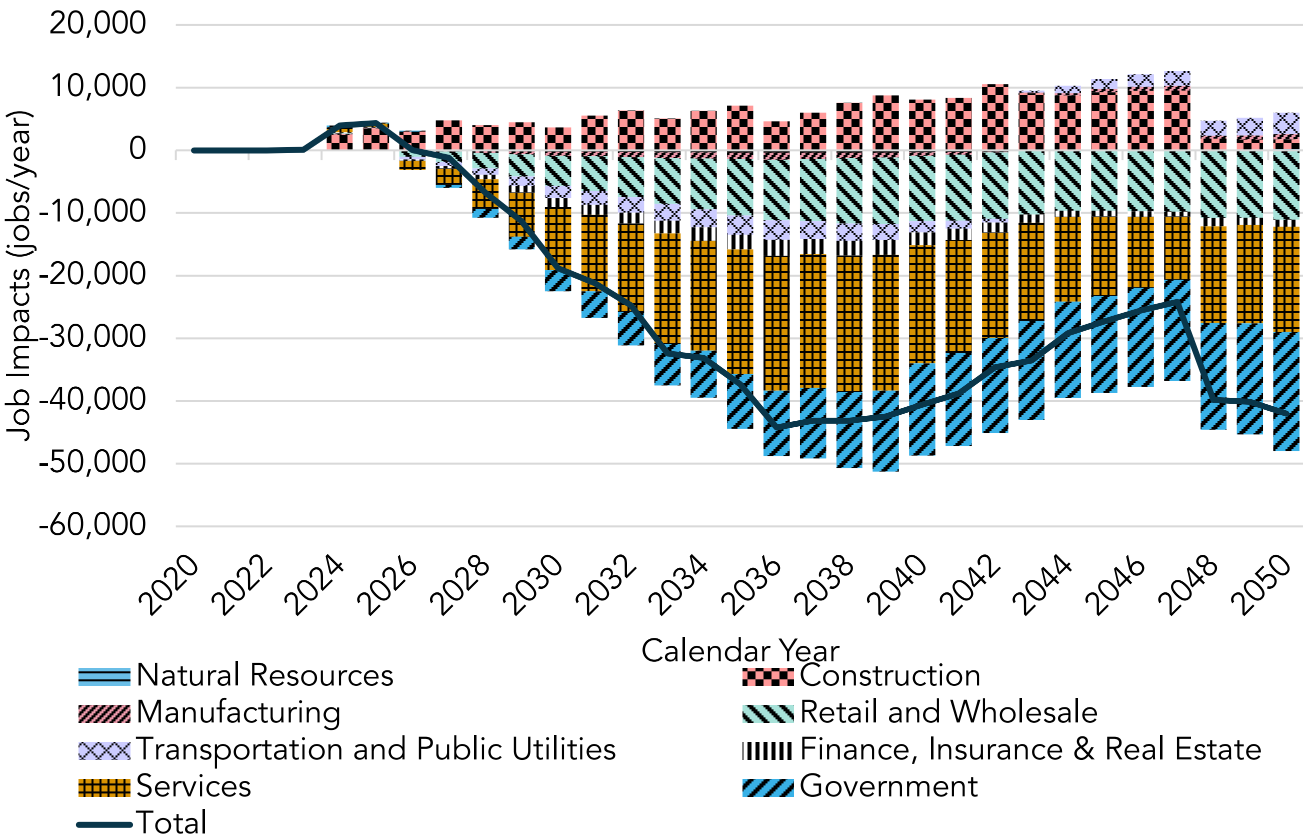


Figure 44. Change in Output by Major Sector relative to the Modified Baseline

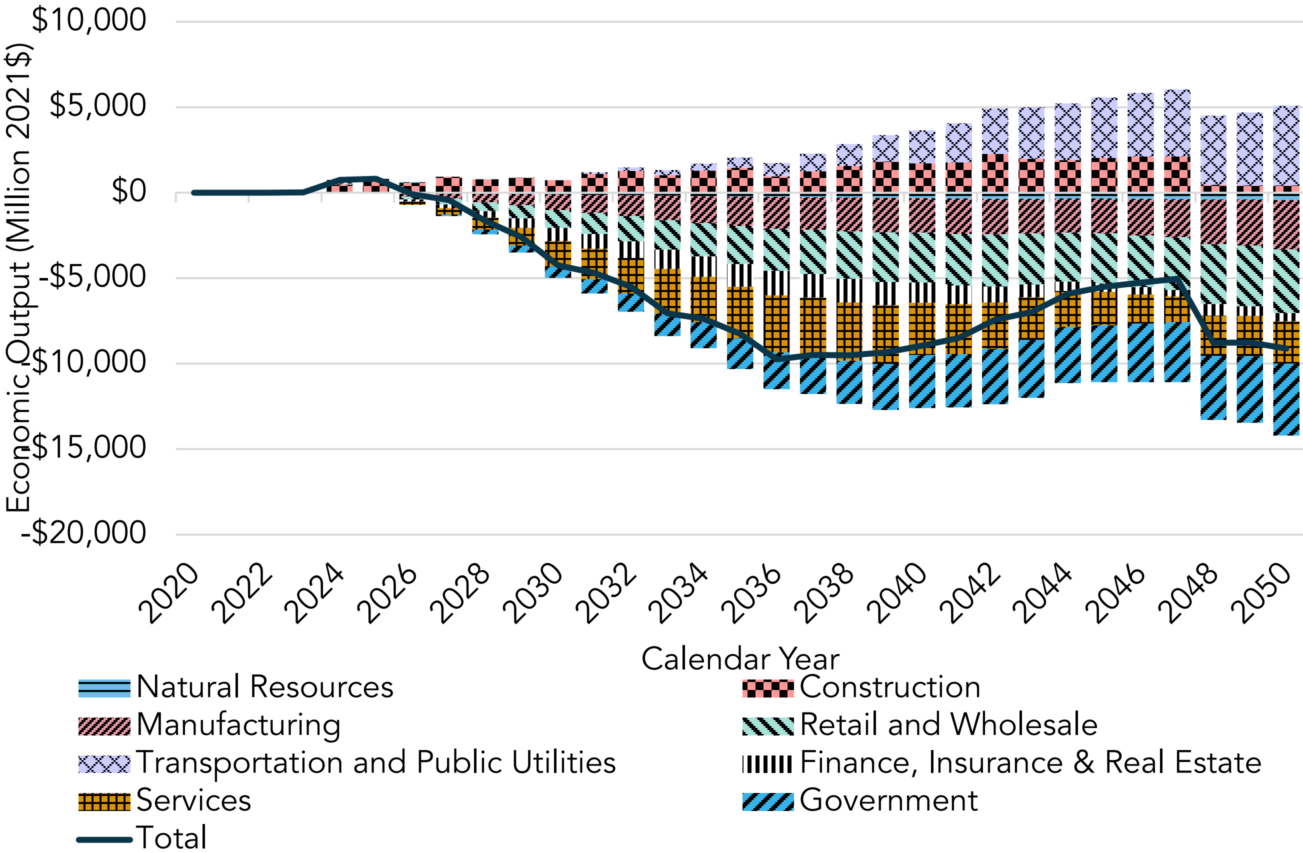


Table 71. Change in Growth of Economic Indicators for the Proposed Regulation Relative to the Modified Baseline

Indicator	GSP		Personal Income		Employment		Output		Private Investment	
Calendar Year	Total Change (2021M$)	% Change	Total Change (2021M$)	% Change	Total Jobs	% Change	Total Change (2021M$)	% Change	Total Change (2021M$)	% Change
2023	-55.26	0.00%	-48.17	0.00%	-568	0.00%	-103.58	0.00%	-18.73	-0.01%
2024	-165.73	-0.01%	-153.63	0.00%	-1734	-0.01%	-315.05	-0.01%	-68.97	-0.02%
2025	-115.28	0.00%	-123.83	0.00%	-1118	0.00%	-221.71	0.00%	-58.87	-0.01%
2026	-99.41	0.00%	-115.90	0.00%	-947	0.00%	-192.99	0.00%	-45.63	-0.01%
2027	-76.91	0.00%	-100.05	0.00%	-728	0.00%	-153.02	0.00%	-28.57	-0.01%
2028	-64.04	0.00%	-90.63	0.00%	-604	0.00%	-129.73	0.00%	-16.32	0.00%
2029	-56.15	0.00%	-84.17	0.00%	-528	0.00%	-115.12	0.00%	-8.27	0.00%
2030	-51.40	0.00%	-80.92	0.00%	-481	0.00%	-106.07	0.00%	-3.41	0.00%
2031	-49.35	0.00%	-80.06	0.00%	-459	0.00%	-101.82	0.00%	-1.00	0.00%
2033	-48.39	0.00%	-82.50	0.00%	-448	0.00%	-98.89	0.00%	-0.11	0.00%
2034	-49.36	0.00%	-85.63	0.00%	-454	0.00%	-100.05	0.00%	-0.81	0.00%

Indicator	GSP		Personal Income		Employment		Output		Private Investment	
Calendar Year	Total Change (2021M$)	% Change	Total Change (2021M$)	% Change	Total Jobs	% Change	Total Change (2021M$)	% Change	Total Change (2021M$)	% Change
2035	-50.49	0.00%	-89.25	0.00%	-461	0.00%	-101.60	0.00%	-1.79	0.00%
2036	-51.89	0.00%	-93.49	0.00%	-470	0.00%	-103.75	0.00%	-2.88	0.00%
2037	-53.21	0.00%	-97.96	0.00%	-479	0.00%	-105.87	0.00%	-3.91	0.00%
2038	-53.90	0.00%	-102.05	0.00%	-483	0.00%	-107.02	0.00%	-4.69	0.00%
2039	-54.45	0.00%	-106.15	0.00%	-485	0.00%	-107.93	0.00%	-5.25	0.00%
2040	-55.26	0.00%	-110.76	0.00%	-490	0.00%	-109.39	0.00%	-5.72	0.00%
2041	-56.24	0.00%	-115.57	0.00%	-494	0.00%	-111.26	0.00%	-6.29	0.00%
2042	-57.32	0.00%	-120.81	0.00%	-500	0.00%	-113.35	0.00%	-6.81	0.00%
2043	-58.42	0.00%	-126.39	0.00%	-506	0.00%	-115.58	0.00%	-7.27	0.00%
2044	-59.53	0.00%	-132.23	0.00%	-512	0.00%	-117.86	0.00%	-7.66	0.00%
2045	-61.01	0.00%	-138.84	0.00%	-520	0.00%	-120.88	0.00%	-8.09	0.00%
2046	-11.86	0.00%	-67.24	0.00%	-117	0.00%	-32.50	0.00%	-1.94	0.00%

Indicator	GSP		Personal Income		Employment		Output		Private Investment	
Calendar Year	**Total Change (2021M$)**	**% Change**	**Total Change (2021M$)**	**% Change**	**Total Jobs**	**% Change**	**Total Change (2021M$)**	**% Change**	**Total Change (2021M$)**	**% Change**
2047	-65.41	0.00%	-146.64	0.00%	-537	0.00%	-129.35	0.00%	-7.44	0.00%
2048	-65.96	0.00%	-156.60	0.00%	-546	0.00%	-131.16	0.00%	-8.82	0.00%
2049	-68.96	0.00%	-168.21	0.00%	-565	0.00%	-137.13	0.00%	-9.93	0.00%
2050	-71.45	0.00%	-179.44	0.00%	-580	0.00%	-142.28	0.00%	-10.71	0.00%

7.3 Fiscal Impacts

7.3.1 Local Government

Table 72 shows the estimated fiscal cost to local governments due to the proposed regulation relative to the Modified Baseline scenario. The fiscal impact to local government is estimated to be $4.4 billion over the regulatory analysis period.

Table 72. Estimated Fiscal Impacts to Local Government versus Modified Baseline (million 2021$)

Year	Local Government Fleet Cost Pass-Through	Utility User Tax Revenue	Local Gasoline and Diesel Fuel Taxes	Local Sales Tax	Total Fiscal Impact*
2024	-$75	$2	$64	$16	$7
2025	-$47	$4	$59	$17	$33
2026	-$30	$11	$50	$64	$94
2027	-$57	$18	$39	$81	$80
2028	-$15	$25	$28	$64	$102
2029	$32	$39	$10	$98	$179
2030	$48	$54	-$10	$98	$190
2031	$76	$72	-$32	$123	$239
2032	$94	$91	-$53	$127	$258
2033	$105	$110	-$72	$105	$248
2034	$110	$133	-$97	$127	$272
2035	$114	$159	-$123	$125	$275
2036	$128	$182	-$147	$70	$233
2037	$126	$206	-$173	$79	$237
2038	$124	$231	-$201	$87	$241
2039	$140	$256	-$225	$81	$253
2040	$134	$280	-$251	-$44	$119
2041	$126	$304	-$280	-$27	$124
2042	$120	$329	-$309	-$9	$131
2043	$114	$344	-$323	-$69	$67
2044	$117	$352	-$335	-$49	$85
2045	$119	$365	-$350	-$28	$106
2046	$129	$376	-$369	-$13	$124
2047	$147	$387	-$386	$0	$148
2048	$168	$398	-$402	$13	$177
2049	$185	$409	-$420	$22	$196
2050	$203	$431	-$456	$32	$210
Total	$2,438	$5,568	-$4,764	$1,187	$4,429

*Note: Totals may differ due to rounding

7.3.2 State Government

Table 73 shows the estimated fiscal impacts to the State government due to the proposed regulation relative to Legal Baseline conditions. The fiscal impact to local government is estimated to be -$38.2 billion over the regulatory analysis period.

Table 73. Estimated Fiscal Impacts on State Government (million 2021$)

Year	CARB Staffing and Resources	State Fleet Cost Pass-Through	State Fuel Taxes	Energy Resources Fees	Registration Fees	State Sales Taxes	Depreciation	Total Fiscal Impact*
2023	-$2	$0	$0	$0	$0	$0	$0	**-$2**
2024	-$3	-$18	-$15	$0	$0	$14	-$6	**-$29**
2025	-$3	-$11	-$27	$0	-$2	$14	-$24	**-$53**
2026	-$3	-$7	-$59	$0	-$8	$54	-$80	**-$104**
2027	-$3	-$13	-$101	$0	-$17	$68	-$177	**-$242**
2028	-$3	-$3	-$139	$1	-$24	$54	-$266	**-$381**
2029	-$3	$7	-$209	$1	-$35	$83	-$365	**-$521**
2030	-$3	$11	-$286	$1	-$52	$83	-$487	**-$733**
2031	-$3	$18	-$370	$1	-$72	$104	-$595	**-$918**
2032	-$3	$22	-$454	$2	-$90	$107	-$683	**-$1,099**
2033	-$3	$25	-$524	$2	-$108	$88	-$732	**-$1,252**
2034	-$3	$26	-$623	$2	-$136	$107	-$778	**-$1,405**
2035	-$3	$27	-$725	$3	-$164	$106	-$829	**-$1,586**
2036	-$3	$30	-$817	$3	-$193	$59	-$827	**-$1,748**
2037	-$3	$30	-$918	$3	-$226	$66	-$788	**-$1,837**
2038	-$3	$29	-$1,026	$4	-$259	$73	-$762	**-$1,944**
2039	-$3	$33	-$1,121	$4	-$286	$69	-$731	**-$2,035**
2040	-$3	$31	-$1,223	$4	-$309	-$37	-$584	**-$2,120**
2041	-$3	$30	-$1,338	$5	-$340	-$23	-$385	**-$2,054**
2042	-$3	$28	-$1,458	$5	-$369	-$8	-$254	**-$2,059**
2043	-$3	$27	-$1,507	$5	-$379	-$58	-$81	**-$1,997**
2044	-$3	$27	-$1,556	$5	-$394	-$42	$121	**-$1,840**
2045	-$3	$28	-$1,617	$6	-$409	-$24	$221	**-$1,800**
2046	-$3	$30	-$1,688	$6	-$421	-$11	$239	**-$1,849**
2047	-$3	$35	-$1,755	$6	-$431	$0	$225	**-$1,925**
2048	-$3	$39	-$1,823	$6	-$442	$11	$174	**-$2,038**
2049	-$3	$43	-$1,892	$6	-$451	$18	$85	**-$2,193**
2050	-$3	$48	-$2,042	$7	-$483	$27	-$8	**-$2,456**
Total*	**-$92**	**$572**	**-$25,313**	**$89**	**-$6,102**	**$1,004**	**-$8,378**	**-$38,220**

*Note: Totals may differ due to rounding

8 Vehicle Cost Attributes Appendix

8.1 Vehicle Prices

Table 74. Vehicle Prices, 2024-2029

Model Year	2024	2025	2026	2027	2028	2029
Class 2B Cargo Van - Diesel	$40,137	$40,137	$40,137	$40,611	$40,611	$40,611
Class 2B Pickup - Diesel	$47,137	$47,137	$47,137	$47,611	$47,611	$47,611
Class 3 Service - Diesel	$57,137	$57,137	$57,137	$57,611	$57,611	$57,611
Class 5 Cutaway - Diesel	$91,621	$91,621	$91,621	$95,176	$95,176	$95,176
Class 5 Walk-in Van - Diesel	$90,935	$90,935	$90,935	$94,490	$94,490	$94,490
Class 5 Service - Diesel	$68,935	$68,935	$68,935	$72,490	$72,490	$72,490
Class 6 Box Truck - Diesel	$89,622	$89,622	$89,622	$93,705	$93,705	$93,705
Class 6 Bucket Truck - Diesel	$130,622	$130,622	$130,622	$134,705	$134,705	$134,705
Class 8 Box Truck - Diesel	$125,886	$125,886	$125,886	$129,192	$129,192	$129,192
Class 8 Dump Truck - Diesel	$180,886	$180,886	$180,886	$184,192	$184,192	$184,192
Class 8 Refuse Packer - Diesel	$231,886	$231,886	$231,886	$235,192	$235,192	$235,192
Class 8 Transit Bus - Diesel	$440,886	$440,886	$440,886	$444,192	$444,192	$444,192
Class 8 Day Cab - Diesel	$145,396	$145,396	$145,396	$150,688	$150,688	$150,688
Class 8 Sleeper Cab - Diesel	$153,494	$153,494	$153,494	$157,399	$157,399	$157,399
Class 8 Specialty - Diesel	$277,386	$277,386	$277,386	$280,692	$280,692	$280,692
Class 8 Yard Tractor - Diesel	$120,886	$120,886	$120,886	$124,192	$124,192	$124,192
Class 8 Motor Coach - Diesel	$634,419	$634,419	$634,419	$637,725	$637,725	$637,725
Class 2B Cargo Van - Gasoline	$36,137	$36,137	$36,137	$36,611	$36,611	$36,611
Class 2B Pickup - Gasoline	$37,137	$37,137	$37,137	$37,611	$37,611	$37,611
Class 3 Service - Gasoline	$47,137	$47,137	$47,137	$47,611	$47,611	$47,611
Class 5 Cutaway - Gasoline	$76,247	$76,247	$76,247	$77,288	$77,288	$77,288
Class 2B Cargo Van - Battery-Electric	$57,659	$54,835	$52,448	$50,420	$48,389	$46,687
Class 2B Pickup - Battery-Electric	$74,010	$69,786	$66,216	$63,185	$60,146	$57,599
Class 3 Service - Battery-Electric	$75,942	$72,592	$69,792	$67,364	$64,964	$62,903
Class 5 Cutaway - Battery-Electric	$109,378	$105,826	$102,773	$100,262	$97,688	$95,612
Class 5 Walk-in Van - Battery-Electric	$110,856	$107,074	$103,816	$101,142	$98,394	$96,182
Class 5 Service - Battery-Electric	$94,990	$90,806	$87,236	$84,259	$81,236	$78,756
Class 6 Box Truck - Battery-Electric	$130,358	$124,527	$119,516	$115,394	$111,168	$107,758
Class 6 Bucket Truck - Battery-Electric	$171,358	$165,527	$160,516	$156,394	$152,168	$148,758

Model Year	2024	2025	2026	2027	2028	2029
Class 8 Box Truck - Battery-Electric	$174,269	$166,150	$159,174	$153,433	$147,550	$142,800
Class 8 Dump Truck - Battery-Electric	$229,356	$221,235	$214,257	$208,514	$202,629	$197,877
Class 8 Refuse Packer - Battery-Electric	$304,729	$293,965	$284,660	$277,093	$269,273	$263,049
Class 8 Transit Bus - Battery-Electric	$489,425	$481,293	$474,305	$468,554	$462,661	$457,903
Class 8 Day Cab - Battery-Electric	$216,451	$204,579	$194,297	$185,964	$177,332	$170,490
Class 8 Sleeper Cab - Battery-Electric	$317,605	$295,597	$276,385	$261,050	$244,991	$232,495
Class 8 Specialty - Battery-Electric	$355,453	$344,182	$334,428	$326,508	$318,312	$311,800
Class 8 Yard Tractor - Battery-Electric	$156,979	$149,807	$143,576	$138,558	$133,337	$129,231
Class 8 Motor Coach - Battery-Electric	$714,355	$702,702	$692,593	$684,428	$675,950	$669,257
Class 2B Cargo Van - Fuel Cell Electric	$96,456	$89,469	$83,750	$78,307	$73,132	$68,224
Class 2B Pickup - Fuel Cell Electric	$127,898	$117,681	$109,303	$101,317	$93,738	$86,542
Class 3 Service - Fuel Cell Electric	$137,898	$127,681	$119,303	$111,317	$103,738	$96,542
Class 5 Cutaway - Fuel Cell Electric	$134,212	$128,530	$123,935	$119,556	$115,377	$111,408
Class 5 Walk-in Van - Fuel Cell Electric	$133,524	$127,842	$123,247	$118,869	$114,689	$110,720
Class 5 Service - Fuel Cell Electric	$138,101	$129,836	$123,115	$116,704	$110,602	$104,803
Class 6 Box Truck - Fuel Cell Electric	$162,419	$153,485	$146,212	$139,276	$132,676	$126,406
Class 6 Bucket Truck - Fuel Cell Electric	$203,679	$194,713	$187,414	$180,450	$173,826	$167,530
Class 8 Box Truck - Fuel Cell Electric	$213,194	$201,033	$191,102	$181,622	$172,623	$164,066
Class 8 Dump Truck - Fuel Cell Electric	$282,290	$269,500	$259,154	$249,257	$239,837	$230,857
Class 8 Refuse Packer - Fuel Cell Electric	$332,686	$319,922	$309,592	$299,712	$290,309	$281,346
Class 8 Transit Bus - Fuel Cell Electric	$541,611	$528,852	$518,526	$508,650	$499,251	$490,291
Class 8 Day Cab - Fuel Cell Electric	$234,111	$221,352	$211,026	$201,150	$191,751	$182,791
Class 8 Sleeper Cab - Fuel Cell Electric	$268,770	$254,774	$243,624	$232,923	$222,699	$212,915
Class 8 Specialty - Fuel Cell Electric	$378,111	$365,352	$355,026	$345,150	$335,751	$326,791
Class 8 Yard Tractor - Fuel Cell Electric	$167,617	$160,670	$155,131	$149,832	$144,759	$139,920
Class 8 Motor Coach - Fuel Cell Electric	$722,868	$711,400	$702,138	$693,279	$684,841	$676,798
Class 8 Refuse Packer - Natural Gas	$259,135	$259,135	$259,135	$260,172	$260,172	$260,172
Class 8 Day Cab - Natural Gas	$192,376	$192,376	$192,376	$195,419	$195,419	$195,419
Class 8 Sleeper Cab - Natural Gas	$242,130	$242,130	$242,130	$245,020	$245,020	$245,020

Table 75. Vehicle Prices, 2030-2035

Age	2030	2031	2032	2033	2034	2035
Class 2B Cargo Van - Diesel	$40,611	$40,611	$40,611	$40,611	$40,611	$40,611
Class 2B Pickup - Diesel	$47,611	$47,611	$47,611	$47,611	$47,611	$47,611
Class 3 Service - Diesel	$57,611	$57,611	$57,611	$57,611	$57,611	$57,611
Class 5 Cutaway - Diesel	$95,176	$96,081	$96,081	$96,081	$96,081	$96,081
Class 5 Walk-in Van - Diesel	$94,490	$95,395	$95,395	$95,395	$95,395	$95,395
Class 5 Service - Diesel	$72,490	$73,395	$73,395	$73,395	$73,395	$73,395
Class 6 Box Truck - Diesel	$93,705	$93,917	$93,917	$93,917	$93,917	$93,917
Class 6 Bucket Truck - Diesel	$134,705	$134,917	$134,917	$134,917	$134,917	$134,917
Class 8 Box Truck - Diesel	$129,192	$128,581	$128,581	$128,581	$128,581	$128,581
Class 8 Dump Truck - Diesel	$184,192	$183,581	$183,581	$183,581	$183,581	$183,581
Class 8 Refuse Packer - Diesel	$235,192	$234,581	$234,581	$234,581	$234,581	$234,581
Class 8 Transit Bus - Diesel	$444,192	$443,581	$443,581	$443,581	$443,581	$443,581
Class 8 Day Cab - Diesel	$150,688	$150,083	$150,083	$150,083	$150,083	$150,083
Class 8 Sleeper Cab - Diesel	$157,399	$157,126	$157,126	$157,126	$157,126	$157,126
Class 8 Specialty - Diesel	$280,692	$280,081	$280,081	$280,081	$280,081	$280,081
Class 8 Yard Tractor - Diesel	$124,192	$123,581	$123,581	$123,581	$123,581	$123,581
Class 8 Motor Coach - Diesel	$637,725	$637,114	$637,114	$637,114	$637,114	$637,114
Class 2B Cargo Van - Gasoline	$36,611	$36,611	$36,611	$36,611	$36,611	$36,611
Class 2B Pickup - Gasoline	$37,611	$37,611	$37,611	$37,611	$37,611	$37,611
Class 3 Service - Gasoline	$47,611	$47,611	$47,611	$47,611	$47,611	$47,611
Class 5 Cutaway - Gasoline	$77,288	$77,190	$77,190	$77,190	$77,190	$77,190
Class 2B Cargo Van - Battery-Electric	$45,167	$44,068	$43,010	$42,096	$41,213	$40,361
Class 2B Pickup - Battery-Electric	$55,326	$53,685	$52,103	$50,739	$49,421	$48,150
Class 3 Service - Battery-Electric	$61,037	$59,784	$58,573	$57,509	$56,479	$55,482
Class 5 Cutaway - Battery-Electric	$93,805	$92,344	$90,943	$89,768	$88,639	$87,556
Class 5 Walk-in Van - Battery-Electric	$94,260	$92,694	$91,185	$89,918	$88,707	$87,552
Class 5 Service - Battery-Electric	$76,575	$74,896	$73,283	$71,912	$70,591	$69,193
Class 6 Box Truck - Battery-Electric	$104,791	$102,396	$100,099	$98,167	$96,310	$94,526
Class 6 Bucket Truck - Battery-Electric	$145,791	$149,946	$147,649	$145,717	$143,860	$142,076
Class 8 Box Truck - Battery-Electric	$138,666	$135,333	$132,135	$129,446	$126,860	$124,377
Class 8 Dump Truck - Battery-Electric	$193,741	$195,908	$192,710	$190,021	$187,435	$184,952
Class 8 Refuse Packer - Battery-Electric	$257,685	$253,179	$248,861	$245,262	$241,808	$238,496
Class 8 Transit Bus - Battery-Electric	$453,762	$450,423	$447,219	$444,525	$441,934	$439,447

Age	2030	2031	2032	2033	2034	2035
Class 8 Day Cab - Battery-Electric	$164,611	$159,611	$154,821	$150,844	$147,027	$143,371
Class 8 Sleeper Cab - Battery-Electric	$221,901	$212,404	$203,325	$195,863	$188,716	$181,883
Class 8 Specialty - Battery-Electric	$306,195	$316,618	$312,090	$308,321	$304,703	$301,236
Class 8 Yard Tractor - Battery-Electric	$125,723	$122,670	$119,749	$117,332	$115,015	$112,797
Class 8 Motor Coach - Battery-Electric	$663,523	$658,589	$653,865	$649,949	$646,192	$642,594
Class 2B Cargo Van - Fuel Cell Electric	$63,567	$60,493	$56,592	$53,171	$50,944	$48,115
Class 2B Pickup - Fuel Cell Electric	$79,710	$75,252	$69,549	$64,559	$61,358	$58,015
Class 3 Service - Fuel Cell Electric	$89,710	$85,252	$79,549	$74,559	$71,358	$68,015
Class 5 Cutaway - Fuel Cell Electric	$107,631	$105,044	$101,837	$98,994	$97,048	$92,743
Class 5 Walk-in Van - Fuel Cell Electric	$106,944	$104,356	$101,149	$98,307	$96,361	$92,056
Class 5 Service - Fuel Cell Electric	$99,288	$95,594	$90,947	$86,850	$84,126	$79,411
Class 6 Box Truck - Fuel Cell Electric	$120,445	$116,463	$111,445	$107,026	$104,099	$99,273
Class 6 Bucket Truck - Fuel Cell Electric	$161,543	$164,096	$159,054	$154,615	$151,678	$146,852
Class 8 Box Truck - Fuel Cell Electric	$155,930	$150,566	$143,750	$137,763	$133,862	$128,523
Class 8 Dump Truck - Fuel Cell Electric	$222,299	$222,009	$214,766	$208,352	$204,025	$195,054
Class 8 Refuse Packer - Fuel Cell Electric	$272,805	$267,034	$259,811	$253,416	$249,108	$240,309
Class 8 Transit Bus - Fuel Cell Electric	$481,754	$475,984	$468,763	$462,369	$458,063	$449,265
Class 8 Day Cab - Fuel Cell Electric	$174,254	$168,484	$161,263	$154,869	$150,563	$141,765
Class 8 Sleeper Cab - Fuel Cell Electric	$203,552	$196,958	$188,911	$181,693	$176,562	$160,833
Class 8 Specialty - Fuel Cell Electric	$318,254	$327,634	$320,413	$314,019	$309,713	$300,915
Class 8 Yard Tractor - Fuel Cell Electric	$135,297	$132,020	$128,040	$124,471	$121,918	$114,045
Class 8 Motor Coach - Fuel Cell Electric	$669,130	$663,914	$657,413	$651,647	$647,730	$639,138
Class 8 Refuse Packer - Natural Gas	$260,172	$260,076	$260,076	$260,076	$260,076	$260,076
Class 8 Day Cab - Natural Gas	$195,419	$195,324	$195,324	$195,324	$195,324	$195,324
Class 8 Sleeper Cab - Natural Gas	$245,020	$244,977	$244,977	$244,977	$244,977	$244,977

8.2 Accrual Rate

Table 76. Accrual Rate Years 0 – 9

Age	0	1	2	3	4	5	6	7	8	9
Class 2B Cargo Van - Diesel	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 2B Pickup - Diesel	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 3 Service - Diesel	23,167	19,844	17,893	16,505	15,426	14,542	13,792	13,141	12,563	12,045
Class 5 Cutaway - Diesel	28,514	27,411	26,314	25,220	24,139	23,068	22,011	20,969	19,946	18,939
Class 5 Walk-in Van - Diesel	16,398	15,787	15,210	14,668	14,160	13,685	13,245	12,840	12,468	12,131
Class 5 Service - Diesel	16,253	16,211	16,136	16,029	15,890	15,719	15,515	15,280	15,012	14,712
Class 6 Box Truck - Diesel	16,398	15,787	15,210	14,668	14,160	13,685	13,245	12,840	12,468	12,131
Class 6 Bucket Truck - Diesel	16,253	16,211	16,136	16,029	15,890	15,719	15,515	15,280	15,012	14,712
Class 8 Box Truck - Diesel	23,077	22,248	21,431	20,614	19,806	19,007	18,211	17,402	16,579	15,745
Class 8 Dump Truck - Diesel	28,588	27,514	26,440	25,367	24,295	23,225	22,157	21,090	20,023	18,956
Class 8 Refuse Packer - Diesel	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Transit Bus - Diesel	20,874	20,872	20,729	20,414	19,952	19,369	18,688	17,937	17,134	16,296
Class 8 Day Cab - Diesel	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Diesel	100,672	97,261	94,127	91,241	88,589	86,167	84,366	82,762	81,378	80,227
Class 8 Specialty - Diesel	28,588	27,514	26,440	25,367	24,295	23,225	22,157	21,090	20,023	18,956
Class 8 Yard Tractor - Diesel	3,034	3,012	2,840	2,643	2,566	2,490	2,425	2,343	2,297	2,257
Class 8 Motor Coach - Diesel	45,912	45,911	45,910	45,910	45,909	45,908	45,908	45,907	45,907	41,316
Class 2B Cargo Van - Gasoline	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 2B Pickup - Gasoline	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 3 Service - Gasoline	23,167	19,844	17,893	16,505	15,426	14,542	13,792	13,141	12,563	12,045
Class 5 Cutaway - Gasoline	28,514	27,411	26,314	25,220	24,139	23,068	22,011	20,969	19,946	18,939
Class 2B Cargo Van - Battery-Electric	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 2B Pickup - Battery-Electric	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 3 Service - Battery-Electric	23,167	19,844	17,893	16,505	15,426	14,542	13,792	13,141	12,563	12,045
Class 5 Cutaway - Battery-Electric	28,514	27,411	26,314	25,220	24,139	23,068	22,011	20,969	19,946	18,939
Class 5 Walk-in Van - Battery-Electric	16,398	15,787	15,210	14,668	14,160	13,685	13,245	12,840	12,468	12,131
Class 5 Service - Battery-Electric	16,253	16,211	16,136	16,029	15,890	15,719	15,515	15,280	15,012	14,712
Class 6 Box Truck - Battery-Electric	16,398	15,787	15,210	14,668	14,160	13,685	13,245	12,840	12,468	12,131
Class 6 Bucket Truck - Battery-Electric	16,253	16,211	16,136	16,029	15,890	15,719	15,515	15,280	15,012	14,712
Class 8 Box Truck - Battery-Electric	23,077	22,248	21,431	20,614	19,806	19,007	18,211	17,402	16,579	15,745
Class 8 Dump Truck - Battery-Electric	28,588	27,514	26,440	25,367	24,295	23,225	22,157	21,090	20,023	18,956

Age	0	1	2	3	4	5	6	7	8	9
Class 8 Refuse Packer - Battery-Electric	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Transit Bus - Battery-Electric	20,874	20,872	20,729	20,414	19,952	19,369	18,688	17,937	17,134	16,296
Class 8 Day Cab - Battery-Electric	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Battery-Electric	100,672	97,261	94,127	91,241	88,589	86,167	84,366	82,762	81,378	80,227
Class 8 Specialty - Battery-Electric	28,588	27,514	26,440	25,367	24,295	23,225	22,157	21,090	20,023	18,956
Class 8 Yard Tractor - Battery-Electric	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Class 8 Motor Coach - Battery-Electric	45,912	45,911	45,910	45,910	45,909	45,908	45,908	45,907	45,907	41,316
Class 2B Cargo Van - Fuel Cell Electric	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 2B Pickup - Fuel Cell Electric	24,451	20,834	18,712	17,203	16,030	15,069	14,254	13,546	12,919	12,356
Class 3 Service - Fuel Cell Electric	23,167	19,844	17,893	16,505	15,426	14,542	13,792	13,141	12,563	12,045
Class 5 Cutaway - Fuel Cell Electric	28,514	27,411	26,314	25,220	24,139	23,068	22,011	20,969	19,946	18,939
Class 5 Walk-in Van - Fuel Cell Electric	16,398	15,787	15,210	14,668	14,160	13,685	13,245	12,840	12,468	12,131
Class 5 Service - Fuel Cell Electric	16,253	16,211	16,136	16,029	15,890	15,719	15,515	15,280	15,012	14,712
Class 6 Box Truck - Fuel Cell Electric	16,398	15,787	15,210	14,668	14,160	13,685	13,245	12,840	12,468	12,131
Class 6 Bucket Truck - Fuel Cell Electric	16,253	16,211	16,136	16,029	15,890	15,719	15,515	15,280	15,012	14,712
Class 8 Box Truck - Fuel Cell Electric	23,077	22,248	21,431	20,614	19,806	19,007	18,211	17,402	16,579	15,745
Class 8 Dump Truck - Fuel Cell Electric	28,588	27,514	26,440	25,367	24,295	23,225	22,157	21,090	20,023	18,956
Class 8 Refuse Packer - Fuel Cell Electric	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Transit Bus - Fuel Cell Electric	20,874	20,872	20,729	20,414	19,952	19,369	18,688	17,937	17,134	16,296
Class 8 Day Cab - Fuel Cell Electric	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Fuel Cell Electric	100,672	97,261	94,127	91,241	88,589	86,167	84,366	82,762	81,378	80,227
Class 8 Specialty - Fuel Cell Electric	28,588	27,514	26,440	25,367	24,295	23,225	22,157	21,090	20,023	18,956
Class 8 Yard Tractor - Fuel Cell Electric	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Class 8 Motor Coach - Fuel Cell Electric	45,912	45,911	45,910	45,910	45,909	45,908	45,908	45,907	45,907	41,316
Class 8 Refuse Packer - Natural Gas	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Day Cab - Natural Gas	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Natural Gas	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940

Table 77. Accrual Rates Years 10 - 19+

Age	10	11	12	13	14	15	16	17	18	19
Class 2B Cargo Van - Diesel	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 2B Pickup - Diesel	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 3 Service - Diesel	11,575	11,144	10,749	10,382	10,041	9,723	9,423	9,141	8,875	8,623
Class 5 Cutaway - Diesel	17,953	16,984	16,037	15,110	14,207	13,328	12,476	11,654	10,859	10,097
Class 5 Walk-in Van - Diesel	11,828	11,559	11,324	11,124	10,957	10,825	10,727	10,664	10,664	10,664
Class 5 Service - Diesel	14,380	14,016	13,619	13,191	12,730	12,237	11,712	11,155	10,565	10,565
Class 6 Box Truck - Diesel	11,828	11,559	11,324	11,124	10,957	10,825	10,727	10,664	10,664	10,664
Class 6 Bucket Truck - Diesel	14,380	14,016	13,619	13,191	12,730	12,237	11,712	11,155	10,565	10,565
Class 8 Box Truck - Diesel	14,899	14,040	13,173	12,298	11,418	10,535	9,649	8,762	8,766	8,770
Class 8 Dump Truck - Diesel	17,890	16,825	15,761	14,697	13,633	12,569	11,505	10,442	10,442	10,442
Class 8 Refuse Packer - Diesel	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Transit Bus - Diesel	15,439	14,577	13,719	12,878	12,060	11,276	11,279	11,282	11,284	11,287
Class 8 Day Cab - Diesel	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Diesel	79,330	78,682	78,262	78,061	78,085	78,337	78,819	79,555	79,466	79,368
Class 8 Specialty - Diesel	17,890	16,825	15,761	14,697	13,633	12,569	11,505	10,442	10,442	10,442
Class 8 Yard Tractor - Diesel	2,214	2,169	2,124	2,079	2,032	1,984	1,936	1,936	1,936	1,936
Class 8 Motor Coach - Diesel	37,185	33,467	30,120	27,108	24,398	21,958	21,958	21,958	21,958	21,958
Class 2B Cargo Van - Gasoline	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 2B Pickup - Gasoline	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 3 Service - Gasoline	11,575	11,144	10,749	10,382	10,041	9,723	9,423	9,141	8,875	8,623
Class 5 Cutaway - Gasoline	17,953	16,984	16,037	15,110	14,207	13,328	12,476	11,654	10,859	10,097
Class 2B Cargo Van - Battery-Electric	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 2B Pickup - Battery-Electric	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 3 Service - Battery-Electric	11,575	11,144	10,749	10,382	10,041	9,723	9,423	9,141	8,875	8,623
Class 5 Cutaway - Battery-Electric	17,953	16,984	16,037	15,110	14,207	13,328	12,476	11,654	10,859	10,097
Class 5 Walk-in Van - Battery-Electric	11,828	11,559	11,324	11,124	10,957	10,825	10,727	10,664	10,664	10,664
Class 5 Service - Battery-Electric	14,380	14,016	13,619	13,191	12,730	12,237	11,712	11,155	10,565	10,565
Class 6 Box Truck - Battery-Electric	11,828	11,559	11,324	11,124	10,957	10,825	10,727	10,664	10,664	10,664
Class 6 Bucket Truck - Battery-Electric	14,380	14,016	13,619	13,191	12,730	12,237	11,712	11,155	10,565	10,565
Class 8 Box Truck - Battery-Electric	14,899	14,040	13,173	12,298	11,418	10,535	9,649	8,762	8,766	8,770
Class 8 Dump Truck - Battery-Electric	17,890	16,825	15,761	14,697	13,633	12,569	11,505	10,442	10,442	10,442
Class 8 Refuse Packer - Battery-Electric	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Transit Bus - Battery-Electric	15,439	14,577	13,719	12,878	12,060	11,276	11,279	11,282	11,284	11,287

Age	10	11	12	13	14	15	16	17	18	19
Class 8 Day Cab - Battery-Electric	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Battery-Electric	79,330	78,682	78,262	78,061	78,085	78,337	78,819	79,555	79,466	79,368
Class 8 Specialty - Battery-Electric	17,890	16,825	15,761	14,697	13,633	12,569	11,505	10,442	10,442	10,442
Class 8 Yard Tractor - Battery-Electric	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Class 8 Motor Coach - Battery-Electric	37,185	33,467	30,120	27,108	24,398	21,958	21,958	21,958	21,958	21,958
Class 2B Cargo Van - Fuel Cell Electric	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 2B Pickup - Fuel Cell Electric	11,846	11,379	10,950	10,553	10,183	9,838	9,514	9,208	8,920	8,646
Class 3 Service - Fuel Cell Electric	11,575	11,144	10,749	10,382	10,041	9,723	9,423	9,141	8,875	8,623
Class 5 Cutaway - Fuel Cell Electric	17,953	16,984	16,037	15,110	14,207	13,328	12,476	11,654	10,859	10,097
Class 5 Walk-in Van - Fuel Cell Electric	11,828	11,559	11,324	11,124	10,957	10,825	10,727	10,664	10,664	10,664
Class 5 Service - Fuel Cell Electric	14,380	14,016	13,619	13,191	12,730	12,237	11,712	11,155	10,565	10,565
Class 6 Box Truck - Fuel Cell Electric	11,828	11,559	11,324	11,124	10,957	10,825	10,727	10,664	10,664	10,664
Class 6 Bucket Truck - Fuel Cell Electric	14,380	14,016	13,619	13,191	12,730	12,237	11,712	11,155	10,565	10,565
Class 8 Box Truck - Fuel Cell Electric	14,899	14,040	13,173	12,298	11,418	10,535	9,649	8,762	8,766	8,770
Class 8 Dump Truck - Fuel Cell Electric	17,890	16,825	15,761	14,697	13,633	12,569	11,505	10,442	10,442	10,442
Class 8 Refuse Packer - Fuel Cell Electric	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Transit Bus - Fuel Cell Electric	15,439	14,577	13,719	12,878	12,060	11,276	11,279	11,282	11,284	11,287
Class 8 Day Cab - Fuel Cell Electric	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Fuel Cell Electric	79,330	78,682	78,262	78,061	78,085	78,337	78,819	79,555	79,466	79,368
Class 8 Specialty - Fuel Cell Electric	17,890	16,825	15,761	14,697	13,633	12,569	11,505	10,442	10,442	10,442
Class 8 Yard Tractor - Fuel Cell Electric	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Class 8 Motor Coach - Fuel Cell Electric	37,185	33,467	30,120	27,108	24,398	21,958	21,958	21,958	21,958	21,958
Class 8 Refuse Packer - Natural Gas	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220	24,220
Class 8 Day Cab - Natural Gas	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940
Class 8 Sleeper Cab - Natural Gas	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940	49,940

8.3 Fuel Economy/Fuel-Efficiency

Table 78. Fuel Economy/Fuel Efficiency

Model Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Unit
Class 2B Cargo Van - Diesel	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.3	19.4	19.4	19.3	mpg
Class 2B Pickup - Diesel	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.3	19.4	19.4	19.3	mpg
Class 3 Service - Diesel	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.6	16.6	16.7	16.6	16.6	mpg
Class 5 Cutaway - Diesel	10.4	10.4	10.4	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	mpg
Class 5 Walk-in Van - Diesel	9.4	9.4	9.4	9.5	9.5	9.5	9.5	9.5	9.6	9.6	9.6	9.6	mpg
Class 5 Service - Diesel	8.8	8.8	8.8	8.9	8.9	8.9	8.9	8.9	8.9	9.0	9.0	9.0	mpg
Class 6 Box Truck - Diesel	9.4	9.4	9.4	9.5	9.5	9.5	9.5	9.5	9.6	9.6	9.6	9.7	mpg
Class 6 Bucket Truck - Diesel	8.9	8.9	8.9	8.9	8.9	8.9	9.0	9.0	9.0	9.0	9.0	9.1	mpg
Class 8 Box Truck - Diesel	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	mpg
Class 8 Dump Truck - Diesel	6.6	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	mpg
Class 8 Refuse Packer - Diesel	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.3	mpg
Class 8 Transit Bus - Diesel	7.2	7.0	6.8	6.9	6.5	6.2	5.8	5.5	5.5	5.5	5.5	5.5	mpg
Class 8 Day Cab - Diesel	6.9	6.9	6.9	6.9	6.9	6.9	7.0	7.0	7.0	7.0	7.0	7.0	mpg
Class 8 Sleeper Cab - Diesel	7.1	7.1	7.1	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	mpg
Class 8 Specialty - Diesel	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	mpg
Class 8 Yard Tractor - Diesel	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	mpg
Class 8 Motor Coach - Diesel	6.3	6.3	6.3	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	mpg
Class 2B Cargo Van - Gasoline	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.0	14.0	14.1	14.1	14.0	mpg
Class 2B Pickup - Gasoline	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.0	14.0	14.1	14.1	14.0	mpg
Class 3 Service - Gasoline	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.4	12.4	12.5	12.5	12.4	mpg
Class 5 Cutaway - Gasoline	5.7	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	mpg
Class 2B Cargo Van - Battery-Electric	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	mi./kWh
Class 2B Pickup - Battery-Electric	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	mi./kWh
Class 3 Service - Battery-Electric	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	mi./kWh
Class 5 Cutaway - Battery-Electric	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	mi./kWh
Class 5 Walk-in Van - Battery-Electric	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	mi./kWh
Class 5 Service - Battery-Electric	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	mi./kWh
Class 6 Box Truck - Battery-Electric	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	mi./kWh
Class 6 Bucket Truck - Battery-Electric	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	mi./kWh
Class 8 Box Truck - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh
Class 8 Dump Truck - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh

Model Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Unit
Class 8 Refuse Packer - Battery-Electric	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	mi./kWh
Class 8 Transit Bus - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh
Class 8 Day Cab - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh
Class 8 Sleeper Cab - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh
Class 8 Specialty - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh
Class 8 Yard Tractor - Battery-Electric	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	mi./kWh
Class 8 Motor Coach - Battery-Electric	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	mi./kWh
Class 2B Cargo Van - Fuel Cell Electric	42.5	42.5	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	mi./kg
Class 2B Pickup - Fuel Cell Electric	42.5	42.5	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	mi./kg
Class 3 Service - Fuel Cell Electric	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	mi./kg
Class 5 Cutaway - Fuel Cell Electric	16.2	16.2	16.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	mi./kg
Class 5 Walk-in Van - Fuel Cell Electric	16.1	16.1	16.1	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	mi./kg
Class 5 Service - Fuel Cell Electric	15.0	15.0	15.0	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	mi./kg
Class 6 Box Truck - Fuel Cell Electric	16.0	16.0	16.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	mi./kg
Class 6 Bucket Truck - Fuel Cell Electric	15.1	15.1	15.1	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	mi./kg
Class 8 Box Truck - Fuel Cell Electric	10.7	10.7	10.7	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	mi./kg
Class 8 Dump Truck - Fuel Cell Electric	10.7	10.7	10.7	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	mi./kg
Class 8 Refuse Packer - Fuel Cell Electric	5.2	5.2	5.2	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	mi./kg
Class 8 Transit Bus - Fuel Cell Electric	11.2	11.2	11.2	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	mi./kg
Class 8 Day Cab - Fuel Cell Electric	10.9	10.9	10.9	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	mi./kg
Class 8 Sleeper Cab - Fuel Cell Electric	11.0	11.0	11.0	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	mi./kg
Class 8 Specialty - Fuel Cell Electric	10.7	10.7	10.7	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	mi./kg
Class 8 Yard Tractor - Fuel Cell Electric	6.9	6.9	6.9	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	mi./kg
Class 8 Motor Coach - Fuel Cell Electric	9.9	9.9	9.9	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	mi./kg
Class 8 Refuse Packer - Natural Gas	6.6	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	mpg
Class 8 Day Cab - Natural Gas	6.7	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.9	6.9	6.9	6.9	mpg
Class 8 Sleeper Cab - Natural Gas	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	mpg

8.4 Maintenance Cost

Table 79. Maintenance Cost

Model Year	Cost per mile	Sources
Class 2B Cargo Van - Diesel	$0.337	Argonne NL AFLEET 2019[199,]
Class 2B Pickup - Diesel	$0.248	Argonne NL AFLEET 2019, Utilimarc[200]
Class 3 Service - Diesel	$0.248	Argonne NL AFLEET 2019, Utilimarc
Class 5 Cutaway - Diesel	$0.657	Access LA Report[201], Argonne NL AFLEET 2019
Class 5 Walk-in Van - Diesel	$0.210	NREL Reports[202,203,204]
Class 5 Service - Diesel	$0.315	Argonne NL AFLEET 2019
Class 6 Box Truck - Diesel	$0.247	Argonne NL AFLEET 2019, NREL Report[205]
Class 6 Bucket Truck - Diesel	$0.199	Argonne NL AFLEET 2019
Class 8 Box Truck - Diesel	$0.276	Argonne NL AFLEET 2019, NREL Report[206]
Class 8 Dump Truck - Diesel	$0.199	Argonne NL AFLEET 2019
Class 8 Refuse Packer - Diesel	$0.943	M.J. Bradley and Associates[207]
Class 8 Day Cab - Diesel	$0.198	Argonne NL AFLEET 2019, Bloomberg, 2018 ATRI Report[208,209]

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209 American Truck Research Institute, *An Analysis of the Operational Costs of Trucking: 2018 Update*, 2018. (web link: https://truckingresearch.org/wp-content/uploads/2018/10/ATRI-Operational-Costs-of-Trucking-2018.pdf, last accessed January 2022).

Model Year	Cost per mile	Sources
Class 8 Sleeper Cab - Diesel	$0.159	Argonne NL AFLEET 2019, Fleet Advantage[210], 2018 ATRI Report
Class 8 Specialty - Diesel	$0.199	Argonne NL AFLEET 2019
Class 8 Yard Tractor - Diesel	$0.199	Argonne NL AFLEET 2019
Class 8 Motor Coach - Diesel	$0.838	ICT Staff Report
Class 2B Cargo Van - Gasoline	$0.337	Argonne NL AFLEET 2019
Class 2B Pickup - Gasoline	$0.248	Argonne NL AFLEET 2019, Utilimarc
Class 3 Service - Gasoline	$0.248	Argonne NL AFLEET 2019, Utilimarc
Class 5 Cutaway - Gasoline	$0.657	Access LA Report, Argonne NL AFLEET 2019
Class 2B Cargo Van - Battery-Electric	$0.202	40 percent reduction from diesel
Class 2B Pickup - Battery-Electric	$0.149	40 percent reduction from diesel
Class 3 Service - Battery-Electric	$0.149	40 percent reduction from diesel
Class 5 Cutaway - Battery-Electric	$0.394	40 percent reduction from diesel
Class 5 Walk-in Van - Battery-Electric	$0.126	40 percent reduction from diesel
Class 5 Service - Battery-Electric	$0.189	40 percent reduction from diesel
Class 6 Box Truck - Battery-Electric	$0.148	40 percent reduction from diesel
Class 6 Bucket Truck - Battery-Electric	$0.119	40 percent reduction from diesel
Class 8 Box Truck - Battery-Electric	$0.165	40 percent reduction from diesel
Class 8 Dump Truck - Battery-Electric	$0.119	40 percent reduction from diesel
Class 8 Refuse Packer - Battery-Electric	$0.566	40 percent reduction from diesel
Class 8 Day Cab - Battery-Electric	$0.119	40 percent reduction from diesel
Class 8 Sleeper Cab - Battery-Electric	$0.095	40 percent reduction from diesel
Class 8 Specialty - Battery-Electric	$0.119	40 percent reduction from diesel
Class 8 Yard Tractor - Battery-Electric	$0.119	40 percent reduction from diesel
Class 8 Motor Coach - Battery-Electric	$0.503	40 percent reduction from diesel
Class 2B Cargo Van - Fuel Cell Electric	$0.202	40 percent reduction from diesel
Class 2B Pickup - Fuel Cell Electric	$0.149	40 percent reduction from diesel
Class 3 Service - Fuel Cell Electric	$0.149	40 percent reduction from diesel
Class 5 Cutaway - Fuel Cell Electric	$0.394	40 percent reduction from diesel
Class 5 Walk-in Van - Fuel Cell Electric	$0.126	40 percent reduction from diesel
Class 5 Service - Fuel Cell Electric	$0.189	40 percent reduction from diesel
Class 6 Box Truck - Fuel Cell Electric	$0.148	40 percent reduction from diesel

[210] Fleet Advantage, *Mitigating Rising M&R Costs for Class-8 Truck Fleets*, 2018 (web link: http://info.fleetadvantage.com/mitigating-rising-fleet-maintenance-and-repair-costs-for-class-8-trucks, last accessed January 2022).

Model Year	Cost per mile	Sources
Class 6 Bucket Truck - Fuel Cell Electric	$0.119	40 percent reduction from diesel
Class 8 Box Truck - Fuel Cell Electric	$0.165	40 percent reduction from diesel
Class 8 Dump Truck - Fuel Cell Electric	$0.119	40 percent reduction from diesel
Class 8 Refuse Packer - Fuel Cell Electric	$0.566	40 percent reduction from diesel
Class 8 Day Cab - Fuel Cell Electric	$0.119	40 percent reduction from diesel
Class 8 Sleeper Cab - Fuel Cell Electric	$0.095	40 percent reduction from diesel
Class 8 Specialty - Fuel Cell Electric	$0.119	40 percent reduction from diesel
Class 8 Yard Tractor - Fuel Cell Electric	$0.119	40 percent reduction from diesel
Class 8 Motor Coach - Fuel Cell Electric	$0.503	40 percent reduction from diesel
Class 8 Refuse Packer - Natural Gas	$0.943	M.J. Bradley and Associates
Class 8 Day Cab - Natural Gas	$0.198	Argonne NL AFLEET 2019, Bloomberg, 2018 ATRI Report
Class 8 Sleeper Cab - Natural Gas	$0.159	Argonne NL AFLEET 2019, Fleet Advantage, 2018 ATRI Report

9 Macroeconomic Appendix

Table 80. Macroeconomic Modeling Inputs

REMI Policy Variable	REMI Industry /Spending Category	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Production Costs	Natural Resources	8.6	9.9	21.3	35.8	37.1	57.9	64.0	70.0	72.7	68.1	86.3	92.7	77.7	69.9	69.1
Production Costs	Construction	15.8	18.1	39.0	65.4	67.8	105.8	116.9	127.8	132.8	124.5	157.7	169.3	142.0	127.6	126.3
Production Costs	Manufacturing	7.4	8.4	18.2	30.5	31.7	49.4	54.5	59.7	62.0	58.1	73.6	79.0	66.3	59.6	58.9
Production Costs	Retail and Wholesale	26.1	29.8	64.3	107.9	112.0	174.6	192.9	211.0	219.1	205.5	260.2	279.4	234.4	210.7	208.5
Production Costs	Transportation and Public Utilities	85.1	97.4	210.0	352.1	365.6	570.1	629.7	688.8	715.4	670.7	849.6	912.2	765.2	687.8	680.5
Production Costs	Finance, Insurance & Real Estate	1.9	2.2	4.7	7.9	8.2	12.8	14.2	15.5	16.1	15.1	19.1	20.5	17.2	15.5	15.3
Production Costs	Services	23.9	27.3	58.9	98.8	102.6	160.0	176.7	193.3	200.8	188.2	238.4	256.0	214.7	193.0	191.0
Exogenous Final Demand	Electricity costs	21.4	53.6	146.5	236.5	339.1	523.8	707.2	944.9	1201.0	1446.6	1746.5	2098.9	2400.0	2714.9	3040.6
Exogenous Final Demand	Natural Gas	-0.6	-1.7	-4.8	-8.7	-12.4	-19.0	-26.5	-34.6	-42.7	-49.5	-59.0	-68.8	-77.5	-87.5	-98.1
Exogenous Final Demand	Construction	464.8	690.8	736.9	1248.3	1273.4	1564.1	1588.4	2062.8	2289.2	2093.9	2354.3	2546.7	2016.4	2175.2	2398.3
Exogenous Final Demand	Basic Chemical mfg.	-7.4	-13.7	-8.7	64.4	130.6	381.2	542.6	759.0	953.9	1108.0	1348.6	1641.8	1913.7	2177.6	2440.8
Exogenous Final Demand	Agricultural Chemical mfg.	-0.4	-1.3	-3.7	-6.8	-9.6	-14.9	-20.5	-26.8	-32.9	-38.1	-45.4	-53.1	-59.9	-67.2	-75.0
Exogenous Final Demand	Retail	-0.5	-0.6	1.7	11.8	21.5	54.2	76.4	106.2	133.8	156.6	190.3	231.4	269.0	305.8	342.8
Exogenous Final Demand	Insurance	3.1	6.6	19.1	34.1	42.5	56.6	67.2	81.3	92.0	94.9	101.8	106.7	101.3	98.4	97.6
Exogenous Final Demand	Private education and training	25.9	32.9	32.2	60.6	57.0	71.4	67.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exogenous Final Demand	Motor Vehicle repair	-13.0	-32.8	-94.9	-160.0	-215.0	-302.6	-407.9	-516.1	-618.7	-853.1	-770.2	-907.6	-968.6	-1027.9	-1098.3
Consumer Spending	Motor Vehicle Fuels	-31.6	-91.2	-260.5	-476.3	-677.4	-1041.4	-1448.1	-1894.3	-2339.4	-2711.9	-3228.5	-3765.9	-4240.5	-4789.8	-5370.8
Gas Prices	All Industries	34.3	79.2	197.8	310.1	425.5	555.5	634.9	748.1	851.1	916.9	969.1	1009.8	1008.1	992.3	967.6
Government Spending	State & Local Government	23.1	-0.2	16.7	-49.7	-151.6	-195.7	-328.3	-413.3	-528.5	-653.0	-744.3	-895.0	-1103.8	-1199.5	-1318.5

Table 81: Macroeconomic Modeling Inputs (continued)

REMI Policy Variable	REMI Industry /Spending Category	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Production Costs	Natural Resources	67.5	14.8	-1.9	-17.3	-64.7	-95.7	-85.9	-94.1	-105.0	-126.2	-145.5	-185.6
Production Costs	Construction	123.2	27.0	-3.4	-31.7	-118.3	-174.8	-156.8	-171.8	-191.8	-230.6	-265.9	-339.0
Production Costs	Manufacturing	57.5	12.6	-1.6	-14.8	-55.2	-81.6	-73.2	-80.2	-89.5	-107.6	-124.1	-158.2
Production Costs	Retail and Wholesale	203.4	44.6	-5.7	-52.3	-195.2	-288.5	-258.8	-283.6	-316.6	-380.6	-438.8	-559.5
Production Costs	Transportation and Public Utilities	663.9	145.7	-18.5	-170.7	-637.2	-941.8	-845.0	-925.9	-1033.6	-1242.4	-1432.5	-1826.4
Production Costs	Finance, Insurance & Real Estate	14.9	3.3	-0.4	-3.8	-14.3	-21.2	-19.0	-20.8	-23.3	-28.0	-32.2	-41.1
Production Costs	Services	186.3	40.9	-5.2	-47.9	-178.8	-264.3	-237.1	-259.9	-290.1	-348.7	-402.0	-512.5
Exogenous Final Demand	Electricity costs	3383.5	3695.8	4014.5	4360.9	4554.9	4649.5	4829.0	4975.0	5115.2	5267.0	5424.0	5734.6
Exogenous Final Demand	Natural Gas	-107.2	-117.8	-129.6	-141.6	-147.3	-152.4	-158.4	-166.3	-173.4	-180.3	-187.6	-202.1
Exogenous Final Demand	Construction	2551.0	2191.1	2019.6	2301.4	1790.7	1492.6	1564.8	1636.0	1679.2	192.1	203.6	213.5
Exogenous Final Demand	Basic Chemical mfg.	2695.6	2903.0	3090.3	3273.8	3287.6	3188.0	3142.9	3106.8	3066.7	3023.2	2971.6	3015.2
Exogenous Final Demand	Agricultural Chemical mfg.	-82.0	-88.4	-95.8	-103.6	-106.2	-109.0	-113.0	-117.1	-121.2	-125.6	-129.9	-140.4
Exogenous Final Demand	Retail	379.2	409.5	437.4	465.5	470.9	461.0	459.1	457.5	455.3	452.9	449.7	460.3
Exogenous Final Demand	Insurance	94.4	62.1	39.0	25.1	2.4	-11.8	-16.5	-16.9	-14.3	-9.6	-4.3	1.9
Exogenous Final Demand	Private education and training	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exogenous Final Demand	Motor Vehicle repair	-1121.5	-983.0	-1007.2	-1042.6	-1096.5	-1083.8	-1027.9	-931.7	-835.7	-1176.4	-1328.6	-1547.3
Consumer Spending	Motor Vehicle Fuels	-5867.5	-6449.2	-7094.2	-7752.7	-8062.8	-8341.2	-8672.2	-9106.4	-9491.3	-9869.9	-10268.5	-11066.8
Gas Prices	All Industries	930.0	847.2	751.2	650.5	536.4	413.8	288.6	296.0	304.3	314.1	324.1	340.6
Government Spending	State & Local Government	-1441.3	-1730.3	-1768.1	-1871.3	-1998.9	-1983.3	-2031.6	-2122.1	-2213.1	-2299.4	-2392.2	-2590.8

Table 82. Gas Price Policy Variable Industry Distribution

Category	Commodity or Industry	Spread Weight
Consumer	Motor vehicle fuels, lubricants, and fluids	65.08%
Business	Forestry and Logging	0.00%
Business	Fishing, hunting and trapping	0.01%
Business	Support activities for agriculture and forestry	0.01%
Business	Oil and gas extraction	0.00%
Business	Coal mining	0.00%
Business	Metal ore mining	0.02%
Business	Nonmetallic mineral mining and quarrying	0.02%
Business	Support activities for mining	0.02%
Business	Electric power generation, transmission and distribution	0.00%
Business	Natural gas distribution	0.00%
Business	Water, sewage, and other systems	0.01%
Business	Construction	1.31%
Business	Sawmills and wood preservation	0.01%
Business	Veneer, plywood, and engineered wood product manufacturing	0.02%
Business	Other wood product manufacturing	0.05%
Business	Clay product and refractory manufacturing	0.01%
Business	Glass and glass product manufacturing	0.06%
Business	Cement and concrete product manufacturing	0.07%
Business	Lime, gypsum and other nonmetallic mineral product manufacturing	0.04%
Business	Iron and steel mills and ferroalloy manufacturing	0.07%
Business	Steel product manufacturing from purchased steel	0.01%
Business	Alumina and aluminum production and processing	0.01%
Business	Nonferrous metal (except aluminum) production and processing	0.02%
Business	Foundries	0.01%
Business	Forging and stamping	0.02%
Business	Cutlery and handtool manufacturing	0.00%
Business	Architectural and structural metals manufacturing	0.03%
Business	Boiler, tank, and shipping container manufacturing	0.01%
Business	Hardware manufacturing	0.00%
Business	Spring and wire product manufacturing	0.00%
Business	Machine shops; turned product; and screw, nut, and bolt manufacturing	0.05%
Business	Coating, engraving, heat treating, and allied activities	0.05%
Business	Other fabricated metal product manufacturing	0.03%
Business	Agriculture, construction, and mining machinery manufacturing	0.01%
Business	Industrial machinery manufacturing	0.01%
Business	Commercial and service industry machinery manufacturing, including digital camera manufacturing	0.11%
Business	Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	0.01%
Business	Metalworking machinery manufacturing	0.01%
Business	Engine, turbine, and power transmission equipment manufacturing	0.03%
Business	Other general purpose machinery manufacturing	0.03%
Business	Computer and peripheral equipment manufacturing, excluding digital camera manufacturing	0.04%
Business	Communications equipment manufacturing	0.01%
Business	Audio and video equipment manufacturing	0.00%
Business	Semiconductor and other electronic component manufacturing	0.05%

Category	Commodity or Industry	Spread Weight
Business	Navigational, measuring, electromedical, and control instruments manufacturing	0.02%
Business	Manufacturing and reproducing magnetic and optical media	0.00%
Business	Electric lighting equipment manufacturing	0.02%
Business	Household appliance manufacturing	0.00%
Business	Electrical equipment manufacturing	0.01%
Business	Other electrical equipment and component manufacturing	0.05%
Business	Motor vehicle manufacturing	0.02%
Business	Motor vehicle body and trailer manufacturing	0.00%
Business	Motor vehicle parts manufacturing	0.03%
Business	Aerospace product and parts manufacturing	0.05%
Business	Railroad rolling stock manufacturing	0.00%
Business	Ship and boat building	0.00%
Business	Other transportation equipment manufacturing	0.00%
Business	Household and institutional furniture and kitchen cabinet manufacturing	0.02%
Business	Office furniture (including fixtures) manufacturing; Other furniture related product manufacturing	0.02%
Business	Medical equipment and supplies manufacturing	0.08%
Business	Other miscellaneous manufacturing	0.05%
Business	Animal food manufacturing	0.02%
Business	Grain and oilseed milling	0.09%
Business	Sugar and confectionery product manufacturing	0.11%
Business	Fruit and vegetable preserving and specialty food manufacturing	0.08%
Business	Dairy product manufacturing	0.11%
Business	Animal slaughtering and processing	0.03%
Business	Seafood product preparation and packaging	0.00%
Business	Bakeries and tortilla manufacturing	0.06%
Business	Other food manufacturing	0.09%
Business	Beverage manufacturing	0.27%
Business	Tobacco manufacturing	0.01%
Business	Textile mills and textile product mills	0.03%
Business	Apparel, leather and allied product manufacturing	0.02%
Business	Pulp, paper, and paperboard mills	0.06%
Business	Converted paper product manufacturing	0.05%
Business	Printing and related support activities	0.13%
Business	Petroleum and coal products manufacturing	0.00%
Business	Basic chemical manufacturing	0.99%
Business	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	0.21%
Business	Pesticide, fertilizer, and other agricultural chemical manufacturing	0.17%
Business	Pharmaceutical and medicine manufacturing	0.21%
Business	Paint, coating, and adhesive manufacturing	0.03%
Business	Soap, cleaning compound, and toilet preparation manufacturing	0.08%
Business	Other chemical product and preparation manufacturing	0.07%
Business	Plastics product manufacturing	0.13%
Business	Rubber product manufacturing	0.02%
Business	Wholesale trade	0.39%
Business	Retail trade	0.58%
Business	Air transportation	4.62%
Business	Rail transportation	0.94%
Business	Water transportation	0.57%
Business	Truck transportation	7.61%
Business	Couriers and messengers	4.12%
Business	Transit and ground passenger transportation	1.11%

Category	Commodity or Industry	Spread Weight
Business	Pipeline transportation	0.01%
Business	Scenic and sightseeing transportation and support activities for transportation	3.53%
Business	Warehousing and storage	1.77%
Business	Newspaper, periodical, book, and directory publishers	0.00%
Business	Software publishers	0.02%
Business	Motion picture, video, and sound recording industries	0.03%
Business	Data processing, hosting, related services	0.05%
Business	Other information services	0.04%
Business	Radio and television broadcasting; Cable and other subscription programming	0.01%
Business	Telecommunications	0.06%
Business	Monetary authorities, credit intermediation, and related activities	0.15%
Business	Securities, commodity contracts, funds, trusts and other financial investments and related activities	0.12%
Business	Insurance carriers	0.00%
Business	Agencies, brokerages, and other insurance related activities	0.00%
Business	Real estate	2.00%
Business	Automotive equipment rental and leasing	0.04%
Business	Consumer goods rental and general rental centers	0.01%
Business	Commercial and industrial machinery and equipment rental and leasing	0.03%
Business	Lessors of nonfinancial intangible assets (except copyrighted works)	0.00%
Business	Legal services	0.00%
Business	Accounting, tax preparation, bookkeeping, and payroll services	0.00%
Business	Architectural, engineering, and related services	0.06%
Business	Specialized design services	0.00%
Business	Computer systems design and related services	0.04%
Business	Management, scientific, and technical consulting services	0.01%
Business	Scientific research and development services	0.06%
Business	Advertising, public relations, and related services	0.01%
Business	Other professional, scientific, and technical services	0.01%
Business	Management of companies and enterprises	0.13%
Business	Office administrative services; Facilities support services	0.01%
Business	Employment services	0.00%
Business	Business support services; Investigation and security services; Other support services	0.03%
Business	Travel arrangement and reservation services	0.00%
Business	Services to buildings and dwellings	0.12%
Business	Waste management and remediation services	0.05%
Business	Educational services; private	0.08%
Business	Offices of health practitioners	0.03%
Business	Outpatient, laboratory, and other ambulatory care services	0.03%
Business	Home health care services	0.00%
Business	Hospitals; private	0.12%
Business	Nursing and residential care facilities	0.03%
Business	Individual and family services; Community and vocational rehabilitation services	0.03%
Business	Child day care services	0.01%
Business	Performing arts companies; Promoters of events, and agents and managers	0.00%
Business	Spectator sports	0.00%
Business	Independent artists, writers, and performers	0.00%
Business	Museums, historical sites, and similar institutions	0.00%
Business	Amusement, gambling, and recreation industries	0.04%
Business	Accommodation	0.06%
Business	Food services and drinking places	0.31%
Business	Automotive repair and maintenance	0.03%

Category	Commodity or Industry	Spread Weight
Business	Electronic and precision equipment repair and maintenance	0.00%
Business	Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	0.00%
Business	Personal and household goods repair and maintenance	0.00%
Business	Personal care services	0.01%
Business	Death care services	0.00%
Business	Drycleaning and laundry services	0.01%
Business	Other personal services	0.00%
Business	Religious organizations; Grantmaking and giving services and social advocacy organizations	0.04%
Business	Civic, social, professional, and similar organizations	0.02%
Business	Private households	0.00%