State of California

AIR RESOURCES BOARD

Proposed In-Use Locomotive Regulation

Standardized Regulatory Impact Assessment (SRIA)

Date of Release: May 26, 2022

California Air Resources Board
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1 Introduction

1.1 Background on Locomotives

A locomotive is a self-propelled vehicle used to push or pull rail-mounted cars carrying freight or passengers. A typical locomotive in the United States runs on a set of electric traction motors, which drive the locomotive wheels. Most locomotives today derive their electricity from a diesel generator: a diesel engine that drives an electrical generator or alternator.

Locomotives are used by the railroad industry or "railroads." For regulatory purposes, the federal Surface Transportation Board (STB) categorizes freight railroads by Class. Class I (major), Class II (regional), and Class III (shortline) freight railroads designation is based on annual operating revenue.[1] Class I railroads typically use large fleets of locomotives to move freight throughout the country. Class II railroads typically move freight over smaller regions, such as between two or three states. Class III railroads typically operate very small fleets, sometimes one or two locomotives, to move freight over local routes, such as from an industrial area to a local railyard.

In addition to Class I, II, and III railroads, there are also industrial and passenger railroads. Industrial railroads are companies that use locomotives to move their products (freight) but don't provide rail services to others, such as cement plants or oil refineries. Passenger railroads provide commuter transit services. Each railroad type (Class I, II, III, industrial and passenger) has multiple operating companies referred to as "locomotive operators." In 2021, California was served by the following number of operators:

- 2 Class I (Union Pacific Railroad and BNSF Railway)
- 25 Class III
- 42 industrial
- 6 passenger

Throughout this document railroad classes and operator types will be mentioned; however, staff developed the cost analysis using duty cycles (work demand broken down by load and time) and costs for three distinct groups of locomotives. Locomotives are grouped and analyzed as line haul, road and yard switchers, and passenger because locomotives within these categories have similar duty cycles and costs. For the purposes of the SRIA, staff associated the following locomotive groups with the listed operator:

- Class I - line haul and road switchers,
- Class III - road switchers,
- Industrial - yard switchers, and
- Passenger - passenger locomotives.

[1] Surface Transportation Board, Economic Data, June 2021. (web link: https://prod.stb.gov/reports-data/economic-data/)

1.1.1 Line Haul Locomotives

Railroads primarily use "line haul" locomotives for long-distance freight transport. Line haul locomotives are powered by an engine with a maximum rated power (or a combination of engines having a total rated power) greater than 2300 hp, by Federal definition.[2] Line haul locomotives carry freight throughout the North American rail system, often interstate (e.g., Chicago to Los Angeles). A line haul locomotive is shown in Figure 1.1.

Figure 1.1: Line Haul Locomotive

1.1.2 Switch Locomotives

Industry refers to locomotives that are used for short-distance (typically intrastate) and in-yard work as "switch" locomotives. Switch locomotives or "switchers" are often older locomotives because they are used less intensely than line haul locomotives. Generally, road switcher locomotives are operated by Class I and Class III railroads for both in-yard work and short distance hauls. Although they can be used by any operators, yard switcher locomotives are primarily operated by industrial operators within a localized area, moving locomotives or railcars throughout a railyard or industrial facility. A switch locomotive is shown in Figure 1.2.

Figure 1.2: Switch Locomotive

1.1.3 Passenger Locomotives

Passenger locomotives are highly specialized and designed to pull passenger cars. They may travel over long (cross-country) or short (intrastate or local commuter) distances. One major

[2] U.S. Environmental Protection Agency (U.S. EPA), Locomotives: Exhaust Emission Standards, March 2016. (web link: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OA09.PDF?Dockey=P100OA09.PDF)

difference between passenger locomotives and freight locomotives is that passenger locomotives generally have a main propulsion engine and onboard hotel power, sometimes referred to as head-end power. The head-end power can be powered by the primary engine or by a separate diesel generator that provides electricity via cable for the lights, air conditioning, and other material comforts to connected passenger railcars. A passenger locomotive is shown in Figure 1.3.

Figure 1.3: Passenger Locomotive

1.2 Regulatory History

Under the Clean Air Act, the United States Environmental Protection Agency (U.S. EPA) has established emissions standards for new locomotives. All locomotives, whether freight line-haul, switcher, industrial, or passenger, adhere to one of two sets of emission standards based on engine size.

- Locomotives between 1,006 and 2,300 horsepower are defined as switchers and
- Locomotives with horsepower of greater than 2,300 are defined as line haul.

The first set of locomotive emission regulations was approved in 1998, specifying control levels for pollutants in engine Tiers 0-2 (see Table 1.1). In 2008, U.S. EPA approved the second set of locomotive emission regulations introducing “plus” designations when remanufacturing engines Tier 0, 1, and 2, and new standards for newly manufactured locomotives: Tier 3, and Tier 4.

The U.S. EPA locomotive emission regulations set the maximum levels of air pollutants allowable per amount of work, in grams per brake horsepower-hour (g/bhp-hr). This report describes air pollutants as criteria pollutants or toxic air pollutants (toxics). Criteria air pollutants are air pollutants for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set via the Nation Ambient Air Quality Standards. Criteria pollutants include, nitrogen dioxide (a type of NOx), carbon monoxide (CO), particulate matter (PM) with a diameter of 10 microns or less (PM10) and fine particulate matter (PM2.5).

Toxic air contaminants are defined in the California Health and Safety Code[3] as "an air pollutant which may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health." Diesel engines emit a complex mixture of pollutants, including very small carbon particles, or "soot" coated with numerous organic compounds, known as diesel PM. In discussions that include "toxic air contaminants" or "toxics", this report is referring to diesel PM.

Table 1.1: Existing Federal Locomotive Emission Standards[4, 5]

Emissions Tier	Year of Original Manufacture	NO_X Standard (g/bhp-hr)	PM Standard (g/bhp-hr)	HC Standard (g/bhp-hr)	CO Standard (g/bhp-hr)
Line Haul Locomotives (> 2300 hp)					
Tier 0	2000-2001 (1973-1999 when remanufactured)	9.5	0.60	1.00	5.0
Tier 0+	1973-1992	8.0	0.22	1.00	5.0
Tier 1	2002-2004	7.4	0.45	0.55	2.2
Tier 1+	1993-2004	7.4	0.22	0.55	2.2
Tier 2	2005-2011	5.5	0.20	0.30	1.5
Tier 2+	2005-2011	5.5	0.10	0.30	1.5
Tier 3	2012-2014	5.5	0.10	0.30	1.5
Tier 4	2015 or later	1.3	0.03	0.14	1.5

[3] California Health and Safety Code § 39655, Division 26.2, 1992. (web link: https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=39655&lawCode=HSC)

[4] U.S. EPA; 40 CFR Parts 85, 89 and 92 - Emission Standards for Locomotives and Locomotive Engines; April 16, 1998; (web link: https://www.govinfo.gov/content/pkg/FR-1998-04-16/pdf/98-7769.pdf)

[5] U.S. EPA, 2008; 40 CFR Part 1033 – Control of Emissions from Locomotives; June 2008; (web link: https://www.ecfr.gov/cgi-bin/text-idx?SID=159ba6f126272ea1995c71a43b7af309&mc=true&node=pt40.36.1033&rgn=div5)

Emissions Tier	Year of Original Manufacture	NO_X Standard (g/bhp-hr)	PM Standard (g/bhp-hr)	HC Standard (g/bhp-hr)	CO Standard (g/bhp-hr)
Switch Locomotives (1006 hp – 2300 hp)					
Tier 0	2000-2001 (1973-1999 when remanufactured)	14.0	0.72	2.10	8.0
Tier 0+	1973-2001	11.8	0.26	2.10	8.0
Tier 1	2002-2004	11.0	0.54	1.20	2.5
Tier 1+	2002-2004	11.0	0.26	1.20	2.5
Tier 2	2005-2011	8.1	0.24	0.60	2.4
Tier 2+	2005-2010	8.1	0.13	0.60	2.4
Tier 3	2011-2014	5.0	0.10	0.60	2.4
Tier 4	2015 or later	1.3	0.03	0.14	2.4

Manufacturers must ensure that their locomotives meet federal emissions standards throughout their useful life.[6] The minimum useful life is 7.5 times the horsepower in megawatt hours (MWh) or ten years (whichever occurs first), and manufacturers are required to certify to longer useful lives if their locomotives are designed to last longer than the minimum useful life. At the end of its useful life, the locomotive is often remanufactured. If it is upgraded to a cleaner Tier (plus Tier for example), it results in smaller, incremental emission improvements than buying a new locomotive. Otherwise, there is a negligible change in emissions.

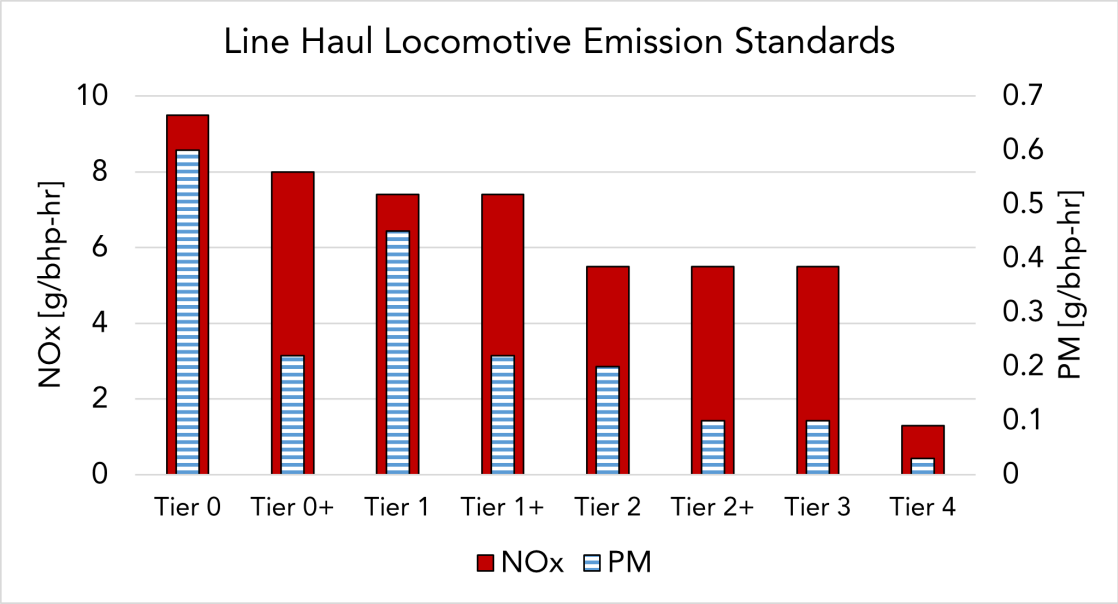
Remanufacture results in the locomotive meeting an improved "plus" emission standard denoted by "Tier 0+", "Tier 1+", or "Tier 2+." Currently, there are no Tier 3+ or Tier 4+ emissions standards, and no remanufacture kits that improve the emissions of Tier 3 or Tier 4 locomotive engines.

There are a wide range of engine standards in diesel locomotives, from no emission controls (uncontrolled) to the cleanest available. As such, older locomotives remanufactured to older

[6] U.S. EPA, 40 CFR Part 1033; Subpart B—Emission Standards and Related Requirements; Section (g); p. 37200. (web link: https://www.govinfo.gov/content/pkg/FR-2008-06-30/pdf/R8-7999.pdf)

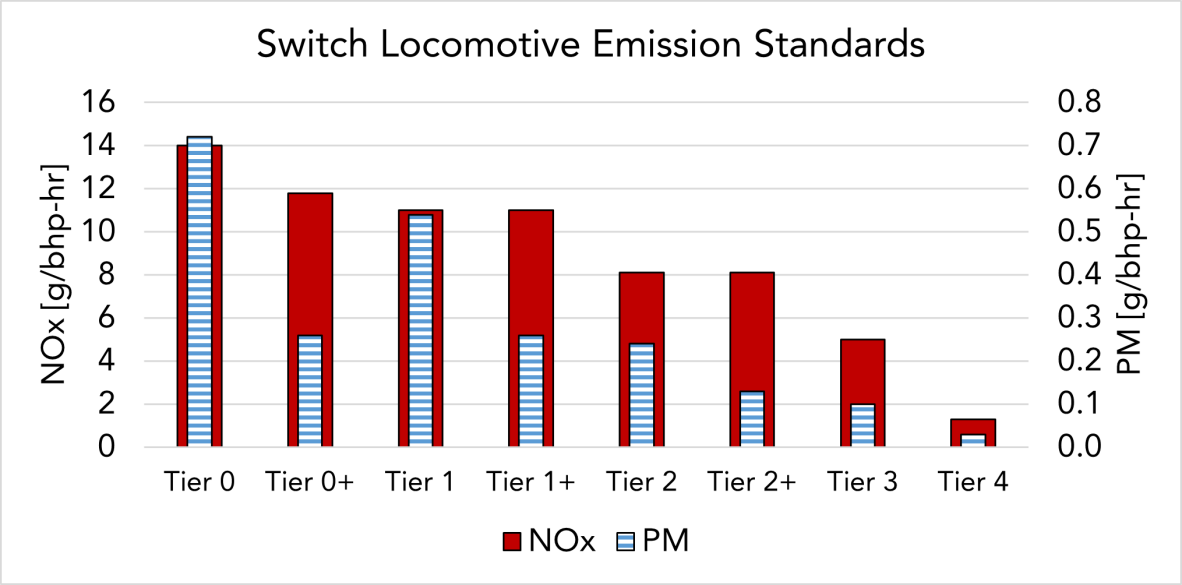
standards emit far more than the current cleanest standard - U.S. EPA Tier 4-certified locomotive. For example, as shown in Table 1.1 and Figures 1.4 and 1.5, Tier 4 standard is 70 to 84 percent cleaner for oxides of nitrogen (NOx) and PM than a remanufactured Tier 2+ standard. Since there is no emission standard for uncontrolled/Pre-Tier 0 locomotives, they are not shown in the figures below. Uncontrolled locomotives pose the greatest health risks per bhp-hr. Uncontrolled switchers emit approximately 17.40 g NOx and 0.44 g PM per bhp-hr – 17 and 29 times more than a Tier 4, respectively.[7]

Figure 1.4: Line Haul Emission Standards by Tier



[7] U.S. EPA, Emission Factors for Locomotives (EPA-420-F-09-025), Office of Transportation and Air Quality, April 2009.

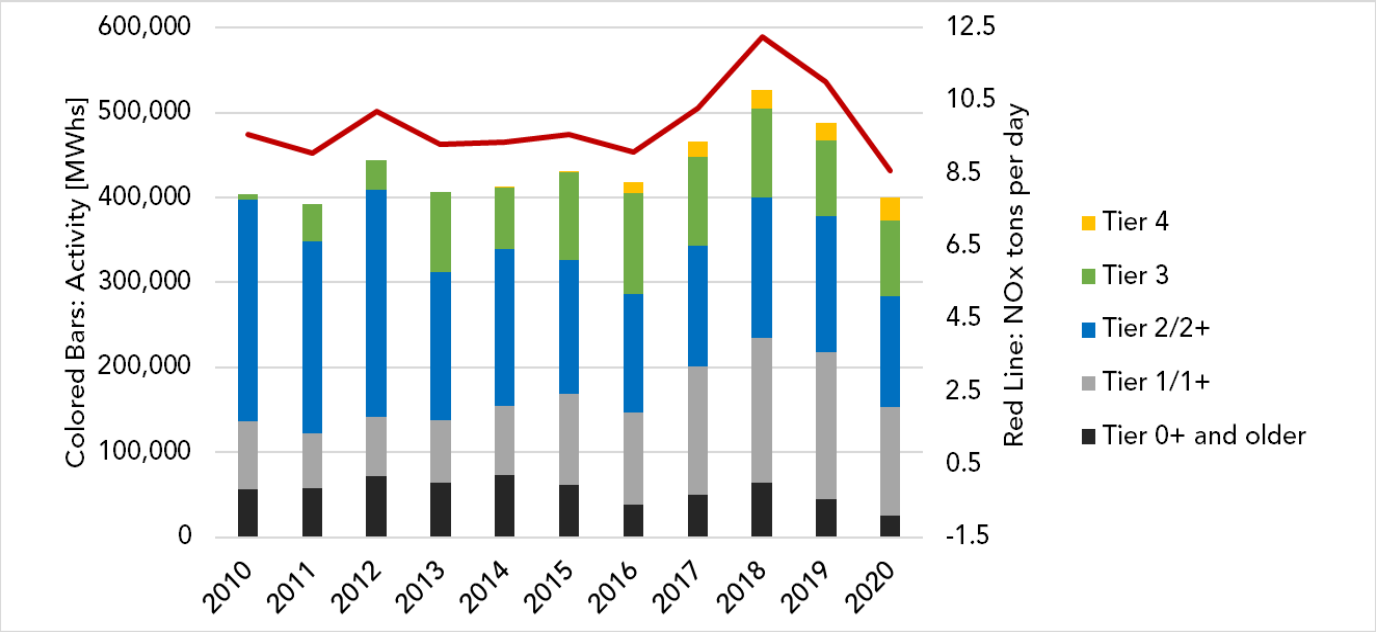
Figure 1.5: Switch Locomotive Emission Standards by Tier



Since 1998, the California Air Resources Board (CARB) has participated in two voluntary memoranda of understanding (MOU) with two Class I railroads: Union Pacific Railroad (UP), and BNSF Railway Company (BNSF). The first MOU, the 1998 Locomotive NOx Fleet Average Emissions Agreement in the South Coast Air Basin (Basin), requires both Class I operators to reach a Tier 2 average NOx emission standard throughout the basin by 2010. The Tier 2 fleet average was attained by both operators in 2010. From 2010, until 2021, UP and BNSF have stayed at a Tier 2 average. As can be seen in Figure 1.6, the UP and BNSF continue to rely on Tier 1 and Tier 2 locomotives for the majority of their operations. Accordingly, as of 2021, UP and BNSF have not made substantial improvement in their locomotive fleet average emissions since meeting their 2010 obligations. The 1998 MOU agreement will terminate in 2030.[8]

[8] California Air Resources Board, Burlington Northern and Santa Fe Railway Company, Union Pacific Railroad Company, MEMORANDUM OF MUTUAL UNDERSTANDINGS AND AGREEMENTS, 1998. (web link: https://ww2.arb.ca.gov/resources/documents/rail-emission-reduction-agreements)

Figure 1.1.6: Locomotive Activity and NOx Emissions in the South Coast



The second MOU, the 2005 Statewide Railyard Agreement (2005 MOU),[9] maximized the use of state and federal ultra-low sulfur diesel in locomotives. From 2007 to 2014, low sulfur diesel fuel was phased in for locomotives. The 2005 MOU also established a statewide idle-reduction program which ensured operator training and the installation of idle-reduction devices on at least 99 percent of Class I locomotives compatible with the technology by 2008. In addition to the idling program, the 2005 MOU required that UP and BNSF work with CARB to obtain Health Risk Assessments at 18 major railyards in California.[10]

Although previous voluntary agreements and federal locomotive standards have sought to reduce emission reductions, in 2018, diesel freight locomotives still contribute approximately 12 percent NOx and 8 percent of PM2.5 of all freight emissions statewide.[11] Additionally, while passenger operators have upgraded to Tier 4 locomotives more quickly than freight operators, passenger locomotives still emit harmful emissions near communities since their corridors run through urban areas, similar to freight locomotives. Further improvements are needed to address the air quality, public health, and climate change impacts associated with locomotive operations. To address the impacts of transportation emissions, Governor

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[9] California Air Resources Board, Burlington Northern and Santa Fe Railway Company, Union Pacific Railroad Company, ARB/Railroad Statewide Agreement Particulate Emissions Reduction Program at California Rail Yards, 2005. (web link: https://ww2.arb.ca.gov/resources/documents/2005-statewide-railyard-agreement)

[10] California Air Resources Board, Railyard Health Risk Assessments, 2007-2008. (web link: https://ww2.arb.ca.gov/resources/documents/railyard-health-risk-assessments-and-mitigation-measures) Accessed 09/02/21.

[11] California Air Resources Board, Concepts for In-Use Locomotive Regulation – Workshop 1, October 30, 2021. (web link: https://ww2.arb.ca.gov/sites/default/files/2020-11/2020.10.28%20907AM%20Workshop%20Slides%20Day%201%20-%20Remediated.pdf)

Newsom issued Executive Order (EO) N-79-20, which includes directive that CARB, in coordination with other state agencies, U.S. EPA, and local air districts, develop and propose strategies to achieve 100 percent zero-emission (ZE) from off-road vehicles and equipment in the state by 2035, which includes locomotives.

In 2017, CARB petitioned U.S. EPA to establish a Tier 5 standard for locomotives.[12] The proposed standard would require lower emissions of PM and NOx, as well as enhanced zero-emission capability for occasional full ZE operation in sensitive areas; ZE operation would also reduce fuel consumption and greenhouse gas (GHG) emissions. As of December 2021, U.S. EPA has taken no action on this petition. Staff is aware of at least one locomotive manufacturer that has a family of locomotives already certified to PM and NOx levels that would meet the proposed Tier 5 emission standard.[13] Additionally, several manufacturers are currently planning and demonstrating ZE locomotives and hybrid consists that exceed all of the proposed Tier 5 emission standards.[14, 15]

Table 1.2: Proposed Federal Locomotive Emission Standard (Tier 5)

Emission Tier	Year of Manufacture	NOx Standard (g/bhp-hr)	PM Standard (g/bhp-hr)	GHG Percent Control	HC Standard (g/bhp-hr)
5	2026	0.2	<0.01	10-25%	0.02

1.3 Proposed Regulatory Action

The proposed In-Use Locomotive Regulation (Proposed Regulation) has four main components: (1) Spending Account, (2) In-Use Operational Requirements, (3) idling limit, and (4) recordkeeping and reporting. The Proposed Regulation applies to all locomotives operating in the State of California except for:

- Locomotives propelled by engines with a total rated power of less than 1,006 horsepower;

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[12] CARB, Locomotive Petition to U.S. EPA, 2017. (web link: https://ww2.arb.ca.gov/sites/default/files/2020-07/final_locomotive_petition_and_cover_letter_4_3_17.pdf)

[13] U.S. EPA, Annual Certification Data for Vehicles, Engines, and Equipment | US EPA, February 2022. (web link: https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment)

[14] Wabtec Corporation, Wabtec's All-Battery Locomotive, FLXdrive, Lowers Freight Train's Fuel Consumption by More Than 11 Percent in California Pilot, May 2021. (web link: https://www.wabteccorp.com/newsroom/press-releases/wabtec-s-all-battery-locomotive-flxdrive-lowers-freight-train-s-fuel-consumption-by-more-than-11)

[15] Progress Rail, Caterpillar, BNSF and Chevron Agree to Pursue Hydrogen Locomotive Demonstration, last accessed March 8, 2022. (web link: https://www.progressrail.com/en/Company/News/PressReleases/CaterpillarBNSFandChevronAgreetoPursueHydrogenLocomotiveDemonstration.html)

- Locomotives used for certification of "hands-on experience" for diesel mechanics and locomotive engineers;
- Equipment designed for operation with both steel wheels for track-mounted operation, and rubber tires, for off-track operation;
- Military locomotives.

In addition, historic railroads with historic locomotive fleets that do not exceed 10,000 gallons of fuel use per year fleetwide would be exempt from the Spending Account and In-Use Operational Requirements of the Proposed Regulation.

1.3.1 Spending Account

The Proposed Regulation would require each operator to create a Spending Account which would be a trust held in the name of the locomotive operator. The locomotive operator would fund the account annually based on the emissions their locomotives create in California. The funds held in the Spending Account would only be allowed to be withdrawn to purchase cleaner locomotives as described in the Proposed Regulation.

Starting January 1, 2023,

- Each locomotive operator would begin tracking California locomotive activity in each air district.

Annually, starting July 1, 2024

- Locomotive operators would be required to register all locomotives operating in California.
- Locomotive operators would be required to report the previous years' California activity by air district.
- Locomotive operators would be required to calculate their emissions from the year prior, deposit funds into their Spending Account, and report the deposit amount in their annual reporting to CARB.

To determine the Spending Account deposit for each locomotive, staff is proposing a formula that allows operators to calculate the cost of their NOx and PM emissions associated with their locomotives' cumulative emissions based on the number of MWh their locomotives operated in each air district over the previous year.

Prior to 2030, by operating a ZE locomotive, ZE rail vehicle or by connecting to wayside power, operators may earn "credits" that can be used to offset their Spending Account funding obligations. A ZE credit would be doubled while operating in a disadvantaged community as defined by California Communities Environmental Health Screening Tool (CalEnviroScreen).[16] The credits could only be used to reduce Spending Account obligations;

[16] Office of Environmental Health Hazard Assessment, CalEnviroScreen 4.0, October 20, 2021. (web link: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40)

they would not have value and would not be tradable. All unused credits would expire January 1, 2030.

Operators would only be permitted to use their Spending Account funds, along with any interest earned, in specified ways. Funds held in the Spending Account could be used for ZE locomotives and locomotives that can be operated in ZE mode (ZE capable locomotives), ZE rail vehicles or infrastructure. Prior to January 1, 2030, operators may also use Spending Account funds to purchase, lease, or rent, remanufacture, or repower to a locomotive with emission levels equivalent to or cleaner than the cleanest standard.

Additionally, at any time, operators would also be permitted to use Spending Account funds for demonstrations or pilot projects of ZE locomotives, ZE rail vehicles, ZE capable locomotives, and supporting infrastructure. During the technology demonstration phase manufacturers are typically focused on producing single vehicle prototypes or small volume vehicle demonstration and testing projects. Pilot projects are generally larger scale deployments where issues around manufacturing design, user acceptance, and support can be assessed. Both demonstration and pilot phases would require supporting infrastructure.

1.3.2 In-Use Operational Requirements

The In-Use Operational Requirements define the number of years, beginning the year of the original engine build date, that a locomotive is allowed to operate in California.

Beginning January 1, 2030,

- All locomotives with an original engine build date prior to January 1, 2007 would not be allowed to operate in California. Every subsequent January 1, any locomotive that is 23 years or older, based on the year the primary engine was originally built, would not be allowed to operate in California. If the locomotive is remanufactured to Tier 4 or a cleaner standard prior to January 1, 2030, the original engine build date would be based on the first year the primary engine was remanufactured to a Tier 4 or cleaner standard.
- Any switch, industrial, and passenger locomotive with an original engine build date 2030 or newer would be required to be a ZE locomotive or ZE capable locomotive to operate in California.

Starting January 1, 2035,

- Any freight line haul locomotive engine with an original engine build date 2035 or newer would be required to be a ZE locomotive or ZE capable locomotive to operate in California.

1.3.2.1 Temporary Locomotive Operating Waiver

Prior to planned operation of a locomotive that would be prohibited from operation in California, a locomotive operator may submit a request to the Executive Officer to temporarily operate the locomotive in California over a specified period. Waivers could be approved to 1) remove a locomotive from California, 2) maintain a locomotive, 3) provide unmet capacity caused by events beyond their reasonable control such as fire, flood,

earthquake, embargoes, shortages, epidemics, quarantines, war, acts of terrorism, riots, strikes, lockouts, or other labor disturbances.

1.3.2.2 Alternative Compliance Plan

Operators seeking an alternative path to comply with the requirements in the Spending Account, the In-Use Operating Requirements, or both, may apply to follow an Alternative Compliance Plan. A proposed Alternative Compliance Plan must reduce the equivalent or more PM, NOx, and GHG emissions that would have been reduced under Spending Account and/or In-Use Operational Requirements.

1.3.3 Idling Limit

Starting January 1, 2023,

- All locomotives equipped with an automatic engine shut down/start up (AESS) system, would be required to shut off no more than 30 minutes after the locomotive becomes stationary unless it is for a specifically permitted reason, such as preventing engine damage or performing maintenance.

1.3.4 Recordkeeping, Reporting, and Registration

Beginning January 1, 2023 and every year thereafter,

- Locomotive operators would be required to track all applicable locomotive activity by air district in MWh, or in some cases fuel usage. The first report would be due July 1, 2024 for all locomotive activity per air district in 2023 and every year thereafter.
- Locomotive operators would be required to register each locomotive operating in California with CARB by reporting company information such as the company name, address, tax identification number, etc. They would also need to submit locomotive information, such as engine tier, engine family, engine build date, engine horsepower, etc.

Starting July 1, 2024,

- Locomotive operators would be required to submit reporting annually.

1.3.4.1 Administrative Charge

CARB would collect an administrative charge to fund implementation costs of the Proposed Regulation. This payment would be due July 1 of each year with reporting documentation.

1.4 Statement of the Need of the Proposed Regulation

California needs to continue to build upon its 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 health based ambient air quality standards and related State Implementation Plan (SIP) commitments across California. Approximately two-thirds of California's 39.5 million residents still live in communities that exceed the federal health

protective standards. [17] Exposure to diesel particulates is too high, especially in communities near freight facilities such as ports, rail yards, distribution centers, and those that are close to freeways and industrial sources. Additionally, meeting GHG emission reduction targets is an essential part of the global action needed to slow global warming and achieve climate stabilization. The Proposed Regulation would reduce health risks, achieve PM, NOx, and GHG emissions reductions from diesel powered locomotives, and increase the use of ZE technology in the off-road sector, all of which is needed to meet the State's air quality, toxics, and climate goals.

1.4.1 Need to Reduce Risk

Many of the communities near railyards and other locations where locomotives operate bear a disproportionate health burden due to their proximity to emissions from locomotive diesel engines. [18, 19] In many cases, locomotive operations are in or near communities that are classified as disadvantaged by the California Environmental Protection Agency (CalEPA). CalEPA uses CalEnviroScreen to rank California communities based on environmental pollution burden and socio-economic indicators. [20] Exposure to diesel PM is a contributor for many communities ranked in the top 10th percentile statewide on CalEnviroScreen.

Staff performed a health risk characterization to evaluate the localized cancer risk experienced by people who live near railyards from emissions attributable to the diesel engines that power locomotives. The health risk characterization shows that even if locomotives convert to the cleanest available engine standard level of Tier 4, the diesel engines that power locomotives would still contribute to cancer risk for communities near railyards. The identified potential cancer risk that would result under both the business-as-usual scenario and the Tier 4 scenario emphasized the need for a transition to ZE technology. More information on the health risk characterization and health benefits that would be achieved by the Proposed Regulation are discussed in Section 2.

1.4.2 Need to Reduce PM2.5 and NOx Emissions

Progress has been achieved in reducing PM2.5 and NOx emissions from mobile sources statewide through implementation of existing CARB programs. These programs are expected to continue to provide further emission reductions, helping the state to meet air quality standards. However, challenges remain in meeting the ambient air quality standards

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[17] California Air Resources Board, 2020 Mobile Source Strategy, December 12, 2020. (web link: https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf)

[18]Soret, S., & Montgomery, S. Project ENRRICH: A Public Health Assessment of Residential Proximity to a Goods Movement Railyard Project, (2014).

[19] Spencer-Hwang R, Pasco-Rubio M, Soret S, et al. Association of major California freight railyards with asthma-related pediatric emergency department hospital visits. *Prev Med Rep*. 2019;13:73-79. doi:10.1016/j.pmedr.2018.11.001

[20] Office of Environmental Health Hazard Assessment, CalEnviroScreen 4.0, October 20, 2021. (web link: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40)

for ozone and PM2.5 in two areas of the state with extreme air quality issues: The South Coast Air Basin and San Joaquin Valley. The near-term targets for these areas are a 2023 deadline for attainment of the 80 parts per billion (ppb) 8-hour ozone standard, 2024 for the 35 microgram per cubic meter (µg/m3) 24-hour PM2.5 standard, and 2025 for the 12 µg/m3 annual PM2.5 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.[21] NOx is a precursor to secondary PM2.5 formation. Consequently, reductions in NOx emissions also provide benefits to help meet the PM2.5 standards. Additional PM2.5 and NOx reductions from all freight sources, including locomotives, are essential to meeting these air quality standards.

1.4.3 Need to Reduce GHG Emissions

California has made significant progress towards meeting the goals of Senate Bill (SB) 32 (Pavley, Chapter 249, Statutes of 2016).[22] SB 32 requires California to reduce GHG emissions to at least 40 percent below 1990 levels by 2030; despite the progress made, more needs to be done to meet this goal. According to U.S. EPA, in 2019 the transportation sector accounted for about 29 percent of total U.S. GHG emissions – an amount that is larger than any other economic sector.[23]

In addition to GHGs, black carbon (soot), a component of PM, is emitted from burning fuels such as diesel. Black carbon is a short-lived climate pollutant (SLCP). SLCPs are powerful climate forcers that remain in the atmosphere for a much shorter period of time than longer-lived climate pollutants, such as carbon dioxide (CO2), but are more potent when measured in terms of global warming potential. For example, per unit of mass in the atmosphere, black carbon can absorb a million times more solar energy than CO2.[24] SB 605 (Lara, Chapter 523, Statutes of 2014)[25] required CARB to develop a plan to reduce emissions of SLCPs, and SB 1383 (Lara, Chapter 395, Statutes of 2016)[26] required the Board to approve and begin implementing the plan by January 1, 2018. SB 1383 also set targets for statewide reductions in SLCP emissions of 50 percent below 2013 levels by 2030 for black carbon.

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[21] 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)

[22] California Health and Safety Code § 38566, Division 25.5, Senate Bill No. 32, September 8, 2016. (web link: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32)

[23] U.S. EPA, Sources of Greenhouse Gas Emissions, 2021 (web link: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions)

[24] U.S. EPA, Basic Information – What is Black Carbon?, 2021 (web link: https://www3.epa.gov/airquality/blackcarbon/basic.html)

[25] 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)

[26] 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)

Reductions in GHGs, including SLCPs like black carbon from locomotives are needed to achieve the state's multiple GHG emission reduction targets and related climate goals.

1.4.4 Need to Address State Policy and Plans Directing CARB to Achieve Further Reductions from locomotives

The Proposed Regulation is needed to address the state policies and plans summarized below directing CARB to achieve additional diesel emission reductions.

1.4.4.1 Executive Order N-79-20

In September 2020, Governor Newsom issued EO N-79-20,[27] which directed CARB, in coordination with other state agencies, U.S. EPA, and local air districts, to develop and propose technologically feasible and cost-effective strategies to achieve 100 percent ZE from off-road vehicles and equipment in the state by 2035. The Proposed Regulation supports the directive of the EO by transitioning diesel-powered locomotives to ZE technology.

1.4.4.2 2020 Mobile Source Strategy

CARB released the revised Draft 2020 Mobile Source Strategy[28] in April 2021. The strategy document looks at existing and emerging technologies to reduce emissions from California's transportation sector, including cars, trucks, locomotives, ships, and other on-road and off-road sources. The strategies laid out in the Mobile Source Strategy illustrate the technology mixes needed for the state to meet its various clean air goals, including federal ambient air quality standards, community risk reduction, and ambitious mid-and long-term climate change targets. The revised Draft 2020 Mobile Source Strategy included the In-Use Locomotive Regulation as a concept that will reduce emissions statewide, and ultimately transition the industry to ZE.

1.4.4.3 2017 State Strategy for the State Implementation Plan (SIP)

The federal Clean Air Act requires areas that exceed the health-based national ambient air quality standards to develop SIPs that demonstrate how they will attain the standards by specified dates. In March 2017, the Board adopted the State Strategy for the SIP (State SIP Strategy) – a comprehensive strategy for CARB to reduce emissions from mobile sources to meet critical air quality and climate goals over the next 15 years.[29] The State SIP Strategy includes statewide control measures CARB committed to bring to the Board for adoption to achieve the NOx reductions needed for attainment by 2023 and 2031. The 2017 SIP Strategy called for action to reduce locomotive emissions. The 2022 SIP Strategy: Draft Measures

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

[28] California Air Resources Board, Draft 2020 Mobile Source Strategy, November 24, 2020. (web link: https://ww2.arb.ca.gov/sites/default/files/2020-11/Draft_2020_Mobile_Source_Strategy.pdf)

[29] California Air Resources Board, Revised Proposed 2016 State Strategy for the State Implementation Plan, March 7, 2017. (web link: https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf)

document describes the In-Use Locomotive Regulation as a proposed measure to reduce PM and NOx.[30]

1.4.4.4 Assembly Bill 617

The State of California placed additional emphasis on protecting local communities from the harmful effects of air pollution through the passage of Assembly Bill (AB) 617 (Garcia, Chapter 136, Statutes of 2017).[31] AB 617 is a significant piece of air quality legislation that highlights the need for further emission reductions in communities with high exposure burdens. AB 617 requires CARB to pursue new community-focused and community-driven actions to reduce air pollution and improve public health in communities that experience disproportionate burdens from exposure to air pollutants. The Proposed Regulation is a strategy to reduce diesel locomotive emissions and exposure in communities experiencing disproportionate exposure burdens.

1.4.4.5 California's 2017 Climate Change Scoping Plan

In 2006, Governor Schwarzenegger signed AB 32, the California Global Warming Solutions Act of 2006 (Núñez, Chapter 488, Statutes of 2006)[32] to address global climate change. AB 32 directed CARB to develop a scoping plan identifying integrated and cost-effective regional, national, and international GHG reduction programs. CARB adopted the AB 32 Scoping Plan in 2008 and subsequent updates in 2013 and 2017. California's 2017 Climate Change Scoping Plan[33] outlines the strategy to achieve the state's 2030 GHG targets and includes the development of more stringent locomotive requirements.

The 2022 Climate Change Scoping Plan Update is currently in-progress and the majority 2022 Climate Change Scoping Plan Update assumptions[34] align with the requirements of the Proposed Regulation.

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[30] California Air Resources Board, Draft Measures Document for the Proposed 2022 State Strategy for the State Implementation Plan (web link: https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy)

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

[32] California Health and Safety Code § 38500 - 38599, Division 25.5, Assembly Bill No. 32, California Global Warming Solutions Act of 2006, September 27, 2006. (web link: http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf)

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

[34] California Air Resources Board, California's 2022 Climate Change Scoping Plan Revised Scenario Assumptions (web link: Revised PATHWAYS Scenario Modeling Assumptions (ca.gov))

1.5 Major Regulation Determination

Per Department of Finance regulations (title 1, California Code of Regulations, sections 2000-2004),[35] the Proposed Regulation is a major regulation requiring a SRIA because the economic impact of the regulation is projected to exceed $50 million in a 12-month period. The Proposed Regulation would result in direct costs exceeding $50 million each year starting in 2025. The first obligations of the Proposed Regulation begin in 2023. Full turnover of the 2023 locomotive fleets is expected by 2047. The SRIA analyzes costs to comply with the Proposed Regulation from 2023 to 2050.

1.6 Baseline Information

Staff estimated the economic impacts of the Proposed Regulation by evaluating the economic and emission impacts of the proposal relative to the baseline (Baseline) each year for the analysis period (from 2023 to 2050). The Baseline for the Proposed Regulation reflects full compliance with existing federal emission standards for diesel locomotive engines, diesel fuel, and U.S. EPA idling limits. The Baseline assumes U.S. EPA takes no action on locomotive emission standards cleaner than Tier 4, since the agency has not made such commitments as of 2021.

Apart from the line haul Locomotive inventory updated in February 2021, CARB statewide locomotive inventories were last released in 2017. For the SRIA, staff used a combination of existing and updated locomotive emission inventories[36] to estimate statewide emissions under the Baseline and Proposed Regulation, as well as to forecast the number of locomotives each year from 2023 to 2050 for which there are direct costs or benefits associated with the Proposed Regulation. Updates to the locomotive emissions inventories were completed to support health risk assessments near railyards, and to support this cost analysis. An updated inventory methodology document will be released for public comment prior to the Board hearing as part of the Initial Statement of Reasons (ISOR or "Staff Report") and will contain detailed information on the data sources and methodology used.

The Proposed Regulation would impact approximately 2 Class I railroads, 25 Class III railroads, 42 industrial railroads, and 6 passenger intrastate railroads.

Figures 1.7, 1.8, 1.9, and 1.10 show the Baseline statewide locomotive PM2.5 and NOx emissions in tons per day from 2023 to 2050.

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[35] 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)

[36] California Air Resources Board, Mobile Source Emissions Inventory – Documentation – Off-Road – Diesel Equipment, Locomotives. (web link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road)

Figure 1.7: Baseline Class I Statewide Locomotive PM2.5 Emissions from 2023 to 2050

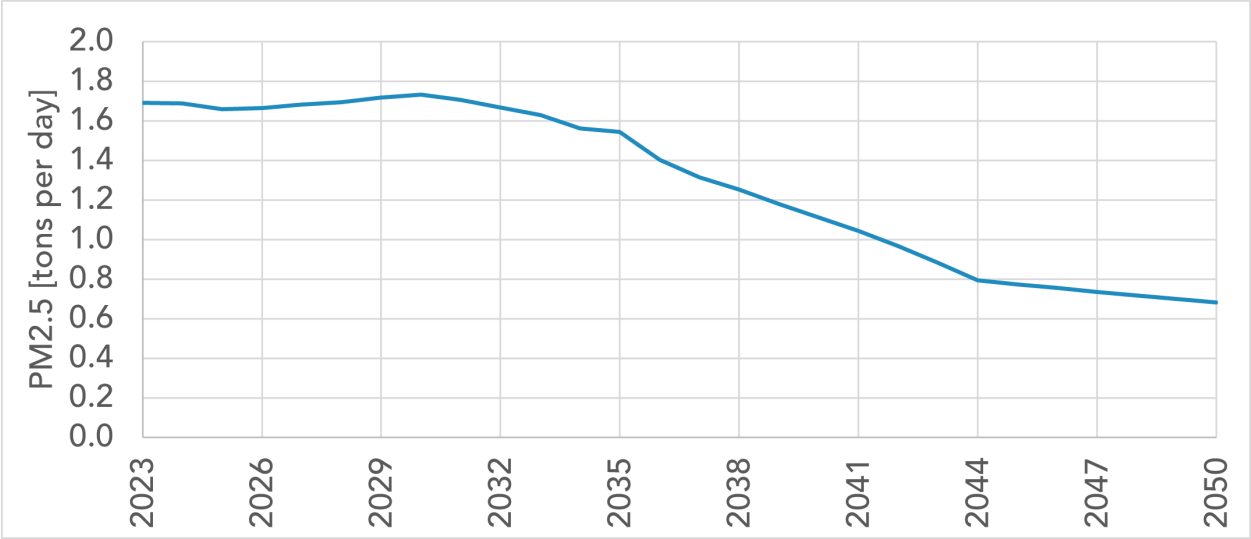


Figure 1.8: Baseline Class III, Industrial, and Passenger Statewide Locomotive PM2.5 Emissions from 2023 to 2050

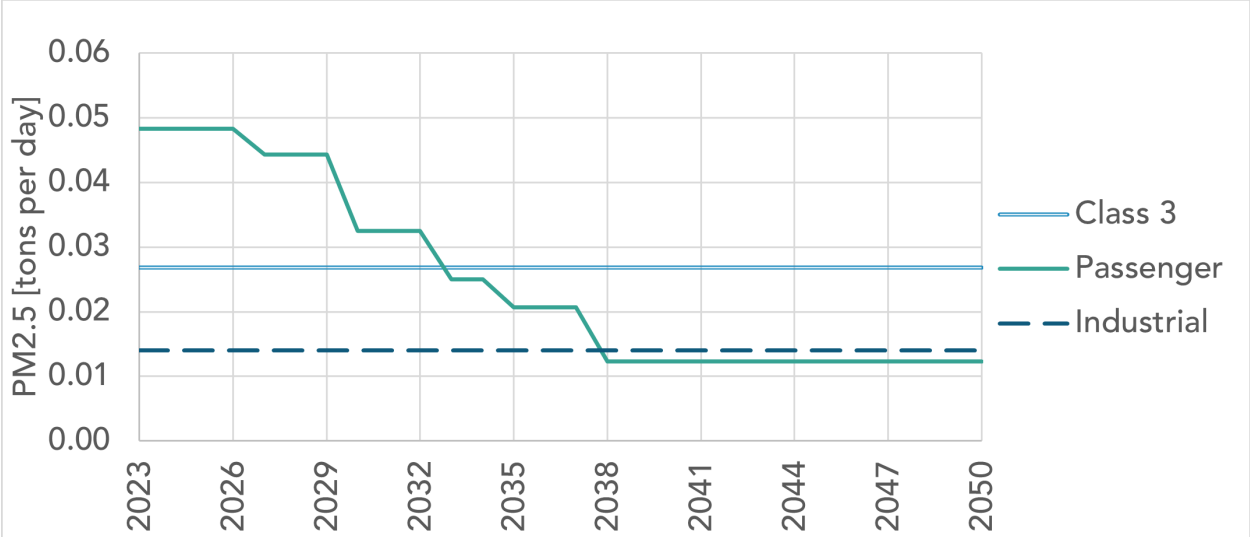


Figure 1.9: Baseline Class I Statewide Locomotive NOx Emissions from 2023 to 2050

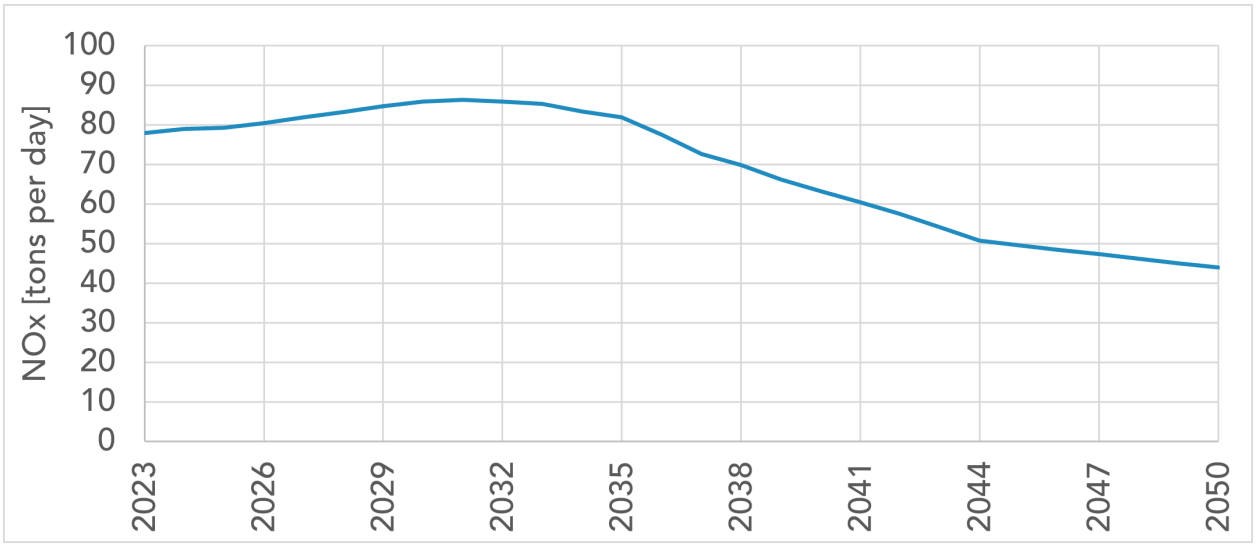
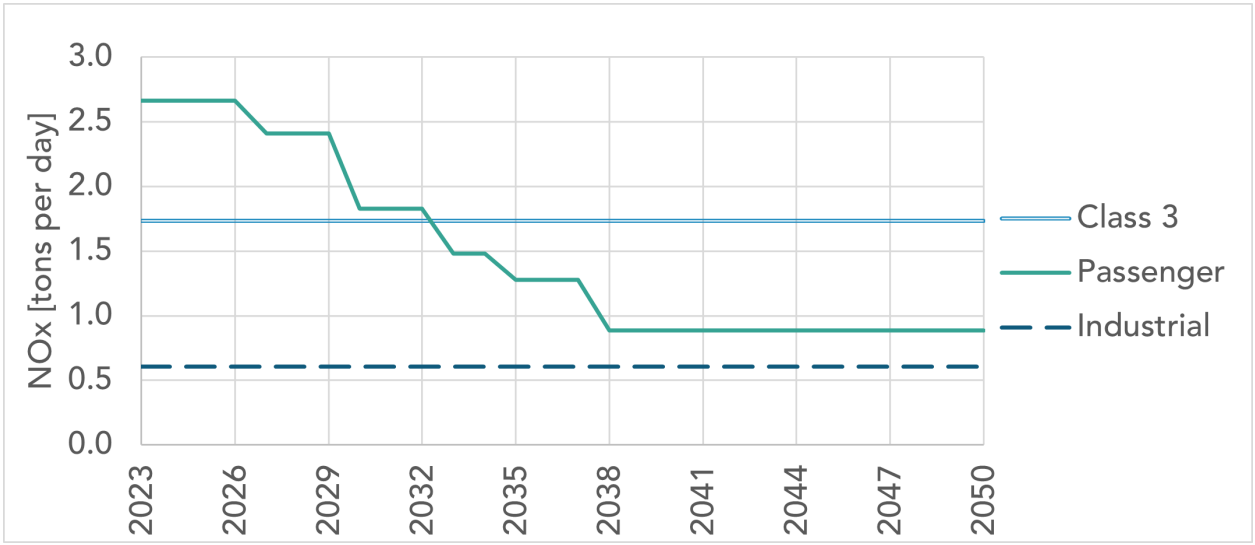


Figure 1.10: Baseline Class III, Industrial, and Passenger Statewide Locomotive NOx Emissions from 2023 to 2050



Staff is aware that the global pandemic that began in 2020 may have an impact on the trajectory of locomotive activity, as there have been changes in human activity which resulted in disruptions to the supply chain and the freight and passenger transportation industries.

However, while freight movement experienced a decline in the first half of 2020 due to the economic slowdown, 2021 had record-breaking volumes. For example, the Port of Los

Angeles and Port of Long Beach both set an annual record for freight volume.[37, 38] Based on 2021 business reports by the Association of American Railroads showing a rebound in freight movement,[39] staff does not anticipate the economic downturn to have a significant impact on future growth of freight movement, and therefore used historical growth trends for the industry, as described in the Inventory Methodology section (Section 2.1.1). Activity growth factors that were developed based on historical trends in the past decade are anticipated to still apply for the following reasons:

1. The first regulatory compliance date that would result in costs to locomotive operators to comply with the Proposed Regulation would not begin until January 1, 2023. Staff expects activities of affected industries will revert to normal economic conditions by this time.
2. Staff considered the latest data from the Department of Finance California Economic Forecast that was released with the 2022-23 Governor's Budget.[40] For the labor force and employment numbers in the Trade, Transportation, Warehousing, and Utilities sector, [41] the employment numbers (in thousands) in 2023 are estimated to be more than the levels in 2019 (3,053 in 2019 vs. 3,096 in 2023). In addition, the employment numbers from the Trade, Transportation, Warehousing, and Utilities sector are predicted to continue to increase in 2024 over 2023 levels.

In contrast, as of mid-2021 passenger locomotive ridership decreased throughout the state and has not yet fully recovered. Through review of ridership statistics for the North County Transit District,[42] Metrolink,[43] and Amtrak Capital Corridor, staff determined that the global situation caused an approximate 50 to 70 percent decline in ridership and is representative of the effects of the situation on all California passenger lines.[44] While it is unclear exactly when

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[37] Logistics Management, Port of Los Angeles and Port of Long Beach each set new volume records in 2021, 2022. (web link: https://www.logisticsmgmt.com/article/port_of_los_angeles_and_port_of_long_beach_each_set_new_volume_records_in_2)

[38] Port of Long Beach, Port of Long Beach Sets Annual Record With 9.38 Million TEUs, 2022. (web link: https://polb.com/port-info/news-and-press/port-of-long-beach-sets-annual-record-with-9-38-million-teus-01-19-2022/)

[39] Union Pacific Reports Fourth Quarter and Full Year 2020 Results. Union Pacific, 2021. (web link: https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_4q20_er_news_release.pdf)

[40] State of California Department of Finance, Economic Forecasts, California Economic Forecast – Annual and Quarterly, November 2021, last accessed April 5, 2022. (web link: https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/California-Economic-Forecast-GB-2022-23.xlsx)

[41] Category most locomotive employment activity would fall under.

[42] North County Transit District, Monthly Performance Reports. (web link: https://lfportal.nctd.org/WebLink/Browse.aspx?startid=176716)

[43] Metrolink, Financial Reports. (web link: https://metrolinktrains.com/about/financial-reports/)

[44] Amtrak, CCJPA Performance, 2021. (web link: https://www.capitolcorridor.org/ccjpa-performance/)

ridership will return to pre-pandemic levels, North County Transit District's April 2021 monthly report shows a 52 percent rebound from April 2020 and Amtrak shows consistently increasing ridership throughout 2021.[45] Additionally, operators have stated that the underlying economics remain the same[46] and that ridership is expected to recover by 2023.[47] Staff expect that the global situation that occurred in 2020 will not have a significant impact on future activity for passenger operators and should not impact the inventory for the Proposed Regulation.

1.7 Public Outreach and Input

Staff engaged in an extensive public process since development of the Proposed Regulation began in late 2019. Staff conducted meetings with members of impacted communities, environmental justice advocates, local air districts, industry stakeholders (including locomotive owners and operators, trade associations, locomotive original equipment manufacturers (OEMs), and other interested parties). Meeting formats included public workshops, work group meetings, community meetings, informal meetings, phone calls, and site visits.

1.7.1 Public Workshops and Meetings

Staff conducted four public workshops to solicit stakeholder feedback and discuss regulatory concepts, methodology and data used to develop the emission inventory and conduct a health risk characterization, as well as compliance and enforcement mechanisms. Staff notified stakeholders of all workshops with the issuance of a public notice at least two weeks prior to their occurrence. Staff posted the notices to the Locomotives and Railyards: Meetings & Workshops webpage[48] and distributed them through several public list serves

[45] Amtrak, Capital Corridors Joint Powers Authority Monthly Service Performance reports. (web link: https://images.capitolcorridor.org/wp-content/uploads/2021/10/Monthly-Service-Performance-September-2021.pdf

[46] Amtrak, Service Line Plans FY21-26, 2021. (web link: https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/businessplanning/Amtrak-Service-Line-Asset-Line-Plans-FY21-26.pdf)

[47] Email to CARB staff from Metrolink, Metrolink White Paper, received May 11, 2021.

[48] California Air Resources Board, Locomotives and Railyards: Meetings & Workshops webpage. (web link: https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california/locomotives-and-railyards-meetings-workshops)

that include over 40,000 recipients.[49] Each of these workshops was open to members of the public. Staff posted meeting materials, including agendas, slide presentations, preliminary cost information, and draft regulatory language, on the CARB locomotive website in advance of the workshops.

Staff held two public workshops in concert with the South Coast Air Quality Management District on November 20, 2019, in Los Angeles, California and on December 11, 2019, in San Bernardino, California. During these workshops, staff discussed concepts to reduce emissions from locomotives, and solicited stakeholder feedback and suggestions on additional ideas. The December workshop was webcast to ensure all interested parties could access the information.

Staff conducted a two-day workshop held on October 29, 2020 and October 30, 2020, via Zoom. During this workshop, staff presented draft concepts for reporting locomotive activity, a locomotive emission reduction spending account, the In-Use Operational Requirements, and a locomotive engine idling limit. Staff solicited stakeholder input on the concepts and asked for alternatives. Staff also discussed emission inventory updates, new locomotive technology, updates on locomotive operations and planning from California partner agencies, as well as data on health effects from exposure to emission from diesel locomotive engines. The workshop included over 300 webcast participants on October 29, 2020, and over 200 participants on October 30, 2020. The workshop was webcast with the ability to submit questions online to ensure the opportunity for broader public participation.

Staff held a Railyard Listening Session with community stakeholders on March 4, 2021. During the Listening Session staff and community members discussed their experiences living with locomotive impacts, such as noise and smoke. Staff explained what changes the community members might see through the Proposed Regulation, as well as timing for the anticipated emission reductions. The Listening Session included over 200 webcast participants. The Listening Session was webcast with the ability to submit questions online to ensure the opportunity for broader public participation.

Staff held a final public workshop on March 30, 2021, via Zoom. During this workshop, staff walked through examples of the Spending Account as well as the Proposed Regulation language, and Preliminary Cost Document which were released prior to the workshop. Staff solicited stakeholder input on the concepts and asked for alternatives as well as feedback on the cost inputs for the SRIA. The workshop included over 270 webcast participants. The

[49] Number of subscribers for the following CARB lists as of April 30, 2021: AB32 Public Health Workgroup; Cargo Handling Equipment Regulatory Activities; Climate Change; Environmental Justice ChERRP, Commerce; Environmental Justice Stakeholders Group; Port and Rail Plan; Goods Movement Emission Reduction Program; Harbor Craft; Harbor Communities Monitoring; Tractor-Trailer GHG Regulation; Locomotive Emission Reduction Program; Environmental Justice ChERRP, Mira Loma; Truck and Bus Regulation; Port Truck; Railyard Emission Reduction Program; Reduction of GHG Emissions from Refrigerated Shipping Containers; Sustainable Freight Transport Initiative; Shore Power for Ocean Going Vessels; State Implementation Plan; Transport Refrigeration Units; Vessel Speed Reduction for Ocean Going Ships; West Oakland Risk Assessment; Environmental Justice ChERRP, Wilmington.

workshop was webcast with the ability to submit questions online to ensure the opportunity for broader public participation.

1.7.2 Stakeholder Meetings and Site Visits

As of April 2021, staff have conducted more than 70 informal meetings, phone calls, and site visits with a broad group of stakeholders. During these meetings, staff discussed regulatory concepts, gathered input, and addressed questions and comments. Stakeholders included members of impacted communities, environmental justice advocates, local air districts, locomotive owners and operators, trade associations, locomotive OEMs, as well as other interested parties.

1.7.3 Informational Documents

On March 16, 2021, staff posted two informational documents on the Locomotives and Railyards: Meetings & Workshops webpage, for public comment: A Preliminary Cost Document which outlined the cost inputs and assumptions to be used for the economic analysis of the Proposed Regulation, and a draft regulatory language document.

2 Benefits

The Proposed Regulation is designed to reduce toxic air contaminant, criteria pollutant, and GHG emissions by transitioning old, highly polluting diesel-powered locomotives to the cleanest diesel-powered locomotive available and ZE locomotives. Cumulatively, from 2023 to 2050, the Proposed Regulation is expected to reduce statewide locomotive emissions by approximately 7,566 tons of PM2.5, 394,360 tons of NOx, and 21.7 million metric tons of carbon dioxide equivalent (MMTCO2e), relative to the Baseline. The total statewide valuation of avoided health outcomes from 2023 to 2050 is approximately $32.3 billion.

2.1 Emission Benefits

2.1.1 Inventory Methodology

Staff estimated locomotive emissions based on the best available information regarding past, current, and projected future locomotive activity. Staff collected fleet data from operators in multiple ways including the 1998 MOU annual reports, periodic surveys, and direct requests to smaller operators for fleet details such as locomotive ages, Tiers, and average fuel consumption or MWh of operation.

An updated emission inventory methodology document will be released for public comment prior to the Board hearing as part of the ISOR and will contain detailed information on the data sources and methodology used in these emissions inventories.

For Class I line haul, the 2021 Linehaul Locomotive Emission Inventory was developed considering retirement, remanufacture and replacement patterns observed in California in datasets provided by UP and BNSF. More detailed information on the 2021 Linehaul

locomotive emission inventory is available at Mobile Source Emission Inventory website.[50] The Class I base locomotive MWh growth is predicted as 2.19 percent per year using the Freight Analysis Framework version 4.5.1 data[51] produced by the Federal Highway Administration. The Freight Analysis Framework tracks national freight movement by industry and provides historic locomotive growth rates.

Class I switcher populations are based on data provided by Class I operators for the 2005 and 2007 Health Risk Analysis at Railyards reports, since these populations have slow turnover and operators have not updated the dataset. Although the Class I switcher inventory assumes the same 2.19 percent growth rate for MWh as the Class I line haul given their interdependent operations, the existing fleet of Class I switchers is expected to have additional capacity to absorb the additional work and therefore does not grow over time.

Class III, industrial, and passenger locomotive inventories were developed using industry surveys and data provided by individual companies as these operators do not consistently report their fleet data to federal nor state agencies. Class III and industrial locomotive tier distribution and activity levels remain the same from the baseline year 2020 until 2050. The passenger locomotive inventory Tier distribution and fuel consumption data were based on the information provided by passenger railroad agencies and through discussions with them. Passenger activity levels are projected to remain the same from the baseline year 2020 until 2050 based on email responses from operators, though fleets are expected to turnover to Tier 4 or ZE locomotives.

The emission inventory for any given year is calculated by combining MWh of locomotive engine activity, emission factors, and conversion factors, in the following equation:

Equation 1: Emissions Inventory Calculation

$$(Emissions) = (Engine\ activity\ [MWh]) \times (Emission\ Factor\ [g/bhp - hr]) \times (conversion\ factor)$$

Where,		Units
Emissions	= Daily emissions from the locomotive in California	ton per day (tpd)
Engine activity	= Annual engine activity in California	MWh
Emission Factor	= Locomotive emissions factors for each Tier	g/bhp-hr
Conversion factor	= Conversion factors for unit consistency	

Staff estimated PM2.5, NOx, and GHG emissions for the Proposed Regulation compared to the Baseline. Emission benefits from the Proposed Regulation would begin in 2025 when the first locomotives purchased with Spending Account funds would be delivered to locomotive operators. Staff quantified emission benefits through 2050, which is consistent with the timeframe used for the cost analysis. Table 2.1 summarizes the assumptions staff used to

[50] California Air Resources Board, 2021 Line-Haul Locomotive Emission Inventory, (web link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road

[51] Bureau of Transportation Statistics, Federal Highway Administration, Freight Analysis Framework. (web link: https://faf.ornl.gov/faf5/)

model the emission reductions for implementation of the Spending Account and In-Use Operational Requirements.

No emission reductions were modelled or assumed for the idling limit or the reporting requirements. Reporting does not require emission reductions, instead it allows CARB to better understand locomotive emissions statewide and to ensure compliance with the regulation. The idling limit will not result in additional emission reductions because staff assume full compliance with existing regulations for this calculation, including the federal regulation which requires that all locomotive engines above Tier 0 must be equipped with idle limiting technology upon manufacture or remanufacture, as applicable. By including the idling limit in the Proposed Regulation, CARB will have the ability to inspect and enforce cases where idle-limiting technology is malfunctioning or manually bypassed and to ensure that the federally mandated limit of 30 minutes is followed in all applicable cases.

2.1.2 Proposed Regulation Emissions Forecast Assumptions

2.1.2.1 General Assumptions

1. Locomotives are ordered and purchased prior to being manufactured. Therefore, a new locomotive will enter service one year after purchase to accommodate locomotive manufacturing.

2.1.2.2 Spending Account Assumptions

1. There is economic incentive to limit how much money is deposited into a Spending Account and to use Spending Account funds as soon as possible. Spending Account funds have more value as an investment in future business operations than they do sitting in an interest earning account where interest earned must also be spent according to the Spending Account Requirements. Therefore, CARB assumes that locomotive operators will expend Spending Account funds within one year of the sufficient accumulation of funds to purchase locomotive(s) to limit the amount of funds sitting in their Spending Account, to reduce Spending Account deposit requirements, and to prepare their fleets for compliance with the In-Use Operational Requirements.

    a. Unless a newly purchased locomotive results in retirement of Tier 4 locomotive less than 23 years old, operators will expend Spending Account funds on locomotive purchases once funds are sufficient to purchase a new locomotive or until their entire fleet is ZE.

        i. From 2029-2033, Class I railroads purchase ZE switchers and ZE line haul infrastructure, then save remaining Spending Account funds until 2034 when ZE line haul locomotives are expected to be commercially available.

    b. Locomotives purchased with Spending Account funds replace activity equal to the locomotive operator's fleet average from the prior calendar year.

2.1.2.3 In-Use Operational Requirements Assumptions

1. California Locomotive Operations Requirement

a. To account for operators' current fleet management patterns and the interchangeability of locomotives within each fleet, staff assumed that each operator's entire fleet would comply with the Proposed Regulation, allowing all locomotives to operate as needed in California. Therefore, staff developed the cost model assuming that when a locomotive is no longer able to operate in California due to the In-Use Operational Requirements (IUOR), the operator would sell or scrap the locomotive.
   Note: The Proposed Regulation does not require operators to make any changes outside of California. For example, operators may continue to use non-compliant locomotives outside of California, or they may sell or scrap the locomotive.
b. Class III, industrial, and passenger operators purchase Tier 4 locomotives until December 31, 2028.
c. To prepare for the switch, industrial, and passenger locomotives Zero Emission Operational Requirement, staff assume that Class III, industrial, and passenger operators purchase ZE locomotives beginning January 1, 2029.
d. Class I railroads purchase Tier 4 locomotives with both Spending Account and non-Spending Account funds until December 31, 2028, then only with non-Spending Account funds until December 31, 2033 since the Spending Account is restricted to ZE locomotive purchases beginning January 1, 2030.
e. To prepare for the Freight Line Haul Zero Emission Operational Requirement, staff assume that Class I operators will purchase ZE locomotives beginning January 1, 2034.

Class I, Cass III, industrial, and passenger operators are assumed to purchase locomotives with both funds held in the Spending Account and funds not held in the Spending Account. Purchases made with funds not held in the Spending Account are often needed when industry growth or retirement projections exceed the number of locomotives that can be purchased with the funds solely in the Spending Account. The Spending Account purchases and non-Spending Account purchases for the Proposed Regulation are modeled as shown in Table 2.1.

Table 2.1: Emission Inventory Modeling Assumptions – Proposed Regulation

Purchase Year[52]	2023-2028	2029-2033	2034-2050
Class I Line Haul – Spending Account Funds	Tier 4	No SA line haul locomotive purchases. Up to 50% on ZE Infrastructure Up to 50% Deposits used on Class I switchers until full ZE conversion.	ZE locomotives
Class I Line Haul – Non-Spending Account Funds	Tier 4	Tier 4	ZE locomotives
Class I Switcher, Class III, Industrial, Passenger – All funds	Tier 4	ZE infrastructure and locomotives	ZE infrastructure and locomotives

2.1.3 Anticipated Emission Benefits

The Proposed Regulation is expected to reduce PM2.5, NOx, and GHG emissions from locomotives beyond levels that would be achieved under business as usual. Staff estimates that from 2023 to 2050, the Proposed Regulation would reduce cumulative statewide emissions by approximately 7,566 tons of PM2.5, 394,360 tons of NOx, and 21.7 million metric tons of GHG. PM2.5, NOx, and GHG emission reductions would begin in 2025 when the first locomotives purchased using spending account funds would enter service. Substantial reductions would occur in 2030 since the IUOR allows only locomotives less than 23 years old to operate in the State. Table 2.2 shows the estimated annual emission reductions that would result from the Proposed Regulation from 2023 to 2050.

Table 2.2: Estimated Annual PM2.5, NOx, and GHG Emission Reductions Resulting from the Proposed Regulation from 2023 to 2050

Year	PM2.5 (tons)	NOx (tons)	GHG (MMTCO2e)
2023	0	0	0.00
2024	0	0	0.00
2025	21	1,191	0.00

[52] Locomotives are purchased prior to manufacture. It may take up to one year to deploy a newly built locomotive. Therefore, a new locomotive enters into service one year after purchase. For example, a locomotive purchase in 2029 will be for a locomotive with an Original Engine Build Date in 2030.

Year	PM2.5 (tons)	NOx (tons)	GHG (MMTCO2e)
2026	51	2,527	0.00
2027	77	3,658	0.00
2028	103	4,865	0.00
2029	137	6,221	0.00
2030	449	18,532	0.07
2031	460	20,004	0.09
2032	450	20,056	0.09
2033	439	20,066	0.11
2034	418	19,590	0.11
2035	455	22,012	0.38
2036	432	22,283	0.57
2037	431	22,637	0.78
2038	406	21,507	0.86
2039	380	20,274	0.97
2040	357	19,273	1.07
2041	332	18,304	1.15
2042	307	17,433	1.31
2043	276	16,195	1.40
2044	244	14,955	1.49
2045	237	14,558	1.59
2046	230	14,167	1.67

Year	PM2.5 (tons)	NOx (tons)	GHG (MMTCO2e)
2047	223	13,692	1.71
2048	220	13,597	1.91
2049	217	13,456	2.10
2050	214	13,307	2.30
Total	7,566	394,360	21.74

Figures 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6 show the PM2.5, NOx, and GHG emissions impact of the Proposed Regulation relative to the Baseline from 2023 to 2050.

Figure 2.1: Statewide PM2.5 Emissions from Class I Locomotive under the Baseline and Proposed Regulation from 2023 to 2050

Figure 2.2: Statewide PM2.5 Emissions from Class III, Industrial, and Passenger Locomotive under the Baseline and Proposed Regulation from 2023 to 2050

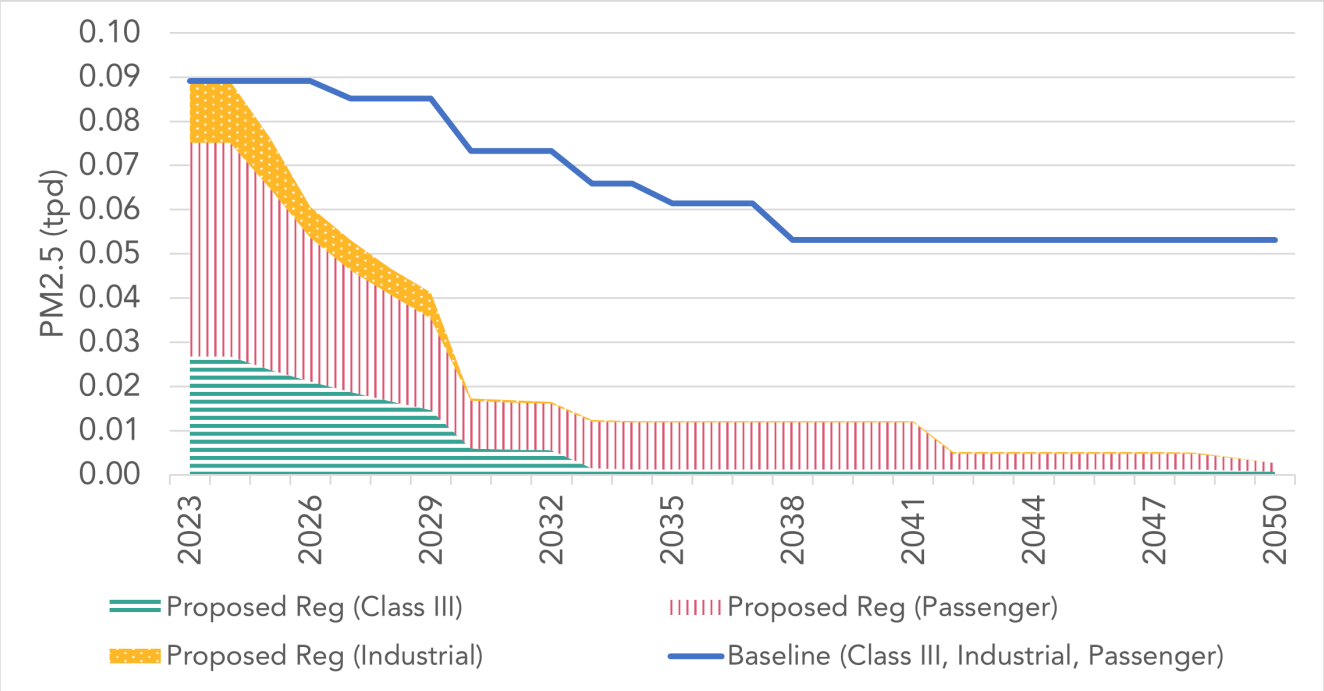


Figure 2.3: Statewide NOx Emissions from Class I Locomotives under the Baseline and Proposed Regulation from 2023 to 2050

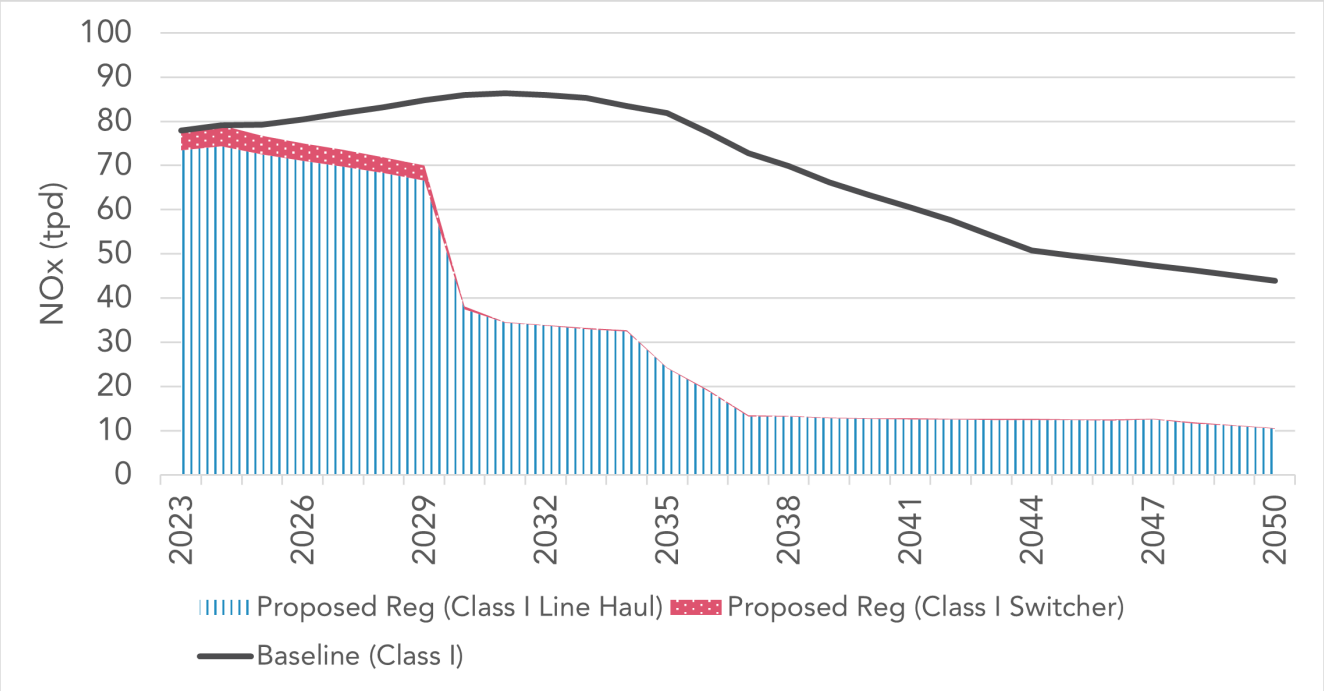


Figure 2.4: Statewide NOx Emissions from Class III, Industrial, and Passenger Locomotive under the Baseline and Proposed Regulation from 2023 to 2050

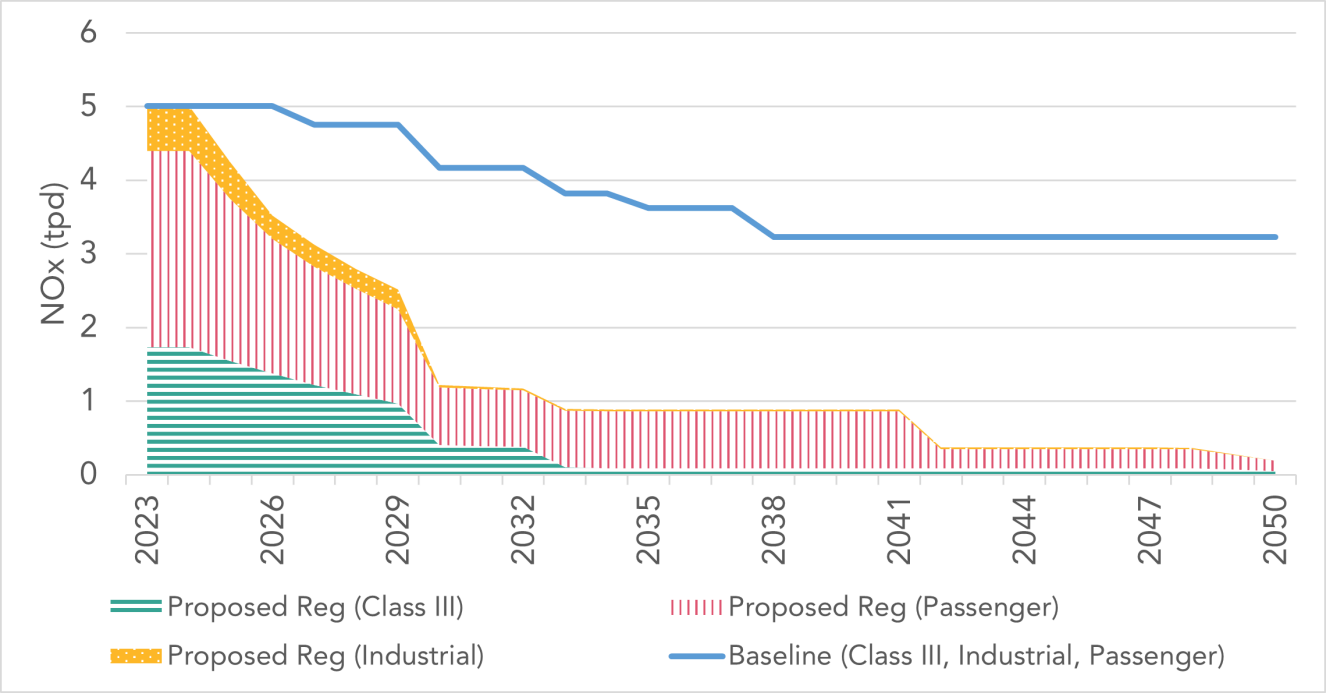


Figure 2.5. Statewide Annual GHG Emissions from Class I Locomotives under the Baseline and Proposed Regulation from 2025 to 2050

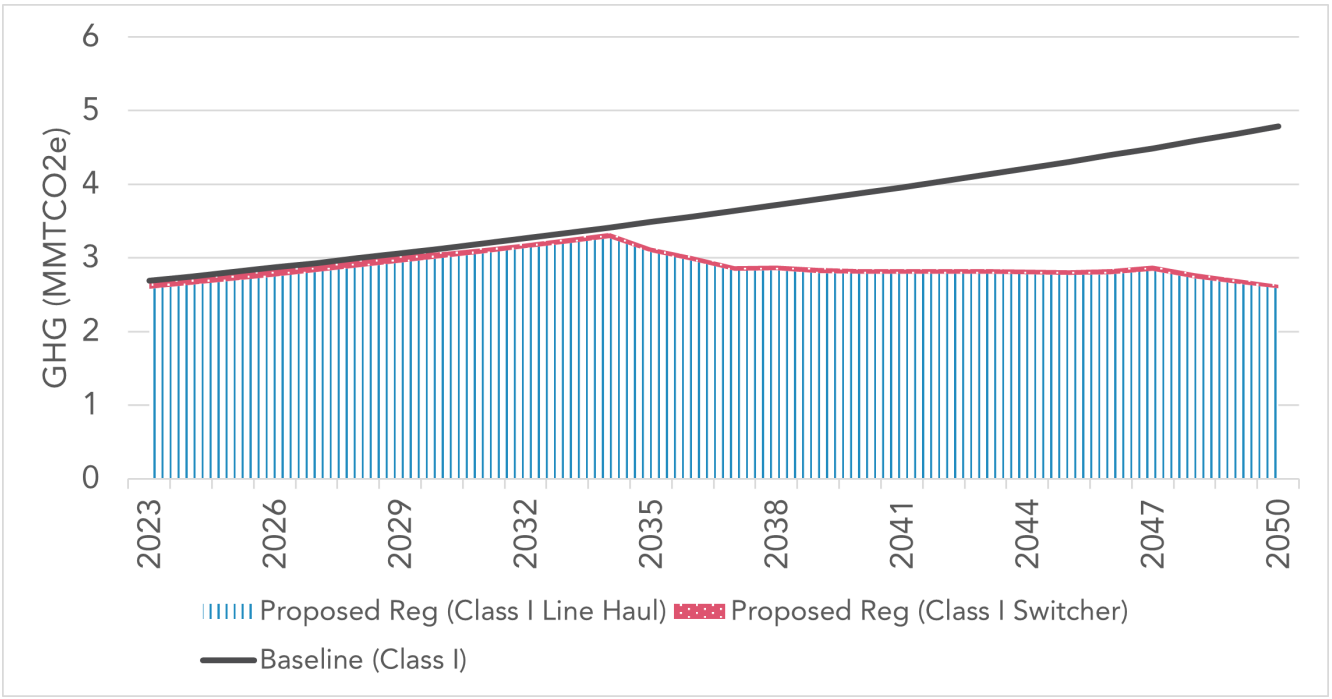
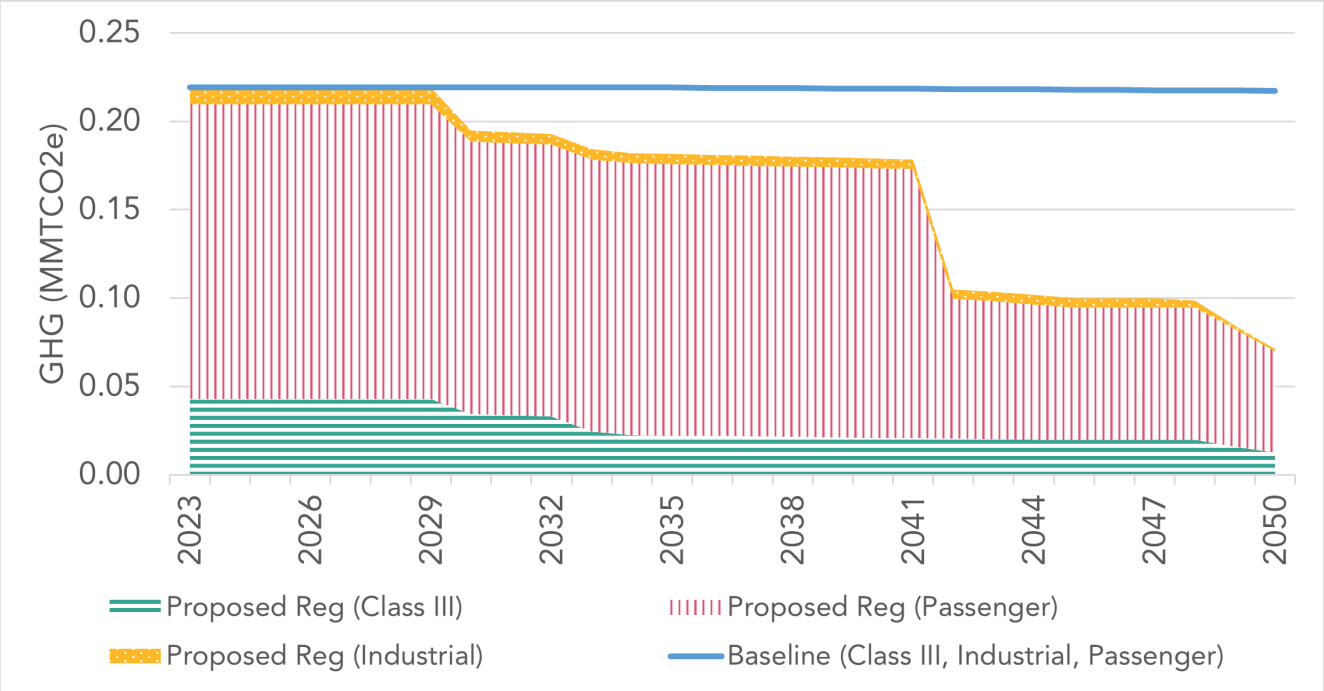


Figure 2.6: Statewide Annual GHG Emissions from Class III, Industrial, and Passenger Locomotive under the Baseline and Proposed Regulation from 2025 to 2050



The PM2.5 and NOx emission projections for the Proposed Regulation account for tank-to-wheel emissions, and do not include upstream emissions associated with producing and delivering the fuel or energy source to the locomotive that are addressed by other measures and policies to reduce those emissions. However, upstream emissions from locomotives are expected to show greater PM2.5 and NOx 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. [53]

The GHG emissions are calculated considering both tailpipe and upstream emissions to allow direct comparison between the global impact of diesel and ZE locomotive technologies. The upstream emissions, or well-to-tank (WTT) emissions, were quantified using the same approach as the 2020 Mobile Source Strategy [54] with updated assumptions for fuel and energy supply. WTT emissions include sources from fuel production facilities such as electricity power plants, hydrogen, biofuel production, and refineries, in addition to fuel feedstock collection (e.g., crude oil extraction from in-state wells) and finished fuel product transportation and distribution. The WTT emission factors capture GHG emission sources within the scope of AB 32. WTT emission factors for gasoline, diesel, and hydrogen fuels

[53] California Air Resources Board, Advanced Clean Cars II, 2022. (web link: https://www.dof.ca.gov/forecasting/economics/major_regulations/major_regulations_table/documents/ACCII-SRIA.pdf, last accessed January 2022)

[54] California Air Resources Board. Appendix A – Upstream Energy Emission Factors for Scenario Modeling. (web link: https://ww2.arb.ca.gov/sites/default/files/2021-09/Proposed_2020_Mobile_Source_Strategy.pdf)

were developed based on California-specific data, including Low Carbon Fuel Standard (LCFS) data[55], CEIDARS/CEPAM[56], and CA-GREET[57], while considering LCFS compliance scenarios that require fuel production with decreasing carbon intensities and SB 1505.[58] Electricity emission factors reflect compliance with SB 100 Renewable Portfolio Standard targets.[59] The Proposed Regulation compared to the baseline increases electricity and hydrogen consumption while reducing diesel fuel consumption.

2.2 Benefits to Typical Businesses

The Proposed Regulation would benefit locomotive manufacturers, engineering and construction firms, and project management firms. The Proposed Regulation would increase demand for Tier 4 locomotives, repowers, and remanufactures in California due to the Spending Account and IUOR. Staff anticipates increased demand for Tier 4 locomotives in California will result in additional production of Tier 4 locomotives or additional production associated with Tier 4 repowers and remanufactures, along with associated labor increases.

Staff anticipates that the requirements of the Proposed Regulation will also result in increases in the production of ZE locomotives, ZE repowers, or ZE remanufactures. An increase in production would benefit ZE locomotive manufacturers, as well as various businesses in the ZE locomotive supply chain, including those involved in battery, fuel cell, and renewable energy technology throughout the state. Staff are aware of four rail manufacturers currently operating in California: Siemens, Alstom, Rail Propulsion Systems, and Shuttlewagon. Siemens manufactures passenger multiple units – rail vehicles that do not qualify as "locomotives" given their HP. Alstom manufactures and refurbishes both diesel and ZE locomotives. Rail Propulsion Systems is a manufacturer of ZE locomotives and has

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[55] Data includes crude supply, carbon intensity, and in-state production from LCFS data dashboard and LCFS compliance scenario, (web links: https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

https://www.arb.ca.gov/fuels/lcfs/2018-0815_illustrative_compliance_scenario_calc.xlsx?_ga=2.155021808.917945968.1597354480-1389483658.1577128071)

[56] California Air Resources Board, 2018. Criteria Pollutant Emission Inventory Data. (web link: https://ww2.arb.ca.gov/criteria-pollutant-emission-inventory-data)

[57] California Air Resources Board, 2019. CA-GREET3.0 Model. (web link: https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet30-corrected.xlsm?_ga=2.247817287.1944131420.1600710547-1389483658.1577128071)

[58] Senate Bill (SB) 1505 requires at least 33.3 percent of the hydrogen dispensed by fueling stations that receive state funds be made from eligible renewable energy resources. (web link: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060SB1505)

Based on current hydrogen supply from LCFS reporting data and future production investments, the supply of renewable hydrogen can be, at least, maintained at 40% of hydrogen fuel demand.

[59] SB 100 requires renewable energy and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045. For renewable source target in a specific year. (web link: refer to https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100)

demonstrated the conversion of diesel locomotives to battery electric. Shuttlewagon produces ZE railcar movers that may be used in place of some switch locomotives.

Individual businesses that operate ZE locomotives may also be able to lower their total cost of ownership with operational and maintenance cost savings, and credits generated under the LCFS Regulation. LCFS is a regulation designed to reduce the carbon intensity of California's transportation fuel and provide an increasing range of low-carbon and renewable alternatives, which reduce petroleum dependency and achieve air quality benefits. For battery electric charging or hydrogen fuel production, the owner of electric charging infrastructure or hydrogen production facilities where electricity or fuel is dispensed are eligible to generate LCFS credits.[60]

Advanced technologies such as ZE locomotives provide opportunities for design, engineering, construction, and project management firms to create new and expanded infrastructure to serve the needs of ZE locomotives. Increases in the demand for ZE charging and fueling infrastructure would also benefit suppliers, equipment installers, and electricians. Additionally, some of the infrastructure equipment may be manufactured in California.

2.3 Benefits to Small Businesses

Electricians, engineering, construction, and project management companies; parts and components businesses; and others involved in designing, installing, and maintaining electric and fueling infrastructure equipment may fall into the small business category. The benefits to locomotive manufacturers and other related businesses discussed above may also apply to small businesses.

2.4 Benefits to Individuals

The Proposed Regulation would benefit California residents by reducing cancer risk to individual residents and off-site workers near facilities where locomotives operate, and by reducing non-cancer health impacts by lowering direct PM exposure and secondary formation of PM2.5 from NOx. The Proposed Regulation would also reduce NOx-associated ozone exposure and provide GHG emission reductions needed to combat climate change. Emission reductions would reduce occupational air pollution exposure and benefit on-site workers, including, but not limited to locomotive operators, maintenance workers, and other individuals who work at facilities where locomotives operate. Staff estimated the statewide value of health benefits from reduced PM2.5 and NOx emissions, as well as the value of GHG emission reductions using the social cost of carbon, as described below.

2.4.1 Health Benefits

Exposure to pollution from diesel engines that power locomotives has both potential cancer, and non-cancer health impacts. Staff conducted a Health Risk Characterization (HRC) to

[60] California Air Resources Board, Unofficial electronic version of the Low Carbon Fuel Standard Regulation, July 2020, (web link: https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf)

evaluate the cancer risk reductions that would be gained if 100 percent of the locomotives operated at California railyards were Tier 4. Separately, staff estimated the noncancer health impacts associated with the Proposed Regulation, such as cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and emergency room visits for asthma associated with exposure to ambient levels of directly emitted PM2.5 and secondary PM2.5 formed in the atmosphere from locomotive NOx emissions. The health studies that support the Proposed Regulation will be released as part of the ISOR for public comment prior to the Board hearing.

2.4.1.1 Reduction in Potential Cancer Risk

The HRC evaluated the cancer risk associated with emissions from locomotives operating at two California railyards of different sizes to represent the range of results for railyards throughout California; one located in the northern part of the state, one located in the southern part of the state. The HRC focused on cancer risk from exposure to "primary" (directly emitted) diesel PM emissions experienced by people who live near railyards. Refer to the ISOR HRC Appendix for additional modeling details.

Since the HRC is intended to characterize the reductions in health risks for a representative railyard facility, and not a specific facility, cancer risk is presented as the average cancer risk for residential receptors over a geographic area extending out one mile from the railyard boundaries, rather than identifying specific receptors such as a point of maximum impact or maximally exposed individual resident. All health impact results were calculated using the methodology of 30-year individual cancer risk defined in the 2015 California Office of Environmental Health Hazard Assessment Cancer Risk Guidance Manual.[61]

For the HRC, cancer risk is presented as averages within a one-mile distance from the facility boundary using two averaging methods. For Method I (Table 2.3), the average cancer risk was calculated in three geographic areas (or banded areas). For Method II (Table 2.4), the average cancer risk was calculated at three specific distances from the railyard facility boundary. The first at 0.25 miles, the second at 0.5 miles and the third at 1.0 mile from the railyard facility boundary.

Table 2.3 and Table 2.4 show a reduction of 91 to 93 percent for the average cancer risk in 2045 from both railyards when compared to the 2020 level (the baseline year). The reduction is consistent with the projected emission inventory in 2045. The HRC indicates an overall cancer risk benefit from both railyards with the implementation of the Proposed Regulation.

[61] Office of Environmental Health Hazard Assessment, Risk Assessment Guidelines Guidance Manual for Preparation of Health Risk Assessments, 2015, (web link: https://oehha.ca.gov/media/downloads/crnr/2015guidancemanual.pdf)

Table 2.3: Percentage Reduction of Average Cancer Risk from the Southern California Railyard in 2045 as Compared to the 2020 Level

Study Method	Area Referenced	2045
Method I	0 - 0.25 mile band	91.2%
Method I	0.25 – 0.5 mile band	90.9%
Method I	0.5 – 1.0 mile band	91.1%
Method II	0.25 mile perimeter	91.2%
Method II	0.5 mile perimeter	91.1%
Method II	1.0 mile perimeter	91.3%

Table 2.4: Percentage Reduction of the Average Cancer Risk from the Northern California Railyard in 2045 as Compared to the 2020 Level

Study Method	Area Referenced	2045
Method I	0 - 0.25 mile band	92.4%
Method I	0.25 – 0.5 mile band	93.2%
Method I	0.5 – 1.0 mile band	90.9%
Method II	0.25 mile perimeter	92.4%
Method II	0.5 mile perimeter	93.0%
Method II	1.0 mile perimeter	92.9%

As can be seen through the Northern California and Southern California railyard studies, which compare average modeled cancer risk from locomotive emissions in 2020 and average modeled cancer risk with an all-Tier 4 fleet, the introduction of freight locomotives with at least Tier 4 average emissions can result in over a 90 percent decrease in average cancer risks in the communities that surround railyards.

2.4.1.2 Non-Cancer Health Impacts and Valuations

Staff evaluated the statewide non-cancer health impacts associated with exposure to PM2.5 and NOx emissions from locomotives. PM2.5 may be directly emitted or created through secondary formation. Both directly emitted PM2.5 and secondary PM2.5 from locomotives

are associated with adverse health outcomes, such as cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and emergency room visits for asthma. Locomotive NOx emissions include nitrogen dioxide, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled.[62] However, the most serious quantifiable impacts of NOx emissions occur through its role in the formation of secondary PM2.5. Reductions in PM2.5 and NOx emissions are associated with reductions in these health outcomes.

2.4.1.3 Incidence-Per-Ton Methodology

CARB uses the incidence-per-ton (IPT) methodology to quantify the health benefits of emission reductions in cases where dispersion modeling results are not available. A description of this method is included on CARB's webpage.[63] CARB's IPT methodology is based on the methodology developed by U.S. EPA.[64, 65, 66]

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 PM2.5 for a baseline scenario using measured ambient concentrations and dividing by the emissions of PM2.5 or a precursor. The calculation is performed separately for each air basin using the following equation:

Equation 2: Incidence Per Ton Calculation

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

[62] United States Environmental Protection Agency, Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-15/068, January 2016. (web link: http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=526855)

[63] California Air Resource Board, Methodology for Estimating the Health Effects of Air Pollution, accessed February 9, 2021. (web link: https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution)

[64] 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, 2019. (web link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/)

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

[66] 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)

Multiplying the emission reductions from the Proposed Regulation in an air basin[67] 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 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 IPT factors were computed. IPT factors are computed for the two types of PM2.5: primary PM2.5 and secondary PM2.5 of ammonium nitrate aerosol formed from precursors.

2.4.1.4 Reduction in Adverse Health Impacts

Staff evaluated the reduction in adverse health impacts including cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and emergency room visits for asthma. Staff estimates that the total number of cases statewide that would be reduced (from 2023 to 2050) from implementation of the Proposed Regulation are as follows:

- 3,268 cardiopulmonary mortality reduced (2,556 to 3,994, 95 percent confidence interval [CI])
- 1,503 emergency room visits reduced (951 to 2,055, 95 percent CI)
- 603 hospital admissions for respiratory illness (141 to 1,063, 95 percent CI)
- 505 hospital admissions for cardiovascular illness reduced (0 to 989, 95 percent CI)

Table 2.5 shows the estimated reductions in health outcomes resulting from the Proposed Regulation from 2023 to 2050.

Table 2.5: Estimated Total Reductions in Health Outcomes as a Result of the Proposed Regulation from 2023 to 2050

Air Basin	Cardiopulmonary mortality	Emergency room visits	Hospitalizations for respiratory illness	Hospitalizations for cardiovascular illness
Mojave Desert	221 (173 - 271)	86 (54 - 117)	39 (9 - 68)	32 (0 - 64)
Mountain Counties	66 (51 - 80)	22 (14 - 30)	7 (2 - 13)	6 (0 - 12)
North Central Coast	1 (1 - 1)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	7 (6 - 9)	3 (2 - 4)	1 (0 - 2)	1 (0 - 2)

[67] California is divided into 15 Air Basins. Air basin boundaries are generally determined by grouping together areas with similar geographical and meteorological features. However, political boundaries are also considered in determining the air basin boundaries. More info on California Air Basins can be found on the CARB California Air Basin Map webpage. (web link: https://www.arb.ca.gov/app/emsinv/maps/2021statemap/abmap.php)

Air Basin	Cardiopulmonary mortality	Emergency room visits	Hospitalizations for respiratory illness	Hospitalizations for cardiovascular illness
Sacramento Valley	147 (115 - 180)	55 (35 - 76)	22 (5 - 39)	18 (0 - 36)
Salton Sea	94 (73 - 115)	44 (28 - 60)	16 (4 - 29)	14 (0 - 27)
San Diego County	16 (13 - 20)	6 (4 - 9)	3 (1 - 5)	2 (0 - 5)
San Francisco Bay	103 (80 - 126)	56 (35 - 76)	19 (5 - 34)	16 (0 - 32)
San Joaquin Valley	627 (491 - 765)	225 (143 - 307)	92 (21 - 161)	77 (0 - 150)
South Central Coast	12 (10 - 15)	5 (3 - 7)	2 (1 - 4)	2 (0 - 4)
South Coast	1,974 (1,545 – 2,412)	1,000 (633 – 1,367)	401 (94 - 708)	336 (0 - 659)
Statewide	3,268 (2,556 – 3,994)	1,503 (951 – 2,055)	603 (141 – 1,063)	505 (0 - 989)

Note: The values in parentheses represent the 95 percent confidence intervals of the central estimate. Totals may not add due to rounding.

2.4.1.5 Monetization of Health Impacts

In accordance with U.S. EPA practice, staff monetized health outcomes by multiplying incidence by a standard value derived from economic studies.[68] Table 2.6 shows the valuation per incident avoided health outcome in 2019 U.S. Dollars (2019$). The valuation for avoided premature mortality is based on willingness to pay.[69] This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risk of dying in a year, such that one death would be avoided in the year across the population. This is not an estimate of how much any

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

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

single individual would be willing to pay to prevent a certain death of any particular person,[70] nor does it consider any specific costs associated with mortality, such as hospital expenditures.

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

Table 2.6. Valuation per Incident Avoided Health Outcomes (2019$)

Outcome	Valuation per Incident
Avoided Premature Deaths	$9,865,659
Avoided Cardiovascular Hospitalizations	$58,275
Avoided Acute Respiratory Hospitalizations	$50,831
Avoided Emergency Room Visits	$834

The statewide valuation of health benefits is calculated by multiplying the number of avoided adverse health outcomes by valuation per incident. Staff quantified the annual and total statewide valuation of avoided adverse health outcomes from 2023 to 2050, as shown in Table 2.7 and Table 2.8, respectively. The statewide distribution of these benefits follows the distribution of emission reductions and avoided adverse health outcomes; therefore, most benefits to individuals would occur in the South Coast, San Joaquin Valley, and Mojave Desert Air Basins.

[70] United States Environmental Protection Agency, Mortality Risk Valuation – What does it mean the place a value on a life? .(web link: https://www.epa.gov/environmental-economics/mortality-risk-valuation#means)

Table 2.7. Annual Statewide Incidents and Valuation of Avoided Adverse Health Outcomes as a Result of the Proposed Regulation from 2023 to 2050 (2019$)

Year	Cardio-pulmonary mortality	Hospitalizations for respiratory and cardiovascular illness	Emergency room visits	Valuation
2023	0	0	0	$0
2024	0	0	0	$0
2025	9	3	4	$89,764,000
2026	19	6	9	$191,059,000
2027	28	8	13	$278,474,000
2028	38	11	18	$373,294,000
2029	49	15	23	$482,603,000
2030	144	45	67	$1,419,800,000
2031	155	49	73	$1,536,028,000
2032	157	50	73	$1,551,606,000
2033	158	51	73	$1,560,201,000
2034	156	51	72	$1,537,905,000
2035	173	58	80	$1,713,560,000
2036	175	59	81	$1,730,786,000
2037	179	61	82	$1,768,023,000
2038	172	59	79	$1,700,671,000
2039	165	56	75	$1,628,748,000
2040	159	55	73	$1,570,254,000

Year	Cardio-pulmonary mortality	Hospitalizations for respiratory and cardiovascular illness	Emergency room visits	Valuation
2041	153	53	70	$1,511,923,000
2042	148	51	67	$1,462,703,000
2043	140	49	64	$1,380,465,000
2044	131	46	60	$1,296,473,000
2045	129	46	59	$1,279,988,000
2046	128	45	58	$1,263,192,000
2047	125	45	57	$1,240,287,000
2048	126	45	57	$1,243,759,000
2049	126	45	57	$1,246,193,000
2050	126	45	57	$1,247,425,000
Total	3,268	1,108	1,503	$32,305,183,000

Table 2.8. Total Statewide Valuation of Avoided Adverse Health Outcomes as a Result of the Proposed Regulation from 2023 to 2050 (2019$)

Outcome	Valuation
Avoided Premature Deaths	$32,243,896,000
Avoided Hospitalizations	$60,033,000
Avoided Emergency Room Visits	$1,253,000
Total	$32,305,183,000

Note: Values have been rounded to the nearest thousand.

In addition to the monetized health impacts, the Proposed Regulation would achieve health benefits that are not currently monetized. Health impacts not monetized include reductions

in elevated vulnerability and impacts in disadvantaged communities, lost workdays, lost school days, and cancer risk. The Proposed Regulation also reduces negative outcomes in brain health, lung health, cancer risk, and birth.[71, 72] Staff are developing methodologies that will allow these additional benefits to be quantified in the future.

2.4.2 Social Cost of Carbon

The benefit of GHG reductions achieved by the Proposed Regulation can be estimated using the social cost of carbon (SC-CO2), 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.

The Council of Economic Advisors and the Office of Management and Budget convened an Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) to develop a methodology for estimating the SC-CO2. The methodology relies on a standardized range of assumptions and can be used consistently when estimating the benefits of regulations across agencies and around the world.[73] Staff utilized the current IWG-supported SC-CO2 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, in line with the Office of Management and Budget Circular A-4 of September 17, 2003 and reflects the best available science in the estimation of the socioeconomic impacts of carbon.[74, 75]

The IWG describes the social cost of carbon as follows:

"The social cost of carbon (SC-CO2) 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 carbon dioxide (CO2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO2 emissions by the same amount in that year. The SC-CO2 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 CO2.

These 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

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[71] Health Organization W, Office for Europe R. Review of Evidence on Health Aspects of Air Pollution-REVIHAAP Project Technical Report, 2013, accessed April 13, 2021.

[72] U.S. EPA. Integrated Science Assessment for Particulate Matter, December, 2019.

[73] Additional technical detail on the IWG process is available in the Technical Updates of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866 (by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government). (web link: https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf, and https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf)

[74] California Air Resources Board, California's 2017 Climate Change Scoping Plan, November 2017. (web link: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf)

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

damages, such as the services that natural ecosystems provide to society. Many of these damages from CO2 emissions today will affect economic outcomes throughout the next several centuries."[76]

The SC-CO2 is year-specific and is highly sensitive to the discount rate used to adjust the value of the damages in the future due to CO2. The SC-CO2 increases over time as systems become more stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. A higher discount rate decreases the value today of future environmental damages. This analysis uses the IWG standardized range of discount rates from 2.5 to 5 percent to represent varying valuation of future damages. Table 2.9 shows the range of IWG SC-CO2 values (CPI adjusted) used in California's regulatory assessments.[77, 78] For cost calculations, staff linearly interpolated values between the years identified.

Table 2.9. Social Cost of Carbon (2019$/Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2025	$18	$59	$88
2030	$21	$65	$94
2035	$23	$71	$101
2040	$27	$77	$108
2045	$29	$83	$115
2050	$34	$89	$123

The avoided SC-CO2 in a given year is the total emission reductions (in MTCO2e) multiplied by the SC-CO2 (in $/MTCO2e) for that year. The annual emission reductions from the Proposed Regulation and the estimated benefits are shown in Table 2.10. The total benefits range between $602 million to $2.367 billion from 2023 to 2050, depending on the discount rate.

[76] National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of Carbon Dioxide. (web link: http://www.nap.edu/24651)

[77] The SC-CO2 values are of July 2015 and are available at: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, revised July 2015. (web link: https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf)

[78] The IWG SC-CO2 values are provided in 2007 dollars. Staff adjusted from 2007 to 2019 dollars by using the California Department Industrial Relations Consumer Price Index (CPI-U), adjusting from 2007 dollars to 2019 dollars. (web link: https://www.dir.ca.gov/OPRL/CPI/EntireCCPI.PDF)

Table 2.10. Avoided Social Cost of CO2 from 2023 to 2050 (Million 2019$)

Year	GHG Emission Reductions (MMTCO2e)	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2023	0.00	$0	$0	$0
2024	0.00	$0	$0	$0
2025	0.00	$0	$0	$0
2026	0.00	$0	$0	$0
2027	0.00	$0	$0	$0
2028	0.00	$0	$0	$0
2029	0.00	$0	$0	$0
2030	0.07	$1	$5	$7
2031	0.09	$2	$6	$8
2032	0.09	$2	$6	$9
2033	0.11	$2	$7	$10
2034	0.11	$2	$7	$11
2035	0.38	$8	$26	$37
2036	0.57	$13	$39	$56
2037	0.78	$18	$55	$77
2038	0.86	$21	$61	$85
2039	0.97	$24	$71	$100
2040	1.07	$28	$79	$111
2041	1.15	$30	$87	$121

Year	GHG Emission Reductions (MMTCO2e)	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2042	1.31	$34	$100	$138
2043	1.40	$37	$108	$150
2044	1.49	$41	$118	$162
2045	1.59	$45	$126	$175
2046	1.67	$48	$134	$185
2047	1.71	$50	$139	$194
2048	1.91	$57	$158	$220
2049	2.10	$65	$177	$244
2050	2.29	$74	$195	$269
Total	21.73	$602	$1,703	$2,367

SC-CO2, while intended to be a comprehensive estimate of the damages 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-CO2, 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 has stated that the IWG SC-CO2 estimates are likely underestimated due to the omission of impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts.[79]

2.4.3 Other Benefits

2.4.3.1 Establishing ZE Technology in the Off-Road Sector

The Proposed Regulation would start the transition to ZE for locomotives operating in California. In the short term, locomotive switchers (Class I, Class III, and industrial) provide a unique opportunity to accelerate the deployment of ZE technology in the off-road sector. Unlike line haul locomotives, which may travel throughout the country and return to a base

[79] Intergovernmental Panel on Climate Change, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007, last accessed February 2020. (web link: https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg3_full_report-1.pdf)

only for periodic maintenance, switchers are generally used for railyard operations or local and regional delivery, returning to a railyard or home base each night. Due to their daily operational characteristics and the operating range of current ZE technologies, switchers are well suited for ZE pilots in California.[80, 81, 82] Passenger operators are also beginning to implement ZE technology and are expected to have access to commercially available ZE locomotives by 2030 (see upcoming Technology Assessment within the ISOR for further details). Even with line haul locomotives, UP and BNSF have committed to integrating ZE technology.[83, 84] As use of ZE technologies expands, technical capabilities will improve, and they are expected to operate comparably with diesel technology. Additionally, as ZE switchers are increasingly adopted, industry acceptance of advanced technologies is improving. The current state of ZE locomotive technology is expected to progress and expand into extended range applications, as well as other off-road sectors.

2.4.3.2 Infrastructure

The Proposed Regulation would increase the installation of electric charging and hydrogen fueling infrastructure needed to support the use of ZE locomotives. ZE technologies are underutilized due, in part, to limited access to supporting infrastructure at facilities where locomotives operate. Additional installations of electric charging and hydrogen fueling infrastructure will support the use of these technologies, as well as other advanced technology equipment and vehicles.

The increased use of electric charging infrastructure will also increase the amount of electricity supplied by utility providers and help the state's investor-owned utilities meet the goals of SB 350.[85] SB 350 requires the state's investor-owned utilities to develop programs to accelerate widespread transportation electrification with goals to reduce dependence on petroleum, increase the uptake of ZE vehicles, help meet air quality standards, and reduce GHGs. The three large investor-owned utilities in the State, Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison, have either proposed or have been approved to establish new business electricity rate options that make charging more affordable during certain times of the day. Although not required by SB 350, several publicly owned utilities

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[80]U.S. House of Representatives, House Committee on Transportation and Infrastructure "The Business Case for Climate Solutions. May, 2021. (web link: Santana Testimony.pdf (house.gov))

[81] Canadian Pacific, "CP to employ Ballard fuel cells in Hydrogen Locomotive Project." March, 2021. (web link: CP to employ Ballard fuel cells in Hydrogen Locomotive Project (cpr.ca))

[82] Railway Age, "Zero-Emission Locomotives on U.S. Railways?" February, 2021. (web link: Zero-Emission Locomotives on U.S. Railways? - Railway Age)

[83] Trains: *The Magazine of Railroading*, "Union Pacific Sees Battery-Electric Locomotives as the Future." May, 2021. (web link: https://www.trains.com/trn/union-pacific-sees-battery-electric-locomotives-as-the-future/)

[84] BNSF, "Orange is the New Green." April, 2021. (web link: https://www.bnsf.com/news-media/railtalk/community/orange-new-green.html)

[85] California Legislature, Senate Bill No. 350, signed October 7, 2015. (web link: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB350)

have taken similar action. For example, Los Angeles Department of Water and Power and Sacramento Municipal Utility District have made ready charging infrastructure programs and new commercial rates for charging. The Proposed Regulation supports the utilities' programs and the goals of SB 350 by increasing the number of ZE locomotives in the State to make use of these utility investments and rates, where feasible.

Hydrogen use by the line haul and passenger locomotives under this regulation is expected to increase U.S. hydrogen demand by about 1.9 million metric tons between 2030 and 2050, resulting in a demand of about 211,000 metric tons in 2050. For hydrogen fuel cell (FC) line haul locomotives to operate with the same duty cycle as diesel line-haul locomotives, each locomotive is expected to need a carrying capacity of approximately 4,000 kg of liquid hydrogen split between on-board tanks and a fuel tender.[86] Assuming a liquid hydrogen fuel tender can carry close to 8,000 kg, each tender could service two locomotives. Staff expect that up to 100 locomotives could be fueled by a fueling station with capacity between 200,000 and 375,000 kg liquid hydrogen per day (depending on companies' refueling practices). Staff assume that pipeline delivery would be prioritized for Class I, given the scale of daily demand, while passenger operators could either receive hydrogen via truck or generate hydrogen on-site, if and where space allows. This level of demand falls within the projected demand in California Energy Commission's (CEC) 2021 Integrated Energy Policy Report Transportation Demand Forecasts,[87] but is an expected portion of total demand projected by the United States Department of Energy (U.S. DOE).[88] This level of demand will help support California's transition to clean transportation, the U.S. DOE Energy Earthshots goals[89] and the Biden Administration's energy goals. The amount of hydrogen required to fuel ZE locomotives can encourage continued pairing of renewable energy and hydrogen production. Hydrogen production offers additional value when linked to renewable energy production facilities since excess renewable energy produced during the day can be converted into hydrogen for storage and later use instead of being curtailed.

2.4.3.3 Benefits in Disadvantaged Communities

The Proposed Regulation would reduce PM2.5 and NOx emissions, resulting in health benefits for Californians, including those in disadvantaged and low-income communities. Many of the communities near facilities where locomotives operate bear a disproportionate health burden due to their proximity to emissions from the diesel engines that power

[86] A fuel tender is a special railcar containing fuel for the locomotive's use. It includes a fuel line connecting to the locomotive to allow for fueling while in transit.

[87] California Energy Commission, Integrated Energy Policy Report 2021, Presentation – Transportation Energy Demand Forecast, TN 240934. (web link: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=21-IEPR-03)

[88] Department of Energy, Hydrogen Program Plan, 2020. (web link: https://www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf)

[89] Department of Energy. Hydrogen Earthshot. 2021. (web link: https://www.energy.gov/eere/fuelcells/hydrogen-shot)

locomotives. Approximately 50 percent of all California railyards are in areas identified as disadvantaged communities per CalEnviroScreen designation.[90]

Table 2.11: Railyards in Disadvantaged Communities

Operator Type	Railyards in Disadvantaged Communities	Total Railyards[91]	Percent in Disadvantaged Communities
Class I	44	64	69%
Class III	16	30	53%
Military and Industrial	23	39	59%
Passenger – Major Hubs	3	7	43%
Grand Total	86	140	61%

Prior to January 1, 2030, locomotive operators may receive a credit for operation of a ZE locomotive, ZE rail vehicle, or use of wayside power. The ZE credit reduces the locomotive operator's Spending Account obligation under the Proposed Regulation. In addition, all ZE locomotive operations in a designated disadvantaged community can receive double the ZE locomotive credit until 2030. The credits can only be used toward Spending Account obligations and do not have any monetary value. To meet this requirement, applicable operators must collect information on all ZE locomotives that operate within the disadvantaged community boundary and report it to CARB on a yearly basis. By allowing double ZE credit CARB is providing extra incentives for the adoption of ZE locomotives in the most negatively impacted areas of California. The double credit provision would incentivize expedited and increased emission reductions in disadvantaged communities. However, due to the uncertainty of early adoption of ZE locomotives, staff has not assumed credit generation or early emission reductions from the ZE locomotive credit in the emission inventory nor is early adoption and ZE locomotive credit assumed in the cost analysis.

2.4.3.4 Noise

The Proposed Regulation may provide noise reduction benefits through operation of locomotives with ZE technology. Diesel-powered locomotive engines produce a substantial amount of noise, which results in adverse health impacts. This is of concern when locomotives

[90] Office of Environmental Health Hazard Assessment, CalEnviroScreen 4.0, October 20, 2021. (web link: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40)

[91] Some railyards are not included in the counts and percentages due to an insufficient population in the census tract to be given a CalEnviroScreen 4.0 percentile.

operate near places where people live, work, and play. Staff have received several noise complaints related to locomotive activity near schools, hospitals, elder care facilities, and residential neighborhoods. The Proposed Regulation encourages use of ZE technology such as battery electric, which produces less engine noise than diesel engines.

3 Direct Costs

3.1 Direct Cost Inputs

The direct costs of the Proposed Regulation to California are estimated to be approximately $15.9 billion (2019$) from 2023 to 2050. Direct costs reflect the incremental cost of the Proposed Regulation as compared to the Baseline. The direct costs include capital costs for locomotives, including new Tier 4 locomotives, end-of-life remanufactures/overhaul, ZE locomotives and fueling tenders, and supporting fueling infrastructure development and maintenance, and annual costs for locomotive maintenance; Levelized Cost of Energy[92] prices for diesel, hydrogen, and electricity; reporting and locomotive registration, Spending Account management, and CARB's annual administrative charge. The direct costs in this section include costs to state and local governments, which are also quantified separately in the Fiscal Impacts section (Section D). The assumptions underlying the direct costs are detailed in the sections below.

3.1.1 Locomotive Populations, New Locomotive Purchases and Remanufactures, Reporting Hardware

3.1.1.1 Locomotive Populations

The Proposed Regulation includes different costs for each locomotive type. Staff divided the locomotive populations by operator: Class I uses freight line haul locomotives and road switchers, Class III uses road switchers, industrial uses yard switchers, and passenger uses passenger locomotives. As described in Section 1.6 and Section 2.1.1., all estimates for annual locomotive populations and new sales are from the Locomotive Emission Inventories.[93] Table 3.1 shows number of locomotives in California by operator category in 2020.

[92] Fuel costs are based on financial analysis performed by California Energy Commission, U.S. Energy Information Administration, and California Air Resources Board. These costs incorporate the cost of production, infrastructure, and delivery of different fuel types to facilitate direct comparison to established fuels like diesel.

[93] California Air Resources Board, MSEI – Documentation – Off-Road – Diesel Equipment, 2021. (web link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road)

Table 3.1: Number of locomotives operating in California in 2020.

Locomotive Operator Category	Class I Line Haul*	Class I Switcher*	Class III	Industrial	Passenger
Baseline Number of Locomotives	11,759**	596	159	66	129

* Estimated number of Class I Locomotives that operated in California in 2020, that is about 70 percent of the total locomotives operated by UP and BNSF.

** Increases to 17,107 by 2050

Figure 3.1 to Figure 3.10 show locomotive population projections under the Baseline and Proposed Regulation. Each population under the Proposed Regulation shows increasing levels of Tier 4 starting in 2025, with significant changes occurring in 2030 as the In-Use Operational Requirements come into effect.

Figure 3.1: Class I Line Haul Locomotive Population in California under the Proposed Regulation.

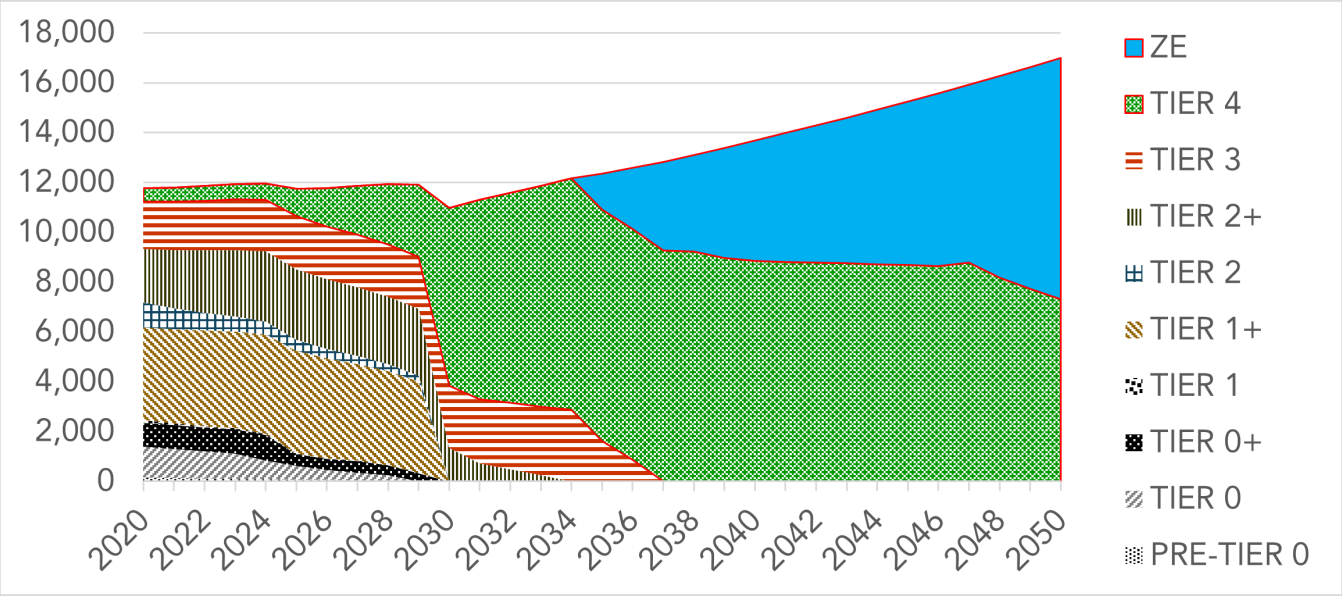


Figure 3.2: Baseline Class I Line Haul Locomotive Population in California.

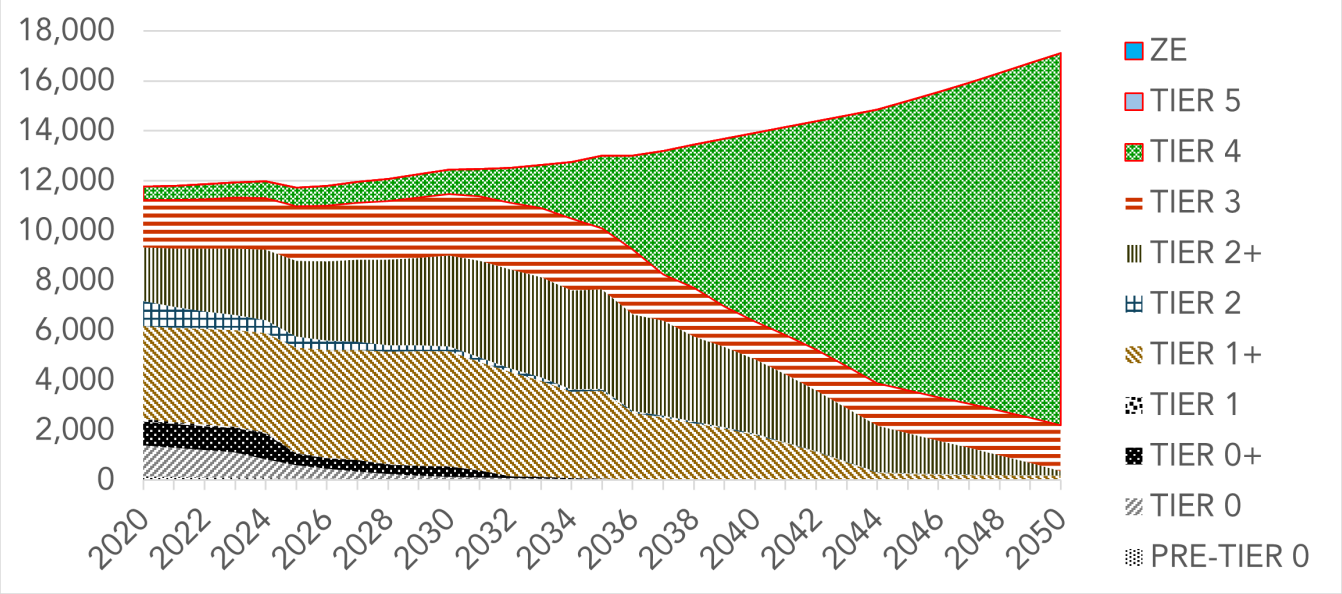


Figure 3.3: Class I Switcher Population in California under the Proposed Regulation.

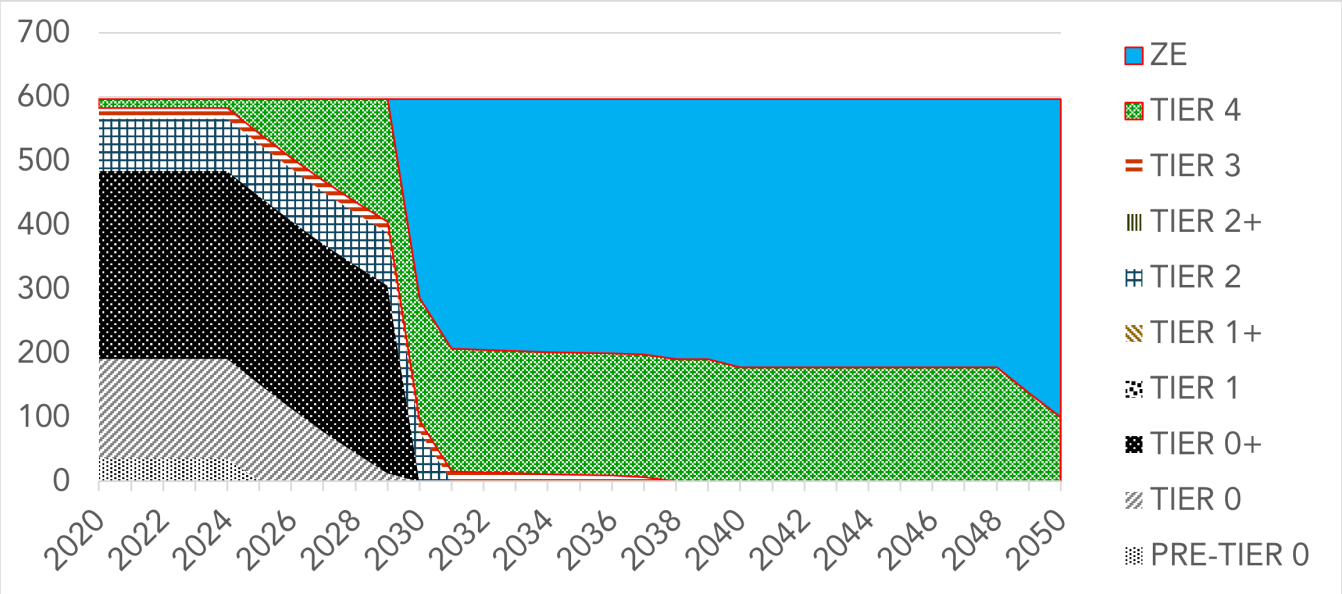


Figure 3.4: Baseline Class I Switcher Population in California.

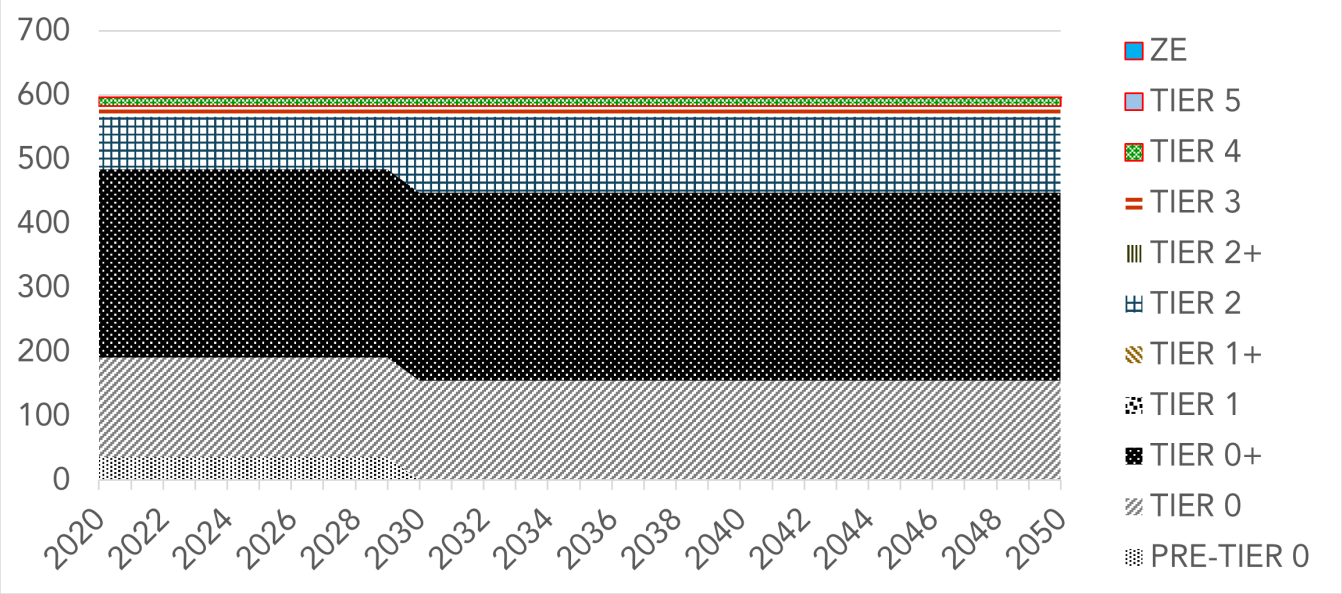


Figure 3.5: Class III Locomotive Population in California under the Proposed Regulation.

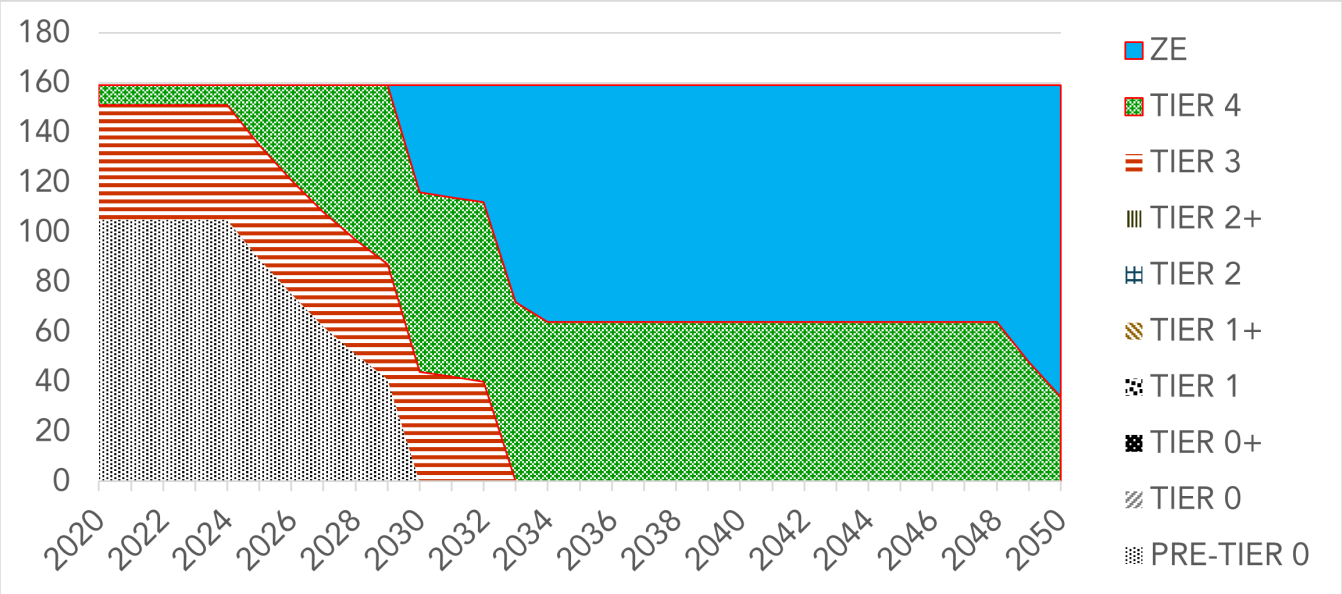


Figure 3.6: Baseline Class III Locomotive Population in California.

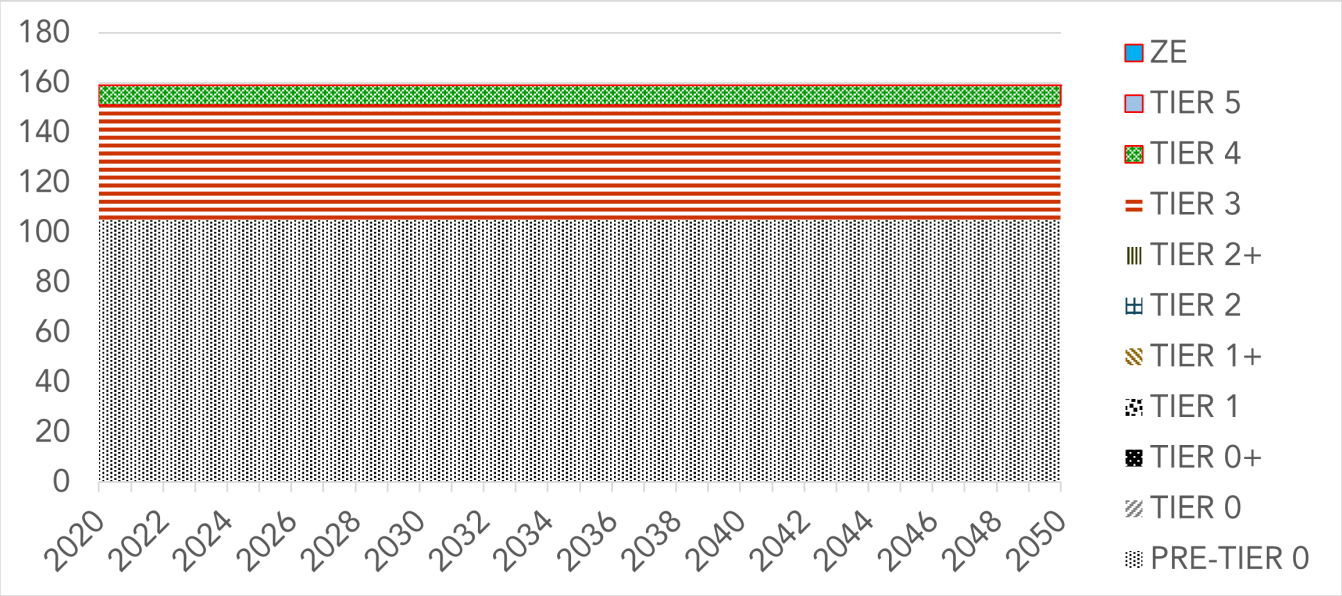


Figure 3.7: Industrial Locomotive Population in California under the Proposed Regulation.

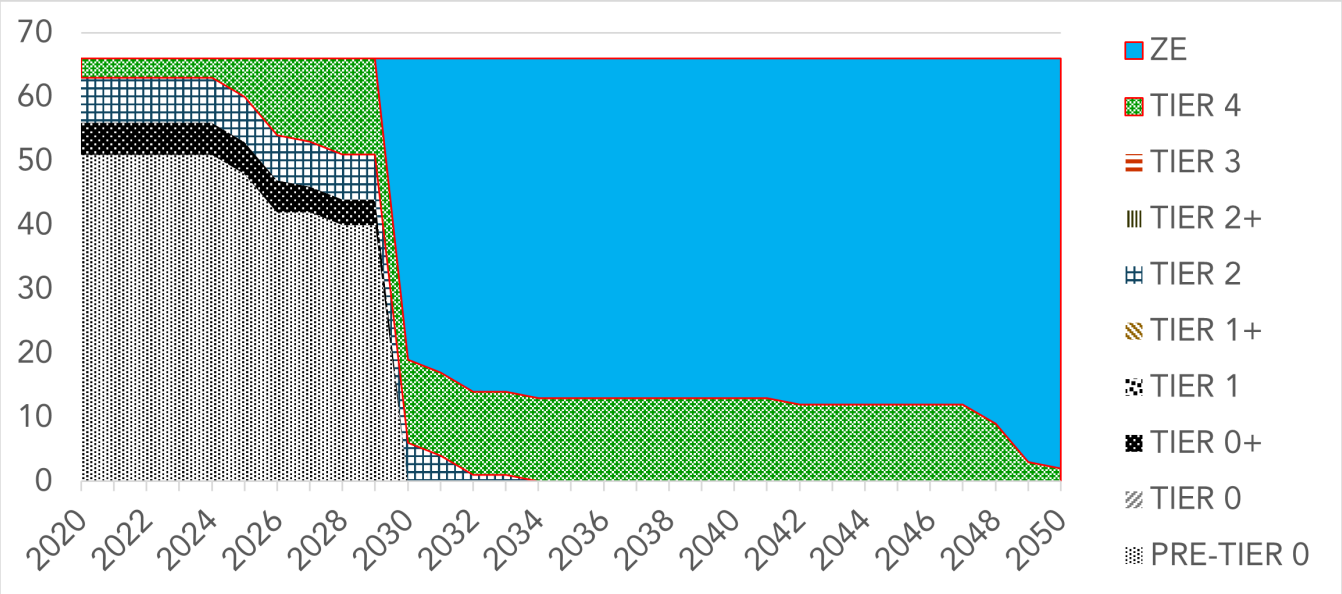


Figure 3.8: Baseline Industrial Locomotive Population in California.

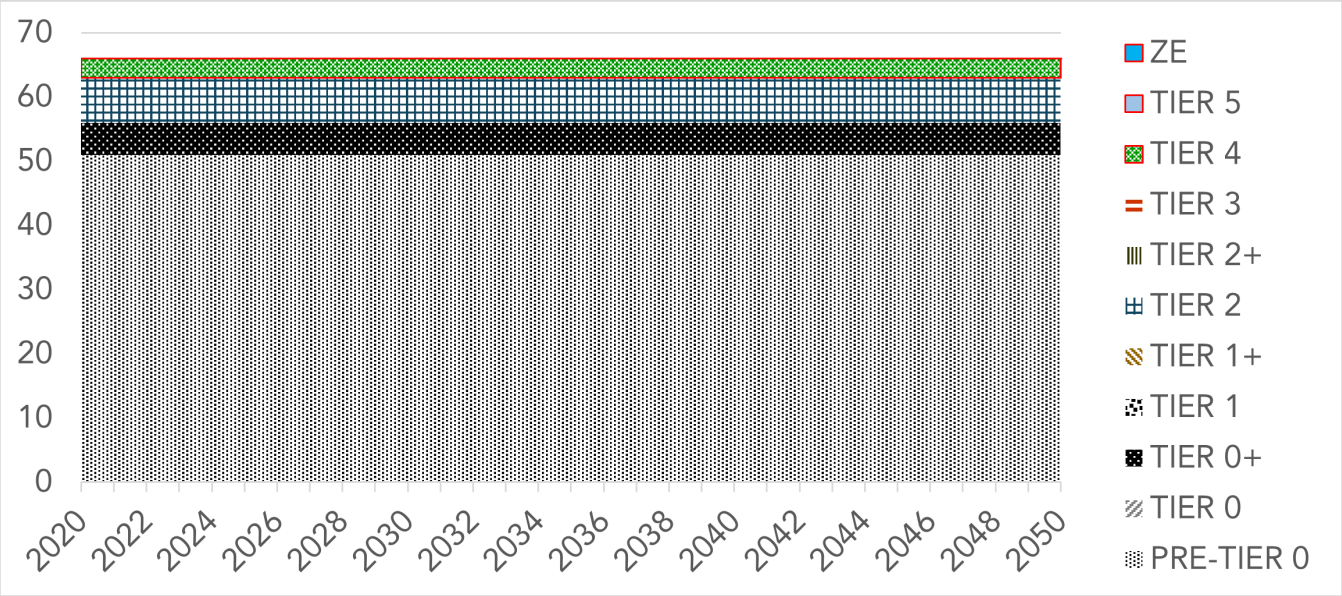


Figure 3.9: Passenger Locomotive Population in California under the Proposed Regulation.

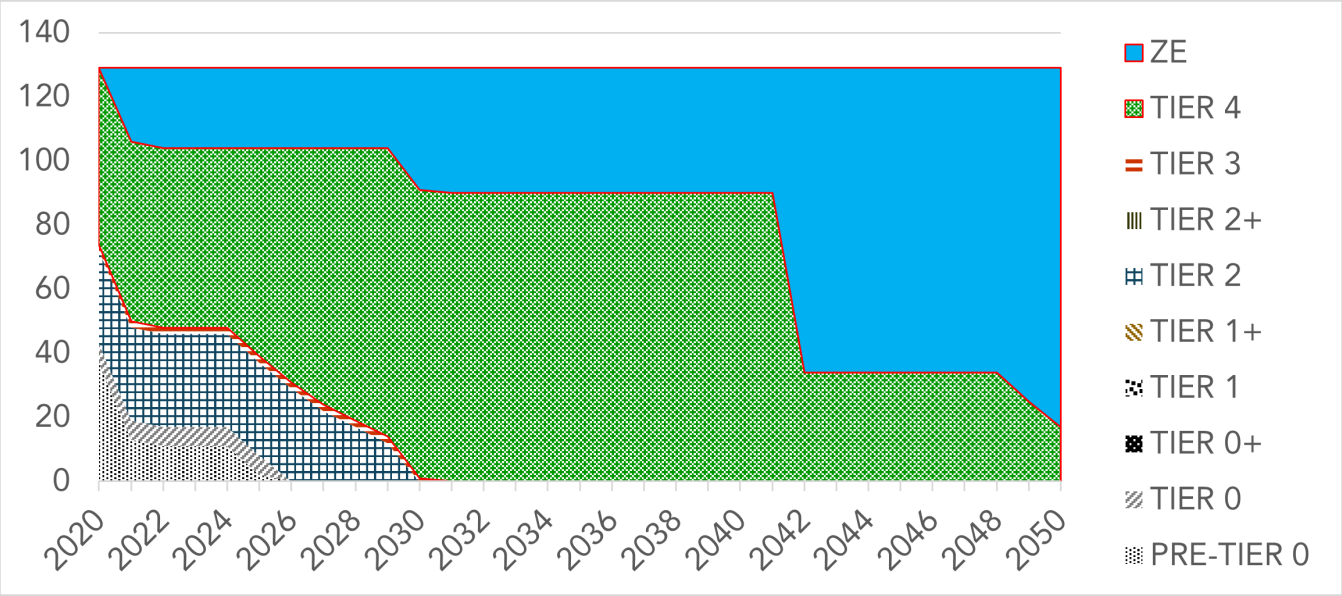
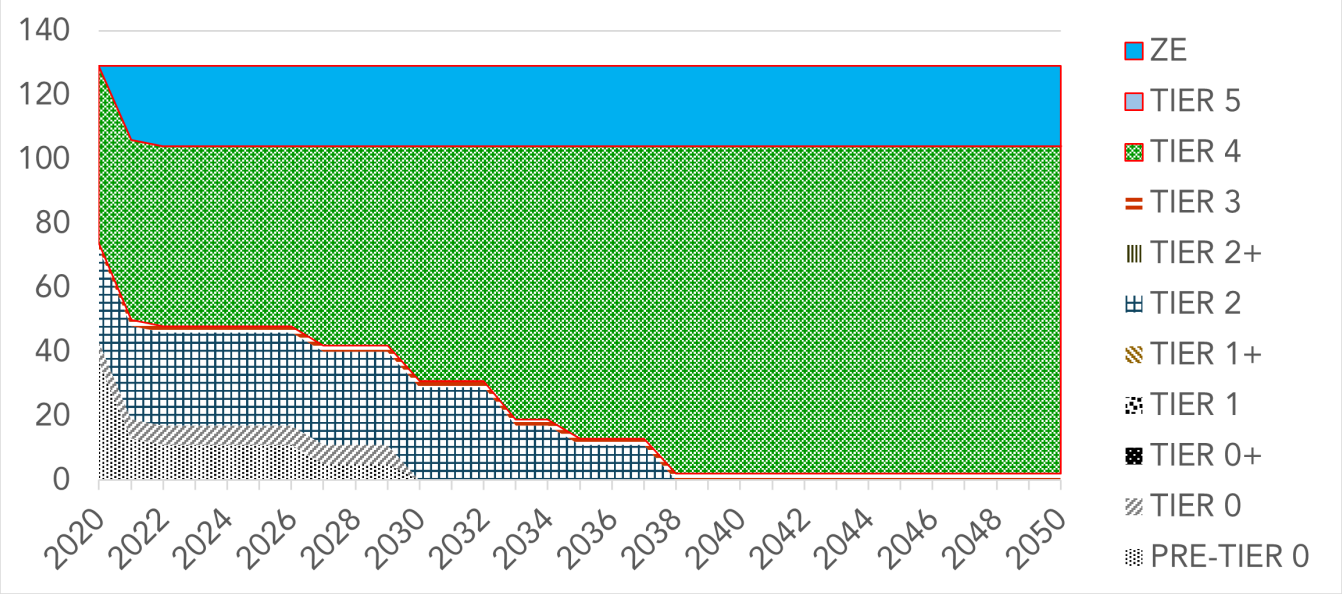


Figure 3.10: Baseline Passenger Locomotive Population in California.



3.1.1.2 New Locomotive Purchases and Remanufactures

Annual costs of new locomotive purchases are based on the number of new locomotives entering the operators' inventory populations. Staff modeled new locomotive purchase costs by amortizing the purchase at five percent over twelve years. Staff amortized the costs using the following equations:

Equation 3: Amortized Cost of Capital

$$Amortized\ Cost\ of\ Capital\ =\ capital\ expenditures\ \times\ capital\ recovery\ factor\ (CRF)$$

$$CRF\ =\ i\ (1+i)^n\ /\ (1+i)^n - 1$$

Where: Amortized cost of capital = uniform payment amount over the life of the capital ($)

Capital expenditures = capital cost of the equipment ($)

i = interest rate (assumed to be 5 percent)

n = life of the capital (assumed to be 12 years)

The interest for all operators was assumed to be five percent, one percent higher than Class I's long-term debt costs from 2008-2020,[94] to account for possible fluctuations in cost and the likelihood of higher debt costs for smaller operators. The five percent amortization cost accounts for the operators' ability to take out loans or to lease the locomotives to distribute purchase costs over time. Additionally, the five percent is the average of what the United States Office of Management and Budget recommends (three and seven percent) and what U.S. EPA has used historically for regulatory analyses.[95] The loan period of 12 years was set above the U.S. EPA year-based definition of locomotive minimum useful life[96] since locomotives may not reach the minimum MWh per useful life within the U.S. EPA definition by the end of ten years.

To accurately compare in-State health benefits to in-State costs, and because UP and BNSF line haul locomotives have activity in California and Out-of-State, staff had to determine the capital costs attributable to only in-state operation. To do this, staff first determined the capital cost of compliance for UP and BNSF's entire line haul fleet, then multiplied these costs by the ratio of in-state to total operation. Using Class I annual reports and data provided as part of their commitments under the 1998 MOU, staff calculated that approximately ten percent of UP and BNSF line haul activity occurs within California. Therefore, staff allocated ten percent of the capital costs of compliance for UP and BNSF's entire line haul fleet to California.

In contrast to the line haul fleet, Class I switchers, Class III, industrial, and California passenger locomotives are generally used for local and regional transport and delivery, and the locomotive inventories assume that they only operate in California. Therefore, the capital costs for their entire fleets to comply with the Proposed Regulation was allocated to California.

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[94] Surface Transportation Board, Economic Data – Cost of Capital. (web link: https://www.stb.gov/reports-data/economic-data/ Last accessed: January 10, 2022.)

[95] United States Environmental Protection Agency, Guidelines for Preparing Economic Analyses, December 2010. (web link: https://www.epa.gov/environmental-economics/guidelines-preparingeconomic-analyses)

[96] U.S. EPA, "Control of Emission of Air Pollution From Locomotive Engines..." (EPA-420-F-09-025).

Table 3.2 shows purchase costs, including tax, for Tier 4 and ZE battery electric and hydrogen fuel cell locomotives. Cost ranges were determined through interviews with railroads and OEMs and corroborated using CARB incentive program data and industry feasibility studies. These cost ranges were published in a Preliminary Cost Document released for comment in March 2021.

Based on comments and discussions with industry, manufacturers, and stakeholders following the March 2021 workshop, staff modeled diesel locomotive costs associated with mid to high ends of the ranges (zero to ten percent above average) within the Preliminary Cost Document rather than lower end costs seen in incentive program purchases. By modeling mid to high range costs, the projected costs of the Proposed Regulation accounted for design options that operators often select that increase the overall costs of the locomotive purchase. ZE technology is currently being successfully demonstrated and OEMs expect commercial production by the years identified in Table 3.2. Therefore, the projected prices for fully commercialized ZE locomotives and hydrogen fuel tenders for fuel cell line haul locomotives were used.

To model ZE locomotive populations and related costs, staff matched ZE technologies with the duty cycles that would likely be best based on the power, range, and refueling/charging requirements of each operator; assumed ZE technologies are shown in Table 3.2. In addition, staff considered the energy density of batteries as compared to the energy density of fuel cells. Class I line haul and passenger locomotives have high power duty cycles and are required to travel over long ranges with limited down-time, qualities which hydrogen fuel cell locomotives can more easily accommodate. While hydrogen fuel cell switchers are a viable ZE option, most switchers have a duty cycle well suited to battery electric technology given their limited range and power demands. Additionally, electricity prices are lower and electric charging equipment is more readily available than hydrogen fueling infrastructure. Existing battery electric switchers can operate eight hours between recharge and battery prices and technology are projected to continue to improve, leading to better affordability.[97] Therefore, staff assume that Class I, Class III, and industrial operators will use battery electric switchers. Electrified railways using locomotives primarily powered by overhead catenary lines were not modeled due to concerns about cost, vertical clearance required for catenary lines, the lack of locomotive technology that accommodates both a diesel engine and catenary power, and low and/or variable utilization along many rail lines.

[97] Bloomberg New Energy Finance, "Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh," 2020.

Table 3.2: New Locomotive Purchase Prices (Including Tax)

Locomotive Type	Tier 4 Cost	Battery Electric Locomotive Cost	Hydrogen Fuel Cell Locomotive Cost
Estimated Year Entering Fleets	**Current**	**2030**	**2030***
Class I Line Haul	$3,100,000	NA	$5,250,000 – includes fuel tender @ $1M/loco *2035 for Line Haul
Class I Road Switcher	$2,700,000	$3,400,000	NA
Class III Road Switcher	$2,700,000	$3,400,000	NA
Industrial Yard Switcher	$2,160,000	$3,100,000	NA
Passenger	$7,500,000	NA	$13,000,000

Some older switcher locomotives may be able to be converted to Tier 4 or ZE locomotives for approximately 15 percent less cost than a new switcher. Currently, there are manufacturers offering the conversion and some operators are in the process of converting their existing locomotives to Tier 4 or ZE locomotives. Multiple switchers have been remanufactured to Tier 4 operate in California. Additionally, a freight demonstration project is in progress to convert a Tier 3 locomotive to a ZE locomotive.[98, 99] Per discussions with passenger operators, some Tier 2 passenger locomotives upgrades may be capable of achieving Tier 4 for roughly 8 percent of the cost of a new Tier 4 passenger locomotive, though this has not yet been demonstrated. Additional remanufacture of passenger locomotives to ZE may be possible and are predicted to cost approximately 30 percent less than a new ZE locomotive. The actual number or percentage of locomotives that can or will be converted is not known, therefore staff assumes all Tier 4 and ZE locomotives are new purchases. If operators choose to remanufacture a significant number of locomotives, this would reduce the cost of the Proposed Regulation.

[98] Progress Rail, Host Port Authorities for Up Close and Personal Look at the EMD®24B Tier 4 Switcher Locomotive, October 2, 2017. (web link: https://www.progressrail.com/en/Company/News/PressReleases/Progress_Rail_and_Pacific_Harbor_Line_Host_Port_Authorities_EMD24B_Tier_4_Switcher_Locomotive.html)

[99] California Energy Commission, GFO-20-604 - Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM), 2020, (web link: https://www.energy.ca.gov/solicitations/2020-07/gfo-20-604-hydrogen-fuel-cell-demonstrations-rail-and-marine-applications)

3.1.1.3 Locomotive Tracking Hardware, Subscription, and Database Upgrades

Under the Federal Railroad Administration's Federal Positive Train Control (PTC) regulation,[100] Class I operators already have reporting hardware installed on all locomotives. However, during discussions with staff, Class I railroads cited the need for one-time upgrades to their existing reporting database to report activity within individual air districts at a cost of $3 million. Following CARB's March 2021 Draft In-Use Locomotive Regulation workshop, Class III operators reported that Tier 2 and lower locomotives will need to add reporting hardware to report locomotive activity per air district as would be required by the Proposed Regulation. Additionally, Class III operators indicated they would need subscriptions to software that provide reporting data for each locomotive. Per their input, the hardware is $45,000 per locomotive on average, and a subscription fee is $200 per month. Industrial operators are limited to small geographic ranges and are not expected to need reporting hardware nor services. Passenger operators already have reporting hardware installed on their locomotives due to PTC and are expected to be able to report with their current systems. See Section 3.1.4.1 for reporting costs.

3.1.2 Locomotive Operation and Maintenance

3.1.2.1 Locomotive Operation – Annual Activity and Activity within California

Locomotive annual activity and California-specific activity are used to calculate fuel and maintenance costs. Activity values are from locomotive emission inventories from CARB.[101]

3.1.2.2 Maintenance and Overhaul

Maintenance costs for the Baseline scenario and the Proposed Regulation are average annual values provided through interviews with industry and manufacturers that reflect the cost of labor and parts for annual maintenance and locomotive overhauls. Based on trends in ZE bus (the most comparable commercialized ZE technology) and data from the National Renewable Energy Laboratory,[102] staff estimated annual maintenance costs for hydrogen and battery-electric locomotives to be equal to and ten percent lower than diesel-powered locomotives respectively, while overhaul costs of both hydrogen and battery-electric locomotives are estimated to be comparable to Tier 4 diesel overhaul costs. Annual locomotive maintenance costs differ depending upon locomotive Tier and type, as shown in Table 3.3. Total annual maintenance costs are calculated by multiplying the locomotive maintenance cost by the population of each locomotive type per calendar year, see Table 3.15 for year-over-year costs.

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[100] Federal Railroad Administration, Federal Register: Positive Train Control Systems, 2019.

[101] California Air Resources Board, MSEI – Documentation – Off-Road – Diesel Equipment, 2021. (web link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road)

[102] Eudy, Leslie. Fuel Cell Bus Evaluations, NREL. 2021, 2020, 2019, 2018. AMR Project ID ta013

Overhaul of locomotives occurs in order to replace worn parts every six to fourteen years depending on the activity of each locomotive. Staff normalized the costs of overhaul differently in the Baseline versus the Proposed scenario to account for the IUOR. In the Baseline, overhaul costs are normalized by type of locomotive assuming 25 years of operation, see Table 3.5. In the Proposed scenario, staff determined the number of overhauls that would be performed within the years of operation allowed by the IUOR (23 for the Proposed Scenario, Alternative 1 and Sensitivity, 35 years for Alternative 2)[103], and normalized the associated cost over the allowed years (see Table 3.5 and Table 3.6). This reflects the likelihood that operators will not overhaul a locomotive shortly before it is removed from operation in California.

Table 3.3: Annual Locomotive Maintenance Costs on a Per-Locomotive Basis from 2023 to 2050 (2019$)

Tier	Pre-Tier 0	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	FC Cost	BE Cost
Cost/year	$50,000	$50,000	$50,000	$50,000	$75,000	$79,000	$79,000	$71,100

Table 3.4: Overhaul Cycle and Life by Locomotive Type

Locomotive Type	Overhaul Period (years)	Baseline Life	Proposed Life of Diesel Locomotives	Proposed Life of ZE Locomotives
Freight Line Haul	6	25	23	25
Road Switcher, Yard Switcher	14	40	23	40
Passenger	7	30	23	30

Table 3.5: Normalized Overhaul Costs - Baseline (2019$)

Normalized Overhaul Cost – Baseline	Pre-Tier 0	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
Class 1 Line Haul	$15,429	$20,571	$20,571	$36,000	$38,571	$51,429
Class 3	$6,964	$9,286	$9,286	$11,607	$15,089	$20,196
Industrial/Switcher	$6,964	$9,286	$9,286	$9,286	$12,768	$17,089

[103] See Section 6 for more information on Alternatives

Normalized Overhaul Cost – Baseline	Pre-Tier 0	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
Passenger	$20,000	$26,667	$26,667	$26,667	$30,000	$33,333

Table 3.6: Normalized Overhaul Costs - Proposed Regulation (2019$)

Normalized Overhaul Cost - Proposed	Pre-Tier 0	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	BE	FC
Class 1 Line Haul	$14,907	$19,876	$19,876	$34,783	$37,267	$49,689	NA	$51,429
Class 3	$4,193	$5,590	$5,590	$6,988	$9,084	$12,158	$23,795	NA
Industrial/ Switcher	$4,193	$5,590	$5,590	$5,590	$7,686	$10,288	$18,281	NA
Passenger	$18,478	$24,638	$24,638	$24,638	$27,717	$30,797	NA	$33,333

3.1.2.3 Diesel Fuel, Electricity and Hydrogen Costs

Diesel fuel, electricity, and hydrogen costs for locomotives are calculated by multiplying reported fuel consumption by the cost of fuel per unit. Where activity is reported by MWh instead of specific fuel consumption, staff converted MWh to the appropriate fuel units.

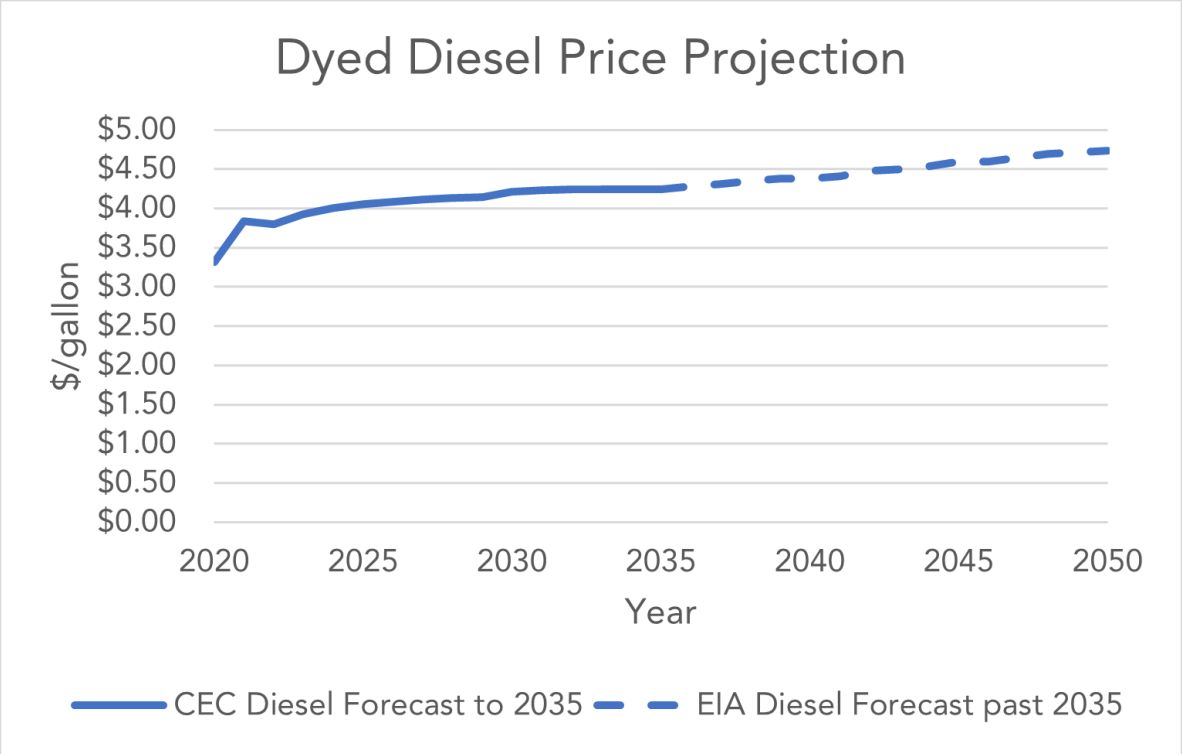
Class I diesel consumption is calculated using U.S. EPA fuel consumption rates, which provide diesel gallons per MWh for locomotives by type, shown in Table 3.7.[104] Class III, industrial, and passenger operators reported their diesel consumption in 2015 and fleet inventories, from which staff developed fuel consumption rates (see Emission Inventory for additional information). Diesel price per gallon is from the CEC 2021 Integrated Energy Policy Report (IEPR) "Mid Electricity Demand" scenario values.[105] These prices are adjusted to reflect the cost of Dyed Diesel, also known as Ultra-Low Sulfur Diesel, which is treated with a red dye to denote that it is for off-road or untaxed purposes only. Prices are extended past

[104] Estimated emission factors and MWh/gallon based on U.S. EPA 2009 "Emission Factors for Locomotives" (EPA-420-F-09-025).

[105] California Energy Commission, Presentation - Transportation Energy Demand Forecast, Docket Number 21-IEPR-03, TN #240934. (web link: https://efiling.energy.ca.gov/GetDocument.aspx?tn=240934&DocumentContentId=74780)

2035 by scaling using year-over-year percent changes in price from the United States Energy Information Administration (EIA) 2020 transportation diesel price projections.[106]

Figure 3.11: Dyed Diesel Price Projection



Annual electricity usage is based on the total ZE road switcher locomotive MWh per calendar year from the inventory. Battery electric locomotives are assumed to have an 85 percent traction drive efficiency, translating to approximately 2.2 times more efficient operation than diesel locomotives.[107] Staff also account for a ten percent battery charging loss factor,[108] which is reflected in the conversion of MWh to electricity consumption shown in Table 3.7.

Locomotive operators will need to work closely with ZE locomotive manufacturers to determine the appropriate size battery for the specific locomotive operation. In doing so, operators can reduce capital costs and ensure the locomotive is suited to their daily operations, thereby preventing recharge during times that would incur time-of-use charges. Electricity costs from 2023-2035 are from the CEC 2021 IEPR "Mid Electricity Demand" scenario values for commercial customers,[109] and are extended to 2050 by scaling using

[106] U.S. Energy Information Administration, 2020 Table 3 Energy Prices by Sector and Source. Transportation, Diesel Fuel (distillate fuel oil).

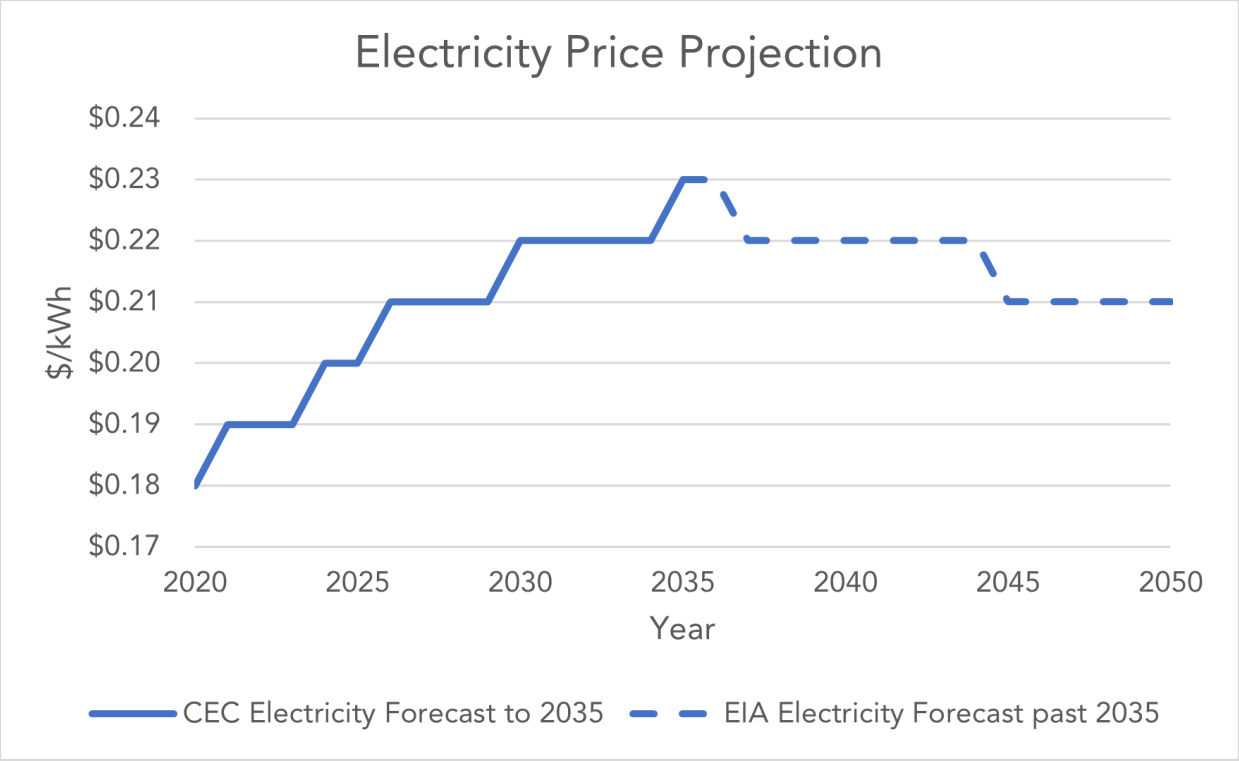
[107] California Air Resources Board, "Transitioning to a Zero or Near-Zero Emission Line-Haul Freight Rail System in California: Operational and Economic Considerations Final Report," 2016.

[108] Ibid.

[109] California Energy Commission, Transportation Energy Demand Forecast, 2021 IEPR Update.

year-over-year percent changes in price from EIA 2020 commercial electricity from 2035-2050.[110] EIA projections show a similar increase in electricity prices as CEC until the early 2030s, after which prices are projected to decline.

Figure 3.12: Commercial Electricity Price Projection



Note: Prices for the figure were rounded to the nearest whole cent

Hydrogen usage is based on total ZE line haul and passenger MWh per calendar year as calculated in the Proposed Regulation Emission Inventories. Hydrogen consumption is determined by converting diesel to hydrogen using U.S. EPA diesel fuel consumption rates per type of locomotive[111] and Argonne National Laboratory engine efficiency estimates of hydrogen fuel cells.[112] Staff selected hydrogen costs from the CEC Mid Electricity Demand scenario, and modeled costs beyond 2035 linearly declining to $5 per kg, as projected in "Road Map to a U.S. Hydrogen Economy," a report released by a coalition of major

[110] United States EIA, Annual Energy Outlook 2020, Table 3. Energy Prices by Sector and Source, Case: Reference Case, Region: Pacific, Energy Prices: Commercial: Electricity. (web link: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2020&region=1-9&cases=ref2020&start=2018&end=2050&f=A&linechart=~ref2020-d112119a.13-3-AEO2020.1-9&map=ref2020-d112119a.4-3-AEO2020.1-9&ctype=linechart&sourcekey=0)

[111] U.S. EPA, 2009 "Emission Factors for Locomotives" (EPA-420-F-09-025).

[112] Ahluwalia, Papadias, Wang, U.S. Department of Energy, 2020 Annual Merit Review and Peer Evaluation Meeting, Project TA034, pages 12-14, 2020.

hydrogen stakeholders including automotive, fuel cell, petroleum, and power companies.[113] Prices decline rapidly as the hydrogen sector is expected to realize significant economies of scale as hard-to-decarbonize sectors transition from fossil fuel to hydrogen use. These prices align with the high volumes of estimated demand from the Proposed Regulation, of approximately 1,600,000 kg of liquid hydrogen per day per Class I railyard.[114] These costs also align with the price targets identified in the Department of Energy, Energy Earthshots. After accounting for potential environmental credits associated with low carbon intensity renewable production, prices may be lower than projected here.[115]

Figure 3.13: Hydrogen Price Projection

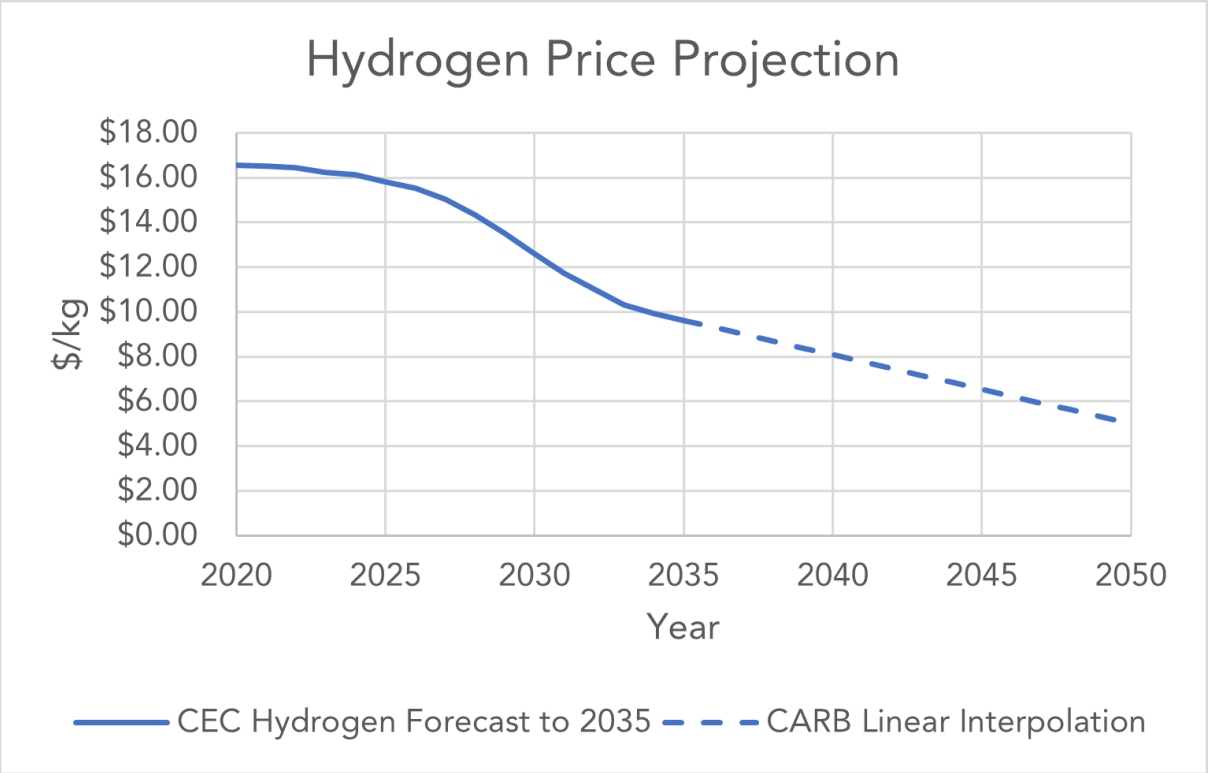


Table 3.7 shows the diesel, electricity, and hydrogen engine efficiency inputs used for the SRIA. Staff determined the electricity and hydrogen fuel consumed each year using the engine efficiency ratios to account for the improved engine efficiency of ZE locomotives.

[113] Fuel Cell & Hydrogen Energy Association, Road Map to a US Hydrogen Economy, 2021. (web link: https://www.fchea.org/us-hydrogen-study).

[114] Sandia National Laboratories, 2021 DOE Hydrogen Program Annual Merit Review and Peer Evaluation Meeting (AMR), Project TA047, Brian Ehrhart, 2021.

[115] University of California, Irvine. "Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California." June 2020. (web link: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-HYD-01, last accessed December 2021.)

Table 3.7: Locomotive Engine Efficiency

Fuel Efficiency	Conversion Value	Engine Efficiency Ratio
Diesel Road Switcher Locomotive Fuel Consumption	73.7 gal/MWh	1
Diesel Line Haul and Passenger Locomotive Fuel Consumption	64.5 gal/MWh	1
ZE Battery-Electric Locomotive Battery Charging	1385 kWh/MWh	2.2
ZE Hydrogen Fuel Cell Line Haul Locomotive Fuel Consumption	1.125 kg hydrogen/gal diesel	1.3
ZE Hydrogen Fuel Cell Passenger Locomotive Fuel Consumption	1.125 kg hydrogen/gal diesel	1.37

Table 3.8 shows the diesel, electricity, and hydrogen price projections used for the SRIA.

Table 3.8: Diesel, Hydrogen and Hydrogen Price Projections from 2020 to 2050 (2019$)

Year	Diesel (gallon)	Electricity (kWh)	Hydrogen (kg)
2020	$3.32	$0.18	$16.55
2021	$3.84	$0.19	$16.53
2022	$3.80	$0.19	$16.43
2023	$3.93	$0.19	$16.23
2024	$4.00	$0.20	$16.13
2025	$4.05	$0.20	$15.83
2026	$4.08	$0.21	$15.53
2027	$4.11	$0.21	$15.03
2028	$4.13	$0.21	$14.33
2029	$4.14	$0.21	$13.53

Year	Diesel (gallon)	Electricity (kWh)	Hydrogen (kg)
2030	$4.21	$0.22	$12.62
2031	$4.23	$0.22	$11.72
2032	$4.24	$0.22	$11.02
2033	$4.24	$0.22	$10.32
2034	$4.24	$0.22	$9.92
2035	$4.24	$0.23	$9.62
2036	$4.28	$0.23	$9.31
2037	$4.31	$0.22	$9.00
2038	$4.35	$0.22	$8.69
2039	$4.38	$0.22	$8.39
2040	$4.38	$0.22	$8.08
2041	$4.41	$0.22	$7.77
2042	$4.48	$0.22	$7.46
2043	$4.50	$0.22	$7.15
2044	$4.54	$0.22	$6.85
2045	$4.60	$0.21	$6.54
2046	$4.60	$0.21	$6.23
2047	$4.65	$0.21	$5.92
2048	$4.69	$0.21	$5.61
2049	$4.71	$0.21	$5.31
2050	$4.74	$0.21	$5.00

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.[116, 117] 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.[118] 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.

3.1.2.4 Low Carbon Fuel Standard Revenue

The LCFS Regulation is designed to reduce GHG emissions by requiring fuel producers to reduce the carbon intensity in fuel or purchase credits from those who supply low carbon fuel. The regulation incentivizes the use of low carbon fuels, including electricity, hydrogen, natural gas, and biofuels.[119] Locomotive operators who use electricity as a power source to charge their ZE locomotives may be able to generate credits based on the amount of energy they use. Additionally, hydrogen producers may produce credits and pass on savings to hydrogen users such as locomotive operators. Staff expects that all parties eligible to generate LCFS credits will take advantage of the incentive provided by LCFS. However, Staff are unable to determine credit values since there are not approved pathways for locomotives. Additionally, hydrogen credit values are undefined for locomotive operators due to the inherent uncertainty of LCFS credits being passed on. Accordingly, staff are not including LCFS credits in the Proposed Regulation's cost calculations.

3.1.2.5 Fueling Infrastructure Capital and Maintenance Cost

Fuel production and infrastructure maintenance costs are integrated into the sales price of all fuels. To address the potential need for electric and on-site hydrogen refueling, staff incorporated refueling infrastructure costs per ZE locomotive. Staff estimated costs of refueling infrastructure based on interviews with industry, feasibility studies, and SANDIA National Laboratories and U.S. Department of Energy program records. Electric supply equipment capable of serving five switcher locomotives at a time is estimated to cost

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[116] U.S Energy Information Administration, Short-Term Energy Outlook. December 2021. Accessed April 13, 2022. https://www.eia.gov/outlooks/steo/archives/Dec21.pdf

[117] U.S. Energy Information Administration, Short-Term Energy Outlook. March 2022. Accessed April 13, 2022. https://www.eia.gov/outlooks/steo/archives/Mar22.pdf

[118] U.S. Energy Information Administration, Annual Energy Outlook 2020-2022, Table 3 Energy Prices by Sector and Sources, Pacific Region. Available at: https://www.eia.gov/outlooks/aeo/

[119] California Air Resources Board, Unofficial Electronic Version of the Low Carbon Fuel Standard Regulation, July 2020. (web link: https://ww2.arb.ca.gov/sites/default/

operators $1,500,000 on average, resulting in a capital cost of $300,000 per locomotive.[120, 121] Electric supply equipment annual maintenance is estimated to cost 1.5 percent of the capital cost per year based on San Bernardino County Transit Authority (SBCTA) estimates for 1 to 1.5MW capacity and existing electric bus infrastructure.[122, 123] Following the recommendation of their ZEMU Concept Feasibility Study, SBCTA is building a gaseous hydrogen fueling production and distribution facility for their hydrogen electric multiple units. Passenger locomotive operators may be able to build similar facilities on-site at passenger rail maintenance yards for an approximate cost of $1,500,000 per locomotive.[124] For Class I ZE line haul locomotives, Staff estimates that if railyards refuel 40 locomotives and their tenders on average per day[125] with 4000 kg of liquid hydrogen per locomotive, hydrogen fueling infrastructure capital costs on a per locomotive basis would be approximately $100,000, accounting for material costs based on analysis performed by SANDIA National Laboratories.[126] Hydrogen fueling stations' annual maintenance costs are estimated to be three percent of their capital cost.[127] Since Class I hydrogen station cost is calculated on a per locomotive basis, the direct costs for infrastructure reflect staff's assumption that California accounts for 10 percent of their national line haul operation, and therefore 10 percent of their hydrogen demand.

In staff's cost model, staff assumed that operators would install hydrogen line haul infrastructure five years prior to ZE line haul locomotive deployment since large scale hydrogen infrastructure capable of serving Class I railyards is not yet readily available. Staff assume that electric infrastructure for BE switchers and the BE switcher will be paid for in the same year. Since charging infrastructure is already commercialized and installation processes are more established than for hydrogen, staff assumes that the charging infrastructure and BE switcher would be deployed a year after their purchase. Lastly, staff assumes passenger operators will purchase hydrogen infrastructure in the same year that each hydrogen passenger locomotive is purchased, and that their deployment would coincide the following

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[120]Claimed confidential data obtained from industry sources that requested non-attribution.

[121] ZEMU Concept Feasibility Study, San Bernardino County Transportation Authority, 2019. (web link: https://www.gosbcta.com/project/diesel-multiple-unit-to-zero-emission-multiple-unit-pilot/)

[122] Ibid.

[123] Department of Energy, Financial Analysis of Battery Electric Transit Buses, 2020. (web link: https://afdc.energy.gov/files/u/publication/financial_analysis_be_transit_buses.pdf)

[124] ZEMU Concept Feasibility Study, San Bernardino County Transportation Authority, 2019. (web link: https://www.gosbcta.com/project/diesel-multiple-unit-to-zero-emission-multiple-unit-pilot/)

[125] American Association of Railroads, "Comments on Draft Text and Preliminary Cost Document for Proposed In-Use Regulation," 2021.

[126] SANDIA National Laboratories, Refueling Infrastructure Scoping and Feasibility Assessment for Hydrogen Rail Applications, 2021. (web link: https://energy.sandia.gov/wp-content/uploads/2021/12/Refueling-Infrastructure-Scoping-and-Feasability-Assessment_SAND2021-12851.pdf)

[127] California Air Resources Board, Hydrogen Station Network Self-Sufficiency Analysis per Assembly Bill 8, 2021. (web link: https://ww2.arb.ca.gov/sites/default/files/2021-10/hydrogen_self_sufficiency_report.pdf)

year since small scale hydrogen refueling stations are commercially available currently. Capital costs for fueling infrastructure are expected to decline as technology matures and may be absorbed by the fueling industry if refueling facilities are owned by fuel providers. Staff acknowledge that infrastructure deployment may occur prior to the ZE locomotive purchase order, and that timelines for refueling infrastructure permitting and installation may vary.

3.1.3 Locomotive Sale and Scrappage

Locomotives can have long lifetimes spanning between 25 to 50 years or more. As such, Class I locomotives that no longer provide the power or reliability Class I operators expect are sold to smaller railroads and internationally. Additionally, staff assumes Class III, industrial, and passenger locomotives removed from locomotive operator fleets under the IUOR could be sold outside of California. In modeling costs, staff accounts for the remaining value of locomotives assumed to be removed from California fleets due to IUOR by assuming that the locomotive operator will sell locomotives with at least seven years of remaining usability per the baseline scenario. Staff assumes that these locomotives are sold for 20 percent of their original value (see Preliminary Cost Document[128]). All other locomotives are scrapped for five percent[129] of their original value when they are removed from an operator's fleet.[130]

3.1.4 Administrative Costs

Locomotive owners would incur costs associated with registration, reporting and CARB administrative charges to comply with the Proposed Regulation. These costs are detailed below.

3.1.4.1 Registration and Reporting

The Proposed Regulation would require locomotive operators to track their California operations beginning in 2023, then register all locomotives operating in California by July 1, 2024 and report their 2023 activity. Following registration, operators would report on all locomotives that operate in California beginning in 2024, regardless of the state where their company is based. To report operations and manage their Spending Accounts annually, staff estimated that each operator would require work by a staff person, financial specialist, and manager. Each operator is estimated to have different workloads to complete reporting and Spending Account management. Table 3.9 below shows the estimated work type, personnel years (PY) required and average pay for each job type.

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[128] California Air Resources Board, Preliminary Cost Document, March 2021. (web link: https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california/locomotives-and-railyards-meetings-workshops)

[129] Claimed confidential data obtained from industry sources that requested non-attribution.

[130] When the Proposed Regulation results in a locomotive being scrapped, there will be additional revenue relative to the baseline in that year. In a future year, there would be a cost associated with this earlier scrappage.

Staff estimates that Class I fleets will account for approximately 98 percent of all locomotive reporting and that Class I operators will need 0.5 PY in staff and 0.1 in manager PY for the Proposed Regulation reporting requirements. California's Class I operators have approximately 0.25 PY in staff and 0.02 PY in managers working on the reporting requirements of the 1998 MOU. Reporting for the 1998 MOU includes approximately 20 percent of the activity of all Class I operations in the state, and approximately 70 percent of the Class I fleet population visiting the South Coast Air Basin during a single year. To scale up reporting for the Proposed Regulation, staff assumes an additional 0.25 PY will be needed. To create, maintain, and oversee funds held in the Spending Account, staff estimates Class I operators will need two full time financial specialists. To review collection and storage of reporting information as well as Spending Account funds, staff estimates Class I operators would require an additional 0.08 PY of management personnel.

Class III operators have fewer locomotives than Class I operators. On average, each Class III will have approximately 6 locomotives to report on each year. When considering all reporting information that is required for a Class III operator, staff estimates each Class III operator will need 0.08 PY for reporting and 0.08 PY for a financial specialist to maintain and oversee the Spending Account. To manage and check all documents prior to submittal, CARB estimates Class III operators will need 0.02 PY for a manager.

Industrial operators serve on an even smaller scale than Class I and Class III operators. industrial operators are expected to require less time for reporting and Spending Account management because of their fleet size and limited operations. Staff estimates that each industrial operator will need 0.02 PY for reporting, 0.005 PY for management of the submittals to CARB and 0.02 PY for a financial specialist to oversee and maintain the Spending Account.

Passenger operators have approximately 130 locomotives operating in the state in any given year. Staff estimates passenger operators will need 0.08 PY of staff for reporting, 0.08 PY for a financial specialist to maintain and administer the Spending Account, and 0.02 PY for a manager to review.

The total cost to report approximately 20,000 locomotives per year to CARB from 2023 to 2050 is estimated to be approximately $39 million. Although the first annual reporting requirement is not until July 1, 2024, the cost of collecting reporting information such as MWh operated per district will begin in 2023. Therefore, costs for reporting are calculated starting in 2023.

Table 3.9: Estimated Personnel, Time, and Pay needed for Reporting of the Proposed Regulation

Applicable Company	Program Expense	PYs - Current	PYs - Proposed and Alternatives	2021 Salary + Benefits (Adjusted to 2019$)	Total Incremental Cost
Class I	Reporting - Rail Transportation Worker	0.25	0.50	$76,923	$19,230
Class I	Reporting - Transportation, Storage, and Distribution Managers	0.02	0.10	$149,582	$11,506
Class I	Spending Account - Financial Specialist	0	2.00	$135,644	$271,329
Class III	Reporting - Rail Transportation Worker	0	0.08	$76,923	$6,410
Class III	Reporting - Transportation, Storage, and Distribution Managers	0	0.02	$149,582	$3,116
Class III	Spending Account - Financial Specialist	0	0.08	$135,664	$11,305
Industrial	Reporting - Rail Transportation Worker	0	0.02	$76,923	$1,479
Industrial	Reporting - Transportation, Storage, and Distribution Managers	0	0.00	$149,582	$719
Industrial	Spending Account - Financial Specialist	0	0.02	$135,664	$2,609
Passenger	Reporting - Rail Transportation Worker	0	0.08	$76,923	$5,917

Applicable Company	Program Expense	PYs - Current	PYs - Proposed and Alternatives	2021 Salary + Benefits (Adjusted to 2019$)	Total Incremental Cost
Passenger	Reporting - Transportation, Storage, and Distribution Managers	0	0.02	$149,582	$2,877
Passenger	Spending Account - Financial Specialist	0	0.08	$135,664	$10,436

3.1.5 CARB Administrative Charge

The Proposed Regulation includes a per locomotive yearly administrative charge that would impose a direct, ongoing cost to owners. The proposed charge will result in revenue to the State to offset costs of activities needed to implement and enforce the Proposed Regulation including: 1) receiving and processing annual locomotive reports, 2) reviewing and approving Alternative Compliance Plan applications, and 3) statewide enforcement of the regulation. Collectively, these implementation and enforcement activities are required for CARB to assess the compliance of operators to the Proposed Regulation in the state.

Using the projected diesel locomotive populations from 2023-2050, the administrative charge amounts per locomotive, shown in Table 3.10, were calculated to fully recover implementation and enforcement costs. Administrative charges would be payable to CARB by July 1 of each calendar year beginning in 2024 with reporting information.

For each diesel locomotive operated in the state, locomotive operators are required to report information such as hours of operation per California Air District, Spending Account calculation and deposit amount, idling information, etc. Staff expects each report would require approximately the same amount of review by staff regardless of how much each locomotive was operated in the state. Locomotive operators are required to report annually and review by CARB would ensure that reported information is accurate and kept up to date. Staff determined that compliance monitoring and enforcement activities related to ZE locomotives are not applicable since these locomotives do not have emissions, and therefore have no fee.

Table 3.10 shows the yearly administrative charge under the Proposed Regulation. This administrative charge is located in the Draft Regulation Order and could potentially change prior to the Final Regulation Order being approved. The fiscal impacts to state government are described in the Fiscal Impacts section (Section 4.2).

Table 3.10: Administrative Charge Amounts

Type	Yearly Charge Amount per Locomotive
Locomotive	$170

The total administrative charges from 2023 to 2050 are estimated to be approximately $66 million. The cost would be incurred by locomotive operators.

3.1.5.1 Spending Account & Opportunity Cost

The Spending Account funds are held by each operator in a trust where any interest made returns to the trust. It is assumed that operators will update their locomotive fleet to minimize Spending Account charges by expending Spending Account funds whenever the balance is sufficient to purchase a new locomotive (without replacing a Tier 4 or cleaner locomotive prior to 23 years).

ZE line haul locomotives, primarily used by Class I operators, are expected to reach full commercial readiness in 2035. From 2029 until 2034 staff assumes Class I operators will spend half of their Spending Account funds on purchasing ZE road switchers (until finished turning over all road switchers to ZE) and related charging infrastructure, and the other half on hydrogen infrastructure for ZE line haul locomotives to prepare for their deployment in 2035 (detailed in Table 3.11). Once Class I operators finish converting their road switchers to ZE locomotives using Spending Account funds (expected to occur by 2031), staff assumes half the Spending Account funds collected from 2032-2033 would be spent on hydrogen infrastructure to support ZE locomotives and half the funds collected from 2032-2033 would be saved to purchase ZE line haul locomotives in 2034.

Table 3.11: Class I Spending Account Purchase Assumptions

Class I	2023-2028	2029	2030	2031	2032	2033	2034+
Spending Account Fund Purchases	Tier 4	Up to 50 Percent - Purchase ZE Switchers (or save once all 23+ year old Switchers replaced) Up to 50 Percent - Purchase Hydrogen Infrastructure					ZE

Staff assumes Class III, industrial, and passenger operators would hold money for multiple years until sufficient funds have accumulated to buy a new locomotive. Funds accumulated prior to 2029 will be used towards Tier 4 locomotives and after 2029 funds will be used for ZE locomotives, based on eligible Spending Account purchase requirements and accounting for a one-year delay between placing an order and delivery of the locomotive.

Table 3.12: Class III, Industrial and Passenger Spending Account Purchase Assumptions

Class III, Industrial and Passenger	2023-2028	2029+
Spending Account Fund Purchases	Tier 4	ZE

Given the financial expertise and scale of Class I operators, staff assume that Class I investments will be in larger money markets. Other operators may prefer low-risk investments since they have less access to capital and may aim to avoid market fluctuations. In either case, these investments may result in lower returns than funds that are invested into the railroads' primary business, resulting in opportunity costs detailed below and in Table 3.13.

To estimate the opportunity costs for Class I Spending Account funds held for more than a year instead of used for normal business purposes, staff used ten percent as the assumed S&P 500 returns, based on data from 2010 to 2019[131] as a proxy for their Spending Account investments and compared the returns to Class I's Return-on-Investment (ROI). According to the STB's Class I Railroad Revenue Adequacy reports,[132] the average ROI was 13.5 over the last 10 years, shown in Table 3.13, leading to a 3.5 percent opportunity cost per year. To estimate Class III and industrial opportunity costs, staff estimate 5 percent profit margin based on their smaller size and compared this to approximately 2.5 percent of the Treasury Bond.[133] Opportunity costs do not apply to passenger operators, since their funding is often controlled by public agencies or joint powers with specific holding and spending requirements.

[131] Derived from Yahoo Finance, SPDR S&P 500 ETF Trust (SPY), accessed September 17, 2021. (web link: https://finance.yahoo.com/quote/SPY/history?period1=1104537600&period2=1631750400&interval=1mo&filter=history&frequency=1mo&includeAdjustedClose=true)

[132] Surface Transportation Board, Railroad Revenue Adequacy Reports. (web link: https://www.stb.gov/reports-data/economic-data/)

[133] Derived from Federal Reserve Economic Data (FRED), 10-Year Treasury Constant Maturity Rate, accessed September 17, 2021. (web link: https://fred.stlouisfed.org/series/DGS10)

Table 3.13: Average Annualized Returns Over 10 Years - 10 Year Treasury Bonds, S&P 500, Railroad ROIs

Years	S&P 500 (Percent)	Class I ROI (Percent)	Treasury Bond Average 10 Year Constant Maturity (Percent)	Assumed Class III and Industrial ROI (Percent)
Average	10.0	13.5	2.5	5

3.1.6 Total Net Costs

Table 3.15 shows the total net costs in California of the Proposed Regulation from 2023 to 2050. These costs include all capital, maintenance, fuel, administrative, and opportunity costs and savings incurred by all parties. Table 3.14 shows the percent of total net costs by operator type.

Table 3.14: Proportion of Total Net Costs by Operator Type

Operator	Percent of Total Net Direct Costs
Class I	85%
Class III	5%
Industrial	2%
Passenger	8%

Table 3.15: Total Amortized Net Costs of the Proposed Regulation (costs in California) from 2023 to 2050 (2019$)

Year	Equipment Capital Costs	Equipment Maintenance Costs	Infra-structure Capital Costs	Infra-structure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2023	$0	-$5,350,549	$0	$0	$0	$0	$0	$11,106,600	-$1,769,000	$0	$0	$0	$0	$3,987,051
2024	$41,914,640	-$13,533,170	$0	$0	$0	$0	$0	$381,600	-$7,860,000	$0	$1,442,215	$2,982,480	$349,825	$25,677,589
2025	$85,118,874	-$8,691,039	$0	$0	$0	$0	$0	$381,600	$947,800	$0	$1,442,215	$2,928,250	$463,338	$82,591,039
2026	$120,442,253	-$4,324,495	$0	$0	$0	$0	$0	$381,600	-$4,298,200	$0	$1,442,215	$2,935,900	$592,091	$117,171,364
2027	$158,115,786	-$539,569	$0	$0	$0	$0	$0	$381,600	-$4,292,930	$0	$1,442,215	$2,958,680	$747,595	$158,813,377
2028	$195,367,352	$3,321,436	$0	$0	$0	$0	$0	$381,600	-$4,695,800	-$1,414,400	$1,442,215	$2,974,320	$1,063,911	$198,440,634
2029	$561,517,398	$5,721,206	$12,815,544	$0	$0	$0	$0	$381,600	-$44,103,000	-$188,822,400	$1,442,215	$2,968,710	$1,101,258	$353,022,532
2030	$630,361,207	$42,295,388	$16,040,493	$2,385,000	-$35,832,904	$25,033,908	$17,359,805	$381,600	-$4,070,572	-$17,347,200	$1,442,215	$2,678,860	$30,568,778	$711,296,579
2031	$638,645,977	$52,279,833	$17,431,900	$2,803,500	-$43,113,958	$31,289,788	$16,392,159	$381,600	$1,541,800	$0	$1,442,215	$2,739,380	$81,199,329	$803,033,523
2032	$649,186,127	$54,998,905	$18,772,753	$2,835,000	-$44,327,094	$32,561,893	$15,411,431	$381,600	$1,568,000	-$13,952,000	$1,442,215	$2,803,980	$151,755,832	$873,438,643
2033	$647,775,809	$56,777,328	$19,653,014	$3,019,500	-$48,858,179	$36,909,480	$14,430,704	$381,600	$3,982,088	-$11,070,400	$1,442,215	$2,864,330	$242,358,810	$969,666,300
2034	$611,813,838	$57,199,808	$20,128,853	$3,069,000	-$50,509,261	$38,729,290	$13,870,288	$381,600	-$11,937,000	$0	$1,442,215	$2,931,990	$242,469,331	$929,589,952
2035	$651,909,168	$58,771,908	$20,542,102	$3,679,800	-$191,104,734	$39,824,604	$301,432,650	$381,600	-$3,479,856	$0	$1,442,215	$2,635,680	$117,928,957	$1,003,964,095
2036	$644,127,599	$56,886,105	$20,964,178	$4,098,000	-$290,225,681	$40,221,713	$481,984,866	$381,600	$10,251,600	-$48,080,000	$1,442,215	$2,455,650	$12,766,358	$937,274,203
2037	$581,669,145	$56,319,837	$21,515,445	$4,564,200	-$400,351,714	$40,888,095	$669,303,627	$381,600	$12,238,000	-$1,948,800	$1,442,215	$2,250,970	$49,925,520	$1,038,198,141
2038	$543,930,738	$52,232,092	$21,907,029	$4,728,000	-$436,467,641	$41,935,647	$703,209,966	$381,600	$3,392,698	$0	$1,442,215	$2,241,110	$56,258,216	$995,191,669
2039	$504,405,176	$49,540,149	$22,621,188	$4,958,100	-$495,915,802	$42,333,077	$773,585,299	$381,600	$6,113,000	$0	$1,442,215	$2,178,550	$74,683,434	$986,325,986
2040	$457,932,954	$46,865,251	$23,030,425	$5,185,500	-$538,327,950	$43,786,161	$812,562,679	$381,600	$5,799,600	$0	$1,442,215	$2,149,820	$101,827,269	$962,635,523

Year	Equipment Capital Costs	Equipment Maintenance Costs	Infra-structure Capital Costs	Infra-structure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2041	$161,999,801	$43,677,968	$30,026,776	$5,331,000	-$577,670,855	$44,235,374	$837,549,782	$381,600	-$135,400	$0	$1,442,215	$2,137,920	$139,501,232	$688,477,413
2042	$77,795,377	$40,478,478	$31,089,188	$7,995,300	-$657,785,281	$44,980,368	$908,527,049	$381,600	$6,307,800	$0	$1,442,215	$2,121,260	$183,678,893	$647,012,246
2043	$54,276,920	$36,972,668	$31,973,461	$8,138,400	-$697,796,977	$45,518,944	$921,610,513	$381,600	$6,868,800	$0	$1,442,215	$2,114,120	$228,410,302	$639,910,966
2044	$42,959,403	$33,418,422	$32,864,956	$8,284,800	-$740,410,430	$46,072,448	$931,482,062	$381,600	$6,868,200	$0	$1,442,215	$2,106,470	$228,629,429	$594,099,576
2045	$43,695,025	$31,106,891	$32,864,956	$8,434,800	-$789,118,538	$46,725,147	$938,001,185	$381,600	$2,765,600	$0	$1,442,215	$2,098,820	$232,705,768	$551,103,470
2046	$71,872,607	$28,704,868	$32,864,956	$8,587,800	-$829,039,583	$47,487,400	$941,027,425	$381,600	$3,307,000	$0	$1,442,215	$2,090,660	$259,197,214	$567,924,162
2047	$79,178,616	$26,270,779	$32,937,175	$8,674,500	-$859,755,847	$48,311,412	$919,875,796	$381,600	-$7,351,600	$0	$1,442,215	$2,122,110	$118,210,668	$370,297,425
2048	$114,294,397	$23,947,687	$35,512,962	$9,085,200	-$969,976,538	$49,367,515	$982,223,608	$381,600	-$10,873,000	$0	$1,442,215	$1,978,970	$15,326,556	$252,711,172
2049	$197,916,078	$21,761,386	$24,936,186	$10,099,800	-$1,073,889,384	$56,112,661	$1,019,075,354	$381,600	-$2,356,400	$0	$1,442,215	$1,863,540	$1,384,181	$258,727,218
2050	$200,331,106	$19,507,943	$21,711,237	$11,031,600	-$1,178,540,044	$61,697,014	$1,046,592,400	$381,600	$3,425,400	$0	$1,442,215	$1,750,320	$1,510,617	$190,841,408
Total	$8,768,553,369	$866,617,514	$542,204,779	$126,988,800	-$10,949,018,396	$904,021,942	$13,265,508,649	$21,409,800	-$31,845,372	-$282,635,200	$38,939,810	$66,062,850	$2,574,614,712	$15,911,423,255

3.1.7 Total Net Costs – Union Pacific and BNSF Railway Cost Including National Line Haul Fleet

Approximately 72 percent of the combined UP and BNSF line haul fleet enters the South Coast air basin each year. Staff assumes that Class I operators, UP and BNSF, would continue their current business practice of sending any available line haul locomotive from their fleets to California. This assumption may be a conservative one—the Proposed Regulation only applies to locomotives operating in California; nothing in the Proposed Regulation would require UP or BNSF to replace, retrofit, or otherwise modify any locomotive that does not visit California.

Using this assumption, staff calculated the cost for UP and BNSF, respectively, to make their entire line haul locomotive fleet compliant with the Proposed Regulation, along with their California-based switchers. To model this scenario, staff used the same cost inputs as described in Section 3 but ran the cost model accounting for 100 percent of the UP and BNSF line haul locomotives, and their associated operations. The analysis shows that costs increase at the beginning of the transition to ZE and then decline. The change in fuel type and declining price of hydrogen are the primary factors influencing cost and savings after 2040. The Proposed Regulation results in net savings starting in 2049 which would continue to increase beyond 2050. Table 3.16 shows the total net amortized costs to the Class I operators' national line haul fleets.

Table 3.16: Total Potential Net, Amortized Costs to Class I Operators – Including Turnover of UP and BNSF National Line Haul Fleets

Year	100% Line Haul Fleet	100% Line Haul Fleet + California Yard Switchers
2023	-$34,188,870	-$30,529,696
2024	$104,918,487	$104,781,193
2025	$406,015,331	$418,996,660
2026	$562,794,761	$588,147,912
2027	$769,536,884	$806,387,196
2028	$979,825,667	$1,027,408,022
2029	$1,674,303,929	$1,795,226,559
2030	$3,580,343,638	$3,839,691,219

Year	100% Line Haul Fleet	100% Line Haul Fleet + California Yard Switchers
2031	$3,790,594,951	$4,131,424,419
2032	$3,862,159,251	$4,277,545,078
2033	$3,736,395,647	$4,249,585,453
2034	$3,379,467,082	$3,898,052,232
2035	$7,526,837,135	$7,714,133,198
2036	$7,750,938,157	$7,870,846,037
2037	$6,965,053,193	$7,294,546,305
2038	$6,611,630,080	$6,943,030,350
2039	$6,497,422,567	$6,846,989,289
2040	$6,149,476,035	$6,523,249,385
2041	$3,825,164,795	$4,120,824,619
2042	$3,056,814,335	$3,377,397,337
2043	$2,590,484,753	$2,964,610,738
2044	$2,213,981,169	$2,597,520,521
2045	$1,827,628,351	$2,214,938,119
2046	$1,712,158,438	$2,126,832,094
2047	$1,178,403,383	$1,451,717,194
2048	$254,014,190	$488,894,683
2049	-$254,771,095	$4,161,554
2050	-$1,318,226,102	-$1,026,309,155

Year	100% Line Haul Fleet	100% Line Haul Fleet + California Yard Switchers
Total	$79,399,176,143	$86,620,098,516

3.2 Direct Costs on Typical Businesses - both summative and normalized costs/MWh

UP and BNSF account for 98 percent of all locomotives that operate in California, and therefore represent "typical businesses." Since there are only two Class I railroads operating in California, staff divided Class I's calculated costs in half to present the average cost to a typical business.

To assess the costs to a typical business, staff assumed that the operator would also own the railyards where charging and hydrogen infrastructure would be installed to support ZE road switcher and ZE line haul locomotives. As discussed in Section 3.1.2.5, staff assumed operators would install charging infrastructure on the same schedule as their BE road switcher purchases, adding enough chargers to accommodate the BE road switchers each year, and start hydrogen fueling infrastructure installations in 2029, five years prior to fuel cell line haul locomotive deployment.

Between 2023 and 2050, the average Class I business has an average of 9,555 locomotives in their national fleet and is projected to operate an approximate total of 65,332,000 MWh in California. The amortized cost associated with California operations to a typical business is $6,726,000,000 (shown in Table 3.17), and the costs per MWh are about $103. To show the feasibility of compliance for a typical business, staff compared the average amortized annual cost of the Proposed Regulation to a typical business of $240,198,000 to their annual revenue of $20 billion dollars, representing 1.2 percent of their annual revenue.[134] If companies chose to turn over their entire Line Haul fleets, the average amortized annual cost would rise to 9.4 percent of their average annual revenues.

Table 3.18 shows the annual unamortized cost for a typical business to comply with the Proposed Regulation from 2023 to 2050. The total unamortized cost for a typical business to comply with the Proposed Regulation from 2023 to 2050 is estimated to be approximately $6,726,000,000.

[134] Union Pacific and BNSF 10-K Forms 2010-2019. (web links: https://www.up.com/investor/annual/, https://www.bnsf.com/about-bnsf/financial-information/form-10-k-filings/)

Table 3.17: Amortized Costs to Typical Business

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2023	$0	$0	-$1,995,357	$0	$0	$0	$0	$3,000,000	-$884,500	$0	$0	$0	$0	$120,143
2024	$14,346,879	$0	-$6,086,667	$0	$0	$0	$0	$0	-$3,119,200	$0	$302,066	$1,463,275	$36,265	$6,942,618
2025	$29,700,725	$0	-$4,199,906	$0	$0	$0	$0	$0	$1,266,700	$0	$302,066	$1,436,160	$23,912	$28,529,657
2026	$44,837,382	$0	-$2,527,478	$0	$0	$0	$0	$0	-$1,497,100	$0	$302,066	$1,439,985	$3,509	$42,558,364
2027	$59,639,512	$0	-$888,200	$0	$0	$0	$0	$0	-$1,864,000	$0	$302,066	$1,451,375	$14,688	$58,655,441
2028	$74,626,675	$0	$715,997	$0	$0	$0	$0	$0	-$1,877,900	-$707,200	$302,066	$1,459,195	$24,889	$74,543,721
2029	$236,355,131	$4,542,132	$1,643,154	$0	$0	$0	$0	$0	-$21,815,300	-$83,872,000	$302,066	$1,456,390	$25,732	$138,637,305
2030	$269,310,305	$6,046,279	$18,278,548	$697,500	-$11,846,085	$10,192,512	$0	$0	-$2,377,100	-$8,673,600	$302,066	$1,320,220	$14,785,499	$298,036,143
2031	$272,544,445	$6,681,800	$23,221,360	$875,250	-$15,280,132	$13,196,955	$0	$0	$941,500	$0	$302,066	$1,350,905	$39,983,150	$343,817,300
2032	$275,219,536	$6,870,772	$24,519,399	$879,750	-$15,731,382	$13,688,056	$0	$0	$784,000	$0	$302,066	$1,383,630	$75,198,180	$383,114,005
2033	$272,805,072	$7,202,575	$25,406,394	$882,000	-$16,116,930	$14,179,124	$0	$0	$1,801,500	-$5,424,000	$302,066	$1,417,205	$120,536,811	$422,991,817
2034	$257,362,658	$7,440,494	$25,585,794	$886,500	-$16,553,747	$14,703,264	$0	$0	-$5,968,500	$0	$302,066	$1,451,800	$120,634,382	$405,844,710
2035	$277,410,323	$7,647,119	$26,478,844	$1,191,900	-$86,851,484	$15,206,587	$143,991,337	$0	-$2,050,700	$0	$302,066	$1,303,645	$58,311,233	$442,940,869
2036	$280,129,980	$7,858,157	$25,535,942	$1,401,000	-$136,323,613	$15,445,444	$234,482,663	$0	$5,125,800	-$24,040,000	$302,066	$1,213,630	$5,686,410	$416,817,477
2037	$259,803,072	$8,133,790	$25,252,808	$1,634,100	-$191,326,907	$15,797,866	$328,357,262	$0	$6,119,000	-$974,400	$302,066	$1,111,290	$24,223,751	$478,433,697
2038	$243,458,901	$8,329,582	$23,405,102	$1,716,000	-$209,310,088	$16,344,915	$345,525,650	$0	$1,126,600	$0	$302,066	$1,106,360	$27,348,626	$459,353,713
2039	$227,730,756	$8,686,661	$22,059,131	$1,831,050	-$238,957,503	$16,578,150	$380,928,535	$0	$3,056,500	$0	$302,066	$1,075,080	$36,563,950	$459,854,376
2040	$208,133,265	$8,891,280	$20,721,682	$1,944,750	-$260,163,177	$17,339,797	$400,632,443	$0	$2,899,800	$0	$302,066	$1,060,715	$50,181,761	$451,944,381

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2041	$40,269,927	$9,007,230	$19,128,040	$2,017,500	-$279,777,079	$17,596,118	$413,341,213	$0	$2,999,500	$0	$302,066	$1,054,765	$69,028,521	$294,967,801
2042	-$365,554	$9,538,436	$17,457,234	$2,087,400	-$301,356,140	$17,962,532	$422,718,681	$0	$3,153,900	$0	$302,066	$1,051,280	$91,048,594	$263,598,428
2043	-$11,216,538	$9,980,573	$15,704,329	$2,158,950	-$321,194,977	$18,256,372	$430,561,377	$0	$3,434,400	$0	$302,066	$1,047,710	$113,392,429	$262,426,691
2044	-$14,280,312	$10,426,321	$13,927,206	$2,232,150	-$342,285,023	$18,557,052	$436,798,115	$0	$3,434,100	$0	$302,066	$1,043,885	$113,478,283	$243,633,842
2045	-$12,203,196	$10,426,321	$12,771,441	$2,307,150	-$366,255,645	$18,898,697	$441,358,640	$0	$1,382,800	$0	$302,066	$1,040,060	$115,494,250	$225,522,584
2046	-$652,977	$10,426,321	$11,570,429	$2,383,650	-$386,199,266	$19,285,973	$444,172,724	$0	$1,653,500	$0	$302,066	$1,035,980	$128,760,054	$232,738,453
2047	$2,475,389	$10,426,321	$10,353,385	$2,427,000	-$401,292,992	$19,699,890	$434,897,873	$0	-$3,546,200	$0	$302,066	$1,051,705	$58,201,917	$134,996,352
2048	$9,314,866	$10,907,776	$9,191,698	$2,625,600	-$455,881,210	$20,009,518	$467,372,743	$0	-$3,827,300	$0	$302,066	$980,390	$6,705,371	$67,701,519
2049	$37,744,613	$6,823,027	$8,056,965	$2,880,900	-$504,238,795	$22,334,050	$485,110,757	$0	$53,000	$0	$302,066	$925,310	$51,323	$60,043,215
2050	$38,952,127	$5,318,880	$6,893,898	$3,133,050	-$553,205,646	$24,568,192	$498,123,186	$0	$1,712,700	$0	$302,066	$870,655	$118,454	$26,787,562
Total	$3,393,452,960	$181,611,844	$372,181,170	$38,193,150	-$5,110,147,821	$359,841,063	$6,308,373,197	$3,000,000	-$7,882,500	-$123,691,200	$8,155,777	$32,602,600	$1,269,861,944	$6,725,552,184

Table 3.18: Unamortized Costs to Typical Business

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	AESS/GPS Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2023	$0	$0	-$1,995,357	$0	$0	$0	$0	$300,000	-$884,500	$0	$0	$0	$0	$120,143
2024	$127,160,000	$0	-$6,086,667	$0	$0	$0	$0	$0	-$3,119,200	$0	$302,066	$1,463,275	$36,265	$119,755,739
2025	$136,085,000	$0	-$4,199,906	$0	$0	$0	$0	$0	$1,266,700	$0	$302,066	$1,436,160	$23,912	$134,913,932
2026	$134,160,000	$0	-$2,527,478	$0	$0	$0	$0	$0	-$1,497,100	$0	$302,066	$1,439,985	$3,509	$131,880,982
2027	$131,195,000	$0	-$888,200	$0	$0	$0	$0	$0	-$1,864,000	$0	$302,066	$1,451,375	$14,688	$130,210,929
2028	$132,835,000	$0	$715,997	$0	$0	$0	$0	$0	-$1,877,900	-$707,200	$302,066	$1,459,195	$24,889	$132,752,046
2029	$1,433,440,000	$56,605,000	$1,643,154	$0	$0	$0	$0	$0	-$21,815,300	-$83,872,000	$302,066	$1,456,390	$25,732	$1,387,785,043
2030	$292,090,000	$18,745,000	$18,278,548	$697,500	-$11,846,085	$10,192,512	$0	$0	-$2,377,100	-$8,673,600	$302,066	$1,320,220	$14,785,499	$333,514,559
2031	$28,665,000	$7,920,000	$23,221,360	$875,250	-$15,280,132	$13,196,955	$0	$0	$941,500	$0	$302,066	$1,350,905	$39,983,150	$101,176,054
2032	$23,710,000	$2,355,000	$24,519,399	$879,750	-$15,731,382	$13,688,056	$0	$0	$784,000	$0	$302,066	$1,383,630	$75,198,180	$127,088,698
2033	-$21,400,000	$4,135,000	$25,406,394	$882,000	-$16,116,930	$14,179,124	$0	$0	$1,801,500	-$5,424,000	$302,066	$1,417,205	$120,536,811	$125,719,170
2034	-$136,870,000	$2,965,000	$25,585,794	$886,500	-$16,553,747	$14,703,264	$0	$0	-$5,968,500	$0	$302,066	$1,451,800	$120,634,382	$7,136,558
2035	$177,687,500	$2,575,000	$26,478,844	$1,191,900	-$86,851,484	$15,206,587	$143,991,337	$0	-$2,050,700	$0	$302,066	$1,303,645	$58,311,233	$338,145,928
2036	$151,265,000	$2,630,000	$25,535,942	$1,401,000	-$136,323,613	$15,445,444	$234,482,663	$0	$5,125,800	-$24,040,000	$302,066	$1,213,630	$5,686,410	$282,724,341
2037	-$44,077,500	$3,435,000	$25,252,808	$1,634,100	-$191,326,907	$15,797,866	$328,357,262	$0	$6,119,000	-$974,400	$302,066	$1,111,290	$24,223,751	$169,854,336
2038	-$10,702,500	$2,440,000	$23,405,102	$1,716,000	-$209,310,088	$16,344,915	$345,525,650	$0	$1,126,600	$0	$302,066	$1,106,360	$27,348,626	$199,302,731
2039	-$8,207,500	$4,450,000	$22,059,131	$1,831,050	-$238,957,503	$16,578,150	$380,928,535	$0	$3,056,500	$0	$302,066	$1,075,080	$36,563,950	$219,679,458
2040	-$40,862,500	$2,550,000	$20,721,682	$1,944,750	-$260,163,177	$17,339,797	$400,632,443	$0	$2,899,800	$0	$302,066	$1,060,715	$50,181,761	$196,607,336
2041	-$54,375,000	$1,445,000	$19,128,040	$2,017,500	-$279,777,079	$17,596,118	$413,341,213	$0	$2,999,500	$0	$302,066	$1,054,765	$69,028,521	$192,760,643

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	AESS/GPS Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2042	-$68,072,500	$6,620,000	$17,457,234	$2,087,400	-$301,356,140	$17,962,532	$422,718,681	$0	$3,153,900	$0	$302,066	$1,051,280	$91,048,594	$192,973,046
2043	-$67,510,000	$5,510,000	$15,704,329	$2,158,950	-$321,194,977	$18,256,372	$430,561,377	$0	$3,434,400	$0	$302,066	$1,047,710	$113,392,429	$201,662,656
2044	-$3,445,000	$5,555,000	$13,927,206	$2,232,150	-$342,285,023	$18,557,052	$436,798,115	$0	$3,434,100	$0	$302,066	$1,043,885	$113,478,283	$249,597,834
2045	-$2,990,000	$0	$12,771,441	$2,307,150	-$366,255,645	$18,898,697	$441,358,640	$0	$1,382,800	$0	$302,066	$1,040,060	$115,494,250	$224,309,460
2046	-$34,497,500	$0	$11,570,429	$2,383,650	-$386,199,266	$19,285,973	$444,172,724	$0	$1,653,500	$0	$302,066	$1,035,980	$128,760,054	$188,467,609
2047	$205,415,000	$0	$10,353,385	$2,427,000	-$401,292,992	$19,699,890	$434,897,873	$0	-$3,546,200	$0	$302,066	$1,051,705	$58,201,917	$327,509,642
2048	$211,885,000	$6,000,000	$9,191,698	$2,625,600	-$455,881,210	$20,009,518	$467,372,743	$0	-$3,827,300	$0	$302,066	$980,390	$6,705,371	$265,363,877
2049	$207,902,500	$5,700,000	$8,056,965	$2,880,900	-$504,238,795	$22,334,050	$485,110,757	$0	$53,000	$0	$302,066	$925,310	$51,323	$229,078,075
2050	$0	$0	$6,893,898	$3,133,050	-$553,205,646	$24,568,192	$498,123,186	$0	$1,712,700	$0	$302,066	$870,655	$118,454	-$17,483,445
Total	$2,900,485,000	$141,635,000	$372,181,170	$38,193,150	-$5,110,147,821	$359,841,063	$6,308,373,197	$300,000	-$7,882,500	-$123,691,200	$8,155,777	$32,602,600	$1,269,861,944	$6,192,607,380

3.3 Direct Costs on Small Businesses – both summative and normalized costs/MWh

To identify small businesses and model their estimated costs of compliance with the Proposed Regulation, staff reviewed locomotive populations and fuel usage for Class III and industrial companies. Among the companies reviewed, staff identified that operators that have an average annual revenue over $5 million, have seven or more locomotives and are already buying new locomotives using their revenue and often grants. Small businesses (companies with less than $5 million in revenue per year) rarely, if ever, purchased new locomotives. They primarily operate pre-Tier 0 engines which have the highest emissions and therefore would also incur the highest Spending Account charges. To reflect the potential costs to these small operators, staff took average fleet, operational, and financial values from among small businesses. Based on data gathered directly from Class III operators and Dunn & Bradstreet estimates, the average small business has three Pre-Tier 0 locomotives, uses approximately 10,000 gallons of diesel per locomotive per year, and has annual revenue of approximately $1.3 million.

To assess the costs to a small business, staff assumes that the operator would also own the railyards or industrial facilities where charging and hydrogen infrastructure would be installed to support ZE road and yard switchers. As discussed in Section 3.1.2.4, staff assumes operators would install charging infrastructure on the same schedule as their battery-electric road switcher purchases, adding enough chargers to accommodate the battery-electric road switchers each year.

Table 3.18 shows the annual amortized cost for a small business to comply with the Proposed Regulation from 2023 to 2050, which ranges from -$26,045 to $543,806. At maximum, this is approximately 42 percent of their annual revenue. The maximum annual unamortized cost is $2,700,000, representing 208 percent of their annual revenue. The average unamortized cost is $122,679, representing 9.4 percent of their annual revenue.

Recognizing that the Proposed Regulation requirements may challenge some small businesses, especially those operating Pre-Tier 0 locomotives, staff has included a Small Business Hardship Extension provision. The provision would apply to operators that can demonstrate to CARB that full payment of Spending Account charges and/or restriction of a locomotive use resulting from the In-Use Operational Requirements will prevent the locomotive operator from meeting other financial obligations as they come due or will cause the taking of property or the closing and eliminating of a business. If an extension is approved, CARB may grant the applicant up to a three-year- extension in the time required to deposit the Spending Account charge, or a reduced Spending Account payment for the year(s) requested, or an extension of eligibility to operate under the In-Use Operational Requirement by up to three years, or a combination of these relief options. Lastly, while they are not included in this analysis, grants, incentives, and utility infrastructure programs can further reduce the upfront costs to operators that act early. Section 3.3.1 below describes several grants and incentive programs that may be used by operators.

Table 3.19: Amortized Small Business Costs

Costs by Category	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Hydrogen Fuel Costs	AESS/GPS Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Total Class 3 Incremental Costs
2023	$0	$0	-$8,315	$0	$0	$0	$142,200	$0	$0	$0	$0	$133,885
2024	$0	$0	-$8,315	$0	$0	$0	$7,200	$0	$0	$20,832	$510	$39,632
2025	$0	$0	-$8,315	$0	$0	$0	$7,200	$0	$0	$20,832	$510	$59,814
2026	$304,629	$0	-$8,315	$0	$0	$0	$7,200	-$59,200	$0	$20,832	$510	$326,228
2027	$304,629	$0	$28,651	$0	$0	$0	$7,200	$0	$0	$20,832	$510	$444,227
2028	$304,629	$48,146	$28,651	$0	$0	$0	$7,200	$0	-$473,600	$20,832	$510	-$26,045
2029	$304,629	$48,146	$110,055	$9,000	-$82,838	$72,917	$7,200	$0	$0	$20,832	$170	$543,806
2030	$304,629	$48,146	$110,055	$9,000	-$84,215	$73,750	$7,200	$0	$0	$20,832	$170	$489,565
2031	$304,629	$48,146	$110,055	$9,000	-$84,609	$74,375	$7,200	$0	$0	$20,832	$170	$490,232
2032	$304,629	$48,146	$110,055	$9,000	-$84,806	$75,104	$7,200	$0	$0	$20,832	$170	$491,217
2033	$304,629	$48,146	$110,055	$9,000	-$84,806	$75,937	$7,200	$0	$0	$20,832	$170	$492,520
2034	$304,629	$48,146	$110,055	$9,000	-$84,806	$76,667	$7,200	$0	$0	$20,832	$170	$493,738
2035	$304,629	$48,146	$110,055	$9,000	-$84,806	$77,396	$7,200	$0	$0	$20,832	$170	$494,976
2036	$304,629	$48,146	$110,055	$9,000	-$85,667	$76,733	$7,200	$0	$0	$20,832	$170	$493,981
2037	$304,629	$48,146	$110,055	$9,000	-$86,249	$76,417	$7,200	$0	$0	$20,832	$170	$493,632
2038	$0	$48,146	$110,055	$9,000	-$86,978	$76,034	$7,200	$0	$0	$20,832	$170	$188,463
2039	$0	$48,146	$110,055	$9,000	-$87,725	$75,466	$7,200	$0	$0	$20,832	$170	$187,743
2040	$0	$48,146	$110,055	$9,000	-$87,729	$74,889	$7,200	$0	$0	$20,832	$170	$187,780
2041	$0	$48,146	$110,055	$9,000	-$88,290	$74,367	$7,200	$0	$0	$20,832	$170	$187,342

Costs by Category	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Hydrogen Fuel Costs	AESS/GPS Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Total Class 3 Incremental Costs
2042	$0	$48,146	$110,055	$9,000	-$89,581	$74,289	$7,200	$0	$0	$20,832	$170	$186,642
2043	$0	$48,146	$110,055	$9,000	-$90,125	$73,886	$7,200	$0	$0	$20,832	$170	$186,393
2044	$0	$48,146	$110,055	$9,000	-$90,830	$73,493	$7,200	$0	$0	$20,832	$170	$186,021
2045	$0	$48,146	$110,055	$9,000	-$92,077	$73,242	$7,200	$0	$0	$20,832	$170	$185,277
2046	$0	$48,146	$110,055	$9,000	-$92,132	$73,141	$7,200	$0	$0	$20,832	$170	$185,907
2047	$0	$48,146	$110,055	$9,000	-$92,992	$73,110	$7,200	$0	$0	$20,832	$170	$185,834
2048	$0	$0	$110,055	$9,000	-$93,781	$72,668	$7,200	$0	$0	$20,832	$170	$137,310
2049	$0	$0	$110,055	$9,000	-$94,356	$72,477	$7,200	$0	$0	$20,832	$170	$137,435
2050	$0	$0	$110,055	$9,000	-$94,885	$72,052	$7,200	$0	$0	$20,832	$170	$137,410
Total	$3,655,543	$962,911	$2,445,246	$198,000	-$1,944,282	$1,638,407	$336,600	-$59,200	-$473,600	$562,461	$6,290	$7,740,965

3.4 Potential Incentive Funding

The analysis attributes all the incremental costs associated with the Proposed Regulation when compared to the baseline to the Proposed Regulation, and no grant funding is included in this analysis. Thus, the costs included in this analysis represent an upper bound where all incremental costs of the Proposed Regulation are borne by the operator. However, the Proposed Regulation is structured to provide an opportunity for operators to take early action ahead of regulatory deadlines and would allow them to be eligible for grant funding that could substantially reduce or eliminate the costs of Tier 4 or cleaner locomotive purchases and infrastructure. Table 3.19 and the following section describe several funding sources for locomotives and infrastructure and identifies how incremental costs to operators of the Proposed Regulation could be offset without relying on financing options. Each of these programs have different funding requirements, application timelines, and limited funding availability. CARB encourages interested stakeholders to act early and utilize funding while it is available.

Table 3.20: Potential Incentive Funding Programs

Program Name[1]	Program Administrator	What the Program Targets	More Information
SB 350 - California Public Utilities Commission (CPUC) [3]	See local utility programs[4] Incentives and rebates for zero-emission charger infrastructure. Please see local utility program sites for specifics.	California Public Utilities Commission (CPUC)[3]	See local utility programs[4] Incentives and rebates for zero-emission charger infrastructure. Please see local utility program sites for specifics. https://www.cpuc.ca.gov/sb350te/
Carl Moyer Memorial Air Quality Attainment Standards Program (Carl Moyer)	Local Air District	Cleaner-than-required by law engines, equipment, and other sources of air pollution Engine / Motor Equipment Infrastructure	https://ww2.arb.ca.gov/our-work/programs/carl-moyer-program-locomotives

Program Name[1]	Program Administrator	What the Program Targets	More Information
Clean Diesel and Diesel Emissions Reduction Act Programs (DERA)	U.S. EPA	Projects that protect human health and improve air quality by reducing harmful emissions from diesel engines Engine / Motor Equipment	https://www.epa.gov/dera
Clean Off-Road Voucher Incentive Project (CORE)	CARB	Zero-emission off-road equipment in early stages of commercial development Equipment Infrastructure	https://ww2.arb.ca.gov/our-work/programs/clean-off-road-equipment-voucher-incentive-project
Community Air Protection Incentives (CAP Incentives) Assembly Bill 617	Local Air District	Projects that result in immediate air quality benefits to the most impacted communities across the State. Engine / Motor Equipment Infrastructure	https://ww2.arb.ca.gov/our-work/programs/community-air-protection-incentives
Low Carbon Fuel Standard (LCFS)	CARB	Low-carbon and renewable alternatives Low Carbon Fuels	https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard
Low Carbon Transportation Investments	CARB	Accelerate the next generation of advanced technology vehicles, equipment, or emission controls which are not yet commercialized Equipment	https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program-0

Program Name[1]	Program Administrator	What the Program Targets	More Information
Low Carbon Transit Operations Program	California State Transportation Agency (CalSTA)	Noncompetitive, formula-based operating and capital assistance for transit agencies to reduce GHG emissions and improve mobility, with a priority on serving disadvantaged communities Equipment Maintenance	
Proposition 1B: Goods Movement Emissions Reduction Program (Proposition 1B)	Select Local Air Districts	Projects that achieve early or extra emissions reductions from freight not otherwise required by law. Equipment Infrastructure	https://ww2.arb.ca.gov/prop-1b-local-agency-contact-and-solicitation-information
Targeted Airshed Grants Program	U.S. EPA	Air pollution in the nation's areas with the highest levels of ozone and (PM2.5) ambient air concentrations Equipment Infrastructure	https://www.epa.gov/air-quality-implementation-plans/targeted-airshed-grants-program
Transit Intercity Rail Capital Program	CalSTA	Competitive grants for transformative capital improvements that will modernize California's intercity, commuter and urban rail systems to significantly reduce GHG emissions, vehicle miles traveled, and congestion Equipment Infrastructure	https://calsta.ca.gov/subject-areas/transit-intercity-rail-capital-prog

Program Name[1]	Program Administrator	What the Program Targets	More Information
VW Mitigation Trust	CARB	Accelerate the replacement of older, higher polluting engines throughout the state of California, including but not limited to areas that are disproportionately impacted by air pollution, such as freight corridors, ports, and rail yards Equipment	https://xappprod.aqmd.gov/vw/combustion.html

SB 350 – Clean Energy and Pollution Reduction Act of 2015

SB 350 provides additional opportunities for ZE locomotives through the California Public Utilities Commission (CPUC).[135] The three large investor owned- electric utilities in California (Pacific Gas & Electric, Southern California Edison and San Diego Gas & Electric), and three small electrical corporations filed applications on how they plan to develop electric infrastructure to enable the transportation electrification of light-, medium- and heavy-duty vehicles in California, with an estimated total cost of approximately $1 billion. The utilities' proposals focus on installing electric vehicle charging infrastructure and education programs to encourage the electrification of the transportation sector to reduce GHG emissions. ZE locomotive infrastructure projects may be eligible for this funding.

Clean Off-Road Equipment (CORE)

The Clean Off-Road Equipment Voucher Incentive Project (CORE) is intended to accelerate deployment of advanced technology in the off-road sector by providing a streamlined way for fleets to access funding that helps offset the incremental cost of such technology. CORE targets commercial-ready products that have not yet achieved a significant market foothold. By promoting the purchase of clean technology over internal combustion options, the project is expected to reduce emissions, particularly in areas that are most impacted; help build confidence in zero-emission technology in support of CARB strategies and subsequent regulatory efforts where possible; and provide other sector-wide benefits, such as technology transferability, reductions in advanced-technology component costs, and larger infrastructure investments.

[135] California Public Utilities Commission, SB 350 TE Programs, 2021. (web link: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/transportation-electrification-activities-pursuant-to-senate-bill-350)

Carl Moyer Memorial Air Quality Standards Attainment Program

The Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program) provides grant funding for cleaner-than-required engines, equipment, and other sources of air pollution. The Carl Moyer Program is implemented as a partnership between CARB and California's 35 local air districts. CARB works collaboratively with the air districts and other stakeholders to set Guidelines and ensure the Program reduces pollution and provides cleaner air for Californians.

- Applicants: Class 3, industrial, and passenger
- Up to 85 percent of eligible costs on locomotive replacement or repower to Tier 4
- Up to 85 percent of eligible costs on locomotive replacement or repower to zero-emission
- Maximum grant life 15 years
- Infrastructure grants such as grants for ZE fueling/charging or for wayside power are currently being evaluated on a case-by-case basis.

Because grants are based on emissions reduced in each year of the grant, longer grant lives typically correlate with higher grant amounts.

On the date a regulation is approved by the Board, project life requirements for any new grants are altered: the project life must be entirely prior to the regulatory requirement. The In-Use Locomotive Regulation may be fully approved on the date of the second Board hearing, currently scheduled for early 2023.

To receive full grant life, and the fullest possible grant amount, it is important to ensure Carl Moyer program grant contracts are executed prior to Board approval. Locomotive grants are administered by several Air Districts in the State, see Table 1 for a complete list. For more information, visit the Carl Moyer Program webpage.[136]

Community Air Protection Incentives

To support the AB 617 effort, the California Legislature has appropriated incentive funding to support early actions to address localized air pollution in the most impacted communities. Funding for Community Air Protection (CAP) incentives are to be administered by air districts in partnership with local communities. The Legislature directed that air districts spend CAP funds on mobile source projects pursuant to the Carl Moyer Program and the Proposition 1B

[136] California Air Resources Board, Carl Moyer Memorial Air Quality Standards Attainment Program. (web link: https://ww2.arb.ca.gov/our-work/programs/carl-moyer-memorial-air-quality-standards-attainment-program)

Goods Movement Emission Reduction Program. The scope of projects eligible for CAP incentives includes ZE locomotives and supporting fueling and charging infrastructure.

Diesel Emission Reduction Act National Grants

EPA annually offers a competitive funding opportunity for projects that achieve reductions in diesel emissions from mobile sources, including locomotives that operate 1,000 hours per year during the two years prior to upgrade.

Low Carbon Fuel Standard

LCFS credits could be available for electricity use by operators once applicable fuel reporting entities have applied for and obtained a pathway carbon intensity based on approved ZE locomotive EER. To illustrate possible credit values, Staff ran the LCFS Credit Calculator using a hypothetical scenario where the LCFS credit value is $200, and BE Locomotives have an average Carbon Intensity of 53 grams of carbon dioxide equivalent emissions per megajoule of fuel energy and a EER of 2.1.[137] The results suggest that operators could receive 9 to 10 cents per kWh in the short term (2023-2030), though LCFS is a market-based program and credit values are subject to change.

Low Carbon Transportation Investments

The purpose of the Advanced Technology Demonstration Projects is to help accelerate the next generation of advanced technology vehicles, equipment, or emission controls which are not yet commercialized. Typically, local air districts, other public agencies, and California-based non-profit organizations would be eligible to apply for these projects to demonstrate promising technologies to reduce emissions. Funding is expected in 2022 for Off-Road Advanced Technology Demonstration and Pilot projects.

Low Carbon Transit Operations Program

The Low Carbon Transit Operations Program (LCTOP) was created to provide operating and capital assistance for transit agencies to reduce GHG emissions and improve mobility, with a priority on serving disadvantaged communities. Approved projects in LCTOP will support new or expanded bus or rail services, expand intermodal transit facilities, and may include equipment acquisition, fueling, maintenance and other costs to operate those services or facilities, with each project reducing GHG emissions. Five percent of the annual auction proceeds in the Greenhouse Gas Reduction Fund (GGRF) are continuously appropriated for

[137] California Air Resources Board, Credit Value Calculator – Figure 7, last accessed February 11, 2022. (web link: https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard)

LCTOP. To the extent that passenger operators take early action and utilize this program their costs would be lower than estimated in this analysis.

Proposition 1B

The $1 billion Proposition 1B Goods Movement Emission Reduction Program is a partnership between CARB and local agencies, air districts, and seaports to quickly reduce air pollution emissions and health risk from freight movement along California's trade corridors. Local agencies apply to CARB for funding, then those agencies offer financial incentives to owners of equipment used in freight movement to upgrade to cleaner technologies. Projects funded under this program must achieve early or extra emission reductions not otherwise required by law or regulation. While funding has been allocated, additional solicitations may be released when existing projects are canceled.

Targeted Airshed Grants Program

The Targeted Airshed Grants program assists local, state, and tribal air pollution control agencies with developing plans and conducting projects to reduce air pollution in nonattainment areas that EPA determines are the top five most polluted areas relative to ozone, annual average PM2.5, or 24-hour PM2.5 National Ambient Air Quality Standards. Congress authorized this program in 2010 and every year since 2015.

Transit and Intercity Rail Capital Program

The Transit and Intercity Rail Capital Program (TIRCP) receives ten percent of annual GGRF funds to provides grants to fund transformative capital improvements that will modernize California's intercity, commuter, and urban rail systems, and bus and ferry transit systems, to significantly reduce GHG emissions, vehicle miles traveled, and congestion. To the extent that transit agencies take early action and utilize this program, their costs would be lower than estimated in this analysis. Funding amounts are formula based and determined by the State Controller's Office.

VW Mitigation

The Volkswagen (VW) Environmental Mitigation Trust (Trust) provides about $423 million for California to mitigate the excess nitrogen oxide (NO_X) emissions caused by VW's use of illegal emissions testing defeat devices in certain VW diesel vehicles. The Trust is a component of partial settlements with VW. The Trust provides funding opportunities for specified eligible actions that are focused mostly on "scrap and replace" projects for the heavy-duty sector, including on-road freight trucks, transit and shuttle buses, school buses, forklifts and port cargo handling equipment, commercial marine vessels, and freight switcher

locomotives. The Combustion Freight and Marine Projects Category, which includes locomotive funding, has $26 million of available project funds remaining.

3.5 Direct Costs on Individuals

The Proposed Regulation would not result in any direct costs to individuals. However, staff anticipate the Proposed Regulation could result in indirect costs over the early years of the regulation and indirect cost savings in later years to individuals to the extent that compliance costs and savings are passed through to the ultimate consumers of freight transported via railcar and to passengers riding on passenger locomotives.

Freight operators may be eligible for federal and state grants, although the majority of their locomotive purchases are unsubsidized. As such, staff assumes that freight operators will pass the incremental cost and savings to consumers. In later years of the Proposed Regulation, operators are expected to see incremental savings associated with lower fuel and maintenance costs of ZE locomotives.

Passenger locomotive operators that incur increased costs after pursuing local, state, and federal funding may decide to pass on costs to individuals, through changes in service or fares. However, government grant funding could reduce or eliminate the additional capital costs of the Proposed Regulation. To the extent that passenger locomotive operators are successful in offsetting the upfront incremental costs, fares could be unaffected for individuals and could lead to potential fare reductions in later years due to operational cost savings.

Individuals may see health benefits as described in Section 2. Individuals may see macroeconomic indirect and induced benefits and costs, which are discussed further in Section 5.

3.5.1 Freight

Assuming California's share of the total net cost of the Proposed Regulation on freight transported by Class I, Class III and industrial locomotives are fully passed through to consumers, the estimated cost to California is calculated by dividing the total cost of the Proposed Regulation to Class I, Class III and industrial locomotives by the number of California households, a standard economic metric.[138] Staff linearly extended the Department of Finance's projected number of households out to 2050, then took the average value. Staff do not expect changes in delivery time nor speed, therefore only direct costs were considered.

[138] California Department of Finance, Projections, 2019 Baseline, June 12, 2020. (web link: https://dof.ca.gov/Forecasting/Demographics/projections/?msclkid=8336bef9afc611ec82513638a78a2b69)

The total impact of the Proposed Regulation on California freight transported by locomotives from 2023 to 2050 is $976 per household with a yearly average of $36.

Freight transported by locomotives may have a final destination in California or in any state serviced by UP or BNSF, but the Proposed Regulation does not account for costs outside of California.

3.5.2 Passenger Fares

Passenger railroads are funded by various levels of government (federal, state, and local), primarily through fuel taxes, vehicle fees, and local bond measures, and through passenger fares. Purchases of locomotives are considered capital costs and are funded with a combination of government grants and local tax revenues. The broader economic impacts of these changes in government spending are modeled in the macroeconomic analysis in Section 5.

Operational and maintenance costs are more reliant on passenger fares, but these costs are also paid in part through state and local government funds. According to the Legislative Analyst's Office, passenger fares make up less than half of transit operating revenues.[139] Additionally, Senate Bill No. 508, requires public transit operators (Metrolink, Caltrain, etc.) to maintain a farebox recovery ratio of 20 percent in urban areas in order to receive Transportation Development Act funds. A farebox recovery ratio of 20 percent means that the fares collected by transit agencies must cover at least 20 percent of the operating costs.[140] Passenger rail operators in California currently average 46 percent farebox recovery. Since the Proposed Regulation does not increase operating costs, staff expect farebox costs not to increase. The other main revenue sources for passenger operators are government subsidies. Staff assume the costs to passenger operators would be addressed through federal and state grants, and local government transportation funds.

While changes in passenger fares are not directly linked to changes in operational and capital costs, staff calculated the hypothetical impact to fares if passenger operators passed through 100 percent of their costs to riders. Under this assumption, local passenger fares could increase by approximately 35 cents and state passenger fares could increase by $2.00 on average, assuming 1.5 percent growth in ridership year-over-year.

Lastly, the Proposed Regulation includes the option of creating an Alternative Compliance Plan whereby operators could propose a business plan that better fits their business model while obtaining the same emission reductions as the Proposed Regulation. Staff have worked closely with operators who have shown interest in creating an alternative, including passenger operators, to scope potential alternatives that align closely with their capital

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[139] Legislative Analyst's Office, California's Transportation System, June, 2018. (web link: https://lao.ca.gov/reports/2018/3860/californias-transportation-060418.pdf)

[140] Senate Bill No. 508

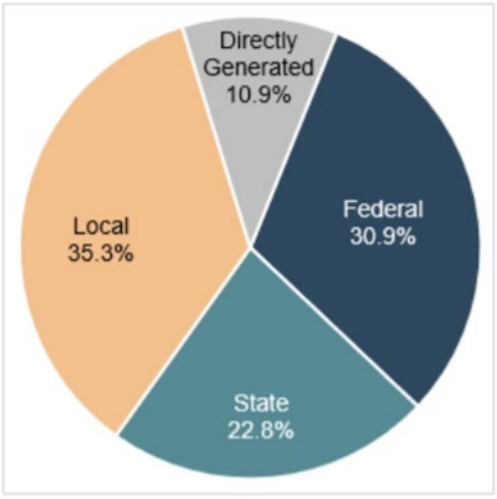
financing model. Through work with passenger operators, staff are providing additional assurance that local, state, and federal transit funds will continue to support their capital costs.

4 Fiscal Impacts

This chapter describes costs and benefits that would be incurred by local, state, and federal government agencies due to the Proposed Regulation. While Class I, Class III, and industrial locomotives are owned and operated by private companies, passenger locomotives are bought and operated by government. Local government agencies that operate passenger locomotives would be subject to the same direct costs and benefits outlined in Section 3. They would also experience changes in revenue from utility user taxes, diesel fuel taxes, and local sales taxes as all operators switch from diesel to ZE locomotives and related fuel and ZE infrastructure construction taxes change commensurately. State government agencies that operate passenger locomotives are also subject to the same direct costs and benefits outlined in Section 3. Other state agencies would experience changes in revenue from diesel fuel taxes, energy resources fees, and state sales taxes due to operators' fuel switches and related ZE infrastructure construction as well as the CARB administrative charge. Costs to CARB would include staffing and resources needed to implement and enforce the Proposed Regulation. CARB does not own any locomotives. Federal government agencies are also involved in capital purchases of passenger locomotives for state and local government use and would therefore incur direct costs.

For passenger operators, capital expenditures are funded by federal, state, and local government grants. Capital expenditures include planning, engineering, design and evaluation of transit projects, crime prevention, security equipment, and construction of maintenance and passenger facilities. It also includes investments in new and existing systems including rolling stock, overhaul and rebuilding of vehicles, track, signals, communications, and computer hardware and software. Based on data from the Federal Transit Administration's National Transit Summaries and Trends 2019, shown in Figure 4.1, staff attributed 31 percent of the local and state passenger locomotive capital and maintenance costs to the Federal Government.

Figure 4.1: National Transit Summaries and Trends 2019[141]



In addition, the Proposed Regulation would result in health benefits to individuals in California. These benefits may translate to cost savings for local and state healthcare providers.

4.1 Local government

4.1.1 Locomotive Operator Costs

The Proposed Regulation would cost local government agencies that own locomotives (e.g., Metrolink, Caltrain) approximately $492 million. Using the locomotive Inventories[142] created for the Proposed Regulation, staff calculated direct costs incurred by local government locomotive owners. In attributing costs for local government, staff allocated local governments a 46 percent share of capital costs and 69 percent of maintenance costs associated with the Proposed Regulation. State funding provided 23 percent of capital costs, and federal funding providing 31 percent of capital costs and maintenance costs, shown in Table 4.1.

[141] Federal Transit Administration, National Transit Summaries and Trends 2019. (web link: https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307)

[142] California Air Resources Board, MSEI - Documentation - Off-Road - Diesel Equipment, 2021. (web link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road)

Table 4.1: Local Operator Cost – Percent Share by Level of Government

Type of Cost	Local (%)	State (%)	Federal (%)
Capital	46	23	31
Maintenance	69	0	31

The assumptions underlying the direct costs to local government agencies are identical to those identified in Section 3 of the SRIA. The estimated direct costs to local government locomotive owners are summarized in Table 4.2.

Table 4.2: Total Direct Equipment and Infrastructure-Related Costs to Local Governments from 2023 to 2050 (2019$)

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Hydrogen Fuel Costs	Geo-Tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2023	$0	$0	-$120,335	$0	$0	$0	$0	$0	$0	$0	$0	$0	-$120,335
2024	$2,607,054	$0	-$120,335	$0	$0	$0	$0	-$396,502	$0	$76,918	$13,157	$0	$2,180,292
2025	$4,924,435	$0	$70,616	$0	$0	$0	$0	-$352,446	$0	$76,918	$13,157	$0	$4,732,680
2026	$5,214,108	$0	$221,373	$0	$0	$0	$0	-$362,567	$0	$76,918	$13,157	$0	$5,162,989
2027	$6,662,471	$0	$217,325	$0	$0	$0	$0	$5,358	$0	$76,918	$13,157	$0	$6,975,229
2028	$8,110,835	$0	$307,594	$0	$0	$0	$0	-$258,977	$0	$76,918	$13,157	$0	$8,249,527
2029	$11,451,726	$535,647	$397,864	$0	$0	$0	$0	-$51,795	-$2,278,995	$76,918	$13,157	$0	$10,144,522
2030	$11,953,825	$576,851	$416,502	$435,349	-$3,964,006	$10,242,285	$0	$484,614	$0	$76,918	$11,513	$0	$20,233,850
2031	$11,953,825	$576,851	$421,440	$468,837	-$4,049,816	$9,671,374	$0	$0	$0	$76,918	$11,386	$0	$19,130,815
2032	$8,477,753	$576,851	$421,440	$468,837	-$4,059,234	$9,092,744	$0	$0	$0	$76,918	$11,386	$0	$15,066,695
2033	$8,477,753	$576,851	$201,667	$468,837	-$4,059,234	$8,514,115	$0	$621,544	$0	$76,918	$11,386	$0	$14,889,837
2034	$6,739,717	$576,851	$201,667	$468,837	-$4,059,234	$8,183,470	$0	$0	$0	$76,918	$11,386	$0	$12,199,612
2035	$6,739,717	$576,851	$91,780	$468,837	-$4,059,234	$7,935,486	$0	$310,772	$0	$76,918	$11,386	$0	$12,152,514
2036	$4,132,663	$576,851	$91,780	$468,837	-$4,100,449	$7,681,528	$0	$0	$0	$76,918	$11,386	$0	$8,939,515
2037	-$1,371,117	$576,851	$91,780	$468,837	-$4,128,312	$7,427,571	$0	$0	$0	$76,918	$11,386	$0	$3,153,914
2038	-$1,660,790	$576,851	-$109,678	$468,837	-$4,163,200	$7,173,613	$0	$569,749	$0	$76,918	$11,386	$0	$2,943,685
2039	-$3,109,153	$576,851	-$109,678	$468,837	-$4,198,967	$6,919,656	$0	$0	$0	$76,918	$11,386	$0	$635,849
2040	-$4,557,517	$576,851	-$109,678	$468,837	-$4,199,154	$6,665,698	$0	$0	$0	$76,918	$11,386	$0	-$1,066,659

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Hydrogen Fuel Costs	Geo-Tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2041	$20,219,152	$2,884,254	-$109,678	$468,837	-$4,226,003	$6,411,741	$0	-$4,500,837	$0	$76,918	$11,386	$0	$21,235,770
2042	$19,717,053	$2,884,254	-$36,748	$2,344,186	-$25,919,292	$37,222,915	$0	$0	$0	$76,918	$4,301	$0	$36,293,587
2043	$19,717,053	$2,884,254	-$36,748	$2,344,186	-$26,076,495	$35,687,778	$0	$0	$0	$76,918	$4,301	$0	$34,601,247
2044	$23,193,125	$2,884,254	-$36,748	$2,344,186	-$26,280,449	$34,152,641	$0	$0	$0	$76,918	$4,301	$0	$36,338,228
2045	$23,193,125	$2,884,254	-$36,748	$2,344,186	-$26,641,363	$32,617,504	$0	$0	$0	$76,918	$4,301	$0	$34,442,177
2046	$24,931,160	$2,884,254	-$36,748	$2,344,186	-$26,657,271	$31,082,367	$0	$0	$0	$76,918	$4,301	$0	$34,629,168
2047	$24,931,160	$2,884,254	-$36,748	$2,344,186	-$26,906,149	$29,547,229	$0	$0	$0	$76,918	$4,301	$0	$32,845,153
2048	$29,450,054	$3,255,087	-$36,748	$2,344,186	-$27,134,500	$28,012,092	$0	-$723,349	$0	$76,918	$4,301	$0	$35,248,042
2049	$36,653,248	$3,049,069	-$25,027	$2,645,581	-$29,720,490	$28,823,766	$0	-$642,977	$0	$76,918	$3,163	$0	$40,863,251
2050	$36,653,248	$3,007,865	-$14,608	$2,913,488	-$32,695,755	$29,704,156	$0	$0	$0	$76,918	$2,151	$0	$39,647,462
Total	$345,405,683	$36,382,808	$2,176,577	$27,560,929	-$297,298,608	$382,769,731	$0	-$5,297,414	-$2,278,995	$2,076,781	$251,126	$0	$491,748,616

4.1.1.1 Utility User Tax

Several 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. For this analysis, staff used a value of 3.53 percent, representing a population-weighted average. Since Class I, Class III, and industrial switchers are modeled to transition to BE locomotives and therefore increase the amount of electricity used, there would be an increase in the amount of utility user tax revenue collected by cities and counties. Line haul and passenger locomotives are assumed to be hydrogen fuel cell, and therefore do not affect utility user taxes.

4.1.1.2 Diesel Fuel Tax

The off-road diesel locomotives use is exempt from on-road diesel taxes, but it does incur sales tax.[143] Displacing diesel with electricity or hydrogen would decrease the total amount of diesel fuel dispensed in the state, resulting in a reduction in tax revenue collected by local governments. For this analysis, staff used the combined state and local sales tax rate of 8.6 percent, which is a weighted average based on county-level output, with 3.94 percent[144] going towards state sales tax and 4.67 percent[145] going towards local sales tax.

4.1.1.3 Local Sales Tax

Sales tax is levied in California to fund a variety of programs at the local and state levels. The Proposed Regulation would result in the sale of more locomotives from manufacturers in and outside of California at more expensive prices and new ZE infrastructure in California, creating a direct increase in sales tax revenue collected by local governments. Additionally, Class I line haul locomotive sales were excluded from this calculation because locomotives and railroad equipment purchased outside of the state and used for interstate commerce, like Class I line haul locomotives, are generally exempt from use and sales tax.[146] For this analysis, staff used the combined state and local sales tax rate of 8.6 percent, which is a

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[143] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October, 2020. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm)

[144] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate, last accessed January 29, 2021. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm)

[145] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October, 2020. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm)

[146] California Department of Tax and Fee Administration, Regulation 1620, Interstate and Foreign Commerce, last accessed February 2, 2022. (web link: https://www.cdtfa.ca.gov/lawguides/vol1/sutr/sales-and-use-tax-regulations-art11-all.html)

weighted average based on county-level output, with 3.94 percent[147] going towards state sales tax and 4.67 percent[148] going towards local sales tax.

4.1.1.4 Fiscal Impact on Local Governments

From 2023 to 2050, the cost to local government passenger operators due to the Proposed Regulation is estimated to be about $492 million. Local governments would see a direct increase in utility user and local sales tax revenue of $443 million and a decrease in diesel fuel tax revenue of $488 million. Table 4.3 shows the total fiscal impact on local governments, which is estimated to be a net loss of about $537 million from 2023 to 2050.

Table 4.3: Estimated Fiscal Impact on Local Governments from 2023 to 2050 (2019$)

Year	Passenger Operator Costs	Utility Users Fee	Diesel Fuel Tax Impact	Local Sales Tax Impact	Fiscal Impact
2023	-$120,335	$0	$0	-$478,511	-$598,846
2024	$2,180,292	$0	$0	-$10,046,724	-$7,866,432
2025	$4,732,680	$0	$0	-$9,519,358	-$4,786,678
2026	$5,162,989	$0	$0	-$6,333,746	-$1,170,758
2027	$6,975,229	$0	$0	-$7,166,288	-$191,059
2028	$8,249,527	$0	$0	-$6,612,152	$1,637,375
2029	$10,144,522	$0	$0	-$70,132,540	-$59,988,019
2030	$20,233,850	-$853,566	$1,598,736	-$14,321,869	$6,657,151
2031	$19,130,815	-$1,066,869	$1,923,590	-$1,115,410	$18,872,125
2032	$15,066,695	-$1,110,243	$1,977,716	-$2,752,833	$13,181,335

[147] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate, last accessed January 29, 2021. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm)

[148] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October, 2020. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm)

Year	Passenger Operator Costs	Utility Users Fee	Diesel Fuel Tax Impact	Local Sales Tax Impact	Fiscal Impact
2033	$14,889,837	-$1,258,480	$2,179,877	-$1,802,503	$14,008,731
2034	$12,199,612	-$1,320,529	$2,253,542	$1,842,658	$14,975,283
2035	$12,152,514	-$1,357,876	$8,526,408	-$26,313,645	-$6,992,599
2036	$8,939,515	-$1,371,415	$12,948,829	-$29,228,212	-$8,711,284
2037	$3,153,914	-$1,394,137	$17,862,258	-$5,836,942	$13,785,093
2038	$2,943,685	-$1,429,854	$19,473,621	-$14,543,835	$6,443,616
2039	$635,849	-$1,443,405	$22,125,984	-$12,821,642	$8,496,786
2040	-$1,066,659	-$1,492,950	$24,018,262	-$9,196,558	$12,262,095
2041	$21,235,770	-$1,508,267	$25,773,602	-$45,216,504	$284,600
2042	$36,293,587	-$1,533,669	$29,348,020	-$9,044,862	$55,063,076
2043	$34,601,247	-$1,552,032	$31,133,198	-$9,253,444	$54,928,970
2044	$36,338,228	-$1,570,904	$33,034,458	-$9,480,988	$58,320,793
2045	$34,442,177	-$1,593,159	$35,207,639	-$9,670,608	$58,386,049
2046	$34,629,168	-$1,619,149	$36,988,773	-$5,480,011	$64,518,780
2047	$32,845,153	-$1,647,245	$38,359,222	-$25,560,743	$43,996,387
2048	$35,248,042	-$1,683,254	$43,276,874	-$36,873,235	$39,968,427
2049	$40,863,251	-$1,913,240	$47,913,093	-$34,978,153	$51,884,952
2050	$39,647,462	-$2,103,646	$52,582,230	$0	$90,126,046

Year	Passenger Operator Costs	Utility Users Fee	Diesel Fuel Tax Impact	Local Sales Tax Impact	Fiscal Impact
Total	$491,748,616	-$30,823,891	$488,505,932	-$411,938,661	$537,491,996

4.2 State Government

4.2.1 Locomotive Operator Costs

The Proposed Regulation would have a small fiscal impact to state government relative to the total estimated cost of the Proposed Regulation. Locally operated passenger railroads and state agencies that own locomotives will have increased costs, as shown in Table 4.3. Staff calculated the cost of the Proposed Regulation to the state using passenger operators' specific equipment, maintenance, and operational data. California High Speed Rail, once operational, is expected to operate ZE passenger locomotives exclusively and would therefore not be subject to the Proposed Regulation as long as their fleet remains entirely ZE.

The assumptions underlying the direct costs to state government are identical to those identified in Section 3 of the SRIA. From 2023 to 2050, the cost to state government passenger operators due to the Proposed Regulation is estimated to be about $449 million. Table 4.4 shows the estimated direct costs to state government locomotive owners from 2023 to 2050.

Table 4.4: Total Direct Equipment and Infrastructure-Related Cost to State Government from 2023 to 2050 (2019$)

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Hydrogen Fuel Costs	Geo-Tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2023	$0	$0	-$239,941	$0	$0	$0	$0	$0	$0	$0	$0	$0	-$239,941
2024	$2,647,790	$0	-$239,941	$0	$0	$0	$0	-$136,298	$0	$38,459	$4,523	$0	$2,314,533
2025	$5,001,380	$0	-$174,301	$0	$0	$0	$0	-$121,154	$0	$38,459	$4,523	$0	$4,748,907
2026	$5,295,579	$0	-$122,479	$0	$0	$0	$0	-$124,633	$0	$38,459	$4,523	$0	$5,091,450
2027	$6,766,573	$0	-$123,870	$0	$0	$0	$0	$175,312	$0	$38,459	$4,523	$0	$6,860,996
2028	$8,237,567	$0	-$92,840	$0	$0	$0	$0	-$89,023	$0	$38,459	$4,523	$0	$8,098,686
2029	$11,630,661	$544,017	-$61,810	$0	$0	$0	$0	-$17,805	-$783,405	$38,459	$4,523	$0	$11,354,640
2030	$12,140,605	$585,864	-$55,403	$103,259	-$2,754,649	$7,117,520	$0	$484,614	$0	$38,459	$3,957	$0	$17,664,228
2031	$12,140,605	$585,864	-$53,706	$111,202	-$2,814,279	$6,720,785	$0	$0	$0	$38,459	$3,914	$0	$16,732,845
2032	$8,610,219	$585,864	-$53,706	$111,202	-$2,820,824	$6,318,687	$0	$0	$0	$38,459	$3,914	$0	$12,793,816
2033	$8,610,219	$585,864	-$129,253	$111,202	-$2,820,824	$5,916,589	$0	$621,544	$0	$38,459	$3,914	$0	$12,937,715
2034	$6,845,026	$585,864	-$129,253	$111,202	-$2,820,824	$5,686,818	$0	$0	$0	$38,459	$3,914	$0	$10,321,207
2035	$6,845,026	$585,864	-$167,026	$111,202	-$2,820,824	$5,514,490	$0	$310,772	$0	$38,459	$3,914	$0	$10,421,878
2036	$4,197,237	$585,864	-$167,026	$111,202	-$2,849,465	$5,338,011	$0	$0	$0	$38,459	$3,914	$0	$7,258,197
2037	-$1,392,541	$585,864	-$167,026	$111,202	-$2,868,827	$5,161,532	$0	$0	$0	$38,459	$3,914	$0	$1,472,578
2038	-$1,686,740	$585,864	-$236,277	$111,202	-$2,893,071	$4,985,053	$0	$569,749	$0	$38,459	$3,914	$0	$1,478,153
2039	-$3,157,734	$585,864	-$236,277	$111,202	-$2,917,926	$4,808,574	$0	$0	$0	$38,459	$3,914	$0	-$763,924
2040	-$4,628,728	$585,864	-$236,277	$111,202	-$2,918,056	$4,632,095	$0	$0	$0	$38,459	$3,914	$0	-$2,411,527

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Hydrogen Fuel Costs	Geo-Tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Costs	Total
2041	$20,535,079	$2,929,321	-$236,277	$111,202	-$2,936,714	$4,455,616	$0	-$1,547,163	$0	$38,459	$3,914	$0	$23,353,437
2042	$20,025,134	$2,929,321	-$211,208	$556,012	-$18,011,712	$25,866,772	$0	$0	$0	$38,459	$1,479	$0	$31,194,257
2043	$20,025,134	$2,929,321	-$211,208	$556,012	-$18,120,954	$24,799,981	$0	$0	$0	$38,459	$1,479	$0	$30,018,224
2044	$23,555,520	$2,929,321	-$211,208	$556,012	-$18,262,685	$23,733,191	$0	$0	$0	$38,459	$1,479	$0	$32,340,089
2045	$23,555,520	$2,929,321	-$211,208	$556,012	-$18,513,490	$22,666,401	$0	$0	$0	$38,459	$1,479	$0	$31,022,494
2046	$25,320,713	$2,929,321	-$211,208	$556,012	-$18,524,544	$21,599,611	$0	$0	$0	$38,459	$1,479	$0	$31,709,842
2047	$25,320,713	$2,929,321	-$211,208	$556,012	-$18,697,493	$20,532,820	$0	$0	$0	$38,459	$1,479	$0	$30,470,103
2048	$29,910,215	$3,305,948	-$211,208	$556,012	-$18,856,178	$19,466,030	$0	-$248,651	$0	$38,459	$1,479	$0	$33,962,106
2049	$37,225,959	$3,096,711	-$207,179	$627,499	-$20,653,222	$20,030,075	$0	-$221,023	$0	$38,459	$1,087	$0	$39,938,367
2050	$37,225,959	$3,054,863	-$203,597	$691,043	-$22,720,779	$20,641,871	$0	$0	$0	$38,459	$739	$0	$38,728,559
Total	$350,802,690	$36,951,294	-$4,811,919	$6,537,109	-$206,597,338	$265,992,525	$0	-$343,759	-$783,405	$1,038,390	$86,324	$0	$448,871,912

4.2.1.1 Diesel Fuel Tax

Displacing diesel with electricity or hydrogen would decrease the total amount of diesel fuel dispensed in the state, resulting in a reduction in diesel fuel tax revenue collected by state government. For this analysis, staff used the combined state and local sales tax rate of 8.6 percent, which is a weighted average based on county-level output, with 3.94 percent[149] going towards state sales tax and 4.67 percent[150] going towards local sales tax.

4.2.1.2 Energy Resource Fee

The energy resources fee is a $0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities.[151] 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.

4.2.1.3 CARB Administrative Charge

The Proposed Regulation includes a yearly administrative charge (see Section 3) that would impose a direct, on-going cost to locomotive owners. The fee schedule is presented in Section 3.1.5 The proposed charge would result in revenue to the state to offset costs to CARB to implement and enforce the Proposed Regulation.

4.2.1.4 State Sales Tax

Sales tax is levied in California to fund a variety of programs at the local and state levels. The Proposed Regulation would result in the sale of more locomotives from manufacturers in and outside of California at more expensive prices and new ZE infrastructure in California, which would result in a direct increase in sales tax revenue collected by the state. Additionally, Class I line haul locomotive purchases are generally exempt from state sales and use taxes,[152] which results in much lower sales tax benefits than realized with other mobile source regulations. For this analysis, staff used the combined state and local sales tax rate of

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[149] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate, last accessed January 29, 2021. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm)

[150] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October 2020. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm)

[151] California Department of Tax and Fee Administration, 2022 Electrical Energy Surcharge Rate, last accessed February 2022. (web link: https://www.cdtfa.ca.gov/formspubs/L793-2022.pdf)

[152][152] California Department of Tax and Fee Administration, Regulation 1620, Interstate and Foreign Commerce, last accessed February 2, 2022. (web link: https://www.cdtfa.ca.gov/lawguides/vol1/sutr/sales-and-use-tax-regulations-art11-all.html)

8.6 percent, which is a weighted average based on county-level output, with 3.94 percent[153] going towards state sales tax and 4.67 percent[154] going towards local sales tax.

4.2.2 Costs to CARB

4.2.2.1 Additional Staffing

The following additional permanent, full-time CARB staff would be needed to successfully implement and enforce the Proposed Regulation:

- 1.0 Air Pollution Specialist, and 1.0 Air Resources Technician II (ART II), beginning in Fiscal Year 2023-2024 to implement the Proposed Regulation. Duties would include assisting locomotive operators with registration and reporting, reviewing Alternative Compliance Plans and exemptions as well as providing technical assistance.
- 3.0 Air Pollution Specialist, and 3.0 ART II, positions beginning in fiscal year 2023-2024 to conduct enforcement activities, such as issuing and processing citations and set up. The need for increased enforcement would result from additional requirements in the Proposed Regulation requiring reporting, locomotive Spending Account funds, IUOR enforcement, and enforcement penalties.

CARB will seek authorization to use fees collected to augment staff once the Board acts on the proposal. Table 4.5 shows the total number of positions needed by CARB (existing and new) and the cost for each classification in 2021.

[153] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate, last accessed January 29, 2021. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm)

[154] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October, 2020. (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm)

Table 4.5: Total (Existing and New) Number of CARB Positions Needed and 2021 Costs (2019$)

Position	Number of Positions Needed	Initial Budget Year Cost (Annual Salary plus Benefits per Position)	Ongoing Cost (Annual Salary plus Benefits per Position)
Air Resources Supervisor (existing)	0.83	$238,473	$237,473
Staff Air Pollution Specialist (existing)	0.75	$219,920	$218,920
Air Pollution Specialist (new)	4.0	$196,729	$195,729
Air Pollution Specialist (existing)	2.0	$196,729	$195,729
Air Resource Engineer (existing)	2.0	$205,078	$204,078
Air Resources Technician II (new)	4.0	$98,401	$97,401
Air Resources Technician II (existing)	1.0	$98,401	$97,401

Table 4.6 shows the estimated staffing costs expected to be incurred by CARB from 2023 to 2050. SB 854 authorizes CARB to assess fees to cover its reasonable costs, with specific considerations, on all off-road and other mobile sources certification and compliance programs not currently covered under the existing fee regulation authority (Health and Safety Code section 43019).[155] The Proposed Regulation includes yearly CARB administrative charge for each locomotive operated in California. CARB intends to seek authority to use the collected fees to cover program costs as allowed by SB 854.

[155] California Health and Safety Code § 43019.1, Division 26, Senate Bill No. 854, July 27, 2018. (web link: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB854)

Table 4.6: Estimated Incremental Annual Staffing Costs Incurred by CARB from 2023 to 2050

Year	Annual Incremental CARB Staffing Costs	Total Annual CARB Staffing Costs
2023	$0	$0
2024-2050	$1,177,521	$2,435,085
2050	$1,172,521	$2,435,085
Total	$31,663,062	$65,747,307

4.2.3 Fiscal Impact on State Government

From 2023 to 2050, the cost to state government due to the Proposed Regulation is estimated to be $1.37 billion resulting from the cost of passenger locomotive purchases required of state government operators (e.g., state-operated Amtrak lines), an estimated 23 percent cost share of local passenger operators' capital costs, and reduced tax revenues. CARB would incur costs of approximately $31.7 million.

State government would also see a direct increase in revenue from energy resources fees, CARB administrative charges, and state sales tax of approximately $417 million and a decrease in diesel fuel tax revenue of about $1.3 billion. This foregone revenue, which supports important programs in the state, may eventually be replaced by revenue from other sources, in which case the associated negative job impacts to state and local government, described in Section 5.3.1, 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 corresponds to substantial health benefits for California communities and long-term cost benefits to ZE locomotive owners who are anticipated to have lower operational costs from the lower fuel, maintenance, and repair expenses of ZE locomotives. Table 4.7 shows the total fiscal impact to state government agencies which is estimated to be -$1.37 billion from 2023 to 2050 (costs are show as positive values, savings are negative values). CARB will seek authorization to use collected fees to offset costs incurred to implement and enforce the Proposed Regulation.

Table 4.7: Estimated Fiscal Impact to State Government from 2023 to 2050 (2019$)

Year	Costs to CARB	CARB Admin Charge	Direct Locomotive Operator Costs	Diesel Fuel Tax	Energy Resources Fee	State Sales Tax	Total Fiscal Impact
2023	$0	$0	-$239,941	$0	$0	-$406,547	-$646,488
2024	$1,177,521	-$2,982,480	$2,314,533	$0	$0	-$8,535,782	-$8,026,209
2025	$1,172,521	-$2,928,250	$4,748,907	-$0	$0	-$8,087,728	-$5,094,550
2026	$1,172,521	-$2,935,900	$5,091,450	$0	$0	-$5,381,205	-$2,053,134
2027	$1,172,521	-$2,958,680	$6,860,996	$0	$0	-$6,088,540	-$1,013,702
2028	$1,172,521	-$2,974,320	$8,098,686	$0	$0	-$5,617,741	$679,146
2029	$1,172,521	-$2,968,710	$11,354,640	$0	$0	-$59,585,203	-$50,026,752
2030	$1,172,521	-$2,678,860	$17,664,228	$4,510,388	-$34,693	-$12,167,982	$8,465,603
2031	$1,172,521	-$2,739,380	$16,732,845	$5,409,235	-$42,998	-$947,662	$19,584,561
2032	$1,172,521	-$2,803,980	$12,793,816	$5,552,435	-$44,311	-$2,338,830	$14,331,650
2033	$1,172,521	-$2,864,330	$12,937,715	$6,120,001	-$49,677	-$1,531,422	$15,784,808

Year	Costs to CARB	CARB Admin Charge	Direct Locomotive Operator Costs	Diesel Fuel Tax	Energy Resources Fee	State Sales Tax	Total Fiscal Impact
2034	$1,172,521	-$2,931,990	$10,321,207	$6,326,816	-$51,630	$1,565,538	$16,402,462
2035	$1,172,521	-$2,635,680	$10,421,878	$23,937,877	-$52,590	-$22,356,297	$10,487,709
2036	$1,172,521	-$2,455,650	$7,258,197	$36,098,991	-$53,573	-$24,832,538	$17,187,947
2037	$1,172,521	-$2,250,970	$1,472,578	$49,563,081	-$54,686	-$4,959,116	$44,943,408
2038	$1,172,521	-$2,241,110	$1,478,153	$53,720,022	-$56,370	-$12,356,566	$41,716,650
2039	$1,172,521	-$2,178,550	-$763,924	$60,677,057	-$57,332	-$10,893,376	$47,956,396
2040	$1,172,521	-$2,149,820	-$2,411,527	$65,864,314	-$59,757	-$7,813,474	$54,602,256
2041	$1,172,521	-$2,137,920	$23,353,437	$70,367,995	-$60,794	-$38,416,327	$54,278,912
2042	$1,172,521	-$2,121,260	$31,194,257	$79,331,217	-$61,883	-$7,684,592	$101,830,260
2043	$1,172,521	-$2,114,120	$30,018,224	$83,808,888	-$62,965	-$7,861,805	$104,960,743
2044	$1,172,521	-$2,106,470	$32,340,089	$88,454,656	-$64,071	-$8,055,128	$111,741,596

Year	Costs to CARB	CARB Admin Charge	Direct Locomotive Operator Costs	Diesel Fuel Tax	Energy Resources Fee	State Sales Tax	Total Fiscal Impact
2045	$1,172,521	-$2,098,820	$31,022,494	$93,401,764	-$65,202	-$8,216,231	$115,216,527
2046	$1,172,521	-$2,090,660	$31,709,842	$98,087,100	-$66,357	-$4,655,864	$124,156,582
2047	$1,172,521	-$2,122,110	$30,470,103	$101,081,818	-$67,537	-$21,716,625	$108,818,170
2048	$1,172,521	-$1,978,970	$33,962,106	$113,390,221	-$69,434	-$31,327,814	$115,148,630
2049	$1,172,521	-$1,863,540	$39,938,367	$125,021,302	-$79,128	-$29,717,736	$134,471,785
2050	$1,172,521	-$1,750,320	$38,728,559	$136,688,572	-$87,516	$0	$174,751,815
Total	$31,663,062	-$66,062,850	$448,871,912	$1,307,413,750	-$1,242,504	-$349,986,591	$1,370,656,779

Note: Costs are shown as positive values, and increased revenue shown as negative values.

4.3 Federal Government

4.3.1 Support for Local and State Government Operators

The Proposed Regulation would have a small fiscal impact to federal government agencies that provide funding for state and local locomotives, relative to the total estimated cost of the Proposed Regulation.

As Figure 4.1 illustrates, in 2019, about 31 percent of all capital funds for all U.S. public transit agencies came from federal sources. Local and state governments funded almost 69 percent of capital funding and directly generated funds from transit agencies, including fares and marketing, only accounted for about 10 percent of all capital expenditures.[156] Staff assumes that passenger operators will continue using federal, state, and local grants to fund most capital expenses throughout the implementation of the Proposed Regulation.

Assuming a 31 percent cost share of new passenger locomotive purchases, staff determined the cost to the federal government to be approximately $356 million. Table 4.8 shows the estimated direct costs to federal government associated with their share of state and local passenger locomotive purchases from 2023 to 2050.

[156] Federal Transit Administration, National Transit Summaries and Trends 2019. (web link: https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307)

Table 4.8: Total Direct Equipment and Infrastructure-Related Cost to Federal Government from 2023 to 2050 (2019$)

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Total
2023	$0	$0	-$161,863	$0	-$161,863
2024	$2,360,872	$0	-$161,863	$0	$2,199,009
2025	$4,459,424	$0	-$46,583	$0	$4,412,841
2026	$4,721,743	$0	$44,431	$0	$4,766,174
2027	$6,033,339	$0	$41,987	$0	$6,075,326
2028	$7,344,934	$0	$96,484	$0	$7,441,418
2029	$10,370,348	$485,066	$150,981	$0	$11,006,395
2030	$10,825,034	$522,379	$162,233	$181,350	$11,690,996
2031	$10,825,034	$522,379	$165,214	$195,300	$11,707,927
2032	$7,677,205	$522,379	$165,214	$195,300	$8,560,098
2033	$7,677,205	$522,379	$32,534	$195,300	$8,427,418
2034	$6,103,291	$522,379	$32,534	$195,300	$6,853,504
2035	$6,103,291	$522,379	-$33,806	$195,300	$6,787,164
2036	$3,742,419	$522,379	-$33,806	$195,300	$4,426,292
2037	-$1,241,644	$522,379	-$33,806	$195,300	-$557,770
2038	-$1,503,963	$522,379	-$155,429	$195,300	-$941,713
2039	-$2,815,558	$522,379	-$155,429	$195,300	-$2,253,308
2040	-$4,127,153	$522,379	-$155,429	$195,300	-$3,564,904

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Total
2041	$18,309,872	$2,611,896	-$155,429	$195,300	$20,961,639
2042	$17,855,185	$2,611,896	-$111,400	$976,500	$21,332,181
2043	$17,855,185	$2,611,896	-$111,400	$976,500	$21,332,181
2044	$21,003,014	$2,611,896	-$111,400	$976,500	$24,480,010
2045	$21,003,014	$2,611,896	-$111,400	$976,500	$24,480,010
2046	$22,576,929	$2,611,896	-$111,400	$976,500	$26,053,925
2047	$22,576,929	$2,611,896	-$111,400	$976,500	$26,053,925
2048	$26,669,106	$2,947,711	-$111,400	$976,500	$30,481,917
2049	$33,192,107	$2,761,147	-$104,324	$1,102,050	$36,950,981
2050	$33,192,107	$2,723,835	-$98,034	$1,213,650	$37,031,558
Total	$312,789,269	$32,947,205	-$1,183,994	$11,480,850	$356,033,330

4.3.2 Fiscal Impacts to Federal Government

Staff does not anticipate any additional fiscal impact on federal government agencies other than the direct costs shown in Table 4.8. The fiscal impact to federal government agencies from 2023 to 2050 is estimated to be approximately $356 million.

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 will result in costs and cost-savings as businesses comply with the regulation. As described above, the direct costs of the Proposed Regulation include capital costs for locomotives and infrastructure, ongoing costs and cost -savings for maintenance and fuels, reporting and registration costs, and CARB's administrative charge. These changes in costs will result in direct changes in expenditures in the economy as costs are passed on to other businesses and individuals. These changes in

expenditures by users of rail transportation will indirectly affect employment, output, and investment in sectors that supply goods and provide services to the railroads.

These direct and indirect effects 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 are presented in this section. The total economic impacts of the Proposed Regulation are simulated relative to the baseline using cost data described in Section 3 of the SRIA. The analysis focuses on incremental change in major macroeconomic indicators from 2023 to 2050 including employment, output growth, and Gross State Product (GSP). The years of the analysis are used to simulate the Proposed Regulation through at least twelve 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.[157] 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.[158, 159]

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 2021.[160, 161, 162, 163] After the Department of Finance economic forecasts end in 2025, staff

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

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

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

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

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

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

[163] 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.

made assumptions that post-2025, economic variables would continue to grow at the same rate projected in the REMI baseline forecasts.

5.2 Inputs 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 estimated in Section 3 and the non-mortality health benefits estimated in Section 2 are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[164]

The direct impacts of the Proposed Regulation include capital costs for locomotives and infrastructure, ongoing costs and cost-savings for maintenance and operation, and various administrative costs associated with registration, reporting, and program implementation and enforcement, and increased revenue from scrappage and sale of older locomotives. The Proposed Regulation also requires operators to hold funds within a Spending Account which will impose an opportunity cost on operators. Capital, operational, administrative, and opportunity costs will impact California's rail transportation industry and are input into the economic model as a change in production costs or changes in spending, with specific assumptions dependent on the impacted operator.

For Class I line haul operators, changes in costs are modeled as increased production costs that are spread across all industries as well as state, local, and federal government based on each industries' use of rail transportation as an intermediate input.[165] Within the REMI model, changes in production costs within California impact the costs of production relative to the rest of the nation. Because Class I line haul operators have a national fleet, staff determined the most appropriate assumption for Class I line haul costs would be to illustrate costs as passed through to businesses that utilize rail transportation, instead of introducing additional aspects of in-state and out-of-state competition for Class I rail.

Costs to Class III and industrial switchers are modeled as increased production costs to the California rail transportation industry (NAICS 482). Passenger rail is operated by local and state government with a portion of funding coming from the federal government. As described in Section 3.4.2, staff do not anticipate increases in costs will be reflected in increased fares. In this modeling exercise, costs to passenger rail are modeled as changes in government spending at the local, state, and federal government level.

Costs incurred by locomotive operators would result in corresponding changes in demand for industries supplying those goods or services as shown in Table 5.1. The Proposed

[164] Refer to Technical Appendix: Macroeconomic Modeling Inputs for a full list of REMI inputs for this analysis.

[165] Based on REMI's National Input Output table that is scaled by California rail transportation output. See the macroeconomic appendix for specific scaling factors.

Regulation would result in additional demand for new locomotives and is modeled as increased demand for railroad and rolling stock manufacturing (NAICS 3365). Staff assume that approximately 1 percent of this demand would be met by in state manufacturers. Demand for ZE infrastructure is modeled as increased demand for construction (NAICS 23), electrical equipment manufacturing (NAICS 3353) for electric infrastructure, and industrial machinery and equipment (NAICS 4238), liquefied petroleum gas production/distribution (NAICS 2212), industrial gas manufacturing (NAICS 3251), and other electronic and precision equipment repair and maintenance (NAICS 8112) for hydrogen infrastructure. The Proposed Regulation results in changes in diesel, electricity, and hydrogen demand which are modeled as changes in demand for petroleum and coal products manufacturing (NAICS 324), electric power generation, transmission, and distribution (NAICS 2211), and basic chemical manufacturing (NAICS 3251) respectively. The increased needs for reporting and recordkeeping are modeled as increased demand for office and administrative services (NAICS 5611). The geo-location database upgrade, location service subscription, and related hardware is modeled as increased demand for management, scientific, and technical consulting services (NAICS 5416), computer systems design and related services (NAICS 5415) and navigational, measuring, and control instruments manufacturing (NAICS 3345) respectively.

Table 5.1: Sources of Changes in Production Cost and Final Demand by Industry

Source of Cost or Savings	Industries with Change in Production Cost or Spending	Industries with Changes in Final Demand
Locomotive purchase, sale, and scrappage	Rail transportation (482), state government, local government, federal government, and all*	Railroad and rolling stock manufacturing (3365)
Locomotive maintenance and operation	Rail transportation (482), state government, local government, federal government, and all*	Railroad and rolling stock manufacturing (3365)
Diesel	Rail transportation (482), state government, local government, federal government, and all*	Petroleum and coal products manufacturing (324)
Electricity	Rail transportation (482), state government, local government, federal government, and all*	Electric power generation, transmission and distribution (2211)
Hydrogen	Rail transportation (482), state government, local government, federal government, and all*	Basic chemicals manufacturing (3251)

Source of Cost or Savings	Industries with Change in Production Cost or Spending	Industries with Changes in Final Demand
Infrastructure	Rail transportation (482), state government, local government, federal government, and all*	Construction (23), electrical equipment manufacturing (3353), industrial machinery and equipment (4238), liquefied petroleum gas production/distribution (2212), industrial gas manufacturing (3251), and other electronic and precision equipment repair and maintenance (8112)
Reporting, recordkeeping	Rail transportation (482), state government, local government, federal government, and all*	Office administrative services and facilities support services (5611, 5612)
Locomotive tracking hardware, database upgrades, and subscription services	Rail transportation (482), state government, local government, federal government, and all*	Navigational, measuring electromedical and control instruments manufacturing (NAICS 3345), management, scientific, and technical consulting services (5416), computer systems design and related services (5415)

In addition to these changes to production costs, spending, and demand, there will also be economic impacts because of the fiscal effects. This includes administrative charge revenue, tax associated with the purchase of in-state equipment, changes in fuels that are used, changes in implementation and enforcement costs, and changes in fee revenues. These changes are input as a change in state and local government spending, assuming these revenue changes are not offset elsewhere. Additional CARB staff to implement the Proposed Regulation is modeled as an increase in government employment and a decrease in State government spending to reflect opportunity costs of additional hires. As this implementation cost would be covered by the administrative charges collected, the associated economic impacts would be mostly offset.

The non-mortality health benefits resulting from emissions reductions of the Proposed Regulation reduce healthcare costs for individuals. This reduction in healthcare cost is modeled as a decrease in spending on hospitals, with a reallocation of the spending towards other goods and increased savings. The GHG emission reduction benefits as valued through the SC-CO_2 represent the avoided damages from climate change worldwide. These benefits fall outside the scope of the 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 California's economy. These results represent the annual incremental change from the implementation of the Proposed Regulation relative to the baseline scenario. California's economy is anticipated 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 in the tables are reported in five-year intervals from 2025 through 2050.

5.3.1 California Employment Impacts

Table 5.2 presents the impacts of the Proposed Regulation on total employment in California across all private industries and the public sector and for directly impacted industry. Figure 5.1 illustrates the trends for each calendar year by major sector. 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 across the economy, which is composed of positive impacts for some industries and negative impacts for others.

The Proposed Regulation is estimated to result in a decrease in employment growth in California most years of the assessment. These changes in employment represent about 0.01 percent of baseline California employment in 2025, grow to represent a decrease of 0.06 percent of baseline California employment in 2035, and diminishes to be approximately 0.02 percent of baseline California employment by 2050. The patterns of decreasing employment growth closely track the annual costs of the Proposed Regulation as the direct impacts of the Proposed Regulation more broadly impact businesses and individuals in California. In 2023 and 2024, the modeled results show an increase in employment. This is primarily associated with increase revenue from the sale and scrappage of locomotives and the associated decrease in maintenance costs in those years.

The rail transportation industry in California bears the greatest direct cost of the regulation and is also estimated to see the greatest impact to employment growth. As shown in Table 5.2, the Proposed Regulation results in a decrease in employment growth in 2025 of 15 jobs, a decrease in employment growth in 2040 of 245 jobs, and a decrease in employment growth in 2050 of 74 jobs; a decrease of about two percent in the years of greatest impact.

The Proposed Regulation is anticipated to result in an increase in demand for several industries including: railroad and rolling stock manufacturing; construction; natural gas distribution (for hydrogen supply); electric equipment manufacturing; electric equipment manufacturing; electric power generation, transmission and distribution; basic chemical manufacturing; office administrative services; navigational instruments manufacturing; management, scientific, and technical consulting services; and computer systems design and related services. In general, increased demand in a specific industry will be associated with

increases in employment growth. However, rail transportation is an intermediate input for many of these industries and industries will be impacted as the costs of the Proposed Regulation are passed on. As a result, the annual impacts to these industries are mixed with increased employment growth in some years and decreases in employment growth in others.

For example, the Proposed Regulation is anticipated to increase demand in the construction sector starting in 2030 as new electric and hydrogen infrastructure is installed. However, the construction sector also relies heavily on rail transportation as an intermediate input. As shown in Figure 5.1, the Proposed Regulation is estimated to have positive impacts on employment within the construction sector from 2047 through 2050. In 2029, the magnitude of the negative impact is significantly lower than other years, which is associated more generally with additional revenue to the rail transportation industry associated with scrap and sale of older locomotives. From 2047 through 2050, the increases in employment growth are a result of increased demand for construction outweighing the negative impacts of increased costs to rail transportation in general.

Industries that are anticipated to face a reduction in demand because of the Proposed Regulation would be anticipated to see a decrease in employment growth. If these industries also rely on rail transportation as an intermediate good, there would be additional decreases in employment growth associated with the costs of the direct costs of the regulation. The petroleum and coal products manufacturing industry is anticipated to see a decrease in employment growth for both of these reasons and is anticipated to see a decrease in employment, relative to the baseline, of 0.71 percent in 2050.

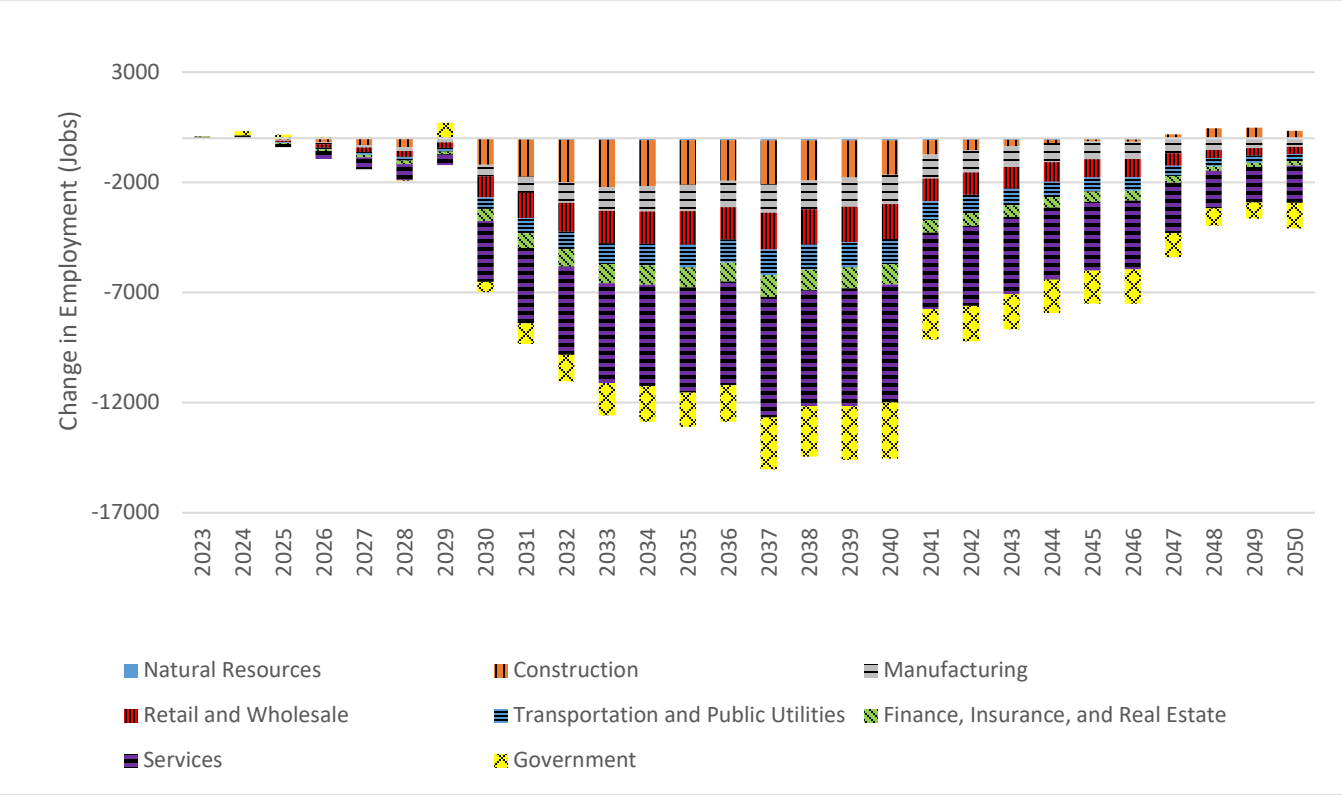
Table 5.2: Employment Changes of Proposed Regulation 2023-2050

Industry	Units	2025	2030	2035	2040	2045	2050
CA statewide	Total Employment (millions)	25.9	26.0	26.3	26.9	27.7	28.7
CA statewide	Percent change	-0.01%	-0.04%	-0.06%	-0.03%	-0.02%	-0.02%
CA statewide	Change in jobs	-247	-6,991	-13,101	-14,543	-7,509	-3,760
Rail transportation	Percent change	-0.13%	-0.98%	-2.21%	-2.30%	-1.19%	-0.76%
Rail transportation	Change in jobs	-15	-112	-243	-245	-123	-74
Railroad rolling stock manufacturing	Percent change	0.15%	0.18%	-0.06%	-0.28%	-0.16%	-0.13%

Industry	Units	2025	2030	2035	2040	2045	2050
Railroad rolling stock manufacturing	Change in jobs	1	1	0	-2	-1	0
Construction	Percent change	-0.01%	-0.09%	-0.15%	-0.12%	-0.01%	0.01%
Construction	Change in jobs	-69	-1,159	-2,023	-1,554	-88	340
Natural gas distribution	Percent change	0.00%	0.00%	-0.04%	-0.05%	-0.03%	-0.03%
Natural gas distribution	Change in jobs	0	0	-5	-5	-3	-1
Electric equipment manufacturing	Percent change	0.00%	0.02%	-0.05%	-0.06%	-0.04%	-0.03%
Electric equipment manufacturing	Change in jobs	0	2	-4	-5	-3	-1
Electric power generation, transmission, and distribution	Percent change	0.00%	-0.01%	-0.02%	-0.03%	0.01%	0.04%
Electric power generation, transmission, and distribution	Change in jobs	-1	-2	-8	-9	3	16
Basic chemical manufacturing	Change in jobs	0.00%	-0.01%	0.51%	1.41%	1.53%	1.57%
Basic chemical manufacturing	Percent change	0	-1	37	106	118	128
Petroleum and coal products manufacturing	Percent change	0.00%	-0.07%	-0.25%	-0.48%	-0.55%	-0.71%
Petroleum and coal products manufacturing	Change in jobs	0	-9	-28	-53	-59	-71
Office administrative services; facilities support services	Percent change	0.01%	-0.01%	-0.03%	-0.03%	-0.02%	-0.02%

Industry	Units	2025	2030	2035	2040	2045	2050
Office administrative services; facilities support services	Change in jobs	7	-14	-37	-46	-25	-12
Navigational, measuring, electromedical and control instruments manufacturing	Percent change	0.00%	-0.01%	-0.02%	-0.03%	-0.02%	-0.01%
Navigational, measuring, electromedical and control instruments manufacturing	Change in jobs	-1	-10	-19	-20	-11	-5
Management, scientific, and technical consulting services	Percent change	0.00%	-0.02%	-0.03%	-0.04%	-0.02%	-0.02%
Management, scientific, and technical consulting services	Change in jobs	-3	-70	-139	-166	-103	-61
Computer systems design and related services	Percent change	0.00%	-0.01%	-0.02%	-0.03%	-0.02%	-0.02%
Computer systems design and related services	Change in jobs	-1	-60	-165	-240	-199	-152
State and local government	Percent change	0.01%	-0.02%	-0.06%	-0.10%	-0.06%	-0.06%
State and local government	Change in jobs	164	-424	-1,497	-2,492	-1,466	-1,163

Figure 5.1: Change in Employment Between 2023-2050 Associated with Proposed Regulation



5.3.2 California Business Impacts

Gross output is used as a measure for business impacts because as it represents an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output is the sum of the amount of production, including all intermediate goods purchased as well as value added (compensation and profit), across all private industries and the public sector, and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth.

The results of the analysis show a decrease in output growth of $61 million in 2025, a decrease in output growth of $4.1 billion in 2040, and a decrease in output growth of $1.7 billion in 2050 as shown in Table 5.3. This represents a decrease in output of approximately 0.06 percent relative to baseline levels in the years of greatest impact. The results for each directly impacted industry are also shown in Table 5.3.

Table 5.3: Gross Output Changes of Proposed Regulation 2023-2050

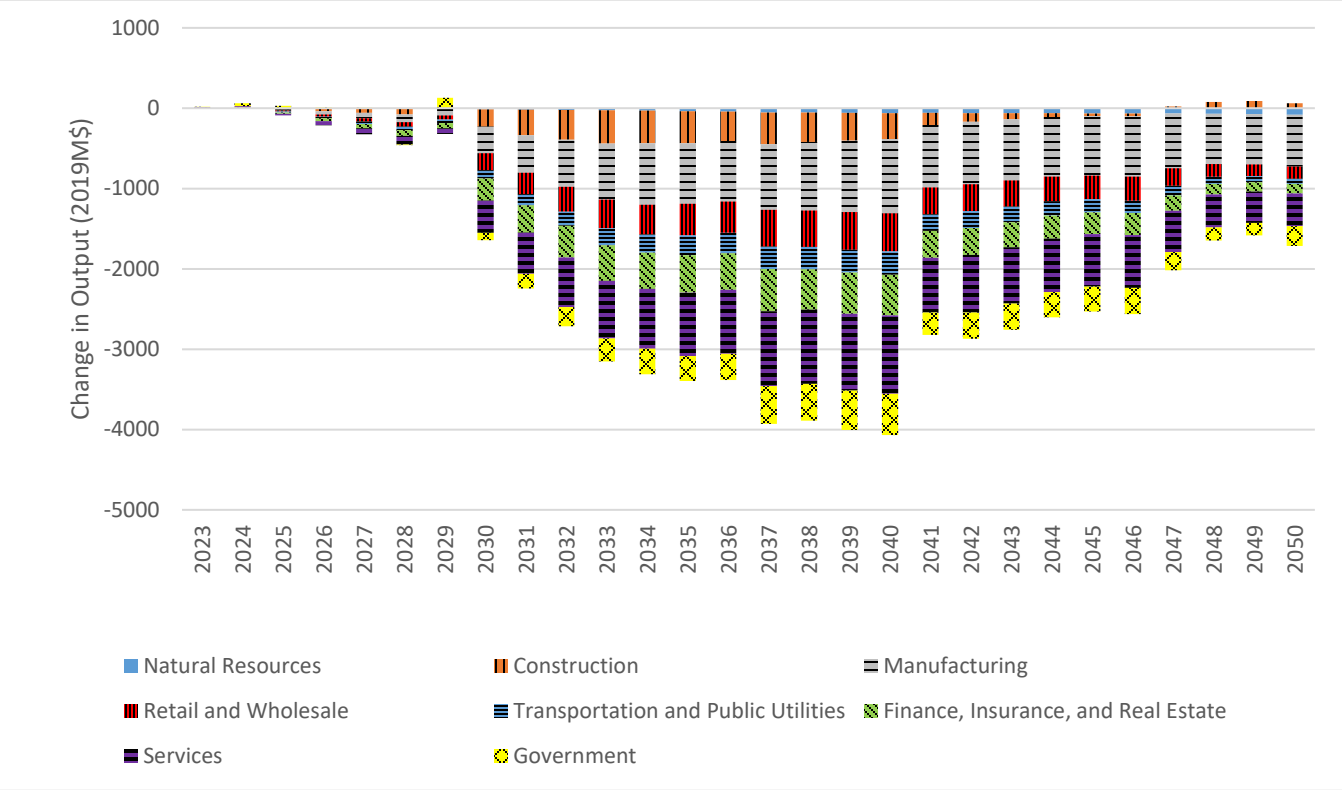
Industry	Units	2025	2030	2035	2040	2045	2050
CA statewide	Total Output (2019B$)	5,679	6,034	6,472	7,084	7,830	8,691
CA statewide	Percent change	-0.01%	-0.04%	-0.06%	-0.03%	-0.02%	-0.02%
CA statewide	Change (2019M$)	-61	-1,642	-3,394	-4,071	-2,531	-1,654
Rail transportation	Percent change	-0.13%	-0.99%	-2.24%	-2.36%	-1.25%	-0.77%
Rail transportation	Change (2019M$)	-5	-37	-85	-93	-51	-33
Railroad rolling stock manufacturing	Percent change	0.16%	0.19%	-0.06%	-0.28%	-0.17%	-0.09%
Railroad rolling stock manufacturing	Change (2019M$)	3	3	-1	-5	-3	-2
Construction	Percent change	-0.01%	-0.09%	-0.16%	-0.12%	-0.01%	0.02%
Construction	Change (2019M$)	-12	-217	-397	-325	-34	60
Natural gas distribution	Percent change	0.00%	0.00%	-0.05%	-0.05%	-0.03%	-0.02%
Natural gas distribution	Change (2019M$)	0	0	-5	-6	-4	-2
Electric equipment manufacturing	Percent change	0.00%	0.02%	-0.06%	-0.07%	-0.04%	-0.02%
Electric equipment manufacturing	Change (2019M$)	0	0	-1	-1	-1	-1

Industry	Units	2025	2030	2035	2040	2045	2050
Electric power generation, transmission, and distribution	Percent change	0.00%	-0.01%	-0.03%	-0.03%	0.01%	0.05%
Electric power generation, transmission, and distribution	Change (2019M$)	-2	-3	-14	-18	4	33
Basic chemical manufacturing	Percent change	0.00%	-0.01%	0.50%	1.41%	1.54%	1.61%
Basic chemical manufacturing	Change (2019M$)	-1	-2	142	433	517	595
Petroleum and coal products manufacturing	Percent change	0.00%	-0.08%	-0.25%	-0.49%	-0.56%	-0.70%
Petroleum and coal products manufacturing	Change (2019M$)	-2	-74	-262	-555	-695	-946
Office administrative services; facilities support services	Percent change	0.01%	-0.01%	-0.03%	-0.04%	-0.02%	-0.01%
Office administrative services; facilities support services	Change (2019M$)	1	-2	-6	-8	-5	-3
Navigational, measuring, electromedical and control instruments manufacturing	Percent change	0.00%	-0.01%	-0.03%	-0.03%	-0.02%	-0.01%
Navigational, measuring, electromedical and control instruments manufacturing	Change (2019M$)	-1	-6	-14	-17	-12	-7

Industry	Units	2025	2030	2035	2040	2045	2050
Management, scientific, and technical consulting services	Percent change	0.00%	-0.02%	-0.03%	-0.04%	-0.02%	-0.01%
Management, scientific, and technical consulting services	Change (2019M$)	0	-11	-23	-30	-20	-13
Computer systems design and related services	Percent change	0.00%	-0.01%	-0.02%	-0.03%	-0.02%	-0.02%
Computer systems design and related services	Change (2019M$)	0	-13	-37	-57	-50	-40
State and local government	Percent change	0.01%	-0.02%	-0.06%	-0.10%	-0.06%	-0.04%
State and local government	Change (2019M$)	30	-81	-291	-499	-302	-246

Figure 5.2 illustrates the impacts to output by major California sector. The trends in output changes are like the trends in employment. Industries and sectors facing direct costs or decreases in demand are estimated to see decreases in output growth. Industries that see increased demand may still see decreases in output growth as a result of the overall increased costs to the rail transportation industry. Like the results for employment, some of the industries with the greatest impact to output growth include rail transportation, construction, petroleum and coal products manufacturing, and basic chemical manufacturing. That is, industries with direct compliance costs, industries directly involved in installation of infrastructure, and the industries that would be impacted from a switch from diesel to ZE fuels. Figure 5.2 also illustrates that the manufacturing sector, while not directly impacted by the Proposed Regulation, is anticipated to see one of the larger impacts by major sector. This is because many manufacturing sectors rely on rail transportation as an intermediate good in their production processes. After the rail transportation industry, the industries with greatest negative impact in 2035, in percentage terms, are the grain and oilseed milling industry, animal food manufacturing, clay product and refractory manufacturing, sawmills and wood preservation, veneer, plywood, and engineered wood which are estimated to see a decrease of output of 0.34 percent of 0.69 percent, relative to baseline levels.

Figure 5.2: Change in Gross Output 2023-2050



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 Proposed Regulation will directly increase investment in cleaner technology locomotives and ZE infrastructure. However, the increased costs associated with the Proposed Regulation may also decrease other types of investments as it results in decreases in employment and subsequent decreases in investment by businesses in other types of structures and equipment.

The relative changes to growth in private investment for the Proposed Regulation are shown in Table 5.4 and show a decrease of private investment by about $26 million in 2025, a decrease in investment of $715 million in 2035, and a decrease in investment of $105 million in 2050. In the year of greatest impact this represents a change of approximately 0.12 percent of baseline investment.

Table 5.4: Changes to Growth in Private Investment

	2025	2030	2035	2040	2045	2050
Private Investment (2019B$)	514	550	589	642	701	767
Percent Change	-0.01%	-0.07%	-0.12%	-0.11%	-0.04%	-0.01%
Change (2019M$)	-26	-358	-715	-698	-305	-105

5.3.4 Impacts on Individuals in California

As modeled, the Proposed Regulation does not impose direct costs on individuals in California. However, the costs incurred by impacted businesses and the public sector would cascade through the economy and affect individuals. One measure of the statewide impact is the change in real personal income.

Table 5.5 shows the annual change in real personal income across all individuals in California. Total personal income decreases by $78 million in 2025, decreases by $2.3 billion in 2040, and decreases by $0.6 billion in 2050. The change in personal income can also be divided by the California population to show the average or per capita impact on personal income. Personal income decreases by $2 per person in 2025. In 2040, personal income decreases by $54 per person, corresponding to one of the years of greatest direct costs. By 2050, the impact of the Proposed Regulation on personal income lessens to approximately $15 per person.

Table 5.5: Annual Change in Real Personal Income from 2023-2050

	2025	2030	2035	2040	2045	2050
Personal Income (2019B$)	2,922	3,235	3,559	3,925	4,340	4,800
Percent Change	-0.01%	-0.05%	-0.06%	-0.04%	-0.02%	-0.03%
Change (2019M$)	-78	-1,176	-2,012	-2,341	-1,385	-643

	2025	2030	2035	2040	2045	2050
Per Capita Change (2019$)	-2	-28	-47	-54	-32	-15

5.3.5 Impacts on Gross State Product (GSP)

Gross State Product is the market value of all goods and services produced in California and is one of the primary indicators used to gauge the health of the economy. Table 5.6 shows the changes in GSP as estimated as a result of the Proposed Regulation. Under the Proposed Regulation, GSP is anticipated to decrease by $34 million in 2025, decrease by $2.2 billion in 2040, and decrease by $0.8 billion in 2050. These impacts to GSP range between a decrease of less than 0.01 percent to a decrease of 0.05 percent.

Table 5.6: Gross State Product Changes 2023-2050

	2025	2030	2035	2040	2045	2050
Gross State Product (2019B$)	3,384	3,633	3,944	4,318	4,748	5,233
Percent Change	-0.01%	-0.04%	-0.05%	-0.03%	-0.02%	-0.03%
Change (2019M$)	-34	-927	-1,893	-2,246	-1,333	-804

5.3.6 Creation or Elimination of Businesses

The Proposed Regulation does not directly result in business creation or elimination and the REMI model cannot directly estimate the creation or elimination of businesses. However, changes in the jobs and output for California and the overall costs to directly impacted businesses and to California can be used to understand some of the potential impacts.

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

Based on the modeling of changes in output and employment, businesses involved in the manufacture and installation of hydrogen infrastructure, as well as hydrogen manufacturing, may see expansions in business. To the degree that any California business are involved in the manufacture of new locomotives, these businesses may also expand to meet demands.

The greatest impacts to output and employment occur in the rail transportation industry. A large portion of the costs will be borne by Class I operators. The Class I operators are large

national corporations and are not anticipated to experience business elimination because of the Proposed Regulation. It is likely that these operators will be able to pass on costs of the Proposed Regulation across the nation. Some smaller Class III locomotive operators in California may face significant compliance costs. If these businesses are unable to pass on the costs of the Proposed Regulation to customers or if there is a significant change in demand for services, it is possible some of these businesses would be eliminated. If small businesses face cost pressures that could cause bankruptcy, CARB may issue an extension in the time required to set aside funds into the Spending Account, reduce the Spending Account contribution requirement, or provide an extension of eligibility to operate a locomotive by up to three years. Section 3 describes the impact of the regulation on typical and small businesses and describes the potential impacts on customers if the costs of the Proposed Regulation were to be passed on.

5.3.7 Incentives for Innovation

The Proposed Regulation would provide a strong signal for the development of ZE technologies in the off-road sector and help in building a robust market for advanced technologies. Growth in the industries that manufacture ZE locomotives will also strengthen the supply chain and promote technology improvements that may not have happened otherwise. The Proposed Regulation would result in deploying ZE locomotives into the railroad sector in California, which responds to Governor Newsom's EO N-79-20 by establishing a strategy to achieve zero-emission off-road equipment operations, where feasible, by 2035.

5.3.8 Competitive Advantage or Disadvantage

Staff do not anticipate significant direct impacts to the overall competitive advantage or disadvantage of locomotive operators currently doing business in the State because the Proposed Regulation imposes requirements equally on all locomotives that operate in California, whether the business that operates them is based in-state or out-of-state. All businesses operating Locomotives would be subject to the same requirements, regardless of instate or out-of-state ownership status. Thus, the Proposed Regulation is not expected to create competitive disadvantages to California locomotive operators.

Operators that already use ZE Locomotives or plan to employ ZE locomotives prior to 2030 may gain a competitive advantage compared to operators that rely on diesel-powered locomotives. Early adoption of ZE Locomotives removes the need for compliance with the SA, IUOR, and idling requirements. Operators using ZE Locomotives prior to 2030 would have access to funding sources and would have reduced compliance costs associated with the Proposed Regulation.

Additionally, staff reviewed literature on cargo diversion and mode shift and spoke with industry experts and did not find empirical research that focused on the impact of regulatory

costs on cargo diversion or mode shifts from rail to trucks.[166] Staff researched and directly engaged industry stakeholders for their experience or data and found that a company's decision to divert freight from one location to another or to use rail rather than trucks to move freight is complex and unique to individual businesses. Staff was unable to obtain information on business level responses to regulatory costs due to the highly competitive nature of the freight industry.

According to staff's research, it appears that mode shift due to the Proposed Regulation is not likely for a few salient reasons:

1) Locomotive operators often have longstanding clients that value their proximity and ease-of-access to the railyard,
2) locomotives are more cost-effective for long-haul transport,
3) some bulk commodity deliveries can be less time-sensitive and therefore realize cost savings from rail, and
4) California's trucking industry is currently operating at capacity and is not expected to have additional capacity in the near-term.[167]

Though the four reasons mentioned above greatly impact cargo owners' selection of shipping modes, local and international cargo transport delivery companies rely on multiple factors and sophisticated proprietary models to guide decisions on when, where, and how to move freight. The factors include access to consumer markets and intermodal transportation networks; reliability and velocity of transport modes; trans-loading infrastructure; the overall efficiency of the supply chain as it is impacted by the availability of labor; congestion delays and other impediments; and costs, including compliance costs for all regulations. To date, the available data and research has been insufficient to quantify the Proposed Regulation's potential effects regarding freight diversion or mode shift to trucks.

Quantifying the potential for the Proposed Regulation to cause freight diversion or mode shift requires a detailed understanding of how increased regulatory costs would impact each cargo owner's use of a specific mode of transport. Alternatively, absent industry knowledge, assessing the potential for diversion or mode shift would require making inferences about what changes in rail uses were caused by cost changes, and requires an understanding of all factors that affect choice of rail over other modes of freight movement.

As mentioned, there are several factors for which a cargo owner may choose to transport goods via train over other modes of transport (i.e., truck or ship). According to one study done for the Florida Department of Transportation Rail Planning and Safety, the main factors

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[166] CARB staff Outreach Meeting California Trucking Association June 29, 2021.

[167] Transport Topics, Truck Driver Shortage Looms Over 2022, December 2021. (web link: https://www.ttnews.com/articles/truck-driver-shortage-looms-over-2022#:~:text=Trucking%20is%20likely%20to%20continue,industry%20needs%2080%2C000%20more%20drivers.)

that affect the mode choice for commodities are as shown in Figure 5.3 below. As can be seen, transportation costs are only one of many factors determining the freight mode choice.

Figure 5.3: Key Factors Affecting Mode Choice [168]

Total Logistics Costs [a]	Order and handling costs [a]
	Transportation charges [a]
	Loss and damage costs [a]
	Capital carrying cost in transit [a]
	Inventory carrying cost at destination [a]
	Unavailability of equipment costs [a]
	Service reliability costs [a]
	Intangible service costs e.g. Billing processes [a]
Physical Attributes of Goods [c]	Shipment size [c]
	Package characteristics [c]
	Shipment shelf life [a]
	Shipment value [a]
	Shipment density [a]
Flow and Spatial Distribution of Shipments [c]	Shipment frequency [c]
	Distance of Shipment [c]
Modal Characteristics [a]	Capacity [a]
	Trip time and reliability [a]
	Equipment availability [a]
	Customer Service [a b]
	Handling Quality – Damage Loss Reputation

a – (Cook, Das, Aeppli and Martland 1999) b - (Cullinane, and Toy 2000) c – (Jiang, Hohnson an Calzada 1999)

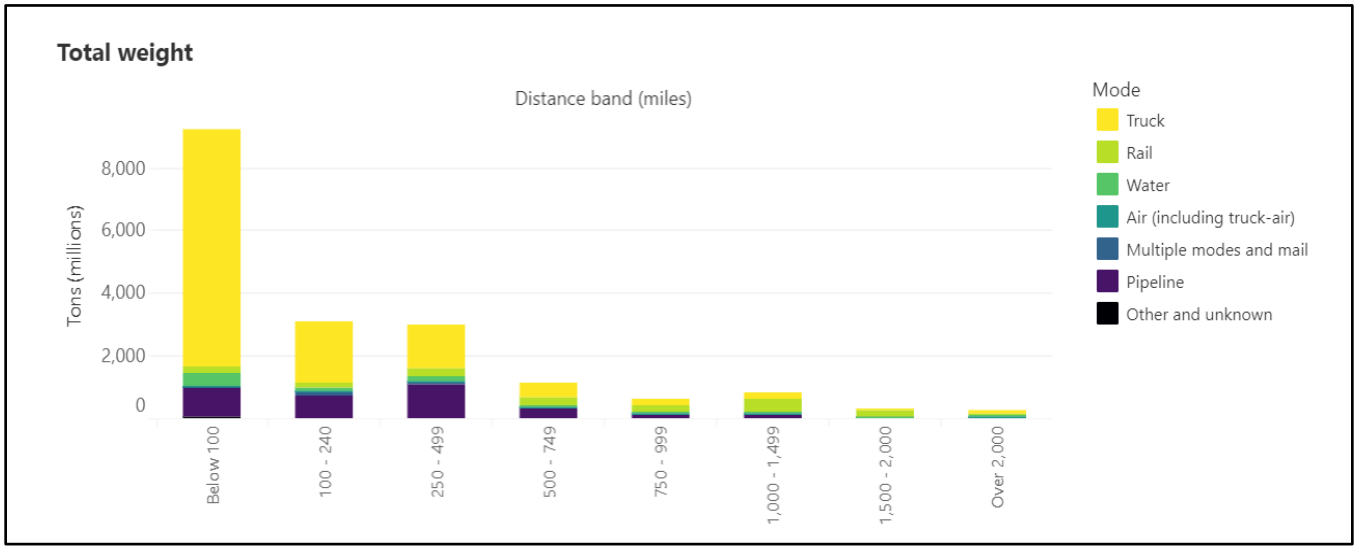
Additional to the key factors that are considered when picking a mode to move goods, there are some commodities that are just not suited for transport via truck. For example, rail is considered to have an advantage over other modes of transport when moving heavy or oversized freight over long distances. Also, rail may be superior for items that are or can be carried in bulk or that are not containerized. Some examples of goods best suited for transport by rail are products such as coal, lumber, and ore, whereas trucks may be better suited to transport cargo that is time-sensitive or high value over shorter distances. [169] As can be seen in Figures 5.4 and 5.5 below, trucks are utilized most often for lower weight

[168] The Center for Urban Transportation Research at the University of South Florida for Florida Department of Transportation Rail Planning and Safety, Analysis of Freight Movement Mode Choice Factors, 2002. (web link: https://www.fdot.gov/docs/default-source/rail/Publications/Studies/Planning/ModeChoiceFactors.pdf)

[169] U.S. Department of Transportation, Federal Railroad Administration; Freight Rail Overview,2020. https://railroads.dot.gov/rail-network-development/freight-rail-overview.

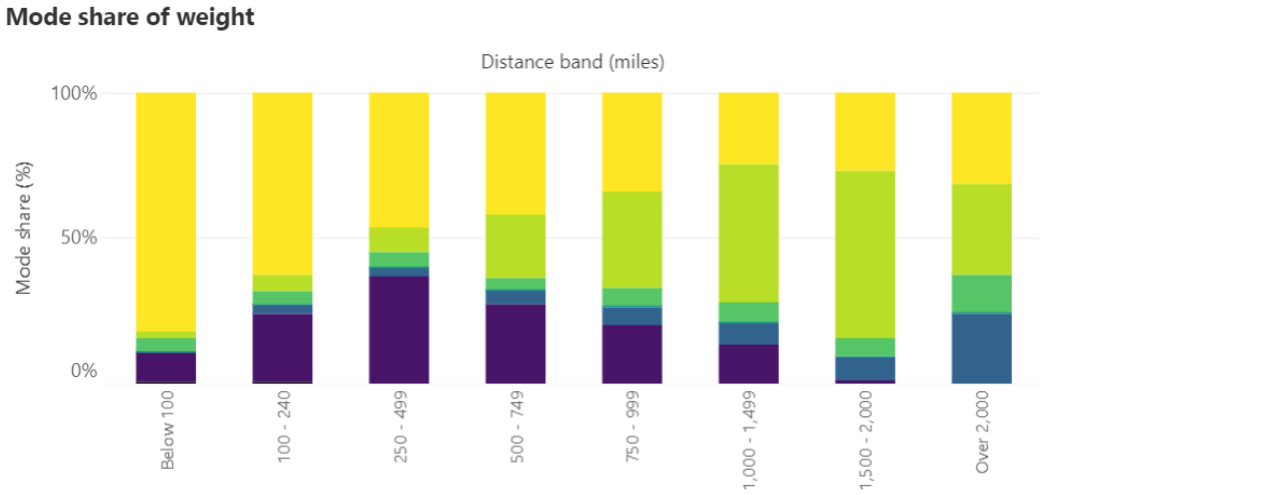
commodities and rail transports heavier freight over longer distances. Specifically, rail may be the only feasible mode of transport for some freight commodities. This suggests that locomotive operators could pass through costs of the Proposed Regulation, especially where they have a distinct market advantage currently.

Figure 5.4: Weight of freight by mode and distance [170]



[170] United States Department of Transportation, Bureau of Transportation Statistics; Freight Facts and Figures, 2018. (web link: https://data.bts.gov/stories/s/Moving-Goods-in-the-United-States/bcyt-rqmu)

Figure 5.5: Mode Share of Weight



Notes: Multiple modes and mail includes freight that is transferred between two or more modes on the journey between an origin and destination.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 4.5.1, 2019, https://www.bts.gov/faf.

Lastly, there could be indirect competitive disadvantages to California businesses that depend primarily on rail transport. California producers and their products compete with producers and products from other states and nations. The extent and nature of that competition depend on commodity type. For example, some California products are differentiated by source or brand, such as Napa Valley wines, California raisins, or Tesla autos. Since customers may not see wines, raisins, or autos from elsewhere as perfect substitutes, differentiated products can often command a somewhat higher price and have a greater ability to absorb transportation cost differences without losing market share. Other California products dominate their industry due to production volume and are somewhat shielded from competition because other sources cannot satisfy the market demand. However, California products that are not differentiated by source or brand must compete on delivered price and reliability of supply. Some California businesses may therefore face increased competition to the extent that their product prices are affected by increased shipping costs associated with the Proposed Regulation.

5.4 Summary and Agency Interpretation of the Assessment Results

As modeled, CARB estimates the Proposed Regulation is unlikely to have a significant impact on the California economy. Impacts to GSP, personal income, employment, and output are not estimated to exceed 0.06 percent of baseline in 2035, one of the years of greatest impact. In 2035, there is estimated to be a decrease in private investment of 0.12 percent of baseline. By 2050, the Proposed Regulation is anticipated to not exceed an impact of 0.03 percent in any of the economic indicators presented.

Table 5.7: Economic Indicators Summary

Indicator	Unit	2025	2030	2035	2040	2045	2050
GSP	Percent Change	-0.01%	-0.04%	-0.05%	-0.03%	-0.02%	-0.03%
GSP	Change (2019M$)	-34	-927	-1,893	-2,246	-1,333	-804
Personal Income	Percent Change	-0.01%	-0.05%	-0.06%	-0.04%	-0.02%	-0.03%
Personal Income	Change (2019M$)	-78	-1,176	-2,012	-2,341	-1,385	-643
Employment	Percent Change	-0.01%	-0.04%	-0.06%	-0.03%	-0.02%	-0.02%
Employment	Change (jobs)	-247	-6,991	-13,101	-14,543	-7,509	-3,760
Output	Percent Change	-0.01%	-0.04%	-0.06%	-0.03%	-0.02%	-0.02%
Output	Change (2019M$)	-61	-1,642	-3,394	-4,071	-2,531	-1,654
Private Investment	Percent Change	-0.01%	-0.07%	-0.12%	-0.11%	-0.04%	-0.01%
Private Investment	Change (2019M$)	-26	-358	-715	-698	-305	-105

6 Alternatives

6.1 Alternative 1

Alternative 1 is a more stringent requirement for locomotives operating in California. Under this alternative, all the Proposed Regulation requirements detailed in Section 1 remain the same except the date by which Spending Account funds would be dedicated to ZE Locomotives and associated infrastructure.

Starting July 1, 2024,

- Spending Account funds shall be used for ZE locomotives and associated infrastructure.

For comparison, the Proposed Regulation requires Spending Account funds to be used to purchase ZE Locomotives starting on January 1, 2030 but increases the diesel locomotive population before then.

Modeling Assumptions for Alternative 1:

- Spending Account – staff assume that between 2024-2029, Class I switchers, Class III, industrial, and passenger operators will purchase up to 25 ZE locomotives per year then save the remaining funds. Staff assumes this limited adoption of ZE locomotives prior to 2030 based on operators' input that they will pursue pilot and demonstration projects from 2024-2029 to provide time for manufacturers to scale up production.

Table 6.1: Assumptions for Alternative 1 Inventory Modeling

Purchase Year[171]	2023-2028	2029-2033	2034-2050
Class I Line Haul – Spending Account Funds	Save Money	No SA line haul locomotive purchases. 50% on ZE infrastructure. 50% Deposits used on Class I switchers until full ZE conversion.	ZE
Class I Line Haul – Non-Spending Account Funds	Tier 4	Tier 4	ZE
Class I Switcher, Class III, Industrial, Passenger – Spending Account	25 ZE Locomotives per Operator per year	ZE	ZE
Class I Switcher, Class III, Industrial, Passenger – Non-Spending Account Funds	Tier 4	ZE	ZE

6.1.1 Costs

The total direct cost of Alternative 1 to all locomotive operators is the summation of the cost of new locomotives, supporting electric and hydrogen infrastructure, differences in maintenance, fuel costs by type, reporting, and opportunity costs. From 2023 to 2050, Alternative 1 is estimated to cost approximately $26.3 billion compared to the Baseline, whereas the Proposed Regulation is $15.9 billion compared to the Baseline. The higher cost of Alternative 1 is largely due to the increased opportunity costs associated with funds accumulating in the Spending Account prior to commercial deployment of ZE locomotives and the purchase and installation of associated infrastructure for Class I switcher, Class III, industrial, and passenger locomotives in 2030 and line haul locomotives in 2035. Table 6.1 summarizes the annual and total direct costs to locomotives operators for Alternative 1.

[171] Locomotives are purchased prior to manufacture. It may take up to one year to deploy a newly built locomotive. Therefore, a new locomotive enters into service one year after purchase. For example, a locomotive purchase in 2029 will be for a locomotive with an Original Engine Build Date in 2030.

Table 6.2: Annual and Total Projected Net Costs for Alternative 1 from 2023 to 2050

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-Tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Cost	Total
2023	$0	$0	-$5,350,549	$0	$0	$0	$0	$11,106,600	-$1,769,000	$0	$0	$0	$0	$3,987,051
2024	-$2,168,504	$0	-$13,533,170	$0	$0	$0	$0	$381,600	-$4,350,400	$0	$1,442,215	$2,982,480	$61,348,435	$46,102,655
2025	$3,138,803	$1,420,294	-$13,155,872	$0	$0	$0	$0	$381,600	$3,679,000	$0	$1,442,215	$2,940,660	$196,838,647	$196,685,347
2026	$4,905,649	$2,936,879	-$11,445,822	$355,500	-$4,896,598	$2,879,553	$5,171,245	$381,600	-$1,458,000	$0	$1,442,215	$2,954,090	$407,917,963	$411,144,273
2027	$10,143,004	$4,260,881	-$10,006,320	$751,500	-$10,074,758	$5,588,315	$11,259,982	$381,600	-$1,968,930	$0	$1,442,215	$2,982,820	$696,738,624	$711,498,933
2028	$15,450,312	$5,512,666	-$8,511,951	$1,089,000	-$14,976,222	$8,182,408	$16,454,668	$381,600	-$728,600	$0	$1,442,215	$3,005,090	$885,984,122	$913,285,308
2029	$547,784,289	$24,099,256	-$7,132,337	$1,413,000	-$19,924,135	$10,649,516	$21,830,426	$381,600	-$67,168,600	-$211,809,600	$1,442,215	$3,045,720	$1,075,212,733	$1,379,824,083
2030	$615,544,974	$27,044,159	$43,249,008	$5,053,500	-$74,327,355	$43,463,278	$46,107,541	$381,600	-$4,070,572	-$17,569,600	$1,442,215	$2,630,070	$1,305,155,422	$1,994,104,239
2031	$624,145,655	$27,566,538	$53,261,744	$5,431,500	-$82,049,990	$50,182,203	$42,814,145	$381,600	$1,768,200	$0	$1,442,215	$2,690,590	$1,556,233,036	$2,283,867,437
2032	$635,069,411	$28,931,465	$55,958,000	$5,494,500	-$83,519,106	$51,684,695	$40,508,661	$381,600	$1,568,000	-$14,300,800	$1,442,215	$2,755,530	$1,827,106,008	$2,553,080,179
2033	$632,891,881	$29,763,580	$57,747,233	$5,683,500	-$88,453,106	$56,599,636	$37,930,837	$381,600	$4,121,288	-$11,070,400	$1,442,215	$2,815,710	$2,118,545,866	$2,848,399,841
2034	$596,929,910	$30,239,419	$58,148,092	$5,724,000	-$90,252,153	$58,740,665	$36,457,795	$381,600	-$26,367,000	$0	$1,442,215	$2,883,710	$2,118,486,524	$2,792,814,777
2035	$623,077,199	$30,628,596	$61,414,852	$6,746,400	-$326,058,322	$60,313,018	$518,830,487	$381,600	$7,169,744	-$32,680,000	$1,442,215	$2,342,090	$1,905,811,059	$2,859,418,938
2036	$591,291,460	$31,026,599	$59,237,060	$7,091,400	-$410,760,125	$60,747,286	$660,778,498	$381,600	$10,321,200	$0	$1,442,215	$2,203,200	$1,144,510	$1,014,904,902
2037	$569,031,571	$31,722,302	$57,246,499	$7,210,200	-$441,583,408	$61,543,754	$689,804,748	$381,600	$12,238,000	-$3,619,200	$1,442,215	$2,203,030	$1,136,880	$988,758,192
2038	$564,849,697	$32,113,886	$53,223,619	$7,401,000	-$478,955,561	$63,268,300	$723,010,128	$381,600	$3,392,698	$0	$1,442,215	$2,192,150	$1,191,616	$973,511,348
2039	$557,760,312	$32,828,045	$50,531,676	$7,631,100	-$539,136,791	$63,818,309	$792,684,504	$381,600	$6,113,000	$0	$1,442,215	$2,129,590	$1,137,328	$977,320,887

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-Tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Cost	Total
2040	$543,232,348	$33,237,282	$47,856,778	$7,858,500	-$581,926,985	$65,423,274	$830,960,926	$381,600	$5,799,600	$0	$1,442,215	$2,100,860	$1,092,007	$957,458,405
2041	$81,115,264	$40,233,633	$44,669,495	$8,004,000	-$621,935,473	$66,042,725	$855,247,071	$381,600	$5,999,000	$0	$1,442,215	$2,088,960	$1,033,915	$484,322,405
2042	-$2,006,036	$40,866,747	$41,470,004	$10,668,300	-$703,098,531	$67,092,681	$925,523,386	$381,600	$6,307,800	$0	$1,442,215	$2,072,300	$1,132,895	$391,853,362
2043	-$25,840,404	$41,300,057	$37,964,195	$10,811,400	-$743,797,395	$67,844,327	$937,905,892	$381,600	$6,868,800	$0	$1,442,215	$2,065,160	$1,053,099	$337,998,946
2044	-$37,541,527	$41,736,577	$34,409,949	$10,957,800	-$787,195,304	$68,617,666	$947,076,483	$381,600	$6,868,200	$0	$1,442,215	$2,057,510	$1,061,984	$289,873,154
2045	-$36,038,692	$40,316,283	$32,098,418	$11,107,800	-$836,985,843	$69,538,077	$952,894,648	$381,600	$2,765,600	$0	$1,442,215	$2,049,860	$1,067,854	$240,637,820
2046	-$7,861,110	$38,799,698	$29,696,395	$11,260,800	-$877,385,300	$70,620,664	$955,219,929	$381,600	$3,307,000	$0	$1,442,215	$2,041,700	$989,158	$228,512,748
2047	-$19,346,173	$37,475,695	$27,262,306	$11,347,500	-$909,016,904	$71,794,072	$933,367,342	$381,600	-$458,400	$0	$1,442,215	$2,073,150	$1,080,353	$157,402,756
2048	$13,786,701	$36,223,911	$24,845,890	$11,584,200	-$978,671,789	$72,582,294	$950,514,616	$381,600	$2,770,200	$0	$1,442,215	$2,021,470	$1,160,431	$138,641,738
2049	$29,490,306	$17,637,321	$22,329,233	$11,746,200	-$1,027,904,031	$73,637,639	$940,930,027	$381,600	$3,389,200	$0	$1,442,215	$2,013,650	$1,074,065	$76,167,424
2050	$31,905,334	$14,692,418	$19,749,644	$11,909,400	-$1,077,451,245	$74,471,858	$926,669,434	$381,600	$3,425,400	$0	$1,442,215	$2,007,020	$1,074,065	$10,277,142
Total	$7,160,741,633	$722,614,187	$843,234,069	$184,332,000	-$11,810,336,431	$1,365,326,213	$13,799,953,414	$21,409,800	-$10,467,572	-$291,049,600	$38,939,810	$65,348,170	$14,171,808,597	$26,261,854,290

6.1.2 Benefits

Health benefits for Alternative 1 were calculated using the methodology described in Section 2. Alternative 1 would result in fewer emission reductions than the Proposed Regulation because turnover to Tier 4 is slower than is projected to be under the Proposed Regulation from 2023-2029 since operators would not be permitted to purchase Tier 4 locomotives with Spending Account funds. Staff assume that as a result, a typical operator would keep funds in their Spending Account until ZE locomotives become available. This causes emissions to decline more dramatically than in the Proposed Regulation in 2030 for switcher, industrial, and passenger locomotives and in 2035 for line haul locomotives, because operators would have larger Spending Account reserves to spend on ZE [locomotives. Figure 6.1, Figure 6.2, and Figure 6.3 below show the comparison of PM, NOx, and GHG emissions Alternative 1 to the Proposed Regulation and Baseline. As seen in the Figures, the decreased emissions from greater ZE purchases under Alternative 1 do not make up for the increased emissions earlier, and thus Alternative 1 would result in fewer total emission reductions than the Proposed Regulation.

Figure 6.1: Statewide PM2.5 Emissions from Locomotives under the Baseline, Proposed Regulation, and Alternative 1

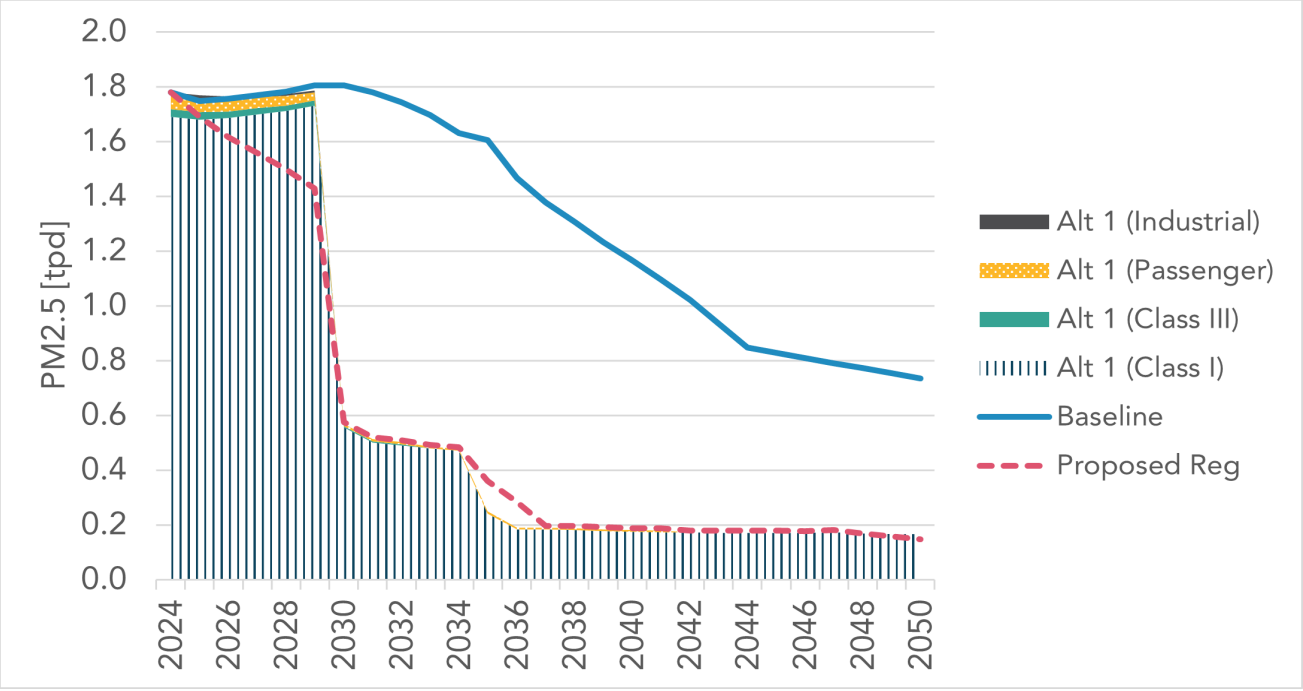


Figure 6.2: Statewide NOx Emissions of Locomotives under the Baseline, Proposed Regulation, and Alternative 1

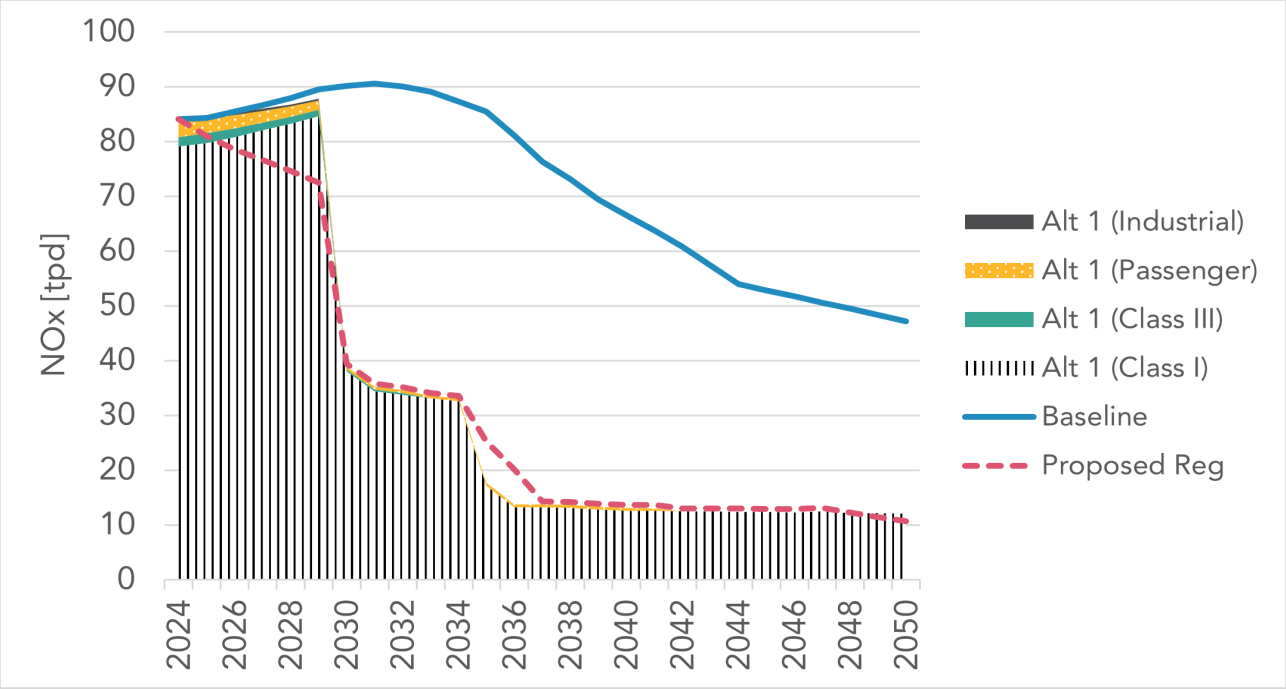
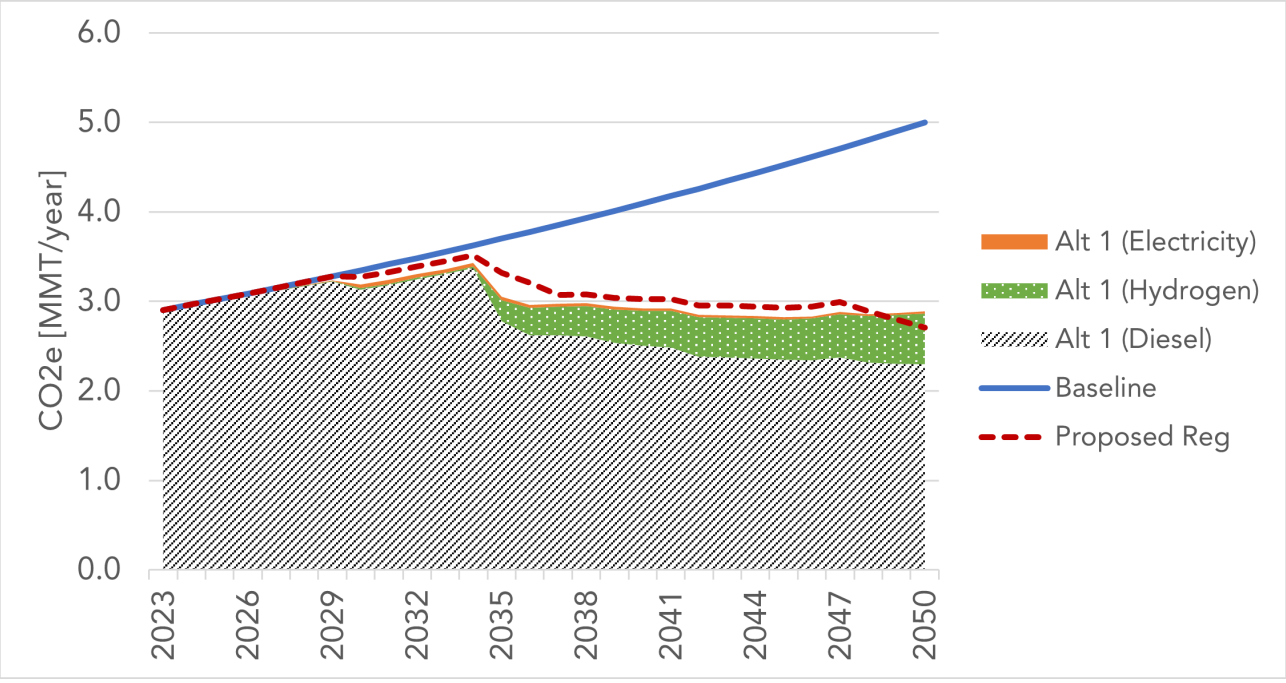


Figure 6.3: Statewide GHG Emissions from Locomotives under the Baseline, Proposed Regulation, and Alternative 1



The estimation methodologies described in Section 2 were used to quantify avoided cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, as well as emergency room visits for respiratory illness and asthma that would be expected to result from Alternative 1. Table 6.3 shows the statewide valuation from avoided health outcomes for Alternative 1. Alternative 1 results in a lower valuation of health benefits at $31.7 billion compared to the Proposed Regulation at $32.3 billion, shown in Section 3.

Table 6.3: Statewide Valuation from Avoided Health Outcomes for Alternative 1 from 2023 to 2050

Outcome	Avoided Incidents	Valuation
Avoided Premature Deaths	3,208	$31,644,185,138
Avoided Hospitalizations	1,092	$59,211,017
Avoided Emergency Room Visits	1,474	$1,229,121
Total Valuation	--	$31,704,625,276

6.1.3 Economic Impacts

As mentioned, Alternative 1 is more stringent compared to the Proposed Regulation, requiring Spending Account funds to be used towards ZE locomotives starting in 2024. The more stringent requirements of Alternative 1 result in higher incremental costs relative to the Proposed Regulation. The macroeconomic impact analysis results are qualitatively similar to the results of the Proposed Regulation, but of a larger magnitude as shown in Table 6.4 and Figure 6.4.

Alternative 1 is estimated to result in a decrease to GSP, personal income, employment, output, and private investment by 0.01 to 0.30 percent below baseline levels with the largest impact between 2030 and 2035, as the bulk of new locomotives are purchased. After 2035, the trend starts to reverse and leads to gains in the construction industry and slight impacts to the other indicators. The impacts of Alternative 1 occur earlier and are approximately two to three times as large as those estimated under the Proposed Regulation in certain years.

Table 6.4: Change in Growth of Economic Indicators for Alternative 1

Description	Impact	2025	2030	2035	2040	2045	2050
GSP	% Change	-0.01%	-0.08%	-0.14%	-0.05%	-0.02%	-0.01%
GSP	Change (2019M$)	-239	-3,064	-5,545	-2,323	-900	-564

Description	Impact	2025	2030	2035	2040	2045	2050
Personal Income	% Change	-0.01%	-0.11%	-0.17%	-0.07%	-0.02%	-0.01%
Personal Income	Change (2019M$)	-317	-3,594	-5,923	-2,537	-920	-405
Employment	% Change	-0.01%	-0.09%	-0.15%	-0.05%	-0.02%	-0.01%
Employment	Change (2019M$)	-1,970	-23,070	-38,110	-14,010	-4,400	-2,360
Output	% Change	-0.01%	-0.09%	-0.15%	-0.06%	-0.02%	-0.01%
Output	Change (2019M$)	-420	-5,441	-9,945	-4,353	-1,791	-1,189
Private Investment	% Change	-0.02%	-0.20%	-0.30%	-0.06%	-0.01%	-0.01%
Private Investment	Change (2019M$)	-92	-1,085	-1,772	-355	-39	-35

Figure 6.4: Changes in Employment by Major Sector Associated with Alternative 1

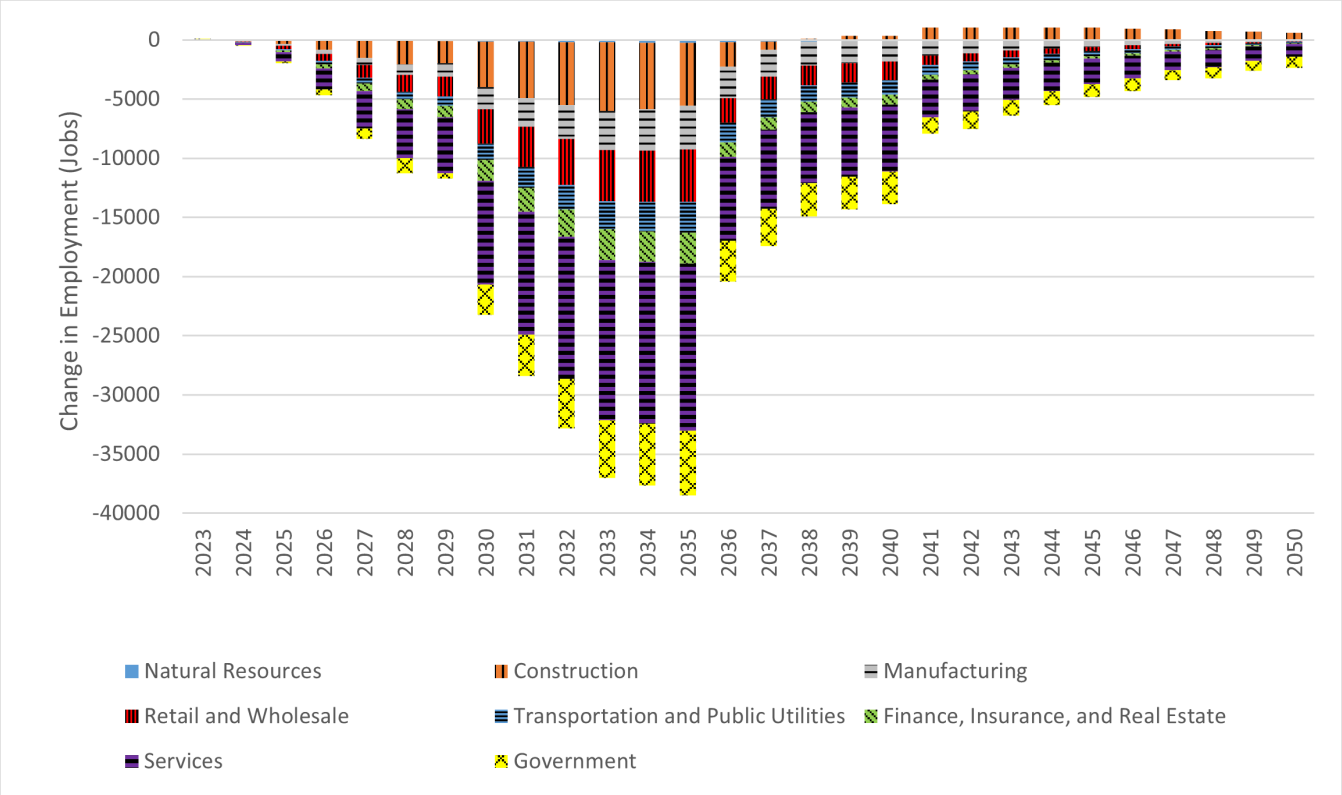
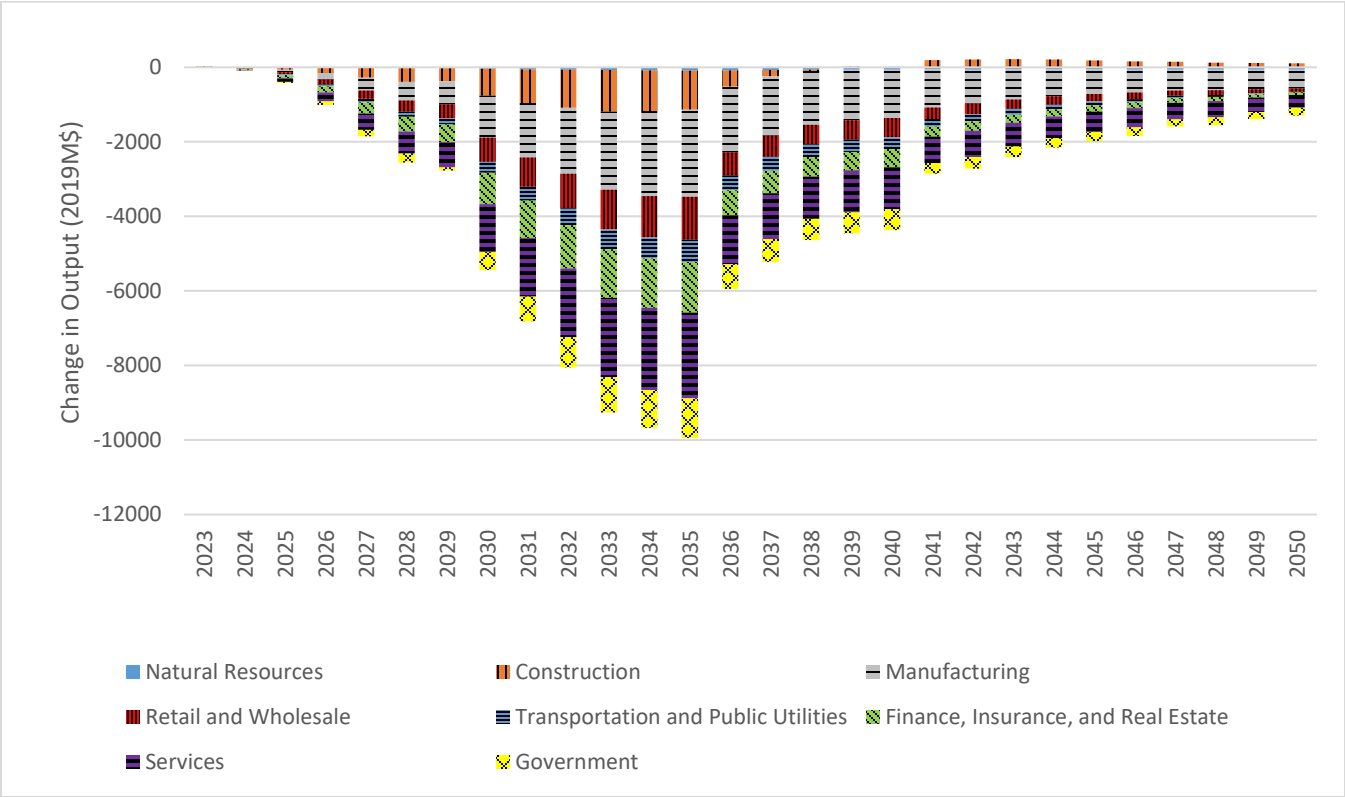


Figure 6.5 illustrates the changes in output by major sector associated with Alternative 1. The trends in output are similar to the trends that were observed for employment. Alternative 1 is estimated to result in decrease in California employment and output from 2024 to 2050, primarily due to increase in production costs and decrease in government spending.

Figure 6.5: Changes in Output by Major Sector Associated with Alternative 1



6.1.4 Cost-Effectiveness

Cost-effectiveness is a measure of the cost of a regulation per ton of expected emissions reduction. Staff calculated the cost-effectiveness of Alternative 1 (in $/weighted ton) using the cost-effectiveness method provided in the Carl Moyer Guidelines Appendix C by dividing the cost over time by the weighed emissions reductions (in tons per year) over the same time period.[172] Table 6.5 below summarizes the cost effectiveness for the Proposed Regulation and Alternative 1. Staff estimated that Alternative 1 would be less cost-effective than the Proposed Regulation due to the higher direct costs and lower health benefits.

[172] California Air Resources Board, The Carl Moyer Program Guidelines, 2017 Revisions, Appendix C. (web link: https://ww3.arb.ca.gov/msprog/moyer/guidelines/current.htm)

Table 6.5: Cost Effectiveness of the Proposed Regulation and Alternative 1

Proposal	Carl Moyer Cost-Effectiveness ($/weighted ton)
Proposed Regulation	$29,159
Alternative 1	$49,529
Difference in Cost-Effectiveness	$20,370

6.1.5 Reason for Rejecting

Staff rejected Alternative 1 because it is less cost effective to implement than the Proposed Regulation and leads to larger indirect economic impacts. Additionally, ZE technologies may not be readily commercially available at large scale for most locomotive types by 2025. However, given that advancements in ZE locomotive technologies are being made and their costs are expected to decrease over time, staff will continue to analyze the rapidly evolving technical progress of these categories to determine if additional requirements are needed.

6.2 Alternative 2

Alternative 2 is a less stringent requirement for locomotives operating in California. Under this alternative, all the Proposed Regulation requirements detailed in Section 1 remain the same except for the amount of time a locomotive is allowed to operate in California under the IUOR requirements. Starting in 2030 under Alternative 2, locomotives less than 35 years may operate in California, compared to the Proposed Regulation 23-year IUOR requirement (see Section 1.3.2 for description of IUOR).

Starting January 1, 2030,

- Only locomotives less than 35 years old may operate in California, unless the locomotive is remanufactured to Tier 4 or a cleaner standard prior to January 1, 2030. Then the age of the locomotive will be based on the first year the primary engine was remanufactured to a Tier 4 or cleaner standard.

This alternative aligns with proposals from stakeholders advocating for longer use for locomotives before requiring the locomotive be replaced or remanufactured.

6.2.1 Costs

The total direct cost to all locomotive operators is the summation of the cost of new locomotives, supporting electric and hydrogen infrastructure, differences in maintenance, fuel costs by type, reporting, and opportunity costs. From 2023-2050, Alternative 2 is estimated to cost approximately $14.5 billion compared to the Baseline versus $15.9 billion

for the Proposed Regulation compared to the Baseline. Alternative 2 would result in fewer purchases of locomotives and will result in lower costs to operators compared to the Proposed Regulation. Table 6.6 summarizes the annual and total direct costs to operators for Alternative 2.

Table 6.6: Annual and Total Projected Net Costs for Alternative 2 from 2023 to 2050

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	AESS/GPS Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Cost	Total
2023	$0	$0	-$614,337	$0	$0	$0	$0	$11,106,600	-$1,769,000	$0	$0	$0	$0	$8,723,263
2024	$41,914,640	$0	-$8,780,479	$0	$0	$0	$0	$381,600	-$7,860,000	$0	$1,442,215	$2,982,480	$349,825	$30,430,280
2025	$85,118,874	$0	-$3,643,898	$0	$0	$0	$0	$381,600	$947,800	$0	$1,442,215	$2,928,250	$463,375	$87,638,216
2026	$120,442,253	$0	$999,288	$0	$0	$0	$0	$381,600	-$4,298,200	$0	$1,442,215	$2,935,900	$592,166	$122,495,223
2027	$158,115,786	$0	$5,036,030	$0	$0	$0	$0	$381,600	-$4,292,930	$0	$1,442,215	$2,958,680	$747,709	$164,389,090
2028	$195,367,352	$0	$9,134,113	$0	$0	$0	$0	$381,600	-$4,695,800	-$1,414,400	$1,442,215	$2,974,320	$1,064,065	$204,253,464
2029	$235,266,930	$4,338,717	$11,748,517	$0	$0	$0	$0	$381,600	-$4,985,000	-$47,280,000	$1,442,215	$2,968,710	$1,025,091	$204,906,779
2030	$271,161,206	$5,905,052	$16,027,574	$553,500	-$7,936,877	$5,578,339	$2,844,423	$381,600	-$5,575,772	$0	$1,442,215	$2,966,670	$64,464,032	$357,811,961
2031	$293,835,728	$8,112,526	$20,104,534	$729,000	-$10,629,887	$6,964,329	$5,282,490	$381,600	-$505,000	$0	$1,442,215	$2,958,680	$206,484,144	$535,160,359
2032	$299,991,483	$9,481,464	$22,593,385	$900,000	-$13,295,512	$8,366,014	$7,449,670	$381,600	-$790,800	$0	$1,442,215	$2,962,590	$424,869,710	$764,351,819
2033	$321,862,688	$11,172,175	$23,892,293	$1,030,500	-$15,533,742	$9,940,419	$8,138,197	$381,600	-$3,554,312	$0	$1,442,215	$2,986,900	$719,487,654	$1,081,246,588
2034	$294,971,880	$12,529,880	$26,383,707	$1,197,000	-$18,207,806	$11,426,469	$10,057,054	$381,600	-$11,378,200	$0	$1,442,215	$3,014,270	$719,735,134	$1,051,553,204
2035	$401,800,620	$18,434,130	$30,882,520	$1,968,600	-$160,419,868	$12,990,748	$299,274,887	$381,600	$2,783,744	-$46,146,400	$1,442,215	$2,669,170	$496,668,609	$1,062,730,575
2036	$419,559,903	$19,190,015	$39,339,010	$3,314,700	-$257,655,593	$30,009,827	$440,070,115	$381,600	-$4,130,800	$0	$1,442,215	$2,495,260	$143,151,663	$837,167,915
2037	$390,850,350	$19,986,021	$41,544,831	$3,955,500	-$395,010,415	$30,818,031	$680,595,678	$381,600	$7,258,000	$0	$1,442,215	$2,235,670	$1,408,313	$785,465,795
2038	$386,807,251	$20,521,239	$41,254,322	$4,327,800	-$469,679,416	$31,780,262	$784,484,484	$381,600	-$406,902	$0	$1,442,215	$2,146,590	$1,470,834	$804,530,280
2039	$363,841,639	$21,065,284	$41,510,104	$4,743,900	-$567,784,884	$32,598,435	$917,916,116	$381,600	$4,834,200	$0	$1,442,215	$1,996,310	$1,428,771	$823,973,690

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	AESS/GPS Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Cost	Total
2040	$331,904,150	$21,561,986	$40,870,382	$5,040,000	-$632,202,864	$33,452,936	$989,746,321	$381,600	$3,702,000	$0	$1,442,215	$1,918,790	$1,376,020	$799,193,535
2041	$293,544,639	$22,753,588	$39,694,398	$5,271,900	-$687,772,323	$34,232,447	$1,032,471,258	$381,600	$3,847,800	$0	$1,442,215	$1,877,140	$1,160,101	$748,904,763
2042	$272,501,572	$25,080,623	$38,087,137	$5,505,000	-$746,224,196	$35,448,203	$1,062,486,361	$381,600	$4,920,600	-$26,243,200	$1,442,215	$1,844,840	$1,411,195	$676,641,950
2043	$236,034,707	$26,206,427	$37,583,359	$5,942,100	-$803,820,404	$40,575,990	$1,085,655,060	$381,600	$6,632,800	$0	$1,442,215	$1,806,420	$1,435,742	$639,876,015
2044	$235,611,611	$27,141,253	$34,434,195	$6,106,200	-$847,495,023	$41,380,846	$1,088,400,075	$381,600	$6,895,000	-$6,849,600	$1,442,215	$1,799,960	$1,338,141	$590,586,473
2045	$214,473,207	$27,381,980	$32,507,450	$6,345,600	-$897,461,454	$43,717,398	$1,084,838,911	$381,600	$2,357,600	-$8,704,000	$1,442,215	$1,795,200	$1,321,182	$510,396,889
2046	$282,726,374	$27,430,126	$30,294,453	$6,531,300	-$935,301,114	$45,255,586	$1,077,102,948	$381,600	$-4,632,200	$0	$1,442,215	$1,793,670	$1,253,709	$534,278,668
2047	$218,633,644	$27,478,272	$28,710,657	$6,904,800	-$1,037,452,092	$46,223,855	$1,130,540,120	$381,600	$-4,888,000	$0	$1,442,215	$1,660,730	$1,351,336	$420,987,136
2048	$202,532,329	$27,502,344	$27,077,232	$7,288,800	-$1,143,163,493	$46,951,479	$1,175,792,185	$381,600	$3,271,000	-$102,080,000	$1,442,215	$1,523,370	$1,562,233	$250,081,294
2049	$186,396,603	$23,283,992	$25,434,284	$7,678,200	-$1,250,113,996	$47,761,464	$1,212,246,870	$381,600	$3,389,200	-$4,732,800	$1,442,215	$1,382,270	$1,415,203	$255,965,104
2050	$155,116,323	$21,717,656	$22,877,743	$7,852,200	-$1,298,045,892	$48,827,811	$1,179,412,497	$381,600	$3,425,400	$0	$1,442,215	$1,381,420	$1,853,775	$146,242,746
Total	$6,910,383,741	$428,274,748	$674,982,804	$93,186,600	-$12,195,206,852	$644,300,888	$15,274,805,719	$21,409,800	-$9,497,772	-$243,450,400	$38,939,810	$62,964,260	$2,798,889,732	$14,499,983,077

6.2.2 Benefits

Benefits for Alternative 2 were calculated using the methodology described in Section 2. Alternative 2 would result in fewer PM2.5 and NOx emission reductions, but slightly greater GHG emissions, than the Proposed Regulation. Figure 6.6, Figure 6.7, and Figure 6.8 show the PM, NOx, and GHG emissions under Alterative 2, the Proposed Regulation, and the Baseline.

Figure 6.6: Statewide PM2.5 Emissions from Locomotives under the Baseline, Proposed Regulation, and Alternative 2

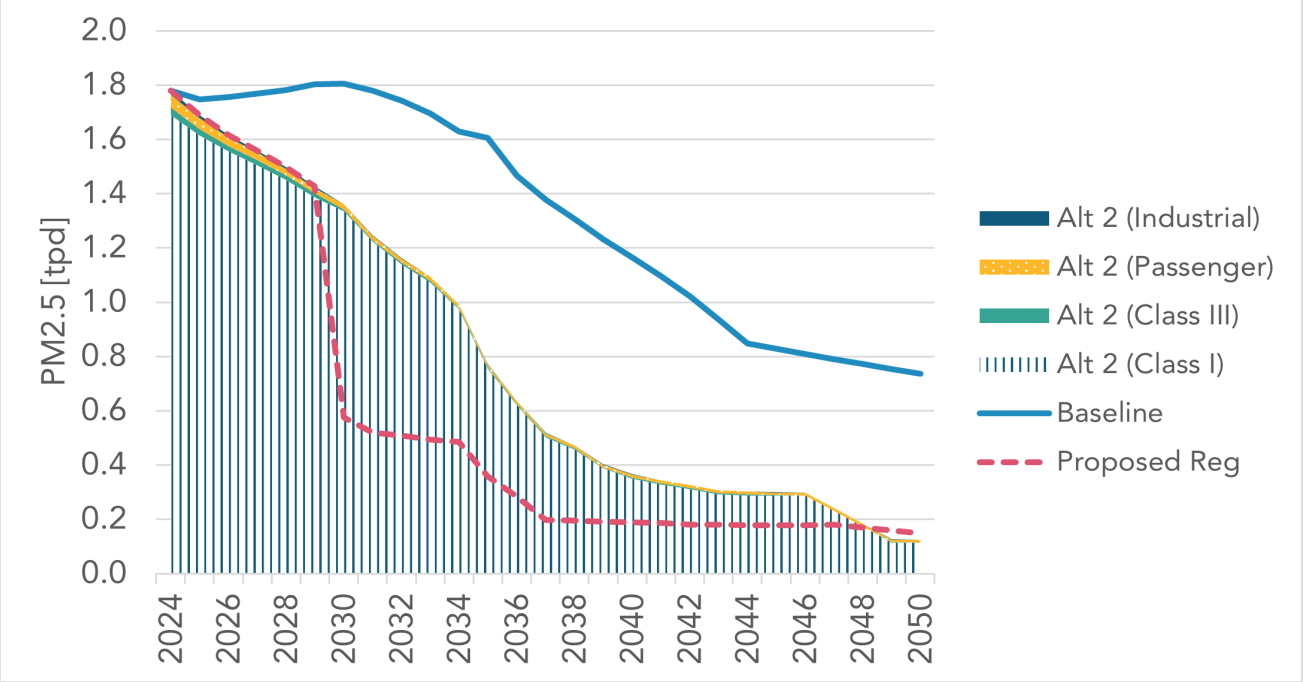


Figure 6.7: Statewide NOx Emissions from Locomotives under the Baseline, Proposed Regulation, and Alternative 2

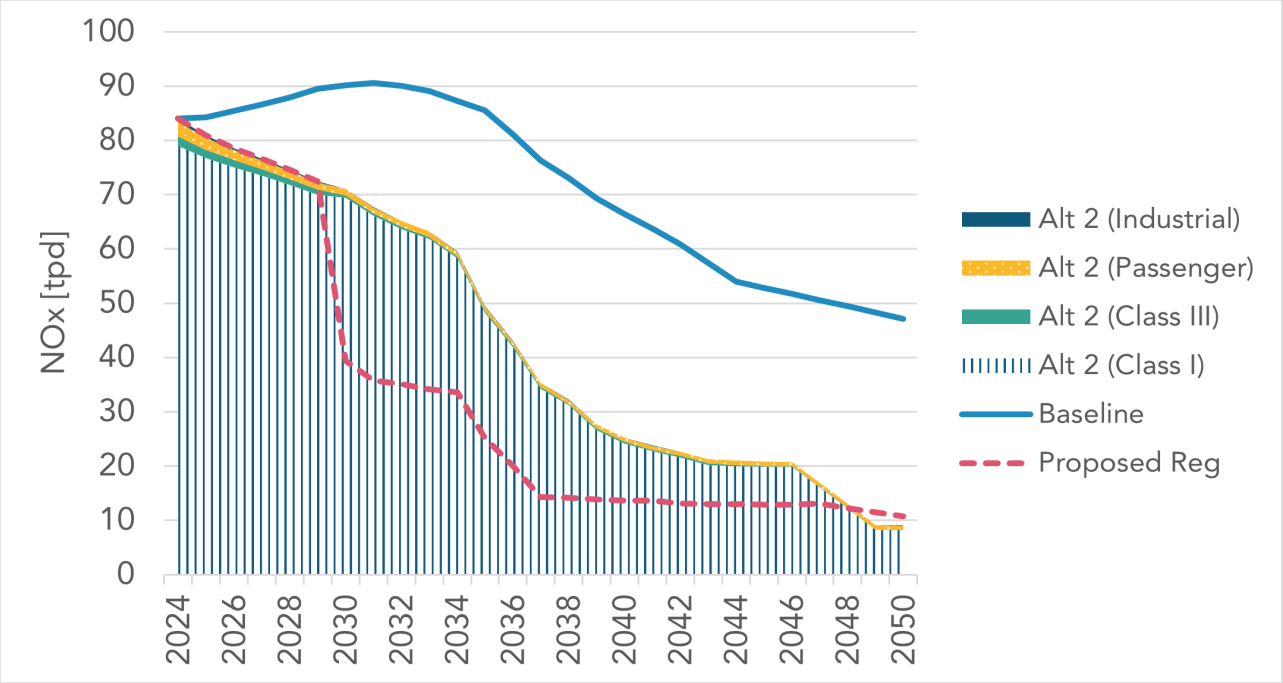
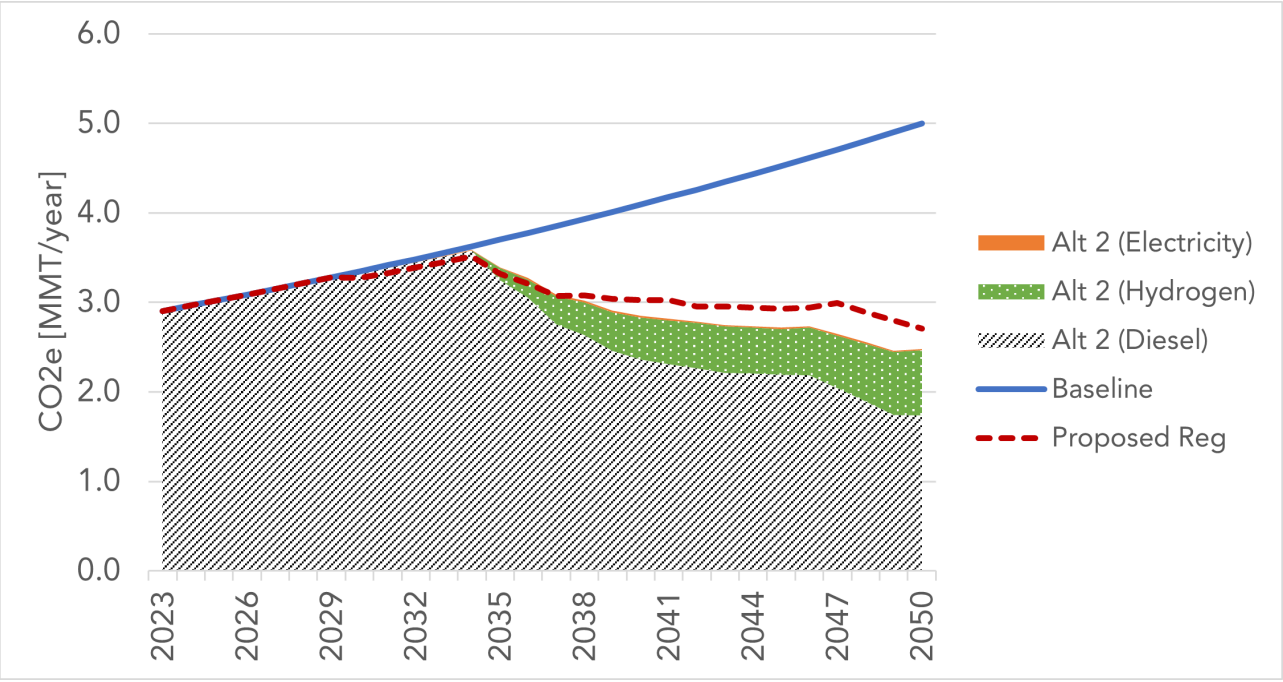


Figure 6.8: Statewide GHG Emissions from Locomotives under the Baseline, Proposed Regulation, and Alternative 2



The estimation methodologies described in Section 2 were used to quantify avoided cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, as well as emergency room visits for respiratory illness and asthma that would be expected to result from Alternative 2. Table 6.6 shows statewide valuation from avoided health outcomes for Alternative 2. Alternative 2 results in a lower valuation of health benefits at about $23.8 billion compared to the Proposed Regulation at $32.3 billion, shown in Section 3.

Table 6.7: Statewide Valuation from Avoided Health Outcomes for Alternative 2 from 2023 to 2050

Outcome	Avoided Incidents	Valuation
Avoided Premature Deaths	2,405	$23,773,094,565
Avoided Hospitalizations	823	$44,602,071
Avoided Emergency Room Visits	1,106	$922,552
Total Valuation		$23,773,094,565

6.2.3 Economic Impacts

Alternative 2 is less stringent compared to the Proposed Regulation because it allows for a locomotive that is less than 35 years old (instead of 23 years under the Proposed Regulation) to operate in California. This results in lower incremental costs relative to the Proposed Regulation. The macroeconomic impact analysis results are qualitatively similar to the results of the Proposed Regulation, but of a smaller magnitude as shown in Table 6.8 and Figure 6.9.

Alternative 2 is estimated to result in a decrease to GSP, Personal Income, Employment, Output, and Private Investment by 0.01 to 0.13 percent below baseline levels with the largest impact between 2030 and 2035, as the bulk of new locomotives are purchased. After 2035, the trend starts to reverse, but without creating the growth in construction seen in the Proposed Regulation. The impacts of Alternative 2 occur later and are either equal to or below those estimated under the Proposed Regulation.

Table 6.8: Change in Growth of Economic Indicators for Alternative 2

Description	Impact	2025	2030	2035	2040	2045	2050
GSP	% Change	0.00%	-0.01%	-0.05%	-0.04%	-0.03%	-0.02%
GSP	Change (2019M$)	-42	-517	-1,814	-1,844	-1,517	-1,116

Description	Impact	2025	2030	2035	2040	2045	2050
Personal Income	% Change	0.00%	-0.02%	-0.06%	-0.05%	-0.04%	-0.02%
Personal Income	Change (2019M$)	-87	-596	-1,982	-1,937	-1,511	-890
Employment	% Change	0.00%	-0.02%	-0.05%	-0.05%	-0.03%	-0.02%
Employment	Change (2019M$)	-310	-3,850	-12,460	-12,030	-8,930	-5,840
Output	% Change	0.00%	-0.02%	-0.05%	-0.05%	-0.04%	-0.03%
Output	Change (2019M$)	-75	-922	-3,237	-3,342	-2,845	-2,215
Private Investment	% Change	0.00%	-0.03%	-0.13%	-0.09%	-0.06%	-0.03%
Private Investment	Change (2019M$)	-30	-219	-751	-556	-354	-186

Figure 6.9: Changes in Employment by Major Sector Associated with Alternative 2

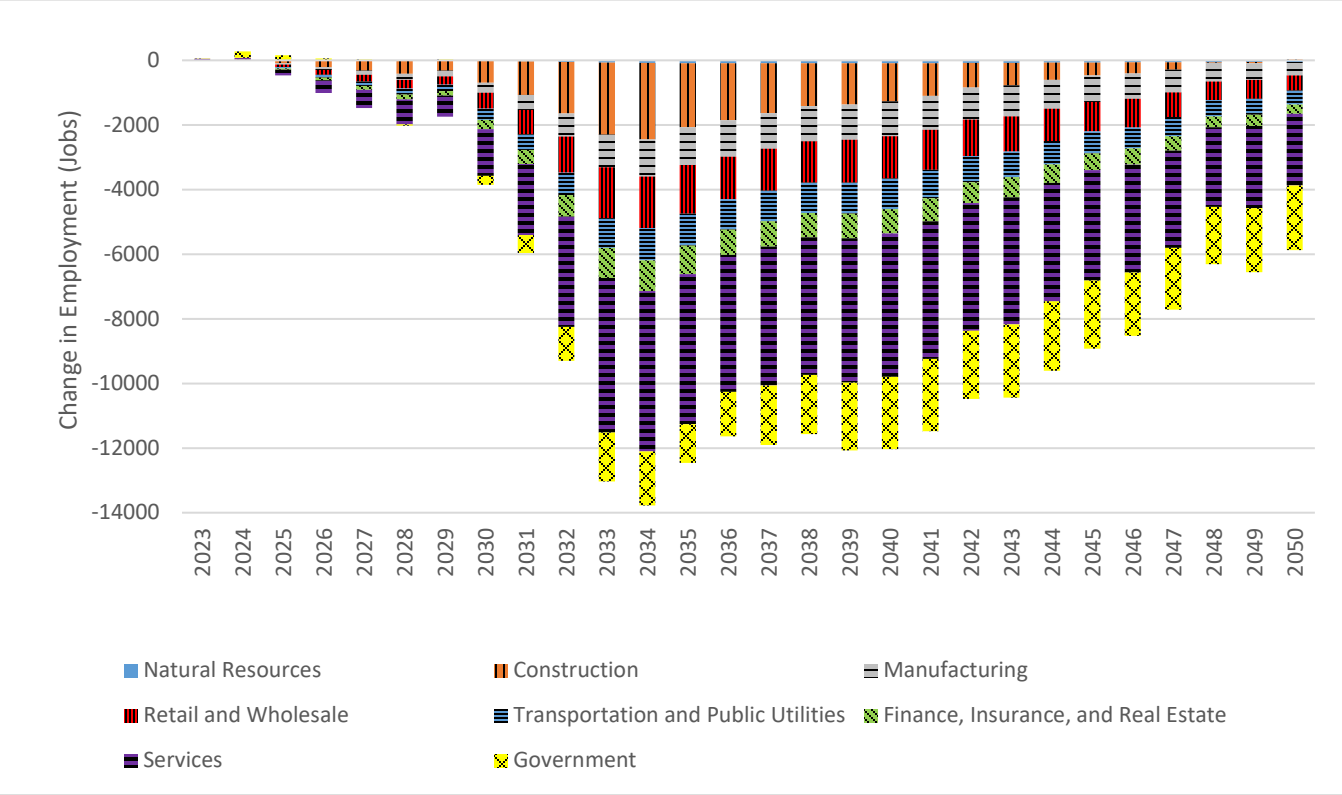
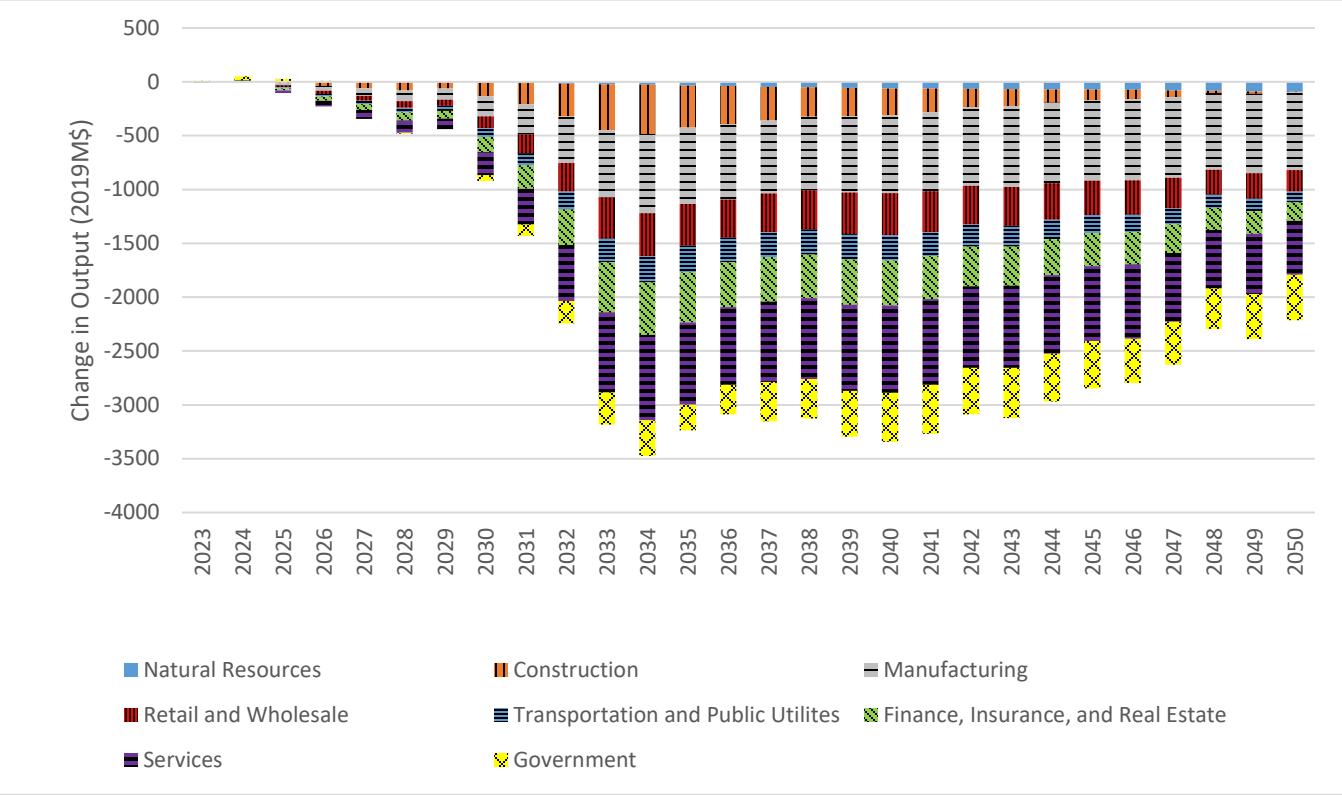


Figure 6.10 illustrates the changes in output by major sector associated with Alternative 2. The trends in output are similar to the trends that were observed for employment. Alternative 2 is estimated to result in decreases in California output and employment from 2025 to 2050, primarily due to increases in production costs and decreases in government spending. The negative impact would peak in 2034 and declines after that.

Figure 6.10 Changes in Output by Major Sector Associated with Alternative 2



6.2.4 Cost-Effectiveness

Cost-effectiveness is a measure of the cost of a regulation per ton of expected emissions reduction. There are multiple approaches to calculating cost-effectiveness. Staff calculated the cost-effectiveness of Alternative 2 (in $/weighted ton) using the cost-effectiveness method provided in the Carl Moyer Guidelines Appendix C by dividing the cost over time by the weighed emissions reductions (in tons per year) over the same time period.[173] Table 6.9 summarizes the cost-effectiveness for the Proposed Regulation and Alternative 2. Staff estimated that Alternative 2 would be less cost-effective than the Proposed Regulation due to the comparable costs and fewer emissions benefits.

[173] California Air Resources Board, The Carl Moyer Program Guidelines, 2017 Revisions, Appendix C. (web link: https://ww3.arb.ca.gov/msprog/moyer/guidelines/current.htm)

Table 6.9: Cost Effectiveness of the Proposed Regulation and Alternative 2

Proposal	Carl Moyer Cost-Effectiveness ($/weighted ton)
Proposed Regulation	$29,159
Alternative 2	$37,312
Difference in Cost-Effectiveness	$8,153

6.2.5 Reason for Rejecting

Staff rejected Alternative 2 because it would result in fewer PM2.5 and NOx emission reductions than the Proposed Regulation. It is also less cost effective than the Proposed Regulation since diesel locomotives continue to emit pollutants and are subject to Spending Account payments. Additionally, diesel locomotives are expected to have higher maintenance costs. Alternative 2 would provide less of the NOx reductions needed to meet SIP attainment goals, and the increase in PM2.5 emissions when compared to the Proposed Regulation would have negative environmental and health impact on communities surrounding locomotive operations. Additionally, Alternative 2 fails to align with the goals of EO N-79-20.

6.3 Alternative 3 - Sensitivity Analysis

The ZE IUOR of the Proposed Regulation dictates that switcher, industrial, and passenger locomotives operating in California with an original build date 2030 or newer and line haul locomotives operating in California with an original build date 2035 or newer are required to be ZE locomotives or ZE capable Locomotives. In 2027, staff will publish an assessment of the progress made in ZE technologies for use with Freight line haul, switch, industrial and passenger locomotives, as well as the status of infrastructure improvements that may be needed to support ZE locomotives. Staff will make the assessment available for public review at least 30 calendar days prior to presenting the report to the Board. If staff finds that the compliance deadlines under Proposed Regulation need to be adjusted forward or backward in time, the report will include recommendations to initiate staff's development of potential formal regulatory amendments.

As a bounding exercise, staff ran a Sensitivity Analysis to determine how locomotive operator fleets and costs would change if the ZE IUOR did not take effect, and operators are allowed to operate Tier 4 locomotives in California with an original build date after 2030, or 2035 for line haul. As such, the Sensitivity Analysis is a less stringent requirement for locomotives operating in California. Under this analysis, all other requirements of the Proposed Regulation detailed in Section 1 remain the same. Spending Account purchases after 2030

would still be restricted to ZE locomotives, although non-Spending Account purchases would be the cleanest federally-established standard (assumed Tier 4 for modeling purposes).

6.3.1 Costs

The total direct cost to all locomotive operators is the summation of the cost of new locomotives, supporting electric and hydrogen infrastructure, differences in maintenance, fuel costs by type, reporting, and opportunity costs. From 2023 to 2050, the Sensitivity Analysis has an estimated cost of approximately $7.12 billion compared to the Baseline, whereas the Proposed Regulation is $15.9 billion compared to the Baseline. The lower cost is associated with fewer ZE locomotive and infrastructure purchases. Table 6.10 summarizes the annual and total direct costs to locomotive operators for the Sensitivity Analysis.

Table 6.10: Annual and Total Projected Net Costs for Sensitivity Analysis from 2023 to 2050

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Cost	Total
2023	$0	$0	-$5,350,549	$0	-$0	$0	$0	$11,106,600	-$1,769,000	$0	$0	$0	$0	$3,987,051
2024	$41,914,640	$0	-$13,533,170	$0	-$0	$0	$0	$381,600	-$7,860,000	$0	$1,442,215	$2,982,480	$277,295	$25,605,059
2025	$85,118,874	$0	-$8,691,039	$0	$0	$0	$0	$381,600	$947,800	$0	$1,442,215	$2,928,250	$415,515	$82,543,216
2026	$120,442,253	$0	-$4,324,495	$0	-$0	$0	$0	$381,600	-$4,298,200	$0	$1,442,215	$2,935,900	$585,072	$117,164,345
2027	$158,115,786	$0	-$539,569	$0	-$0	$0	$0	$381,600	-$4,292,930	$0	$1,442,215	$2,958,680	$718,219	$158,784,001
2028	$195,367,352	$0	$3,321,436	$0	-$0	$0	$0	$381,600	-$4,695,800	-$1,414,400	$1,442,215	$2,974,320	$1,014,134	$198,390,857
2029	$522,278,977	$1,576,767	$5,721,206	$0	-$0	$0	$0	$381,600	-$44,073,000	-$215,632,000	$1,442,215	$2,968,710	$960,790	$275,625,265
2030	$585,596,597	$2,026,125	$41,013,081	$94,500	-$24,679,587	$4,814,981	$293,289	$381,600	-$4,279,372	-$26,243,200	$1,442,215	$2,966,670	$1,018,388	$584,445,287
2031	$594,330,412	$2,316,603	$50,704,173	$166,500	-$31,853,896	$6,194,501	$544,679	$381,600	$1,385,000	$0	$1,442,215	$2,958,680	$37,721,983	$666,292,452
2032	$602,253,013	$2,538,875	$53,444,586	$193,500	-$33,041,405	$7,588,639	$512,091	$381,600	$1,359,200	-$13,254,400	$1,442,215	$2,962,590	$110,334,073	$736,714,577
2033	$598,051,394	$2,713,804	$55,091,842	$211,500	-$33,812,502	$9,154,418	$479,504	$381,600	$4,776,488	-$134,910,400	$1,442,215	$2,986,900	$228,750,232	$735,316,997
2034	$581,638,682	$2,894,350	$55,495,150	$225,000	-$34,686,136	$10,632,921	$460,882	$381,600	-$11,867,400	-$4,732,800	$1,442,215	$3,014,270	$169,882,506	$774,781,241
2035	$593,443,605	$3,009,097	$57,008,522	$684,000	-$138,185,863	$12,189,653	$212,005,418	$381,600	-$3,410,256	$0	$1,442,215	$2,669,170	$2,974,201	$744,211,362
2036	$552,341,308	$3,131,868	$54,899,213	$753,000	-$156,535,736	$29,215,593	$237,021,231	$381,600	$10,390,800	-$92,120,000	$1,442,215	$2,495,260	$1,579,814	$644,996,167
2037	$478,524,719	$3,259,454	$54,077,933	$807,600	-$171,353,467	$30,027,071	$253,451,069	$381,600	$12,870,400	$0	$1,442,215	$2,235,670	$1,726,385	$667,450,649
2038	$412,379,694	$3,396,669	$49,865,121	$854,700	-$185,392,609	$30,993,264	$265,001,292	$381,600	$7,955,898	$0	$1,442,215	$2,146,590	$1,871,422	$590,895,856
2039	$352,063,794	$3,540,303	$47,049,178	$893,100	-$196,967,861	$31,817,314	$271,496,198	$381,600	$9,170,600	$0	$1,442,215	$1,996,310	$1,928,084	$524,810,836

Year	Equipment Capital Costs	Infrastructure Capital Costs	Equipment Maintenance Costs	Infrastructure Maintenance Costs	Diesel Fuel Costs	Electricity Fuel Costs	Hydrogen Fuel Costs	Geo-tracking Subscription Costs	Salvage Revenue	Sale Revenue	Reporting Costs	Admin Costs	Opportunity Cost	Total
2040	$294,882,184	$3,693,566	$44,264,143	$933,600	-$208,734,395	$32,647,801	$277,656,928	$381,600	$6,667,600	$0	$1,442,215	$1,918,790	$1,898,389	$457,652,422
2041	-$52,976,043	$3,878,124	$41,030,250	$976,500	-$221,281,112	$33,432,920	$283,548,384	$381,600	$6,421,000	$0	$1,442,215	$1,877,140	$1,940,924	$100,671,903
2042	-$140,872,115	$4,048,239	$37,634,297	$1,026,900	-$236,652,686	$34,626,052	$289,210,132	$381,600	$6,828,600	$0	$1,442,215	$1,844,840	$2,140,530	$1,658,603
2043	-$174,068,171	$4,228,784	$34,060,313	$1,074,600	-$250,799,338	$39,702,820	$294,214,698	$381,600	$7,426,800	$0	$1,442,215	$1,806,420	$2,246,360	-$38,282,898
2044	-$192,198,650	$4,420,564	$30,463,807	$1,125,900	-$266,416,193	$40,490,855	$298,889,788	$381,600	$7,426,200	$0	$1,442,215	$1,799,960	$2,355,872	-$69,818,083
2045	-$198,018,749	$4,420,564	$28,070,712	$1,179,600	-$284,565,722	$42,807,838	$302,814,260	$381,600	$3,360,800	$0	$1,442,215	$1,795,200	$2,462,367	-$93,849,314
2046	-$191,549,340	$4,420,564	$25,638,948	$1,236,900	-$300,092,668	$44,347,279	$306,130,584	$381,600	$3,307,000	$0	$1,442,215	$1,793,670	$2,484,297	-$100,458,951
2047	-$213,356,235	$4,420,564	$23,189,381	$1,296,900	-$319,155,559	$45,315,937	$308,564,855	$381,600	$3,311,200	$0	$1,442,215	$1,660,730	$2,676,119	-$140,252,293
2048	-$223,890,180	$4,444,637	$20,659,748	$1,360,500	-$339,243,580	$46,049,054	$310,215,207	$381,600	$3,254,200	$0	$1,442,215	$1,523,370	$1,347,431	-$172,455,798
2049	-$203,254,412	$2,867,870	$18,088,402	$1,432,500	-$365,042,930	$46,955,327	$310,910,636	$381,600	$3,389,200	$0	$1,442,215	$1,382,270	$1,261,065	-$180,186,256
2050	-$172,432,767	$2,418,512	$15,468,638	$1,504,200	-$391,916,481	$48,026,400	$310,583,041	$381,600	$3,425,400	$0	$1,442,215	$1,381,420	$1,328,196	-$178,389,624
Total	$5,006,126,625	$73,665,905	$813,821,256	$18,031,500	-$4,190,409,724	$627,030,640	$4,534,004,166	$21,409,800	$17,128,228	-$488,307,200	$38,939,810	$62,964,260	$583,899,663	$7,118,304,927

6.3.2 Benefits

Benefits for the Sensitivity Analysis were calculated using the methodology described in Section 2. The Sensitivity Analysis would result in fewer emission reductions than the Proposed Regulation. This is because there would be slower uptake of ZE locomotives than in the Proposed Regulation since operators would continue using Tier 4 locomotives purchased after 2030. Figure 6.10, Figure 6.11, and Figure 6.12 below show the comparison of PM, NOx, and GHG emissions from the Sensitivity Analysis to the Proposed Regulation and Baseline.

Figure 6.10: Statewide PM2.5 Emissions from Locomotives under the Baseline, Proposed Regulation, and Sensitivity Analysis

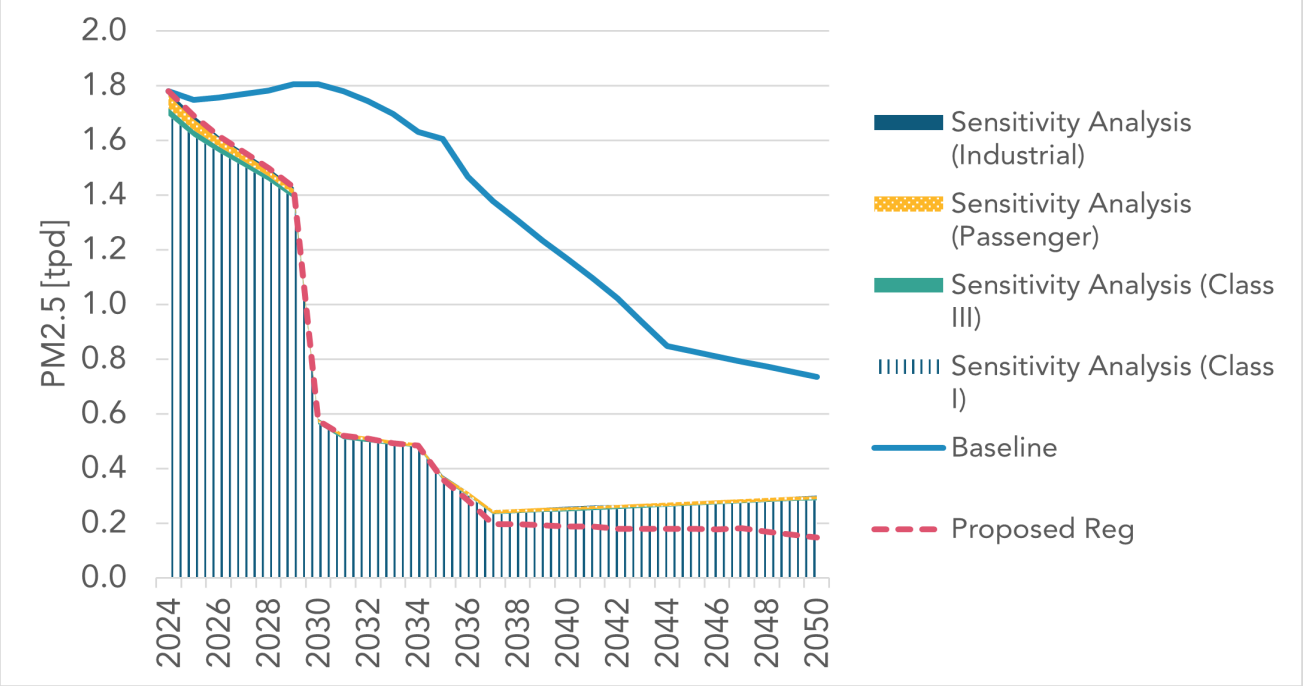


Figure 6.11: Statewide NOx Emissions from Locomotives under the Baseline, Proposed Regulation, and Sensitivity Analysis

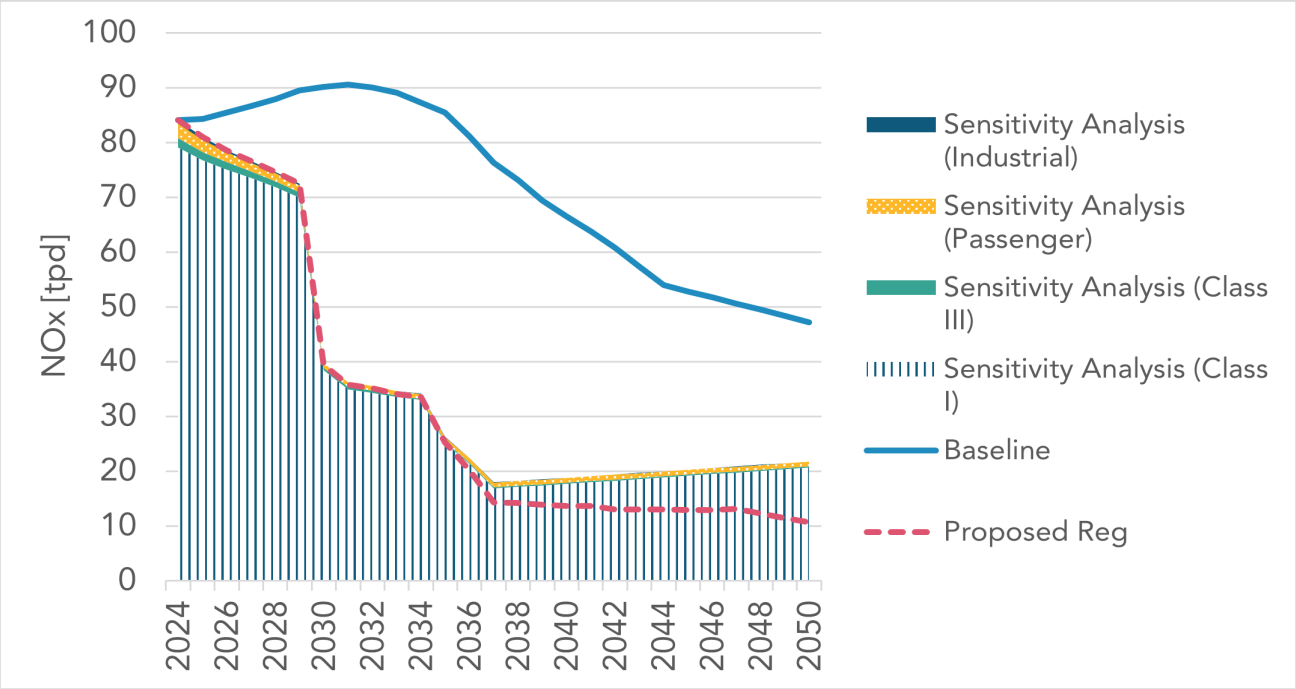
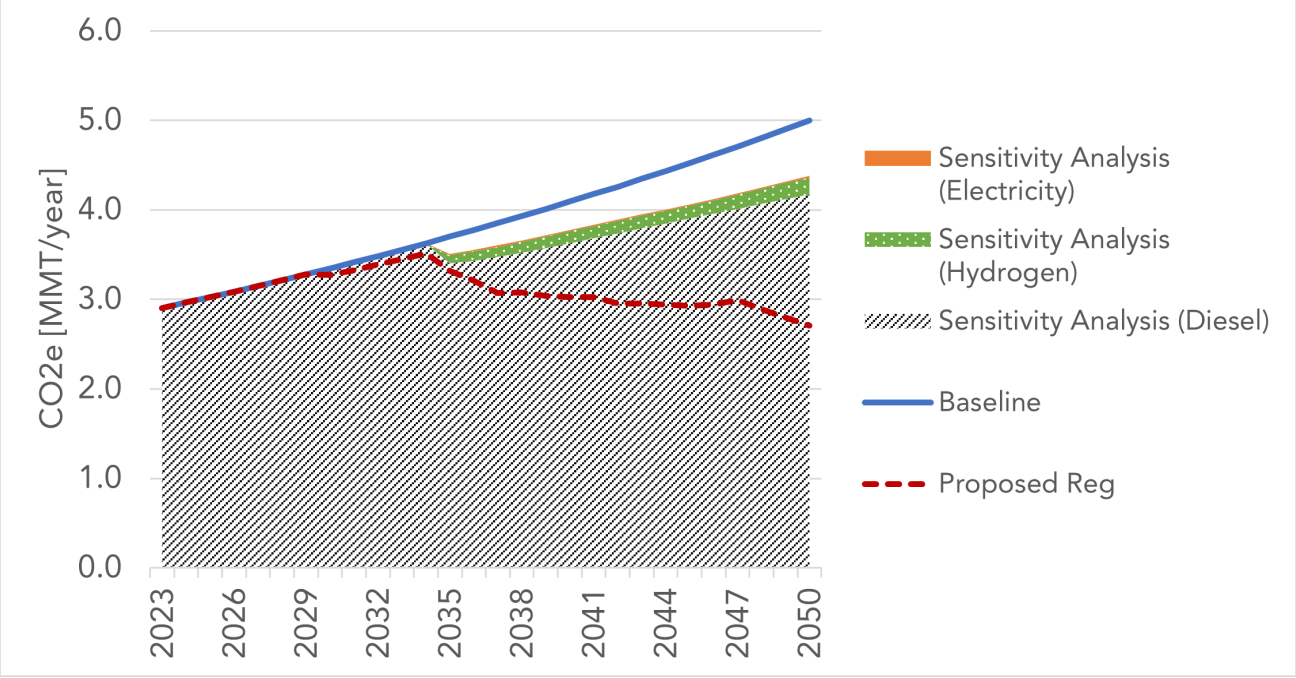


Figure 6.12: Statewide GHG Emissions from Locomotives under the Baseline, Proposed Regulation, and Sensitivity Analysis



The estimation methodologies described in Section 2 were used to quantify avoided cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, as well as emergency room visits for respiratory illness and asthma that would be expected to

result from the Sensitivity Analysis. Table 6.12 shows the statewide valuation from avoided health outcomes for the Sensitivity Analysis. The Sensitivity Analysis results in a lower valuation of health benefits at $29.4 billion compared to the Proposed Regulation at $32.3 billion, shown in Section 3.

Table 6.11: Statewide Valuation from Avoided Health Outcomes for Sensitivity Analysis from 2023 to 2050

Outcome	Avoided Incidents	Valuation
Avoided Premature Deaths	2,976	$29,361,517,154
Avoided Hospitalizations	1,006	$54,532,002
Avoided Emergency Room Visits	1,371	$1,143,379
Total Valuation	--	$29,417,192,536

6.3.3 Economic Impacts

As mentioned, the Sensitivity Analysis is less stringent compared to the Proposed Regulation, not requiring ZE locomotive purchases with non-Spending Account funds. The less stringent requirements of the Sensitivity Analysis result in lower incremental costs relative to the Proposed Regulation. The macroeconomic impact analysis results are qualitatively similar to the results of the Proposed Regulation, but of a slightly smaller magnitude as shown in Table 6.12 and Figure 6.13.

The Sensitivity Analysis is estimated to result in a decrease to GSP, Personal Income, Employment, Output, and Private Investment by 0.03 to 0.09 percent below baseline levels in 2035, which is among the years with the largest impact, as the bulk of new ZE line haul locomotives are purchased. The impacts would turn positive in the last a few years mainly driven by the growth in construction. The timing of impacts of the Sensitivity Analysis mimic those estimated under the Proposed Regulation.

Table 6.12: Change in Growth of Economic Indicators for the Sensitivity Analysis

Description	Impact	2025	2030	2035	2040	2045	2050
GSP	% Change	0.00%	-0.02%	-0.03%	-0.03%	0.00%	0.00%
GSP	Change (2019M$)	-33	-858	-1,361	-1,231	-148	77
Personal Income	% Change	0.00%	-0.03%	-0.04%	-0.03%	0.00%	0.00%
Personal Income	Change (2019M$)	-78	-1,013	-1,449	-1,243	-117	175
Employment	% Change	0.00%	-0.03%	-0.04%	-0.03%	0.00%	0.00%
Employment	Change (2019M$)	-240	-6,450	-9,160	-7,650	-480	700
Output	% Change	0.00%	-0.03%	-0.04%	-0.03%	0.00%	0.00%
Output	Change (2019M$)	-60	-1,519	-2,462	-2,271	-346	79
Private Investment	% Change	-0.01%	-0.06%	-0.09%	-0.06%	0.00%	0.01%
Private Investment	Change (2019M$)	-26	-328	-557	-380	11	37

Figure 6.13: Changes in Employment by Major Sector Associated with Sensitivity Analysis

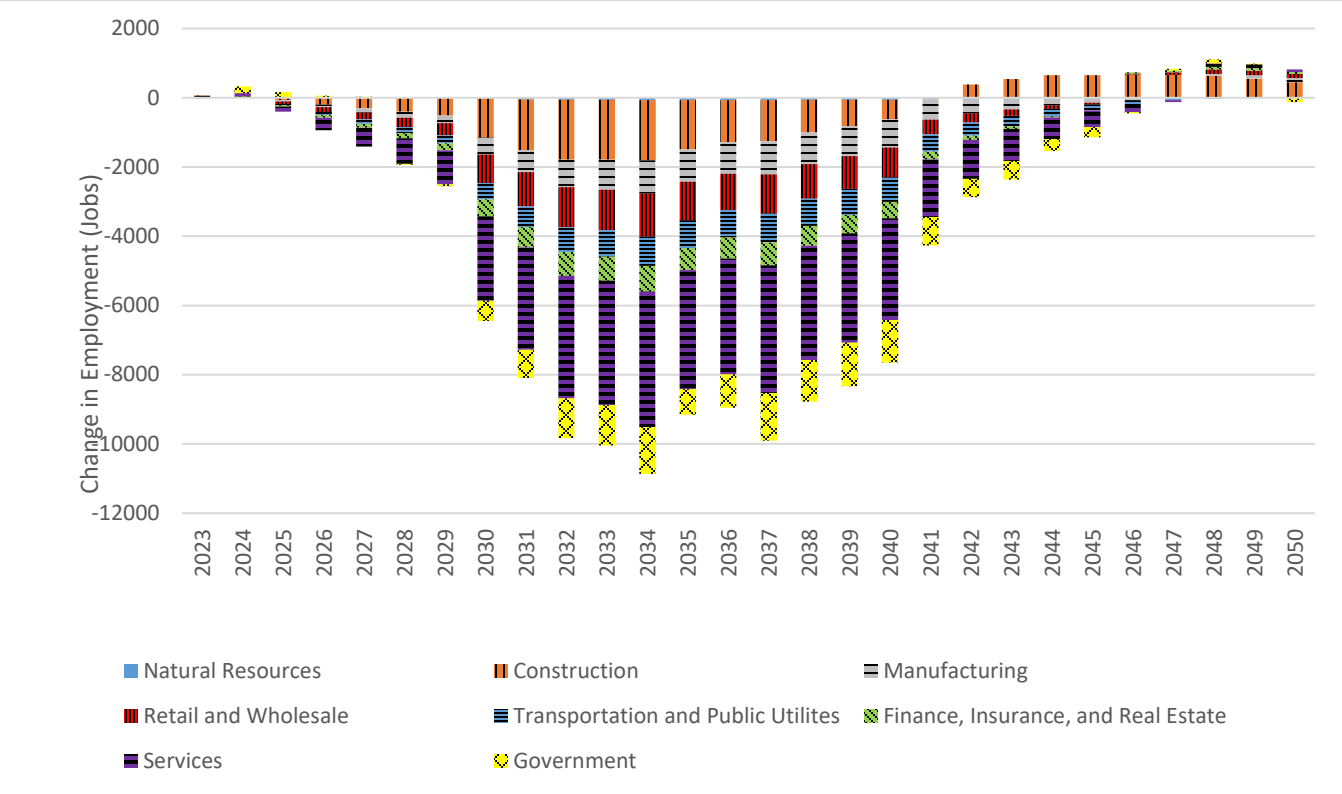
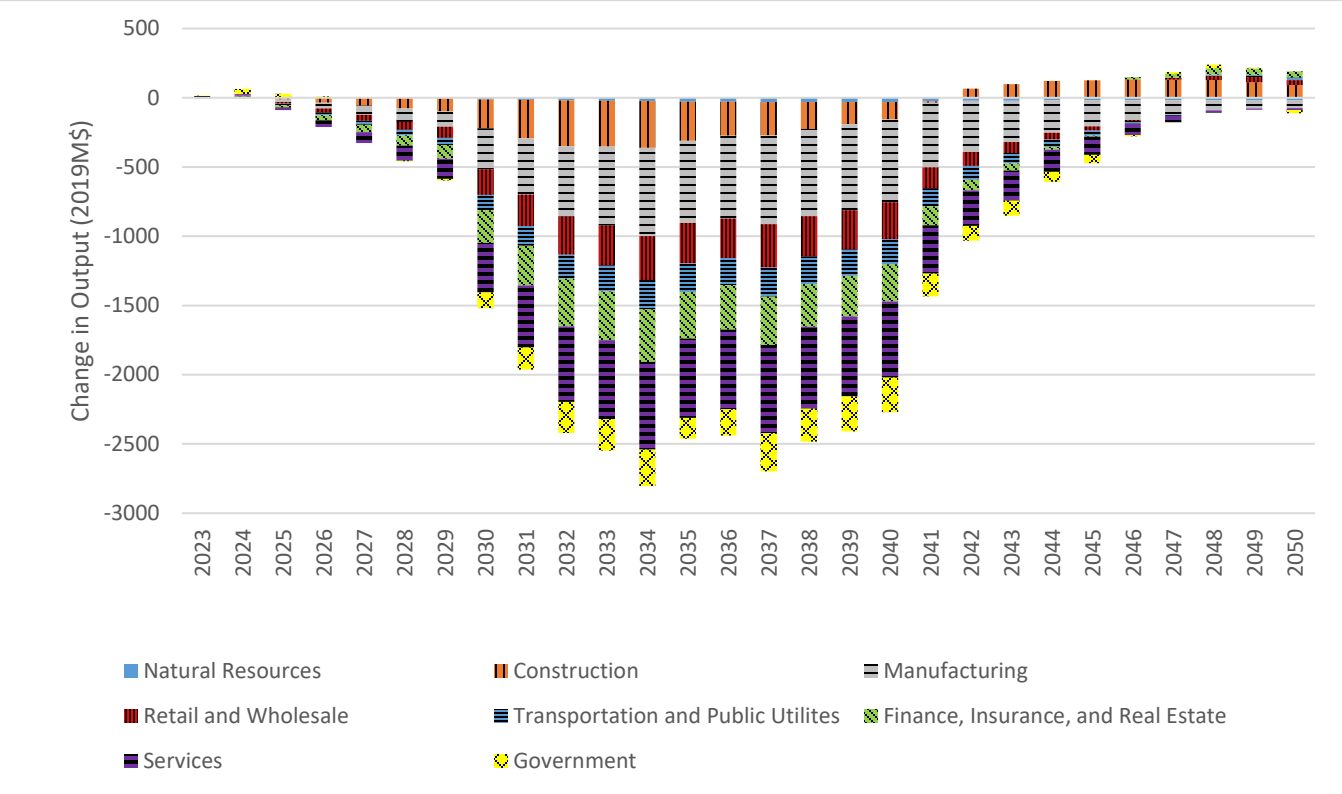


Figure 6.14 illustrates the changes in output by major sector associated with the Sensitivity Analysis. The trends in output are similar to the trends that were observed for employment. The Sensitivity Analysis is estimated to result in decreases in California employment and output from 2025 to 2050, primarily due to increases in production costs and decrease in government spending.

Figure 6.14: Changes in Output by Major Sector Associated with the Sensitivity Analysis



6.3.4 Cost-Effectiveness

Cost-effectiveness is a measure of the cost of a regulation per ton of expected emissions reduction. Staff calculated the cost-effectiveness of the Sensitivity Analysis (in $/weighted ton) using the cost-effectiveness method provided in the Carl Moyer Guidelines Appendix C by dividing the cost over time by the weighed emissions reductions (in tons per year) over that same time period.[174] Table 6.14 below summarizes the cost effectiveness for the Proposed Regulation and the Sensitivity Analysis. Staff estimated the Sensitivity Analysis would be more cost-effective than the Proposed Regulation due to the lower direct costs and similar health benefits early in the regulated time period. While the Sensitivity Analysis is more cost-effective in reducing toxic air pollutants, it achieves fewer total PM and NOx emission reductions than the Proposed Regulation. Also, without a ZE In-Use Operational Requirement, GHG emissions would continually increase.

[174] California Air Resources Board, The Carl Moyer Program Guidelines, 2017 Revisions, Appendix C. (web link: https://ww3.arb.ca.gov/msprog/moyer/guidelines/current.htm)

Table 6.13: Cost Effectiveness of the Proposed Regulation and the Sensitivity Analysis

Proposal	Carl Moyer Cost-Effectiveness ($/weighted ton)
Proposed Regulation	$29,159
Sensitivity Analysis	$14,281
Difference in Cost-Effectiveness	-$14,878

6.3.5 Reason for Rejecting

Staff rejected the Sensitivity Analysis because it provides fewer PM2.5 and NOx emission reductions and prevents fewer adverse health outcomes than the Proposed Regulation. While it is more cost effective per ton of weighted emissions to implement than the Proposed Regulation, it is not stringent enough because it would;

1) Allow for continued diesel operations at rates higher than permitted for trucks in California,
2) indefinitely extend diesel toxics emissions from locomotives,
3) fail to achieve the state's GHG emission reduction goals and the Governor's EO N-79-20 for ZE adoption,
4) not provide maximum criteria pollutant reductions feasible for the SIP.

7 Macroeconomic Analysis Appendix

Table A-I presents the specific inputs used in the Regional Economic Models, Inc. (REMI) modeling for the Proposed Regulation. It only reports the selected years. The complete inputs tables cover all the years from 2023 to 2050 and are available if requested. REMI version 2.5.0 accepts inputs in 2020 dollars. Costs were adjusted from 2019 to 2020 dollars when input into the REMI model.

The impacts on Class I line haul operators are reported in the second row of Table A-1. As explained in Section 5.2, these changes in costs are modeled as increased production costs that are spread across all industries as well as state, local, and federal government based on each industries' use of rail transportation as an intermediate input, as shown in Table A-2.

Table A-1: REMI Inputs for the Proposed Regulation (Million 2020$)

REMI Policy Variable	REMI Industry	2025	2030	2035	2040	2045	2050
Production Cost	All*	58.01	606.01	900.65	918.95	458.56	54.47
Production Cost	482 - Rail transportation	11.44	66.07	89.28	65.97	9.95	21.89
State and Local Government Spending	State Government	17.22	29.69	12.91	-58.03	-51.67	-96.53
State and Local Government Spending	Local Government	14.49	34.37	31.82	-14.64	10.67	-11.01
Exogenous Final Demand	3365 - Railroad rolling stock manufacturing	3.80	6.64	4.22	-0.35	0.29	0.25
Exogenous Final Demand	23 - Construction	0.00	14.21	0.65	0.52	0.00	0.00
Exogenous Final Demand	2212 - Natural Gas Distribution	0.00	3.50	1.11	1.17	0.00	0.00
Exogenous Final Demand	3251-industrial gas manufacturing	0.00	3.50	1.11	1.17	0.00	0.00

REMI Policy Variable	REMI Industry	2025	2030	2035	2040	2045	2050
Exogenous Final Demand	4238-industrial machinery and equipment	0.00	3.50	1.11	1.17	0.00	0.00
Exogenous Final Demand	8112-other electronic and precision equipment repair and maintenance	0.00	3.50	1.11	1.17	0.00	0.00
Exogenous Final Demand	3353 - Electrical equipment manufacturing	0.00	12.66	0.15	0.00	0.00	0.00
Exogenous Final Demand	2211 - Electric power generation, transmission and distribution	0.00	25.45	40.49	44.52	47.50	62.73
Exogenous Final Demand	3251 - Basic chemical manufacturing	0.00	17.65	306.46	826.10	953.63	1064.03
Exogenous Final Demand	324 - Petroleum and coal products manufacturing	0.00	-36.43	-194.29	-547.30	-802.27	-1198.18
Exogenous Final Demand	5611, 5612 - Office administrative services; Facilities support services	1.47	1.47	1.47	1.47	1.47	1.47
Exogenous Final Demand	3345 - Navigational, measuring, electromedical and control instruments mfg	0.00	0.00	0.00	0.00	0.00	0.00

REMI Policy Variable	REMI Industry	2025	2030	2035	2040	2045	2050
Exogenous Final Demand	5416 - Management, scientific, and technical consulting services (5416)	0.00	0.00	0.00	0.00	0.00	0.00
Exogenous Final Demand	5415 - Computer systems design and related services	0.38	0.38	0.38	0.38	0.38	0.38
State Government Employment	State Government	8.00	8.00	8.00	8.00	8.00	8.00
Consumer Spending	Reallocate Consumption: Hospitals	0.15	2.57	3.31	3.13	2.61	2.60

Table A-2: Spread Costs across Industries from Class I Line Haul Operators (Million 2020$)

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	113 - Forestry and Logging	0.02	0.16	0.24	0.24	0.12	0.01
Production Cost	114 - Fishing, hunting and trapping	0.00	0.03	0.04	0.04	0.02	0.00
Production Cost	115 - Support activities for agriculture and forestry	0.34	3.52	5.24	5.34	2.67	0.32
Production Cost	211 - Oil and gas extraction	0.22	2.31	3.43	3.50	1.75	0.21
Production Cost	2121 - Coal mining	0.05	0.52	0.77	0.78	0.39	0.05
Production Cost	2122 - Metal ore mining	0.01	0.15	0.23	0.23	0.12	0.01
Production Cost	2123 - Nonmetallic mineral mining and quarrying	0.03	0.36	0.53	0.54	0.27	0.03
Production Cost	213 - Support activities for mining	0.04	0.40	0.59	0.61	0.30	0.04
Production Cost	2211 - Electric power generation, transmission and distribution	3.60	37.58	55.84	56.98	28.43	3.38
Production Cost	2212 - Natural gas distribution	0.13	1.33	1.97	2.01	1.00	0.12
Production Cost	2213 - Water, sewage, and other systems	0.14	1.48	2.21	2.25	1.12	0.13
Production Cost	23 - Construction	3.72	38.86	57.75	58.92	29.40	3.49
Production Cost	3211 - Sawmills and wood preservation	0.13	1.39	2.06	2.10	1.05	0.12
Production Cost	3212 - Veneer, plywood, and engineered wood product manufacturing	0.12	1.27	1.89	1.93	0.96	0.11
Production Cost	3219 - Other wood product manufacturing	0.32	3.39	5.04	5.14	2.56	0.30

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	3271 - Clay product and refractory manufacturing	0.09	0.97	1.45	1.48	0.74	0.09
Production Cost	3272 - Glass and glass product manufacturing	0.77	8.09	12.02	12.26	6.12	0.73
Production Cost	3273 - Cement and concrete product manufacturing	0.95	9.96	14.81	15.11	7.54	0.90
Production Cost	3274, 3279 - Lime, gypsum and other nonmetallic mineral product manufacturing	0.47	4.92	7.31	7.46	3.72	0.44
Production Cost	3311 - Iron and steel mills and ferroalloy manufacturing	0.61	6.38	9.49	9.68	4.83	0.57
Production Cost	3312 - Steel product manufacturing from purchased steel	0.06	0.61	0.91	0.93	0.46	0.06
Production Cost	3313 - Alumina and aluminum production and processing	0.04	0.42	0.62	0.63	0.32	0.04
Production Cost	3314 - Nonferrous metal (except aluminum) production and processing	0.10	1.04	1.55	1.58	0.79	0.09
Production Cost	3315 - Foundries	0.08	0.86	1.27	1.30	0.65	0.08
Production Cost	3321 - Forging and stamping	0.17	1.73	2.58	2.63	1.31	0.16
Production Cost	3322 - Cutlery and hand tool manufacturing	0.01	0.14	0.21	0.21	0.11	0.01
Production Cost	3323 - Architectural and structural metals manufacturing	0.29	3.03	4.51	4.60	2.30	0.27
Production Cost	3324 - Boiler, tank, and shipping container manufacturing	0.08	0.81	1.21	1.23	0.61	0.07
Production Cost	3325 - Hardware manufacturing	0.01	0.14	0.21	0.22	0.11	0.01
Production Cost	3326 - Spring and wire product manufacturing	0.01	0.12	0.19	0.19	0.09	0.01

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	3327 - Machine shops; turned product; and screw, nut, and bolt manufacturing	0.14	1.49	2.21	2.26	1.13	0.13
Production Cost	3328 - Coating, engraving, heat treating, and allied activities	0.13	1.37	2.04	2.08	1.04	0.12
Production Cost	3329 - Other fabricated metal product manufacturing	0.13	1.37	2.03	2.08	1.04	0.12
Production Cost	3331 - Agriculture, construction, and mining machinery manufacturing	0.05	0.54	0.80	0.82	0.41	0.05
Production Cost	3332 - Industrial machinery manufacturing	0.04	0.39	0.58	0.59	0.30	0.04
Production Cost	3333 - Commercial and service industry machinery manufacturing, including digital camera manufacturing	0.03	0.28	0.42	0.43	0.21	0.03
Production Cost	3334 - Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	0.03	0.30	0.44	0.45	0.22	0.03
Production Cost	3335 - Metalworking machinery manufacturing	0.03	0.27	0.40	0.40	0.20	0.02
Production Cost	3336 - Engine, turbine, and power transmission equipment manufacturing	0.12	1.31	1.94	1.98	0.99	0.12
Production Cost	3339 - Other general purpose machinery manufacturing	0.11	1.13	1.68	1.72	0.86	0.10
Production Cost	3341 - Computer and peripheral equipment manufacturing, excluding digital camera manufacturing	0.03	0.30	0.45	0.46	0.23	0.03
Production Cost	3342 - Communications equipment manufacturing	0.01	0.10	0.15	0.15	0.08	0.01

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	3343 - Audio and video equipment manufacturing	0.00	0.01	0.02	0.02	0.01	0.00
Production Cost	3344 - Semiconductor and other electronic component manufacturing	0.09	0.91	1.35	1.38	0.69	0.08
Production Cost	3345 - Navigational, measuring, electromedical, and control instruments manufacturing	0.05	0.47	0.70	0.72	0.36	0.04
Production Cost	3346 - Manufacturing and reproducing magnetic and optical media	0.01	0.06	0.08	0.08	0.04	0.01
Production Cost	3351 - Electric lighting equipment manufacturing	0.02	0.20	0.30	0.31	0.15	0.02
Production Cost	3352 - Household appliance manufacturing	0.01	0.11	0.17	0.17	0.09	0.01
Production Cost	3353 - Electrical equipment manufacturing	0.02	0.19	0.29	0.29	0.15	0.02
Production Cost	3359 - Other electrical equipment and component manufacturing	0.20	2.05	3.04	3.10	1.55	0.18
Production Cost	3361 - Motor vehicle manufacturing	0.36	3.80	5.65	5.77	2.88	0.34
Production Cost	3362 - Motor vehicle body and trailer manufacturing	0.04	0.41	0.60	0.62	0.31	0.04
Production Cost	3363 - Motor vehicle parts manufacturing	0.28	2.91	4.32	4.41	2.20	0.26
Production Cost	3364 - Aerospace product and parts manufacturing	0.20	2.08	3.09	3.15	1.57	0.19
Production Cost	3365 - Railroad rolling stock manufacturing	0.12	1.22	1.81	1.84	0.92	0.11
Production Cost	3366 - Ship and boat building	0.01	0.12	0.17	0.18	0.09	0.01

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	3369 - Other transportation equipment manufacturing	0.12	1.30	1.93	1.97	0.98	0.12
Production Cost	3371 - Household and institutional furniture and kitchen cabinet manufacturing	0.16	1.69	2.51	2.56	1.28	0.15
Production Cost	3372, 3379 - Office furniture (including fixtures) manufacturing; Other furniture related product manufacturing	0.14	1.43	2.12	2.16	1.08	0.13
Production Cost	3391 - Medical equipment and supplies manufacturing	0.16	1.68	2.50	2.55	1.27	0.15
Production Cost	3399 - Other miscellaneous manufacturing	0.20	2.09	3.11	3.17	1.58	0.19
Production Cost	3111 - Animal food manufacturing	0.57	6.00	8.92	9.10	4.54	0.54
Production Cost	3112 - Grain and oilseed milling	2.03	21.18	31.47	32.11	16.02	1.90
Production Cost	3113 - Sugar and confectionery product manufacturing	0.39	4.11	6.11	6.23	3.11	0.37
Production Cost	3114 - Fruit and vegetable preserving and specialty food manufacturing	0.56	5.82	8.65	8.82	4.40	0.52
Production Cost	3115 - Dairy product manufacturing	0.27	2.85	4.24	4.32	2.16	0.26
Production Cost	3116 - Animal slaughtering and processing	0.06	0.64	0.95	0.97	0.48	0.06
Production Cost	3117 - Seafood product preparation and packaging	0.01	0.06	0.08	0.08	0.04	0.01
Production Cost	3118 - Bakeries and tortilla manufacturing	0.56	5.84	8.68	8.86	4.42	0.53
Production Cost	3119 - Other food manufacturing	0.72	7.55	11.21	11.44	5.71	0.68

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	3121 - Beverage manufacturing	1.35	14.13	21.00	21.42	10.69	1.27
Production Cost	3122 - Tobacco manufacturing	0.01	0.09	0.14	0.14	0.07	0.01
Production Cost	313, 314 - Textile mills and textile product mills	0.05	0.54	0.81	0.82	0.41	0.05
Production Cost	315, 316 - Apparel, leather and allied product manufacturing	0.03	0.35	0.52	0.54	0.27	0.03
Production Cost	3221 - Pulp, paper, and paperboard mills	0.33	3.47	5.16	5.27	2.63	0.31
Production Cost	3222 - Converted paper product manufacturing	0.77	8.00	11.89	12.13	6.05	0.72
Production Cost	323 - Printing and related support activities	0.13	1.41	2.09	2.14	1.07	0.13
Production Cost	324 - Petroleum and coal products manufacturing	3.51	36.64	54.46	55.57	27.73	3.29
Production Cost	3251 - Basic chemical manufacturing	2.02	21.08	31.33	31.97	15.95	1.89
Production Cost	3252 - Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	0.51	5.36	7.97	8.13	4.06	0.48
Production Cost	3253 - Pesticide, fertilizer, and other agricultural chemical manufacturing	0.31	3.28	4.88	4.98	2.49	0.30
Production Cost	3254 - Pharmaceutical and medicine manufacturing	0.48	4.97	7.38	7.53	3.76	0.45
Production Cost	3255 - Paint, coating, and adhesive manufacturing	0.37	3.83	5.69	5.81	2.90	0.34
Production Cost	3256 - Soap, cleaning compound, and toilet preparation manufacturing	0.34	3.56	5.29	5.39	2.69	0.32

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	3259 - Other chemical product and preparation manufacturing	0.28	2.95	4.38	4.47	2.23	0.26
Production Cost	3261 - Plastics product manufacturing	1.10	11.47	17.05	17.40	8.68	1.03
Production Cost	3262 - Rubber product manufacturing	0.04	0.44	0.65	0.67	0.33	0.04
Production Cost	42 - Wholesale trade	0.70	7.31	10.86	11.08	5.53	0.66
Production Cost	44-45 - Retail trade	0.59	6.13	9.11	9.29	4.64	0.55
Production Cost	481 - Air transportation	0.12	1.21	1.80	1.84	0.92	0.11
Production Cost	482 - Rail transportation	0.15	1.57	2.34	2.39	1.19	0.14
Production Cost	483 - Water transportation	0.01	0.13	0.20	0.20	0.10	0.01
Production Cost	484 - Truck transportation	6.52	68.14	101.27	103.33	51.56	6.12
Production Cost	492 - Couriers and messengers	0.05	0.54	0.81	0.82	0.41	0.05
Production Cost	485 - Transit and ground passenger transportation	0.05	0.53	0.78	0.80	0.40	0.05
Production Cost	486 - Pipeline transportation	0.00	0.01	0.01	0.01	0.00	0.00
Production Cost	487, 488 - Scenic and sightseeing transportation and support activities for transportation	0.70	7.27	10.80	11.02	5.50	0.65
Production Cost	493 - Warehousing and storage	0.08	0.87	1.30	1.33	0.66	0.08
Production Cost	5111 - Newspaper, periodical, book, and directory publishers	0.02	0.26	0.38	0.39	0.20	0.02
Production Cost	5112 - Software publishers	0.07	0.70	1.04	1.06	0.53	0.06

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	512 - Motion picture, video, and sound recording industries	0.07	0.74	1.10	1.12	0.56	0.07
Production Cost	518 - Data processing, hosting, related services	0.08	0.89	1.32	1.34	0.67	0.08
Production Cost	519 - Other information services	0.18	1.83	2.73	2.78	1.39	0.16
Production Cost	515 - Radio and television broadcasting; Cable and other subscription programming	0.03	0.30	0.44	0.45	0.23	0.03
Production Cost	517 - Telecommunications	0.53	5.50	8.18	8.34	4.16	0.49
Production Cost	521, 522 - Monetary authorities, credit intermediation, and related activities	0.13	1.31	1.95	1.99	0.99	0.12
Production Cost	523, 525 - Securities, commodity contracts, funds, trusts and other financial investments and related activities	0.10	1.00	1.49	1.52	0.76	0.09
Production Cost	5241 - Insurance carriers	0.10	1.03	1.53	1.56	0.78	0.09
Production Cost	5242 - Agencies, brokerages, and other insurance related activities	0.00	0.05	0.07	0.07	0.04	0.00
Production Cost	531 - Real estate	0.78	8.10	12.04	12.29	6.13	0.73
Production Cost	5321 - Automotive equipment rental and leasing	0.02	0.23	0.35	0.36	0.18	0.02
Production Cost	5322, 5323 - Consumer goods rental and general rental centers	0.01	0.14	0.21	0.22	0.11	0.01
Production Cost	5324 - Commercial and industrial machinery and equipment rental and leasing	0.05	0.52	0.78	0.79	0.40	0.05
Production Cost	533 - Lessors of nonfinancial intangible assets (except copyrighted works)	0.02	0.24	0.36	0.37	0.18	0.02

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	5411 - Legal services	0.04	0.44	0.65	0.66	0.33	0.04
Production Cost	5412 - Accounting, tax preparation, bookkeeping, and payroll services	0.02	0.22	0.33	0.34	0.17	0.02
Production Cost	5413 - Architectural, engineering, and related services	0.26	2.67	3.97	4.05	2.02	0.24
Production Cost	5414 - Specialized design services	0.04	0.37	0.56	0.57	0.28	0.03
Production Cost	5415 - Computer systems design and related services	0.08	0.88	1.31	1.34	0.67	0.08
Production Cost	5416 - Management, scientific, and technical consulting services	0.48	5.01	7.44	7.59	3.79	0.45
Production Cost	5417 - Scientific research and development services	0.69	7.19	10.69	10.90	5.44	0.65
Production Cost	5418 - Advertising, public relations, and related services	0.10	1.04	1.54	1.58	0.79	0.09
Production Cost	5419 - Other professional, scientific, and technical services	0.09	0.95	1.42	1.45	0.72	0.09
Production Cost	55 - Management of companies and enterprises	0.08	0.83	1.23	1.25	0.62	0.07
Production Cost	5611, 5612 - Office administrative services; Facilities support services	0.14	1.44	2.14	2.19	1.09	0.13
Production Cost	5613 - Employment services	0.05	0.50	0.75	0.77	0.38	0.05
Production Cost	5614, 5616, 5619 - Business support services; Investigation and security services; Other support services	0.12	1.22	1.81	1.85	0.92	0.11
Production Cost	5615 - Travel arrangement and reservation services	0.06	0.61	0.90	0.92	0.46	0.05

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	5617 - Services to buildings and dwellings	0.38	3.99	5.92	6.04	3.02	0.36
Production Cost	562 - Waste management and remediation services	0.06	0.63	0.93	0.95	0.47	0.06
Production Cost	61 - Educational services; private	0.08	0.83	1.23	1.25	0.63	0.07
Production Cost	6211-6213 - Offices of health practitioners	0.21	2.22	3.31	3.37	1.68	0.20
Production Cost	6214, 6215, 6219 - Outpatient, laboratory, and other ambulatory care services	0.56	5.89	8.76	8.94	4.46	0.53
Production Cost	6216 - Home health care services	0.05	0.50	0.74	0.76	0.38	0.05
Production Cost	622 - Hospitals; private	0.21	2.19	3.26	3.33	1.66	0.20
Production Cost	623 - Nursing and residential care facilities	0.12	1.28	1.90	1.94	0.97	0.11
Production Cost	6241-6243 - Individual and family services; Community and vocational rehabilitation services	0.19	2.00	2.98	3.04	1.51	0.18
Production Cost	6244 - Child day care services	0.06	0.67	0.99	1.01	0.51	0.06
Production Cost	7111, 7113, 7114 - Performing arts companies; Promoters of events, and agents and managers	0.01	0.07	0.10	0.10	0.05	0.01
Production Cost	7112 - Spectator sports	0.01	0.09	0.13	0.13	0.07	0.01
Production Cost	7115 - Independent artists, writers, and performers	0.01	0.05	0.08	0.08	0.04	0.00
Production Cost	712 - Museums, historical sites, and similar institutions	0.00	0.02	0.03	0.03	0.02	0.00
Production Cost	713 - Amusement, gambling, and recreation industries	0.11	1.10	1.64	1.67	0.83	0.10

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
Production Cost	721 - Accommodation	0.14	1.46	2.17	2.21	1.10	0.13
Production Cost	722 - Food services and drinking places	0.88	9.20	13.67	13.95	6.96	0.83
Production Cost	8111 - Automotive repair and maintenance	0.11	1.13	1.67	1.71	0.85	0.10
Production Cost	8112 - Electronic and precision equipment repair and maintenance	0.01	0.05	0.08	0.08	0.04	0.00
Production Cost	8113 - Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	0.02	0.26	0.39	0.40	0.20	0.02
Production Cost	8114 - Personal and household goods repair and maintenance	0.01	0.13	0.19	0.19	0.09	0.01
Production Cost	8121 - Personal care services	0.01	0.16	0.23	0.24	0.12	0.01
Production Cost	8122 - Death care services	0.00	0.01	0.01	0.01	0.00	0.00
Production Cost	8123 - Drycleaning and laundry services	0.04	0.40	0.59	0.61	0.30	0.04
Production Cost	8129 - Other personal services	0.01	0.10	0.14	0.15	0.07	0.01
Production Cost	8131-8133 - Religious organizations; Grantmaking and giving services and social advocacy organizations	0.03	0.32	0.48	0.49	0.25	0.03
Production Cost	8134, 8139 - Civic, social, professional, and similar organizations	0.04	0.43	0.64	0.65	0.32	0.04
Production Cost	814 - Private households	0.00	0.00	0.00	0.00	0.00	0.00
State and Local Government Spending	State Government	-1.89	-19.77	-29.38	-29.97	-14.96	-1.78

REMI Policy Variable	Industry	2025	2030	2035	2040	2045	2050
State and Local Government Spending	Local Government	-5.43	-56.74	-84.32	-86.04	-42.93	-5.10
Federal Civilian Government Spending	Total	-1.02	-10.65	-15.83	-16.16	-8.06	-0.96
Federal Military Government Spending	Total	-0.44	-4.62	-6.86	-7.00	-3.49	-0.41