

Appendix A: Economic Analysis

Summary and Interpretation of the Results

Over the life of the strategy, from 2023 through 2037, the total net cost of the proposed measures is estimated as \$96.2 billion, which includes \$42.7 billion in CARB measures and \$53.4 billion in measures that require federal actions. The average annual cost from 2023 to 2037 is estimated at \$8.8 billion, which is less than 0.3 percent of projected California GDP in 2037. In the context of the California economy, the anticipated economic impacts of the State SIP Strategy are small across all economic indicators. The maximum annual percentage change in statewide employment, output, personal income, and gross state product are all below 0.4 percent of baseline levels. Note, that these costs and economic impacts do not reflect the potential health and environmental benefits of attaining the federal ambient air quality standards which could result in positive economic growth.

The proposed measures will also achieve significant emissions reduction benefits. Through 2037, the State SIP Strategy is anticipated to result in estimated emissions reductions of approximately 205.6 tons per day NO_x. As a co-benefit, the measures will also result in significant GHG reductions. In addition, unquantified environmental, societal, and health benefits can result from implementation of the State SIP Strategy, resulting in the continued growth in the well-being of Californians and the California economy.

Table A-1 below provides a summary of the estimated statewide costs of all proposed measures presented in this section with quantified emissions reductions and a macroeconomic analysis that estimates the impact of the Proposed 2022 State SIP Strategy on the California economy. Details for each measure are provided in the subsequent text below. The metric to quantify cost-effectiveness of the Proposed State SIP Strategy is the ratio of total amortized cost divided by the cumulative NO_x reduction through 2037; the total amortized cost includes some of the measures which are not designed for NO_x reduction, such as the measure of Consumer Products.

Table A-1 Summary of Statewide Impacts of the Proposed 2022 State SIP Strategy

Category of Cost or Benefits	Value
Total Amortized Cost of Control Measures Through 2037 (Billion 2021\$)	\$96.18
Average Annual Amortized Cost (Billion 2021\$)	\$8.84
Cumulative NO _x Reduction (Million tons through 2037)	1.04
Average Annual Job Impacts (From 2023 through 2037)	-53,000
Cost-Effectiveness (\$ per ton of NO _x)	\$92,000

*Values may differ from below due to rounding.

Many measures are still in development and the initial cost estimates in this analysis will be updated as proposed measures are refined through the regulatory process. Each measure containing a regulatory action will be subject to the Administrative Procedures Act regulatory process. There will be additional opportunity for public input, including participating in public

workshops. The measures that require a regulatory action will also be accompanied by additional economic impact assessments where the distribution of potential costs and benefits on California businesses, individuals, and the economy will be discussed.

Direct Costs of State SIP Strategy Measures

Two approaches are used in quantifying costs of the Proposed State SIP Strategy measures. The first approach estimates the incremental costs of the measure by quantifying additional capital equipment purchases, ongoing cost and savings, and end-user infrastructure costs, such as household electric panel upgrades for building electrification and privately owned vehicle charging equipment for measures that increase adoption of zero emission technology. A second approach is used to calculate the costs of measures in the earliest stages of development. The total costs for these measures are estimated by multiplying the estimated emissions reductions by the average cost-per ton of emissions reductions from related SIP measures.

Capital equipment and end-user infrastructure costs are amortized (spread out) over the useful life of equipment while ongoing costs and savings are not amortized. Amortized capital costs are incurred annually, starting in the year of purchase, and continue through the useful life of the equipment. Some amortized costs are expected to continue beyond 2037 but are not included in the analysis.¹⁸¹ The assumptions on equipment useful life and interest rates vary across each measure. More details on these assumptions can be found in the footnotes to the following tables. Unless otherwise stated, staff relied on the fuel and energy price estimates in the 2021 Integrated Energy Policy Report (IEPR).¹⁸² Where the IEPR forecast ends, fuel and energy prices are estimated using the growth rate of the U.S. Energy Information Administration's Annual Energy Outlook.

On-Road Medium- and Heavy-Duty Vehicles

Advanced Clean Fleets Regulation

The Advanced Clean Fleet Regulation will set zero-emission requirements for fleets and focus on strategies to ensure that the cleanest vehicles are deployed by government, business, and other entities in California to meet transportation needs. Businesses and governments that are required to adopt zero-emission trucks would face capital costs associated with infrastructure upgrades, electric vehicle supply equipment, and an accelerated transition to zero-emission trucks. These entities would also face ongoing costs and cost-savings associated with changes in maintenance costs and changes in diesel, natural gas, electricity, and hydrogen use. The decrease in diesel tax revenue corresponding with reduced consumption would reduce government spending without any offsetting revenues. There would also be additional costs associated with reporting and workforce training and education.

¹⁸¹ There would also be ongoing costs and savings associated with each measure beyond 2037 that are not included in this analysis.

¹⁸² California Energy Commission, "2021 Integrated Energy Policy Report", Available at: <https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report>

As shown in Table A-2, the Advanced Clean Fleets Regulation is estimated to result in a net cost of \$9.1 billion from 2024 through 2037. While the analysis for the Proposed State SIP Strategy estimates costs for all measures through 2037, the Advanced Clean Fleets Regulation is anticipated to eventually result in net cost savings for truck transportation as result of lower operating costs. By from 2024 through 2050, the Advanced Clean Fleets Regulation is estimated to result in a net cost-savings of \$12.4 billion. A comprehensive economic impact analysis of the Advanced Clean Fleets Regulation is included in the Standardized Regulatory Impact Assessment.¹⁸³

Zero-Emissions Truck Measure

If CARB is given the authority, the proposed measure would use market signal tools to implement differentiated registration fees, restrictions or fees for combustion trucks entering low/zero emission zones, and/or indirect source rules to establish zero-emissions zones by 2035. In the absence of new authority, starting in 2030 the measure would require fleets to phase-in ZEVs into fleets operating in California that aren't already covered by the proposed Advanced Clean Fleets regulation. The strategy would consider the most economical compliance options available in the secondary markets to upgrade to ZEVs, including used ZEVs, everywhere feasible.

As shown in Table A-2, the Zero-Emissions Truck Measure is estimated to result in a net cost of \$5.4 billion from 2030 through 2037. The costs of the Zero-Emissions Truck Measure were estimated by applying the average cost effectiveness of emissions reductions from the Advanced Clean Fleets Regulation to the anticipated annual emissions reductions.

Table A-2 Cost of On-Road Medium- and Heavy-Duty Vehicles Measures

Measure	Initial Year of Costs	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
Advanced Clean Fleets Regulation ¹⁸⁴	2024	\$9,089	\$649
Zero-Emissions Truck Measure	2030	\$5,392	\$674

¹⁸³ California Air Resources Board. Advanced Clean Fleets Regulation, Standardized Regulatory Impact Assessment. https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/ARB-ACF-SRIA_2022-05-18.pdf

¹⁸⁴ Preliminary cost estimates. Board recommendation anticipated in Fall 2022. Vehicle purchases are amortized over 5 years with a 7 percent interest rate. Infrastructure is amortized over 20 years with a 5 percent interest rate.

On-Road Light-Duty Vehicles

On-Road Motorcycles New Emissions Standards

The On-Road Motorcycle (ONMC) New Emissions Standards would reduce emissions from new ONMCs by adopting more stringent exhaust and evaporative emission standards, on-board diagnostics requirements, and zero emission sales thresholds. By 2035, when the regulation is fully implemented, the ONMC New Emission Standards is estimated to impact approximately 350,000 of the 750,000 motorcycles in California.

The costs of improved emission controls needed to meet more stringent exhaust and evaporative standards and on-board diagnostic requirements are anticipated to be reflected in higher costs for gasoline motorcycles. In general, zero-emission motorcycles currently cost more than similar gasoline powered motorcycles, but this cost differential is projected to decrease over time as battery technology improves. Overall, businesses and individuals would likely spend more for ONMCs in the early implementation years as the zero-emission sales thresholds and more stringent exhaust and evaporative emission standard and on-board diagnostics becomes effective. Customer is likely to spend more in warranty cost as well. This measure may also have costs and cost savings associated with decreased gasoline use, reduced maintenance costs and increased electricity use.

As shown in Table A-3, the On-Road Motorcycles New Emissions Standards are estimated to result in a net cost of \$304 million from 2025 through 2037. The net cost includes the amortized capital cost and the changes in on-going cost till 2037. The total capital cost is calculated by multiplying the number of conventional and zero-emission motorcycles subject to the proposed measure by the incremental capital cost plus the margin to get the cost paid by consumers. The total capital cost after sales tax is then amortized for 5 years at 5% and then was accounted in the total cost till 2037. A comprehensive economic impact analysis of the ONMC New Emissions Standards is included in the Standardized Regulatory Impact Assessment.¹⁸⁵

Clean Miles Standard

The Clean Miles Standard is a light-duty fleet rule that reduces GHG emissions and promotes the state's electrification goals by proposing electrification targets, greenhouse gas emission targets, and reporting requirements for Transportation Network Companies (TNCs). As TNCs and TNC drivers increase electric vehicle miles traveled and decrease GHG emissions, there would be resulting costs and cost savings. The TNC industry is anticipated to initially face increased capital costs associated with vehicle and home charger purchases. As ZEVs reach price parity with conventional gasoline vehicles there may be subsequent capital cost savings to the TNC industry. While the upfront costs of ZEVs are currently higher than traditional gasoline vehicles, the costs of ZEVs are anticipated to decline over time and reach cost parity with gasoline vehicles. The TNC industry would also face ongoing cost and cost savings associated

¹⁸⁵

California Air Resources Board. Proposed Amendments to On-Road Motorcycle (ONMC) Emission Standards and Test Procedures, Standardized Regulatory Impact Assessment. <https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/ONMC-2022-SRIA-final-for-ADA-compliant-July-13.pdf>

with increased electricity use, decreased gasoline use, and decreased vehicle maintenance costs. Finally, TNC companies may face costs associated with recordkeeping and reporting.

As shown in Table A-3, the Clean Miles Standard is estimated to result in a statewide net cost-savings to of \$756 million from 2023 through 2037. Statewide cost-savings are a result of high mileage TNC vehicles switching over to ZEVs and realizing gasoline and maintenance cost savings that outweigh the electricity fuel costs.¹⁸⁶ A comprehensive economic impact analysis can be found in the published Standardized Regulatory Impact Assessment (SRIA) and Initial Statement of Reasons (ISOR) of the Clean Miles Standard.¹⁸⁷

Reducing Vehicle Miles Travelled

CARB is considering measures to reduce ROG and NO_x emissions through reductions in VMT. Specifically, CARB will consider whether and how to change the process for developing Motor Vehicle Emissions Budget (MVEB). Then CARB will assess and improve the Reasonably Available Control Measures (RACM) analysis in the State Implementation Plan (SIP) by providing a comprehensive list of Transportation Control Measures (TCMs) and emission quantification methodology. Finally, CARB will update the guidelines for the California Motor Vehicle Registration Fee (MV Fees) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program to fund a broader range of transportation and air quality projects. Staff expects an increased workload for CARB, which the current capacity may absorb. The costs to the related industries are likely to be minimal, and cost estimates will be determined as part of measure development.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

¹⁸⁶ While TNC companies, drivers, and riders may bear direct costs or savings associated with the purchase of ZEVs and BEV charging equipment, the costs of ZEVs and charging equipment are attributed to CARB's Zero Emission Vehicle Regulation. The Clean Miles Standard is not anticipated to change the overall purchases of ZEVs and charging equipment within California. However, if utilization of a ZEV by a TNC vehicle is greater than that of a typical non-TNC vehicle, the Clean Miles Standard will result in statewide incremental increases in zero emission miles.

The price inputs for gasoline and electricity come from the 2020 Integrated Energy Policy Report's (IEPR) update to the 2019 IEPR price forecasts, the most current forecasts at the time of the analysis: California Energy Commission, Transportation Energy Demand Forecast 2020 IEPR Update, December 3, 2020, last accessed January 2021), <https://efiling.energy.ca.gov/GetDocument.aspx?tn=235841&DocumentContentId=68785>.

¹⁸⁷ CARB, 2020. Clean Miles Standard SRIA.

https://www.dof.ca.gov/forecasting/economics/major_regulations/major_regulations_table/documents/Clean_Miles_Standard_SRIA.pdf

CARB, 2021. Clean Miles Standard ISOR. <https://ww3.arb.ca.gov/regact/2021/cleanmilesstandard/isor.pdf>

Table A-3 Cost of On-Road Light-Duty Vehicles Measures

Measure	Initial Year of Costs	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
On-Road Motorcycle New Emissions Standards ¹⁸⁸	2025	\$304	\$23
Clean Miles Standard ¹⁸⁹	2023	-\$756	-\$50
Reducing Vehicle Miles Travelled	2023+	NYQ	NYQ

Off-Road Equipment Measures

Tier 5 Off-Road Vehicles and Equipment

This measure would develop and propose aftertreatment--based PM standards for new off-road compression-ignition engines less than 19 kW (25 hp), aftertreatment--based NO_x standards for new off-road compression-ignition engines greater than or equal to 19 kW (25 hp) and less than 56 kW (75 hp), and more stringent PM and NO_x standards for new off-road compression-ignition engines greater than or equal to 56 kW (75 hp). Other possible elements include enhancing in-use compliance, proposing more representative useful life periods, and developing a low load test cycle. This measure is anticipated to result in increased costs for engines that are used in a variety of applications and industries including, construction, mining (off-road equipment used above ground), manufacturing, industries that rely on transport refrigeration units (TRUs), airport ground support, forestry and logging, and agriculture. In addition to increased capital costs of engines, there may also be ongoing costs associated with the additional consumption of diesel exhaust fluid.

As shown in Table A-4, the Tier 5 Off-Road Vehicles and Equipment measure is estimated to result in a net cost of \$650 million from 2028 through 2037. This estimate does not include the net cost of Tier 5 Standards for Preempted Engines, which will be presented in the Section of Federal Actions. The net cost includes the amortized capital cost through 2037. The total capital cost is calculated by multiplying the number of engines in each horsepower bin subject to the proposed measure by the incremental capital cost. The total capital cost is then amortized for

¹⁸⁸ Preliminary cost estimates. Board recommendation anticipated in winter 2022. Vehicle purchases are amortized over 5 years with a 5 percent interest rate.

¹⁸⁹ Cost estimates are from the Clean Miles Standard Regulatory Impact Assessment and Initial Statement of Reasons. Costs for 2032 to 2037 are assumed to be equal to estimates in 2031, where the SRIA and ISOR analyses end.

5 years at 5% and is accounted in the net cost till 2037. The net cost also includes on-going cost from Diesel Exhaust fluid (DEF) consumption.

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

The amendments to the In-Use Off-Road Diesel-Fuel Fleets Regulation would create additional requirements to the currently regulated fleets to turnover the oldest and dirtiest equipment that is operating in their fleets as well as require only the cleanest engines available be added to fleets. As equipment is phased out, fleets would likely purchase newer and more expensive engines, resulting in increased capital costs for the fleet. The end user industries with associated vehicle types, such as mining, construction, industrial, airport ground support transportation, and so on, will likely see production cost increase. The industries that supply the newer and more expensive engines and associated vehicles will likely see increase in final demand due to the engine turnover.

As shown in Table A-4, the Amendments to the In-Use Off-Road Diesel-Fuel Fleets Regulation is estimated to result in a net cost of around \$2,029 million from 2023 through 2037.¹⁹⁰ The direct costs include capital costs for new Tier 4 final off-road diesel vehicles, used Tier 4 final off-road diesel vehicles,¹⁹¹ annual cost for maintenance of Tier 4 final vehicles, and administrative costs for reporting of public works awarding bodies and prime contractors. The vehicle capital cost is calculated by multiplying the vehicle numbers and the incremental cost per vehicle by horsepower group.¹⁹² The net cost is the sum of the amortized capital cost till 2037, on-going costs for vehicle maintenance and the reporting requirements. A comprehensive economic impact analysis of the amendments to the In-Use Off-Road Diesel-Fuel Fleets Regulation can be found in the Standardized Regulatory Impact Assessment.¹⁹³

Transport Refrigeration Unit Regulation Part 2

This measure would require trailer TRUs, domestic shipping container TRUs, railcar TRUs, TRU generator sets, and direct-drive refrigeration units to use zero-emission technology. While the specific proposed requirements have not been determined at this time, CARB staff are currently assessing zero-emission technologies for trailer TRUs and the remaining TRU categories. Staff anticipate that the regulated businesses will incur incremental costs for purchase of zero-emission TRU equipment and installation of zero-emission fueling infrastructure. Businesses that supply the zero-emission technology can expect increase in demand. There may be on-going cost or savings resulting from changes in fuel use and maintenance.

As shown in Table A-4, the Transport Refrigeration Unit Regulation Part 2 measure is estimated to result in a net cost of \$2,918 million from 2026 through 2037. The costs of this measure were

¹⁹⁰ Costs are assumed to occur beginning in 2023 to meet the first Tier phase-out date in 2024.

¹⁹¹ Based on the response from a CARB survey, CARB staff developed six compliance pathways used to analyze direct costs for vehicle owners. Vehicle owners may retire off-road diesel vehicles and replacing them with new Tier 4 final vehicles, or replacing with 5-year-old used Tier 4 final vehicles, among four other compliance pathways.

¹⁹² CARB staff divided off-road vehicles into eight different horsepower groups to establish the vehicle capital costs,

¹⁹³ Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation, Standardized Regulatory Impact Assessment. <https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/SRIA-ORD.pdf>

estimated by applying the average cost effectiveness of emissions reductions from the Off-Road category to the anticipated annual emissions reductions.

Commercial Harbor Craft Amendments

The Commercial Harbor Craft Amendments establish expanded and more stringent in-use requirements to reduce criteria and air toxics emissions from commercial harbor craft. The amendments also mandate accelerated deployment of zero-emission and advanced technologies in vessel categories where technology feasibility has been demonstrated.

This measure would result in changes in costs to numerous CHC sectors to comply with in-use and new-build vessel performance standards, zero emission advanced technology requirements, and other vessel requirements. This includes costs associated with the repower and retrofit of existing CHC, replacement costs for certain CHC, infrastructure costs, and administrative costs. These costs would primarily be borne in the water transportation, scenic and sightseeing transportation and support activities for transportation, construction, and fishing industries.

As shown in Table A-4, the Commercial Harbor Craft Amendments are estimated to result in a net cost of \$1,914 million from 2023 through 2037. A comprehensive economic impact analysis of the Commercial Harbor Craft Amendments can be found in the SRIA and other associated rulemaking documents.¹⁹⁴

Cargo Handling Equipment Amendments

This measure would start transitioning cargo handling equipment (CHE) to full zero-emission (ZE) starting in 2026 and result in costs associated with equipment and infrastructure. Specific types of equipment impacted include yard tractors, forklifts, rubber tiered gantry cranes, and other cargo handling equipment. The regulation would likely result in increased spending on CHE equipment and charger and increase the production and capital cost of the end user sectors. There may also be cost savings associated with decreased diesel fuel consumption and higher costs due to increased electricity and hydrogen fuel consumption, which could lead to a change in the demand for fuel and electricity.

As shown in Table A-4, the Cargo Handling Equipment Amendments are estimated to result in a net cost of \$2,100 million from 2026 through 2037. The net cost is calculated by adding the amortized capital cost till 2037. The total capital cost is calculated by multiplying the number of yard tractor, forklift, RTG crane, and other CHE subject to the proposed amendments by the incremental cost of each equipment type. Because of changes in equipment and uncertainty

¹⁹⁴ California Air Resources Board, 2022. Commercial Harbor Craft Regulation Amendments.

<https://ww2.arb.ca.gov/rulemaking/2021/chc2021>

The price inputs for fuels come from the 2020 Integrated Energy Policy Report's (IEPR) update to the 2019 IEPR price forecasts: California Energy Commission, Transportation Energy Demand Forecast 2020 IEPR Update, December 3, 2020, last accessed January 2021),

<https://efiling.energy.ca.gov/GetDocument.aspx?tn=235841&DocumentContentId=68785>.

regarding energy requirements of ZE equipment, staff assume that the cost of electricity are the same as the savings in diesel.

Off-Road Zero-Emission Targeted Manufacturer Rule

Staff proposes to develop a regulatory measure that would require manufacturers of off-road equipment and/or engines to produce for sale zero-emission equipment and/or powertrains as a percentage of their annual statewide sales volume. While staff are still refining the details of the regulation, staff anticipate that this measure will lead to increased costs for zero-emission off-road equipment and/or powertrains that are used in a variety of applications and industries. In addition to increased capital costs of equipment, there may also be ongoing costs and savings associated with the new technology, such as reduced fuel and maintenance costs.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Clean Off-Road Fleet Recognition Program

The primary goal of this program would be to create a non-monetary incentive to encourage off-road fleets to go above and beyond existing regulatory fleet rule compliance and adopt advanced technology equipment with a strong emphasis on zero-emission technology. This program would provide a standardized methodology for contracting entities, policymakers, state and local government, and other interested parties to establish contracting criteria or require participation in the program to achieve their individual policy goals. While the detail of the measure is still under development, staff anticipate increased government spending on technology review, consulting, and administrative cost. Businesses are expected to spend more on zero-emission or low-emission technologies voluntarily and the cost may be passed down to consumers.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy

Spark-Ignition Marine Engine Standards

The Spark-Ignition Marine Engine Standards measure would develop and propose more stringent emission standards for outboard and personal watercraft engines. This measure may result in increased costs to the manufacturers of outboard and personal watercraft engines, which would likely be passed on to businesses and individuals that purchase these engines.

As shown in Table A-4, the Spark-Ignition Marine Engine Standards are estimated to result in a net cost of \$45 million from 2029 through 2037. The net cost includes the amortized capital cost till 2037. The total capital cost is calculated by multiplying the number of outboard and personal watercraft engines subject to the standards by the average incremental cost per equipment.

Table A-4 Cost of Off-Road Measures

Measure	Initial Year of Costs	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
Tier 5 Off-Road Vehicles and Equipment ¹⁹⁵	2028	\$650	\$65
Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation ¹⁹⁶	2023	\$2,029	\$135
Transport Refrigeration Unit Regulation Part 2 ¹⁹⁷	2026	\$2,918	\$243
Commercial Harbor Craft Amendments ¹⁹⁸	2023	\$1,914	\$128
Cargo Handling Equipment Amendments ¹⁹⁹	2026	\$2,100	\$175
Off-Road Zero-Emission Targeted Manufacturing Rule ²⁰⁰	2031	NYQ	NYQ
Clean Off-Road Fleet Recognition Program	2027	NYQ	NYQ
Spark-Ignition Marine Engine Standards ²⁰¹	2029	\$45	\$5

¹⁹⁵ Preliminary cost estimates that will be revised over the course of the rulemaking process. Engine purchases are amortized over 5 years with a 5 percent interest rate.

¹⁹⁶ Preliminary cost estimates that will be revised over the course of the rulemaking process. Engine purchases are amortized over 5 years with a 5 percent interest rate.

¹⁹⁷ Preliminary cost estimates based on average cost-effectiveness of measures in the Off-Road category. Costs will be revised over the course of the rulemaking process.

¹⁹⁸ Estimates based on the Commercial Harbor Craft Rulemaking. Capital purchases are amortized over 18 years with a 5 percent interest rate.

¹⁹⁹ Preliminary cost estimates that will be revised over the course of the rulemaking process. Capital purchases are amortized over the lifetime for equipment and over 18 years for infrastructure with a 5 percent interest rate.

²⁰⁰ The emission reduction and cost are not quantified yet.

²⁰¹ Preliminary cost estimates that will be revised over the course of the rulemaking process. Capital purchases are amortized over 5 years with a 5 percent interest rate.

Other Measures

Consumer Products Regulation

Efforts to reduce the ozone impact of consumer products will include CARB staff's consideration of control strategies that utilize new reactivity-based limits along with the traditional method of implementing new and lower VOC standards. Costs to manufacturers are likely to include purchasing new equipment, research and development, data processing, relabeling and advertising, and so on. The on-going costs of chemical ingredients can also change. Staff anticipate that the change in capital and on-going cost will be passed on to consumers.

As shown in Table A-5, the Consumer Products Regulation is estimated to result in a net cost of \$121 million from 2029 through 2037. The net cost is calculated by adding the amortized capital cost and on-going cost till 2037. The amortized capital cost is calculated by multiplying the VOC or VOC equivalent reduction per year in the eight categories of consumer products by the amortized fixed reformulation cost. The ongoing cost is calculated by multiplying the VOC or VOC equivalent reduction per year by the formula ingredient cost.

Zero-Emission Standard for Space and Water Heaters

The primary goal of this measure is to reduce emissions from space and water heaters installed in new and existing residential and commercial buildings. Staff would develop and propose zero-emission standards for space and water heaters sold in California. Beginning in 2030, 100 percent of sales of new space and water heaters (for either new construction or equipment replacement of burned-out equipment in existing buildings) would need to meet zero-emission standards. This measure would not mandate retrofits in existing buildings, but some buildings may require retrofits such as electric service panel upgrades to be able to use the new technology that this measure would require.

Depending on various factors including the up-front cost of equipment appliances and whether electric service panel upgrades are needed, and assumptions of the speed of technology development, this regulation could lead to an increase or decrease in spending on new zero-emission water and space heaters, compared to their higher-emission counterparts. This regulation is also anticipated to result in a decrease in natural gas consumption and increase in electricity consumption. The lifecycle cost impacts of this measure on consumers and businesses are thus highly dependent on the relative costs of natural gas and electricity, which may also be dependent on the time of use, and presence or absence of on-site solar and/or energy storage.

As shown in Table A-5, this measure is estimated to result in a net cost of \$10,048 million from 2026 through 2037. The net cost is calculated by adding the amortized capital cost, net energy cost, and amortized panel upgrade cost from 2026 until 2037. Although implementation would not begin until 2030, there would be costs associated with this measure beginning in 2026 assuming that the market gradually ramps up to 100 percent sales from today's sales share. Capital cost estimates reflect the incremental cost of replacing a gas space and water heater with an electric space and water heater, which is then amortized over 10 or 20 years at 5 percent, depending on whether it is an old appliance replacement or part of new residential home construction. All capital costs in the commercial buildings are amortized over 20 years at 5 percent due to most commercial buildings being under long-term leases. Net ongoing cost

contains the additional cost of electricity and savings of natural gas. Panel upgrades are assumed to be required in buildings constructed before 2005.

Pesticides: 1, 3-Dichloropropene Health Risk Mitigation

DPR is developing a regulation to address both cancer and acute risk to non-occupational bystanders from the use of 1,3-D. The regulation will be developed in consultation with the County Agricultural Commissioners (CACs), the local air districts, the California Air Resources Board (CARB), the Office of Environmental Health Hazard Assessment (OEHHA), and the California Department of Food and Agriculture (CDFA).

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Table A-5 Cost of Measures in the Other Category

Measure	Initial Year of Costs	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
Consumer Products Standards ²⁰²	2029	\$121	\$13
Zero-Emission Standard for Space and Water Heaters	2026	\$10,048	\$837
Pesticides: 1, 3-Dichloropropene Health Risk Mitigation	2024	NYQ	NYQ

Primarily-Federally and Internationally Regulated Sources: CARB Measures

In-Use Locomotive Regulation

The In-Use Locomotive Regulation would accelerate the adoption of advanced, cleaner technology, and zero-emission locomotives by; 1) establishing spending accounts for locomotive operators and 2) through in-use operational requirements. 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 could 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. The In-Use Operational Requirements would define the number of years that

²⁰² Preliminary cost estimates that will be revised over the course of the rulemaking process. Capital purchases are amortized over 5 years with a 5 percent interest rate.

locomotives are allowed to operate in California. This measure would result in costs to locomotive operators for new locomotive purchases, remanufactures, and additional hardware. There would also be ongoing costs and costs savings associated with changes in fuel use, maintenance, and the spending account.

As shown in Table A-6, the In-Use Locomotive Regulation is estimated to result in a net cost of \$8,887 million from 2023 through 2037. These costs include capital costs for locomotives, including new Tier 4 locomotives, end-of-life remanufactures/overhaul, ZE locomotives and supporting fueling infrastructure development and maintenance, and annual costs for locomotive maintenance; costs and savings associated with diesel, hydrogen, and electricity; reporting and locomotive registration, Spending Account management, and CARB's annual administrative charge. A comprehensive economic impact analysis of the In-Use Locomotive Regulation is included in the Standardized Regulatory Impact Assessment.²⁰³

Future Measures for Aviation Emissions Reductions

The primary goal of future measures for aviation is to reduce emissions from airport and aircraft related activities. CARB would require all larger airports to perform a comprehensive and standardized emission inventory, which would establish a baseline and enable verifiable and quantifiable future emissions reductions. Staff assume that not all airports would conduct complete emissions tracking and reporting without the regulation, and their existing information systems are sufficient for the added inventory tracking and reporting requirements. CARB staff anticipates that airports will increase staff time to perform the necessary activities for emission reporting and inventory, which may include energy audits, inventory accounting, data tracking, and so on. Therefore, the proposed action will result in an increase in jobs and staffing costs.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Future Measures for Ocean-Going Vessel Emissions Reductions

CARB would pursue evaluating further regulatory actions to achieve additional reductions in NO_x, PM, and GHG emissions from OGVs through the use of operational changes and new technologies currently in development. In pursuing regulatory measures, CARB would collaborate with U.S. EPA, California air districts, seaports, and industry stakeholders to determine which measure would provide the most effective emissions reductions, as well as CARB's ability to implement each potential measure. Depending on the proposed regulatory measures, staff expect that the measure will result in cost and cost savings due to the change in fuel usage, increasing investment and spending in exhaust capture and control, mobile shore power connections, and equipment in alternative power sources and vessel side technologies (such as water-in-fuel emulsion).

For incentive measures, CARB would collaborate with U.S. EPA, California air districts, seaports, and industry stakeholders to expand ongoing efforts already underway by air districts. Incentives

²⁰³ Proposed In-Use Locomotive Regulation, Standardized Regulatory Impact Assessment. <https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/SRIA-Locomotive.pdf>

to encourage ships using cleaner engines or fuels to visit California seaports would involve identification of funding sources and implementation mechanisms such as development of new programs or the enhancement of existing incentive programs, such as expanding existing VSR zones, developing a “Green Shipping Lane” to encourage incentives amongst multiple Pacific seaports, etc. Staff expect that the incentive measure may result in changes in fuel usage pattern in the vessels visiting California, and spending and investment in cleaner vessels.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Table A-6 Costs for Primarily Federally and Internationally Regulated Source: CARB Measure

Measure	Initial Year of Costs	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
In-Use Locomotive Regulation ²⁰⁴	2023	\$8,887	\$592
Future Measures for Aviation Emissions reductions	2029	NYQ	NYQ
Future Measures for Ocean-Going Vessel Emissions Reductions	TBD	NYQ	NYQ

Primarily-Federally and Internationally Regulated Sources: Federal Action Needed

On-Road Heavy-Duty Vehicle Low-NOx Engine Standards

The goal of this proposed measure is to introduce near-zero emission engine technologies that will substantially lower NOx emissions from on-road heavy-duty vehicles. CARB would petition and/or advocate to U.S. EPA for federal zero-emission on-road heavy-duty vehicle requirements, along with more stringent GHG standards for medium- and heavy-duty vehicles that would apply to new heavy-duty trucks sold nationwide. Additionally, CARB would advocate that U.S. EPA enable state leadership on zero-emission trucks by prioritizing federal grants toward zero-emission technology and their associated infrastructure.

As shown in Table A-7, the On-Road Heavy-Duty Vehicle Low-NOx Engine Standards are estimated to result in a net cost of \$220 million from 2027 through 2037. The direct cost is estimated by multiplying the annual emission reduction from 2027 to 2037 by \$3.62 (2017\$) per

²⁰⁴ Preliminary cost estimates that will be revised over the course of the rulemaking process. Locomotive purchases and remanufactures are amortized over 12-years with a 5 percent interest rate.

pound or \$8,192 (2021\$) per ton of NO_x reduction. The cost per pound of NO_x reduction is derived from the average of calendar year 2030 and 2040 cost per pound of NO_x emissions reductions of the Proposed Rule for Control of Pollution for New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards.²⁰⁵

On-Road Heavy-Duty Vehicle Zero-Emission Requirements

CARB would petition and/or advocate to U.S. EPA for federal zero-emission on-road heavy-duty vehicle requirements, along with more stringent GHG standards for medium- and heavy-duty vehicles that would apply to new heavy-duty trucks sold nationwide. Additionally, CARB would advocate that U.S. EPA enable state leadership on zero-emission trucks by prioritizing federal grants toward zero-emission technology and their associated infrastructure.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Off-Road Equipment Tier 5 Standard for Preempted Engines

This measure is the same as the one described in the Off-Road section but applies to preempted Engines, which are beyond CARB's authority to regulate. This measure is anticipated to result in increased costs for engines that are used in a variety of applications and industries including, construction, mining (off-road equipment used above ground), manufacturing, industries that rely on transport refrigeration units (TRUs), airport ground support, forestry and logging, and agriculture. In addition to increased capital costs of engines, there may also be ongoing costs associated with the additional consumption of diesel exhaust fluid.

As shown in Table A-7, this measure is estimated to result in a net cost of \$488 million from 2028 through 2037. It does not include the net cost of Tier 5 Standards for Non-Preempted Engines, which was presented in the Section of Off-Road Equipment.

Off-Road Equipment Zero-Emission Standards Where Feasible

CARB would petition and/or advocate to U.S. EPA to require zero-emission standards for off-road equipment where the technology is feasible. Staff expect that the measure would result in spending and investment in zero-emission off-road equipment, cost and cost-savings in fuel use, and off-road equipment maintenance. The businesses in the end-user industries where off-road equipment are used may see production cost increase.

Staff estimated that this measure will result in a net cost of \$3.3 billion from 2028 to 2037.

More Stringent Aviation Engine Standards

CARB would petition and/or advocate to U.S. EPA for more stringent criteria and GHG standards for aircraft engines. With innovative research and advanced optimization of engine design, it has been demonstrated that NO_x emissions can be further reduced beyond the

²⁰⁵ U.S. Environmental Protection Agency. Proposed Rule and Related Materials for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards. <https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-and-related-materials-control-air-1>

CAEP/8 standards. Staff anticipate that more stringent aviation engine standards would result in spending and investment in low emission aviation engines and possible cost increase in aviation.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Cleaner Fuel and Visit Requirements for Aviation

CARB would petition and/or advocate to U.S. EPA and/or FAA to require aircraft to use cleaner fuels when travelling through California, and to require visits from cleaner aircraft. Staff anticipates that the requirements would result in changes in fuel usage, spending and investment in cleaner technologies in aviation, which may also lead to cost and/or cost savings in air transportation.

As shown in Table A-7, this measure is estimated to result in a net cost of \$5.9 billion from 2028 through 2037. The cost is estimated using the measure's NO_x reductions and average cost per ton NO_x of all other SIP measures with cost data.

Zero-Emission On-Ground Operation Requirements at Airports

CARB would petition and/or advocate to U.S. EPA to require zero-emission on-ground operation at California airports. Staff anticipates the requirements would result in changes in spending and investment in cleaner technologies in on-ground operation, which may also lead to cost and/or cost savings in air transportation.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Airport Aviation Emissions Cap

CARB would petition and/or advocate to appropriate agencies, including the U.S. EPA for additional actions to control emissions from aviation, such as requiring an aviation emissions cap at each California airport. This emissions cap would set an emissions level for all aircraft activities related to the airports preventing emissions to increase with airport growth and reduce existing emissions by replacing airport activities with cleaner combustion and zero-emission technologies. Staff anticipate that these additional activities would result in spending and investment in cleaner engines and aircraft and changes in cost of air transportation. These additional reductions could potentially also be achieved through incentivized turnover of aircraft or upgrades to cleaner engines, or other available regulatory mechanisms.

As shown in Table A-7, this measure is estimated to result in a net cost of \$9.4 billion from 2028 through 2037. The cost is estimated using the NO_x reductions and average cost per ton NO_x of all other SIP measures with cost data.

More Stringent National Locomotive Emission Standards

This measure describes the emissions levels that CARB staff believes would be achievable with a new generation of national emissions standards for locomotives, including both newly manufactured and remanufactured units.

The cost of this measure is included in the cost estimate of the CARB action measure of In-Use Locomotive Regulation.

Zero-Emission Standards for Locomotives

CARB would petition and/or advocate to U.S. EPA to promulgate national zero-emission standards for locomotives to reduce criteria and toxic pollutants, fuel consumption, and GHG emissions.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

Address Unlimited Locomotives Remanufacturing

For this measure, CARB would petition and/or advocate to U.S. EPA to address the regulatory provision that allows continued remanufacturing of old and polluting locomotives to the same pollution tier standards, and persistent pollution from these sources.

Emissions reductions and costs associated with this measure have not been quantified in the Proposed State SIP Strategy.

More Stringent NO_x and PM Standards for Ocean-Going Vessels

As shown in Table A-7, the More Stringent NO_x and PM Standards for Ocean-Going Vessel Requirements are estimated to result in a net cost of \$428 million from 2030 through 2037. The direct cost is estimated by multiplying the annual emission reduction from 2030 to 2037 by the average cost per ton of NO_x reduction in all other measures in SIP.

Clean Fuel and Visit Requirements for Ocean-Going Vessels

The primary goal of future measures for Ocean-Going Vessels ("OGV" or "vessel") is to further reduce emissions from OGVs that are transiting, maneuvering, or anchoring in Regulated California Waters (RCW) and while docking at berth at California seaports. CARB staff performed cost and emissions analysis to evaluate a potential measure to further reduce emissions from OGVs visiting CA. Under this measure, all vessel categories visiting California ports would need to meet Tier 3 emission standards or equivalency by 2037. The costs and emissions analysis considered the scenario where half of all vessels visiting California that would not already be naturally turned over to Tier 3 by 2037 would need to be replaced with a new Tier 3 vessel, while the other half of the vessels would be retrofit to meet Tier 3 standards through a combination of Selective Catalytic Reduction (SCR) and other vessel side technologies (using cost estimates for one possible technology, water-in-fuel (WIF) emulsion) for main engines and Exhaust Gas Recirculation (EGR) for auxiliary engines and boilers. Replacements and retrofits are assumed to occur in equal numbers in each year commencing in 2028 and concluding in 2037.

While there may be other less costly mechanisms to achieve emissions reductions from the OGV sector such as incentivizing cleaner Tier 3 vessels to visit California ports or a greater reliance on retrofits, staff chose to model costs by equally applying retrofits and vessel replacements in this manner because: 1) worldwide, there would not be enough Tier 3 vessels deployed that could be incentivized to call California ports and 2) retrofitting to Tier 3 NO_x equivalency with SCR may have some degree of limitations, and therefore CARB staff included WIF emulsion

technology to supplement SCR retrofit costs for the portion of vessels that are not assumed to be replaced.²⁰⁶

As shown in Table A-7, the Future Measures of Ocean-Going Vessel Emissions Reductions is estimated to cost \$33.7 billion (Statewide amortized cost from 2028 through 2037). To estimate vessel replacement costs, the number of vessels being replaced in each year was multiplied by the estimated vessel replacement costs, ranging between \$37 million to \$1 billion depending on the vessel category. These costs were then amortized over 25 years with a 5 percent interest rate to derive the amortized vessel replacement costs.

Retrofits are estimated to result in additional upfront capital and installation costs of approximately \$615 thousand per vessel for SCR, \$818 thousand per vessel for water injection technologies, and \$68 per kilowatt for EGR. In addition, there would be additional on-going costs of \$236 thousand per vessel for SCR and \$4 per megawatt-hour for EGR (dollar values converted to 2021\$).^{207,208} Installation costs were amortized over 25 years with a 5 percent interest rate while on-going costs were not amortized.

Because a large fraction of all vessels visiting California are assumed to be upgraded to achieve emissions equivalent to the Tier 3 standard by 2037, areas in the rest of the U.S. and worldwide would also experience the emissions reductions. These incremental benefits are not included in the emissions benefit for the Proposed State SIP Strategy. Additionally, the costs would likely be spread beyond California's borders and would be shared across the U.S. and worldwide shipping markets. If this measure were implemented as a federal regulatory requirement, it is possible that shipping lines may bear the direct costs and subsequently pass on cost through the supply chain, ultimately resulting in increased prices for intermediate and final goods. To be conservative in estimating the economic impact of this measure, all vessel retrofits and replacement are assumed to occur outside the State of California and would therefore not result in any additional positive economic impacts for the economy.

²⁰⁶ For example, typical SCR systems tolerate some temperature fluctuation, but will not operate optimally at the low exhaust temperatures that correspond to vessel main engines operating at low load conditions such as vessel maneuvering or reduced speed operations.

²⁰⁷ IACCSEA. (2013). Marine SCR – Cost benefit analysis. <https://www.iaccsea.com/wp-content/uploads/2018/12/IACCSEA-Marine-SCR-Cost-benefit-analysis-2013.pdf>

²⁰⁸ California Air Resources Board. (2018). Draft Technology Assessment: Ocean-Going Vessels. https://ww2.arb.ca.gov/sites/default/files/classic/msprog/tech/techreport/ogv_tech_report.pdf?_ga=2.150505470.974679874.1607353296-2132954763.1524507134

Table A-7 Costs for Primarily Federally and Internationally Regulated Source: Federal Action Needed

Measure	Initial Year of Costs	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
On-Road Heavy-Duty Vehicle Low-NOx Engine Standards	2027	\$220	\$20
On-Road Heavy-Duty Vehicle Zero-Emission Requirements	TBD	NYQ	NYQ
Off-Road Equipment Tier 5 Standard for Preempted Engines ²⁰⁹	2028	\$488	\$49
Off-Road Equipment Zero-Emission Standards Where Feasible	2028	\$3,311	\$331
More Stringent Aviation Engine Standards	TBD	NYQ	NYQ
Cleaner Fuel and Visit Requirements for Aviation	2028	\$5,874	\$587
Zero-Emission On-Ground Operation Requirements at Airports	TBD	NYQ	NYQ
Airport Aviation Emissions Cap	2028	\$9,431	\$943
More Stringent NOx and PM Standards for Ocean-Going Vessels	2030	\$428	\$54
Cleaner Fuel and Vessel Requirements for Ocean-Going Vessels ²¹⁰	2028	\$33,689	\$3,369

²⁰⁹ Preliminary cost estimates that will be revised over the course of the rulemaking process. Capital equipment purchases are amortized over 5-years with a 5 percent interest rate.

²¹⁰ Preliminary cost estimates that will be revised over the course of the rulemaking process. Vessel purchases are amortized over 25-years with a 5 percent interest rate.

Statewide Summary of Direct Costs

Table A-8 presents the direct costs of the Proposed State SIP Strategy.

Table A-8 Direct Cost of the Proposed State SIP Strategy by CARB and Federal Measures

Measure	Total Amortized Cost of Control Measure Through 2037 (Million 2021\$)	Average Annual Amortized Cost (Million 2021\$)
CARB Measures	\$42,739	\$3,490
Measures that Require Federal Action	\$53,441	\$5,353
Total	\$96,181	\$8,843

Figure A-1 and Figure A-2 present the share of direct costs and NO_x emissions reductions by category. In general, the direct costs of the measures are proportional to the amount of emissions reductions that are anticipated to be achieved. However, some measures included in the Proposed State SIP Strategy do not specifically target NO_x emissions reductions. For example, the Consumer Products measure targets VOC reductions and is not associated with any NO_x emissions reductions. The Consumer Products measure contributes to the cost in Figure A-1 but not NO_x reductions in Figure A-2. Similarly, many measures target a variety of pollutants, including NO_x. All the Proposed State SIP Strategy measures that accelerate the adoption of zero emission technologies will also reduce greenhouse gas emissions and toxics, which will result in additional benefits not quantified here.

Figure A-1 Share of Total Amortized Cost Through 2037 by Major Categories

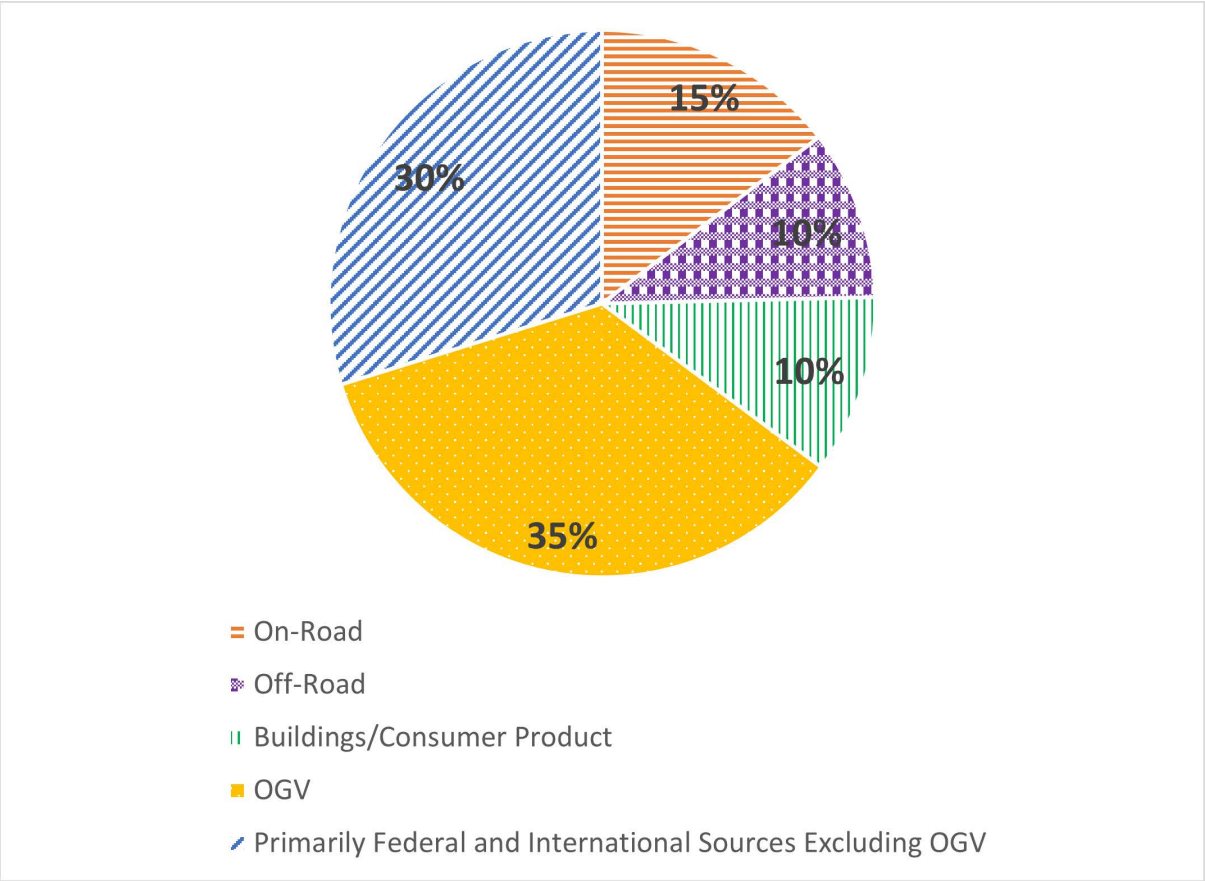
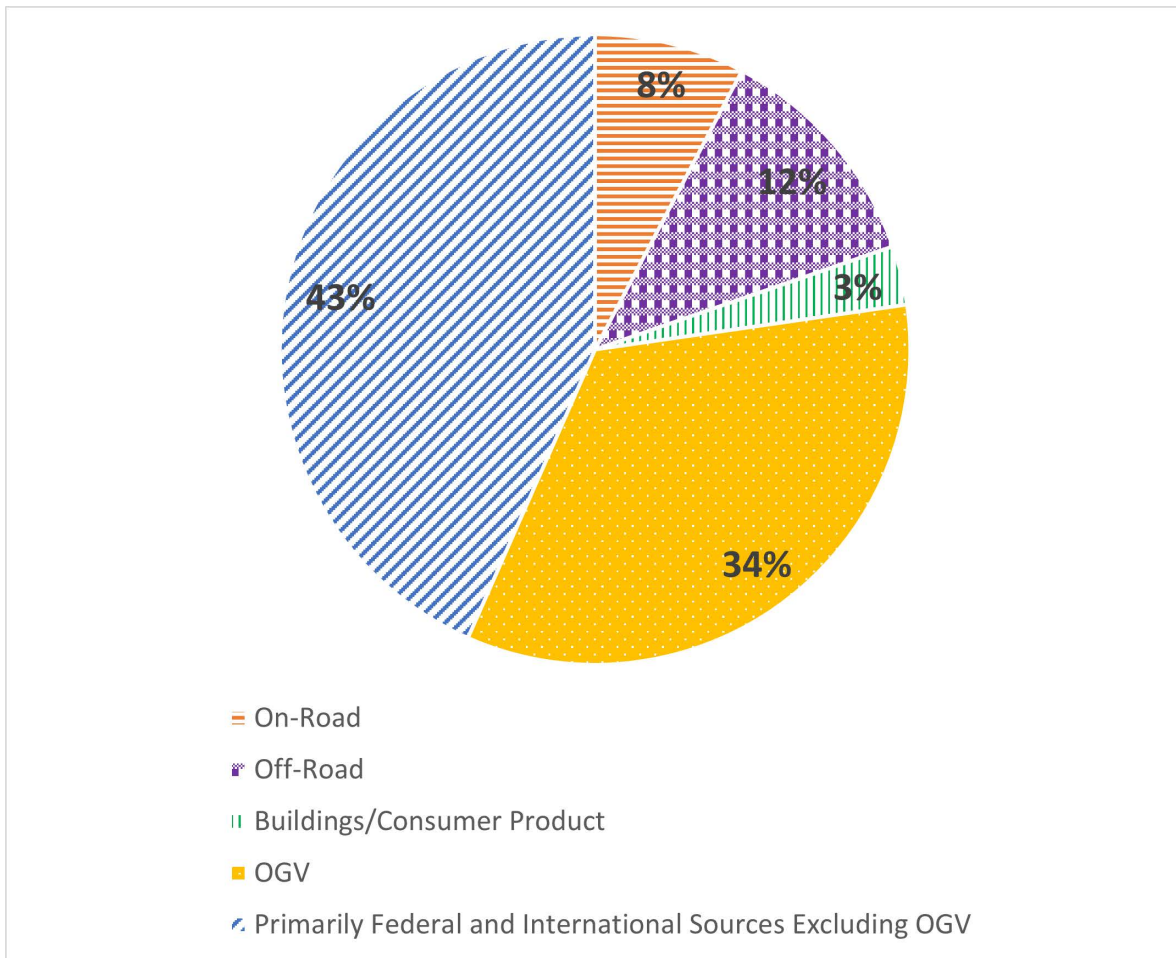


Figure A-2 Share of Total NOx Emissions reductions Through 2037 by Major Categories



Statewide Economic Impacts (Macroeconomic Analysis)

This section describes the total impact of the Proposed State SIP strategy on the California economy. The analysis focuses on incremental change between the baseline and attainment scenario and the impact on various major macroeconomic indicators from 2023 to 2037 including employment, output growth, and gross state product (GSP).

The direct compliance costs associated with the Proposed State SIP Strategy measures would result in changes in behavior and expenditures by California businesses and individuals and result in changes in the prices of products and equipment in California. These changes in expenditures will indirectly affect employment, output, and investment in sectors that supply goods and provide services to the affected businesses. There would also be additional indirect and induced effects, like changes in personal income that affects consumer expenditures across other spending categories.

Inputs to the Assessment

REMI Policy Insight Version 2.5.0 is used to estimate the macroeconomic impacts of the Proposed State SIP Strategy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.²¹¹ Staff used the REMI single region, 160 sector model with the model reference case adjusted to reflect California Department of Finance's (DOF) latest publicly available economic and demographic projections. Specifically, the REMI model's National and Regional Control was updated to conform to DOF economic forecasts, released as part of the 2022-23 Governor's Budget, which include U.S. real GDP, income, and employment, as well as California population and civilian employment by industry.²¹²

The measures in the Proposed State SIP Strategy would result in both costs and cost-savings to businesses, individuals, and government entities. For each measure the direct costs and savings were input into the model as changes in productions costs, consumer prices, consumer spending, and state and local government spending. The production cost impacts to businesses input into the REMI model at the industry and major sector level, as categorized by the North American Industry Classification System (NAICS). Table A-9 summarizes the direct costs for some of the industries and major sectors that are estimated to see the greatest increase in production costs.

²¹¹ See REMI's webpage for more details on the model. <https://www.remi.com/>

²¹² The DOF forecasts extend through 2025. For subsequent years, CARB staff assumed economic variables would continue to grow at the same rate projected in the REMI baseline forecasts.

Table A-9 Industries and Sectors with Greatest Costs or Cost-Savings

Industry or Sector ²¹³	Cumulative Change in Production Costs (\$2020M) ²¹⁴
Air transportation (Industry)	\$14,756
Transportation and Public Utilities (Sector)	\$13,876
Truck transportation (Industry)	\$9,119
Construction (Sector)	\$4,458
Retail and Wholesale (Sector)	\$4,251
Services (Sector)	\$3,893
Increased prices for commodities in motor vehicles and parts, furnishings and durable household equipment, recreational goods and vehicles and other durable goods, clothing and footwear, and other nondurable goods ²¹⁵	\$3,618
Aggregation of Forestry, Mining, Utilities, Construction, and Manufacturing (Industry)	\$3,450
Transit and ground passenger transportation (Industry)	\$2,953
Scenic and sightseeing transportation and support activities for transportation (Industry)	\$2,802
Personal and laundry services ²¹⁶ (Industry)	\$2,158

The changes in costs and spending across the economy would correspond with changes in demand for industries supplying goods and services. For example, transitioning to cleaner tier

²¹³ Within the REMI model, production costs can be input at the industry or sector level. Some of the State SIP Strategy measures had production costs input at the industry level while other measures were modeled at the sector level.

²¹⁴ Costs are input into REMI in 2020 dollars.

²¹⁵ The Clean Fuel and Visit Requirements for OGV are modeled by increasing prices for a variety of California commodities. The direct costs to shipping companies are likely to be impact worldwide shipping markets and may result in increased intermediate and final goods. For purposes of the macroeconomic modeling, Staff scaled the costs of this measure by the share of imports to California relative to the entire U.S.

²¹⁶ It includes the following detail industries: personal care services, death care services, dry cleaning and laundry services, and other personal services. The item applies to the Zero-Emission Standard for Space and Water Heaters measure to reflect the potential cost increase in commercial building in personal services (NAICS code: 812).

engines would result in increased demand from the manufacturing industry. As another example, increases in electrification across many sectors of the economy would result in a decreased demand for fossil fuels and an increased demand for electricity. These changes in demand were input into the model as changes in exogenous final demand or industry sales.²¹⁷ Table A-10 summarizes some of the industries with the greatest increases and decreases in final demand.

The largest increase in final demand is in the electric power generation, transmission and distribution industry. This is associated with increased electrification of on-road and off-road vehicles. Increased demand for the electric power generation, transmission and distribution industry reflects an increase demand for electricity for fuel. The increased demand for the construction industry and other electrical equipment and component manufacturing industry reflects the increasing demand for electric infrastructure and the need for construction services to install infrastructure.

Some industries are expected to see significant decreases in final demand. ZEVs generally have lower demands for ongoing maintenance and repair. As a result, measures that increase the penetration of ZEVs are anticipated to decrease in-state demand for the automotive repair and maintenance industry. Similarly, many of the measures result in decreased reliance on fossil fuels. As a result, there would be a decrease in the in-state demand for the petroleum and coal products manufacturing industry. However, separate policy, regulatory, or industry actions – such as changing import/export balance decisions at refiners – would ultimately determine the final impacts to this industry.

²¹⁷ When there is an increase in exogenous final demand, the REMI model allocates that demand to both increases in California output and imports from out of the State based on industry-specific trade flow estimates. As a result, an increase in final demand for a specific industry will not result in the same level of increase in California output.

Table A-10 Industries with Greatest Changes in Final Demand

Industry or Sector	Cumulative Change in Demand
Electric power generation, transmission and distribution (Industry)	\$18,971
Construction (Sector)	\$17,903
Other electrical equipment and component manufacturing (Industry)	\$9,423
Basic chemical manufacturing (Industry)	\$8,854
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing (Industry)	\$8,215
Motor vehicle manufacturing (Industry)	\$5,535
Agriculture, construction, and mining machinery manufacturing (Industry)	\$4,558
Motor vehicle body and trailer manufacturing (Industry)	\$2,799
Automotive repair and maintenance (Industry)	-\$3,607
Petroleum and coal products manufacturing (Industry)	-\$39,114

Results

Results of the macroeconomic analysis are presented in Table A-11. The impact of the Proposed State SIP Strategy is presented for 2037, the year in which California must demonstrate SIP compliance. The economic impact is also presented as an annual average from 2023 through 2037. In 2037, the Proposed SIP Measures will lead to decrease of approximately 99 thousand jobs in California. The economic output and Gross State Product (GSP) in California will be decreased correspondingly in 2037 by \$26 billion and \$14 billion dollar respectively. Per capita personal income in 2037 will be \$239 less compared to the baseline. The Average annual impacts from 2023 to 2037 are, in general, less than the impact in 2037 with no annual percentage change relative to the baseline greater than 0.4 percent.

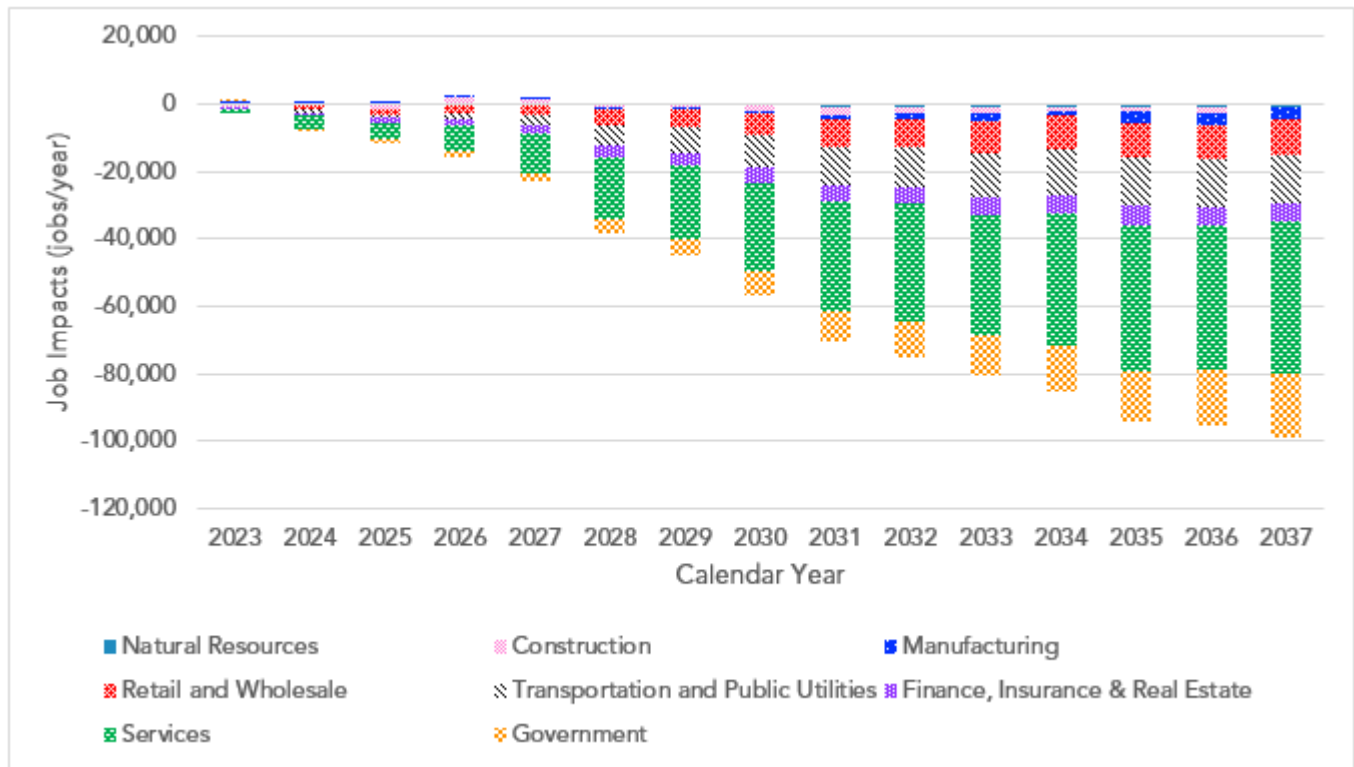
Table A-11 Summary of Macroeconomic Impacts

Macroeconomic Indicator (Units)	Impact in 2037	Average Annual Impact from 2023-2037	Maximum annual percentage change relative to baseline from 2023-2037
Employment (Jobs)	-99,077	-52,986	-0.38%
Output (Million 2021\$)	-25,516	-12,935	-0.37%
Per Capita Personal Income (2021\$)	-239	-113	-0.26%
Gross State Product (Million 2021\$)	-13,878	-7,258	-0.33%

Figure A-3 shows the impacts on the major sectors of the California economy. Impacts on job growth are largest in 2037, the year in which California must demonstrate SIP compliance. As the requirements of the Proposed SIP measures are implemented, sectors such as transportation and services will see direct increases in production costs which would result in decreases in employment growth. Some sectors and industries will experience increases in final demand in certain years and would see an increase in employment growth.

Most of the sectors are estimated to experience negative employment growth, some of which starts in 2023. The manufacturing sector is estimated to experience slight job increase before 2028, which is mostly driven by increased demand of cleaner vehicles and equipment. The Services sector is estimated to experience the greatest negative employment growth due to production cost and price increases with almost no increases in demand to offset the negative impacts. While other sectors also experience increased production costs, the service sector is generally more labor intensive than other sectors, and therefore a similar level of impact to output is usually associated with higher employment impacts relative to other sectors. However, the relative negative impact to the Service sector in percentage terms is smaller than that in the Transportation and Public Utilities sector, Government sector, and the statewide average. Impacts never exceed 1 percent of the baseline in any of the major sectors.

Figure A-3 Employment Impacts by Major Sector



The trend in output changes by major sector is illustrated in Figure A-4 and shows similar patterns as the impacts to employment. Like the results for employment, the manufacturing sector is estimated to see slight increase in output growth before 2024 and eventually see decreases in output growth because of the production cost increase that outweighs the diminishing impact of positive final demand.

The Proposed Measures also result in a similar pattern of output impacts in the service sector, which experiences the greatest negative impact among all the major sectors. The Proposed Measures increases the relative cost of production in the services sectors and therefore decreases the output. The negative impact on the output peaks in 2037 and is expected to diminish afterwards. The impacts of the Proposed Amendments on output are never anticipated to exceed 1.4 percent of baseline levels of output.

Figure A-4 Output Impacts by Major Sectors

