APPENDIX C

State of California
Air Resources Board

Proposed Amendments to On-Road Motorcycle Emission Standards and Test Procedures and Adoption of New On-Board Diagnostics and Zero-Emission Motorcycle Requirements

Economic Analysis

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1 Introduction

The California Air Resources Board (CARB) "Proposed Amendments to On-Road Motorcycle Emissions Standards and Test Procedures and Adoption of New On-Board Diagnostics and Zero-Emission Motorcycle Requirements" (Proposal) analyzed in this document would create a legally binding framework to significantly transition toward zero emission motorcycles (ZEMs) for ONMC sales in California while also reducing emissions from remaining internal combustion-powered vehicle sales by greatly harmonizing with more stringent European Union 5 (Euro 5) exhaust emissions standards, proposing more stringent evaporative emissions standards, and adopting additional on-board diagnostic requirements beyond Euro 5. Further, new ONMCs sales that are under 50 cc of engine displacement will be required to be fully transitioned to ZEMs by 2028. The proposal will drive the sales of ZEMs to 50 percent in California by the 2035 model year, thereby reducing GHG and smog forming emissions, while also reducing smog-forming emissions from newer internal combustion engine (ICE) motorcycles. Doing so is critical to meeting California's public health goals, including its climate and state and federal air quality targets. This is because mobile sources are the greatest contributor to emissions of criteria pollutants and greenhouse gases (GHG) in California, accounting for about 80 percent of ozone precursor emissions (e.g., NOx) and approximately 40 percent of statewide GHG emissions, when accounting for transportation fuel production and delivery.[1] As shown in Table 5, in 2020 ONMCs accounted for a disproportionately high 2.2 percent of all oxides of nitrogen and reactive organic gases (NOx + ROG) emitted from mobile sources in California while only accounting for 0.4 percent of vehicle miles traveled (VMT). As other vehicle categories continue to adopt more stringent emissions controls, the proportion of emissions from ONMCs would continue to grow if no action is taken.

ZEMs are defined in the proposal as zero emission motorcycles that "*...produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) or greenhouse gas under any possible operational modes or conditions.*" Most current ZEMs are battery electric vehicles (BEVs), and this is expected to remain the case in the coming years, although the regulation does not preclude other zero emission technologies. These ZEMs are all capable of Level 1 charging, with many having an option for level 2 charging and only a few having level 3 charging options.[2] ZEMs have no tailpipe or evaporative emissions and therefore are a clear solution to several public health and environmental threats. They reduce mobile source emissions that contribute to unhealthy regional ozone and particulate matter levels. They reduce local exposure to toxics. They reduce demand for petroleum production, delivery, and combustion that is destabilizing the climate. And while ZEMs do still have upstream emissions that are associated with the production of the electricity or other fuel used to

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[1] CARB, 2020 Mobile Source Strategy. October 28, 2021.

[2] Level 1 charging is a basic 110-to-120-volt wall plug. Level 2 is a 220-to-240-volt outlet common at many EV charging stations. Level 3 is DC fast charging.

power them (and are accounted for in the analysis of this proposal), the criteria pollutants and carbon intensity of transportation electricity and other fuels is already cleaner than gasoline in California and is aggressively becoming cleaner under state laws mandating renewable sources of fuel.

This analysis shows that transitioning new ONMC sales to zero emission will produce real public benefits. By 2045, the proposal will result in approximately 218,554 cumulative ZEMs sold statewide over baseline (Table 20). From this, staff expects a reduction in cumulative Greenhouse Gases (GHG) emissions by an estimated 0.58 million metric tons (MMT) relative to the baseline by 2045. The cumulative total emissions reductions by 2045 (Table 22) are estimated to be 16,536 tons of reactive organic gases (ROG), 4,805 tons of oxides of nitrogen (NOx), and 28 tons of fine particulate matter (PM2.5) relative to the baseline leading to an estimated 42 lives saved and other avoided hospital visits (Table 23) ZEMs are currently more expensive than the comparable equivalent internal combustion motorcycle. However, for the individual vehicle owner, operational savings from ZEM use will offset any incremental costs over time as described in section 3.2 of this report. The incremental cost difference of ZEMs compared to conventional internal combustion engine (ICE) ONMCs is expected to decrease over time as zero emission technologies reach economies of scale. Staff estimates that by the 2036 model year, it is expected that operational savings of a Highway ZEM (Tier III ZEM) would offset the retail cost difference in less than ten years of ownership. The proposal would also likely contribute to a shift towards employment in ZEM sectors, furthering California's efforts to foster green jobs.

CARB staff based these projections on their best estimates of costs and benefits grounded in the data currently available; as the zero-emission vehicle (ZEV) sector continues to expand, private sector investments accelerate technology development, and public investments continue, costs may drop further, or benefits increase. For instance, CARB anticipates that just as the private sector continues its rollout of zero-emission vehicles in the light duty and heavy-duty categories, supporting government actions will also accelerate, including continued investments in equitably distributed, accessible, and reliable charging infrastructure for light duty vehicles that can also be utilized by ZEMs. Further, ongoing incentives programs to increase zero-emission vehicle access are expected to continue to accompany this program, as they do today, though the precise design of these efforts will be determined over time. CARB staff will continue to further refine costs and benefits as they develop the final proposal and through continued conversations with stakeholders.

The benefits of a move toward ZEMs in new vehicle sales are, in sum, very substantial. CARB considered a range of alternatives (section 6) for this analysis – including no ZEM requirement (Alternative 1) or faster ZEM deployment requirements (Alternative 2). Slower deployments generally produced fewer benefits. CARB did not select the faster ZEM timetable alternatives in this proposal due to unique considerations to the motorcycle sector, but their greater potential benefits suggest a need to further review options between the current proposal and the alternatives as regulatory development continues. CARB will continue reviewing options to capture enhanced public benefits and accelerate the ZEM transition throughout the course of this rulemaking and will update economic analyses as warranted as the public process continues.

A summary of statewide costs and benefits of the Proposal are given below in Table 1. This summary table is intended to give a snapshot of the major economic impact findings illustrated throughout this report. Unless otherwise noted, all dollar figures discussed throughout this paper are adjusted to the value of dollars as they were valued in 2020 (2020$).

Table 1. Summary of Statewide Impacts of the Proposed Regulation.

Category of Cost or Benefit	Value	Section
Total Net Costs of the Proposal (Cumulative through 2045, Millions 2020$)	$276	3.6
NOx Reduction (Cumulative tons through 2045)	4,805	2.1.4
$PM_{2.5}$ Reduction (Cumulative tons through 2045)	28	2.1.4
GHG Reduction (Cumulative MMT CO_2 through 2045)	0.58	2.1.4
Avoided Cumulative Cardiopulmonary Mortalities	42	2.4.1.5
Monetized Health Benefits (Cumulative Millions 2020$)	$564	2.4.1.5
Social Cost of Carbon Benefit (Cumulative Millions 2020$, Range Due to Choice of Discount Rate)	$16 - $65	2.4.2
Average Annual Job Loss (From 2028 through 2045)	334	5.3.1
Cost-Effectiveness ($ per ton of NOx, ROG and PM (x20) Reduced)	$12,615	3.6

1.1 Updates Since the SRIA

The analysis for the Proposal has been updated since the release of the Standard Regulatory Impact Assessment (SRIA) on July 13, 2022.[3] The changes are as follows:

[3] CARB, Proposed Amendments to On-Road Motorcycle Emission Standards and Test Procedures: Standardized Regulatory Impact Assessment, July 13, 2022.

1.1.1 Change in Proposed Start Date for Internal Combustion Engine On-Road Motorcycle Requirements

Due to concerns that manufacturers would not have enough lead time to plan for the 2025 MY with a Board adoption in 2023, Staff has altered the Proposal to push the start date to begin at 30% of new ICE ONMC sales for all ICE ONMC changes in the 2028 MY increasing to 60% in 2029 MY and 100% in the 2030 MY. This more gradual exhaust harmonization with the EU5 standard and new ICE requirements allows manufacturers times to smooth out their resources for ICE certifications but does not impact ZEM implementation dates. The effect is to delay ICE related cost and emissions reductions by a few years. It is difficult to determine the overall effect of this move by itself as several other changes occurred to the Proposal which are discussed here as well. Thus, the overall impact will be mentioned at the end of these changes.

1.1.2 Change in Economic Analysis Time Frame

The prior SRIA analysis had only been performed for 2025 to 2040. However, because the implementation dates of section 1.1.1 had changed to begin in 2028, and because it was deemed more consistent with the ownership experience of section 3.5.1 to capture 10 years of ownership costs and savings at full implementation in 2035, the analysis time frame was shifted to the calendar years of 2028 to 2045. It is difficult to determine the overall effect of this move by itself as several other changes occurred to the Proposal which are discussed here as well. Thus, the overall impact will be mentioned at the end of these changes.

1.1.3 Change in Proposed Internal Combustion Engine Durability Requirements

This section of the proposal previously applied to all ICE. It required durability be tested out to longer mileage distances to ensure performance of emissions equipment for the life of the ONMC. The cost impact resulted from the need for an extra test data point beyond what was currently required to meet standards to capture the added distance. Manufacturers provided data showing that the only ONMCs that practically achieved the higher proposed durability mileages were larger ONMCs that people were comfortable riding long distances.[4] From the data, staff determined that over 50% of ONMCs 800cc and larger would exceed the proposed 50,000 km distance in a normal lifetime, but for smaller bikes there was a significant decrease in these lifetime riding distances. Staff determined that because most of the population of California ONMCs were over 800cc, and there was significant fall-off of distances ridden over a lifetime for bikes under 800cc, that it was reasonable to establish this as a cutoff point for this requirement to reduce the cost impact

[4] Trinity Consultants, Motorcycle Industry Council Comments/Analysis on Proposed OHMC Useful Life Extension. June 2023.

of the proposal. The overall impact of this change will be summarized with that of all other changes at the end of this section.

1.1.4 Added Costs for Internal Combustion Engine On-Road Motorcycle Improvements

Cost analysis was considered for OBD production motorcycle evaluation testing and increased durability testing which were previously assumed to be negligible. Further costs were also considered for binging EU5 motorcycles to the California market. Previously these costs were also considered negligible as the EU models were assumed through CARB testing to already meeting CARB proposed standards. However, manufacturers clarified to CARB that because there still remains some differences in the test procedures, such as with fuels, that these ONMCs would still need to be tested by manufacturers to verify performance on both EU and CARB test procedures. The overall impact of this change will be summarized with that of all other changes at the end of this section.

1.1.5 Further Disaggregation of Zero-Emission Motorcycle Classifications

In the SRIA, ZEMs were categorized as either the larger Highway ZEM (HZEM) or the smaller Local ZEM (LZEM) used primarily for short trips in urban areas. Feedback from stakeholders suggested this disaggregation was not sufficient to properly characterize the ONMC size categories currently available as reflected in Table 6. Thus, Staff further disaggregated ZEMs to Tiers I, II and III as shown in Table 10 and Figure 3. By adding the mid-range Tier II classification, this also caused a change in the credit formulations. Because Tiers I and II together represent less than 10% of the ONMC population when assuming current ONMC performance and size characteristics, this change is not expected to have a large impact by itself on the Proposal in terms of costs or emissions. However, it is difficult to determine the overall effect of this move by itself as several other changes occurred to the Proposal which are discussed here as well. Thus, the overall impact will be mentioned at the end of these changes.

1.1.6 Change in Zero-Emission Motorcycle Credit Formulas and Obligations

ZEM credit formulas and multipliers were included in the original proposal to both incentivize early and larger ZEM (Tiers II and III) sales. ZEM credit Obligations are to help ensure that nominal sales requirements would in fact be representative of actual real-world sales. Early ZEM sales and corresponding accumulation of credits will help to smooth compliance requirements. Larger ZEMs with higher ranges and fast charging are more challenging and costly to build, requiring more incentives early on for manufacturers than building small Tier I ZEMs that don’t require the long range or fast charging capabilities. Current credit formulas are given above under ZEM Requirements. The specific changes made to credit formulas were to eliminate the formulas in MY 2036 and go to a constant of 1 credit generated for a Tier III ZEM sold and 0.5 credits generated for a Tier II ZEM sold. The prior proposal for ZEM credit obligations was to require ZEMs to count in the sales population when calculating total obligation such that ZEM Tier I would require 0.25 credits, ZEM Tier II would 0.5 credits and ZEM Tier III would require 1 credit. The specific changes made to ZEM credit obligations were to eliminate any obligations for ZEM sales prior to MY 2036 and require the previously proposed obligations thereafter. The net effect of the change will be to dramatically increase the number of ZEMs sold after 2036 to approach 50%. Previous nominal credit surrender requirements of 50% would have only approached actual minimum ZEM sales of approximately 30% due to the incentives built into the ZEM credit generation formulas. By removing these, nominal credit surrender requirements of 50% will achieve a minimum of 49% in actual ZEM sales, but very likely results in more than 50% sales. Note, it is difficult to determine the overall effect of this move by itself as several other changes occurred to the Proposal which are discussed here as well. Thus, the overall impact will be mentioned at the end of these changes.

1.1.7Changes to REMI Modeling

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 3.0.0 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.[5] REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the Proposed Regulation, pursuant to the requirements of SB 617 (Calderon, Stats. 2011, Ch. 496) and the California Department of Finance.[6,7] 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.

Specifically, the REMI model's National and Regional Control was updated to conform to the most recent California Department of Finance economic forecasts which include U.S. Real Gross Domestic Product, income, and employment, as well as California civilian employment by industry, released with the 2023-2024 May Revision to the Governor's Budget on May 12, 2023 and Department of Finance demographic forecasts for California

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

[6] California Senate Bill 617. October 2011.

[7] California Department of Finance (DOF). Chapter 1: Standardized Regulatory Impact Analysis for Major Regulations - Order of Adoption. December 2013.

population forecasts, last updated in July 2021.[8,9,10,11] After the Department of Finance economic forecasts end in 2026, CARB staff made assumptions that post-2026, economic variables would continue to grow at the same rate projected in the REMI baseline forecasts.

1.1.8 Changes to Health Impact Analysis

CARB recently initiated an expanded health analysis to include additional health endpoints to provide a more comprehensive analysis of the benefits of the agency's plans and regulations. A description of the updated and new health outcomes is provided in further detail in the section 2.4.1. Details of the benefits are given in Table 25 and Table 26. This caused the cumulative health benefits of the regulation to increase from $329M to $564M.

1.1.9 Error Corrected in the Calculation of Gasoline Sales Tax Revenue

Staff corrected an error in the reported gasoline sales tax revenue that affects the fiscal impact on local government. The SRIA reported the total value of reduced gasoline sales instead of the reduction in gasoline sales tax revenue. This has reduced the magnitude of the gasoline sales tax decrease by about 96 percent and the economic impacts, such as the job impact to local government. Gasoline sales tax revenue impact is shown in Table 53.

1.1.10 Summary of Net Impacts of Above Changes

These changes have led to a net change in the population of ZEM sales over baseline and ICE ONMCs most of which would require upgraded exhaust and evaporative emissions controls as shown in Table 2.

Table 2. Cumulative Change in Projected Total Unit Sales MY 2028 Through 2045.

	Projected Minimum ZEM Sales Required Over Baseline (units)	Total ICE ONMC Sales (units)
Updated Analysis	218,554	1,036,608
SRIA Proposal	111,890	940,712

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

[9] California Department of Finance (DOF). Economic Research Unit. California Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.

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

[11] California Department of Finance (DOF). Demographic Research Unit. Report P-3: Population Projections, California, 2010-2060 (Baseline 2019 Population Projections; Vintage 2020 Release). Sacramento: California. July 2021.

These changes in sales population of ONMCs impacted by the proposal lead to the emissions changes shown in Table 3. The reason the NOx and CO have fewer reductions under the Proposal relative to the SRIA Proposal is that the increased reductions due to increased ZEM sales are offset due to the exhaust requirements being pushed from MY 2025 to 2028.

Table 3. Cumulative Change in Projected Emissions Reductions Through 2045.

	NOx (tons)	ROG Exhaust (tons)	ROG Evap (tons)	CO (tons)	PM2.5 (tons)	GHG (MMT)
Current Proposal	4,805	9,121	7,416	132,351	28	0.58
SRIA Proposal	3,458	5,780	2,595	90,109	25	0.52
Difference	1,347	3,341	4,821	42,243	4	0.06

This leads to an overall cost effectiveness change as shown in Table 4. This results in a 14 percent increase in efficiency of the proposal.

Table 4. Change in Cost Effectiveness of Proposal as Measured Through 2045.

	Combined Direct Cost and Savings ($)	Total Weighted Emissions Reduced (tons)	Cost Per Ton Reduced ($)
Current Proposal	$276,375,810	21,909	$12,615
SRIA Proposal	$390,518,567	12,323	$31,691
Difference	-$114,142,757	9,586	-$19,076

1.2 Regulatory History

The proposal analyzed here builds upon many decades of CARB regulations seeking to reduce emissions from on-road vehicles. Each of those regulations ultimately yielded significant public benefits. This Proposal is in keeping with that history of bringing ONMCs down to the most stringent exhaust emission standards while leading the way in new evaporative emissions standards, on-board diagnostics (OBD) and ZEM sales requirements.

CARB has been regulating emissions from ONMCs since 1978 and these regulations were last updated to the current emissions standards in 1998. Since then, more stringent exhaust emissions standards have been developed by other jurisdictions around the world, most notably in the European Union. These stringent exhaust standards have prompted industry to develop cleaner motorcycles than what are currently required in California. While current CARB ONMC evaporative standards are on par with most other jurisdictions around the world, other similar categories regulated by CARB are subject to much lower evaporative emissions limits. For example, in 2013 CARB adopted stringent evaporative emissions limits with more robust test methods for the Off Highway Recreational Vehicle (OHRV) category, which includes off-highway motorcycles that are closely related to ONMCs.

Currently CARB does not have specific regulatory requirements for ONMCs that have an engine displacement of lower than 50cc, defined by the United States Environmental Protection Agency (U.S. EPA) as Class IA motorcycles. These low displacement motorcycles are only required to demonstrate that they meet U.S. EPA emissions standards.

Because California has not enacted new emissions standards for ONMCs since 1998, the allowable emissions rate per mile for motorcycles is significantly higher than for other vehicle categories that are subject to more recent and stringent regulatory standards. Accordingly, ONMCs currently account for a small percentage of all on-road vehicle miles travel (VMT) in California while disproportionally accounting for a larger percentage of all on-road emissions. If no action is taken, the proportion of emissions from ONMC will continue to grow as a percentage of overall on-road emissions. Table 5 shows staff estimates for the 2020 ONMC population, usage, and emissions compared to all on-road vehicle sources. Staff's emission estimates and economic analysis are based on recent CARB ONMC emission testing and the latest version of CARB's emission inventory tool, EMission FACtor 2021 (EMFAC2021) for all other on-road sources.[12,13,14,15] Updated assumptions to ONMC emission rates, derived from recent CARB testing, will be amended into the next revision of EMFAC.

Table 5. 2020 Contribution of On-road Emissions from ONMCs.

	Population	VMT* (miles/day)	NOx** (tpd)	ROG*** Total (tpd)	NOx + ROG (tpd)	CO**** (tpd)	CO2***** (tpd)
% From ONMC	2.4%	0.4%	0.6%	6.3%	2.6%	3.6%	0.2%
ONMC Contributions	687K	3.4M	3	15	18	73	831

* Vehicle Miles Travels, ** Oxides of Nitrogen, ***Reactive Organic Gases which includes hydrocarbons (HC), ****Carbon Monoxide, *****Carbon Dioxide

Since 2018, CARB has been working closely with many other jurisdictions in the spirit of trying to achieve harmonization where possible on more stringent and robust ONMC

[12] CARB, Emissions Inventory Derivations Spreadsheet to Support the Proposed Amendments to On-Road Motorcycle Emissions Standards, October 6, 2023.

[13] CARB, Emissions Inventory Derivations Spreadsheet for Alternative 1 to Support the Proposed Amendments to On-Road Motorcycle Emissions Standards, October 6, 2023.

[14] CARB, Emissions Inventory Derivations Spreadsheet for Alternative 2 to Support the Proposed Amendments to On-Road Motorcycle Emissions Standards, October 6, 2023.

[15] CARB, Economic Analysis Spreadsheet to Support the Proposed Amendments to On-Road Motorcycle Emissions Standards, October 6, 2023.

emissions standards and test procedures. Specifically, CARB has worked closely with U.S. EPA, Environment and Climate Change Canada (ECCC), the European Union (EU) and the United Nations (UN). The Proposal gains some economic benefits from harmonization with other jurisdictions where possible, while also pushing for the adoption of newer and lower emitting existing technologies where feasible. This strategy achieves a significant reduction of both GHG and criteria pollutants for the state of California by requiring lower emitting ICE ONMCs and an increasing percentage of ZEMs.

1.3 Current Certification Requirements and Vehicle Technology for Conventional Internal Combustion Engine On-Road Motorcycles

California ONMCs are defined in the California Vehicle Code, with limited exceptions, as a motor vehicle having a seat or saddle for the use of the rider, designed to travel on not more than three wheels in contact with the ground.[16] California ONMCs are currently divided into three categories per U.S. EPA classification paradigm as given in Table 6.

Table 6. U.S. EPA ONMC Classifications.

Class	Subclass	Displacement (cc)
I	A*	< 50
	B	≥ 50 and < 170
II	-	≥ 170 and < 280
III	-	≥ 280

*Class IA are often characterized as small scooters or moped that can exceed 28 mph.

A visual representation of these classifications is given in Figure 1 below.

Figure 1. Visual Illustration of ONMC Classifications.

[16] California Vehicle Code § 400.

For manufacturers to sell new ONMCs in California, they must be certified by CARB and issued an Executive Order. Note that California does not currently have any certification requirements for Class IA motorcycles beyond those required by U.S. EPA. Also, ZEMs are currently not subject to CARB certification requirements as they have no tail pipe emissions but will be subject to CARB certification under this Proposal. To obtain CARB certification, a manufacturer of an ONMC with an internal combustion engine (ICE) must demonstrate that its exhaust and evaporative emissions control systems comply with the emission standards and test procedures for the vehicle's useful life as shown in Table 7.

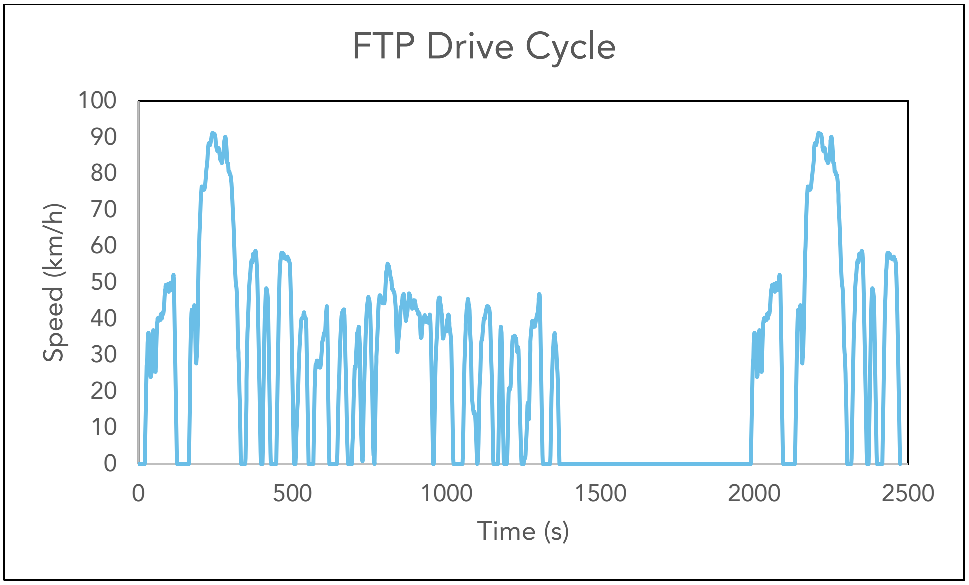
Table 7. CARB/U.S. EPA ONMC Useful Life (whichever occurs first).

Class	Useful Life Years	Useful Life Mileage (km)
I	5	12,000
II	5	18,000
III	5	30,000

Certification testing is carried out by the vehicle manufacturer, and the vehicle(s) tested for certification, represents a group of similar vehicle models. Vehicles are sorted into test groups for exhaust and evaporative emissions testing, called engine and evaporative families. Vehicles in the same test group share attributes such as similar engine size and the number and arrangement of cylinders, while vehicles in the same evaporative family share similar fuel tank size as well as common evaporative emission control components. This method of grouping vehicle models into test groups and testing a representative vehicle streamlines the testing process for certification and reduces the total number of tests that must be conducted.

Each test group must meet emission standards as measured in a testing laboratory using specific test cycles. The current CARB emission test for ONMCs is the Federal Test Procedure (FTP), which includes a prescribed vehicle speed/time profile, or drive cycle, as shown in Figure 2. The FTP drive cycle is intended to represent urban driving and captures both hot and cold start driving conditions.

Figure 2. FTP Drive Cycle.



The current CARB ONMC exhaust emissions certification standards for Class I-B and Class II ONMCs is 1 gram of HC per kilometer (g/km) and 12 g/km of CO. The current CARB certification emissions limit for Class III ONMCs is 0.8 g/km for combined HC + NOx and 12 g/km of CO. Class III certification includes provisions for corporate fleet averaging which allows for balancing very clean models with models that emit up to 2.5 g/km HC+NOx so long as the average emissions are less than the certification limit.

1.4 Proposed Amendments

The Proposal amends current exhaust and evaporative requirements by changing the test procedures and lowering emissions limits for conventional ICE ONMCs and adding some OBD. The Proposal also creates new ZEM sales thresholds and quality assurance measures that must be met. The Proposal will be implemented in multiple phases beginning in model year (MY) 2024 and reaching full implementation in 2035 to allow for a smooth transition from ICE ONMCs to a mix of lower emitting conventional ICE ONMCs and ZEMs. The most significant aspects of the Proposal are described in this section, beginning with the ZEM requirements. The section will conclude with a schedule showing the phases of implementation.

1.4.1Zero-Emission Motorcycle Requirements

Although CARB currently has no ZEM sales requirements, staff analyzed 2020 California Department of Motor Vehicles (DMV) registration records and found there were already over 2,000 ZEMs registered in California. There has been significant regulatory activity by CARB and other jurisdictions to require zero emission vehicles in other categories as well. In

2020, Governor Gavin Newsom issued executive order N-79-20 which set a goal that 100 percent of in-state sales of new passenger cars and trucks, among other categories, will be zero-emission by 2035.[17] Although the order did not specifically reference ONMCs, staff believes that this category is technologically capable of achieving significant strides towards increased ZEM. However, due to significant difference in physical characteristics and usage patterns between ONMCs and passenger cars, most prominently that ONMCs are used to a large degree for recreational riding, staff believes that requiring 100 percent sales of ZEMs is not currently feasible. As described in section 6.2.5, staff was concerned that many recreational riders strongly prefer the range, performance, and aesthetic characteristics of ICE motorcycles and will be reluctant to adopt ZEM alternatives. An effective ban on selling new low emitting ICE ONMCs in trying to promote ZEM sales could result in the perverse outcome that ONMC users who felt their needs could not be met by ZEM would turn to legally buying and bringing into California older and higher emitting used ONMCs from out of state, which would ultimately lead to an increase in emissions. Considering the potential for this unintended outcome and the high levels of purely or primarily recreational ONMC riders whose needs may not be met by ZEMs, staff are proposing a pragmatic target of 50 percent ZEM sales by 2035. Allowing this mix of ZEMs and low emitting ICE motorcycles would ensure that all riders will have a selection of clean ONMCs that meet their needs.

Beginning in MY 2024, the Proposal includes ZEM certification and quality assurance requirements along with a tradeable ZEM credit program to allow for greater compliance flexibility, as shown in section 1.4.1.2. Participation in those program elements is completely voluntary for the purpose of accumulating early compliance credits that could be used starting in 2028 when manufacturers selling more than 750 ONMCs annually in California will be required to surrender ZEM credits equal to at least 10 percent of their vehicles sold in California for that year. The credits will be surrendered on a basis of one credit surrendered for each ZEM the manufacturer is required to produce. This ZEM sales percent requirement will increase gradually to 50 percent in 2035 as shown in Table 8. Manufacturers will be able to accumulate early bankable compliance credits for ZEMs sold prior to 2028 to provide flexibility and encourage faster adoption of ZEMs into the market.

Table 8. ZEM Sales Percent Requirements for MY 2028 and Subsequent Years.

Model Year (MY)	ZEM Sales Requirement*
2028	10%
2029	15%
2030	20%
2031	25%
2032	31%
2033	37%

[17] Governor's Office (GO), Governor Gavin Newsom. Executive Order N-79-20. September 23, 2020.

2034	43%
2035 and beyond	50%

*Applies only to manufactures selling more than 750 ONMCs per year in California.

The annual calculated credit obligations are based on the total number of street-use motorcycles sold in each motorcycle class, as reported pursuant to section 1958.1. A manufacturer's obligations is determined by considering the sales of an entire MY of both ZEM and ICE. The values in Table 9 illustrate those obligations.

Table 9. Credit Obligation Per ONMC Sold by Type.

ONMC Type	Credit Obligation MY 2028-2035	Credit Obligation MY 2036+
Tier I ZEM	0	0.25
Tier II ZEM	0	0.5
Tier III ZEM	0	1
Class I ICE	0.25	0.25
Class II ICE	0.5	0.5
Class III ICE	1	1

Also beginning in MY 2028, CARB will no longer allow California sales of EPA-certified Class IA ONMCs (Table 6). These small ONMCs which are the most polluting per mile driven, are the most feasible to shift completely to ZEM production as they require less battery capacity due to lower vehicle weight and performance requirements. Further, other jurisdictions in Asia that have much greater annual sales of scooters and small displacement motorcycles are also pushing regulations that require electrification in this category. Small ZEMs developed for larger Asian markets can be brought to the California market as well, leading to greater benefits in harmonization by aggressively pushing for zero emission in this category.[18]

1.4.1.1 ZEM Credit Program

To ensure an increase in the population of ZEMs, this Proposal requires that a certain percentage of ZEM credits be surrendered by large conventional ICE ONMC manufacturers selling ONMCs in California. ZEM credits will be generated for each CARB-certified ZEM sold in California, starting with MY 2024. The generation of these credits will be dependent upon the following ZEM characteristics:

[18] Reuters, Fossil Fuel-Based Vehicle Bans Across The World, November 18, 2020.

- Classification as either Tier I, II or III based upon certified range and top speed;
- Whether it has a fast charge capability; and
- Model year (MY) the ZEM credit was generated.

ZEM credits may be used by a manufacturer to satisfy their ZEM sales compliance requirements as show in Table 8. ZEM credits are surrendered at a rate of one credit being equivalent to one ZEM produced in satisfying a manufacturer's compliance obligation. ZEM credits may also be banked for later use or sold to other manufacturers to help them meet their compliance obligation. A tradeable ZEM credit program allows great flexibility in meeting the standard as a manufacturer will not then directly have to produce a ZEM that may be outside their expertise and remain focused on low emission ICE ONMCs. This will also help those manufactures who do transition to building ZEMs by providing more time for them to make the transition.

The first consideration in determining ZEM credits is to classify the ZEM as either Tier I, II or III. These classifications are determined by the vehicle range and constant speeds per Society of Automotive Engineers (SAE) J2982[19], as shown in Table 10. Note that if the vehicle does not meet the minimum constraints for a Tier I then the vehicle is not a ZEM for the purposes of this regulation and does not generate any ZEM credits.

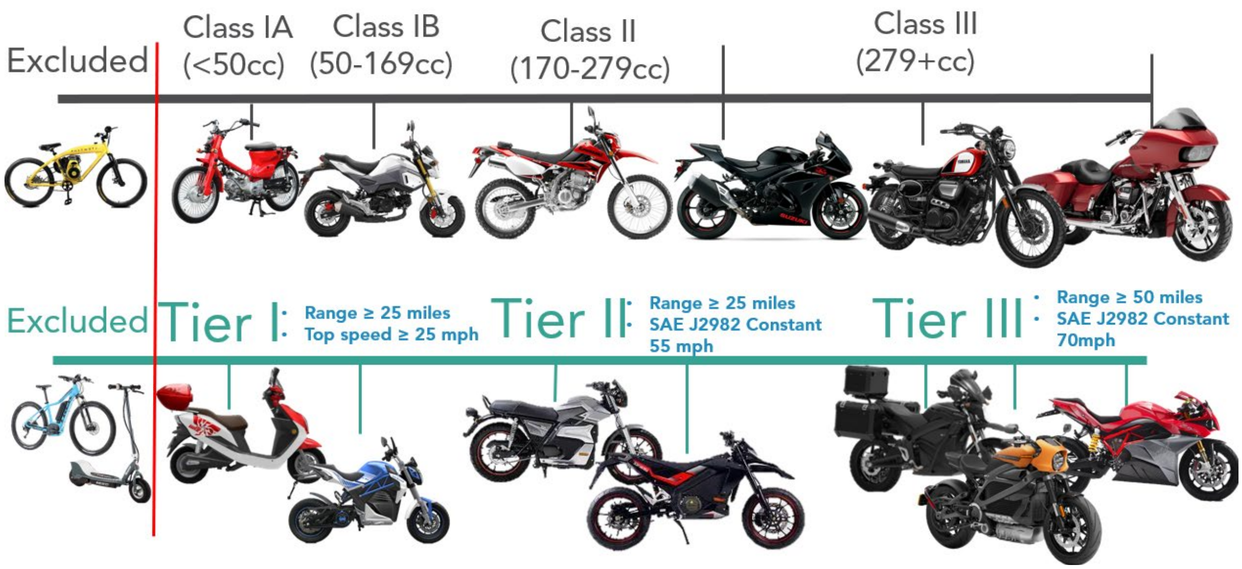
Table 10. ZEM Subcategory Constraints of Tiers I, II and III.

	Range (miles)	SAE J2982 Speed (mph)
Tier I	≥ 25	> 25
Tier II	≥ 25	≥ 55
Tier III	≥ 50	≥ 70

A visual representation of these ZEM subcategories and how they align with conventional ICE ONMC classifications is given in Figure 3 below.

[19] Society of Automotive Engineers (SAE) International J2982_202210, Riding Range Test Procedure for On-Highway Electric Motorcycles, Revised 2022-10-13.

Figure 3. Visual Illustration of ZEM Subcategories and How They Align with ONMC Classifications.



If the ZEM is classified as a Tier I, it will generate 0.25 credits per ZEM sold.

If the ZEM is classified as Tier II, through MY 2035, credit generation will be as follows:

$$Cr = (R * 0.01) * M + FC$$

where:

Cr = ZEM credits generated

R = range in miles to a maximum of 100

M = early adoption multiplier:

- For ZEM sold between calendar year (CY) 2024 – 2027, M = 3
- For ZEM sold between CY 2028 – 2031, M = 1.5
- For ZEM sold after CY 2031, M = 1

FC = fast charge credit:

- If vehicle has fast charge capability, FC = 0.25
- If not equipped, FC = 0

If the ZEM is classified as Tier III, credit generation will be as follows:

ZEM Credit Formula

$$Cr = [(R * 0.01) + 0.5] * M + FC$$

where:

Cr = ZEM credits generated

R = range in miles to a maximum of 200

M = early adoption multiplier:

- For ZEM sold between CY 2024 – 2027, M = 6
- For ZEM sold between CY 2028 – 2031, M = 3
- For ZEM sold after CY 2031, M = 1

FC = fast charge credit:

- If vehicle has fast charge capability, FC = 0.5
- If not equipped, FC = 0

For MY 2036 and beyond, ZEM credit generation will simplify as follows:

- Tier I: Cr = 0.25
- Tier II: Cr = 0.50
- Tier III: Cr = 1.00

Because there are already several ZEM manufacturers in both the domestic and global markets, it is anticipated that beginning in CY 2024 and prior to compliance requirements in MY 2028, manufacturers will have the opportunity to generate and bank significant tradeable ZEM credits. These can be traded between manufacturers to help smooth out compliance obligations as they begin. To ensure against excessive banking of ZEM credits, beginning in CY 2028 all credits generated will have a 5-year expiration from date they are generated. Credits generated prior to CY 2028 will be treated as though they were generated in CY 2028 for the purposes of expiration.

1.4.1.2 ZEM Certification and Quality Assurance

There are currently no CARB certification standards or procedures for ZEMs because they have no tailpipe or evaporative emissions. Therefore, unlike ICE ONMCs, there are some manufactures who currently sell ZEMs for on-road use in California that are registered by the California DMV without a CARB certification. The Proposal will require CARB certification of ZEMs if the manufacturer desires to accumulate ZEM compliance credits from them, either for the purpose of meeting compliance obligations if they also produce ICE ONMCs for sale in California or if they would like to sell the ZEM credits to another manufacturer to assist in meeting its compliance obligations.

CARB has long designed its regulations and certification programs to ensure that vehicles, including emissions controls, perform properly throughout the life of the vehicle. In the ZEM context, the Proposal continues this approach by imposing certain quality assurance measures. ZEMs themselves reduce emissions by replacing an internal combustion vehicle. This means that the ZEM drivetrain and energy storage systems are critical to pollution control, and if they fail, a ZEM may be replaced with a conventional ICE ONMC – a concern that intensifies as vehicles age and compete on the used vehicle market. To secure the emissions benefits of this Proposal, ZEMs must meet continuing assurance requirements throughout their useful lives. Such requirements can improve the performance of vehicles bought used – when most people buy vehicles, and when vehicles are more affordable for lower-income consumers. Thus, the ZEM assurance measures can support equitable access to reliable ZEMs in communities that need reliable and durable mobility options.

For a ZEM to be CARB certified, the manufacturer will have to meet the following quality assurance standards that will also be used to determine if ZEM credits can be generated for the sale of a particular ZEM. For certification, the applicant must demonstrate and/or provide:

- Full replacement battery warranty standard of 5 years or 50,000 km, whichever comes first;
- Range as determined by SAE J2982 for battery electric vehicles (BEVs) or SAE J2572[20] for hydrogen fuel cell vehicles Top speed as determined by the Euro 5 standard in Appendix 1 and 1.1 of Annex X of EU No134/2014;[21]
- Level 2 or 3 fast charge capability; and
- Battery label listing capacity performance among other items.

Ultimately some of these parameters will be used to determine how many ZEM credits are generated by each ZEM sold as shown in section 1.4.1.1.

1.4.1.3 Battery Label

Staff's proposal would result in high volumes of ZEM batteries that would eventually either go into second life applications or would need to be recycled or disposed. Ensuring the success of endeavors to avoid waste helps increase the recycled content available for future battery development and decrease the demand for new critical mineral resources. Requiring information on the battery itself can help enable second use and recycling processes.[22] To this end, staff proposes requiring a standardized battery label for all vehicles with a traction battery, or a battery used to power the electric motor(s) of a ZEM. The proposed required label would contain four key pieces of information:

- Cell cathode chemistry;
- Capacity performance;
- Composition and voltage; and

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[20] Society of Automotive Engineers (SAE) International J2572_201410, Recommended Practice for Measuring Fuel Consumption and Range of Fuel Cell and Hybrid Fuel Cell Vehicles Fueled by Compressed Gaseous Hydrogen, Revised 2014-10-16.

[21] Commission Delegated Regulation (EU) No 134/2014 of 16 December 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to environmental and propulsion unit performance requirements and amending Annex V thereof, Annex X, Appendix 1, Amended 2/28/2018.

[22] Luqman Azhar, et al. Recycling for All Solid-State Lithium-Ion Batteries, Matter. December 2, 2020.

- Digital identifier (QR Code) linked to a digital repository that can be updated with current information relevant to secondary users, vehicle dismantlers, and recyclers.

1.4.2 Internal Combustion Engine On-Road Motorcycle Requirements

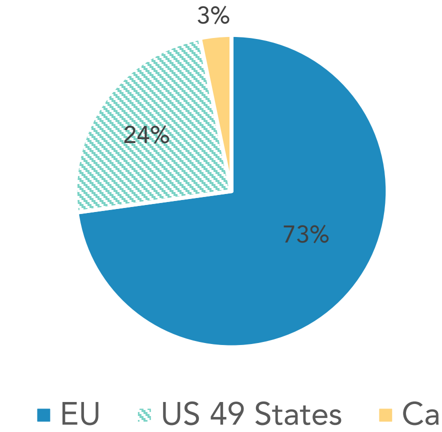
While the proposal has robust new ZEM requirements, there remains a significant need among certain ONMC users to have access to conventional ICE ONMCs due to limitations on ZEM range and/or lack of charging locations in many of the remote areas of frequent ONMC use. While CARB has not updated regulations for this category since 1998, significant strides have been made in other jurisdictions to reduce emissions from conventional ICE powered ONMCs. The most notable improvements were observed in the European Union (EU), which has taken great efforts to standardize their testing requirements at the global level through participation in United Nations (UN) working groups. Staff has reached out to these EU regulators and manufacturers to consider harmonizing with more stringent exhaust regulations while also working to lead the world in developing new cutting-edge CARB evaporative emissions standards, testing procedures and on-board diagnostics to capture readily available emissions reductions that are not being addressed by current CARB or EU regulations.

The Proposal considers the potential for lower costs of emissions reductions if aggressive standards can be harmonized across large and expanding markets by spreading the implementation and development costs over more units sold. By harmonizing with existing EU requirements, the Proposal allows manufacturers to eliminate some amount of duplicative design research and certification testing. It is important to note that California is a relatively small market for new ONMC sales when compared to the sales of markets of the combined 49 United States (US) and EU. As a comparison of market size, staff determined that in 2019 the California ONMC sales were 48,165 units, US 49 state ONMC sales (not including California) were approximately 354,855 units,[23] and EU ONMC sales were approximately 1,079,520 units.[24] From this, it is clear that California is just a small sliver of this broader ONMC market, accounting for just 3 percent of ONMC sales. Adopting unique emission control standards for California would impose additional design and certification costs on manufacturers which could then only be distributed over 3 percent of this broader market (Figure 4).

[23] Motorcycle Industry Council (MIC), 2020 Motorcycle Statistical Annual. Published 2020.

[24] Statista, Motorcycle sales in the European Union from 2010 to 2020, March 17, 2022. (https://www.statista.com/statistics/279580/new-motorcycle-registrations-in-eu-27/. Accessed March 23, 2022)

Figure 4. Relative Proportion of Unit Sales of Combined US and EU Markets.



In order to ease certification resource burdens of trying to certify all new ICE standards in one year, The Proposal allows manufacturers to phase in all of the following new ICE requirements discussed below for new ICE sold as

Table 11. ICE ONMC Upgrade Schedule.

Model Year	% ICE Sales Requirement
2028	30%
2029	60%
2030	100%

1.4.2.1 Amended Exhaust Emissions Standard

Beginning in MY 2028, the Proposal requires that ICE ONMCs sold in California harmonize to a large degree with the stringent exhaust emissions limits and test procedures currently being employed in the EU, as seen in Table 12. They are commonly referred to as Euro 5 standards as found in the following Regulation: 02013R0168-EN-14.11.2020-003.001.[25] Harmonizing with Euro 5 standards will lower the current CARB HC + NOx limits by 80 percent and current CO limits by 92 percent in addition to requiring new limits for non-methane hydrocarbons (NMHC), and particulate matter (PM) if powered by a compression ignition ICE.

[25] Regulation (EU) No 168/2013 Of The European Parliament And Of The Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles, Annex VI. Amended 11/14/2020.

Table 12. Current and Proposed CARB ICE ONMC Exhaust Emissions Standards (g/km).

	HC	NOx	HC + NOx	CO	NMHC	PM*
CARB (Class IB and II)	1	-	-	12	-	-
CARB (Class III)	-	-	0.8	12	-	-
Proposed Standard, Euro 5 (all ONMC ≥ 50cc)	0.1	0.06	0.16**	1	0.068	0.0045

*Applies only to compression ignition ONMCs
**Is the combined result of separate HC and NOx standards.

Aside from requiring lower emissions, the Proposal calls for adopting a new dynamometer drive cycle, the World Motorcycle Testing Cycle (WMTC), as referenced in the Euro 5 standards. Because this represents a harmonization where the only significant difference is test fuel which staff has found in its own testing to have negligible impact on exhaust testing, manufacturer will be allowed to certify to these exhaust standards with Euro 5 testing data provided the results are at least 10 percent under the Proposed limits.

1.4.2.2 Amended Evaporative Emissions Standard

Staff's ONMC evaporative testing has shown the current evaporative certification test is not as good of a predictor of real-world emissions as the Proposal and that more stringent evaporative standards are readily achievable.[26] Beginning in MY 2028, the Proposal will require that manufacturers to meet a new evaporative emissions standard and test procedure.[27] The new standard will require access to variable volume Sealed Housings for Evaporative Determination (SHEDs) that can control temperature and precisely measure hydrocarbon emissions. Even though variable volume SHED testing has been used for years in the automotive industry, some ONMC manufacturers have not had need of these before. Therefore, compliance with the new standards will either require them to purchase SHEDs or contract out more of their design and certification testing work.

1.4.3New On-Board Diagnostics (OBD) Requirements

Beginning in MY 2028, the Proposal would require all Class III ONMCs to harmonize with Euro 5 OBD.[28] Because all major ONMC manufacturers currently doing business in California are already building ONMCs with compliant OBD systems for sale in the EU, they should be easily produced for sale in California. Beginning in MY 2028, all OBD systems

[26] The test procedure requires emissions to be measured from the vehicle over a one-hour hot soak followed by a one-hour heat ramp meant to simulate an accelerated diurnal temperature cycle. The limit for the combined two-hour CARB test is 2 g and the combined two-hour EU test limit is 1.5 g. The one-hour heat ramp requires invasive ports to be drilled into the motorcycle fuel tank to allow for the installation of thermocouples to monitor temperature.

[27] This new standard will require a one-hour hot soak followed by a three-day diurnal test where temperature is modulated from 65-105°F. The limit for the hot soak test is 0.1 g and the limit for the three-day diurnal test is 1 g/day for each day.

[28] Regulation (EU) No 168/2013, Annex IV.

must also include the capability to monitor the fuel system to determine compliance with applicable emissions standards. This change would not require any new hardware beyond the typical Euro 5 OBD system and can be met with calibration and programming adjustments.

1.4.4Durability Amendments

It is important that emissions related equipment last the life of the vehicle if emissions are to be controlled for the life of the vehicle. To obtain CARB certification, manufacturers must conduct emissions tests on a representative motorcycle that has been aged following an approved protocol. This is typically satisfied by accumulation several thousand miles on a test vehicle following a specified drive cycle. Staff has determined that current durability and warranty assumptions do not reflect the typical useful life of current ONMCs on the road. Staff estimates that current vehicle durability mileage requirements are not reflective of real-world vehicle lifetime mileage accrual rates. Staff estimates from EMFAC2021 modeling that the average useful lifetime of a registered motorcycle in California is 18 years. Assuming the average fuel efficiency of an ONMC is 44 mpg[29], and average annual gasoline consumed per ONMC of 51.1 gallons as derived from EMFAC2021 fuel consumption estimates, staff determined that the average annual mileage of a California ONMC is approximately 2207 miles (3551 km). From this, the average lifetime mileage of a California ONMC is estimated to be 39,721 miles (63,926 km). From these Staff arrived at the proposed changes in durability mileages as given in Table 13.

Table 13. Proposed Increase in ONMC Lifetime Durability Mileage of Emissions Related Components.

CARB/EPA Class	Current EPA/CARB Distance (km)	Proposed CARB Distance for CY 2028+ (km)	% Increase Over Current CARB/EPA Distance
IB (50-169 cc)	12,000	11,000	-8%
II (170-279 cc)	18,000	20,000	11%
III (280 to 799 cc)	30,000	35,000	17%
III (800+ cc)	30,000	50,000	67%

To offer manufacturers more certification flexibility, beginning in MY 2028 the Proposal will allow manufacturers to use catalyst bench aging[30] in lieu of mileage accumulation to ease burdens associated with whole vehicle aging. However, if the manufacturer selects vehicle

[29] U.S. Department of Energy (DOE), Alternative Fuels Data Center, Average Fuel Economy By Major Vehicle Category. February 2020.

[30] Catalyst bench ageing is a testing technique that simulates the wear from miles driven on a catalytic convertor by exposing it to heat cycling in an oven. This can eliminate the need of a rider and vehicle being necessary to test durability over time which results in less testing cost.

bench aging, they will be subject later to an In Use Verification Program (IUVP) to verify that the bench aging was representative of long-term performance of the emission controls. The IUVP will be based on current CARB requirements for LDVs and would apply only to models selling more than 300 units per year in California. Subject manufacturers would be required to test four in-use vehicles per engine family to and submit that data to CARB to show that the vehicles are compliant, and the emissions controls are working as expected.

1.4.5Warranty Amendments

Current vehicle warranty requirements are set at 5 years or a specific useful life mileage by vehicle class as given in Table 7. However, as discussed above in durability amendments 1.4.4, Current useful life mileages are not reflective of real-world use.

Table 33 shows the current warranty mileage requirements and the proposed increase in vehicle warranty mileages for emissions related equipment. Beginning in 2028, the Proposal requires ONMC manufacturers to phase in warranty coverage for emissions control components through the increased mileage distance. The Proposal does not call for any change to the current 5-year life of the warranty because staff believes it would be difficult to design for material degradation due to the combination of time and variables of extreme exposure beyond 5 years. Although the Proposal does not change the length of the warranty from its current 5 years, staff believes that requiring these changes in warranty mileage will result in manufacturers' emission control systems and components are durable thus providing a better assurance of real-world vehicle lifetime emissions reductions.

1.4.6Phases of Implementation

All proposed ONMC improvements except for voluntary ZEM early adoption sales credits will begin being phased in with MY 2028 as given in Table 8 and Table 11. ZEM credits may be earned from ZEM sales beginning in MY 2024.Table 14 is listed here for convenience to help understand the totality of measures that are being adopted.

Table 14. Regulatory Phases of Implementation.

Implementation Phase	MY	Regulatory Action Starts
1	2024	ZEV Credit Generation Allowed
2	2028	EU 5 Exhaust Harmonization Required
		Optional Catalyst Bench Aging Allowed
		ZEM Certification Requirement Schedule Begins
		No New CARB Certification of Class IA Allowed
		New CARB Multiday Day Diurnal Evaporative Emissions Certification Required

Implementation Phase	MY	Regulatory Action Starts
		New Emissions Durability Testing Distances Requirements
		New Emissions Warranty Requirements
		EU 5 OBD with Additional CARB Requirement for Fuel System Monitoring
		IUVP Required for Optional Catalyst Bench Aging

In MY 2028, all new ICE sales with the proposed ICE requirements will follow the schedule laid out in Table 11 and new ZEM sales with the proposed ZEM requirements will follow the schedule laid out in Table 8.

1.5 Statement of the Need of the Proposed Regulation

According to the California 2020 Mobile Source Strategy, mobile sources including ONMCs contribute a significant amount of smog-forming NOx and the largest portion of GHG emissions in California.[31] While ONMCs are a small portion of on-road emissions, they are a disproportionately large contributor of non-GHG emissions. As shown previously in Table 5, statewide ONMCs account for 0.4 percent of vehicle miles traveled of all on-road sources, yet they contribute 0.6 percent of NOx, 4.7 percent of ROG, and 3.6 percent of CO. Without action, ONMC emissions will continue to grow in relation to emissions from other mobile sources that are subject to increasingly stringent emissions control requirements.

The Proposal is a draft measure in the 2022 State Strategy for the State Implementation Plan (SIP) and a significant part of CARB's comprehensive effort to meet air quality standards.[32] The Proposal would cut emissions from new internal combustion vehicles while ramping up sales of ZEMs to 50 percent by 2035, reducing NOx emissions from today's ONMCs by up to 53 percent by 2045. Emissions reductions from ONMCs will also contribute to meeting SIP goals for attainment of ozone air quality standards. NOx is a precursor to ozone and secondary PM formation. Exposure to ozone and PM2.5 is associated with increased premature death, hospitalizations, visits to doctors, use of medication, and emergency room visits due to exacerbation of chronic heart and lung diseases and other adverse health conditions.

[31] CARB, 2020 Mobile Source Strategy. 2021.

[32] CARB, 2022 State Strategy for the State Implementation Plan, September 2022.

1.6 Major Regulation Determination

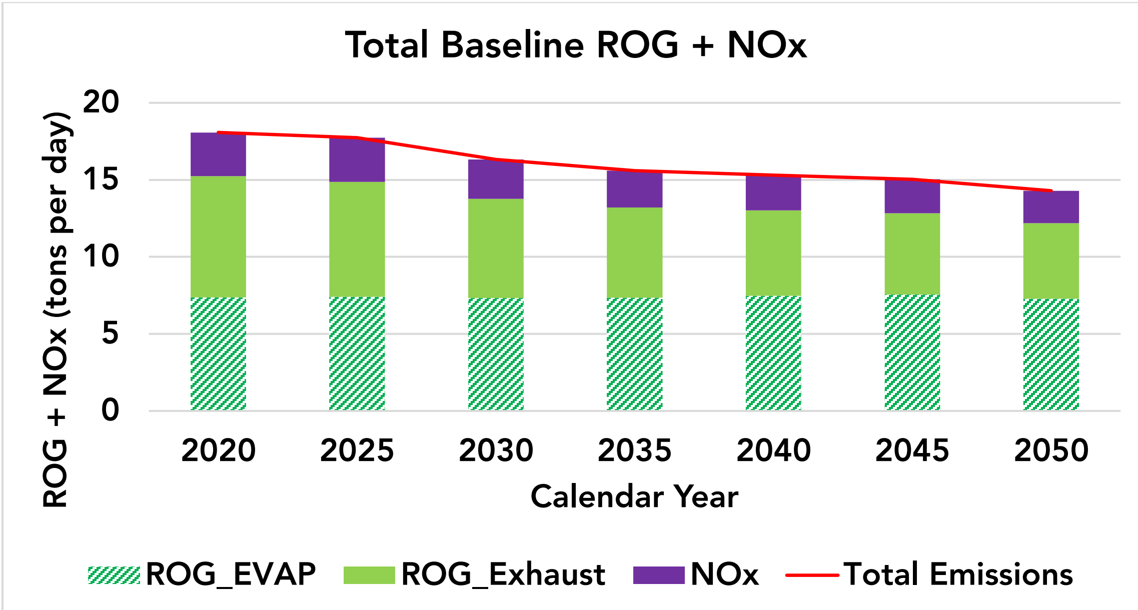
Any agency that anticipates promulgating a regulation that will have an economic impact on California business enterprises and individuals in an amount exceeding $50 million in any 12-month period between the date it is filed with the Secretary of State through 12 months after it is fully implemented (defined as major regulation) is required to prepare a Standardized Regulatory Impact Assessment (SRIA).[33] Impact is calculated by combining the absolute values of both costs and savings. The Proposal would be fully implemented in 2035. For the SRIA, the analysis time period was from 2025 to 2040. However, the analysis has been updated to reflect delayed implementation date changes beginning to reflect 2028 to 2045. After considering tax and amortization, the Proposal is estimated to result in a total impact of over $50 million to California output in from each of the years from 2031 and beyond. The estimated maximum annual direct costs are approximately $52.5 million in 2039, with offsetting operational savings that year of approximately $27.5 million. On an annual basis, direct savings (not including health benefits) overtake costs in 2043.

1.7 Baseline Information

For this analysis, the economic and emissions impacts of the Proposal are evaluated against a baseline scenario each year for the analysis period from calendar years 2028 through 2045, five years after the regulation takes full effect. The baseline reflects implementation of currently existing state and federal laws and regulations, with total baseline emissions trending down slightly from 2020-2050 as older high-emitting ONMC are gradually replaced by new models with improved emission controls. This is due to turnover of the ONMC population as vehicles built prior to the effective date of the 1998 regulations are retired from the population, along with newer technologies migrating to California due to the more stringent European motorcycle regulations. The baseline vehicle inventory includes the same vehicle sales and population growth assumptions currently reflected in CARB's EMFAC2021 emission inventory modeling with two modifications. First, CARB staff made adjustments to diurnal evaporative emissions assumptions. Second, CARB staff adjusted the assumptions on ZEM baseline sales. These new assumptions will be incorporated into the next update of EMFAC.

[33] Cal. Code Regs., Tit. 13, § 2001, et seq.

Figure 5. ONMC ROG and NOx Baseline Emissions.



1.8 Public Outreach and Input

Consistent with the Board's long-standing practice, staff have engaged in an extensive public process in development of the Proposal. Staff sought input from stakeholders through various outreach and engagement events, including public workshops, stakeholder working groups and informal meetings and phone calls. Staff conducted meetings with manufacturers and component suppliers, regulators from U.S. EPA and other jurisdictions throughout the world, environmental and health advocacy organizations, and other interested stakeholders.

CARB staff conducted three virtual public workshops and several other stakeholder meetings to discuss regulatory concepts and to solicit feedback on the data and methods used to develop cost impacts. Staff notified stakeholders of all workshops via email distribution of a public notice at least two weeks prior to their occurrence. These notices were posted to the program's website and distributed through several public list serves. The public workshops were open to all members of the public. Meeting materials, including slide presentations and draft regulatory documents were posted online. Staff solicited input on for the regulatory alternatives at the November 17, 2020, public workshop. A complete listing of previously held public outreach events appears in Table 9.

Table 15. Public Outreach for ONMC Regulation Development.

Date	Topic	Format
April 2018	ONMC Rulemaking Kick-off	Public Workshop
June 2018	Development of ONMC Emissions Test Plan	Technical Working Group
June 2018	In-Use Compliance Discussion	Technical Working Group
June 2018	ZEM Workgroup Kick-off	Technical Working Group
August 2018	OBD Technical Discussion	Technical Working Group
August 2018	Test Cycle Discussion	Technical Working Group
October 2018	CARB – Euro 5 OBD Comparison	Technical Working Group
November 2018	Review of United Nations Global Technical Regulations	Technical Working Group
December 2018	ZEM Incentives Discussion	Technical Working Group
September 2019	Feasibility of I&M Program, Tampering Reduction	Technical Working Group
November 2020	Proposed Regulatory Concepts	Virtual Public Workshop
June 2021	Proposed ZEM Program Concepts	ONMC Manufacturers Virtual Forum
January 2022	Proposed Evaporative Emissions Standards and Test Procedures	Virtual Public Workshop
June 2023	Public Workshop to Discuss Proposed On-Road Motorcycle (ONMC) Regulatory Amendments	Virtual Public Workshop
August 2023	Meeting with MIC and ONMC Manufacturers to Discuss Feedback and Proposal Changes from June 2023 Workshop	ONMC Manufacturers Virtual Forum

Starting in 2020, many meetings and public events were held virtually via webinars and videoconferences. Virtual or remote workshops and meetings are in many ways more accessible than a physical location, as they can be attended from anywhere with internet or cell service. Holding remote workshops help make events more widely available than merely involving parties who would be subject to the proposed regulations.

These informal pre-rulemaking events and discussions provided staff with important information that was considered during development of the Proposal and impact assessment. Supporting documentation for determination of economic impact will be publicly posted prior to the Board Hearing. Stakeholders provided input on various cost elements, such as battery costs, component costs, vehicle range assumptions, and vehicle design assumptions. This specific cost feedback, in addition to input from stakeholders in other forums, helped shape the data, methods, and assumptions for the impact assessment. Public input was also considered in determining regulatory alternatives for the Proposal. Staff will continue to engage stakeholders throughout the development of this regulatory proposal.

2 Benefits

Conventional ICE ONMCs emit harmful pollutants, which this proposal would help to reduce or eliminate. These pollutants include NOx and PM2.5. ROG and NOx are precursors to ozone and secondary particulate matter formation. Exposure to ozone and to fine particulate matter (PM2.5), which are inhalable particles with diameters that are generally 2.5 micrometers and smaller, is associated with increases in premature death, hospitalizations, visits to doctors, use of prescription medication, and emergency room visits due to exacerbation of chronic heart and lung diseases and other adverse health conditions. California’s South Coast air basin has the highest ozone pollution levels in the nation. The San Joaquin Valley has some of the highest levels of PM2.5 in the nation. Reducing this pollution would benefit Californians by reducing emergency room and doctor’s office visits for asthma, hospitalizations for heart diseases, and premature deaths. This in turn would result in reduced asthma-related school absences, sick days off from work, health care costs and increased economic productivity.

Section 2.1 below discusses in greater detail the emission benefits of the Proposal. Section 2.2 discusses benefits to typical businesses. Section 2.3 discusses benefits to small businesses. Finally, section 2.4 discusses benefits to individuals.

2.1 Emission Benefits

2.1.1 Inventory Methodology

The emission benefits of the Proposal for ONMCs are estimated using the latest version of CARB’s on-road vehicle emission inventory tool EMFAC2021, along with more recent ONMC emissions and population data collected and analyzed by CARB staff but not yet incorporated into the EMFAC2021 model.[34] EMFAC2021 reflects the latest planning assumptions, California-specific driving and environmental conditions, and most importantly the impact of California's unique mobile source regulations. With respect to ONMCs, EMFAC2021 is based on CARB's prior ONMC regulations, but also considers updated California Department of Motor Vehicles data through calendar year (CY) 2019. It should be noted that the current model is only capable of representing business-as-usual conditions and using the best available data. Factors such as the ongoing COVID-19 pandemic and global supply chain issues introduce both short- and long-range uncertainties in the ability of the model to accurately forecast future trends. To assess the impact of the proposed regulation from 2028 through 2045, EMFAC2021 output was customized with the most current data and control technology emissions factors generated from staff and industry input.

An important simplifying assumption used through the rest of this economic analysis is the assumption that MY and CY year coincide for the purpose of determining cost. Often a MY is made available prior to the CY for which its name coincides. For example, a 2020 MY may have initial sales in the 2019 CY with continuing sales into the 2020 CY and potentially onward. Because this is not consistent or predictable between manufacturers, it is assumed for simplicity that MY and CY are the same for economic calculations.

2.1.2Modeling the Baseline

The baseline reflects implementation of currently existing state and federal laws and regulations, with total baseline emissions trending down slightly from 2020-2050 as older high-emitting ONMC are gradually replaced by new models with improved emission controls. This is due to turnover of the ONMC population as vehicles built prior to the effective date of the 1998 regulations are retired from the population, along with newer technologies migrating to California due to the more stringent European motorcycle regulations. The baseline vehicle inventory includes the same vehicle sales and population growth assumptions currently reflected in CARB's EMFAC2021 emission inventory modeling with two modifications. First, CARB staff adjusted diurnal evaporative emissions assumptions. Second, CARB staff adjusted the assumptions on ZEM baseline sales. These new assumptions will be incorporated into the next update of EMFAC.

To assess the impact of the Proposal, it was necessary to look at the different ONMC engine displacement categories to understand when or if each vehicle category is impacted by the various elements of the Proposal. Although EMFAC2021 includes a total statewide population number for ONMCs, it is not disaggregated into displacement categories. This required staff to estimate the proportion of Class IA, IB, II and III conventional ONMCs and the proportions of ZEMs that are Tier I, II and III within the baseline population. These category definitions can be found in Table 6 and Table 10 introduced earlier. Further, EMFAC2021 does not currently identify the ZEMs in the population. Although the current

[34] EMFAC2021 is CARB's latest version of its emission inventory modeling tool.

ZEM population is relatively small, it is important for establishing baseline growth of this category.

To model the proportions of each motorcycle class, staff relied on the Motorcycle Statistical Annual 2020[35] produced by the Motorcycle Industry Council (MIC). The proportion of the population that is Class IA is also very difficult to establish but is estimated by staff to be very small. For this, staff assumed it was 1.8 percent and apportioned it from the smaller ONMCs in the MIC data. Staff's estimated breakdown of California's current ONMC population by Class is shown in Table 16.

Table 16. Estimated Baseline Size Categorization Percentages of ICE ONMCs.

Size Category	Class IA	Class IB	Class II	Class III
% of Baseline ICE ONMCs	1.8%	4.5%	2.7%	91.1%

Conventional ICE ONMCs are categorized by displacement, which does not match the criteria selected to define the three ZEM categories. This made it difficult for staff to align the existing ICE categories with ZEM categories for the purpose of initial estimates of baseline. Based upon the top speed constraints of the ZEM categories, it was assumed Tier I aligns with Class IA, Tier II aligns with Class IB and Class II, and Tier III aligns with Class III. From that, staff estimated the baseline proportions of the ZEM population in Table 17.

Table 17. Estimated Baseline Size Categorization Percentages of ZEMs.

Size Category	Tier I	Tier II	Tier III
% of Baseline ZEMs	1.76%	7.17%	91.07%

To determine the baseline population of ZEMs and annual ZEM sales, staff analyzed the California DMV registration database as current through CY 2021. From this, staff determined a baseline of ZEM population of 2,051 units and baseline sales of 423 units in CY 2020 from which to model forward.

The EMFAC2021 model estimates population growth forward to the target analysis date of 2045 at a long-term annual growth rate of approximately 2 percent. However, it again does not currently disaggregate that baseline projected growth by category of ONMC. Staff assumes that the proportions of ICE ONMC classes will be constant as given in Table 16. However, due to the newness of the ZEM market, the ZEM population growth is dynamic and thus must be analyzed to better project baseline growth.

Staff used California DMV registration data to analyze annual statewide ZEM sales from 2014 through 2020 and determined an average annual growth of 22 percent from Table 18.

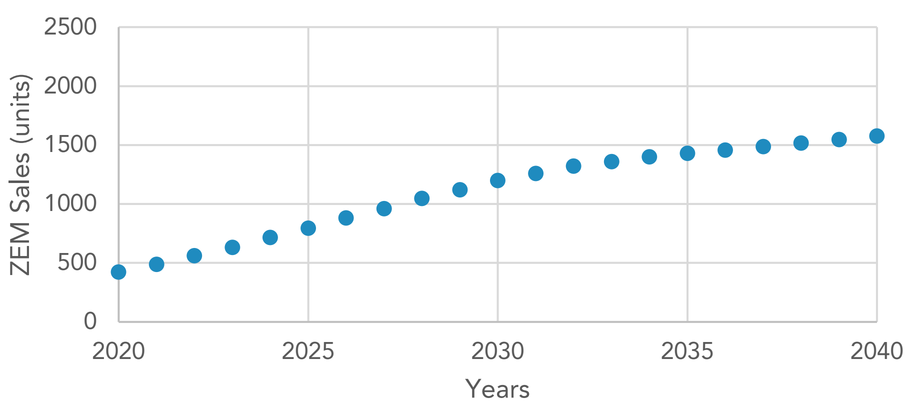
[35] MIC. 2020 Motorcycle Statistical Annual.

Table 18. Annual Percent Sales Growth of California ZEM Sales.

CY	2014	2015	2016	2017	2018	2019	2020
California ZEM Sales	138	170	269	243	307	373	423
% Δ	N/A	23.2%	58.2%	-9.7%	26.3%	21.5%	13.4%

With many varying incentives and statutory requirements going forward in the broader ZEV market, it is difficult to predict the exact growth rate going forward, although it appears reasonably certain there will be growth. Based upon this, Staff estimated baseline ZEM sales growth would increase at an annual rate of 15 percent from CY 2020 and drops approximately 2 percent in two-year increments thereafter until it hit the 2 percent baseline EMFAC2021 assumed growth in 2034. For example, in 2022 it would be 13 percent, in 2024 it would be 11 percent, etc. These assumptions result in estimated annual statewide ZEM baseline sales growth shown in Figure 6. Staff assume that baseline ZEM growth continue to disaggregate by ZEM category per Table 17.

Figure 6. ZEM Baseline Sales Growth Per Calendar Year.



CARB staff projections of baseline sales for ZEM and ICE ONMCs are plotted together for relative scale in Table 19.

Table 19. ZEM and ICE Baseline Sales Projections.

CY	ZEM		ICE	
	Units	%	Units	%
2020	423	0.9%	47,614	99.1%
2021	486	1.3%	36,921	98.7%
2022	559	1.3%	43,843	98.7%
2023	632	1.2%	50,482	98.8%
2024	714	1.4%	50,111	98.6%
2025	793	1.6%	50,072	98.4%
2026	880	1.7%	50,274	98.3%

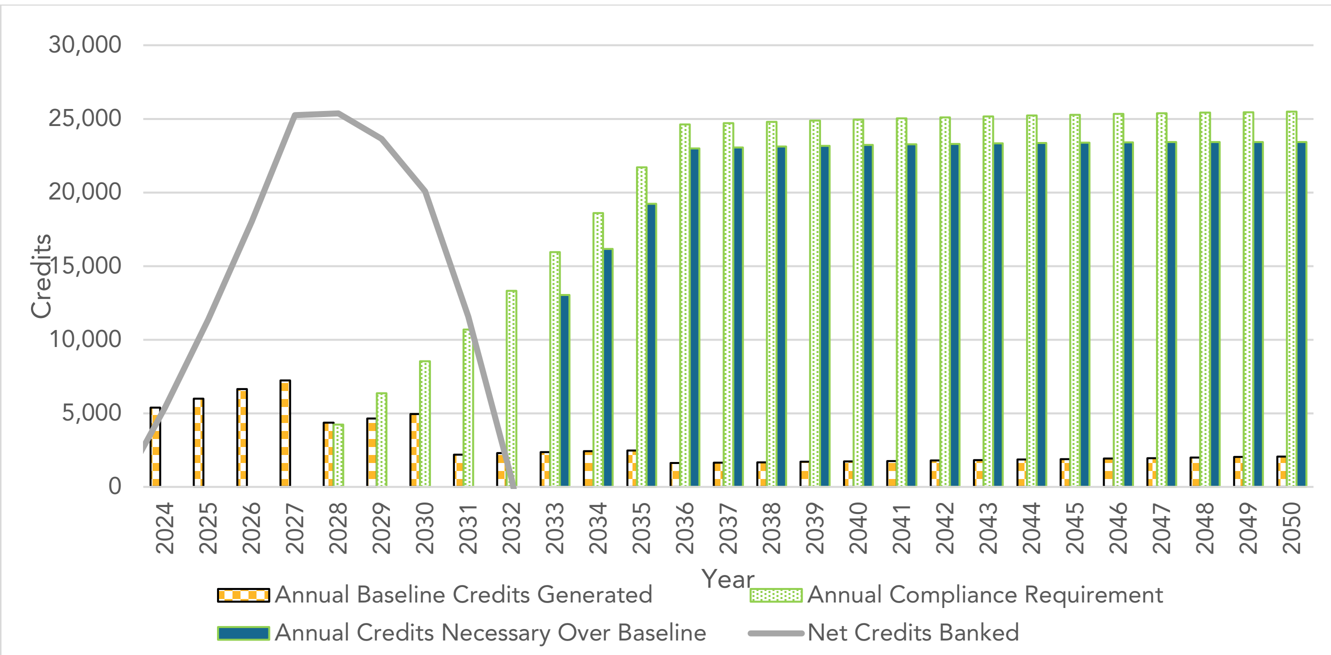
CY	ZEM		ICE	
	Units	%	Units	%
2027	959	1.9%	50,474	98.1%
2028	1,046	2.0%	50,660	98.0%
2029	1,119	2.2%	50,851	97.8%
2030	1,197	2.3%	51,029	97.7%
2031	1,257	2.4%	51,218	97.6%
2032	1,320	2.5%	51,395	97.5%
2033	1,359	2.6%	51,590	97.4%
2034	1,400	2.6%	51,775	97.4%
2035	1,428	2.7%	51,964	97.3%
2036	1,457	2.7%	52,145	97.3%
2037	1,486	2.8%	52,315	97.2%
2038	1,516	2.8%	52,476	97.2%
2039	1,546	2.9%	52,626	97.1%
2040	1,577	2.9%	52,766	97.1%
2041	1,608	3.0%	52,895	97.0%
2042	1,641	3.0%	53,014	97.0%
2043	1,673	3.1%	53,123	96.9%
2044	1,707	3.1%	53,221	96.9%
2045	1,741	3.2%	53,308	96.8%
Totals	31,526	2.3%	1,318,162	97.7%

The emissions baseline is illustrated in Figure 5.

2.1.3Modeling the Proposal

Modeling the emission benefits of the Proposal is highly dependent upon the assumptions made regarding how ZEM credits will be generated and when the costs and benefits associated with ZEM sales are attributable to the Proposal or just normal (baseline) ZEM market growth that would occur naturally in the absence of the Proposal. From the Proposal (see section Background, Specific Proposal Requirements) manufacturers will not be required to surrender ZEM credits prior to MY 2028. However, beginning with MY 2024, manufacturers may begin generating credits per the formula, which will allow a bank of tradeable credits to be built up prior to compliance requirements in MY 2028. It is assumed that manufacturers will register this baseline growth in ZEM sales for credits. In Figure 7 these baseline ZEM credits are reflected by the orange bars. Credit expiration dates assigned MY 2028 and thereafter will help to avoid any significant issues with unforeseen early large accumulations of credits. As a simplifying modeling assumption, staff assumes that manufacturers will not generate ZEMs beyond normal baseline growth until the excess of ZEM credits banked from baseline ZEM sales growth is exhausted. From that point, Staff makes the further simplifying assumption that just enough ZEMs will be built over baseline to satisfy compliance with the regulation. Staff further assumes that all ZEM sales population growth, whether due to baseline ZEM sales or the Proposal, will displace conventional ICE ONMC sales predicted by EMFAC2021. Through these assumptions, staff estimates that the ONMC industry will have sufficient banked credits accumulated such that they will not have to generate additional credits from Tier II and III ZEM sales until MY 2033 to comply, except they will have to build ZEM Tier I replacements to ICE Class IA motorcycles starting in MY 2028 as shown in Figure 7. The Proposal is intended to ensure sufficient time for industry to smoothly transition to meeting their required ZEM sales targets.

Figure 7. Estimated ZEM Credit Generation and Banking Over Time.



These assumptions lead to the following estimated sales counts for ZEM and ICE ONMCs over time as shown in Table 20.

Table 20. Projected Unit Sales of ZEM and ICE ONMCs.

CY	Baseline ZEM Sales (units)	ZEM Sales Required Over Baseline (units)	Total ICE ONMC Sales (units)	Improved ICE ONMC Sales (subset of Total ICE) (units)	Total ONMC Sales (units)
2020	423	0	47,614	0	48,037
2021	486	0	36,921	0	37,408
2022	559	0	43,843	0	44,402
2023	632	0	50,482	0	51,114
2024	714	0	50,111	0	50,825
2025	793	0	50,072	0	50,865
2026	880	0	50,274	0	51,154

CY	Baseline ZEM Sales (units)	ZEM Sales Required Over Baseline (units)	Total ICE ONMC Sales (units)	Improved ICE ONMC Sales (subset of Total ICE) (units)	Total ONMC Sales (units)
2027	959	0	50,474	0	51,433
2028	1,046	891	49,769	14,676	66,381
2029	1,119	894	49,957	29,462	81,432
2030	1,197	898	50,131	49,276	101,502
2031	1,257	901	50,317	49,459	101,934
2032	1,320	904	50,491	49,629	102,345
2033	1,359	7,600	43,989	43,239	96,188
2034	1,400	8,976	42,798	42,068	95,242
2035	1,428	10,194	41,769	41,056	94,449
2036	1,457	24,785	27,360	26,893	80,494
2037	1,486	24,853	27,462	26,993	80,794
2038	1,516	24,917	27,559	27,089	81,081
2039	1,546	24,975	27,651	27,179	81,352
2040	1,577	25,028	27,739	27,265	81,608
2041	1,608	25,075	27,821	27,346	81,850
2042	1,641	25,116	27,898	27,421	82,076
2043	1,673	25,153	27,970	27,492	82,289
2044	1,707	25,184	28,037	27,559	82,487
2045	1,741	25,209	28,099	27,619	82,668
Totals	31,526	281,554	1,036,608	591,721	1,941,410

2.1.4Anticipated Emission Benefits

The projected emission benefits of the Proposal are evaluated for the assumptions described earlier in this chapter. The emissions benefits are equivalent to emissions reductions resulting from the proposed regulatory concepts relative to the "Business-As-Usual" (BAU). Baseline assumptions are given in 2.1.1 and Proposal assumptions are given in section 2.1.2. Table 21 shows the estimated annual reductions in short tons per day of NOx, ROG, CO, PM2.5, and GHG emission benefits resulting from the proposed regulatory scenario for ONMCs in California.

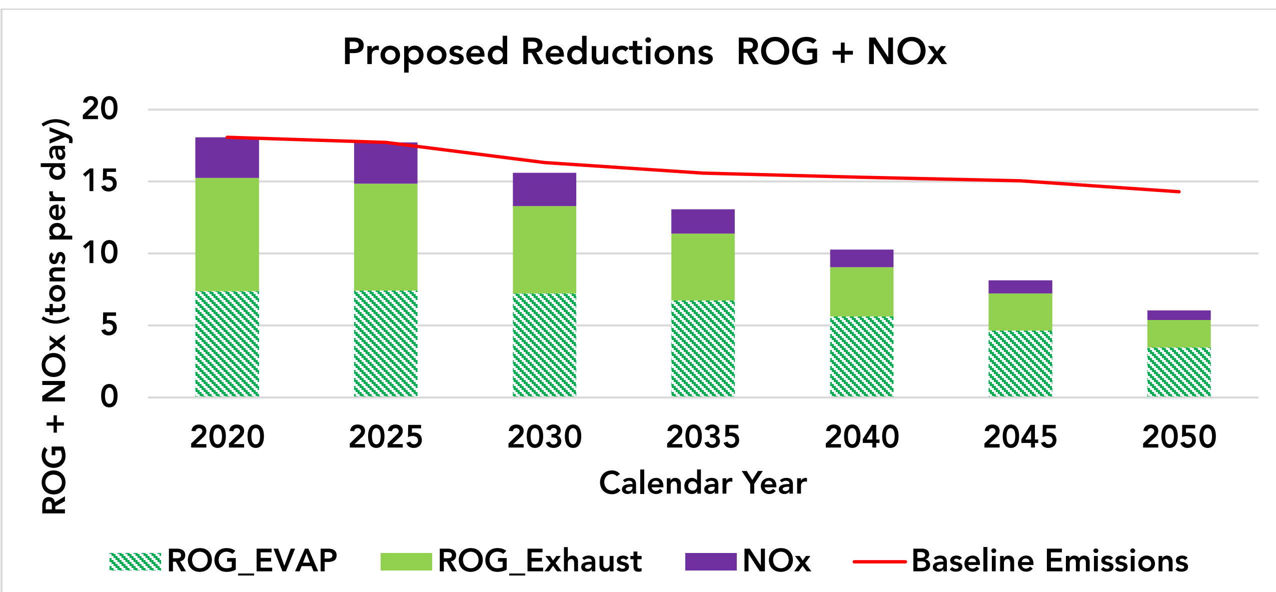
Table 21. Statewide Emissions Reduction Rates by Year.

CY	NOx (tpd)	ROG Exhaust (tpd)	ROG Evap (tpd)	CO (tpd)	PM2.5 (tpd)	GHG (MMT/yr)
2028	0.05	0.07	0.02	1.1	0.0	0.0000
2029	0.13	0.19	0.05	3.1	0.0	0.0000
2030	0.25	0.38	0.09	6.4	0.0	0.0000
2031	0.36	0.55	0.14	9.5	0.0	0.0000
2032	0.45	0.70	0.19	12.2	0.0	0.0000

2033	0.54	0.88	0.32	14.9	0.0	0.0001
2034	0.62	1.04	0.46	17.3	0.0	0.0035
2035	0.69	1.20	0.62	19.4	0.0	0.0074
2036	0.78	1.42	0.89	21.8	0.0	0.0187
2037	0.86	1.61	1.15	24.0	0.0	0.0293
2038	0.94	1.79	1.40	26.0	0.0	0.0390
2039	1.01	1.96	1.64	27.8	0.0	0.0478
2040	1.07	2.11	1.87	29.5	0.0	0.0559
2041	1.12	2.24	2.09	31.1	0.0	0.0633
2042	1.18	2.37	2.30	32.5	0.0	0.0700
2043	1.22	2.49	2.51	33.8	0.0	0.0762
2044	1.26	2.60	2.71	35.0	0.0	0.0818
2045	1.30	2.69	2.91	36.1	0.0	0.0870

The annualized statewide reductions of ROG + NOx relative to baseline over time are shown graphically in Figure 8.

Figure 8. ROG and NOx Emissions Reductions from Baseline.



The cumulative total emissions reductions from 2028 to 2045 ONMCs are estimated in Table 22 to be 16,536 tons of ROG, 4,805 tons of NOx, 132,351 tons of CO, and 28 tons of PM2.5 relative to the baseline.

Table 22. Annual Statewide Emissions Reductions.

CY	NOx (tons)	ROG Exhaust (tons)	ROG Evap (tons)	CO (tons)	PM2.5 (tons)	GHG (MMT)
2028	16	24	7	373	0.0	0.00
2029	44	66	17	1,088	0.0	0.00
2030	88	131	32	2,210	0.0	0.00
2031	126	191	48	3,288	0.0	0.00
2032	158	245	67	4,251	0.0	0.00
2033	188	305	110	5,164	0.2	0.00
2034	216	362	159	5,989	0.4	0.00
2035	241	417	215	6,744	0.6	0.01
2036	272	491	310	7,564	1.0	0.02
2037	300	559	401	8,315	1.5	0.03
2038	326	621	487	9,020	1.9	0.04
2039	349	678	569	9,660	2.3	0.05
2040	371	731	648	10,249	2.6	0.06
2041	390	779	724	10,783	3.0	0.06
2042	408	823	798	11,277	3.3	0.07
2043	424	864	871	11,728	3.6	0.08
2044	438	901	942	12,138	3.9	0.08
2045	451	933	1,010	12,511	4.1	0.09
Total	4,805	9,121	7,416	132,351	28.4	0.58

GHG benefits are expressed as million metric tons of carbon dioxide equivalent per year (MMTCO2e/yr). The GHG benefits presented in this table are solely vehicle fuel tank-to-wheel (TTW) meaning upstream emission reductions are not included. Staff expects the Proposal to reduce cumulative CO2 emissions by an estimated 0.58 MMT relative to the baseline from 2028 to 2045.

2.2 Benefits to Typical Businesses

Typical businesses that may directly benefit from the Proposal are ZEM manufacturers. ZEM and ICE ONMC component suppliers, ZEM service providers, electric utility providers, and electric charging infrastructure providers, may indirectly benefit.

2.2.1Zero-Emission Motorcycle-only Manufacturers

Currently there is only one ZEM manufacturer capable of producing over 100 ZEM a year located in California. This could easily change in future years due to the dynamic nature of this growing industry. The Proposal will create a higher demand for ZEMs, so these businesses in California would likely increase, leading to increases in manufacturing and related jobs with manufacturers that specifically produce ZEMs. ZEM-only manufacturers (and ONMC manufacturers that also build more ZEMs than necessary for compliance) benefit from generating additional ZEM credits through their selling of credits to other manufacturers. While the value of these credits is uncertain, it is likely that the proposed increase in ZEM requirements over time will result in an increase in market value of these tradable credits over time. ZEMs credits will likely be less than the cost of compliance for the manufacturer who does not want to build sufficient ZEMs to meet the Proposal.

2.2.2Zero-Emission Motorcycle and Internal Combustion Engine On-Road Motorcycle Component Suppliers

Component suppliers supply parts directly to ICE and zero-emission ONMC manufacturers. They provide engine components and systems like cylinder deactivation technology, engine management software, emission control systems, batteries, and motors. These businesses would benefit from increased opportunities created by the need to develop, sell, and support technology to decrease emissions from ICE ONMCs and ZEMs. Many of these companies are also changing their business models to include components for ONMC electrification, as demand for conventional ONMC components is projected to decline.

2.2.3Electric Utility Providers

The Proposal will increase the total amount of electric vehicle miles traveled in the state, which in turn will increase the demand for electricity and the amount of electricity used. Electricity infrastructure needed to charge all types of electric ZEVs represents the single largest growth area for electric utility companies as traditional areas of growth have been dampened by energy conservation efforts.

2.2.4Zero-Emission Vehicle Infrastructure Providers and Installers

The Proposal will require ZEM manufacturers seeking ZEM credits to use the SAE J1772[36] plug standards called for in CARBs LDV ZEV standards. Therefore, it is assumed that existing infrastructure built to satisfy the needs of other categories of ZEVs will be sufficient to meet the needs of ZEMs in this proposal, so staff is not claiming a specific benefit within the proposal. However, there will be some additional demand for ZEV infrastructure businesses due to ZEM electricity needs. This includes companies that manufacturer, install, operate, and maintain EV charging stations and equipment. Electric Vehicle Supply Equipment (EVSE) providers will benefit from increased demand for their equipment with home and public fueling stations. The Proposal will increase the total amount of zero emission miles travelled in the state, which in turn could increase utilization of charging stations across the state and lead to increased revenue for these businesses, making the business model for their investment more stable and predictable. This allows investor capital and venture capital funds to be accessed for increased deployment rates of ZEV infrastructure. Increased

[36] Society of Automotive Engineers (SAE) International J1772_201710, SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler, Revised 2017-10-13.

use of public charging stations may also have benefits to retail businesses near charging stations. Many charging stations are in areas with available shopping, food, or other services such as dry cleaning. Additionally, California businesses that are contracted to install stations will benefit from the rapidly growing network.

2.3 Benefits to Small Businesses

It is important to note that under the Proposal only motorcycle manufacturers are directly regulated and thereby have direct compliance costs. None of these manufacturers is classified as a small business. Because small businesses employing motorcycles are hard to quantify and are assumed to own only small numbers of motorcycles, it is assumed their benefits are captured as individual consumers in the form of health benefits, lower maintenance and fuel costs and eventually lower vehicle costs.

The Proposal may provide some small benefit to manufacturers and distributors of small electronics used in ZEM drivetrains and control system, as these components will be used increasingly in lieu of ICE components, but this is difficult to quantify. Some small businesses employing ZEMs for delivery and transport would experience increased vehicle prices in the early years of the regulation along with offsetting decreased maintenance and fuel savings over the life of the vehicle. Because it is hard to quantify businesses that specifically rely on motorcycles in their business plans these costs and savings are captured under direct costs to businesses as discussed in Section 3.2.

2.4 Benefits to Individuals

The Proposal would benefit California residents mainly from the reductions in ROG and NOx resulting in reduced ozone exposure and reduced PM exposure from the secondary formation of NOx to PM2.5, and from improvements in California air quality and reduced adverse health impacts. The modest reduction of GHG emissions, while being a global pollutant, will also benefit California residents monetarily by reducing carbon emissions in the future, represented later in this analysis as the social cost of carbon.

2.4.1 Health Benefits

The proposed regulation for on-road motorcycles would reduce NOx and $PM_{2.5}$ emissions, resulting in health benefits in California. CARB analyzed the value of health benefits associated with 12 health outcomes, most of which were added or updated through CARB's recent expansion of the health analysis[37]: cardiopulmonary mortality, acute myocardial infarction, lung cancer incidence, asthma onset, asthma symptoms, hospitalizations for

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[37] CARB, California Air Resources Board Updated Health Endpoints Bulletin. (https://ww2.arb.ca.gov/sites/default/files/2022-11/California%20Air%20Resources%20Board%20Updated%20Health%20Endpoints%20Bulletin%20-%20Edited%20Nov%202022_0.pdf. Accessed April 4, 2023)

cardiovascular illness, hospitalizations for respiratory illness, hospitalizations for Alzheimer's disease, hospitalizations for Parkinson's disease, cardiovascular emergency department (ED) visits, respiratory ED visits, and work loss days.

These health outcomes have been identified by U.S. EPA as having a causal or likely causal relationship with exposure to $PM_{2.5}$ based on a substantial body of scientific evidence.[38,39] U.S. EPA has determined that both long-term and short-term exposure to $PM_{2.5}$ plays a causal role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between $PM_{2.5}$ exposure and increased risk of death. This relationship persists when other risk factors such as smoking rates, poverty, and other factors are taken into account. U.S. EPA has also determined a causal relationship between non-mortality cardiovascular effects (e.g., acute myocardial infarction) and short- and long-term exposure to $PM_{2.5}$, a likely causal relationship between non-mortality respiratory effects (including worsening asthma) and short- and long-term $PM_{2.5}$ exposure, and a likely causal relationship between non-mortality neurological effects and long-term $PM_{2.5}$ exposure.[40]

CARB staff evaluated health impacts associated with exposure to $PM_{2.5}$ and NOx emissions from the proposed regulation. NOx includes nitrogen dioxide, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled.[41] However, the most serious quantifiable impacts of NOx emissions occur through the conversion of NOx to fine particles of ammonium nitrate aerosols through chemical processes in the atmosphere. $PM_{2.5}$ formed in this manner is termed secondary $PM_{2.5}$. Both directly emitted $PM_{2.5}$ and secondary $PM_{2.5}$ are associated with adverse health outcomes**.** As a result, reductions in $PM_{2.5}$ and NOx emissions are associated with reductions in these adverse health outcomes.

2.4.1.1 Incidence-Per-Ton Methodology

CARB uses the incidence-per-ton (IPT) methodology to quantify the health benefits of emissions reductions in cases where dispersion modeling results are not available. A

[38] U.S. Environmental Protection Agency (U.S. EPA). Integrated Science Assessment for Particulate Matter (Issue EPA/600/R-19/188). December 2019.

[39] U.S. Environmental Protection Agency (U.S. EPA). Technical Support Document (TSD) for the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS, March 2021.

[40] U.S. EPA, Assessment for Particulate Matter, 2019.

[41] U.S. Environmental Protection Agency (U.S. EPA). Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-15/068, January 2016.

description of this method is included on CARB's webpage.[42] CARB's IPT methodology is based on a methodology developed by U.S. EPA.[43,44,45]

Under the IPT methodology, it is assumed that changes in emissions are approximately proportional to changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to $PM_{2.5}$ for a baseline scenario using measured ambient concentrations and dividing by the emissions of $PM_{2.5}$ or a precursor. The calculation is performed separately for each air basin using the following equation:

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

Multiplying the emissions reductions from the proposed regulation in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the proposed regulation. For future years, the number of outcomes is adjusted to account for population growth. CARB's current IPT factors are based on a 2014-2016 baseline scenario, which represents the most recent data available at the time the current IPT factors were computed. IPT factors are computed for the two types of $PM_{2.5}$: primary $PM_{2.5}$ and secondary $PM_{2.5}$ of ammonium nitrate aerosol formed from precursors.

2.4.1.2 Updated Information on Health Impact Analysis

CARB recently initiated an expanded health analysis to include additional health endpoints in order to provide a more comprehensive analysis of the benefits of the agency's plans and regulations. A description of the updated and new health outcomes was provided in CARB's Updated Health Endpoints Bulletin, released November 2022.[46] This expansion was based on U.S. EPA's Technical Support Document (TSD) for the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS and is associated with U.S. EPA's Environmental Benefit Mapping and Analysis Program – Community Edition (BenMAP-CE) version 1.5.8.[47]

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[42] CARB, CARB's Methodology for Estimating the Health Effects of Air Pollution. Retrieved February 9, 2021.

[43] 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.

[44] 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.

[45] 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.

[46] CARB Updated Health Endpoints Bulletin.

[47] U.S. Environmental Protection Agency (U.S. EPA). Technical Support Document (TSD) for the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS: Estimating PM2.5- and Ozone-Attributable Health Benefits (EPA-HQ-OAR-2020-0272). March 2021.

To derive the IPT factors for each of the health endpoints, the number of health outcomes associated with exposure to $PM_{2.5}$ were calculated by inputting PM2.5 concentrations from air monitoring data into U.S. EPA's BenMAP-CE version 1.5.8.4 (released April 16, 2021). The baseline incidence datasets embedded in the BenMAP-CE software were used; the incidence data for mortality, hospital admissions (including myocardial infarctions), and emergency department visits were at the county-level, while the incidence data for work loss days was provided at the national rate in the software.[48]

For most of the health endpoints, the U.S. EPA had identified one effect estimate derived from one study to be used in the respective health impact function. However, for myocardial infarction and respiratory ED visits, the U.S. EPA had identified multiple effect estimates; thus, EPA's health impact functions for these two endpoints were estimated using pooling methods. Pooling combines multiple risk estimates to determine a summary mean value estimate and associated confidence intervals.[49] For the myocardial infarction endpoint, the results were pooled from four different epidemiological studies using the random or fixed effects pooling and sum dependent pooling methods, as specified in the configuration file that U.S. EPA uses for PM quantification. For respiratory ED visits, the results were pooled from analyses across four different locations in the U.S. done in one study; this pooling using the random or fixed effects method, also as specified in U.S. EPA's configuration file.

2.4.1.3 Reduction in Adverse Health Impacts

CARB Staff estimates that the total number of cases statewide that would be reduced (from 2020 to 2045) from implementation of the proposed regulation are as summarized in below in Table 23.

Table 23. Statewide Avoided Mortality and Morbidity Incidents from 2028 to 2045 Under the Proposal.

Health Endpoint	Number of Cases Avoided*
Cardiopulmonary Mortality	42 (24 - 60)
Hospitalizations for Cardiovascular Illness	9 (6 - 11)
Cardiovascular Ed Visits	11 (-4 - 26)
Acute Myocardial Infarction, Nonfatal	5 (2 - 13)
Hospitalizations for Respiratory Illness	1 (0 - 3)
Respiratory ED Visits	25 (5 - 52)
Lung Cancer Incidence	3 (1 - 5)
Asthma Onset	94 (91 - 98)
Asthma Symptoms	8280 (-4048 - 20045)

[48] U.S. Environmental Protection Agency (U.S. EPA). Environmental Benefits Mapping and Analysis Program - Community Edition: User's Manual. March 2023.
[49] U.S. EPA, TSD EPA-HQ-OAR-2020-0272, 2021.

Work Loss Days	6134 (5176 - 7055)
Alzheimer's Disease	19 (15 - 22)
Parkinson's Disease	3 (2 - 4)

* Numbers in parentheses throughout this table represent the 95 percent CI.

These reductions in adverse health cases are expected to be seen across all ages in the state. Children in particular will benefit from the reduced cases of asthma onset and symptoms due to the Proposed Regulation. This may lead to better health outcomes in these children when they become adults since studies have shown that childhood asthma puts individuals at greater risk for respiratory disease and lower respiratory function in adulthood.[50,51] Adults are also expected to benefit from the Proposed Regulation due to fewer hospitalizations and illnesses, lost workdays, nonfatal acute myocardial infarctions (heart attacks), lung cancer incidences, and cardiopulmonary mortality. Seniors may benefit from reduced cases of hospitalizations for not just cardiovascular and respiratory diseases, but also neurological conditions (Alzheimer’s and Parkinson’s diseases). And there will be fewer ED visits for both cardiovascular and respiratory diseases across all ages in the population.

Table 24 shows the air basin distribution of avoided health endpoints for the proposed regulation relative to the baseline.

[50] Sears MR, Greene JM, Willan AR, Wiecek EM, Taylor DR, Flannery EM, Cowan JO, Herbison GP, Silva PA, Poulton R. A longitudinal, population-based, cohort study of childhood asthma followed to adulthood. N Engl J Med. 2003 Oct 9;349(15):1414-22. doi: 10.1056/NEJMoa022363. PMID: 14534334.

[51] McGeachie MJ, Yates KP, Zhou X, Guo F, Sternberg AL, Van Natta ML, Wise RA, Szefler SJ, Sharma S, Kho AT, Cho MH, Croteau-Chonka DC, Castaldi PJ, Jain G, Sanyal A, Zhan Y, Lajoie BR, Dekker J, Stamatoyannopoulos J, Covar RA, Zeiger RS, Adkinson NF, Williams PV, Kelly HW, Grasemann H, Vonk JM, Koppelman GH, Postma DS, Raby BA, Houston I, Lu Q, Fuhlbrigge AL, Tantisira KG, Silverman EK, Tonascia J, Weiss ST, Strunk RC. Patterns of Growth and Decline in Lung Function in Persistent Childhood Asthma. N Engl J Med. 2016 May 12;374(19):1842-1852. doi: 10.1056/NEJMoa1513737. PMID: 27168434; PMCID: PMC5032024.

Table 24. Avoided Mortality and Morbidity Incidents from 2020 to 2045 under the Proposed Regulation. *

Air Basin	Cardiopulmonary mortality	Hospitalizations for cardiovascular illness	Cardiovascular ED Visits	Acute Myocardial Infarction, Nonfatal	Hospitalizations for respiratory illness	Hospitalizations (Cardiovascular and Respiratory)	Respiratory ED Visits	Lung Cancer Incidence	Asthma Onset	Asthma Symptoms	Work Loss Days	Alzheimer's Disease	Parkinson's Disease
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	1 (-1 - 4)	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	9 (-4 - 22)	5 (4 - 6)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	1 (-1 - 3)	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	1 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 1)	0 (0 - 0)	1 (1 - 1)	87 (-43 - 212)	63 (53 - 73)	0 (0 - 0)	0 (0 - 0)
Mountain Counties	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	1 (1 - 1)	58 (-28 - 141)	46 (39 - 53)	0 (0 - 0)	0 (0 - 0)
North Central Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	1 (1 - 1)	78 (-38 - 188)	54 (46 - 62)	0 (0 - 0)	0 (0 - 0)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	13 (-6 - 30)	9 (8 - 10)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	4 (-2 - 9)	2 (2 - 3)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	2 (1 - 3)	0 (0 - 0)	0 (0 - 1)	0 (0 - 1)	0 (0 - 0)	0 (0 - 1)	1 (0 - 2)	0 (0 - 0)	4 (4 - 4)	324 (-158 - 786)	267 (225 - 307)	0 (0 - 1)	0 (0 - 0)
Salton Sea	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	1 (0 - 1)	45 (-22 - 110)	35 (30 - 41)	0 (0 - 0)	0 (0 - 0)
San Diego County	2 (1 - 2)	0 (0 - 1)	0 (0 - 1)	0 (0 - 1)	0 (0 - 0)	1 (0 - 1)	1 (0 - 2)	0 (0 - 0)	4 (4 - 4)	338 (-165 - 820)	287 (242 - 330)	1 (1 - 2)	0 (0 - 0)
San Francisco Bay	4 (2 - 5)	1 (1 - 1)	1 (0 - 2)	0 (0 - 1)	0 (0 - 0)	1 (1 - 1)	3 (1 - 5)	0 (0 - 1)	12 (11 - 12)	1012 (-494 - 2457)	702 (592 - 808)	2 (1 - 2)	0 (0 - 0)
San Joaquin Valley	6 (3 - 8)	1 (1 - 1)	1 (-1 - 3)	1 (0 - 2)	0 (0 - 0)	1 (1 - 2)	4 (1 - 8)	0 (0 - 1)	10 (10 - 11)	957 (-469 - 2314)	741 (625 - 852)	2 (2 - 3)	0 (0 - 0)
South Central Coast	1 (1 - 2)	0 (0 - 0)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)	1 (0 - 1)	0 (0 - 0)	3 (3 - 3)	269 (-131 - 650)	181 (153 - 208)	0 (0 - 1)	0 (0 - 0)

South Coast	27 (15 - 38)	6 (4 - 7)	7 (-3 - 17)	3 (1 - 8)	1 (0 - 2)	7 (4 - 9)	15 (3 - 32)	2 (1 - 3)	58 (56 - 60)	5084 (-2487 - 12300)	3739 (3155 - 4299)	12 (10 - 14)	2 (1 - 2)
Statewide	42 (24 - 60)	9 (6 - 11)	11 (-4 - 26)	5 (2 - 13)	1 (0 - 3)	10 (7 - 14)	25 (5 - 52)	3 (1 - 5)	94 (91 - 98)	8280 (-4048 - 20045)	6134 (5176 - 7055)	19 (15 - 22)	3 (2 - 4)

* Numbers in parentheses throughout this table represent the 95 percent confidence intervals (CI).

2.4.1.4 Uncertainties Associated with the Mortality and Illness Analysis

Although the estimated health outcomes presented in this report are based on a well-established methodology, they are subject to uncertainty. Uncertainty is reflected in the 95% confidence intervals included with the central estimates in Table 24. These confidence intervals take into account uncertainties in translating air quality changes into health outcomes.

Other sources of uncertainty include the following:

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

2.4.1.5 Potential Future Evaluation of Additional Health Benefits

CARB has initiated expanded health analysis to include additional health outcomes to provide a more comprehensive review of the health impacts of PM2.5 exposure for this regulation and upcoming regulations.[52] However, note that the current PM2.5 mortality and morbidity evaluation conducted by CARB staff still focuses on select air pollutants and only captures a portion of the health benefits of the proposed regulation. Further updates to the methodology may be made in the future to quantify additional benefits of reducing air pollution, such as by including additional pollutants and health outcomes. For instance, the current analysis considers the impact of NOx on the formation of secondary PM2.5 particles, but only includes a portion of the secondary PM2.5 particles. In addition, NOx can also react with other compounds to form ozone, which can cause respiratory problems. Ozone impacts are not included in this analysis. Also, CARB will continue to evaluate approaches to provide both quantitative and qualitative information on health outcomes based on the best available science, such as through current literature reviews and CARB funded research contracts. More information on CARB's research contracts can be found on CARB's online research page (*https://ww2.arb.ca.gov/our-work/programs/research-planning/research-division-contracts*).

2.4.1.6 Monetization of Health Impacts

The reductions in adverse health impacts described above can be assigned monetary values so the health benefits can be directly compared to other costs and savings associated

[52] CARB, Methodology for Estimating the Health Effects, 2021.

with the Proposal. These values are derived from economics studies and are based on the expenses that an individual must bear for air pollution related health impacts such as medical bills and lost work, or willingness to pay metrics, which in addition to capturing the direct expenses of the health outcomes also capture the value that individuals place on pain and suffering, loss of satisfaction, and leisure time.

2.4.1.6.1 **Methodology**

Health outcomes are monetized by multiplying each incident by a value per incident that is consistent with the IPT method described above, using the standard economic studies and data as provided in U.S. EPA's Environmental Benefit Mapping and Analysis Program – Community Edition (BenMAP-CE).[53,54] The value per incident is derived from BenMAP-CE using the results for the total status-quo PM-related incidence for each health endpoint used to derive the IPT and dividing them by the total valuation (or cost) as estimated in BenMAP-CE using the standard studies and data as listed in Table 25 to derive a per incident dollar value for an avoided incident. These value per incident estimates are derived for each of the three years considered in our air quality scenario (2014-2016); an average is taken across the three years to derive the final estimate.[55] The economic studies and data used are the same as those used in U.S. EPA's recent Revised Cross-State Air Pollution Rule Update.[56] The dollar values per incident therefore are equivalent to those evaluated in that rule, only varying due to California specific economic and demographic data.[57]

The value per incident for each endpoint derived by the methods described above are shown in Table 25. The value for avoided premature mortality is based on the value of statistical life (VSL), a measure of willingness-to-pay (WTP) from economic theory, which when applied when to mortality risk provides a dollar estimate of benefits for an avoided premature death. The VSL is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks, such that one death would be avoided in the year across the population.[58] Specifically, the U.S. EPA central estimate of $7.4 million (2006$) is used for VSL.[59] The estimate of VSL is

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[53] U.S. Environmental Protection Agency (U.S. EPA). Environmental Benefit Mapping and Analysis Program – Community Edition (BenMAP-CE) version 1.5.8.5, April 2021.

[54] U.S. Environmental Protection Agency (U.S. EPA). BenMAP-CE User's Manual. January 2022.

[55] CARB, ONMC Health Monetization Spreadsheet. Sep 2023.

[56] U.S. Environmental Protection Agency (U.S. EPA). Technical Support Document for the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS, Estimating PM2.5- and Ozone-Attributable Health Benefits. March 15, 2021.

[57] The California specific data that cause variation from national estimates are the data on county-level median daily wages and the age distribution of the population residing in each air basin. Small variations may also arise due to BenMAP-CE's Monte Carlo simulation methods.

[58] U.S. 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.

[59] U.S. EPA, Mortality Risk Valuation: What value of statistical life does EPA use? (web link: *https://www.epa.gov/environmental-economics/mortality-risk-valuation*, last accessed January 2023).

adjusted for per capita income growth using U.S. EPA's central income elasticity estimate of 0.40 and the income growth forecast included in BenMAP-CE. This income elasticity estimate for VSL follows from empirical research and indicates that for every one percent increase in per capita income the VSL increases by 0.4 percent, consistent with health risk reduction being a normal good whose demand increases with income. Finally, the value for VSL is adjusted for California inflation to present the values in 2020 dollars. While the economic benefit associated with premature mortality is important to account for in the analysis, the valuation of avoided premature mortality does not directly correspond to changes in expenditures and is therefore not included in the macroeconomic modeling.

Unlike mortality valuation, the cost-savings for morbidity related endpoints such as avoided hospitalizations, emergency room visits, as well as disease onset and occurrence are based on the cost of illness (COI) methodology.[60] The COI methodology uses a combination of typical costs associated with hospitalization or disease occurrence to assign an economic value to avoidance of such outcomes. The types of cost that are included across the different valuation studies applied here include hospital charges, post-hospitalization medical care, out-of-pocket expenses, lost earnings for both individuals and family members, and lost household production (e.g., valuation of time-losses from inability to maintain the household or provide childcare).

Table 25. Valuation per Incident for Avoided Health Outcomes (2020$).

Endpoint	Value Per Incident (2020$)	Valuation Methodology	Notes
Premature Mortality			
Premature Mortality	$11,934,727	WTP	Shown at 2020 income levels. The estimate will grow annually proportional to income growth using U.S. EPA's central estimate for income elasticity of 0.40, and income growth forecast from BenMAP-CE.
Hospitalizations and ER Visits			
HA, Parkinson's Disease	$14,891	COI	Direct cost of hospitalization incident.
HA, Respiratory-2	$11,336	COI	Direct cost of hospitalization incident.
HA, Alzheimer's Disease	$13,949	COI	Direct cost of hospitalization incident.

[60] The WTP method is also used for valuation of one morbidity-related health endpoint: asthma symptoms.

Endpoint	Value Per Incident (2020$)	Valuation Methodology	Notes
HA, Cardio-, Cerebro- and Peripheral Vascular Disease	$17,938	COI	Direct cost of hospitalization incident.
ER visits, All Cardiac Outcomes	$1,346	COI	Direct cost of ER visit.
ER visits, Respiratory	$1,014	COI	Direct cost of ER visit.
Health Endpoint Onset/Occurrence			
Incidence, Asthma	$51,574	COI	Present value of lifetime healthcare cost and productivity losses using a 3% discount rate.
Asthma Symptoms, Albuterol Use	$243	WTP for symptoms + COI for Albuterol use	Willingness to pay plus cost of albuterol.
Incidence, Lung Cancer	$29,145	COI	Direct medical cost of lung cancer. Cost discounted to present value at 3%.
Acute Myocardial Infarction, Nonfatal	$90,510	COI	Present value of 3 years medical cost and earnings lost over a 5-year period. Using a 3% discount rate.
Work Loss Days	$196	COI	Based on county-level median daily wages.

2.4.1.6.2 **Results**

The statewide valuation of health benefits from 2028-20452045 are shown in Table 26. The total statewide health benefits derived from criteria emissions reductions is estimated to be $564 million, with $555 million resulting from reduced premature cardiopulmonary mortality and $9 million resulting the reductions in other adverse health impacts. The spatial distribution of these benefits across the State follows the distribution of the health impacts by air basin as described in Table 24. These monetized benefits from all COI based endpoint valuations are included in the macroeconomic modeling.

Table 26. Valuation of Statewide Health Benefits.

Calendar Year	Cardiopulmonary mortality	Parkinson's disease	Hospitalizations for respiratory illness	Alzheimer's disease	Hospitalizations for cardiovascular illness	Cardiovascular ED visits	Respiratory ED visits	Asthma onset	Asthma symptoms	Lung cancer incidence	Acute myocardial infarction, Nonfatal	Work loss days	Valuation (Million 2020$)
2028	0	0	0	0	0	0	0	0	27	0	0	19	$2
2029	0	0	0	0	0	0	0	1	75	0	0	52	$4
2030	1	0	0	0	0	0	0	2	146	0	0	103	$9
2031	1	0	0	0	0	0	1	2	206	0	0	148	$13
2032	1	0	0	1	0	0	1	3	255	0	0	187	$16
2033	2	0	0	1	0	0	1	3	307	0	0	227	$20
2034	2	0	0	1	0	0	1	4	354	0	0	262	$23
2035	2	0	0	1	0	1	1	5	397	0	0	295	$26
2036	2	0	0	1	0	1	1	5	454	0	0	338	$30
2037	3	0	0	1	1	1	2	6	507	0	0	378	$34
2038	3	0	0	1	1	1	2	6	557	0	0	416	$38
2039	3	0	0	1	1	1	2	7	603	0	0	450	$41
2040	3	0	0	1	1	1	2	7	646	0	0	481	$45
2041	4	0	0	2	1	1	2	8	685	0	0	509	$48
2042	4	0	0	2	1	1	2	8	720	0	0	535	$50
2043	4	0	0	2	1	1	2	9	752	0	0	558	$53
2044	4	0	0	2	1	1	2	9	781	0	0	579	$56
2045	4	0	0	2	1	1	2	9	807	0	0	597	$58
Total*	42	3	1	19	9	11	25	94	8280	3	5	6134	$564

*Numbers may not add up exactly due to rounding.

2.4.2Social Cost of Carbon

Table 22 summarizes the estimated GHG emissions from the proposed regulation, in units of MMT. Staff expects the proposed regulation to reduce cumulative GHG emissions by an estimated 0.58 MMT relative to the baseline from 2028 to 2045.

The proposed regulation is expected to result in GHG emission reductions, due to replacing ICE ONMCs with ZEMs. The benefit of these GHG emission reductions 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.

In the analysis of the SC-CO2 for the proposed regulation, CARB utilizes the current Interagency Working Group (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[61], is in line with U.S. Government Executive Orders, including 13990 and the Office of Management and Budget's Circular A-4 of September 17, 2003,[62] and reflects the best available science in the estimation of the socio-economic impacts of carbon.

IWG describes the social costs of carbon as follows:

> *The 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 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.*
>
> *Those damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these* damages from CO2 emissions today will affect economic outcomes throughout the next several centuries.[63]

The SC-CO2 is year-specific and is highly sensitive to the discount rate used to discount 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 as future emissions cause incrementally larger damages. This discount rate accounts for the preference for current costs and benefits over future costs and benefits, and a higher discount rate decreases the value today of future environmental damages. While the proposed regulation cost analysis does not account for any discount rate, this social cost analysis uses the IWG standardized range of discount rates from 2.5 to 5 percent to represent varying valuation of future damages. Table 27 shows the range of IWG SC-CO2 discount rates used in California's regulatory assessments, which reflect the societal value of reducing carbon emissions by one metric ton.[64]

Table 27. SC-CO2 by Discount Rate (in 2020$ per Metric Ton of CO2)

CY	5% Avg.	3% Avg	2.5% Avg

[61] CARB, California's 2017 Climate Change Scoping Plan, November 2017.

[62] Office of Management and Budgets (OMB). Circular A-4, September 17, 2003.

[63] National Academies of Sciences (NAS), Engineering, Medicine. Valuing Climate Damages: Updating Estimation of Carbon Dioxide. 2017.

[64] Interagency Working Group on the Social Cost of Carbon, Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 13990, 2021.

2020	$16	$55	$81
2025	$18	$60	$89
2030	$21	$66	$96
2035	$24	$72	$102
2040	$28	$79	$110
2045	$30	$84	$117

The avoided SC-CO2 from 2028 to 2045 is the sum of the annual CO2 emissions reductions multiplied by the SC-CO2 in each year. The cumulative CO2 emissions reductions along with the estimated benefits from the proposed regulation are shown in Table 28 shows these benefits ranging from about $16 million to $65 million through 2045, depending on the chosen discount rate.

Table 28. Avoided Social Cost of Carbon for the Proposal.

Year	CO2 Emissions Reductions (MMT)	Avoided SC-CO2 (Million 2020$) 5% Discount Rate	Avoided SC-CO2 (Million 2020$) 3% Discount Rate	Avoided SC-CO2 (Million 2020$) 2.5% Discount Rate
2028	0.00	$0.00	$0.00	$0.00
2029	0.00	$0.00	$0.00	$0.00
2030	0.00	$0.00	$0.00	$0.00
2031	0.00	$0.00	$0.00	$0.00
2032	0.00	$0.00	$0.00	$0.00
2033	0.00	$0.00	$0.01	$0.01
2034	0.00	$0.08	$0.25	$0.35
2035	0.01	$0.17	$0.53	$0.76
2036	0.02	$0.47	$1.37	$1.94
2037	0.03	$0.73	$2.19	$3.11
2038	0.04	$1.02	$2.96	$4.19
2039	0.05	$1.26	$3.70	$5.21
2040	0.06	$1.54	$4.40	$6.16
2041	0.06	$1.74	$5.07	$7.06
2042	0.07	$2.02	$5.60	$7.90
2043	0.08	$2.20	$6.20	$8.70
2044	0.08	$2.47	$6.76	$9.45
2045	0.09	$2.63	$7.31	$10.16
Total	0.58	$16.33	$46.36	$65.01

3 Direct Costs

The Proposal will require manufacturers to produce and sell vehicles that initially will have a higher incremental cost than the baseline (i.e., without the regulation). This incremental cost will come from both complying with the ZEM sales requirements, and from the ICE ONMC emissions requirements. The analysis will ultimately look at the cost to consumers as it is assumed that all costs will ultimately be passed on to consumers. However, staff will discuss the costs that occur to ONMC manufacturers for the purpose of understanding how those consumer costs are ultimately derived. Thus, all tables showing manufacturer cost include a retail price equivalence factor (RPE) factor of 1.5 multiplied against the manufacturer costs to arrive at the cost to the consumer. The rationale for using such a multiplier is described in detail in the 2016 Draft Technical Assessment Report associated with the federal Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards under the Midterm Evaluation.[65]

The direct costs to ONMC manufacturers for complying with the regulation are presented in section 3.1 and divided into 3 main parts: cost of compliance with the ZEM proposal, the cost of compliance with the ICE ONMC proposals, and aggregate costs for the California fleet. In section 3.2 operational costs of ownership are presented. Section 3.3 will discuss the direct costs to businesses. Section 3.4 will briefly discuss the costs to small business. Section 3.5 will show how these costs ultimately impact the California ONMC owners. Section 3.6 will show the total economic impact of the Proposal. Although currently there are a several rebate and incentive programs in California that can offset some of the incremental cost of zero-emission vehicles, none of these are included in the cost analysis (refer to section 3.5.4 below for further discussion). In subsequent sections, the costs are presented for typical and small businesses and for individuals considering total cost of ownership for these vehicles.

3.1 Direct Cost Inputs

The estimated direct costs from the Proposal will initially occur to the regulated party (the vehicle manufacturer), although they are expected to be passed on the consumer. Section 3.1.1 looks at the cost of complying with the ZEM proposal and section 3.1.2 for the ICE ONMC amendments. Staff will first provide the basis of the estimated incremental cost for each vehicle class by technology where it is possible to disaggregate. These will then be aggregated to determine the estimated fleet compliance cost for the timeframe of the regulation. In some cases where the consumer cost is already reflected in the marketplace, staff will proceed with that cost and expand to the increased impacted population. After Tax

[65] U.S. Environmental Protection Agency (U.S. EPA). Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025. July 2016.

and amortization, the maximum net (after savings) annual statewide direct cost impact of the Proposal to California consumers (including government) is $34.3 million. This occurs in CY 2036 as shown in Table 49. From CY 2036, this cost continues to decrease to a projected net annual cost savings by CY 2043.

3.1.1 Manufacturer Compliance Cost Inputs for Zero-Emission Motorcycle Proposal

The cost of complying with the ZEM Proposal can be broken into two parts: (1) the cost of complying with the vehicle percentage requirements for the fleet, shown in Table 8 and replacement of Class IA vehicle with ZEM and (2) the cost to comply with the ZEM certification and quality assurance measures, described sections 1.4.1.2 and 1.4.1.3.

3.1.1.1 Cost to Comply with the Zero-Emission Motorcycle Sales Requirements

As described in section 1.4.1, an increasing percentage of California ONMC sales by large manufacturers must be ZEMs beginning with 10 percent in 2028 and topping out at 50 percent in 2035. This gradual increase is intended to give time for manufacturers and the public to gradually adjust to more ZEMs in the marketplace. To further assist manufacturers in smoothing compliance burdens, the Proposal as described in section 1.4.1.1 allows for credits to be generated in excess of a manufacturer’s compliance obligations in order to be traded or banked to satisfy another manufacturer’s compliance burdens. Acquiring these credits will allow some manufacturers more time and flexibility in meeting their ZEM compliance obligations.

To calculate costs to comply with the ZEM vehicle percentage portion requirements, it is first assumed that manufacturers produce battery electric ONMCs instead of ICE ONMCs. Staff considers the costs incurred by the industry as a whole by looking at the cost differential in buying a ZEM over a comparable conventional ICE ONMC for individual end users, then applying that per-vehicle cost differential across the total number of ZEMs sold in California.

Staff estimated the average 2020 end user cost for a ZEM Tier III was $20,197 and the comparable ICE ONMC cost was $14,831. Staff estimated that the average 2020 end user cost of ZEM Tier II was $7,192 and comparable ICE ONMC was $4,609. Staff estimated that the average 2020 end user cost of ZEM Tier I was $3,899 and comparable ICE ONMC was $2,666. Note, staff’s cost estimates for ZEM Tier II and III were determined by looking at representative new California vehicle registrations for the 2020 calendar year, while staff’s cost estimate for ZEM Tier I was based on a representative sample of large manufacturers either selling or with announced intent to sell Tier I ZEMs in California due to little registration information on this category. From the above, Staff determined the 2020 retail price differentials for a ZEM Tier III was $5,365, Tier II was $2,584 and a Tier I was $1,233.

Staff estimated the actual manufacturer costs using the RPE which represents the indirect costs incurred by a manufacturer. Specifically, staff divided the retail price calculated above by 1.5 (the RPE factor) to calculate the actual manufacturer cost. For Tier III ZEMs and comparable ICE ONMCs this is calculated to be $13,464 and $9,888, respectively. For Tier II ZEMs and comparable ICE ONMCs this is calculated to be $4,795 and $3,072, respectively. For Tier I ZEMs and comparable ICE ONMCs this is calculated to be $2,599 and $1,777, respectively. The resulting manufacture cost differentials of ZEM to ICE for Tier III, II and I ZEMs are $3,577, $1,722 and $822, respectively.

The biggest ZEM cost component is the battery. From consultation with ZEM manufacturers, staff estimates that in 2020, the battery was approximately 32.5 percent the cost of the vehicle. However, battery costs are also subject to rapid decline in price over time.[66] This drop in price of a significant portion of the ZEM price relative to the ICE ONMC will significantly reduce the cost differential for ZEM over time. Staff estimated a year over year price decline in battery costs of 5.78 percent from CARB's recent battery cost analysis of BEVs in the Advanced Clean Cars II Regulations.[67] Staff estimated the battery cost decline resulting in a decreasing ZEM to ICE ONMC price differential per Table 29. The key takeaway here is that as the battery price gets cheaper over time, the retail price of ZEMs will get closer and closer to their ICE ONMC counterparts.

Table 29. Declining Battery Cost and ZEM to ICE Retail Price Difference.

Year	Tier I Battery Cost	Tier II Battery Cost	Tier III Battery Cost	Tier I and ICE Cost Difference	Tier II and ICE Cost Difference	Tier III and ICE Cost Difference
2020	$1,267	$2,338	$6,564	$1,233	$2,584	$5,365
2021	$1,194	$2,202	$6,184	$1,159	$2,449	$4,986
2022	$1,125	$2,075	$5,827	$1,090	$2,321	$4,628
2023	$1,060	$1,955	$5,490	$1,025	$2,201	$4,292
2024	$999	$1,842	$5,173	$964	$2,088	$3,974
2025	$941	$1,736	$4,874	$906	$1,982	$3,675
2026	$886	$1,635	$4,592	$852	$1,882	$3,394
2027	$835	$1,541	$4,327	$801	$1,787	$3,128
2028	$787	$1,452	$4,077	$752	$1,698	$2,878
2029	$741	$1,368	$3,841	$707	$1,614	$2,642
2030	$699	$1,289	$3,619	$664	$1,535	$2,420
2031	$658	$1,214	$3,410	$624	$1,460	$2,211
2032	$620	$1,144	$3,213	$586	$1,390	$2,014
2033	$584	$1,078	$3,027	$550	$1,324	$1,828
2034	$551	$1,016	$2,852	$516	$1,262	$1,653
2035	$519	$957	$2,687	$484	$1,203	$1,489

[66] Bloomberg New Energy Finance (BNEF). Zero-Emission Vehicles Factbook: A BloombergNEF special report Prepared for COP26. Pg 33. November 10,2021.

[67] CARB, Advanced Clean Cars II Proposed Amendments to the Low Emission, Zero Emission, and Associated Vehicle Regulations, Standardized Regulatory Impact Assessment, January 26, 2022.

Year	Tier I Battery Cost	Tier II Battery Cost	Tier III Battery Cost	Tier I and ICE Cost Difference	Tier II and ICE Cost Difference	Tier III and ICE Cost Difference
2036	$489	$902	$2,532	$454	$1,148	$1,333
2037	$460	$850	$2,386	$426	$1,096	$1,187
2038	$434	$800	$2,248	$399	$1,047	$1,049
2039	$409	$754	$2,118	$374	$1,000	$919
2040	$385	$711	$1,995	$351	$957	$797
2041	$363	$670	$1,880	$328	$916	$681
2042	$342	$631	$1,771	$307	$877	$573
2043	$322	$594	$1,669	$288	$841	$470
2044	$304	$560	$1,573	$269	$806	$374
2045	$286	$528	$1,482	$251	$774	$283

Because there already exist some baseline sales of ZEMs in California, staff begins counting these costs as soon as compliance obligations exceed credits generated from projected baseline ZEM sales. Under current baseline production assumptions, industry will generate enough credits to satisfy total industry credit requirements through 2032. However, because the regulation prevents CARB certification of Class IA ONMCs starting in 2028, it is assumed that sales of those vehicles will all be displaced by Tier I ZEMs from that point on. Thus, the Proposal assumes a cost component to ZEM compliance beginning in CY 2028 due to ZEM Tier I sales and incorporates the cost of ZEM Tier II and III sales starting in CY 2033 as seen in Table 30. Note again, that at this manufacturer level of analysis, staff is not including taxes or amortization as these ZEM and ICE ONMC price differentials were derived from actual retail prices.

Table 30. Proposal Cost of Complying with ZEM Sales Requirements.

Year	Tier I Cost	Tier II Cost	Tier III Cost	Total ZEM Cost
2028	$670,469	$0	$0	$670,469
2029	$632,317	$0	$0	$632,317
2030	$596,061	$0	$0	$596,061
2031	$561,896	$0	$0	$561,896
2032	$529,444	$0	$0	$529,444
2033	$498,919	$646,935	$11,344,118	$12,489,972
2034	$469,949	$742,964	$12,363,091	$13,576,004
2035	$442,582	$815,081	$12,806,735	$14,064,399
2036	$416,621	$1,999,843	$29,499,635	$31,916,098
2037	$391,987	$1,914,286	$26,333,882	$28,640,155
2038	$368,629	$1,833,165	$23,334,155	$25,535,949
2039	$346,468	$1,756,166	$20,491,595	$22,594,229
2040	$325,458	$1,683,148	$17,799,793	$19,808,400
2041	$305,542	$1,613,893	$15,251,592	$17,171,027

2042	$286,666	$1,548,218	$12,840,424	$14,675,308
2043	$268,788	$1,485,978	$10,560,222	$12,314,988
2044	$251,853	$1,426,968	$8,404,625	$10,083,446
2045	$235,811	$1,370,997	$6,367,727	$7,974,535
Total	$7,599,459	$18,837,642	$207,397,593	$233,834,694

3.1.1.2 ZEM Certification and Quality Assurance Costs

Currently there are no CARB ZEM certification standards. The Proposal would change that to include the following requirements as discussed in section 1.4.1.2:

- Full replacement battery warranty standard that meets 5 years or 50,000 km, whichever comes first;
- All electric range as determined by SAE J2982 for BEVs (or SAE J2572 for hydrogen fuel cell vehicles if manufacturers at some point produce these);
- Top constant speed as determined by SAE J2982;
- ZEM has a fast charge capability (if so equipped); and
- A battery label listing capacity performance among other items.

Because ZEMs will be displacing some portion of ICE ONMC certification and these ZEM certification requirements are all considered less burdensome than ICE ONMC certification with respect to testing, it assumed the ZEM certification will result in net fleet cost savings over current ICE certification requirements. These certification cost savings are not included in this analysis due to difficulty and uncertainty in calculating it. Further, with regards to the 5-year 50,000 km battery warranty, some manufactures of ZEM already offer such a warranty so the cost of providing it is already captured in current retail pricing and reflected in the ZEM cost differential described in section 3.1.1.1.

3.1.1.3 ZEM Battery Labeling Costs

For battery labeling requirements as described in section 1.4.1.3, the proposal requires that specific information be printed directly on the label, which includes a QR code with links to a website with additional information, and for such a label to be attached to each portion of the battery pack that is intended to be replaceable. These labels are like those used on many vehicle electro-mechanical parts currently in the automotive industry for passenger cars and ONMCs. Because of this, staff does not expect incremental costs from creation of a new process for labels. The incremental cost is limited to the actual cost, estimated at $0.01 per label or $0.05 per average vehicle based on availability of preprinted custom labels for less than $0.02 to $0.03 per label, even at much lower quantities than typical for the production run of a vehicle model.

A related part of the label requirement is that the manufacturer must include a QR code on the label that links to a free website containing information about the battery. Because this requirement will already be established in CARB's Advance Clean Cars II Regulation for most other on-road vehicles, Staff estimates there will be insignificant incremental costs for battery manufacturers to do this with ZEMs as well.

Although these battery labeling requirements will be new for California ZEMs, they are assumed to be negligible, and are likely to be extremely small, they are assumed to be offset by savings experienced with ZEM certification requirements.

3.1.2 Manufacturer Cost Inputs for Internal Combustion Engine On-Road Motorycle Proposal

The Proposal includes several amendments to current ONMC requirements that are evaluated for costs in this section as discussed in section 1.4.2. These include:

- Revising Exhaust Emissions Standards (section 1.4.2.1)
- New OBD Requirements (section 1.4.3);
- New Durability Mileage and Optional Durability Procedure (section 1.4.4)
- California Calibration Testing for EU 5 ONMC Harmonization;
- Revising Evaporative Emissions Standards (section 1.4.2.2); and
- Revising Emissions Related Warranty Requirements (section 1.4.5)

As previously mentioned, all of these proposed ICE ONMC requirements are phased in gradually from MY 2028 to MY 2030.

3.1.2.1 Compliance Costs for Revised Exhaust Emissions Standards

The Proposal requires manufacturers selling conventional ICE ONMCs in California to certify only motorcycles complying with the Euro 5 emissions standards discussed in section 1.4.2.1. Staff has observed through testing that some CARB certified motorcycles would meet Euro 5 exhaust emissions standards today, however many would not. From limited survey responses from manufacturers, staff has determined that there is one essential component upgrade costs associated with upgrading California ONMCs to meet Euro 5 exhaust emissions standards. This component is the catalytic converter. Currently most California manufacturers have catalytic converters installed on their CARB certified ONMCs. However, those catalysts may not always have the same surface area and loading of precious metals necessary for compliance with Euro 5 standards. Staff estimates from surveying manufacturers that the 2020 cost to upgrade the catalytic converter is $191 per ONMC. Staff applied this catalyst upgrade cost across the entire impacted population going forward from 2028 as shown in Table 31. The total aggregated retail cost to end-users is estimated by applying a RPE of 1.5 to the total manufacturer cost (see section 3.1.1.1. (At this point staff has not included tax or amortization into the analysis.)

3.1.2.2 Compliance Costs for New OBD Requirements

The Proposal requires manufacturers selling conventional ICE ONMCs in California to have Euro 5 compliant OBD systems. Starting in 2028, OBD systems must be certified to more rigorous new CARB OBD standards as discussed in section 1.4.3. The 2028 OBD requirement allows for ONMCs already being built and certified to Euro 5 exhaust standards in Europe to be more quickly brought to California. Staff assumes no additional cost for 2028 OBD requirements as they will already be included on ONMCs built for Euro 5 exhaust certification. New OBD requirements to monitor the fuel system are also included in the proposal. However, staff has determined that fuel system monitoring requires no additional components on the motorcycle. OBD system suppliers will only need to define failure criteria and enable the fuel system monitoring malfunction indicator. The costs of doing so are negligible, and staff is aware that some manufacturers are already voluntarily implementing fuel system monitoring on their OBD-equipped motorcycles.

As part of the proposed OBD requirements, manufactures are required to perform production motorcycle evaluation testing in which an ONMC must be pulled off the production line each year and tested to confirm that the OBD system detects faults as predicted. Staff estimated this cost by assuming 160 hours of engineer testing at the 2020 CPI adjusted rate of $61.45 per hour[68], 90 WMTC test runs at $500 per run[69], and Staff assessment of an average ONMC depreciated by 20% and the fuel necessary to run the testing. Based on manufacturer assumptions, staff estimated the cost was $58,213. Staff estimates that 13 manufacturers would have to run this testing for a total annual industry impact of $756,769 per year as shown in Table 31.

3.1.2.3 Compliance Costs for New Durability Requirements

The Proposal gives manufacturers selling conventional ICE ONMCs in California the option beginning in 2028 to certify their new ONMCs using catalyst bench aging instead of mileage accumulation as discussed in section 1.4.4. However, if they choose this certification method, they will be required to submit four vehicles later for in-use verification testing to ensure that the certified ONMCs are in fact emitting at less than the certification standard. There are many complexities to obtaining in use vehicles for testing that make this cost difficult to assess. However, because it is an optional standard, it is assumed that the manufacturer would only opt for it if there were a net cost savings as compared to traditional certification using mileage accumulation. This option is only included to provide manufacturers flexibility in certification. Therefore, unless stakeholders offer further data to estimate this cost impact, staff assumes this will be a negligible cost savings.

The Proposal further requires manufacturers to test vehicles to longer durability demonstrations of emissions equipment as discussed in section 1.4.4. Staff estimated this cost by assuming ~143 hours of technician testing at the 2020 CPI adjusted rate of $39.33

[68] U.S. Bureau of Labor Statistics (BLS), Occupational Employment and Wage Statistics, 17-2141 Mechanical Engineers with Staff CPI adjustment and includes 29.5% overhead. May 2022.

[69] Estimate from staff consultation with an ONMC manufacturer.

per hour[70], 143 hours of mileage accumulation[71], and Staff assessment of an average ONMC depreciated by 20% and the fuel necessary to run the testing. Staff estimated the cost with assumptions from manufacturers to get $9,284 per manufacturer per engine family. Because the extra mileage mainly applies to ONMC over 800cc in displacement, from CARB certification data, Staff estimates that this is applicable to116 engine families manufacturers would have recertify on an approximate 5 year interval. As shown in Table 31, this averages out in the long run to about $215,388 annually, although it might be higher in the first few years of the proposal due to the phase in period being only 3 years.

3.1.2.4 California Calibration Testing for EU 5 ONMC Harmonization

Although the Proposal attempts to harness the benefits of exhaust harmonization with EU 5 emissions standards, Staff realizes that there will be some calibration testing necessary for manufacturers to ensure themselves that their ONMCs will perform as expected on CARB compliance testing with certification fuels and after having operated in California weather and climate conditions. Staff estimated this cost by assuming 100 hours of engineer testing at the 2020 CPI adjusted rate of $61.45 per hour. The estimated cost by staff was ~$6,145 per engine family. Staff estimates that 261 manufacturers would have to be recertified on an approximate 5-year interval with ICE engine families being displaced by ZEMs models at an assumed rate of 2% per year. As shown in Table 31, this averages out in the long run to less than $280,000 annually, although it is gradually decreases every year and might be higher in the first few years of the proposal due to the phase in period being only 3 years.

Table 31. Total Manufacturing and Aggregated Retail Cost of Upgrading from CARB to Euro 5 Exhaust Emissions Standards.

Year	Exhaust Parts Upgrade	OBD Testing Cost	Durability Testing	California Calibration Testing	End User Cost
2028	$842,118	$756,769	$323,082	$423,406	$3,518,064
2029	$3,381,192	$756,769	$323,082	$413,784	$7,312,240
2030	$9,425,031	$756,769	$430,776	$538,881	$16,727,185
2031	$9,460,011	$756,769	$215,388	$263,025	$16,042,790
2032	$9,492,696	$756,769	$215,388	$256,610	$16,082,195
2033	$8,270,315	$756,769	$215,388	$250,195	$14,239,001
2034	$8,046,337	$756,769	$215,388	$243,779	$13,893,411
2035	$7,852,933	$756,769	$215,388	$237,364	$13,593,682
2036	$5,143,864	$756,769	$215,388	$230,949	$9,520,456
2037	$5,163,013	$756,769	$215,388	$224,534	$9,539,556
2038	$5,181,366	$756,769	$215,388	$218,118	$9,557,462
2039	$5,198,659	$756,769	$215,388	$211,703	$9,573,778

[70] U.S. Bureau of Labor Statistics (BLS), Occupational Employment and Wage Statistics, 17-3027 Mechanical Engineering Technicians with Staff CPI adjustment and includes 29.5% overhead. May 2022.
[71] Estimate determined from applying the speed of SCR accumulation cycle over 10,000km.

2040	$5,215,049	$756,769	$215,388	$205,288	$9,588,741
2041	$5,230,472	$756,769	$215,388	$198,873	$9,602,253
2042	$5,244,930	$756,769	$215,388	$192,457	$9,614,317
2043	$5,258,533	$756,769	$215,388	$186,042	$9,625,099
2044	$5,271,174	$756,769	$215,388	$179,627	$9,634,438
2045	$5,282,753	$756,769	$215,388	$173,212	$9,642,182
Total	$108,960,447	$13,621,841	$4,307,765	$4,647,847	$197,306,850

3.1.2.5 Compliance Costs for Revised Evaporative Emissions Standards

Starting in MY 2028, the Proposal requires manufacturers selling conventional ICE ONMCs in California to certify to more rigorous new CARB evaporative emissions standards as discussed in section 1.4.2.2. Staff has observed through CARB evaporative testing that the majority of current CARB certified ONMCs will not meet the proposed evaporative standards. From in-house testing and testing conducted by the Manufacturers of Emission Controls Association (MECA),[72] staff has determined that two cost components will be necessary in meeting the standard proposed in 2028: upgraded carbon canisters and access to SHED testing equipment. Almost all CARB certified ONMCs currently are equipped with carbon canisters. However, to meet the new standard starting in 2028 many of the current canisters will need to be upgraded to have a greater carbon working capacity. To achieve a greater working capacity, this would entail using higher quality carbon, improved canister design, larger canister volume, or some combination of the three. This canister technology has been in place for nearly three decades on light duty passenger cars and trucks. Staff estimates the upgrade cost would be approximately $30 per unit. Staff applied this canister cost across the entire impacted population going forward from CY 2028 as shown in Table 32.

Although some manufacturers have variable volume SHEDs necessary for the multiday diurnal emissions testing required by the Proposal, most do not. Therefore, staff had to estimate the total cost impact on manufacturers to provide necessary capacity to comply with the proposed testing requirements. Staff assumed there would be approximately up to eight large manufacturers impacted. Staff further assumed a $1,000,000 capital cost per SHED and that access to two each would likely be necessary to avoid testing bottlenecks. Staff assumed current manufacturer employed evaporative testing staff operating non-volume variable SHEDs could easily be adapted to the new equipment. Multiplying these together results in a total industry cost of $16,000,000. Because this represents a large one-time capital cost, staff amortized this cost over 10 years to smooth out the cost with an interest rate of 5 percent beginning in 2028 as shown in Table 32. Staff combined the total canister and SHED costs through 2045 to get a total evaporative compliance cost. The total

[72] Manufacturers of Emission Controls Association (MECA), Evaluation of Motorcycle Evaporative Canisters. July 15, 2021.

aggregated retail cost to end-users is estimated by applying a RPE factor of 1.5 (see section 3.1.1.1) to the total manufacturer cost, as found in Table 32.

Table 32. Total Manufacturing and Resulting Aggregated Retail Costs of Upgrading to New CARB Evaporative Emissions Standards.

Year	Canister Cost	SHED Cost	Total Evap Cost	End User Cost
2028	$132,082	$2,072,073	$2,204,155	$3,306,233
2029	$530,323	$2,072,073	$2,602,396	$3,903,594
2030	$1,478,269	$2,072,073	$3,550,342	$5,325,513
2031	$1,483,755	$2,072,073	$3,555,828	$5,333,743
2032	$1,488,882	$2,072,073	$3,560,955	$5,341,432
2033	$1,297,157	$2,072,073	$3,369,231	$5,053,846
2034	$1,262,028	$2,072,073	$3,334,101	$5,001,151
2035	$1,231,693	$2,072,073	$3,303,766	$4,955,650
2036	$806,789	$2,072,073	$2,878,863	$4,318,294
2037	$809,793	$2,072,073	$2,881,866	$4,322,799
2038	$812,671	$0	$812,671	$1,219,007
2039	$815,384	$0	$815,384	$1,223,075
2040	$817,954	$0	$817,954	$1,226,931
2041	$820,373	$0	$820,373	$1,230,560
2042	$822,641	$0	$822,641	$1,233,961
2043	$824,775	$0	$824,775	$1,237,162
2044	$826,757	$0	$826,757	$1,240,136
2045	$828,573	$0	$828,573	$1,242,860
Total	$17,089,899	$20,720,732	$37,810,631	$56,715,947

3.1.2.6 Compliance Costs for Revised Warranty Requirements

The Proposal requires manufacturers selling conventional ICE ONMCs in California to meet a new representative useful life warranty mileage for emissions related components as described in section 1.4.5. Current warranty regulations require the components to last 5 years or the useful life mileage; whichever comes first. Therefore, the new standard is expected to only impact a portion of the ONMCs that exceed the current useful mileage limits within 5 years. Because Class IA will no longer be certified by CARB under the Proposal in 2028, there is no cost to this portion of the population as it is assumed they will all be Tier I ZEMs at that point.

To estimate the cost per year of the increased warranty mileage provisions, staff looked at the 2020 cost of the advertised extended warranty provided by a major ONMC manufacturer.[73] Staff calculated the long term per year cost of this extended warranty to be $214 per year per unit. Staff further estimated that because the warranty would only have to cover the value of emissions related equipment rather than the complete ONMC, that the value could be halved to $107 per year per unit. From fuel usage calculations in section 3.2.1.1, staff estimates that average California ONMC travels 2261 miles (3639 km) per year. Further, smaller Class IB and Class II ONMCs are likely to be ridden less than the average and larger Class III. The Proposal constraints that maximize the number of excess warranty years per class is given in Table 33. It is further assumed that the maximum number of riders who would achieve this usage in any Class necessary to maximize the proposed warranty mileage within the 5-year warranty window is 15 percent based upon staff assumption that touring bike owners are likely to put much more than the average mileage, 3,639 km per year to closer to 10,000 km per year and touring bikes make up approximately 15 percent of the market. To make a rough estimation of the amount of time that high mileage users would exceed current warranty mileage limits withing the 5-year window, staff assumed the necessary mileage per year to reach the mileage limit withing 5 years, then applied that mileage per year to the prior mileage warranty limit to see how quickly that would be exceed and used this difference in time to estimate the cost of extra years of warranty a manufacturer would need to cover. Multiplying 15 percent with $107 per year with the maximum extra years of warranty coverage in Table 33 gives the maximum cost impact per year per unit for each Class.

Table 33. Warranty Cost Sales Cost Impact Per Unit by ONMC Class.

CARB/EPA Class	Current EPA/CARB Distance (km)	Proposed CARB Distance for MY 2028+ (km)	Usage For Max Warranty Years Impact (km/yr)	Max Extra Years Warranty Coverage (yr)	Cost Impact ($/unit/yr)
IB (50-169 cc)*	12,000	12,000	2,400	0.0	$0.00
II (170-279 cc)	18,000	20,000	4,000	0.5	$8.03
III (280 to 799 cc)	30,000	35,000	7,000	0.7	$11.46
III (800 + cc)	30,000	50,000	10,000	2.0	$32.10

This number is further moderated when we consider that it only applies to newly certified engine and evaporative families for MY 2028 and beyond. Therefore, it will take four years before the impact of the warranty being is applied to all ONMC in the population, as some

[73] HondaCare® Protection Plan - Protection Under Our Wing, (web link: https://powersports.honda.com/hondacare-protection-plan/motorcycles-3-year , Accessed 4/5/2022)

percentage of existing engine and evaporative families are expected to carryover each year. From the peak annual cost in 2032, costs decline through 2036 as ZEMs increasingly replace ICE sales. After 2036, the slightly increasing cost reflects overall anticipated sales growth across all categories. The total cost impact to industry can be seen in Table 34. Initially a stepped increase in cost can be seen in the initial years due to some carry over of engine families. A decrease occurs in 2033 when it is expected manufacturers will have exhausted their credit bank and need to build more ZEMs displacing ICE with these warranty requirements. However, note again, amortization has not yet been applied at this stage in the analysis.

Table 34. Maximum Proposed Warranty Cost Impact.

Year	Max Warranty Cost Impact ($/yr)
2028	$368,401
2029	$739,584
2030	$1,236,949
2031	$1,241,539
2032	$1,245,829
2033	$1,085,403
2034	$1,056,008
2035	$1,030,625
2036	$675,085
2037	$677,598
2038	$680,007
2039	$682,276
2040	$684,427
2041	$686,451
2042	$688,349
2043	$690,134
2044	$691,793
2045	$693,313
Total	$14,853,771

3.2 Direct Operational Costs

The Proposal will result in direct changes in cost of ONMC ownership for consumers with respect to fuel use outlined in section 3.2.1, vehicle maintenance as outlined in section 3.2.2, and insurance as outlined in section 3.2.3.

3.2.1 Direct Costs and Savings of Fuel Use

Fuel savings are expected to occur both from increased ZEM use and from evaporative emissions controls on ICE OHMCs. This section estimates the contribution for both sources through 2045. Fuel savings are based in part on projections of future fuel costs, and 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.[74,75] Each year, the EIA releases its Annual Energy Outlook (AEO) that predicts average annual real growth rates of energy prices through 2050. The 2019, 2020, 2021, and 2022 releases of the AEO predicted average annual real growth rates of transportation gasoline prices varied from 0.9 percent, 1.3 percent, 1.3 percent, and 0.6 percent for those years respectively.[76] 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 Proposal 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.

3.2.1.1 ZEM Proposal Fuel Savings

Fuel savings occur for individual ZEM owners by switching from relatively more expensive gasoline to relatively less expensive electricity to power the vehicle. Staff estimated this cost by estimating the individual cost of fuel used per vehicle from EMFAC2021 estimate[77] for 2021 of 51.1 gallons/unit/year and applying that across the population of ZEMs above baseline for each year. Similarly, for electricity consumption, staff determined the average efficiency from several common ZEM models of 0.14 kWh/mile with an additional 10 percent charging loss and an estimated yearly vehicle-miles-traveled of 2,207 miles. These factors were applied across the entire population to calculate the total electricity consumed. Staff determined the price projections for gasoline and electricity through 2035 from the California Energy Commission (CEC) and determined rates beyond 2035 from the Energy Information Administration (EIA).[78,79] Staff combined these totals to estimate total fuel

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[74] U.S Energy Information Administration (EIA),. Short-Term Energy Outlook. December 2021.
[75] U.S. Energy Information Administration (EIA). Short-Term Energy Outlook. March 2022.
[76] U.S. Energy Information Administration (EIA). Annual Energy Outlook 2019-2022, Table 3 Energy Prices by Sector and Sources, Pacific Region.
[77] CARB, Emissions Inventory Derivations, 2023.
[78] California Energy Commission (CEC), Electricity and Natural Gas Demand Forecast, Docket number 21-IEPR-03, December 1, 2021.
[79] U.S. Energy Information Administration (EIA). Annual Energy Outlook 2021, Table 3 Energy Prices by Sector and Sources, Pacific Region.

savings to California end users as shown in Table 35. Note, these fuel prices are retail prices and include applicable taxes in the analysis.

Table 35. Total Fuel Savings Due to ZEM Proposal for California End Users.

-	Total Δ Gasoline Consumption (gal)	Total Δ Gasoline Consumption ($)	Total Δ Electricity Consumption (KWh)	Total Δ Electricity Consumption ($)	Total Fuel Savings
2028	45,532	$182,145	306,250	$78,547	$103,599
2029	88,857	$359,118	597,658	$155,645	$203,473
2030	129,500	$532,561	871,025	$229,705	$302,857
2031	167,986	$702,745	1,129,883	$301,096	$401,649
2032	204,641	$869,214	1,376,426	$370,909	$498,305
2033	581,605	$2,490,474	3,911,901	$1,065,443	$1,425,031
2034	1,009,298	$4,349,483	6,788,584	$1,868,114	$2,481,369
2035	1,472,728	$6,386,861	9,905,634	$2,751,218	$3,635,644
2036	2,655,217	$11,596,797	17,859,107	$4,967,695	$6,629,101
2037	3,778,548	$16,617,715	25,414,676	$7,072,390	$9,545,325
2038	4,837,650	$21,480,967	32,538,247	$9,041,219	$12,439,748
2039	5,842,139	$25,944,091	39,294,479	$10,901,951	$15,042,140
2040	6,798,898	$30,619,503	45,729,682	$12,706,971	$17,912,532
2041	7,711,175	$34,963,208	51,865,700	$14,430,525	$20,532,683
2042	8,580,355	$39,067,378	57,711,842	$16,116,427	$22,950,951
2043	9,411,740	$43,164,431	63,303,773	$17,683,193	$25,481,238
2044	10,206,069	$46,928,861	68,646,460	$19,207,019	$27,721,842
2045	10,961,429	$50,252,411	73,727,049	$20,693,226	$29,559,184
Total	74,483,370	$336,507,963	500,978,377	$139,641,292	$196,866,671

3.2.1.2 Fuel Savings from Amendments to Evaporative Emissions Standards

The Proposal calls for increased stringency in evaporative emissions standards beginning in 2028. Reducing evaporative emissions is a direct savings of fuel for the ONMC owner, since fuel that would otherwise evaporate to the atmosphere is captured in the carbon canister and used to power the vehicle. Staff determined the total fuel savings based upon applying the reduced emissions factor of 1.2 g/day/ONMC against baseline EMFAC2021 assumptions for daily diurnal emissions and then applying this across the impacted population of new ICE ONMC sold from 2028 onward. Staff determined the price projections for gasoline as in section 3.2.1.1 and combined these totals to estimate total fuel savings to California end users as shown in Table 36. Note, these fuel prices are retail prices and include applicable taxes in the analysis.

Table 36. Total Fuel Savings Due to ICE Evaporative Emissions Proposal for California Consumers.

Year	Total Δ Gasoline Consumption (gal)	Total Δ Gasoline Consumption ($)
2028	2,259	$9,035
2029	6,675	$26,976
2030	13,820	$56,833
2031	20,678	$86,503
2032	27,143	$115,289
2033	32,261	$138,142
2034	36,939	$159,183
2035	41,255	$178,914
2036	43,190	$188,636
2037	45,051	$198,130
2038	46,930	$208,387
2039	48,715	$216,336
2040	50,443	$227,175
2041	52,112	$236,282
2042	53,688	$244,447
2043	55,178	$253,060
2044	56,578	$260,154
2045	57,882	$265,358
Total	690,796	$3,068,841

3.2.2Direct Savings on Maintenance

The Proposal creates a requirement for more ZEM sales. ZEMs have fewer moving parts and less complicated mechanical systems than ICE ONMCs, which will reduce ongoing ONMC maintenance requirements. Staff assumes a $0.14/mile ICE ONMC maintenance cost applied to an average of 2,207 miles per year. Staff applied a AAA estimate of 65 percent cost reduction in maintaining a ZEV over a normal passenger car to get a per year maintenance cost savings of $107/unit/yr. Applying this to the ZEMs required by the proposal over baseline, and assuming these displace conventional ICE ONMC, staff estimates the total maintenance savings from the proposal to California consumers in Table 37.

Table 37. ZEM Total Aggregated Maintenance Savings to Californians.

Year	ZEM Maintenance Cost Savings Over ICE $
2028	$95,528
2029	$186,426
2030	$271,696

Year	ZEM Maintenance Cost Savings Over ICE $
2031	$352,441
2032	$429,344
2033	$1,220,227
2034	$2,117,542
2035	$3,089,833
2036	$5,570,735
2037	$7,927,520
2038	$10,149,553
2039	$12,257,003
2040	$14,264,316
2041	$16,178,305
2042	$18,001,874
2043	$19,746,147
2044	$21,412,675
2045	$22,997,447
Total	$156,268,610

3.2.3Direct Costs of Insurance

The Proposal creates a requirement for more ZEM sales. In the early years of the regulation, these ZEMs will be significantly more expensive than their ICE ONMC counterparts. Improvement to ICE ONMCs are also required in the Proposal, which creates a modest price differential with current ICE ONMC. However, this cost differential for ZEM ONMCs is expected to decrease over time as shown in section 3.1.1.1 This will create an additional insurance cost to California consumers, as insurance costs are generally proportionate to the value of the vehicle being insured. The increased insurance cost was derived by applying a factor of 5 percent to the cost difference between active ZEMs above baseline and displaced ICE ONMCs. The increased total aggregated insurance cost to Californians can be found in Table 38.

Table 38. Aggregated Insurance Cost Increase Due to Proposal.

CY	Tier I Aggregated Insurance Cost Δ ($)	Tier II Insurance Cost Δ ($)	Tier III Insurance Cost Δ ($)	ICE Insurance Cost Δ ($)	Total Insurance Cost Δ ($)
2028	$33,523	$0	$0	$227,477	$261,000
2029	$60,211	$0	$0	$567,895	$628,106
2030	$80,520	$0	$0	$1,210,627	$1,291,147
2031	$95,505	$0	$0	$1,735,961	$1,831,466
2032	$105,951	$0	$0	$2,169,360	$2,275,311
2033	$112,471	$16,173	$283,603	$2,450,149	$2,862,397

CY	Tier I Aggregated Insurance Cost Δ ($)	Tier II Insurance Cost Δ ($)	Tier III Insurance Cost Δ ($)	ICE Insurance Cost Δ ($)	Total Insurance Cost Δ ($)
2034	$115,584	$27,122	$462,292	$2,655,991	$3,260,989
2035	$115,770	$31,382	$518,545	$2,797,516	$3,463,212
2036	$114,516	$49,629	$775,699	$2,742,123	$3,681,967
2037	$111,995	$56,639	$849,362	$2,678,852	$3,696,847
2038	$108,428	$53,802	$775,704	$2,518,999	$3,456,934
2039	$104,898	$63,938	$885,780	$2,383,145	$3,437,761
2040	$101,393	$73,034	$970,754	$2,274,718	$3,419,899
2041	$97,920	$81,185	$1,033,140	$2,197,846	$3,410,091
2042	$94,475	$88,456	$1,074,885	$2,147,585	$3,405,400
2043	$91,065	$94,959	$1,098,715	$2,121,032	$3,405,772
2044	$87,700	$100,744	$1,106,129	$2,108,689	$3,403,263
2045	$84,371	$105,822	$1,098,072	$2,108,628	$3,396,893
Total	$1,716,297	$842,886	$10,932,679	$37,096,592	$50,588,454

3.2.4Vehicle Registration and License Fees

Staff expects a small change in vehicle license fees (Table 39) based on application of a 0.65 percent factor (Table 51) to price increases in ONMCs to comply with the Proposal. ZEMs are initially projected to cost more than ICE ONMCs and ICE ONMCs are projected to experience a modest increase in cost due to technology enhancements necessary to meet proposed emission standards. No additional ZEM fees are applicable.[80] Staff confirmed this through the California DMV vehicle registration fee calculator web page by entering ICE ONMC and ZEM registration fee queries with the only difference being the motive power field.[81] Detailed estimates were given that were the same in both cases with no line item related to electric vehicles.

Table 39. Increased ONMC Registration Cost Due to Projected Increased ONMC Prices.

CY	Increased Registration Fees (ICE)	Increased Registration Fees (ZEM)	Increased Registration Fees (all ONMC)
2028	$29,572	$4,358	$33,930
2029	$73,826	$7,827	$81,654
2030	$157,381	$10,468	$167,849

[80] California Revenue and Taxation Code §10753.2, Vehicle License Fees.

[81] California Department of Motor Vehicles (DMV), Results California DMV Vehicle Registration Fee Calculator: ZEM vs ICE ONMC. (https://www.dmv.ca.gov/wasapp/FeeCalculatorWeb/newVehicleForm.do. Generated on March 29, 2022).

CY	Increased Registration Fees (ICE)	Increased Registration Fees (ZEM)	Increased Registration Fees (all ONMC)
2031	$225,675	$12,416	$238,091
2032	$282,017	$13,774	$295,790
2033	$318,519	$53,592	$372,112
2034	$345,279	$78,650	$423,929
2035	$363,677	$86,541	$450,218
2036	$356,476	$122,180	$478,656
2037	$348,251	$132,339	$480,590
2038	$327,470	$121,932	$449,401
2039	$309,809	$137,100	$446,909
2040	$295,713	$148,874	$444,587
2041	$285,720	$157,592	$443,312
2042	$279,186	$163,516	$442,702
2043	$275,734	$167,016	$442,750
2044	$274,130	$168,295	$442,424
2045	$274,122	$167,474	$441,596
Total	$4,822,557	$1,753,942	$6,576,499

3.3 Costs on Typical Businesses

ONMC manufacturers are the typical large businesses that will be affected by the Proposal because they are entities directly regulated and required to comply. The Proposal allows for a gradual ramp up of costs due to incremental compliance requirements on ZEM along with early adoption multipliers on ZEM credits and ZEM credit banking.

The Proposal will impose a wide range of costs on ONMC manufacturers depending upon many factors, but most prominently on whether they are focused on building ZEMs or ICE ONMCs and whether they take advantage of building Tier II and III ZEMs in the early years of the regulation where the ZEM credit multipliers are highest, as shown in section 1.4.1.1. Further, it should also be noted that manufacturers who only make ZEMs have no compliance obligation and only must certify with CARB for the purpose of earning tradeable credits if they choose.

It is estimated that there are 13 manufacturers that would be subject to ZEM credit obligations and increased ICE ONMC production costs associated with meeting more stringent exhaust and evaporative emissions standards. None of these 13 subject manufacturers are California businesses. Based on the total direct compliance cost estimated for all vehicle manufacturers discussed in sections 3.1.1.1, 3.1.2.1, 3.1.2.5, and 3.1.2.7, staff estimated the total manufacturer cost as shown in Table 40. Staff estimated the cost to an average individual manufacturer, by dividing that total number by 13, the number of manufacturers that are most significantly impacted by the Proposal. It is important to note that these costs will likely be passed on to consumers in the form of higher prices as is currently happening with ZEMs already on the market.

Table 40 shows that manufacturer's compliance requirements for both ZEM and ICE ONMCs will cause low average costs as the program phases in of approximately $381,825, to a high of $2,416,511 in 2036 when peak ZEM requirements kick in, that will dramatically taper down in the following years as ZEM prices are expected to fall. No manufacturers with a compliance requirement are located in California. It is assumed the direct costs imposed on these manufacturers by the Proposal would be passed on through higher vehicle prices to end-users in California, although much of this will be offset by fueling and maintenance savings. Although there may be additional small business impacts to some small businesses discussed in section 3.4, staff is not aware of any other large business affected by this regulation. Note, aside from the ICE evaporative emissions SHED capital costs, no amortization or taxes have been included in this part of the analysis.

Table 40. Vehicle Manufacturer Sector Costs and Average Individual Manufacturer Costs.

Year	ZEM Cost	ICE Exhaust Cost	ICE Evaporative Cost	ICE Warranty Cost	Total Manufacturer Costs	Average Individual Manufacturer Cost
2028	$446,979	$842,118	$3,306,233	$368,401	$4,963,731	$381,825
2029	$421,544	$3,381,192	$3,903,594	$739,584	$8,445,915	$649,686
2030	$397,374	$9,425,031	$5,325,513	$1,236,949	$16,384,866	$1,260,374
2031	$374,597	$9,460,011	$5,333,743	$1,241,539	$16,409,890	$1,262,299
2032	$352,963	$9,492,696	$5,341,432	$1,245,829	$16,432,921	$1,264,071
2033	$8,326,648	$8,270,315	$5,053,846	$1,085,403	$22,736,212	$1,748,939
2034	$9,050,669	$8,046,337	$5,001,151	$1,056,008	$23,154,165	$1,781,090
2035	$9,376,266	$7,852,933	$4,955,650	$1,030,625	$23,215,474	$1,785,806
2036	$21,277,399	$5,143,864	$4,318,294	$675,085	$31,414,642	$2,416,511
2037	$19,093,436	$5,163,013	$4,322,799	$677,598	$29,256,846	$2,250,527
2038	$17,023,966	$5,181,366	$1,219,007	$680,007	$24,104,345	$1,854,180
2039	$15,062,820	$5,198,659	$1,223,075	$682,276	$22,166,830	$1,705,141
2040	$13,205,600	$5,215,049	$1,226,931	$684,427	$20,332,007	$1,564,001
2041	$11,447,351	$5,230,472	$1,230,560	$686,451	$18,594,834	$1,430,372
2042	$9,783,539	$5,244,930	$1,233,961	$688,349	$16,950,779	$1,303,906
2043	$8,209,992	$5,258,533	$1,237,162	$690,134	$15,395,821	$1,184,294
2044	$6,722,297	$5,271,174	$1,240,136	$691,793	$13,925,401	$1,071,185
2045	$5,316,357	$5,282,753	$1,242,860	$693,313	$12,535,282	$964,252
Total	$155,889,796	$108,960,447	$56,715,947	$14,853,771	$336,419,960	$25,878,458

3.4 Costs on Small Businesses

Some small businesses employing ZEMs for delivery and transport would experience increased vehicle prices in the early years of the regulation along with offsetting decreased maintenance and fuel savings over the life of the vehicle. Because it is hard to quantify businesses that specifically rely on motorcycles in their business plans these costs and savings are captured under direct costs to individuals as discussed in Section 3.5.

3.5 Costs to Individuals

While this Proposal only directly regulates manufacturers, staff estimates that manufacturers will see increased costs as a result of this rule and will pass the costs through to consumers (individual consumers and government fleets) in the state through price increases. Note that staff disaggregates government costs from individual costs in this analysis by subtracting out 0.65 percent of all retail and operation costs to individuals, as that is the percent of all government fleets given in Table 51 in section 4.

This analysis looks at both the increased vehicle costs and associated operational costs and savings to the individual consumer. The analysis looks at the aggregate costs and benefits from 2028 to 2045 and then disaggregates to the individual consumer. Costs are considered in section 3.5.1, savings in section 3.5.2, and the net impact of cost and savings in section 3.5.3. Although staff does not calculate the impact of various rebate programs benefiting consumers of ZEMs, these programs are discussed in section 3.5.4.

3.5.1Consumer Costs

Direct manufacturing costs passed to ONMC consumers in this Proposal are discussed in section 3.1. To help visualize how all these costs may come together for an individual consumer consider the costs of a Tier III ZEM buyer in 2035 once the full ZEM sales requirements of the regulation are implemented. In this case the owner would experience upfront taxed and sales incremental cost of $1,617 amortized over 5 years, with increased annual costs in registration and insurance while also experiencing annualized operational savings from decreased fuel and maintenance costs. Table 41 shows how these incremental costs and savings impact ownership over ten years resulting in annual operations net savings after five years and net lifetime savings within ten years.

Table 41. Estimated Incremental Ownership Costs and Savings Over Ten Years for a Tier III ZEM Owner.

CY	Purchase Cost	Insurance Cost	Registration Cost	Maintenance Savings	Fuel Savings	Net Annual Cost	Lifetime Incremental Cost
2035	$374	$74	$10	$107	$122	$229	$229
2036	$374	$67	$9	$107	$123	$219	$448
2037	$374	$60	$8	$107	$125	$209	$657
2038	$374	$52	$7	$107	$127	$198	$855

2039	$374	$45	$6	$107	$127	$190	$1,045
2040	$0	$37	$5	$107	$130	-$196	$849
2041	$0	$30	$4	$107	$132	-$205	$644
2042	$0	$22	$3	$107	$132	-$214	$430
2043	$0	$19	$2	$107	$134	-$220	$209
2044	$0	$15	$2	$107	$134	-$225	-$15

Table 42 takes the numbers from Table 41 and explicitly lays out the numbers of costs and savings over the given timeframe.

Table 42. Individual Owner Explicit Costs and Savings.

CY	Costs Only 2020$	Savings Only 2020$
2035	$458	$229
2036	$450	$231
2037	$441	$232
2038	$433	$234
2039	$424	$235
2040	$42	$238
2041	$34	$239
2042	$25	$240
2043	$21	$241
2044	$17	$242
Average after 1st year	$210	$237
Totals	$2,345	$2,360

The total costs to all California individual consumers are appropriately taxed, amortized and summarized in Table 43. Amortization to smooth out costs assumes a 5-year period at 5 percent interest. Costs are disaggregated to ZEM and ICE. Both include costs related to increased cost of insurance and registration fees due to changes in overall vehicle cost. ZEM costs also include the retail price differential with ICE. Whereas additional ICE costs are from technology compliance costs along with increased warranty costs.

Table 43. ONMC Proposal Annualized Statewide Total Cost Increase to Individual Consumers.

CY	ZEM Cost	ICE Cost	Total Annual Cost
2028	$204,928	$2,042,687	$2,247,615
2029	$392,662	$5,393,104	$5,785,766
2030	$564,189	$11,901,021	$12,465,209
2031	$721,214	$18,109,483	$18,830,697
2032	$865,047	$24,227,473	$25,092,519

CY	ZEM Cost	ICE Cost	Total Annual Cost
2033	$4,158,075	$27,818,343	$31,976,418
2034	$7,604,139	$30,038,011	$37,642,150
2035	$11,032,870	$29,275,392	$40,308,262
2036	$19,164,063	$27,202,415	$46,366,478
2037	$26,265,918	$25,114,325	$51,380,243
2038	$29,431,244	$22,716,860	$52,148,103
2039	$31,812,439	$20,458,068	$52,270,507
2040	$33,347,339	$18,327,220	$51,674,560
2041	$29,743,469	$17,493,496	$47,236,965
2042	$26,310,149	$16,687,474	$42,997,623
2043	$23,041,511	$16,681,396	$39,722,907
2044	$19,930,887	$16,689,116	$36,620,003
2045	$16,971,046	$16,708,395	$33,679,441
Total	$281,561,187	$346,884,279	$628,445,466

The cost per unit of the regulation is calculated by aggregating all the costs of the regulation over all the ONMC units impacted by the regulation as shown in Table 44. The lower cost per units in the early years is due to the combined effects of amortization of costs, high ZEM credit multipliers early in the program and the impact of credits accumulated from early baseline sales of ZEMs prior to compliance obligations. See Figure 7 of section 2.1.2 to see how credits accumulate in early years due to baseline sales. Decreasing costs after 2037 occurs due to the combined effect of decreasing cost differentials between ICE and ZEM motorcycles and related taxes and fees.

Table 44. Annualized Aggregated Costs of Proposal Over All Units Impacted.

CY	Total Aggregated Costs	Total ONMC Impacted by Proposal (units)	Cost Per ONMC
2028	$2,247,615	15,567	$144
2029	$5,785,766	30,357	$191
2030	$12,465,209	50,173	$248
2031	$18,830,697	50,359	$374
2032	$25,092,519	50,533	$497
2033	$31,976,418	50,839	$629
2034	$37,642,150	51,044	$737
2035	$40,308,262	51,251	$786
2036	$46,366,478	51,678	$897
2037	$51,380,243	51,846	$991
2038	$52,148,103	52,006	$1,003
2039	$52,270,507	52,154	$1,002
2040	$51,674,560	52,293	$988

CY	Total Aggregated Costs	Total ONMC Impacted by Proposal (units)	Cost Per ONMC
2041	$47,236,965	52,421	$901
2042	$42,997,623	52,538	$818
2043	$39,722,907	52,645	$755
2044	$36,620,003	52,743	$694
2045	$33,679,441	52,828	$638
Total	$628,445,466	$873,275	$720

3.5.2Direct Consumer Savings

Direct savings to ONMC consumers in this Proposal are discussed in section 3.2. The total savings to all California consumers are summarized in Table 45. Savings are disaggregated to ZEM and ICE. They occur through operating cost savings of fuel savings from ZEM use and ICE evaporative emissions reductions, along with maintenance savings from ZEM use.

Table 45. ONMC Proposal Annualized Statewide Total Savings to Individual Consumers.

CY	ZEM Savings	ICE Aggregated Savings	Total Annual Savings
2028	$197,825	$8,976	$206,801
2029	$387,350	$26,799	$414,150
2030	$570,798	$56,461	$627,259
2031	$749,161	$85,938	$835,099
2032	$921,586	$114,535	$1,036,121
2033	$2,627,968	$137,239	$2,765,208
2034	$4,568,853	$158,143	$4,726,996
2035	$6,681,520	$177,745	$6,859,265
2036	$12,120,100	$187,403	$12,307,503
2037	$17,358,645	$196,835	$17,555,480
2038	$22,441,660	$207,025	$22,648,685
2039	$27,120,719	$214,922	$27,335,642
2040	$31,966,543	$225,691	$32,192,234
2041	$36,471,049	$234,738	$36,705,787
2042	$40,685,162	$242,850	$40,928,012
2043	$44,931,784	$251,406	$45,183,189
2044	$48,813,380	$258,453	$49,071,833
2045	$52,213,127	$263,624	$52,476,751
Total	$350,827,232	$3,048,784	$353,876,015

The savings per unit of the regulation is given by aggregating all the savings of the regulation over all the ONMC units impacted by the regulation as shown in Table 46. Note the increasing savings over units impacted over time is a function that the Proposal results in a large long-term operational savings of fuel and maintenance over an ever-increasing ZEM proportion of the total fleet.

Table 46. Aggregated Savings of Proposal Over Units Impacted.

Year	Total Annual Savings	Total ONMC Impacted by Proposal (units)	Savings per ONMC
2028	$206,801	15,567	$13
2029	$414,150	30,357	$14
2030	$627,259	50,173	$13
2031	$835,099	50,359	$17
2032	$1,036,121	50,533	$21
2033	$2,765,208	50,839	$54
2034	$4,726,996	51,044	$93
2035	$6,859,265	51,251	$134
2036	$12,307,503	51,678	$238
2037	$17,555,480	51,846	$339
2038	$22,648,685	52,006	$436
2039	$27,335,642	52,154	$524
2040	$32,192,234	52,293	$616
2041	$36,705,787	52,421	$700
2042	$40,928,012	52,538	$779
2043	$45,183,189	52,645	$858
2044	$49,071,833	52,743	$930
2045	$52,476,751	52,828	$993
Total	$353,876,015	$873,275	$405

3.5.3Net Impact on Consumers

The analysis of the impact to individual consumers combines the analysis of costs from section 3.5.1 and savings from section 3.5.2. Table 47 illustrates the aggregated statewide total costs to California consumers through calendar year 2045. As the table shows, the Proposal will turn into a net annual cost savings by calendar year 2043, due to decreasing battery costs and continued fuel and maintenance savings.

Table 47. Aggregated Net Statewide Cost of Proposal to California Individual Consumers.

CY	Total Aggregated Costs	Total Aggregated Savings	Net Aggregated Costs
2028	$2,247,615	$206,801	$2,040,814
2029	$5,785,766	$414,150	$5,371,616
2030	$12,465,209	$627,259	$11,837,950

CY	Total Aggregated Costs	Total Aggregated Savings	Net Aggregated Costs
2031	$18,830,697	$835,099	$17,995,598
2032	$25,092,519	$1,036,121	$24,056,398
2033	$31,976,418	$2,765,208	$29,211,210
2034	$37,642,150	$4,726,996	$32,915,154
2035	$40,308,262	$6,859,265	$33,448,997
2036	$46,366,478	$12,307,503	$34,058,975
2037	$51,380,243	$17,555,480	$33,824,763
2038	$52,148,103	$22,648,685	$29,499,418
2039	$52,270,507	$27,335,642	$24,934,865
2040	$51,674,560	$32,192,234	$19,482,325
2041	$47,236,965	$36,705,787	$10,531,177
2042	$42,997,623	$40,928,012	$2,069,611
2043	$39,722,907	$45,183,189	-$5,460,283
2044	$36,620,003	$49,071,833	-$12,451,830
2045	$33,679,441	$52,476,751	-$18,797,310
Total	$628,445,466	$353,876,015	$274,569,451

Table 48 shows the net aggregated cost per ONMC impacted by the Proposal. As the table shows, the savings will overtake costs by calendar year 2043, due to decreasing battery costs and continued fuel and maintenance savings.

Table 48. Aggregated Net Cost Per Unit of ONMCs impacted by the Proposal.

CY	Cost Per ONMC	Savings Per ONMC	Net Cost per ONMC
2028	$144	$13	$131
2029	$191	$14	$177
2030	$248	$13	$236
2031	$374	$17	$357
2032	$497	$21	$476
2033	$629	$54	$575
2034	$737	$93	$645
2035	$786	$134	$653
2036	$897	$238	$659
2037	$991	$339	$652
2038	$1,003	$436	$567
2039	$1,002	$524	$478
2040	$988	$616	$373
2041	$901	$700	$201
2042	$818	$779	$39

CY	Cost Per ONMC	Savings Per ONMC	Net Cost per ONMC
2043	$755	$858	-$104
2044	$694	$930	-$236
2045	$638	$993	-$356
Totals	$720	$405	$314

Note that government also is a consumer of motorcycles in California as well, although it is a very small percent of the total population as shown in Table 51. However, for completeness in evaluating the total cost impact of the regulation it is necessary to add those costs in as well. Table 49 summarizes these costs.

Table 49. Direct Costs of Regulation to All Consumers (Including Individuals and Government) (Thousands 2020$).

Year	Vehicle Purchase Cost	Warranty cost	Insurance Cost	Registration Cost	Maintenance Savings	Fuel Savings	Total cost	Total saving	Net Cost
2028	$1,882	$85	$261	$34	$96	$113	$2,262	$208	$2,054
2029	$4,858	$256	$628	$82	$186	$230	$5,824	$417	$5,407
2030	$10,547	$542	$1,291	$168	$272	$360	$12,547	$631	$11,916
2031	$16,057	$828	$1,831	$238	$352	$488	$18,955	$841	$18,114
2032	$21,570	$1,116	$2,275	$296	$429	$614	$25,258	$1,043	$24,215
2033	$27,671	$1,282	$2,862	$372	$1,220	$1,563	$32,187	$2,783	$29,403
2034	$32,850	$1,355	$3,261	$424	$2,118	$2,641	$37,890	$4,758	$33,132
2035	$35,353	$1,307	$3,463	$450	$3,090	$3,815	$40,573	$6,904	$33,669
2036	$41,335	$1,176	$3,682	$479	$5,571	$6,818	$46,672	$12,388	$34,283
2037	$46,496	$1,045	$3,697	$481	$7,928	$9,743	$51,718	$17,671	$34,047
2038	$47,633	$951	$3,457	$449	$10,150	$12,648	$52,491	$22,798	$29,693
2039	$47,865	$865	$3,438	$447	$12,257	$15,258	$52,614	$27,515	$25,099
2040	$47,365	$785	$3,420	$445	$14,264	$18,140	$52,015	$32,404	$19,610
2041	$42,907	$788	$3,410	$443	$16,178	$20,769	$47,548	$36,947	$10,600
2042	$38,642	$790	$3,405	$443	$18,002	$23,195	$43,280	$41,197	$2,083
2043	$35,343	$793	$3,406	$443	$19,746	$25,734	$39,984	$45,480	-$5,496
2044	$32,220	$795	$3,403	$442	$21,413	$27,982	$36,861	$49,395	-$12,534
2045	$29,266	$797	$3,397	$442	$22,997	$29,825	$33,901	$52,822	-$18,921
Total	$559,858	$15,557	$50,588	$6,576	$156,269	$199,936	$632,580	$356,204	$276,376

3.5.4Vehicle Purchase Incentives to Offset Cost to Consumers

There are several zero-emissions vehicle purchase incentives available to California ZEM buyers today, though additional incentives exist for specific income groups: The federal tax credit, the California Clean Vehicle Rebate Project (CVRP), and the California Low Carbon Fuels Standard Clean Fuels Reward (LCFS CFR).[82,83,84] However, staff are not including any of these incentives in the analysis due to the uncertainty that these incentives will be available during the time period of the regulation.

The federal tax credit is only for the first 200,000 cumulative vehicle sales by any given vehicle manufacturer and many of the major manufacturers will be over the limit by 2026, unless Congress changes the law. Additionally, applicants for the tax credit would need a tax liability of at least $7,500 to take full advantage of the program, which means a realistic analysis would need to estimate the varying household income and tax liability levels of ZEM purchasers.

The California CVRP is subject to annual funding by the Legislature and the program itself is intended to phase out in the next few years. As the number of new ZEMs sold in California increases each year, the allocated funds will have to be stretched even further with stricter restrictions on household income and vehicle MSRP. It is unknown whether funds will be available during the time of the regulation, or if they are, what amount of rebate may be available to different income groups for a ZEM purchase.

The California LCFS CFR provides money back at the point of sale of new ZEMs. However, funds for the LCFS CFR program are based on funds held by electric utility companies based on their LCFS credit holding, and the varying market value of LCFS credits. The amount of funds available in the long-term, including how electric utilities would allocate these funds, is unknown.

3.6 Total Economic Impact and Cost Effectiveness of the Proposal

The metric to quantify cost-effectiveness of the Proposal is the ratio of total direct costs and savings divided by the weighted ton of emissions reduced. The total 2028-2045 direct costs and savings include the ownership costs to both individuals and government as discussed in sections 3.5, 4.1, and 4.2 and totals approximately $276 million. The total 2028-2045 weighted emissions reductions are determined by summing tons of NOx, ROG and PM (PM

[82] U.S. Department of Energy (U.S. DOE), Tax Incentives. (https://www.fueleconomy.gov/feg/taxevb.shtml. Accessed 10/1/21).

[83] California Clean Vehicle Rebate Project (CCVRP), (https://cleanvehiclerebate.org/en/eligible-vehicles. Accessed 4/26/22).

[84] California Clean Fuel Reward (https://cleanfuelreward.com/. Accessed 4/26/22).

is weighted by multiply by 20).[85] The cumulative emissions for these pollutants can be found in section 2.1.3 and are weighted and summed to get approximately 21,909 tons. The resulting cost effectiveness is given in Table 50.

Table 50. Cost Effectiveness of Proposal in Dollar per Weighted Ton of Emissions Reduced.

	Combined Direct Cost and Savings ($)	Total Weighted Emissions Reduced (tons)	Cost Per Ton Reduced ($)
Proposal	$276,375,810	21,909	$12,615

It should be noted that cumulative costs and benefits as calculated through 2045 will tend to bias this Proposal toward appearing less cost effective than it really is when considering that much of the cost is experienced in the upfront purchase price differential between ZEMs and conventional ICE ONMCs. However, the savings of the Proposal occurs over the life of the vehicle. Thus, while much of the direct costs are included through 2045, many of the benefits of ongoing emissions reductions and reduced fuel and maintenance costs do not get captured in the same period and thus do not get considered in this analysis.

4 Fiscal Impacts

The Proposal will impact state and local government expenditures through the purchase and operation of new vehicles and will impact revenues generated from a variety of state and local taxes and vehicle registration fee revenues that are collected.

These revenues, particularly those from state and local gasoline taxes and registration fees, are used to fund transportation projects across the state including road maintenance, construction of state highways and local streets, transit facilities and operation, and active transportation projects. Thus, increases or decreases will impact funds available for these projects at the State, county, and local levels for use on road and transportation infrastructure improvements.

To determine the proportional government costs and savings of this regulation due to ownership and operation of ONMCs in compliance with this regulation relative to non-government registrations, staff analyzed the California DMV database from 2017 to 2020 for new registrations by government entities. Staff aggregated these into the categories of local, state and federal in Table 51.

[85] CARB, 2017 Carl Moyer Program Guidelines; Appendix C: COST-EFFECTIVENESS CALCULATION METHODOLOGY.

Table 51. New DMV Government ONMC Registrations as a Percentage of All New ONMC Registrations.

	2017	2018	2019	2020	Average
% Local	0.61%	0.60%	0.61%	0.43%	0.56%
% State	0.06%	0.16%	0.11%	0.03%	0.09%
% Federal	0.00%	0.00%	0.00%	0.00%	0.00%
% Total Government	0.67%	0.76%	0.72%	0.46%	0.65%

4.1 Local government

4.1.1 Local Government Fleet Cost

Local governments are assumed to incur an incremental cost from the purchase of new vehicles, while also realizing operational savings from the use of ZEMs. Local government ZEM fleets are estimated to make up about 0.56 percent of California's new ONMC vehicle fleet sales as discussed in section 4. Thus, local government fleets would realize about 0.56 percent of the statewide vehicle cost and operational savings resulting from the proposed regulation. This statewide change in spending by local governments is reflected in Table 52. These are directly due to local government fleet costs such as police motorcycle fleets.

Table 52. Proposal Impacts to Statewide Local Government Fleet Spending (2020$).

CY	Vehicle Purchase Spending (with tax, amortized)	Vehicle Warranty Spending (amortized)	Vehicle Insurance Spending	Vehicle Registration and License Fees Spending	Maintenance Savings	Fuel Savings	Net Impact
2028	-$10,607	-$479	-$1,471	-$191	$538	$635	-$11,575
2029	-$27,375	-$1,442	-$3,539	-$460	$1,050	$1,299	-$30,467
2030	-$59,428	-$3,052	-$7,275	-$946	$1,531	$2,027	-$67,143
2031	-$90,476	-$4,668	-$10,320	-$1,342	$1,986	$2,751	-$102,069
2032	-$121,545	-$6,289	-$12,821	-$1,667	$2,419	$3,457	-$136,445
2033	-$155,918	-$7,222	-$16,129	-$2,097	$6,876	$8,808	-$165,682
2034	-$185,104	-$7,634	-$18,375	-$2,389	$11,932	$14,879	-$186,691
2035	-$199,206	-$7,366	-$19,515	-$2,537	$17,411	$21,494	-$189,719
2036	-$232,912	-$6,628	-$20,747	-$2,697	$31,390	$38,417	-$193,178
2037	-$261,995	-$5,889	-$20,831	-$2,708	$44,670	$54,903	-$191,850
2038	-$268,405	-$5,361	-$19,479	-$2,532	$57,191	$71,270	-$167,317
2039	-$269,708	-$4,875	-$19,371	-$2,518	$69,066	$85,979	-$141,428
2040	-$266,892	-$4,424	-$19,270	-$2,505	$80,377	$102,214	-$110,501
2041	-$241,770	-$4,439	-$19,215	-$2,498	$91,162	$117,029	-$59,732
2042	-$217,741	-$4,453	-$19,189	-$2,495	$101,437	$130,702	-$11,739
2043	-$199,152	-$4,466	-$19,191	-$2,495	$111,266	$145,008	$30,970
2044	-$181,556	-$4,479	-$19,177	-$2,493	$120,656	$157,673	$70,625
2045	-$164,906	-$4,490	-$19,141	-$2,488	$129,586	$168,056	$106,616

CY	Vehicle Purchase Spending (with tax, amortized)	Vehicle Warranty Spending (amortized)	Vehicle Insurance Spending	Vehicle Registration and License Fees Spending	Maintenance Savings	Fuel Savings	Net Impact
Total	-$3,154,695	-$87,658	-$285,056	-$37,057	$880,544	$1,126,598	-$1,557,325

The statewide change in tax revenues and fees by local governments is reflected in Table 53. These are due to changes in consumer purchases due to the Proposal.

Table 53. Proposal Impacts to Statewide Local Government Revenues (2020$).

Year	Vehicle Sales Tax Revenue Impact	Gasoline Sales Tax Revenue Impact	Gasoline Local Excise Tax Revenue Impact	Utility User Fee Revenue Impact	Total Revenue Impact
2028	$359,849	-$6,821	-$10,514	$2,773	$345,286
2029	$568,869	-$13,776	-$21,017	$5,494	$539,571
2030	$1,087,443	-$21,029	-$31,530	$8,109	$1,042,992
2031	$1,053,338	-$28,160	-$41,506	$10,629	$994,300
2032	$1,054,041	-$35,127	-$50,992	$13,093	$981,014
2033	$1,526,000	-$93,789	-$135,050	$37,610	$1,334,771
2034	$1,559,021	-$160,869	-$230,172	$65,944	$1,233,925
2035	$1,565,895	-$234,266	-$333,076	$97,118	$1,095,670
2036	$2,196,844	-$420,502	-$593,650	$175,360	$1,358,051
2037	$2,040,688	-$599,987	-$841,192	$249,655	$849,165
2038	$1,743,481	-$773,873	-$1,074,608	$319,155	$214,155
2039	$1,603,218	-$933,400	-$1,295,988	$384,839	-$241,331
2040	$1,470,364	-$1,100,605	-$1,506,855	$448,556	-$688,539
2041	$1,344,558	-$1,255,912	-$1,707,923	$509,398	-$1,109,880
2042	$1,225,473	-$1,402,640	-$1,899,490	$568,910	-$1,507,746
2043	$1,112,817	-$1,549,129	-$2,082,722	$624,217	-$1,894,817
2044	$1,006,265	-$1,683,697	-$2,257,782	$678,008	-$2,257,206
2045	$905,512	-$1,802,466	-$2,424,248	$730,471	-$2,590,732
Total	$23,423,675	-$12,116,048	-$16,538,317	$4,929,338	-$301,352

4.1.2Local Sales Tax from Vehicle Sales

Sales taxes are levied in California to fund a variety of programs at the state and local level. The Proposal would increase the cost of ONMCs sold in the state in 2028 and subsequent model years. The average tax rate in California is 8.74 percent with 4.80 percent going to local governments.[86] Overall, state sales tax revenue may increase less than the direct increase from vehicle sales if overall spending does not increase. These revenue changes can be found in Table 53.

4.1.3 Utility Users Tax

Many cities and counties in California levy a Utility Users Tax on electricity. This tax varies by jurisdiction and ranges from 0 to 11 percent. A value of 3.53 percent was used in this analysis, representing a population-weighted average.[87] By increasing the amount of electricity used, there will be an increase in the amount of utility user tax revenue collected by cities and counties. These revenue changes can be found in Table 53.

4.1.4 Gasoline Taxes

Taxes on gasoline include a 51.1 cents per gallon state excise tax, an 18.4 cents per gallon federal excise tax, and a state and local sales tax that averages 3.7 percent across California.[88,89] Approximately 42 percent of the state excise tax is allocated to cities and counties and are used to fund transportation improvements in the state. The 3.7 percent sales tax revenue collected from gasoline sales goes to a variety of funds, some of which support transportation and local government operations, and others which support programs such as local criminal justice activities, local health, and social services programs.[90] Displacing gasoline fuel with electricity will decrease the amount of gasoline dispensed in the state, resulting in a reduction in tax revenue collected by local governments. These revenue changes can be found in Table 53.

4.1.5 Fiscal Impacts on Local Government

Table 55 shows the estimated fiscal impacts to local governments due to the proposed regulation, based on the fiscal aspect explained above. In the early years of the Proposal, local governments will experience a net gain due to taxes from higher ONMC purchase

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[86] CARB, Spreadsheet for California City and County Sales and Use Tax Rates, California Air Resources Board, July 2019.

[87] California State Controller's Office (SCO), User Utility Tax Revenue and Rates, (https://sco.ca.gov/Files-ARD-Local/LocRep/2017-18_Cities_TOT.pdf, Accessed June 2020).

[88] California Legislative Analyst's Office (LAO), Transportation, Frequently Asked Questions (https://lao.ca.gov/Transportation/FAQs, last accessed December 2021).

[89] Gasoline is exempt from the portion of state sales tax that supports the state General Fund and 2011 Realignment. Of the 3.7 percent, 1 percent is under State jurisdiction but goes towards various local revenue funds and is therefore included with the impacts to local government.

[90] Counties can adopt a sales tax increase for transportation programs. The passage of a local sales tax measure requires 2/3 of local voter approval, generally lasting 20 to 30 years. Twenty-five counties have implemented sales tax measures for their transportation needs; and four transit authorities have approved permanent local tax measures. A detailed description of the funds for the sales and use tax rates can be found here: California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate (web link: https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm. Accessed December 2021).

prices. But in later years, losses from gasoline taxes will have a heavier impact on local governments as more ZEMs displace gasoline motorcycles in California. By calendar year 2045, the total annual impact to local government will be a net loss of $2.5 million.

Table 54. Net Statewide Fiscal Impact to Local Government.

CY	Government Fleet Spending	Government Revenue	Net Fiscal Impact
2028	-$11,575	$345,286	$333,711
2029	-$30,467	$539,571	$509,104
2030	-$67,143	$1,042,992	$975,848
2031	-$102,069	$994,300	$892,231
2032	-$136,445	$981,014	$844,569
2033	-$165,682	$1,334,771	$1,169,088
2034	-$186,691	$1,233,925	$1,047,234
2035	-$189,719	$1,095,670	$905,952
2036	-$193,178	$1,358,051	$1,164,873
2037	-$191,850	$849,165	$657,315
2038	-$167,317	$214,155	$46,838
2039	-$141,428	-$241,331	-$382,759
2040	-$110,501	-$688,539	-$799,041
2041	-$59,732	-$1,109,880	-$1,169,611
2042	-$11,739	-$1,507,746	-$1,519,485
2043	$30,970	-$1,894,817	-$1,863,847
2044	$70,625	-$2,257,206	-$2,186,581
2045	$106,616	-$2,590,732	-$2,484,116
Total	-$1,557,325	-$301,352	-$1,858,677

4.2 State Government

4.2.1 State Fleet Cost

State governments are assumed to incur an incremental cost from the purchase of new vehicles, while also realizing operational savings from the use of ZEMs. State government ZEM fleets are estimated to make up about 0.09 percent of California's new ONMC vehicle fleet sales as discussed in section 4. Thus, State government fleets would realize about 0.09 percent of the statewide vehicle cost and operational savings resulting from the Proposal. This statewide change in spending by State governments is reflected in Table 55. These are directly due to State government fleet costs such as California Highway Patrol.

Table 55. Proposal Impacts to State Government Fleet Spending ($2020).

CY	Vehicle Purchase Spending (with tax, amortized)	Vehicle Warranty Spending (amortized)	Vehicle Insurance Spending	Vehicle Registration and License Fees Spending	Maintenance Savings	Fuel Savings	Net Impact
2028	-$1,696	-$77	-$235	-$31	$86	$101	-$1,851
2029	-$4,378	-$231	-$566	-$74	$168	$208	-$4,872
2030	-$9,503	-$488	-$1,163	-$151	$245	$324	-$10,737
2031	-$14,468	-$746	-$1,650	-$215	$318	$440	-$16,322
2032	-$19,436	-$1,006	-$2,050	-$267	$387	$553	-$21,819
2033	-$24,933	-$1,155	-$2,579	-$335	$1,100	$1,409	-$26,495
2034	-$29,600	-$1,221	-$2,938	-$382	$1,908	$2,379	-$29,854
2035	-$31,855	-$1,178	-$3,121	-$406	$2,784	$3,437	-$30,338
2036	-$37,245	-$1,060	-$3,318	-$431	$5,020	$6,143	-$30,891
2037	-$41,896	-$942	-$3,331	-$433	$7,143	$8,780	-$30,679
2038	-$42,921	-$857	-$3,115	-$405	$9,145	$11,397	-$26,756
2039	-$43,129	-$780	-$3,098	-$403	$11,044	$13,749	-$22,616
2040	-$42,679	-$707	-$3,082	-$401	$12,853	$16,345	-$17,670
2041	-$38,662	-$710	-$3,073	-$399	$14,578	$18,714	-$9,552
2042	-$34,819	-$712	-$3,069	-$399	$16,221	$20,901	-$1,877
2043	-$31,847	-$714	-$3,069	-$399	$17,793	$23,188	$4,952
2044	-$29,033	-$716	-$3,067	-$399	$19,294	$25,214	$11,294
2045	-$26,370	-$718	-$3,061	-$398	$20,722	$26,874	$17,049
Total	-$504,472	-$14,018	-$45,584	-$5,926	$140,809	$180,156	-$249,034

The change in tax revenues to State government is reflected in Table 56. These are the result of changes in consumer purchases due to the Proposal.

Table 56. Proposal Impacts to State Government Revenues ($2020).

Year	Vehicle Sales Tax Revenue Impact	Energy Resources Fee Revenue Impact	Excise Tax Revenue Impact	Vehicle Registration and License Fees Revenue Impact	Total Revenue Impact
2028	$295,106	$92	-$13,859	$33,930	$315,269
2029	$466,521	$179	-$27,704	$81,654	$520,650
2030	$891,795	$261	-$41,563	$167,849	$1,018,342
2031	$863,826	$339	-$54,713	$238,091	$1,047,542
2032	$864,402	$413	-$67,217	$295,790	$1,093,388
2033	$1,251,448	$1,174	-$178,021	$372,112	$1,446,713
2034	$1,278,529	$2,037	-$303,409	$423,929	$1,401,085
2035	$1,284,166	$2,972	-$439,055	$450,218	$1,298,300

Year	Vehicle Sales Tax Revenue Impact	Energy Resources Fee Revenue Impact	Excise Tax Revenue Impact	Vehicle Registration and License Fees Revenue Impact	Total Revenue Impact
2036	$1,801,597	$5,358	-$782,538	$478,656	$1,503,072
2037	$1,673,536	$7,624	-$1,108,844	$480,590	$1,052,907
2038	$1,429,801	$9,761	-$1,416,528	$449,401	$472,436
2039	$1,314,774	$11,788	-$1,708,348	$446,909	$65,124
2040	$1,205,823	$13,719	-$1,986,309	$444,587	-$322,180
2041	$1,102,651	$15,560	-$2,251,353	$443,312	-$689,831
2042	$1,004,991	$17,314	-$2,503,873	$442,702	-$1,038,866
2043	$912,604	$18,991	-$2,745,406	$442,750	-$1,371,061
2044	$825,222	$20,594	-$2,976,168	$442,424	-$1,687,927
2045	$742,596	$22,118	-$3,195,600	$441,596	-$1,989,290
Total	$19,209,389	$150,294	-$21,800,508	$6,576,499	$4,135,673

4.2.2State Sales Taxes from Vehicle Sales

Sales taxes are levied in California to fund a variety of programs. The Proposal would result in the sale of more expensive (higher upfront cost) vehicles. The population of new California-sold ONMCs over the entire state was used for this analysis. California sales tax at 8.74 percent was used in this analysis with 3.94 percent going to state government. Overall, state sales tax revenue may increase less than the direct increase from vehicle sales if overall business spending does not increase. These revenue changes can be found in Table 56.

4.2.3Vehicle Registration and License Fees

As discussed in section 3.2.4, staff expects a small change in vehicle license fees (Table 39) based on application of a 0.65 percent factor to price increases in ONMCs to comply with the Proposal. ZEMs are initially projected to cost more than ICE ONMCs and ICE ONMCs are projected to experience a modest increase in cost due to technology enhancements necessary to meet proposed emission standards. This cost increase to consumers results in a revenue gain to state government.

4.2.4Gasoline Taxes

Approximately 58 percent of the 51.1 cent per gallon state excise tax is allocated state funds such as the State Highway Account, State Highway Operation and Protection Program, State Transportation Improvement Program, and the Highway Users' Tax Account. These revenues are used to fund highway projects, prioritized road maintenance and rehabilitation projects, and local street and road projects. As discussed above, displacing gasoline fuel with electricity will decrease the amount of gasoline dispensed in the state, resulting in a reduction in excise tax revenue that is collected. These revenue changes can be found in Table 56.

4.2.5Energy Resources Fee

The Energy Resources Fee is a $0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities. The revenue collected is deposited into the Energy Resources Programs Account of the General Fund, which is used for ongoing electricity programs and projects deemed appropriate by the Legislature, including but not limited to, activities of the California Energy Commission (CEC). Increased use of ZEMs will result in increases in electricity use and increased revenue from the Energy Resources Fee. These revenue changes can be found in Table 56.

4.2.6CARB Staffing and Resources

The Proposal would have a small impact on State staffing resources. The Proposal is not expected to require more positions; existing staff who implement the current emission control program and who are developing this proposal will transition to implementing the new program.

4.2.7Fiscal Impacts on State Government

Table 57 shows the estimated fiscal impacts to State government due to the proposed regulation. In the early years of the Proposal, State government will experience a net gain due to taxes from higher ONMC purchase prices. But in later years, losses from gasoline taxes will have a heavier impact on State governments as more ZEMs displace gasoline motorcycles in California. By calendar year 2045, the total annual impact to State government will be a net loss of approximately $2.0 million mostly due to revenue losses. However, the cumulative impact will still be a net increase of $3.9 million.

Table 57. Net Fiscal Impact to State Government ($2020) (costs and revenue losses are negative values).

CY	Government Fleet Spending	Government Revenue	Net Fiscal Impact
2028	-$1,851	$315,269	$313,418
2029	-$4,872	$520,650	$515,778
2030	-$10,737	$1,018,342	$1,007,605
2031	-$16,322	$1,047,542	$1,031,220
2032	-$21,819	$1,093,388	$1,071,569
2033	-$26,495	$1,446,713	$1,420,218
2034	-$29,854	$1,401,085	$1,371,231
2035	-$30,338	$1,298,300	$1,267,961
2036	-$30,891	$1,503,072	$1,472,181
2037	-$30,679	$1,052,907	$1,022,228
2038	-$26,756	$472,436	$445,680
2039	-$22,616	$65,124	$42,508
2040	-$17,670	-$322,180	-$339,851

CY	Government Fleet Spending	Government Revenue	Net Fiscal Impact
2041	-$9,552	-$689,831	-$699,383
2042	-$1,877	-$1,038,866	-$1,040,743
2043	$4,952	-$1,371,061	-$1,366,108
2044	$11,294	-$1,687,927	-$1,676,634
2045	$17,049	-$1,989,290	-$1,972,241
Total	-$249,034	$4,135,673	$3,886,639

5 Macroeconomic Impacts

5.1 Methods for Determining Economic Impacts

This section describes the estimated total impact of the Proposal on the California economy. The Proposal will result in incremental costs and cost savings for individuals, businesses, and governments that purchase new vehicles. For new conventional ICE ONMCs, it is expected to have a price increase due to the new requirements under the Proposal. For new ZEMs, it is expected there are incremental costs for the vehicles, but operations and maintenance (O&M) savings compared to the conventional ICE ONMCs. These changes in expenditures will indirectly affect employment, output, and investment in sectors that supply goods and provide services to affected businesses. A summary of the results is provided in Section 5.4.

The direct impacts of the Proposal would lead to additional indirect and induced effects, like changes in personal income that affect consumer expenditures across other spending categories. The incremental total economic impacts of the Proposal are simulated relative to the baseline using cost data described in Section 3. The analysis focuses on incremental change in major macroeconomic indicators from 2028 to 2045 including employment, output growth, and Gross State Product (GSP). The years of the analysis are used to simulate the Proposal through more than 12 months post full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 3.0.0 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.[91] REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the Proposed Regulation, pursuant to the requirements of SB 617 (Calderon, Stats. 2011, Ch. 496) and the California Department of Finance.[92,93] Staff used the REMI single region, 160 sector model

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

[92] California Senate Bill 617. October 2011.

[93] DOF, Chapter 1: Standardized Regulatory Impact Analysis for Major Regulations - Order of Adoption. December 2013.

with the model reference case adjusted to reflect California Department of Finance's most current publicly available economic and demographic projections.

Specifically, the REMI model's National and Regional Control was updated to conform to the most recent California Department of Finance economic forecasts which include U.S. Real Gross Domestic Product, income, and employment, as well as California civilian employment by industry, released with the 2023-2024 May Revision to the Governor's Budget on May 12, 2023 and Department of Finance demographic forecasts for California population forecasts, last updated in July 2021.[94,95,96,97] After the Department of Finance economic forecasts end in 2026, CARB staff made assumptions that post-2026, economic variables would continue to grow at the same rate projected in the REMI baseline forecasts.

5.2 Inputs and Assumptions of the Assessment

The estimated economic impact of the Proposal 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 Proposal. The direct costs and savings estimated in Section 3 and the non-mortality related health benefits estimated in Section 2 are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[98]

The direct costs and cost-savings of the Proposal, as described in Section 3, include changes in upfront costs to individuals and governments that purchase new vehicles. Because economic impact is ultimately seen at the consumer level, and for those few businesses that own ONMCs, they are assumed to own small numbers, it is assumed that business purchases fall into the individual purchase category. While these costs are directly incurred by manufacturers, it is assumed that these costs will be passed to vehicle purchasers in California through a change in the average price of all ONMCs sold by the manufacturers in California. The change in vehicle costs is input into the economic model as an increase in the consumer price for ONMCs. CARB staff uses sports and recreational

[94] DOF. Economic Research Unit. National Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.
[95] DOF. Economic Research Unit. California Economic Forecast – Annual & Quarterly. Sacramento: California. November 2021.
[96] DOF. Economic Research Unit. National Deflators: Calendar Year averages: from 1929, April 2021. Sacramento: California. January 2022.
[97] DOF. Demographic Research Unit. Report P-3: Population Projections, California, 2010-2060 (Baseline 2019 Population Projections; Vintage 2020 Release). Sacramento: California. July 2021.
[98] Refer to the Macroeconomic Appendix for a full list of REMI inputs for this analysis.

vehicles commodity in the REMI model as the majority of the ONMCs use is for recreation (Table 58).[99,100]

The consumer price policy variable affects the economy through changes in expenditures on goods and services based on consumers' response to a price increase for this consumption category. Staff evaluates the consumer response based on the elasticity of demand for sports and recreational vehicles. The default REMI demand elasticity of -1.94 is used in this analysis, which means that a price increase of one percent decreases sports and recreational vehicles demand by 1.94 percent.[101]

End-users of ZEMs will also realize operational savings related to their change in fuel and maintenance costs. The operations and maintenance cost savings are input into the model as a change in consumer spending for individuals. Similarly, individuals will see changes in taxes and fees paid related to gasoline and electricity consumptions, these changes are included in the fuel costs, and are modeled as consumer spending for individuals. All costs and savings are allocated to the end-use sectors, including personal (99.35 percent), local government (0.56 percent) and state government (0.09 percent). The percentage allocation to these end-use sectors is based on a staff analysis on the California Department of Motor Vehicles (DMV) data in which staff was able to disaggregate between government and non-government registration.

Costs and savings realized by end-users will result in corresponding changes in final demand for the industries supplying those particular goods or services, such as gasoline or vehicle repair, as shown in Table 58. Industries described below are followed by their North American Industry Classification System (NAICS) code in parenthesis.[102] Motorcycle manufacturers are primarily from out of state, but one major ZEM manufacturer is based in California. As purchases of ZEMs induced by the Proposal are estimated to be primarily from out of state manufacturers, demand changes for the corresponding ZEM supply chain, such as electric motors and batteries, cannot be directly modeled as a change in final demand in California. To account for this, staff estimates the share of demand that may be fulfilled by California businesses, based on California's share of national output of the industry (electrical equipment manufacturing (NAICS 3353)).[103] All other changes in demand are included in this analysis. The reduction in gasoline demand is modeled as a reduction in consumer spending for gasoline. This decreased demand for gasoline also results in decreases in demand for petroleum and coal products manufacturing (NAICS 324) and oil

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99 Institute for Social Research (ISR)at California State University (CSU), Sacramento, Analysis of the 2011 California Survey of On-Highway Motorcycles. August 2011.

100 If "new motor vehicles" commodity is used instead of "sports and recreational vehicles" in the REMI modeling, there wouldn't be significant differences in the modeling results.

101 Based on REMI Policy Insight Plus (v 2.5.0), the price elasticity for sports and recreational vehicles is -1.94.

102 U.S. Census. North American Industry Classification System, 2022.

103 Based on REMI Policy Insight Plus (v 2.5.0), California's share of national output is 4.6% for electrical equipment manufacturing (3353) in 2020.

and gas extraction (NAICS 211), as well as the industries which support the retail sales of gasoline to consumers, such as retail trade (NAICS 44-45) and wholesale trade (NAICS 42). The increased demand for electricity is assumed to be provided by the electric power generation, transmission, and distribution industry (NAICS 2211). The reduction in demand for vehicle maintenance and repair is modeled as a change in consumer spending for motor vehicle maintenance and repair, which maps to the automotive repair and maintenance industry (NAICS 8111) and retail trade (NAICS 44-45).

Table 58 illustrates the sources of changes in prices for end-users and corresponding changes in final demand by industry as described above.

Table 58. Source of Changes in Prices and Final Demand by Industry.

Source of Cost or Savings	Industries with Change in Prices (NAICS)	Industries with Changes in Final Demand (NAICS)
Vehicle prices	Individuals and government purchasers of all new ONMCs (including conventional ICE ONMCs and ZEMs)	Upfront cost: Electrical equipment manufacturing (3353)*
Vehicle warranty cost	Individuals and government purchasers of conventional ICE ONMCs	
Vehicle maintenance and repair	Individuals and government purchasers of ZEMs	Recurring cost: Automotive repair and maintenance (8111)
Gasoline	Individuals and government purchasers of conventional ICE ONMCs and ZEMs	Recurring cost: Petroleum and coal products manufacturing (324), retail trade (44-45), wholesale trade (42), and oil and gas extraction (211)
Electricity	Individuals and government purchasers of ZEMs	Recurring cost: Electric power generation, transmission and distribution (2211)
Motor vehicle insurance	Individuals and government purchasers of ZEMs	Recurring cost: Insurance carriers (5241)
Vehicle registration and license fee	Individuals and government purchasers of all ONMCs	Recurring cost: All consumption categories

*The Industry Sales policy variable is used here rather than Exogenous Final Demand.

In addition to these changes in prices and final demand for businesses, there will also be economic impacts as a result of the fiscal effects. The Proposal would result in changes in government spending in vehicle purchase, vehicle warranty cost, O&M costs for ZEMs, vehicle insurance cost, vehicle registration and license fee, sales tax revenues and fees, as described in Section 3. The fuel cost savings reduces the consumer spending for end-users, as described above. However, it reduces government revenue from fuel taxes. This change in government revenue is modeled as a change in state and local government spending, assuming this revenue reduction is not offset elsewhere.

The health benefits resulting from the emission reductions of the Proposal reduce healthcare costs for individuals on average. This reduction in healthcare cost is modeled as a decrease in spending for hospitals, with a reallocation of this spending towards other goods and increased savings. Costs associated with work loss days are modeled as the implied necessary increase in employment using REMI's baseline employment and compensation values. The implied increase in employment and REMI's baseline output is used to recalculate labor productivity under the Proposal. The percentage change in labor productivity is input into REMI's labor productivity policy variable for the support activities for all industries.

The GHG emission reductions benefits as valued through the social cost of carbon emissions (SC-CO2) represent the avoided damage from climate change worldwide per MT of CO2e. These benefits, or other ways to assess the benefits in California of reduced GHG emissions from the proposal, fall outside the scope and capability of our economic model and are not evaluated here.

5.3 Results of the assessment

The results from the REMI model provide estimates of the impact of the Proposal on the California economy. These results represent the annual incremental change from the implementation of the Proposal relative to the baseline scenario. Negative impacts reported here should be interpreted as a slowing of growth, and positive impacts represent an acceleration of growth resulting from the Proposal. The results are reported here in tables for every year from 2028 through 2045.

5.3.1 California Employment Impacts

Table 59 presents the impact of the Proposal on total employment in California across all industries. Employment comprises estimates of the number of jobs, full-time and part-time, by place of work for all industries. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included. The employment impacts represent the net change in employment, which consist of positive impacts for some industries and negative impacts for others. The Proposal is estimated to have a marginally negative impact on statewide employment starting 2028. The negative impact increases overtime and peaks in 2037 as the Proposal becomes more stringent. The results suggest that the estimated negative employment impact primarily results from the increased in upfront vehicle costs and changes in consumer spending induced by the Proposal; as more is expended on new vehicles, consumers will spend less on other goods and services within the economy.

The changes in statewide employment represent, at most, a 0.002 percent decrease relative to baseline California employment. The average annual job impact from 2028 to 2045 was a decrease of 334.

Table 59. Total California Employment Impacts.

Year	California Employment	Δ in Total Jobs	% Δ
2028	25,999,684	-21	0.000%
2029	26,108,477	-70	0.000%
2030	26,134,421	-155	-0.001%
2031	26,197,201	-258	-0.001%
2032	26,264,145	-352	-0.001%
2033	26,345,764	-419	-0.002%
2034	26,446,143	-482	-0.002%
2035	26,577,325	-493	-0.002%
2036	26,715,659	-509	-0.002%
2037	26,863,919	-548	-0.002%
2038	27,002,812	-536	-0.002%
2039	27,142,809	-504	-0.002%
2040	27,279,960	-460	-0.002%
2041	27,410,451	-372	-0.001%
2042	27,538,399	-291	-0.001%
2043	27,669,097	-228	-0.001%
2044	27,809,324	-179	-0.001%
2045	27,959,311	-143	-0.001%

The total employment impacts shown above are net of changes at the industry level. The overall trend in employment changes by major sector are illustrated in Figure 9. The services, and the retail and wholesale sectors are estimated to make up the largest proportion of job decreases. The services sector includes the automotive repair and maintenance industry, which is directly affected by the Proposal. The decreased consumer spending on gasoline and motor vehicle maintenance and repair will also affect the retail and wholesale sectors.

Figure 9. Change in Employment by Major Sector.

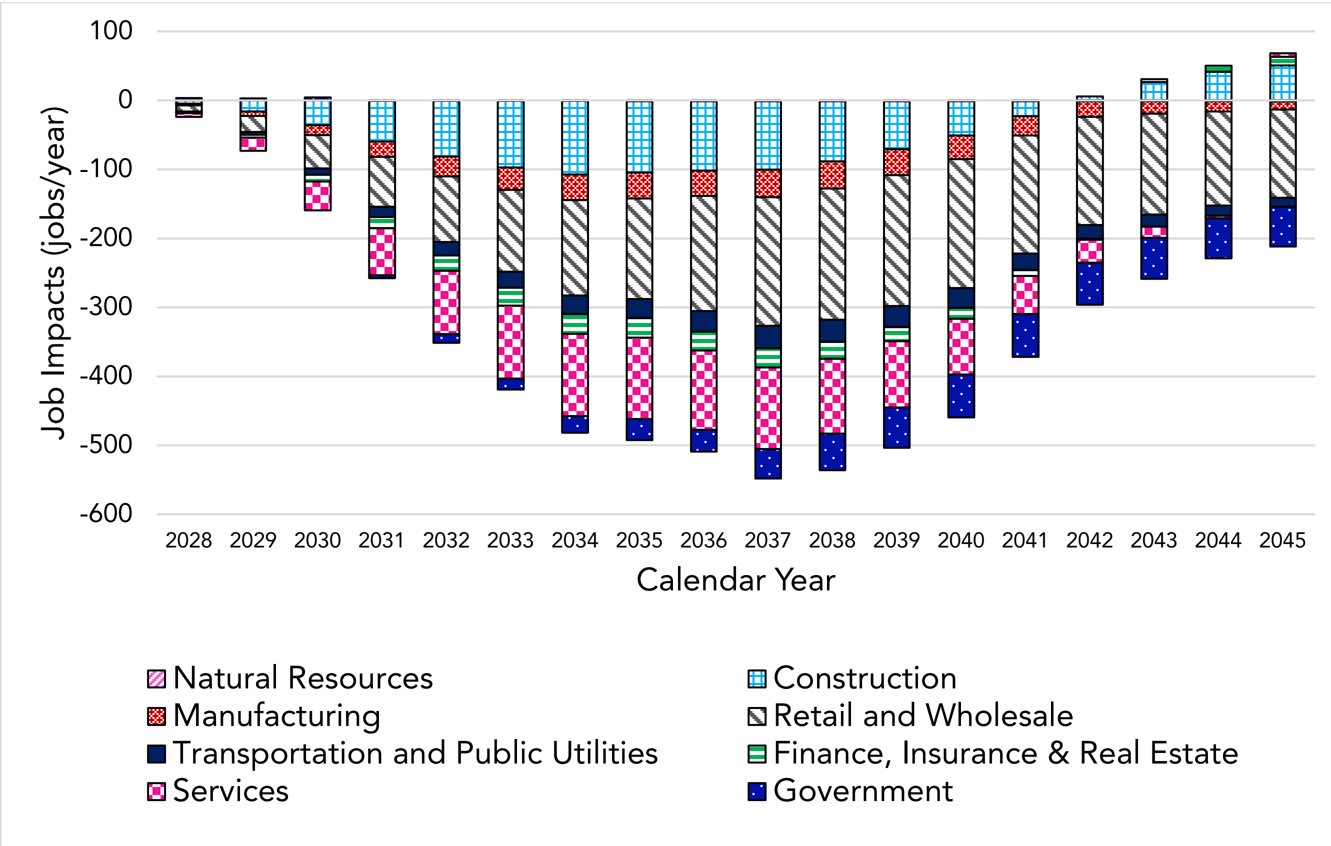


Table 60 shows the changes in employment by industries that are directly impacted by the Proposal. The results suggest that the electrical equipment manufacturing industry is one of the main industries to benefit from the regulation. As ZEM purchase requirements start in 2028, the electrical equipment manufacturing industry is expected to have job increases. The greatest employment increase for this industry is seen in 2036 with approximately a 0.05 percent increase in baseline employment. The main industries that see negative employment impacts include the retail trade, wholesale trade and automotive repair and maintenance industry. The negative impact in employment increases overtime and peaks in 2038 and 2039 for the retail and wholesale sector. The year with the largest employment change in the wholesale trade is in 2037 and 2038, which represents a 0.005 percent decrease relative to the baseline. The year with the largest employment change in the retail trade is in 2039, which represents a 0.008 percent decrease relative to the baseline. As more ZEMs are phased in, the demand for automotive repair and maintenance is expected to decrease over time. It is estimated employment for the automotive repair and maintenance industry will decrease approximately 0.04 percent compared with the baseline in 2045. As discussed in Section 4, the decrease in gasoline sales is estimated to reduce fuel tax revenue at the state and local levels. The decrease in government revenues leads to decreases in government spending and employment over time if revenue decreases are not offset elsewhere. This foregone revenue may eventually be replaced by revenue from other sources, in which case, these negative job impacts to state and local government would be diminished. However, this is outside the scope of the Proposal and not evaluated here.

Table 60. Employment Impacts by Primary Industries.

	Electrical Equipment Manufacturing		Electric Power Generation, Transmission and Distribution		Petroleum and Coal Products Manufacturing		Insurance Carriers		Automotive Repair and Maintenance		Wholesale Trade		Retail Trade		State and Local Government	
Year	Δ in Jobs	% Δ	Δ in Jobs	% Δ	Δ in Jobs	% Δ	Δ in Jobs	% Δ	Δ in Jobs	% Δ	Δ in Jobs	% Δ	Δ in Jobs	% Δ	Δ in Jobs	% Δ
2028	0	0.001%	0	0.000%	0	0.000%	0	0.000%	-1	0.000%	-2	0.000%	-7	0.000%	4	0.000%
2029	0	0.001%	0	0.000%	0	0.000%	1	0.000%	-1	-0.001%	-5	-0.001%	-18	-0.001%	3	0.000%
2030	0	0.001%	0	0.000%	0	-0.001%	1	0.001%	-2	-0.001%	-11	-0.002%	-37	-0.002%	4	0.000%
2031	0	0.001%	0	0.000%	0	-0.001%	1	0.001%	-3	-0.002%	-17	-0.002%	-55	-0.003%	-4	0.000%
2032	0	0.001%	0	-0.001%	0	-0.001%	1	0.001%	-4	-0.002%	-23	-0.003%	-72	-0.004%	-13	-0.001%
2033	3	0.023%	0	0.000%	0	-0.002%	2	0.001%	-8	-0.004%	-28	-0.004%	-91	-0.005%	-16	-0.001%
2034	3	0.024%	0	0.001%	0	-0.003%	2	0.001%	-13	-0.006%	-32	-0.004%	-106	-0.006%	-24	-0.001%
2035	3	0.024%	1	0.003%	0	-0.004%	3	0.002%	-17	-0.008%	-34	-0.004%	-112	-0.006%	-31	-0.001%
2036	7	0.054%	2	0.006%	-1	-0.006%	3	0.002%	-28	-0.013%	-37	-0.005%	-130	-0.007%	-32	-0.001%
2037	6	0.047%	3	0.010%	-1	-0.009%	3	0.002%	-38	-0.018%	-41	-0.005%	-146	-0.008%	-43	-0.002%
2039	5	0.041%	5	0.013%	-1	-0.011%	3	0.002%	-47	-0.022%	-41	-0.005%	-149	-0.008%	-53	-0.002%
2039	5	0.035%	6	0.016%	-2	-0.013%	3	0.002%	-55	-0.026%	-40	-0.005%	-150	-0.008%	-59	-0.002%
2040	4	0.030%	6	0.019%	-2	-0.015%	4	0.002%	-62	-0.030%	-38	-0.005%	-149	-0.008%	-62	-0.003%
2041	3	0.026%	7	0.022%	-2	-0.016%	4	0.002%	-69	-0.033%	-34	-0.004%	-138	-0.007%	-62	-0.003%
2042	3	0.022%	8	0.025%	-2	-0.018%	4	0.003%	-74	-0.036%	-29	-0.004%	-127	-0.007%	-61	-0.002%
2043	2	0.018%	9	0.027%	-2	-0.019%	5	0.003%	-80	-0.039%	-26	-0.003%	-120	-0.006%	-60	-0.002%

2044	2	0.015%	10	0.030%	-3	-0.021%	5	0.003%	-85	-0.041%	-23	-0.003%	-113	-0.006%	-58	-0.002%
2045	2	0.011%	10	0.032%	-3	-0.022%	5	0.003%	-89	-0.044%	-21	-0.003%	-107	-0.005%	-57	-0.002%

5.3.2California Business Impacts

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

As illustrated in Table 61, the Proposal are estimated to result in a decrease in statewide output starting from 2028 with the highest decrease in 2038. It is estimated that the statewide output will decrease by $149 million in 2038, which is approximately a decrease of 0.002 percent compared to the baseline level. After 2038, the magnitude of output decrease becomes smaller. The statewide output is estimated to decrease by $61 million in 2045 compared to the baseline level.

Table 61. Change in California Output Growth.

Year	Output (Millions 2020$)	Δ (Millions 2020$)	% Δ
2028	5,784,790	-5	0.000%
2029	5,865,570	-16	0.000%
2030	5,936,437	-36	-0.001%
2031	6,019,836	-61	-0.001%
2032	6,109,631	-84	-0.001%
2033	6,210,604	-102	-0.002%
2034	6,323,326	-119	-0.002%
2035	6,450,120	-125	-0.002%
2036	6,580,730	-134	-0.002%
2037	6,715,252	-148	-0.002%
2038	6,846,781	-149	-0.002%
2039	6,982,355	-144	-0.002%
2040	7,122,031	-137	-0.002%
2041	7,263,538	-117	-0.002%
2042	7,407,124	-97	-0.001%
2043	7,552,873	-83	-0.001%
2044	7,702,243	-71	-0.001%
2045	7,855,071	-61	-0.001%

The trend in output changes is illustrated by major sector in Figure 10. Similar to the employment impacts, the services, retail and wholesale sectors are estimated to have the largest proportion of output decrease. The manufacturing sector, including electrical equipment manufacturing, and petroleum and coal products manufacturing industries, also sees relatively large output change. Both industries are directly affected by the Proposal. As shown in Table 62 the magnitude of output decrease in the petroleum and coal products manufacturing industry is larger than the output increase in the electrical equipment manufacturing industry. However, the electrical equipment manufacturing industry is estimated to see the greatest impact to output change with approximately a 0.05 percent increase compared with the baseline in 2036. The output decrease for the petroleum and coal products manufacturing industry is estimated to be around 0.02 percent in 2045, the year with the greatest impact. Although there are greater proportional impacts in the electrical equipment manufacturing industry, the output increase from the electrical equipment manufacturing industry does not offset the output decrease from the petroleum and coal products manufacturing industry as it is much larger than the electrical equipment manufacturing industry.

Figure 10. Change in Output in California by Major Sector.

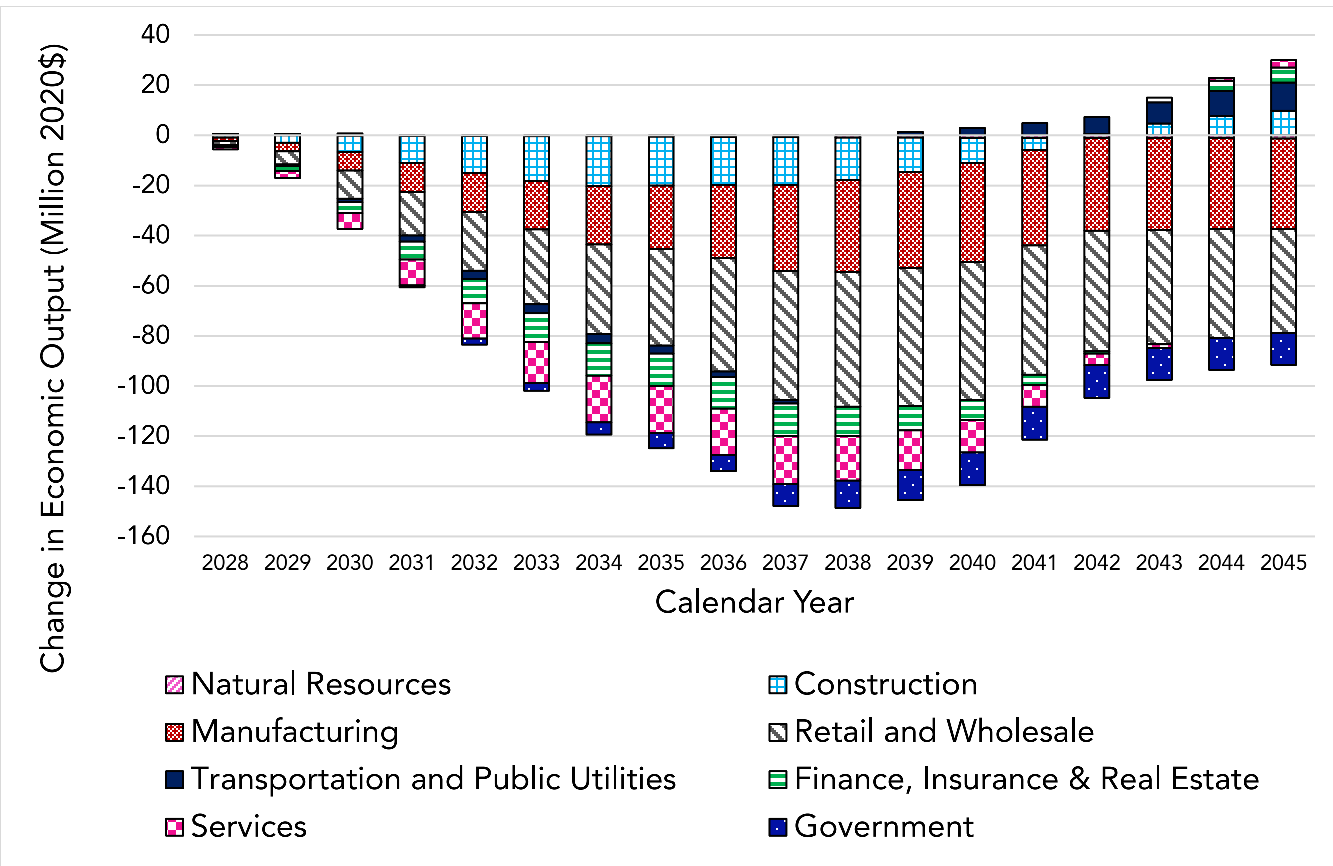


Table 62. Change in California Output Growth by Primary Industries.

	Electrical Equipment Manufacturing		Electric Power Generation, Transmission and Distribution		Petroleum and Coal Products Manufacturing		Insurance Carriers		Automotive Repair and Maintenance		Wholesale Trade		Retail Trade		State and Local Gov't	
Year	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ
2028	0.0	0.001%	0.0	0.000%	-0.1	0.000%	0.1	0.000%	-0.1	0.000%	-0.8	0.000%	-1.1	0.000%	0.7	0.000%
2029	0.0	0.001%	0.0	0.000%	-0.3	0.000%	0.2	0.000%	-0.1	-0.001%	-2.3	-0.001%	-2.9	-0.001%	0.6	0.000%
2030	0.0	0.001%	-0.1	0.000%	-0.5	-0.001%	0.3	0.001%	-0.3	-0.001%	-5.0	-0.002%	-6.2	-0.002%	0.8	0.000%
2031	0.0	0.001%	-0.2	0.000%	-0.8	-0.001%	0.4	0.001%	-0.4	-0.002%	-7.9	-0.002%	-9.5	-0.003%	-0.8	0.000%
2032	0.0	0.001%	-0.3	-0.001%	-1.0	-0.001%	0.5	0.001%	-0.5	-0.002%	-10.6	-0.003%	-12.8	-0.004%	-2.4	-0.001%
2033	0.6	0.023%	0.1	0.000%	-1.9	-0.002%	0.7	0.001%	-0.9	-0.004%	-13.4	-0.004%	-16.5	-0.005%	-3.1	-0.001%
2034	0.7	0.024%	0.6	0.001%	-2.9	-0.003%	0.9	0.001%	-1.4	-0.006%	-15.8	-0.004%	-19.8	-0.006%	-4.8	-0.001%
2035	0.7	0.024%	1.2	0.003%	-3.9	-0.004%	1.0	0.002%	-2.0	-0.008%	-16.9	-0.005%	-21.6	-0.006%	-6.1	-0.001%
2036	1.6	0.054%	2.9	0.006%	-6.5	-0.006%	1.2	0.002%	-3.2	-0.013%	-19.3	-0.005%	-25.8	-0.007%	-6.3	-0.001%
2037	1.4	0.047%	4.4	0.010%	-9.0	-0.009%	1.3	0.002%	-4.5	-0.018%	-21.7	-0.005%	-29.7	-0.008%	-8.7	-0.002%
2038	1.3	0.041%	5.9	0.013%	-11.3	-0.011%	1.3	0.002%	-5.6	-0.022%	-22.2	-0.005%	-31.4	-0.008%	-10.8	-0.002%
2039	1.1	0.036%	7.4	0.016%	-13.4	-0.013%	1.4	0.002%	-6.7	-0.026%	-22.3	-0.005%	-32.5	-0.008%	-12.1	-0.002%
2040	1.0	0.031%	8.8	0.019%	-15.6	-0.015%	1.6	0.002%	-7.7	-0.030%	-22.0	-0.005%	-33.2	-0.008%	-13.0	-0.003%
2041	0.9	0.027%	10.2	0.022%	-17.5	-0.016%	1.8	0.003%	-8.6	-0.033%	-19.9	-0.004%	-31.6	-0.007%	-13.2	-0.003%
2042	0.8	0.022%	11.7	0.025%	-19.4	-0.018%	2.0	0.003%	-9.5	-0.037%	-18.0	-0.004%	-30.2	-0.007%	-13.0	-0.002%
2043	0.6	0.019%	13.0	0.028%	-21.2	-0.019%	2.1	0.003%	-10.3	-0.040%	-16.5	-0.003%	-29.2	-0.006%	-12.8	-0.002%
2044	0.5	0.015%	14.2	0.030%	-23.0	-0.021%	2.2	0.003%	-11.1	-0.042%	-15.1	-0.003%	-28.4	-0.006%	-12.7	-0.002%
2045	0.4	0.012%	15.4	0.032%	-24.5	-0.022%	2.3	0.003%	-11.9	-0.045%	-13.9	-0.003%	-27.7	-0.006%	-12.6	-0.002%

5.3.3Impacts on Investments in California

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

The relative changes to growth in private investment for the Proposal are shown in Table 63. Private investment shows a decreasing trend from 2028, and the decrease peaks in 2034 and 2035. The highest decrease is estimated to be about $28 million in 2034 and 2035, which represents a 0.004 percent decrease compared to the baseline investment. Private investment starts to increase from 2042 as the savings from ZEMs increase.

Table 63. Change in Gross Domestic Investment.

Year	Private Investment (Millions 2020$)	Δ (Millions 2020$)	% Δ
2028	567,959	-1	0.000%
2029	579,402	-4	-0.001%
2030	589,589	-9	-0.002%
2031	599,494	-15	-0.003%
2032	610,097	-21	-0.003%
2033	621,690	-25	-0.004%
2034	634,739	-28	-0.004%
2035	649,437	-28	-0.004%
2036	664,601	-27	-0.004%
2037	680,040	-27	-0.004%
2038	694,984	-23	-0.003%
2039	710,067	-19	-0.003%
2040	725,198	-13	-0.002%
2041	740,334	-5	-0.001%
2042	755,479	3	0.000%
2043	770,718	9	0.001%
2044	786,209	14	0.002%
2045	802,094	18	0.002%

5.3.4Impacts on Individuals in California

The Proposal will impose direct costs on vehicle manufacturers. It is expected that the costs incurred by vehicle manufacturers will pass through to vehicle purchasers in California, who are primarily individuals. Direct cost and savings from upfront vehicle and ongoing O&M costs will cascade through the economy and affect individuals through indirect and induced impacts.

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

Table 64 shows the annual change in real personal income across all individuals in California. Total personal income decreases by $6 million in 2028, then continues a downward trend. The highest decrease is estimated to be about $163 million in 2038. This change represents about 0.004 percent of baseline personal income. The change in personal income can also be divided by the California population to show the average or per capita impact on personal income. These results follow the discussion about the impacts on California businesses, where a negative impact on output and jobs reduces aggregate compensation, which is a component of personal income. Personal income also decreases slightly starting 2030. Personal income per capita is estimated to decrease by about $1 to $2 each year compared to the baseline during the period from 2030 to 2042.

Table 64. Change in Personal Income.

Year	Personal Income (Millions 2020$)	Δ (Millions 2020$)	% Δ	Personal Income Per Capita (2020$)	Δ (2020$)	% Δ
2028	3,025,445	-6	0.000%	72,980	0	0.000%
2029	3,104,254	-18	-0.001%	74,513	0	0.000%
2030	3,168,113	-39	-0.001%	75,683	-1	-0.001%
2031	3,239,646	-61	-0.002%	77,041	-1	-0.001%
2032	3,317,463	-82	-0.002%	78,555	-1	-0.002%
2033	3,399,609	-103	-0.003%	80,175	-2	-0.002%
2034	3,486,658	-122	-0.003%	81,914	-2	-0.002%
2035	3,579,026	-129	-0.004%	83,783	-2	-0.002%
2036	3,671,802	-145	-0.004%	85,667	-2	-0.002%
2037	3,766,774	-162	-0.004%	87,604	-2	-0.002%
2038	3,864,321	-163	-0.004%	89,607	-2	-0.002%
2039	3,963,570	-161	-0.004%	91,659	-2	-0.002%
2040	4,064,280	-156	-0.004%	93,750	-1	-0.001%
2041	4,166,504	-136	-0.003%	95,884	-1	-0.001%
2042	4,269,731	-117	-0.003%	98,047	-1	-0.001%
2043	4,374,727	-102	-0.002%	100,260	0	0.000%
2044	4,481,482	-89	-0.002%	102,520	0	0.000%
2045	4,590,128	-76	-0.002%	104,833	0	0.000%

5.3.5Impacts on Gross State Product (GSP)

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

Table 65 shows the estimated annual change in gross state product as a result of the Proposal. Under the Proposal, GSP is anticipated to decrease starting from 2028. This metric summarizes impacts discussed above, including consumer spending, investment, and government spending. As the decrease in consumer and government spending in California outweigh the increase in investments resulting from the Proposal, the GSP shows a decreasing trend compared to the baseline GSP. The largest GSP decrease is $83 million in 2037, which represents a 0.002 percent decrease relative to the baseline.

Table 65. Change in Gross State Product.

Year	GSP (Millions 2020$)	Δ (Millions 2020$)	% Δ
2028	3,470,781	-3	0.000%
2029	3,532,520	-9	0.000%
2030	3,589,832	-21	-0.001%
2031	3,654,460	-35	-0.001%
2032	3,720,358	-48	-0.001%
2033	3,788,938	-59	-0.002%
2034	3,860,792	-69	-0.002%
2035	3,936,593	-72	-0.002%
2036	4,014,095	-76	-0.002%
2037	4,093,231	-83	-0.002%
2038	4,169,624	-82	-0.002%
2039	4,247,410	-79	-0.002%
2040	4,326,488	-74	-0.002%
2041	4,406,634	-61	-0.001%
2042	4,488,006	-49	-0.001%
2043	4,570,542	-40	-0.001%
2044	4,655,047	-33	-0.001%
2045	4,741,597	-27	-0.001%

5.3.6Creation or Elimination of Businesses

The Proposal do not directly result in business creation or elimination and the REMI model cannot directly estimate the creation or elimination of businesses. However, changes in the jobs and output for California can be used to understand some of the potential impacts. Reductions in output could indicate elimination of businesses. Conversely, increased output within an industry could signal the potential for additional business creation if existing businesses cannot accommodate all future demand. There is no threshold that identifies the creation or elimination of business.

The overall jobs and output impacts are small relative to the total California economy. The employment and output decreases in the State are no larger than 0.002 percent in any given year compared to the baseline. However, impacts in some sectors are proportionately larger or occur at different times, as described in previous sections.

The trend of increasing demand for electricity in the electric power sector sees slight increases in sales starting from 2033, but its services are provided primarily by existing utilities. New utilities are not expected to be created to meet this relatively small increased demand. The decreasing trend in demand for gasoline has only slight potential to result in the elimination of businesses in this industry and downstream industries, such as gasoline stations and vehicle repair businesses, as ONMCs are a very small portion of on-road gasoline consuming vehicles. As described above, the vehicle repair and maintenance service industry is estimated to see negative impacts as ZEMs become a greater portion of the ONMC fleet. This trend would suggest that the number of businesses providing the services may decrease along with the reduced demand.

5.3.7 Incentives for Innovation

The Proposal will further reduce emissions from ONMCs operating in California by harmonizing the exhaust requirements and the OBD system with the Euro 5 standard. In addition, the Proposal will introduce new CARB evaporative emissions testing standards and require the phase-in of ZEMs. CARB will lead the world in developing new cutting-edge evaporative emissions testing standards under the Proposal. The ZEM certification and quality assurance requirements and the tradeable credit program under the Proposal will provide flexibilities and give manufacturers the incentive to innovate and identify lower cost strategies for achieving the ZEM sales requirement. Innovations leading to lower cost ZEM models likely will result in increased sales within the mass market. In addition, manufacturers are incentivized to innovate and bring ZEM models to secure their place in the growing ZEM segment in California.

5.3.8 Competitive Advantage or Disadvantage

It is anticipated the industries that manufacture ZEMs and related components will grow in California under the Proposal. While staff is not aware of any evidence of the extent to which this is occurring under existing requirements, automakers that are already producing ZEMs may have an advantage in growing market share over manufacturers that have not yet come to market with a widely available product. Though some consumers may be holding out for a specific manufacturer’s product, many consumers will purchase products that have wide distribution networks. As the ZEM sales requirement becomes more stringent, this advantage may decline as every ONMC maker invests in ZEM technology and products at a wide scale.

5.4 Summary and Agency Interpretation of the Assessment Results

The results of the macroeconomic analysis of the Proposal are summarized in Table 66. As analyzed here, CARB estimates the Proposal is unlikely to have a significant impact on the California economy. Overall, the change in the growth of jobs, State GDP, and output is projected to not exceed 0.002 percent of the baseline.

Table 66. Summary of Macroeconomic Impacts of the Proposal.

	GSP		Personal Income		Employment		Output		Private Investment	
Year	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ in jobs	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ
2028	-3	0.000%	-6	0.000%	-21	0.000%	-5	0.000%	-1	0.000%
2029	-9	0.000%	-18	-0.001%	-70	0.000%	-16	0.000%	-4	-0.001%
2030	-21	-0.001%	-39	-0.001%	-155	-0.001%	-36	-0.001%	-9	-0.002%
2031	-35	-0.001%	-61	-0.002%	-258	-0.001%	-61	-0.001%	-15	-0.003%
2032	-48	-0.001%	-82	-0.002%	-352	-0.001%	-84	-0.001%	-21	-0.003%
2033	-59	-0.002%	-103	-0.003%	-419	-0.002%	-102	-0.002%	-25	-0.004%
2034	-69	-0.002%	-122	-0.003%	-482	-0.002%	-119	-0.002%	-28	-0.004%
2035	-72	-0.002%	-129	-0.004%	-493	-0.002%	-125	-0.002%	-28	-0.004%
2036	-76	-0.002%	-145	-0.004%	-509	-0.002%	-134	-0.002%	-27	-0.004%
2037	-83	-0.002%	-162	-0.004%	-548	-0.002%	-148	-0.002%	-27	-0.004%
2038	-82	-0.002%	-163	-0.004%	-536	-0.002%	-149	-0.002%	-23	-0.003%
2039	-79	-0.002%	-161	-0.004%	-504	-0.002%	-144	-0.002%	-19	-0.003%
2040	-74	-0.002%	-156	-0.004%	-460	-0.002%	-137	-0.002%	-13	-0.002%
2041	-61	-0.001%	-136	-0.003%	-372	-0.001%	-117	-0.002%	-5	-0.001%
2042	-49	-0.001%	-117	-0.003%	-291	-0.001%	-97	-0.001%	3	0.000%
2043	-40	-0.001%	-102	-0.002%	-228	-0.001%	-83	-0.001%	9	0.001%
2044	-33	-0.001%	-89	-0.002%	-179	-0.001%	-71	-0.001%	14	0.002%
2045	-27	-0.001%	-76	-0.002%	-143	-0.001%	-61	-0.001%	18	0.002%

6 Alternatives

Staff solicited alternatives from ONMC manufacturers and other stakeholders at various public workshops and meetings throughout the process for developing the proposal, and most explicitly at the November 2020 workshop regarding ONMC regulation development. These alternatives are analyzed relative to the same baseline presented in section 1.7 and the results are then compared to the proposed regulation along with the reason(s) for rejection of the alternatives. Alternatives are required to consider one case that achieves benefits beyond those of the proposed regulation (more stringent), and one that achieves the same level of benefits, but is less likely or more costly to achieve those benefits. Alternative 1 considers the case where the proposed requirements are kept for ICE ONMCs, but no requirements are created for ZEM sales. Alternative 2 considers the case where no requirements are created for ICE ONMCs, but ZEM sales would be required to meet a more aggressive schedule, consistent with some other mobile source categories, to achieve 100% ZEM sales in 2035 with no credit program.

6.1 Alternative 1

The first alternative considered proposes to keep the same requirements for ICE ONMCs while eliminating the ZEM sales requirements of the proposal. This alternative would simply bring ICE ONMCs in line with the most aggressive standards in the world (Euro 5) including the other improvements discussed for ICE in the Proposal, while taking no action to promote ZEM adoption. This alternative results in lower upfront costs due in large part to the benefits of harmonizing with existing Euro 5 exhaust emissions standards but does not experience the same offsetting operational savings of the Proposal over the long run due to displacing gasoline usage with electricity. Further this alternative does not reduce emissions as significantly as the Proposal.

6.1.1 Costs

6.1.1.1 Direct Cost to Manufacturers

The total manufacturer costs associated with Alternative 1 are discussed in section 3.1.2, but are different with respect to the number of ICE ONMCs affected, due to the lack of requirements for ZEM sales in the Alternative. These costs are summarized and shown in Table 67.

Table 67. Alternative 1 Total Direct Cost to Manufacturers (2020$).

CY	ONMCs Sold Over Baseline (units)	Direct Costs	Cost Per Unit
2028	14,939	$6,880,809	$461
2029	29,990	$10,201,626	$340
2030	50,158	$14,897,022	$297
2031	50,344	$14,446,969	$287
2032	50,518	$14,479,044	$287
2033	50,709	$14,514,913	$286
2034	50,891	$14,548,714	$286
2035	51,077	$14,583,474	$286
2036	51,255	$14,616,348	$285
2037	51,422	$14,646,997	$285
2038	51,581	$12,603,642	$244
2039	51,728	$12,629,828	$244
2040	51,866	$12,653,837	$244
2041	51,993	$12,675,521	$244
2042	52,109	$12,694,880	$244
2043	52,216	$12,712,161	$243
2044	52,313	$12,727,119	$243
2045	52,398	$12,739,523	$243
Total	867,505	235,252,427	$271

6.1.1.2 Cost to Individuals

Consumers will experience pass through costs from ONMC manufacturers and fuel savings from improved evaporative emissions controls as discussed in section 3.2.1.2. The pass-through costs apply a factor of 1.5 to applicable direct costs to manufacturers along with factoring in amortization, additional warranty, increased insurance and vehicle license fees resulting in statewide costs to consumers as shown in Table 68.

Table 68. Alternative 1 Statewide Net Consumer Costs (2020$).

CY	Fuel Savings	Cost to Consumers	Net Cost to Consumers
2028	$9,137	$2,940,329	$2,931,192
2029	$27,279	$7,349,583	$7,322,304
2030	$57,725	$13,997,357	$13,939,631
2031	$87,566	$20,333,811	$20,246,245
2032	$116,575	$26,580,115	$26,463,539
2033	$144,045	$30,099,549	$29,955,503
2034	$170,425	$32,214,919	$32,044,494
2035	$195,999	$32,384,574	$32,188,575
2036	$220,999	$32,793,944	$32,572,945
2037	$245,284	$33,131,539	$32,886,254
2038	$269,663	$32,411,309	$32,141,646
2039	$290,774	$31,679,397	$31,388,623
2040	$315,377	$30,942,868	$30,627,491
2041	$337,215	$29,706,256	$29,369,041
2042	$357,456	$28,992,425	$28,634,969
2043	$378,078	$29,057,355	$28,679,277
2044	$396,204	$29,124,647	$28,728,443
2045	$411,220	$29,193,156	$28,781,936
Total	$4,031,022	$470,402,889	$466,371,866

Note that government also is a consumer of motorcycles in California as well, although it is a very small percent of the total population as shown in Table 51. However, for completeness in evaluating the total cost impact of Alternative 1, it is necessary to add those costs in as well. Table 69 summarizes these costs.

Table 69. Direct Costs of Alternative 1 to Consumers (Including Individuals and Government) (Thousands 2020$).

Year	Vehicle Purchase Cost	Warranty Cost	Insurance Cost	Registration Cost	Fuel Savings	Total cost	Total saving	Net Cost
2028	$2,592	$88	$344	$45	$9	$3,069	$9	$3,060
2029	$6,436	$265	$804	$104	$27	$7,609	$27	$7,581
2030	$12,048	$561	$1,424	$185	$58	$14,218	$58	$14,159
2031	$17,491	$858	$1,920	$250	$88	$20,518	$88	$20,430
2032	$22,945	$1,156	$2,329	$303	$117	$26,733	$117	$26,616
2033	$25,822	$1,367	$2,662	$346	$145	$30,196	$145	$30,051
2034	$27,459	$1,490	$2,926	$380	$172	$32,255	$172	$32,084
2035	$27,341	$1,496	$3,126	$406	$197	$32,370	$197	$32,172
2036	$27,405	$1,501	$3,281	$427	$222	$32,614	$222	$32,391
2037	$27,468	$1,506	$3,399	$442	$247	$32,815	$247	$32,568
2038	$26,748	$1,511	$3,387	$440	$271	$32,087	$271	$31,815
2039	$26,025	$1,516	$3,374	$439	$293	$31,355	$293	$31,062
2040	$25,298	$1,521	$3,368	$438	$317	$30,625	$317	$30,307
2041	$24,567	$1,525	$3,371	$438	$339	$29,902	$339	$29,562
2042	$23,832	$1,529	$3,382	$440	$360	$29,183	$360	$28,823
2043	$23,873	$1,533	$3,401	$442	$381	$29,249	$381	$28,868
2044	$23,909	$1,537	$3,425	$445	$399	$29,316	$399	$28,917
2045	$23,941	$1,540	$3,455	$449	$414	$29,385	$414	$28,971
Total	$395,200	$22,501	$49,378	$6,419	$4,058	$473,498	$4,058	$469,440

6.1.2Benefits

6.1.2.1 Total Emission and Health Benefits

The total well-to-wheel emission benefits associated with Alternative 1 are summarized in Table 70. The cumulative CO2 emissions reductions are zero for this alternative because it does not increase ZEM sales over baseline and does nothing to increase fuel efficiency in ICE ONMCs.

Table 70. Alternative 1 Annual Statewide Emissions Reductions.

CY	NOx (tons)	ROG Exhaust (tons)	ROG Evap (tons)	CO (tons)	PM2.5 (tons)	GHG (MMT)
2028	18	28	11	417	0	0
2029	48	76	28	1200	0	0

CY	NOx (tons)	ROG Exhaust (tons)	ROG Evap (tons)	CO (tons)	PM2.5 (tons)	GHG (MMT)
2030	95	149	51	2413	0	0
2031	135	213	71	3537	0	0
2032	170	273	97	4566	0	0
2033	200	329	129	5499	0	0
2034	226	380	166	6332	0	0
2035	249	428	210	7079	0	0
2036	267	469	251	7709	0	0
2037	283	502	288	8237	0	0
2038	296	531	322	8695	0	0
2039	308	556	355	9086	0	0
2040	318	577	386	9425	0	0
2041	326	595	416	9711	0	0
2042	333	611	446	9964	0	0
2043	339	624	475	10180	0	0
2044	343	635	503	10363	0	0
2045	347	643	530	10515	0	0
Total	4,301	7,619	4,736	124,927	0	0

Table 71 shows the statewide valuation of avoided health outcomes for Alternative 1, which results in a lower valuation of health benefits at around $467 million compared to the Proposal at $564 million.

Table 71. Statewide Valuation of Avoided Health Outcome from 2025 to 2040 Under Alternative 1.

Calendar Year	Cardiopulmonary mortality	Parkinson's disease	Hospitalizations for respiratory illness	Alzheimer's disease	Hospitalizations for cardiovascular illness	Cardiovascular ED visits	Respiratory ED visits	Asthma onset	Asthma symptoms	Lung cancer incidence	Acute myocardial infarction, Nonfatal	Work loss days	Valuation (Million 2020$)
2028	0	0	0	0	0	0	0	0	30	0	0	21	$2
2029	0	0	0	0	0	0	0	1	83	0	0	57	$5
2030	1	0	0	0	0	0	0	2	159	0	0	112	$9
2031	1	0	0	0	0	0	1	2	221	0	0	159	$13
2032	1	0	0	1	0	0	1	3	274	0	0	200	$17
2033	2	0	0	1	0	0	1	4	320	0	0	237	$20

Calendar Year	Cardiopulmonary mortality	Parkinson's disease	Hospitalizations for respiratory illness	Alzheimer's disease	Hospitalizations for cardiovascular illness	Cardiovascular ED visits	Respiratory ED visits	Asthma onset	Asthma symptoms	Lung cancer incidence	Acute myocardial infarction, Nonfatal	Work loss days	Valuation (Million 2020$)
2034	2	0	0	1	0	0	1	4	361	0	0	268	$23
2035	2	0	0	1	0	1	1	5	397	0	0	295	$26
2036	2	0	0	1	0	1	1	5	427	0	0	317	$28
2037	2	0	0	1	0	1	1	5	451	0	0	336	$30
2038	2	0	0	1	1	1	1	5	472	0	0	352	$32
2039	3	0	0	1	1	1	2	6	491	0	0	366	$34
2040	3	0	0	1	1	1	2	6	507	0	0	377	$35
2041	3	0	0	1	1	1	2	6	521	0	0	387	$36
2042	3	0	0	1	1	1	2	6	532	0	0	395	$37
2043	3	0	0	1	1	1	2	6	542	0	0	402	$38
2044	3	0	0	1	1	1	2	6	550	0	0	408	$39
2045	3	0	0	1	1	1	2	6	557	0	0	411	$40
Total*	35	2	1	15	7	9	21	78	6895	3	4	5102	$467

*Numbers may not add up exactly due to rounding.

6.1.3Economic Impacts

Alternative 1 would have the same requirements for conventional ICE ONMCs as the Proposal but would not impose any ZEM sales requirements. The direct costs associated with Alternative 1 are the manufacturer cost increase to comply with more stringent emissions requirements, which would be passed through to ONMC purchasers. In addition, there would be a small fuel savings due to the increased stringency in evaporative emissions standards. The retail and wholesale sectors, which support the retail sales of gasoline to consumers, see the largest employment and economic impacts. The magnitude of economic impacts for Alternative 1 is less than that of the Proposal because there is no requirement for additional ZEM sales. The largest decrease in output for Alternative 1 is $104 million in 2034, while the largest decrease in output for the Proposal is $149 million in 2038. The largest decrease in employment for Alternative 1 is seen in 2034 with a loss of 426 jobs, while the largest decrease in employment for the Proposal is 548 jobs in 2037. The changes in statewide output and employment for Alternative 1 represent, at most, a 0.002 percent decrease relative to the baseline. The macroeconomic impact analysis for Alternative 1 are shown in Table 72. Figure 11 and Figure 12 show the job and output changes of Alternative 1, respectively.

Table 72. Summary of Economic Impacts of Alternative 1.

	GSP		Personal Income		Employment		Output		Private Investment	
Year	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ in jobs	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ
2028	-4	0.000%	-9	0.000%	-28	0.000%	-7	0.000%	-2	0.000%
2029	-12	0.000%	-24	-0.001%	-93	0.000%	-22	0.000%	-6	-0.001%
2030	-25	-0.001%	-45	-0.001%	-186	-0.001%	-43	-0.001%	-11	-0.002%
2031	-39	-0.001%	-67	-0.002%	-287	-0.001%	-67	-0.001%	-17	-0.003%
2032	-52	-0.001%	-88	-0.003%	-378	-0.001%	-90	-0.001%	-22	-0.004%
2033	-59	-0.002%	-99	-0.003%	-419	-0.002%	-101	-0.002%	-25	-0.004%
2034	-61	-0.002%	-104	-0.003%	-426	-0.002%	-104	-0.002%	-25	-0.004%
2035	-58	-0.001%	-102	-0.003%	-396	-0.001%	-99	-0.002%	-22	-0.003%
2036	-54	-0.001%	-100	-0.003%	-363	-0.001%	-93	-0.001%	-19	-0.003%
2037	-50	-0.001%	-98	-0.003%	-331	-0.001%	-87	-0.001%	-15	-0.002%
2038	-46	-0.001%	-93	-0.002%	-298	-0.001%	-81	-0.001%	-11	-0.002%
2039	-42	-0.001%	-89	-0.002%	-264	-0.001%	-74	-0.001%	-8	-0.001%
2040	-39	-0.001%	-84	-0.002%	-237	-0.001%	-68	-0.001%	-5	-0.001%
2041	-36	-0.001%	-80	-0.002%	-216	-0.001%	-64	-0.001%	-3	0.000%
2042	-34	-0.001%	-75	-0.002%	-200	-0.001%	-61	-0.001%	-2	0.000%
2043	-35	-0.001%	-74	-0.002%	-197	-0.001%	-61	-0.001%	-1	0.000%
2044	-35	-0.001%	-73	-0.002%	-197	-0.001%	-62	-0.001%	-1	0.000%
2045	-36	-0.001%	-73	-0.002%	-199	-0.001%	-63	-0.001%	-2	0.000%

Figure 11. Employment Impacts by Major Sector of Alternative 1.

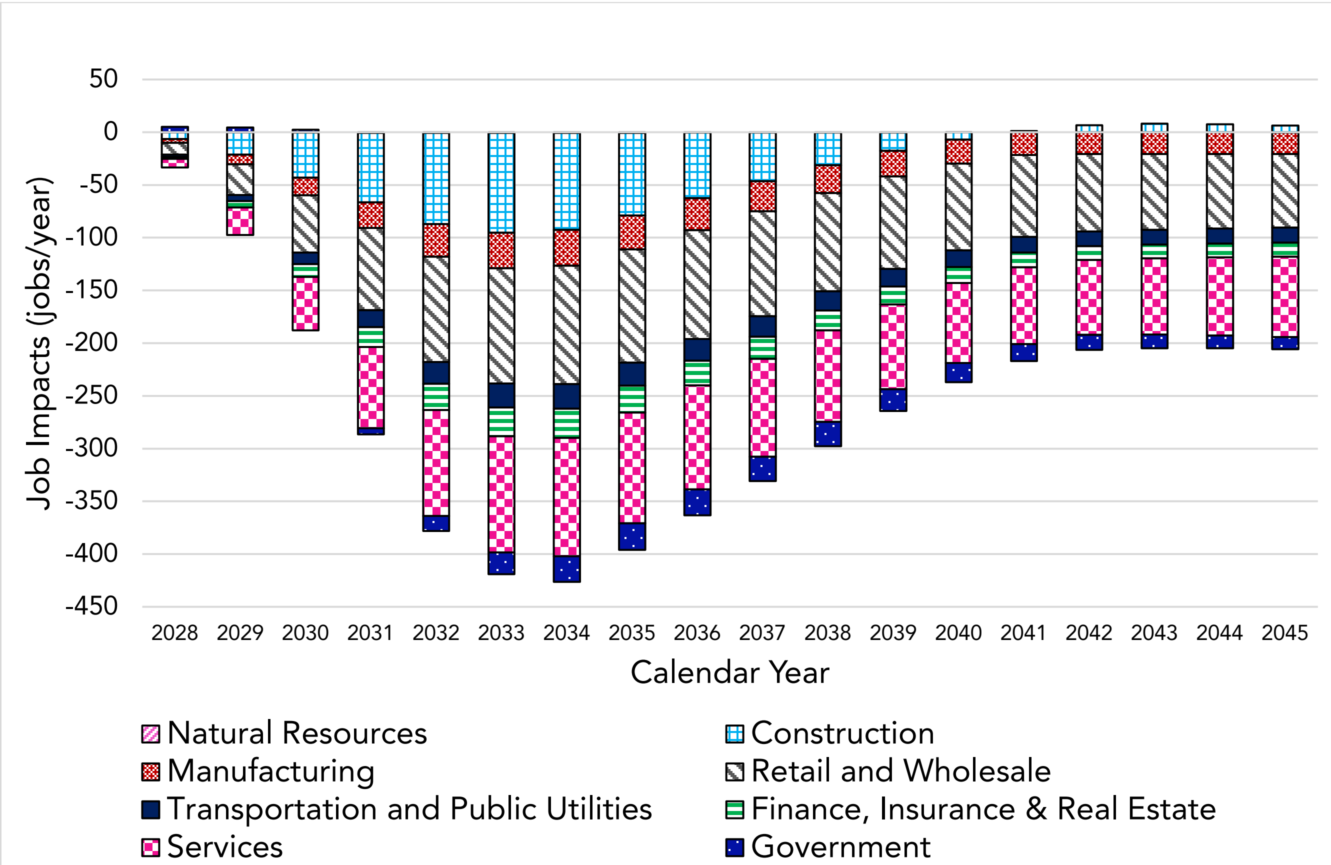
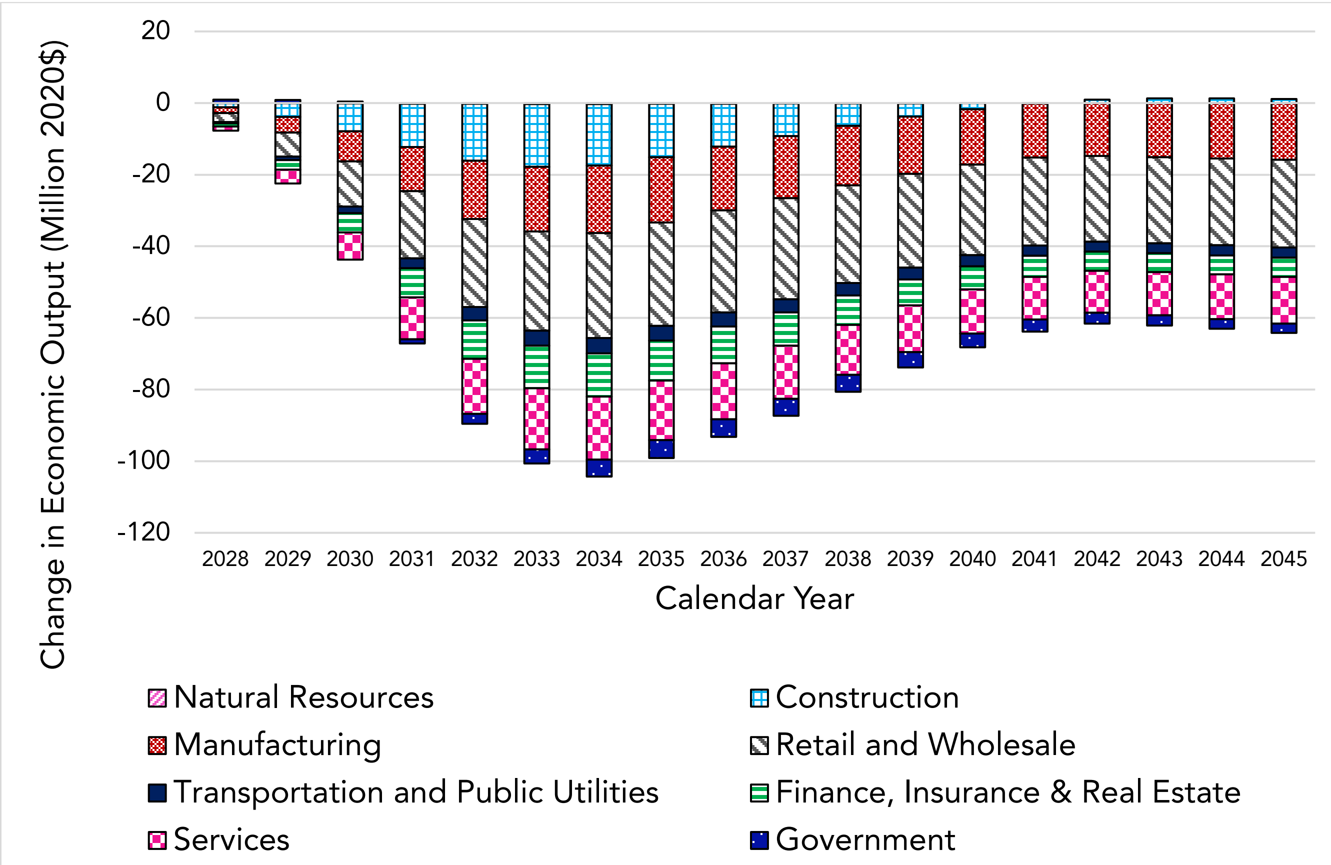


Figure 12. Change in Output in California by Major Sector of Alternative 1.



6.1.4Cost-Effectiveness

The metric to quantify cost-effectiveness of the Alternative 1 is the ratio of total direct costs and savings divided by the weighted ton of emissions reduced. The total 2028-2045 direct costs and savings include the ONMC ownership costs to both individuals and government as shown in Table 69 and totals approximately $469 million. The total 2028-2045 weighted emissions reductions are determined by summing tons of NOx, ROG and PM (PM is weighted and multiplied by 20).[104] The cumulative emissions for these pollutants can be found in section 6.1.2.1 and are weighted and summed to get approximately 16,655 tons. The resulting cost effectiveness is much more expensive than the proposal and is given in Table 73.

[104] CARB, Carl Moyer Program; Appendix C.

Table 73. Cost Effectiveness of Alternative 1 and Proposal in $ per Weighted Ton of Emissions Reduced.

	Net Cost ($)	Total Weighted Emissions Reduced (tons)	Cost Per Ton Reduced ($)
Proposal	$276,375,810	21,909	$12,615
Alternative 1	$469,440,070	16,655	$28,187

Note, the net cost does not include health benefits to avoid the issue of double counting in the metric. Alternative 1 has no associated GHG benefits which is another way that the Proposal compares favorably with this alternative.

6.1.5Reason for Rejecting

Alternative 1, as illustrated in Table 67 and Table 68, results in lower upfront costs due in large part to the benefits of harmonizing with existing Euro 5 exhaust emissions standards, but does not experience the same offsetting operational savings of the Proposal over the long run due to the Proposal displacing gasoline usage with electricity. Further this alternative achieves significantly less emissions reductions than the Proposal as illustrated in Table 70. Ultimately the proposal was more cost effective than Alternative 1 as shown in Table 73, which is why this alternative was rejected.

6.2 Alternative 2

The second alternative aggressively pushes ZEM sales according to the schedule of Table 74 while doing nothing to improve current ICE ONMCs emissions standards. While this alternative would cost more up front, it would achieve greater emissions reductions and cost savings in the long term due mainly to displacing gasoline with electricity as a fuel. However, by eliminating ICE ONMC sales, this may also place some usage constraints on users as well.

Table 74. Alternative 2 ZEMs Sales Requirement.

CY	ZEM Sales Requirement
2028	10%
2029	20%
2030	30%
2031	40%
2032	55%
2033	70%
2034	85%
2035	100%
2036+	100%

6.2.1 Costs

6.2.1.1 Direct Cost to Manufacturers

The total ONMC manufacturer costs associated with Alternative 2 are discussed in section 3.1.1.1, but are different with respect to the number of ZEMs effected due to more aggressive ZEM sales requirements and no ZEM credit program. These costs are summarized and shown in Table 75.

Table 75. Alternative 2 Direct Costs to Manufactures.

CY	Units Sold	Direct Costs	Cost Per Unit
2028	3,599	$6,612,854	$1,837
2029	8,218	$13,886,744	$1,690
2030	12,877	$19,968,785	$1,551
2031	17,599	$24,983,893	$1,420
2032	24,725	$32,048,461	$1,296
2033	31,936	$37,680,020	$1,180
2034	39,202	$41,956,633	$1,070
2035	51,053	$49,367,658	$967
2036	51,230	$44,554,384	$870
2037	51,397	$39,987,916	$778
2038	51,555	$35,658,009	$692
2039	51,702	$31,551,950	$610
2040	51,839	$27,660,627	$534
2041	51,965	$23,973,801	$461
2042	52,081	$20,482,097	$393
2043	52,188	$17,176,881	$329
2044	52,284	$14,049,036	$269
2045	52,368	$11,090,089	$212
Total	707,816	$492,689,840	$696

6.2.1.2 Cost to Individuals

Consumers will experience pass-through costs from ONMC manufacturers, and fuel and maintenance savings as discussed in sections 3.1.1.1 and 3.2. The pass-through costs apply a factor of 1.5 to applicable direct costs to manufacturers resulting in statewide costs to consumers as shown in Table 76. Initially these costs are much higher than the Proposal. Note that by 2040 operational savings of an increasingly large ZEM fleet would overwhelm decreasing costs of new ZEM purchases and this Alternative would result in a net cost savings to consumers.

Table 76. Alternative 2 Statewide Net Cost to Consumers.

CY	Fuel and Maintenance Savings	Total Costs to Consumers	Net Cost to Consumers
2028	$785,518	$3,274,914	$2,489,396
2029	$2,546,297	$9,833,566	$7,287,269
2030	$5,280,315	$19,020,002	$13,739,687
2031	$8,977,310	$30,266,101	$21,288,791
2032	$14,137,277	$44,489,805	$30,352,529
2033	$20,626,246	$58,477,017	$37,850,770
2034	$28,409,683	$71,303,879	$42,894,196
2035	$38,508,288	$84,455,623	$45,947,336
2036	$48,339,955	$93,088,311	$44,748,356
2037	$57,816,014	$96,671,877	$38,855,864
2038	$67,201,184	$95,964,063	$28,762,879
2039	$75,678,900	$91,687,166	$16,008,267
2040	$84,804,839	$82,865,751	-$1,939,088
2041	$93,149,027	$74,248,223	-$18,900,804
2042	$100,897,137	$65,894,372	-$35,002,765
2043	$108,809,086	$57,856,979	-$50,952,107
2044	$115,907,280	$50,155,789	-$65,751,491
2045	$121,986,704	$42,803,355	-$79,183,349
Total	$993,861,057	$1,072,356,791	$78,495,735

Note that government also us a consumer of motorcycles in California as well, although it is a very small percent of the total population as shown in Table 51. However, for completeness in evaluating the total cost impact of Alternative 2, it is necessary to add those costs in as well. Table 77 summarizes these costs.

Table 77. Direct Costs of Alternative 2 to Consumers (Including Individuals and Government) (Thousands 2020$).

Year	Vehicle Purchase Cost	Insurance Cost	Registration Cost	Maintenance Savings	Fuel Savings	Total cost	Total saving	Net Cost
2028	$2,491	$713	$93	$386	$405	$3,296	$791	$2,506
2029	$7,723	$1,925	$250	$1,247	$1,316	$9,898	$2,563	$7,335
2030	$15,246	$3,451	$449	$2,557	$2,758	$19,145	$5,315	$13,830
2031	$24,658	$5,139	$668	$4,297	$4,739	$30,465	$9,036	$21,429
2032	$36,732	$7,124	$926	$6,702	$7,528	$44,782	$14,230	$30,552
2033	$48,437	$9,226	$1,199	$9,746	$11,015	$58,862	$20,762	$38,100
2034	$59,012	$11,293	$1,468	$13,401	$15,196	$71,773	$28,597	$43,176

Year	Vehicle Purchase Cost	Insurance Cost	Registration Cost	Maintenance Savings	Fuel Savings	Total cost	Total saving	Net Cost
2035	$70,087	$13,207	$1,717	$18,125	$20,636	$85,011	$38,762	$46,250
2036	$77,460	$14,372	$1,868	$22,615	$26,043	$93,701	$48,658	$45,043
2037	$80,451	$14,917	$1,939	$26,875	$31,321	$97,308	$58,196	$39,111
2038	$79,690	$14,961	$1,945	$30,935	$36,708	$96,595	$67,643	$28,952
2039	$75,770	$14,620	$1,901	$34,813	$41,364	$92,290	$76,177	$16,114
2040	$67,592	$13,999	$1,820	$38,518	$46,845	$83,411	$85,363	-$1,952
2041	$59,838	$13,184	$1,714	$42,059	$51,703	$74,737	$93,762	-$19,025
2042	$52,490	$12,246	$1,592	$45,443	$56,118	$66,328	$101,561	-$35,233
2043	$45,527	$11,248	$1,462	$48,675	$60,850	$58,238	$109,525	-$51,287
2044	$38,933	$10,224	$1,329	$51,756	$64,914	$50,486	$116,670	-$66,184
2045	$32,690	$9,199	$1,196	$54,694	$68,095	$43,085	$122,789	-$79,704
Total	$874,828	$181,048	$23,536	$452,845	$547,554	$1,079,412	$1,000,400	$79,012

6.2.2Benefits

6.2.2.1 Total Emission and Health Benefits

The total well-to-wheel emission benefits associated with Alternative 2 are summarized in Table 78.

Table 78. Alternative 2 Annual Statewide Emissions Reductions.

CY	NOx (tons)	ROG Exhaust (tons)	ROG Evaporative (tons)	CO (tons)	PM2.5 (tons)	CO2 (MMT)
2028	5	11	11	108	0.00	0.00
2029	18	35	35	363	0.13	0.01
2030	36	72	72	758	0.39	0.02
2031	60	120	120	1,288	0.78	0.03
2032	92	186	187	2,012	1.27	0.04
2033	133	270	272	2,925	1.92	0.06
2034	180	368	374	4,013	2.72	0.08
2035	239	494	510	5,396	3.65	0.10
2036	293	612	639	6,713	4.75	0.12
2037	341	720	762	7,932	5.72	0.14
2038	385	820	881	9,066	6.57	0.16
2039	425	911	995	10,103	7.32	0.17
2040	460	995	1,105	11,057	7.98	0.18
2041	492	1,071	1,212	11,926	8.57	0.19
2042	521	1,142	1,316	12,732	9.10	0.20
2043	548	1,207	1,418	13,470	9.58	0.21

CY	NOx (tons)	ROG Exhaust (tons)	ROG Evaporative (tons)	CO (tons)	PM2.5 (tons)	CO2 (MMT)
2044	571	1,266	1,516	14,147	10.01	0.22
2045	593	1,320	1,612	14,767	10.40	0.23
Total	5,393	11,620	13,039	128,775	91	2

The total statewide valuation of health benefits of Alternative 2 is estimated to be around $720 million (Table 79), which is higher than Proposal at $564 million.

Table 79. Statewide Valuation of Avoided Health Outcome from 2028 to 2045 Under Alternative 2.

Calendar Year	Cardiopulmonary mortality	Parkinson's disease	Hospitalizations for respiratory illness	Alzheimer's disease	Hospitalizations for cardiovascular illness	Cardiovascular ED visits	Respiratory ED visits	Asthma onset	Asthma symptoms	Lung cancer incidence	Acute myocardial infarction, Nonfatal	Work loss days	Valuation (Million 2020$)
2028	0	0	0	0	0	0	0	0	9	0	0	6	$1
2029	0	0	0	0	0	0	0	0	33	0	0	23	$2
2030	0	0	0	0	0	0	0	1	68	0	0	48	$4
2031	1	0	0	0	0	0	0	1	115	0	0	82	$7
2032	1	0	0	0	0	0	1	2	175	0	0	128	$11
2033	1	0	0	1	0	0	1	3	252	0	0	186	$16
2034	2	0	0	1	0	0	1	4	344	0	0	255	$22
2035	2	0	0	1	0	1	1	5	456	0	0	339	$30
2036	3	0	0	1	1	1	2	6	564	0	0	420	$37
2037	3	0	0	2	1	1	2	8	661	0	0	493	$44
2038	4	0	0	2	1	1	2	9	748	0	0	558	$51
2039	4	0	0	2	1	1	3	9	826	0	0	616	$56
2040	5	0	0	2	1	1	3	10	898	0	1	669	$62
2041	5	0	0	2	1	1	3	11	962	0	1	716	$67
2042	5	0	0	2	1	1	3	12	1020	0	1	758	$71
2043	6	0	0	3	1	1	3	12	1073	0	1	796	$76
2044	6	0	0	3	1	2	3	13	1120	0	1	830	$80
2045	6	0	0	3	1	2	4	13	1163	0	1	860	$83
Total*	54	4	2	25	11	14	32	120	10,486	4	6	7,784	$720

*Numbers may not add up exactly due to rounding.

The annual GHG emission reductions multiplied by the SC-CO2 values shown in section 2.4.2 gives a monetary estimate of the benefit of GHG emission reductions from Alternative 2. These benefits range from about $59 million to $238 million through 2045, depending on the chosen discount rate as shown in Table 80.

Table 80. Alternative 2 SC-CO2 Value of ONMC GHG Reductions.

Year	Cumulative CO2 Emissions Reductions (MMT)	Avoided SC-CO2 (Million 2020$) 5% Discount Rate	Avoided SC-CO2 (Million 2020$) 3% Discount Rate	Avoided SC-CO2 (Million 2020$) 2.5% Discount Rate
2028	0.00	$0.05	$0.17	$0.25
2029	0.01	$0.16	$0.54	$0.79
2030	0.02	$0.35	$1.09	$1.59
2031	0.03	$0.57	$1.81	$2.62
2032	0.04	$0.91	$2.79	$4.03
2033	0.06	$1.30	$4.04	$5.79
2034	0.08	$1.84	$5.52	$7.87
2035	0.10	$2.40	$7.32	$10.39
2036	0.12	$3.05	$8.99	$12.68
2037	0.14	$3.50	$10.50	$14.93
2038	0.16	$4.10	$11.90	$16.83
2039	0.17	$4.48	$13.20	$18.57
2040	0.18	$5.05	$14.42	$20.19
2041	0.19	$5.36	$15.56	$21.68
2042	0.20	$5.90	$16.37	$23.07
2043	0.21	$6.16	$17.37	$24.38
2044	0.22	$6.69	$18.33	$25.60
2045	0.23	$6.91	$19.24	$26.75
Total	2.17	$58.78	$169.16	$238.01

6.2.3Economic Impacts

Alternative 2 would impose a more stringent ZEM sales requirement starting at 10 percent in 2028 and increasing annually to 100 percent ZEM sales requirement starting 2035 per Table 74, but would not impose any requirements to improve the current ICE ONMCs emissions standards. The direct cost associated with ZEMs would be the vehicle capital cost increase and the ongoing operation and maintenance cost savings. Like the Proposal, the negative employment and economic impacts would increase and peak in 2036 and 2037. However, the magnitude of the negative impacts decreases after 2037 as the ZEM cost savings increase over time due to the more stringent ZEMs sales requirement. The macroeconomic impact analysis results for Alternative 2 are qualitatively similar to the results of the Proposal, but the impacts are larger than that of the Proposal in the years of greatest impacts. The largest decreases in output for Alternative 2 and the Proposal are $251 million in 2037 and $149 million in 2038, respectively. The largest job decreases for Alternative 2 and the Proposal are 936 jobs in 2036 and 548 jobs in 2037, respectively. The changes in statewide output and employment for Alternative 2 represent, at most, a 0.004 percent decrease relative to the baseline. The macroeconomic impact analysis results for Alternative 2 are shown in Table 81. Figure 13 and Figure 14 show the job and output changes of Alternative 2, respectively.

Table 81. Summary of Economic Impacts of Alternative 2.

	GSP		Personal Income		Employment		Output		Private Investment	
Year	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ	Δ in jobs	% Δ	Δ (Millions 2020$)	% Δ	Δ (Millions 2020$)	% Δ
2028	-3	0.000%	-8	0.000%	-20	0.000%	-5	0.000%	-1	0.000%
2029	-12	0.000%	-26	-0.001%	-87	0.000%	-21	0.000%	-5	-0.001%
2030	-26	-0.001%	-52	-0.002%	-197	-0.001%	-47	-0.001%	-12	-0.002%
2031	-46	-0.001%	-86	-0.003%	-338	-0.001%	-81	-0.001%	-20	-0.003%
2032	-69	-0.002%	-128	-0.004%	-503	-0.002%	-122	-0.002%	-29	-0.005%
2033	-91	-0.002%	-168	-0.005%	-656	-0.002%	-162	-0.003%	-37	-0.006%
2034	-110	-0.003%	-204	-0.006%	-776	-0.003%	-195	-0.003%	-43	-0.007%
2035	-125	-0.003%	-239	-0.007%	-870	-0.003%	-225	-0.003%	-46	-0.007%
2036	-137	-0.003%	-264	-0.007%	-936	-0.004%	-247	-0.004%	-46	-0.007%
2037	-137	-0.003%	-270	-0.007%	-923	-0.003%	-251	-0.004%	-41	-0.006%
2038	-128	-0.003%	-263	-0.007%	-849	-0.003%	-239	-0.003%	-31	-0.004%
2039	-113	-0.003%	-243	-0.006%	-732	-0.003%	-215	-0.003%	-18	-0.003%
2040	-89	-0.002%	-207	-0.005%	-560	-0.002%	-176	-0.002%	-3	0.000%
2041	-66	-0.002%	-174	-0.004%	-405	-0.001%	-140	-0.002%	13	0.002%
2042	-47	-0.001%	-142	-0.003%	-274	-0.001%	-108	-0.001%	26	0.003%
2043	-30	-0.001%	-112	-0.003%	-167	-0.001%	-82	-0.001%	37	0.005%
2044	-17	0.000%	-85	-0.002%	-87	0.000%	-61	-0.001%	45	0.006%
2045	-8	0.000%	-61	-0.001%	-32	0.000%	-45	-0.001%	50	0.006%

Figure 13. Employment Impacts by Major Sector of Alternative 2.

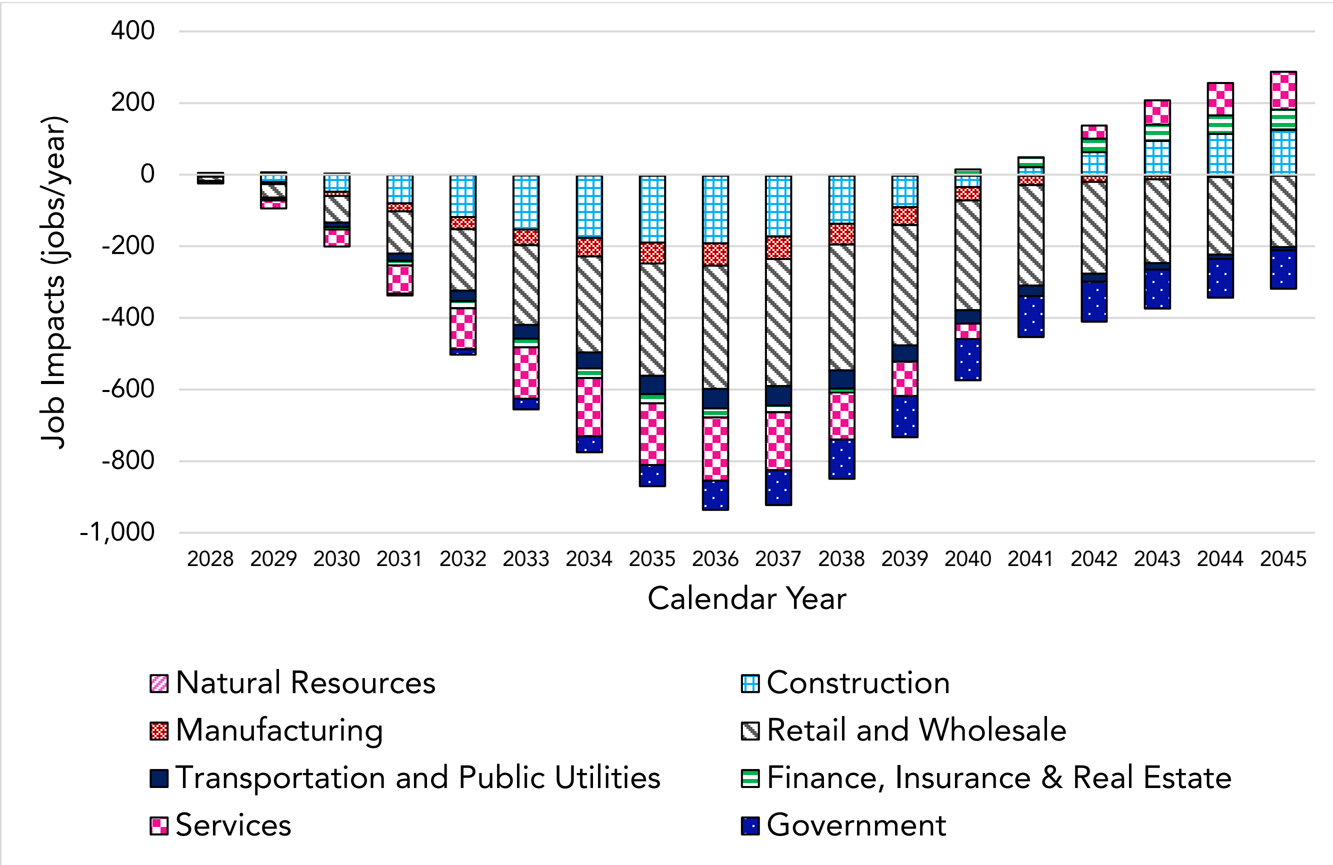
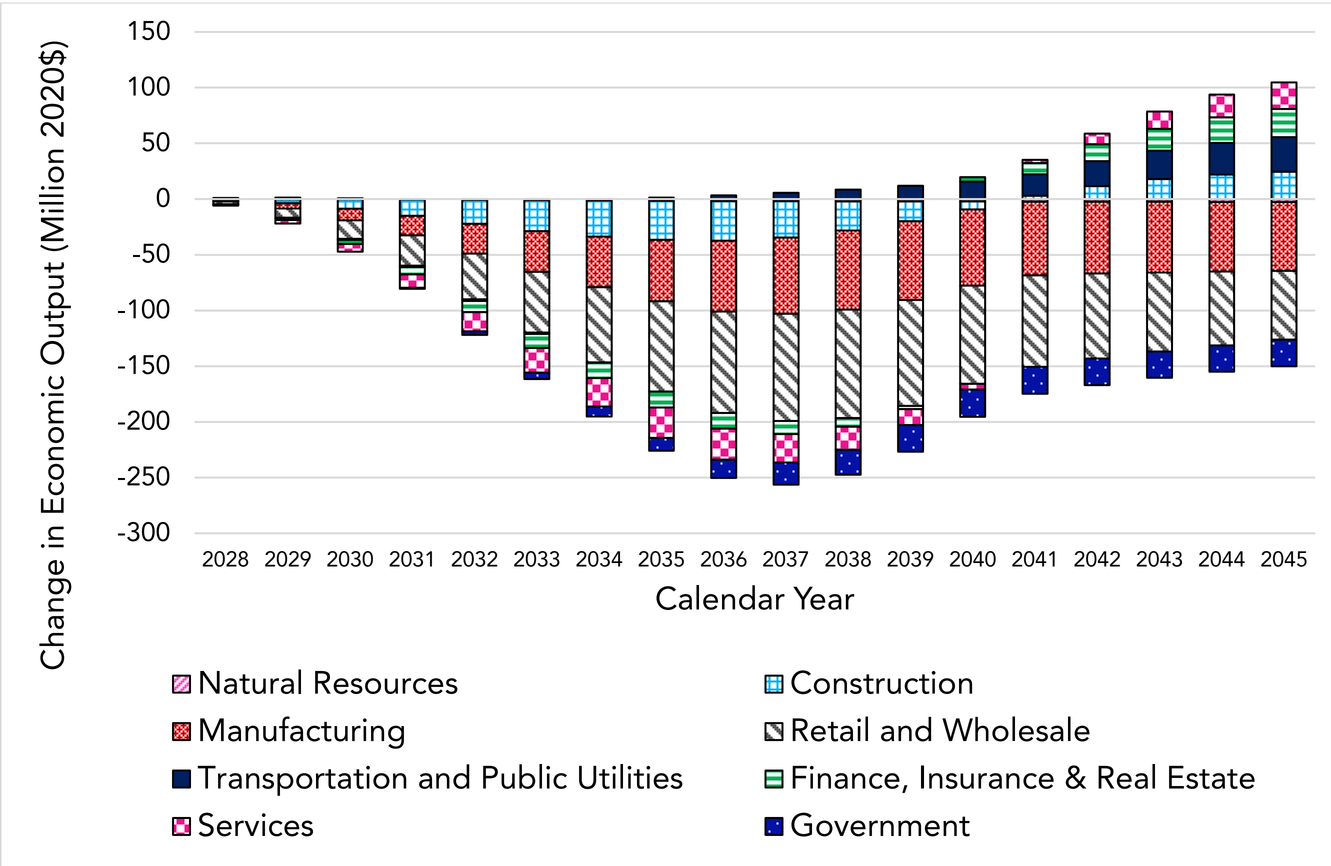


Figure 14. Change in Output in California by Major Sector of Alternative 2.



6.2.4Cost-Effectiveness

The metric to quantify cost-effectiveness of the Alternative 2 is the ratio of total direct costs and savings divided by the weighted tons of emissions reduced. The total 2028-2045 direct costs and savings include the ownership costs to both individuals and government as shown in Table 77 and totals approximately $79 million. The total 2028-2045 weighted emissions reductions are determined by summing tons of NOx, ROG and PM (PM is weighted by multiply by 20).[105] The cumulative emissions for these pollutants can be found in section 6.2.2.1 and are weighted and summed to get approximately 31,869 tons. The resulting cost effectiveness is much more expensive than the proposal and is given in Table 82.

[105] CARB, Carl Moyer Program; Appendix C.

Table 82. Cost Effectiveness of Alternative 2 and Proposal in $ per Weighted Ton of Emissions Reduced.

	Net Cost ($)	Total Weighted Emissions Reduced (tons)	Cost Per Ton Reduced ($)
Proposal	$276,375,810	21,909	$12,615
Alternative 2	$79,012,148	31,869	$2,479

It needs to be noted that cumulative costs and benefits as calculated through 2045 bias the Proposal and Alternative 2 to appearing much less cost effective than they really are. This is because much of the cost is associated with the price differential between ZEMs and conventional ICE ONMCs, incurred at the time of purchase. However, the savings associated with ZEM ownership occurs over the life of the vehicle. Thus, while much of the direct costs are included through 2045, many of the ongoing operational cost savings and emissions reductions do not get captured in the same period and thus do not get considered in this analysis.

If the savings due to the reduced social costs of carbon are considered as quantified in Section 6.2.2.1, the combined direct costs and savings of Alternative 2 are approximately $958 million based on a 2.5 percent discount rate.

6.2.5Reason for Rejecting

Alternative 2, as illustrated in Table 75 and Table 76, results in much higher upfront costs due in large part to the aggressive early push of higher ZEM sales. However, in years farther beyond the analysis it is anticipated this alternative would theoretically result in a greater cost savings with significantly more emissions reductions due to displacing gasoline usage with electricity. Alternative 2 emissions reductions can be found in Table 78. The challenge with this alternative is that it results in an effective ban of new ICE ONMC sales by 2035. ZEMs may not be able to address the needs of many ONMC customers who use their vehicles for recreational riding. Recreational riders represent a very large portion of the ONMC market as shown in a 2011 survey by the Institute for Social Research at California State University Sacramento (CSUS) in which they found that 56 percent of riders characterized their riding as recreational only and an additional 34 percent characterized their riding as both recreational and commuting.[106] Recreational riders include riders who do their riding as touring over long distances in remote areas, riders who prefer the aesthetics of classic ONMC designs with pronounced exhaust features, and riders who prefer the performance characteristics of ICE ONMCs. Often recreational riding is done at freeway speeds which coincides with the most restricted range of ZEMs, currently less than 100 miles. This limited freeway speed range is most constraining when riding in remote areas with limited ability for ZEM riders to recharge their vehicles as charge times may take as much as two hours under level 2 charging conditions. Although there are many ZEM

[106] ISR, Analysis of the 2011 California Survey of On-Highway Motorcycles.

offerings available that can satisfy many rider's needs for city riding and commuting, ultimately it is a challenge for ZEM manufacturers to meet the wide range of recreational rider's needs and desires. If many riders are left with no new ONMC purchase options in California to satisfy their needs, they may ultimately be pushed to buy higher emitting used ONMCs from out of state, with the net effect of bringing more emissions into California while at the same time hurting the California economy by driving sales to other states. The Proposal ultimately tries to address this problem by allowing for a sales mix of ZEMs and state-of-the-art low emitting ICE ONMCs that can satisfy all riders needs and desires. Therefore, staff rejected this alternative.

Appendix A: Acronyms

Δ: delta or change

BEV: battery electric vehicle

CARB: California Air Resources Board

cc: cubic centimeters

CEC: California Energy Commission

CO: carbon monoxide

CO2: carbon dioxide

CY: calendar year

DMV: (California) Department of Motor Vehicles

ECCC: Environment and Climate Change Canada

EIA: Energy Information Administration

EMFAC2021: CARB's EMission FACtor model revision 2021

EU: European Union

EU 5: Euro 5 emissions standards as referenced in Regulation (EU) No 168/2013 Of The European Parliament And Of The Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles: version 02013R0168-EN-14.11.2020-003.001

FTP: federal test procedure

GHG: greenhouse gas

GSP: gross state product

ICE: internal combustion engine

MMT: million metric tons

mph: miles per hour

MY: model year

NMHC: non-methane hydrocarbons

NOx: oxides of nitrogen

ONMC: on-road motorcycle

PM: particulate matter

PM2.5: particulate matter less than 2.5 microns in diameter

ROG: reactive organic gases

RPE: retail price equivalent

SAE: Society of Automotive Engineers

SHED: sealed housing for evaporative determination

SRIA: standardized regulatory impact assessment

tpd: short tons per day

TTW: tank to wheels

U.S. EPA: United States Environmental Protection Agency

UN: United Nations

VMT: vehicle miles traveled

WMTC: worldwide harmonized motorcycle testing cycle' or 'WMTC' means the world harmonized emission laboratory test cycle WMTC as defined by UNECE global technical regulation No 2

ZEM: zero emission motorcycle

ZEV: zero emission vehicle

Appendix B: Macroeconomic Inputs For REMI Analysis (Million 2020$)

Policy Variables	Industry/Spending Category	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Consumer Price	Sports and recreational vehicles	1.7	4.5	10.0	15.3	20.7	23.8	25.7	24.8	23.0	21.1	18.9	16.9	15.0	14.2	13.5	13.5	13.5	13.5
Consumer Price	Sports and recreational vehicles	0.2	0.3	0.5	0.6	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3
Consumer Price	Sports and recreational vehicles	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	1.0	1.5	1.8	2.1	2.3	2.2	2.1	2.0	1.9	1.9
Consumer Price	Sports and recreational vehicles	0.0	0.0	0.0	0.0	0.0	2.8	5.9	9.1	16.5	23.0	26.0	28.1	29.3	25.8	22.4	19.2	16.2	13.3
Consumer Price	Sports and recreational vehicles	0.1	0.3	0.5	0.8	1.1	1.3	1.3	1.3	1.2	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
Consumer Spending	Reallocate Consumption: Motor vehicle maintenance and repair	-0.1	-0.2	-0.3	-0.4	-0.4	-1.2	-2.1	-3.1	-5.5	-7.9	-10.1	-12.2	-14.2	-16.1	-17.9	-19.6	-21.3	-22.8
Consumer Spending	Reallocate Consumption: Motor vehicle fuels, lubricants, and fluids	-0.2	-0.4	-0.6	-0.8	-1.0	-2.6	-4.5	-6.5	-11.7	-16.7	-21.5	-26.0	-30.6	-35.0	-39.1	-43.1	-46.9	-50.2
Consumer Spending	Reallocate Consumption: Electricity	0.1	0.2	0.2	0.3	0.4	1.1	1.9	2.7	4.9	7.0	9.0	10.8	12.6	14.3	16.0	17.6	19.1	20.6
Consumer Spending	Reallocate Consumption: Net motor vehicle and other transportation insurance	0.3	0.6	1.3	1.8	2.3	2.8	3.2	3.4	3.7	3.7	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Consumption Reallocation	All Consumption Categories	0.0	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Policy Variables	Industry/Spending Category	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Industry Sales (Exogenous Production)	Electrical equipment manufacturing	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4
State and Local Government Spending	State Government	0.3	0.5	1.0	1.0	1.1	1.4	1.4	1.3	1.5	1.0	0.4	0.0	-0.3	-0.7	-1.0	-1.4	-1.7	-2.0
State and Local Government Spending	Local Government	0.3	0.5	1.0	0.9	0.8	1.2	1.0	0.9	1.2	0.7	0.0	-0.4	-0.8	-1.2	-1.5	-1.9	-2.2	-2.5
Consumer Spending	Reallocate Consumption: Hospitals	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7	-0.7	-0.7	-0.8	-0.8
Labor productivity (%)	Detail (156)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0