

State of California
AIR RESOURCES BOARD

AMENDMENTS TO THE SMALL OFF-ROAD ENGINE EXHAUST AND EVAPORATIVE
EMISSION REGULATIONS

Standardized Regulatory Impact Assessment (SRIA)

DATE OF RELEASE: August 6, 2020

Air Resources Board
1001 I Street
Sacramento, California 95814

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A. INTRODUCTION

Small off-road engines (SORE), also known as small spark-ignition engines (SSIE), are generally used in off-road power equipment including generators and lawn and garden equipment such as lawn mowers, string trimmers, and leaf blowers. The use of this equipment leads to significant emissions of ozone-forming species including reactive organic gases (ROG) and oxides of nitrogen (NO_x). As an example, operating the best-selling commercial lawn mower for one hour emits as much smog-forming pollution as driving the best-selling 2017 passenger car, a Toyota Camry, about 300 miles – approximately the distance from Los Angeles to Las Vegas. The off-road power equipment and lawn and garden markets have zero-emission equipment (ZEE) alternatives available now. ZEE has no exhaust or evaporative emissions and helps protect public health, reduce petroleum use, and meet sustainability objectives.

The Proposed Amendments to the SORE Regulations (Proposed Amendments) aim to accelerate adoption of ZEE outdoor power equipment while making emission levels more stringent on SORE equipment in the near term. The Proposed Amendments will achieve this by making evaporative and exhaust emission standards for SORE more stringent starting in 2023. In 2025, the emission standards would be set to zero, although some SORE will still be allowed to be produced through the use of a credit system. In 2028, the credit system will be retired and only ZEE may be produced for sale in California. The Proposed Amendments also make small changes to certification and test procedures to clarify and bring them into line with other agencies. The ZEE sales requirement will meet the required emission reduction targets put forward in the 2016 State Implementation Plan (SIP).

1. Regulatory History

Small off-road engines (SORE) are spark-ignited engines rated at or below 19 kW (25.5 hp) of power. The vast majority of SORE is fueled by gasoline, but SORE may also be powered by compressed natural gas, propane, liquified petroleum gas, or liquified natural gas. SORE is predominantly used in lawn and garden equipment as well as other utility equipment (generators, compressors, etc.). SORE was first regulated by CARB in 1990 when exhaust emission standards were adopted. Since then the exhaust standards have been made more stringent over time. In 2003, the first evaporative emission standards for SORE were adopted. Evaporative emissions occur both when the engine is operating and when it is not. Both exhaust and evaporative emission standards have active credit programs, which allows manufacturers to produce engines that pollute at higher levels than the standards, if they offset those with engines that produce lower emission levels than the standards. An extension of this program allowing for credit generation for zero-emission equipment also exists for exhaust standards. The most recent amendments to the SORE regulations were adopted in 2016. Among the regulated pollutants are hydrocarbons (HC) and oxides of nitrogen (NO_x), which contribute to particulate matter and ozone formation in California. As part of CARB's latest State Implementation Plan (SIP) Strategy, which describes the control measures that will be implemented to achieve federal air quality standards required under the Clean Air Act, a measure was included to reduce emissions of NO_x and HC from SORE by 4 and 36 tons per day (tpd), respectively, in 2031. This will be achieved by implementing more stringent emission standards on spark-ignition engines starting in 2023 with a ban on the sale of newly produced spark-ignition engines in 2028.

2. Proposed Amendments

The main action of the Proposed Amendments is to transition all new SORE produced for sale in California to zero-emission equipment (ZEE), which, by definition, does not produce any engine emissions. Currently, nearly all SORE ZEE is electric, but fuel cell or other zero-emission power sources would also be allowed under these regulatory amendments. Zero-emission alternatives for all SORE exist and are constantly improving. However, for certain equipment types ZEE are significantly more expensive due to technology cost. This leads CARB to propose a stepped approach to the Proposed Amendments to allow for continued technological advancement and production costs to come down. Overall, the amendments to the SORE regulations will be phased in through three major steps. First, in 2023, HC and NO_x exhaust emission standards will be decreased by 40-90 percent, depending on engine displacement category. The evaporative emission standards, which are for HC, will also incorporate the “hot soak” period as well as the “diurnal cycle” they currently cover, meaning the standard will cover a greater period of time, so they will be reduced by a relatively modest amount of approximately 50 percent. Evaporative emission testing occurs in a sealed unit where evaporative emissions are collected and measured. In the first step of the test, known as “hot soak”, the engine is placed in a temperature-controlled room at 95F, which is representative of peak heat on a hot summer day, for an hour. This is then immediately followed up by the diurnal cycle, a 24-hour period in which the engine is exposed to a temperature cycle akin to a typical summer day including typical overnight cooling. In 2025, the standards will be set to zero for both HC and NO_x, but continued use of emission reduction credits from the averaging, banking, and trading program will be allowed. In 2028, only sales of zero-emission equipment will be allowed.

The exhaust regulation amendments for SORE will include changes to emission standards and emission durability periods. The reduction in emission standards, shown in Table A-1, ranges from 40-90 percent below current standards. Currently, there are several engines certified for sale in California that meet these more stringent standards. Each displacement category includes several engine families in production whose certification test emissions are below the proposed emission standards, and those engines are used in all major SORE equipment types. The proposed emission standard for the displacement category of ≥ 825 cc is aligned with the emission standard for large spark-ignition engines, i.e., those rated greater than 19 kW and with displacement ≥ 825 cc, which cover overlapping engine displacement sizes.

Table A-1. Current and 2023 Exhaust Emission Standards for SORE

Engine Displacement Category	Current HC + NO _x standard (g/kWh)	2023 HC + NO _x standard (g/kWh)
< 50 cc, handheld	50	20
50-80 cc, inclusive, handheld	72	13
< 225 cc, non-handheld	10	6
≥ 225 cc- < 825 cc	8	3
≥ 825 cc	8	0.8

In 2025, the HC + NO_x standards for all engine displacement categories will be set to 0. From 2025 through 2027, manufacturers may still produce engines if they have sufficient emission reduction credits through the active averaging, banking, and trading (ABT) program to offset the emissions of the engines sold in California. The ABT program allows manufacturers to generate credits when they produce engines that pollute at lower levels than the current standards. These credits may be used to produce engines which pollute at higher levels, they may be saved for future years, or they may be traded with other manufacturers. This regulation amendment will require a transition to zero-emission equipment. Zero-emission options are commercially available across equipment types for all SORE. In 2028, use of credits will be terminated and only zero-emission equipment may be produced for sale in California. A transition to zero-emission equipment for SORE will drive down NO_x and HC emissions and will greatly improve California's air quality.

The change to emission durability periods, shown in table A-2, reflect more accurately how equipment is used. The emission durability periods reflect the run time over which the engines must meet the exhaust emission standard. The current regulations allow applicants for certification to select a durability period for their equipment from a range of choices that generally reflect "residential," "heavy residential," or "commercial" use. The updated durability periods are all set to the "commercial" use version of the current options. They reflect the demands of professional users, as lawn and garden equipment owned by residents is currently over 50 percent zero-emission equipment. The vast majority of engines that meet the proposed 2023 standards are already certified at the longest durability period, so no cost increase is expected from extending the durability periods.

Table A-2. Current and 2023 Emission Standard Durability Periods for SORE

Engine Displacement Category	Current Durability Period (hours)	2023 Durability Period (hours)
< 50 cc Handheld	50/125/300*	300
50-80 cc, inclusive, Handheld	50/125/300*	300
< 225 cc non-Handheld	125/250/500*	500
≥ 225 cc- < 825 cc	125/250/500/1,000*	1000
≥825 cc	125/250/500/1,000*	1000

*Manufacturers chose which durability period to certify to. These categories are generally taken to reflect “residential,” “heavy residential,” “commercial,” and “heavy commercial” use.

Other amendments to the exhaust regulations include sunseting the voluntary “Blue Sky Standards” in 2022, changes to compliance and production line testing procedures, changes to the averaging, banking, and trading program, and expansion of the zero-emission equipment credit program. The Blue Sky Standards were developed to allow manufacturers to receive recognition for certifying to lower standards, but CARB has no record of anyone taking advantage of the program for spark-ignition engines, so they will be ended in 2022.

Currently, the compliance testing requirements for SORE exhaust include some provisions that make compliance testing onerous. The current requirement is for CARB to test “a reasonable number” of engines, which has been changed to “one or more.” Additionally, the requirement that engines be tested in groups of five has been amended for CARB to test single engines for compliance. This will allow for broader compliance testing of SORE and will reduce the burden on CARB’s testing facilities.

In the averaging, banking, and trading program, maximum family emission limits (FEL) have been lowered. A FEL is defined as an emission level that is declared by the manufacturer to serve for the ABT program and in lieu of an emission standard for certification. The lower FELs are would be set to the current HC + NOx standards, shown in table A-1. These limits prevent sales of the highest emitting engines, which are already prohibited in other jurisdictions, such as the European Union. These FELs also maintain maximum flexibility for manufacturers to shift their focus to zero-emission equipment. By setting the FELs to today’s standards, manufacturers can continue using credits they have banked or generate in future years on engines already in production today, without having to develop new technology.

Overall, the changes to the ABT program are expected to spread out cost impact over a longer time, by allowing manufacturers to produce engines for longer. Throughout the analysis, this impact has been assumed to be negligible, to show the highest potential cost impact on individual years.

The zero-emission credit program is to be amended to add clarity and expand eligible equipment categories. In 2018, the first manufacturer successfully applied for zero-emission equipment credits. Additional details were added to increase clarity for applicants, more clearly characterize the ability of ZEE to replace gas-powered equipment, and justify the amount of credit granted. In the current program, manufacturers are required to describe how their equipment and batteries would be used during an 8-hour workday. In the Proposed Amendments, time of use and number of uses per day are both specified for each equipment type. Additionally, ride-on and stand-on mowers were added as eligible equipment categories to encourage more manufacturing of zero-emission alternatives for these equipment types. The other major change to the zero-emission credit program is to allow zero-emission credits to offset all excess emissions, rather than only 40 percent, as allowed today, and allow credit use across displacement categories. This will increase the value of credits and encourage more manufacturers to produce more zero-emission equipment, while allowing them the flexibility to use the credits toward engines that power equipment types which may take longer to convert to zero-emission technology.

In the amendments to the evaporative emission regulations, changes include reducing standards, incorporating the hot soak period emission standards, and adding a zero-emission equipment credit program. The evaporative emission test procedure consists of several steps, including running the equipment, then putting it into a sealed housing for evaporative determination (SHED), where emissions are measured. The SHED would first be held at 95°F for one hour (the hot soak period), then cooled and run through a 24-hour diurnal temperature cycle. Currently, the standards only apply to the 24-hour diurnal temperature cycle, but the amendments will have them also apply to the one-hour hot soak period. As manufacturers are already required to measure and report hot soak emissions, this will not add any testing burden. Some engines tested by CARB have met the 24-hour diurnal emission standard, but had hot soak emissions several times higher than the diurnal emission standard. This change will eliminate the potential for higher-than-expected hot soak emissions to reduce the actual benefits of tightened emission standards.

The diurnal plus hot soak emission standards are approximately fifty percent lower than current diurnal emission standards. Engines currently certified in the state of California are already able to meet or exceed these standards, including the hot soak. The standards, shown in table 3, are met by several engines in each displacement category and include engines used in all major SORE equipment types. Additionally, the full-engine standards will now apply to engines with displacement ≤ 80 cc which previously did not have a full-engine standard. The 0.50 g HC/test standard in that category was developed through testing conducted at CARB, which showed engines for sale in California already meeting this standard. The permeation emission standards currently in effect for engines ≤ 80 cc will be phased out after 2022.

Table A-3. Current and 2023 Evaporative Emission Standards for SORE.

Engine Displacement Category	Current Diurnal Standard (g HC/day)	2023 Diurnal + Hot Soak Standard (g HC/test)
≤ 80 cc	N/A	0.50
> 80 cc - < 225 cc, walk-behind mowers	1.0	0.60
> 80 cc - < 225 cc, non-walk-behind mowers	$0.95 + 0.056 \times \text{capacity}$	0.60
≥ 225 cc	$1.20 + 0.056 \times \text{capacity}$	0.70

As with the exhaust amendments, the evaporative standards will be set to zero for model year 2025 and later.

Another change in the evaporative regulation amendments is incorporating zero-emission equipment credits. Currently, these credits are available for avoided exhaust emissions, but no equivalent credit program exists for avoided evaporative emissions. The amendment allows any equipment that qualifies for zero-emission exhaust credits to also receive zero-emission evaporative credits. This will add more flexibility for manufacturers of zero-emission equipment and allow all manufacturers to focus on transition to zero-emissions, rather than only producing lower-emitting gasoline-powered engines.

A similar modification of the evaporative regulations is allowing alternative fuel equipment to qualify for evaporative emission credits. This includes engines powered with compressed natural gas, propane, liquified petroleum gas, or liquified natural gas as these fuels are contained in sealed or pressurized tanks. These tanks are designed in a way that avoids evaporative emissions, by using more robust material that allows them to maintain pressurization. These engines are not subject to the evaporative regulations, but if manufacturers wish to earn emissions credits, they may follow the test procedure and do so. This will allow more flexibility in production and give credits to manufacturers of low-emitting engines.

Currently, the credit program for evaporative emissions only has provisions for averaging and banking. In the Proposed Amendments, trading is to be added to the program, to align with the exhaust regulations. This will allow more flexibility in the program and allow manufacturers who are able to earn credits to trade them to manufacturers who cannot, encouraging them to make the cleanest engines possible.

A provision was added to the regulations to require that fuel cap tethers must not cause fuel to spill when refueling equipment. This will reduce emissions during refueling. This is not expected to influence equipment costs, overall. This will require some manufacturers to move the tether holding the fuel cap from inside the gas tank to the outside. For some, this should

reduce the cost of the tether, as the material has less exposure to gasoline, while for others, it may increase the costs slightly, as they may have to weld a tab to attach the tether. The cost or cost-savings should each be less than \$1, and across engine models, will likely be close to \$0.

Similarly, to the Blue Sky Standards for exhaust emissions, the optional evaporative emission standards will be phased out in 2022, under these amendments. This program was never utilized, so it is being eliminated.

Small changes are included to test procedures related to these regulations. These changes are primarily administrative and offer clarity to manufacturers. A tilt test is added before evaporative emissions testing. The tilt test consists of tipping a piece of equipment 90 degrees in each direction and will eliminate excess emissions that come from fuel leaks when equipment is turned on its side for cleaning or storage.

3. Statement of the Need of the Proposed Regulation

To meet the emission reductions targets put forth in the SIP, it is necessary to update the SORE regulations and complete a transition to zero-emission equipment more quickly than would be expected to occur under business as usual. ZEE is already on the market in both the residential and commercial lawn and garden categories; however, outreach and survey data suggest consumers are not readily making the switch for several reasons. In order to determine the population that ZEE represents, the Social Science Research Center at California State University, Fullerton was contracted to do an intensive survey between 2017 and 2019 of households businesses, and landscape vendors on their ownership of SORE lawn and garden equipment and their thoughts on ZEE alternatives.¹ The survey reached over 1,100 residents, 1,300 businesses and 600 landscaping vendors spread throughout the state. Topics included ownership, use rates, knowledge of ZEE alternatives and maintenance frequency.

Among households, almost half of those surveyed said they owned at least one piece of lawn and garden equipment and nearly 40% owned another piece of SORE equipment such as a compressor, generator, or pressure washer. This led to an estimate of more than 26 million pieces of equipment owned by individuals statewide, forty-one percent of which was ZEE. While ZEE is similarly priced for several pieces of equipment, individual use of the equipment is lower than for professionals, so households replace equipment less frequently. The survey showed that the median life for a household lawnmower is six years and it is five years for a trimmer/edger. Further, only 7% of households stated that they intended to buy any additional or replacement outdoor power equipment in the next year.

Individual household respondents who noted that they had no plans to purchase new equipment in the next year were asked what factors would be important in a hypothetical purchase in deciding between gasoline powered equipment and ZEE. Cost was the top response, followed closely by power and time to refuel/recharge. These results show that there many residents hold beliefs about ZEE that may be based on old information. Currently, ZEE, in the household

¹ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

sector of the market, are roughly the same price as their gas counterparts. In many cases, ZEE is less expensive to purchase. Further, current ZEE meets consumer needs for utility equally as well as SORE for the vast majority of consumers, and better for some. However, due to low turnover and consumer opinions on the utility of ZEE, full conversion of the population of household ZEE is not expected to occur without amendments to the SORE regulations. The Proposed Amendments would make residential SORE more expensive starting in 2023 due to more stringent emission limits, making ZEE the lowest cost option. It is expected that upon their next purchase, household users will select ZEE based on purchase price.

On the professional side, the survey targeted both businesses and landscape vendors. Businesses were defined as those that do not conduct landscaping as their service, but rather use outdoor power equipment to maintain their own properties. Landscape vendors, both licensed and unlicensed were treated as a separate category in this survey. Of the estimated two million pieces of outdoor power equipment owned by businesses, 57% were electric. Among landscape vendors there were an estimated 803,000 pieces of lawn and garden equipment. Only 8% of this equipment was electric, although 60% of responding vendors stated that they know of electric versions of the equipment types they own. Landscape vendors use their equipment more regularly than individual residents, so it is notable that only 8% of this extensively used equipment is ZEE considering turnover is faster in this market segment. Per the survey, the lifespan of lawn and garden equipment used by vendors is about half that of household equipment.

To better understand the ZEE rate of adoption with landscape vendors, the survey asked participants what qualities of the equipment were most important to them. Performance, run-time, and cost were the top three responses. With sufficient batteries to last a day, the average professional ZEE is more expensive than the SORE counterpart. As an example, a professional ZEE leafblower costs twice as much as its gas counterpart. Cost is a significant barrier to transforming the population of lawn and garden equipment in the professional market. It is not expected at this time that the Proposed Amendments will bring down the cost of ZEE directly. However, to meet our SIP requirements, CARB must do more than reduce emission standards for SORE; ZEE must be a large part of the plan. Given the results of the survey, it is necessary to transition to ZEE more quickly than would occur in the baseline scenario. The Proposed Amendments to the SORE regulations would ensure that transition is complete for new equipment produced on or after January 1, 2028.

4. Major Regulation Determination

The proposed SORE amendments have been determined to be a major regulation because the economic impact of the regulation in California is estimated to exceed \$50 million in multiple years of the regulatory timeline extending from 2020 to 2040. The economic impact is estimated as a result of direct cost and cost-savings to individuals and businesses within the state. Cost increases are associated with purchasing ZEE equipment, which is more expensive in the commercial lawn and garden sector of the market. The prices for ZEE are comparable, or in many cases lower, in the residential sector of the market. Operational cost-savings come in the form of not having to purchase gasoline to fuel SORE as well as reduced maintenance and repair costs.

5. Baseline Information

For the SRIA, the economic and emissions impacts of the Proposed Amendments to the SORE regulations are evaluated against the business-as-usual (BAU) scenario each year for the analysis period from 2022 to 2040. The BAU case for the economic and emissions analysis for the Proposed Amendments is referred to as the baseline and uses the same outdoor power equipment inventory for both analyses. The baseline equipment inventory was developed with the data obtained from the CSU Fullerton SORE survey conducted in early 2019, engine production line testing data provided to CARB, and evaporative emissions certification reporting data.

The projection of the total SORE population was based on household growth projections in California. It is expected that there will be little household growth in California, and SORE population is expected to increase similarly. SORE population in the past has tracked well with household growth, so that has been used as a proxy going forward. Regulatory scenarios assume no change in consumer behavior or total population of SORE and its ZEE equivalents. Because the prices are similar for residential users, we do not expect this regulation to induce a change in landscaping type. The cost of converting landscaping would be significantly higher than the slight increase in equipment costs.

The current economic situation has much more strongly influenced the poorest Americans who likely reside less frequently in single-family homes and, therefore, own less lawn and garden equipment. 39% of Americans earning \$40,000 or less lost work, while job losses were experienced by only 13% of those earning \$100,000 or more.² Additionally, the increase in public safety power shutdowns (PSPS) in California has not yet been fully reflected in the SORE inventory, where we would expect an increase in generator purchases.

The baseline population inventory separates the total amount of outdoor power equipment in the state into several categories. First, the equipment is separated out by type of owner. Here, there are four categories: individual, businesses, landscapers, and government. The fraction of outdoor power equipment belonging to each group is based on the survey data and when projected out to 2040 was not expected to change.

The population data is then separated out by power type, whether SORE or ZEE. ZEE can then be distinguished as either cordless or corded. Corded ZEE is less common in the outdoor power equipment market and does not appear to be where the market is headed. For regulation modeling, it was expected that any gains in the amount of ZEE in the market would be cordless, battery-operated units.

The gasoline equipment sold today is assumed to be minimally compliant with today's standards. While equipment meeting the 2023 standards is available today, through the ABT program, there are corresponding engines sold that emit at levels above the current standards. The ABT

²Smialek, Jeanna. "Poorest Americans Hit Hardest by Job Losses Amid Lockdowns, Fed Says." *New York Times*, 14 May 2020, p. B6.

program ensures that equipment is, on average, compliant with the standards of today, but individual pieces may emit at higher or lower levels.

Finally, the population is delineated by type of equipment. This included eleven categories into which nearly all non-preempt outdoor power equipment can be categorized, and one general category for the remainder. The twelve categories along with the baseline (2022) population in each can be seen in Tables A-4, A-5, A-6, and A-7. The modeled total population of off-road power equipment during the period 2022-2040 is shown in Figure A-1. The inventory shows that while ZEE comprise a significant share of individual household market, they account for less than 10% of the professional lawn and garden equipment commonly used by landscapers.

Table A-4. Inventory of Outdoor Power Equipment Owned by Businesses who are Not Landscapers for the Baseline Year of 2022.

Category	Population	Fraction of total Equipment of Type Statewide (%)	Fraction of population that is ZEE (%)
Chainsaw	169,900	5.0	5.4
Lawn mower	110,000	2.7	3.4
Leaf blower/vacuum	279,900	6.6	32.5
String trimmers	208,400	4.5	20.0
Other L&G	41,500	2.8	11.1
Compressor	305,400	9.2	82.5
Generator	214,000	11.5	14.4
Pressure Washer	248,900	10.4	46.1
Pumps	139,300	7.6	67.0
Snow blowers	6,100	9.7	0.0

Table A-5. Inventory of Outdoor Power Equipment Owned by Landscaping Businesses for the Baseline Year of 2022.

Category	Population	Fraction of total Equipment of Type Statewide (%)	Fraction of population that is ZEE (%)
Chainsaw	209,400	6.2	2.8
Lawn mower	110,700	2.7	2.6
Leaf blower/vacuum	143,200	3.4	8.3
String trimmer	143,000	3.1	3.9
Hedge trimmer	43,900	0.0	8.3
Other L&G	14,100	3.9	65.4
Compressor	13,000	0.4	43.2
Generator	15,000	0.8	17.5
Pressure Washer	10,300	0.4	34.5
Pumps	5,300	0.3	9.7
Snow blowers	9,400	13.9	6.8
Riding mower	2,200	100.0	7.7

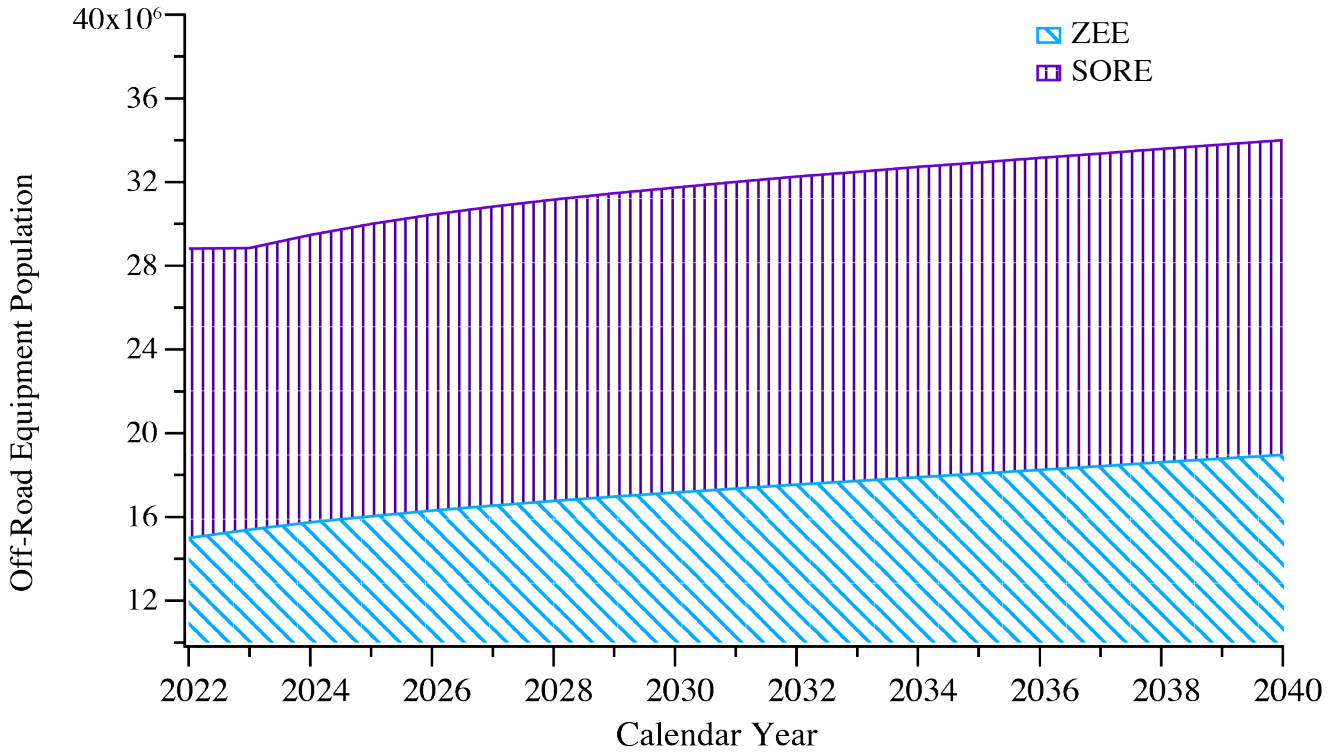
Table A-6. Inventory of outdoor power equipment owned by government entities for the baseline year of 2022.

Category	Population	Fraction of total Equipment of Type Statewide (%)	Fraction of population that is ZEE (%)
Chainsaw	410	0.01	5.4
Lawn mower	260	0.01	3.4
Leaf blower/vacuum	670	0.02	32.5
String trimmer	500	0.01	20.0
Other L&G	100	0.01	11.1
Compressor	730	0.02	82.5
Generator	510	0.03	14.4
Pressure Washer	600	0.02	46.1
Pumps	330	0.02	67.0
Snow blowers	20	0.02	0.0

Table A-7. Inventory of outdoor power equipment owned by individuals for the baseline year of 2022.

Category	Population	Fraction of total Equipment of Type Statewide (%)	Fraction of population that is ZEE (%)
Chainsaw	3,007,400	88.8	39.6
Lawn mower	3,900,200	94.6	23.0
Leaf blower/vacuum	3,808,800	90.0	74.1
String trimmer	4,228,600	92.3	58.8
Other L&G	1,372,800	93.2	61.5
Compressor	3,015,100	90.4	94.0
Generator	1,635,000	87.7	14.9
Pressure Washer	2,131,000	89.2	67.7
Pumps	1,691,000	92.1	94.2
Snow blowers	51,700	77.0	20.0

Figure A-1. Modeled Off-road Power Equipment Statewide Population for BAU scenario



6. Public Outreach and Input

Staff has conducted extensive public outreach around the amendments to SORE regulations and have received many comments from stakeholders. CARB staff has attended many conventions held for landscapers in California. These conventions have provided opportunities for staff to tell professional landscapers about upcoming regulation changes and about zero-emission equipment capabilities and availability. Events attended include the Green Schools Summit in Pasadena in November 2018, California Landscape Industry Show in Ontario in February of 2019, Long Beach Landscape Expo in October 2019, and the NorCal Landscape Show in February of 2020.

Additionally, CARB staff has presented information about zero-emission landscaping equipment and the potential for regulatory amendments aimed at converting all SORE to zero-emission equipment at several meetings attended by landscapers and local decision-makers in California. Presentations were given to the Pleasanton Committee on Energy and the Environment in January 2019, the San Francisco Integrated Pest Management Technical Advisory Committee in March 2019, the San Mateo Integrated Pest Management Workshop in April 2019, and the San Francisco Commission on the Environment in November 2019.

CARB staff also presented an update on zero-emission alternatives to SORE to the Board in November 2018. Staff talked about demonstration projects that gave professional landscapers an opportunity to test professional-grade battery-operated landscaping equipment.

Additionally, staff spoke about cities in California that had already converted their municipal landscaping to zero-emissions and colleges and universities on the path to do the same.

The first pre-rulemaking public workshop on the regulation amendments was held in September 2019 via webinar and in person. Staff presented regulatory concepts and showed a plan to move SORE to zero-emissions. The workshop was attended by industry, environmental groups, and interested citizens. Approximately ten comments were received after the workshop and all indicated a desire to go to zero-emissions as soon as possible.

On November 19, 2019, CARB staff sent an email to the CARB-maintained listserv for the SORE Working Group and the Mobile Source Program Mailouts, soliciting alternatives to what was presented in the September workshop. Thirteen replies were received before the December 31 deadline, with most responders asking CARB to require zero-emissions as soon as possible. Several industry respondents claimed the move toward zero-emissions was too rapid and not feasible.

On June 9, 2020, a second pre-rulemaking public workshop on the amendments was held via webinar. Draft regulation language was released on May 29, 2020. At the workshop, a summary of the draft changes to regulations was presented and a lengthy question and answer period followed. The questions and comments came from environmental groups, industry, and interested citizens. Several questions and comments were about design standards for evaporative certification. Staff requested data from industry demonstrating that the design standards could meet the new whole-engine evaporative standards. Additionally, some questions were asked about generators and zero-emission alternatives to generators. Finally, many questions were asked about why CARB was not moving directly to zero-emission equipment requirements in 2023. As of this writing, approximately fifteen written comments, outside the workshop, have been received. One is a technical comment about test procedures. The rest of the comments have asked for a transition to zero-emission equipment only in 2023.

B. BENEFITS

The 2016 CARB Mobile Source Strategy identifies that “electrification and progress toward zero-emission is critical to address the remaining (from renewable fuels) localized risk of cancer and other adverse effects,” and “(electrification) must play a growing role in reducing GHG emissions and petroleum use.”³ While SORE are regulated separately from mobile sources, the SORE market is prepared for electrification as well. The Proposed Amendments to the SORE regulations support the goals of the SIP and would reduce pollutants linked to multiple adverse health effects with existing California Ambient Air Quality Standards (CAAQS).⁴ These pollutants are oxides of nitrogen (NO_x), which are key ingredients in the formation of several airborne toxic

³ California Air Resources Board. Mobile Source Strategy. May, 2016. (web link: <https://ww3.arb.ca.gov/planning/sip/2016sip/2016mobsrsrc.pdf>. Last accessed June 2020.)

⁴ 30 California Air Resources Board, California Ambient Air Quality Standards (web link: <https://ww2.arb.ca.gov/resources/california-ambient-air-quality-standards>, last accessed June 2020).

substances,⁵ and particulate matter of diameter less than 2.5 microns (PM_{2.5}), which may deposit deep inside the lung. Long-term exposure to PM_{2.5} has been causally linked to premature death, particularly in people who have chronic heart or lung diseases, and reduced lung function in children.⁶ The Proposed Amendments to the SORE regulations also reduce GHG emissions and petroleum use.

1. Emission Benefits

a. Inventory methodology

Emissions benefits for the Proposed Amendments to the SORE regulations are based on a model draft by CARB called SORE2020. This model has been created based on several data sources and projections. The SORE population and activity data inputs are based on the results of the survey conducted in late 2018 by the Social Science Research Center at CSU, Fullerton.⁷ The population data also includes a small amount of new engines which are used in construction and farm equipment or vehicles under 175 horsepower that fall under section 209, subsection (e)(1) of the Clean Air Act. The Clean Air Act, however, does not grant CARB the authority to regulate the emissions from this type of new engine. The population of these engines is assumed to be unchanged from the baseline under any regulatory scenario. Annual scrappage rates were determined for a given calendar year model equipment based on population data for calendar year 2000 equipment still in operation in 2012 and 2018. All equipment is assumed to be scrapped, and no used equipment sales are considered. Exhaust and evaporative emission data were taken from SORE certification applications submitted to CARB and from internal testing conducted by staff. Finally, potential growth of outdoor power equipment sales was estimated via production line testing data and evaporative family reporting data, both of which require manufacturers to submit actual California-directed production volume of each engine or evaporative family for the model year. Growth in ownership of outdoor power equipment was also scaled by projected statewide population growth. In the baseline scenario, no further growth in the fraction of ZEE equipment in the outdoor power equipment sector was modeled.

With these data, emissions factors were created for each type of SORE equipment taking into account known deterioration factors (the rate at which emissions increase as equipment is used). Emissions estimates for each type of SORE in tons per day were calculated out to 2040 by multiplying the emission factor by activity data and total population of the equipment. SORE2020 outputs daily emissions estimates for reactive organic gases (ROG), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM), and carbon dioxide (CO₂). The model was refined after outreach and workshops with the general public and industry stakeholders. Further details on the model methodology can be found in the draft SORE2020 Technical Report.⁸

⁵ California Air Resources Board, Nitrogen Dioxide and Health (web link: <https://ww2.arb.ca.gov/resources/nitrogen-dioxide-and-health>, last accessed June 2020).

⁶ California Air Resources Board, Inhalable Particulate Matter (PM 2.5 and PM10) (web link: <https://ww3.arb.ca.gov/research/aaqs/common-pollutants/pm/pm.htm>, last accessed June 2020).

⁷ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019.

⁸ California Air Resources Board. DRAFT 2020 Emissions Model for Small Off Road Engines – SORE2020. May 2020. (web link: https://ww3.arb.ca.gov/msei/draft_sore2020_technical_documentation_may_2020_ada.pdf last accessed June 2020)

b. Anticipated emission benefits

The projected benefits of the Proposed Amendments to SORE regulations in modeled years 2030 and 2040 are identified in Table B-1 with respect to NO_x, and ROG. Emissions benefits are calculated based on a phase-out of SORE equipment to be replaced by ZEE as per the amendments. The results of the model for both ROG and NO_x are shown graphically for all years in Figures B-1 and B-2. In the baseline scenario, ROG and NO_x emissions increase year over year due to an increase in population of SORE equipment.

Significant reductions in both NO_x and ROG can first be seen in calendar year 2024, even before the zero-emission engine standard goes into effect in 2025. This is due to the cleaner SORE equipment that is compliant with the 2023 emission standards. Emission benefits continue to grow as the 2025 emission standard goes into effect and then the 2028 ZEE requirement is implemented. In 2031, the midpoint of the modeled time period, the reductions will be 76.3 tons per day of ROG and 9.9 tons per day of NO_x. These are 49 percent and 42 percent reductions in tons per day of ROG and NO_x, respectively. By 2028, no emissions would be produced by new equipment subject to California standards due to the implementation of the rule, so any emissions in 2031 are due to federally regulated equipment and older equipment still in use.⁹ The cumulative total emission reductions from 2020 to 2040 as a result of these amendments are estimated to be 454,065 tons of ROG and 59,607 tons of NO_x relative to baseline. By 2040, ROG and NO_x emissions do not reach zero but bottom out near 35 tons per day and 8.5 tons per day, respectively. The remaining emissions are due to a small amount of new engines which are used in construction and farm equipment or vehicles under 175 horsepower that was included in the SORE2020 model; section 209, subsection (e)(1) of the Clean Air Act, however, does not grant CARB the authority to regulate the emissions from this type of new engine.

Table B-1. Reductions of Emissions of Select Pollutants Relative to the Baseline Scenario Due to the Proposed Amendments to the SORE Regulations.

Calendar Year	ROG Reductions (tpd)	NO _x Reductions (tpd)	CO ₂ reductions (tpd)
2025	17.78	2.07	137.67
2031	76.33	9.93	2043.07

⁹ California Air Resources Board. List to Determine Preempt Off-Road Applications. April 4, 2014. (Web link: <https://ww3.arb.ca.gov/msprog/offroad/preempt.htm>. Last accessed June 2020)

Figure B-1. Modeled Emissions of Oxides of Nitrogen (NO_x) from SORE Equipment Under Both a Baseline Scenario and with the Proposed Amendments Enacted.

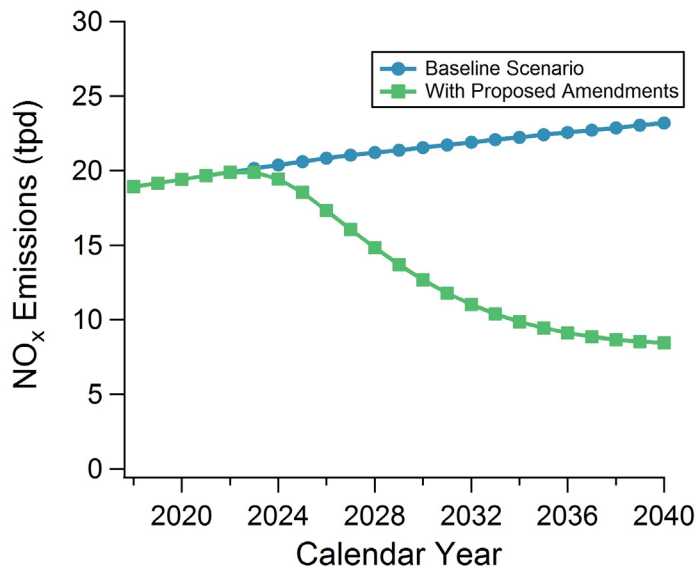
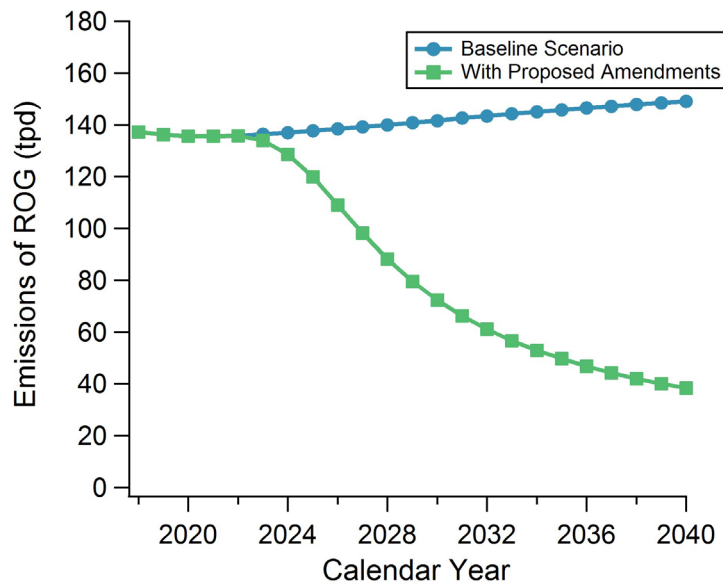


Figure B-2. Modeled Emissions of Reactive Organic Gases (ROG) from SORE Equipment Under Both a Baseline Scenario and with the Proposed Amendments Enacted.



While the proposed SORE regulation will significantly reduce criteria air pollutants to achieve CARB’s SIP goals and associated health benefits, by setting more stringent criteria air pollutant standards, there will be associated GHG reductions in transitioning the SORE sector in California to zero-emission equipment. Modeled results for 2022 to 2040 totaled 32,833 tons per day of CO₂ reduced over the baseline scenario. CO₂ emissions reductions are first seen in 2025 and

increase in each subsequent year. The reductions are seen for milestone modeled year 2025 and 2031 in Table B-1.

2. Benefits to Typical Businesses

Here, typical businesses are defined as those that own outdoor power equipment to maintain their own property, but not businesses that do landscaping for others. The biggest non-cost benefit to typical businesses across the state will be in the durability of the outdoor power equipment they purchase. The Proposed Amendments to the SORE regulations increase the durability requirements for SORE starting with engines produced in 2023. While engine durability as a feature is not something that is necessarily advertised to consumers, it does lead to a more reliable product. With regards to ZEE, despite higher upfront costs, ZEE batteries frequently outlive the lifetime of ZEE equipment. The first purchase of ZEE requires purchasing sufficient batteries for use time, which in a commercial context is a significant contributor to the upfront price. Subsequent equipment purchases may require fewer batteries, therefore lowering the price significantly. In this analysis, upfront equipment prices have been assumed to be constant, as we have no way of tracing which equipment purchases are new versus subsequent and this creates the most conservative estimate. Maintenance is also much less intensive and needed less frequently on ZEE. Having more durable equipment that is not taken out of service for maintenance reduces the need for backup equipment and spare parts. ZEE batteries tend to outlive the equipment itself, so when it is necessary to buy replacement ZEE, the cost will be lower because the battery from the old ZEE can be used in new ZEE within the same product line.

3. Benefits to Small Businesses

Small businesses that will be affected by the Proposed Amendments to the SORE regulations will be landscapers, both licensed and unlicensed. The benefits to these businesses will be similar to those discussed in the typical business section including more reliable ZEE, less intensive maintenance costs, and less frequent turnover of equipment.

4. Benefits to Individuals

a. Health Benefits

i. Background on Health Benefits and Model

The Proposed Amendments to the SORE regulations reduce NO_x and PM_{2.5} emissions and reduce the formation of ozone, resulting in health benefits for individuals in California. These health benefits are fewer instances of premature mortality, fewer hospital and emergency room visits, and fewer lost days of work. As part of setting the National Ambient Air Quality Standard for PM, U.S. EPA quantifies the health risk from exposure to PM and CARB relies on the same health studies for this evaluation.¹⁰ The evaluation method used in this analysis is the same as the one

¹⁰ United States Environmental Protection Agency, Health and Environmental Effects of Particulate Matter (web link: <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>, last accessed June 2020)

used for the Advanced Clean Truck Regulation and the 2018 amendments to the Low Carbon Fuel Standard.^{11,12}

CARB analyzed the value associated with four health outcomes in the BAU, Proposed Amendments, and alternatives: Cardiopulmonary (related to the lungs or heart) mortality, hospitalizations for cardiovascular (related to the heart and blood vessels) illness, hospitalizations for respiratory illness and emergency room (ER) visits for respiratory illness and asthma.

These health outcomes were selected because U.S. EPA has identified these as having a causal or likely causal relationship with exposure to PM_{2.5}.¹³ U.S. EPA examined other health endpoints such as cancer, reproductive and developmental effects, but determined there was only suggestive evidence for a relationship between these outcomes and PM exposure, and insufficient data to include these endpoints in the national health assessment analyses routinely performed by U.S. EPA.

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.¹⁴ While other mortality endpoints could be analyzed, the strongest evidence exists for cardiopulmonary mortality.¹⁵ The greater scientific certainty for this effect, along with the greater specificity of the endpoint, leads to an effect estimate for cardiopulmonary deaths that is both higher and more precise than that for all-cause mortality.¹⁶

Similarly, U.S. EPA has determined a causal relationship between non-mortality cardiovascular effects and short and long-term exposure to PM_{2.5}, and a likely causal relationship between non-mortality respiratory effects and short and long-term PM_{2.5} exposure.¹⁷ These outcomes lead to hospitalizations and ER visits, and are included in this analysis.

¹¹ California Air Resources Board. Advanced Clean Trucks Regulation Standardized Regulatory Impact Assessment. (web link: <https://ww3.arb.ca.gov/regact/2019/act2019/appc.pdf>. Last accessed June 2020)

¹² California Air Resources Board. Staff Report: ISOR for Low Carbon Fuel Standards 2018 amendments. (web link: https://ww3.arb.ca.gov/regact/2018/lcfs18/isor.pdf?_ga=2.70664151.691849149.1592511856-742146528.1552589504. Last accessed June 2020.)

¹³ U.S. EPA, 2010. Quantitative Health Risk Assessment for Particulate Matter (Final Report). (Web link: https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf. Last accessed June 2020)

¹⁴ U.S. EPA, 2010. Quantitative Health Risk Assessment for Particulate Matter (Final Report). (Web link: https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf. Last accessed June 2020)

¹⁵ U.S. EPA, 2010. Quantitative Health Risk Assessment for Particulate Matter (Final Report). (Web link: https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf. Last accessed June 2020)

California Air Resources Board. Estimate of Premature Deaths Associated with Fine Particle Pollution (PM_{2.5}) in California Using a U.S. Environmental Protection Agency Methodology. 2010. (Web link: https://ww3.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf. Last accessed June 2020)

¹⁷ U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009. (Web link: http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959. Last accessed June 2020)

A detailed summary of the health modeling methodology can be found on CARB's website.¹⁸

ii. Results

Table B-2 shows the estimated total avoided premature mortality, hospitalizations, and emergency room visits because of the Proposed Amendments to SORE Regulations between 2022 and 2040 by California air basin, relative to the baseline. Only the regions with values of one or higher are shown. Values in parenthesis represent the 95 percent confidence intervals of the central estimate. As detailed in the previous section, the Proposed Amendments to the SORE Regulations are estimated to reduce overall emissions of ROG and NOx in every year starting in 2024, and lead to net reduction in adverse health outcomes statewide, relative to the baseline. Health benefits are first seen in 2024, and the reduction in cases and deaths continues to increase out to the end of the modeled time period as more SORE equipment is transitioned to ZEE and more units are purchased. Overall, the mortality rate due to cardiopulmonary causes will decrease by 791 (618-966) over the period modeled. The annual avoided health outcomes are shown in Table B-3. The biggest health benefits will occur in the South Coast and San Francisco Bay Air Basins.

¹⁸ California Air Resources Board. CARB's Methodology for Estimating the Health Effects of Air Pollution. May 2019. (Web link: <https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution>. Last accessed June 2020).

Table B-2. Modeled Regional and Statewide Avoided Mortality and Morbidity Incidents from 2020 to 2040 Under the Proposed Amendments. Values in parentheses represent the 95% confidence interval.

Air Basin	Avoided Cardiopulmonary Mortality	Avoided Hospitalizations for cardiovascular illness	Avoided Hospitalizations for respiratory illness	Avoided Emergency room visits
Lake County	1 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	3 (2 - 4)	0 (0 - 1)	0 (0 - 1)	1 (1 - 2)
Mountain Counties	4 (3 - 5)	0 (0 - 1)	0 (0 - 1)	1 (1 - 2)
North Central Coast	3 (3 - 4)	1 (0 - 1)	1 (0 - 1)	2 (1 - 3)
North Coast	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	26 (21 - 32)	3 (0 - 6)	4 (1 - 7)	10 (6 - 14)
Salton Sea	2 (2 - 3)	0 (0 - 1)	0 (0 - 1)	1 (1 - 2)
San Diego County	45 (35 - 56)	6 (0 - 12)	7 (2 - 13)	18 (12 - 25)
San Francisco Bay	100 (78 - 122)	15 (0 - 30)	18 (4 - 33)	55 (35 - 75)
San Joaquin Valley	46 (36 - 56)	5 (0 - 11)	6 (2 - 11)	17 (11 - 23)
South Central Coast	15 (12 - 18)	2 (0 - 4)	3 (1 - 5)	7 (4 - 9)
South Coast	543 (425 - 664)	90 (0 - 177)	108 (25 - 190)	278 (176 - 380)
Statewide	791 (618 - 966)	125 (0 - 244)	149 (35 - 262)	391 (248 - 535)

Table B-3. Annual Statewide Avoided Mortality and Morbidity Incidents Under the Proposed Amendments

Year	Avoided Premature Mortality	Avoided Cardiovascular Hospitalizations	Avoided Acute Respiratory Hospitalizations	Avoided ER Visits
2023	1	0	0	0
2024	3	0	0	2
2025	8	1	1	4
2026	15	2	2	7
2027	22	3	4	11
2028	30	4	5	15
2029	37	5	7	18
2030	43	6	8	21
2031	48	7	9	24
2032	53	8	10	26
2033	57	9	11	28
2034	60	10	11	30
2035	63	10	12	31
2036	66	11	13	33
2037	68	11	13	34
2038	71	12	14	34
2039	72	12	14	35
2040	74	12	14	36
Total	791	125	149	391

iii. Economic Impact of Health Benefits

In accordance with U.S. EPA practice, health outcomes are monetized by multiplying each incident by a standard value derived from the economic studies. The value per incident is shown in Table B-4. The value for avoided premature mortality is based on willingness to pay, which is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year. The economic value associated with reduced premature mortality is a major benefit of the Proposed Amendments. This benefit, however, does not correspond to direct changes in expenditures for households and businesses and is not included in the macroeconomic modeling (Section E). As avoided hospitalizations and emergency room visits correspond to reductions in household expenditures on health care, these values are included in the macroeconomic modeling.

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

childcare). These monetized benefits from avoided hospitalizations and emergency room visits are included in macroeconomic modeling (section E).

Table B-4. Valuation per Incident for Avoided Health Outcomes

Outcome	Value Per Incident (2019\$)
Avoided Premature Mortality	\$9,865,659
Avoided Cardiovascular Hospitalizations	\$58,275
Avoided Acute Respiratory Hospitalizations	\$50,831
Avoided Emergency Room Visits	\$834

Statewide valuation of health benefits was calculated by multiplying the value per incident in Table B-4 by the statewide total number of incidents for 2023 through 2040 as shown in Table B-5. Annual statewide valuation of health benefits is presented in Table B-5. The estimated total statewide health benefits derived from criteria emission reductions is estimated to be \$7.81 billion, with \$7.80 billion resulting from reduced premature mortality and \$15.2 million resulting from reduced hospitalizations and emergency room visits. The spatial distribution of these benefits across the state follows the distribution of the health impacts by air basin as described in Table B-2.

Table B-5. Statewide Valuation from Avoided Health Outcomes Under the Proposed Amendments

Outcome	Avoided Incidents	Valuation (Million 2018\$)
Avoided Premature Mortality	791	\$7,798.8
Avoided Cardiovascular Hospitalizations	125	\$7.3
Avoided Acute Respiratory Hospitalizations	149	\$7.6
Avoided Emergency Room Visits	391	\$0.3
Total	1456	\$7,814

b. Social Cost of Carbon

While the proposed SORE regulation will significantly reduce criteria air pollutants to achieve CARB’s SIP goals and associated health benefits, by setting more stringent criteria air pollutant standards, there will be associated GHG reductions in transitioning the SORE sector in California to zero-emission equipment. The benefit of these GHG 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 this analysis, 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 Plan¹⁹, with U.S. Presidential Executive Order 12866 and the Office of Management and Budget (OMB) Circular A-4 of September 17, 2003, and reflects the best available science in the estimation of the socio-economic impacts of carbon.²⁰

The IWG describes SC-CO₂ as follows:

The social cost of carbon (SC-CO₂) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO₂) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO₂ emissions by the same amount in that year. The SC-CO₂ is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts – from global climate change that result from an additional ton of CO₂.

These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket 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.²¹

Table B-6 presents the range of IWG SC-CO₂ values used in regulatory assessments, including the 2017 Scoping Plan.

Table B-6. Social Cost of Carbon 2020-2040 (2007\$ per Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2020	\$12	\$42	\$62
2025	\$14	\$46	\$68
2030	\$16	\$50	\$73
2035	\$18	\$55	\$78
2040	\$21	\$60	\$84

The SC-CO₂ is year specific; that is, environmental damages are estimated for a given year in the future and the value of the damages is discounted back to the present. The SC-CO₂ increases

¹⁹ California Air Resources Board, California’s 2017 Climate Change Scoping Plan, released in November 2017 (Web link: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf. Last accessed June 2020).

²⁰ Office of Management and Budgets, Circular A-4 (Web link: <https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf>. Last accessed June 2020).

²¹ National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, 2017, (Web link: www.nap.edu/24651. Last accessed June 2020).

over time as systems become stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. The SC-CO₂ is highly sensitive to the discount rate. Higher discount rates decrease the value today of future environmental damages. The IWG estimates the SC-CO₂ across a range of discount rates that encompass a variety of assumptions regarding the correlation between climate damages and consumption of goods and is consistent with OMB's Circular A-4 guidance. CARB utilizes the IWG standardized range of discount rates, from 2.5 to 5 percent to represent varying valuation of future damages.²² An inflation adjustment, using the California Consumer Product Index (CPI), is applied to the values to convert them into 2019 dollars, consistent with the rest of this analysis.²³

If all of the expected emissions reductions projected under the Proposed Amendment are achieved and assumed to be equivalent to CO₂ reductions, the avoided SC-CO₂ in a given year is the total emissions reductions (in MTCO₂e) multiplied by the SC-CO₂ (in \$/MTCO₂e) for that year. The annual emissions reductions from the Proposed Amendments and the estimated benefits are shown in Table B-7 below. The total benefits range between \$280 million to \$1.21 billion through 2040, depending on the discount rate.

²² National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, 2017, (web link: www.nap.edu/24651, Last accessed June 2020). As noted in the 2017 Scoping Plan, CARB is aware that the current federal administration has recently withdrawn certain social cost of carbon reports as no longer representative of federal governmental policy. However, this determination does not call into question the validity and scientific integrity of federal social cost of carbon work, or the merit of independent scientific work. Indeed, the IWG's work remains relevant, valid, reliable, and appropriate for use for these purposes.

²³ California Department of Finance. California Consumer Product Index (CPI-U), (web link: <http://dof.ca.gov/Forecasting/Economics/Indicators/Inflation/>, Last accessed June 2020).

Table B-7. Avoided Social Cost of CO₂ (Million 2019\$)

Year	GHG Emissions Reductions (MMTCO ₂ e)	5% Discount Rate	3% Discount Rate	2.5% Discount Rate
2022	0.0	\$0.0	\$0.0	\$0.0
2023	0.0	\$0.0	\$0.0	\$0.0
2024	0.0	\$0.0	\$0.0	\$0.0
2025	0.0	\$0.8	\$2.7	\$4.0
2026	0.2	\$2.7	\$9.1	\$13.4
2027	0.3	\$5.3	\$16.8	\$24.6
2028	0.4	\$7.6	\$24.7	\$35.7
2029	0.5	\$9.6	\$31.5	\$46.3
2030	0.6	\$12.3	\$38.3	\$55.9
2031	0.7	\$14.0	\$44.5	\$64.6
2032	0.7	\$16.4	\$50.1	\$72.3
2033	0.8	\$17.7	\$55.2	\$79.2
2034	0.9	\$19.9	\$59.8	\$85.3
2035	0.9	\$20.9	\$64.0	\$90.8
2036	0.9	\$23.0	\$67.8	\$95.7
2037	1.0	\$23.8	\$71.3	\$101.3
2038	1.0	\$25.7	\$74.4	\$105.2
2039	1.0	\$26.2	\$77.3	\$108.7
2040	1.0	\$28.0	\$80.0	\$111.9
Total	10.9	\$253.8	\$767.6	\$1,094.9

There is an active discussion within government and academia about the role of SC-CO₂ in assessing regulations, quantifying avoided climate damages, and the values themselves. In January 2017, the National Academies of Sciences, Engineering, and Medicine (NASEM) released a report examining potential approaches for a comprehensive update to the SC-CO₂ methodology to ensure resulting cost estimates reflect the best-available science. The NASEM review did not modify the estimated values of the SC-CO₂, but evaluated the models, assumptions, handling of uncertainty, and discounting used in the estimating of the SC-CO₂. The report titled, “Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide,” recommends near-term improvements to the existing IWG SC-CO₂ as well as a long-term comprehensive updates. The State will continue to follow updates to the IWG SC-CO₂, outlined in the NASEM report, and incorporate appropriate peer-reviewed modifications to estimates based on the latest available data and science.²⁴

²⁴ National Academy of Sciences, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide (Web link: <http://www.nap.edu/24651>, Last accessed June 2020)

It is important to note that the SC-CO₂, while intended to be a comprehensive estimate of the damages caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the SC-CO₂, including costs associated with changes in co-pollutants, the social cost of other GHGs including methane and nitrous oxide, and costs that cannot be included due to modeling and data limitations. The Intergovernmental Panel on Climate Change (IPCC) has stated that the IWG SC-CO₂ estimates are likely underestimated due to the omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts.²⁵ CARB will continue engaging with experts to evaluate the comprehensive California-specific impacts of climate change and air pollution.

c. Other Benefits

In addition to emission reductions, ZEE offer a number of other benefits to operators when compared to SORE powered equipment. ZEE is quieter which reduces noise at the worksite as well as in the community where the equipment is operating. Some local jurisdictions have noise ordinances that limit when outdoor power equipment can be used. The switch to ZEE may allow for longer working hours with this equipment. On an individual level, there is evidence for a health benefit to a landscaper or worker who uses SORE equipment regularly during their workday. By switching to ZEE, frequent users will no longer be exposed to toxic air contaminants (TACs) that are emitted in SORE exhaust from burning gasoline such as benzene and 1,3-butadiene.^{26,27} Chronic exposure to TACs can increase one's individual cancer risk.²⁸

C. DIRECT COSTS

1. Direct Cost Inputs

To estimate the direct cost to all affected entities (individuals, businesses, landscape vendors, and government agencies), the previously described equipment population data from the CSU, Fullerton survey, was combined with activity data to model the population of both ZEE and SORE equipment each year starting in 2022 and continuing through 2040. This was done via the SORE2020 model mentioned in section B. The population of each type of equipment was further broken down by type of owner: individual, business, government, or landscaper. This modeled population was then combined with the prices and factors described in the following sections to estimate direct costs to various segments of the economy of the Proposed Amendments to the SORE regulations. These costs were further split into upfront and ongoing costs.

²⁵ Intergovernmental Panel on Climate Change, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate change (Web link:

https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg3_full_report-1.pdf. Last accessed June 2020).

²⁶ U.S. EPA. Benzene. September 2016 (Web link:

<https://www.epa.gov/sites/production/files/2016-09/documents/benzene.pdf>. Last accessed June 2020).

²⁷ U.S. EPA. Locating and Estimating Air Emissions from Sources of 1,3-Butadiene. November 1996 (Web link:

<https://www3.epa.gov/ttn/chief/le/butadien.pdf>. Last accessed June 2020).

²⁸ Office of Environmental Health Hazard Assessment. Toxic Air Contaminants. (Web link:

<https://oehha.ca.gov/air/toxic-air-contaminants>. Last accessed June 2020).

a. New Equipment Manufacturing

There will be a cost to engine and outdoor power equipment manufacturers to comply with the amendments to the SORE regulation. Manufacturers will have to produce engines that are compliant with the 2023 and 2024 emissions limits or use or buy emission credits to satisfy the regulatory requirements. This may require more research and development and changes to their manufacturing processes which will require large costs. Further, once the emission standard goes to zero in 2025, some manufacturers may choose not to have a ZEE product line and may see a loss in sales in the California market. Because all the major manufacturers of both SORE and outdoor power equipment are based outside of California, these direct costs are assumed to be passed on to equipment end-users and are estimated based the difference in market prices end-users will pay for compliant equipment compared to what would have been purchased in the baseline.

b. New Equipment Purchases

The upfront costs to individuals, businesses, landscapers, and government entities are the purchase of new SORE or ZEE outdoor power equipment. These costs were estimated to be the median cost of the top 10 most popular models of a given piece of equipment in currently compliant SORE, SORE that meets the 2023 emission standards and ZEE. For residential users, costs were determined from the major retailers, while the cost of professional equipment was determined from independent dealers. Prices of equipment were held constant over the modeled period. Professional costs do include enough batteries for the equipment to run for a full eight-hour workday. The example equipment and battery needs can be found in Chapter G Appendix. To be most conservative, it is assumed all businesses own commercial-grade equipment. Many likely own residential equipment to maintain small outdoor spaces, which would decrease their upfront costs and be faster to reach the break-even point. In addition, an 8.5 percent sales tax was added to the equipment costs.²⁹

The costs of cleaner SORE equipment that is currently on the market that would be compliant with the 2023 and 2024 emissions standards was determined from equipment already for sale in California that meets the lower standards. This analysis was further separated into professional and household equipment because the difference in cost in professional ZEE versus SORE creates a very different cost analysis than the residential side. Professional and household equipment population growth was assumed to be proportional to market share and scaled by overall human population growth. New annual sales were determined from the SORE2020 model, using data from the CSU Fullerton survey, and certification and sales data reported to CARB.³⁰ The upfront cost of purchasing SORE equipment and ZEE for the household and professional markets is shown in Tables C-1 and C-2. Several categories of household equipment, such as chainsaws and edgers have a minimal incremental cost in the switch to cleaner SORE and ZEE. In the professional market, ZEE snowblowers and stand-behind

²⁹ The sales tax varies across the state from a minimum of 7.25% up to 10.25% in some municipalities; a value of 8.5% was used for staff's analysis based on a statewide population weighted average.²⁹

³⁰ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

lawnmowers create a negative incremental cost. However, the incremental cost for ZEE pressure washers and generators is substantial. Figure C-1 shows how the fraction of ZEE in the total statewide population is modeled to increase between 2023 and 2040 as a result of the Proposed Amendments. The annual incremental cost to households and professional users statewide is shown in Figure C-3.

Table C-1. Upfront Cost to Purchase Household Outdoor Power Equipment in Both the BAU and Proposed Amendments Scenario Including the Incremental Cost

Type of Equipment	Current SORE Cost	2023 Compliant SORE Cost	ZEE Cost	Incremental Cost 2023 over BAU	Incremental Cost in 2025 over BAU
Chainsaws	\$203	\$211	\$299	\$9	\$97
Generator Sets	\$800	\$1,500	\$2,000	\$700	\$1,200
Lawn Mowers	\$280	\$500	\$450	\$220	\$170
Leaf Blowers/ Vacuums	\$150	\$650	\$200	\$500	\$50
Pressure Washers	\$399	\$326	\$801	-\$73	\$402
Pump <2hp	\$300	\$450	\$319	\$150	\$19
Riding Mowers	\$1,899	\$3,561	\$3,174	\$1,662	\$1,275
Snowblowers	\$280	\$500	\$450	\$220	\$170
Trimmers/ Edgers/ Brush Cutters	\$192	\$200	\$197	\$9	\$5

Table C-2. Upfront Cost to Purchase Professional Outdoor Power Equipment in Both the BAU and Proposed Amendments Scenario Including the Incremental Cost

Type of Equipment	Current SORE Cost	2023 Compliant SORE Cost	ZEE Cost	Incremental Cost in 2023 over BAU	Incremental Cost in 2025 over BAU
Chainsaws	\$900	\$1,135	\$850	\$235	-\$50
Generator Sets	\$4,889	\$13,000	\$22,495	\$8,111	\$17,606
Lawn Mowers	\$3,000	\$2,150	\$2,010	-\$850	-\$990
Leaf Blowers/ Vacuums	\$434	\$650	\$1,370	\$216	\$936
Pressure Washers	\$1,249	\$3,321	\$19,499	\$2,072	\$18,250
Pump <2hp	\$300	\$450	\$319	\$150	\$19
Riding Mowers	\$10,499	\$27,917	\$19,499	\$17,418	\$9,000
Snowblowers	\$3,000	\$2,150	\$2,010	-\$850	-\$990
Trimmers/ Edgers/ Brush Cutters	\$340	\$429	\$980	\$89	\$640

Figure C-1. Modeled Population of Outdoor Power Equipment in the Proposed Amendments Scenario.

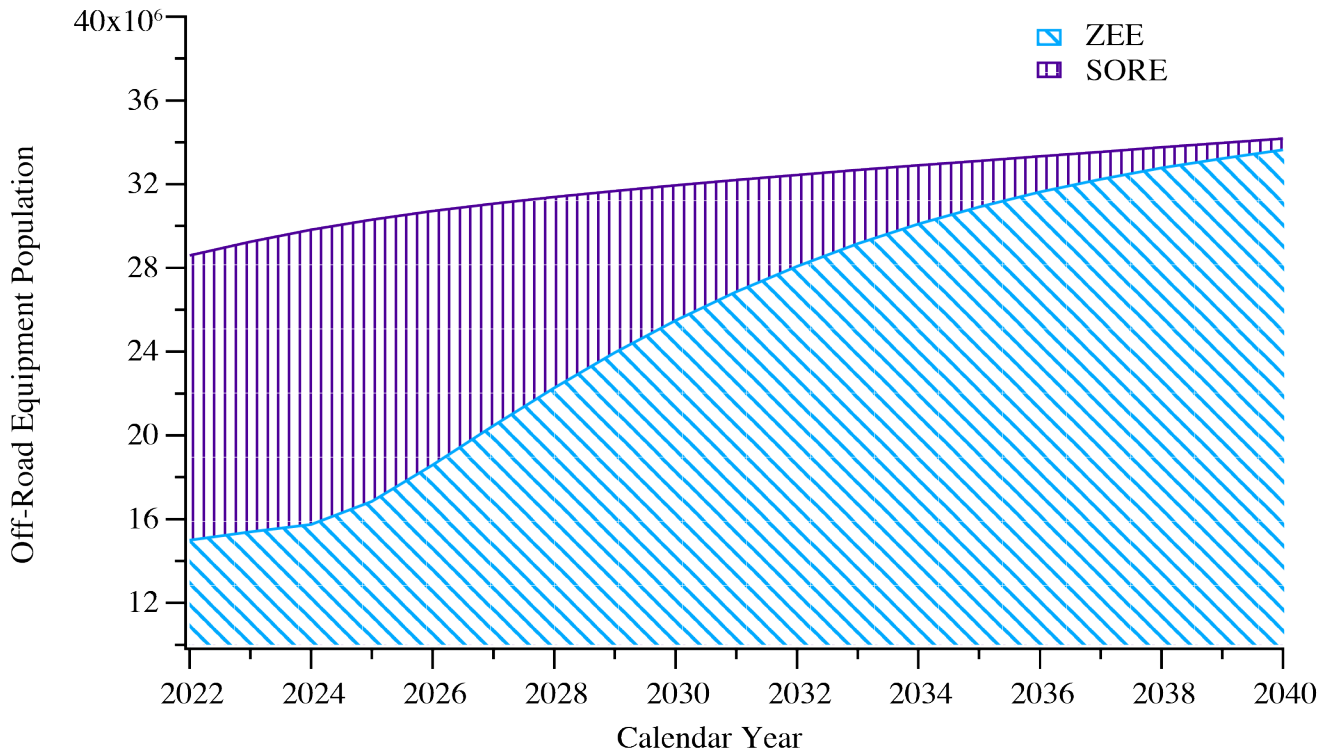


Table C-3. Modeled Outdoor Power Equipment Costs in the Household and Professional Market per Year Due to the Proposed Amendments to the SORE Regulations Relative to the Baseline Scenario. All values in millions of dollars

Year	Gasoline Equipment Costs- Professional	Gasoline Equipment Costs- Household	Electric Equipment Costs- Professional	Electric Equipment Costs- Household	Total Equipment Costs- Professional	Total Equipment Costs- Household	Total Equipment Costs
2022	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
2023	\$80.7	\$132.2	\$8.0	\$25.1	\$88.8	\$157.2	\$246.0
2024	\$81.3	\$132.6	\$8.5	\$25.2	\$89.7	\$157.8	\$247.5
2025	-\$139.4	-\$238.7	\$537.5	\$401.8	\$398.1	\$163.1	\$561.2
2026	-\$139.9	-\$239.6	\$540.2	\$403.4	\$400.4	\$163.8	\$564.2
2027	-\$140.3	-\$240.3	\$543.0	\$405.0	\$402.8	\$164.7	\$567.5
2028	-\$140.7	-\$241.2	\$545.8	\$406.8	\$405.0	\$165.6	\$570.6
2029	-\$141.2	-\$242.0	\$548.6	\$408.5	\$407.4	\$166.5	\$574.0
2030	-\$141.6	-\$242.8	\$551.4	\$410.2	\$409.8	\$167.4	\$577.2
2031	-\$142.0	-\$243.7	\$554.2	\$412.0	\$412.2	\$168.3	\$580.5
2032	-\$142.5	-\$244.6	\$557.0	\$413.7	\$414.6	\$169.2	\$583.7
2033	-\$143.0	-\$245.4	\$559.9	\$415.4	\$416.9	\$170.0	\$586.9
2034	-\$143.4	-\$246.3	\$562.8	\$417.2	\$419.4	\$170.9	\$590.2
2035	-\$143.9	-\$247.2	\$565.6	\$419.0	\$421.7	\$171.9	\$593.6
2036	-\$144.3	-\$248.0	\$568.5	\$420.8	\$424.2	\$172.7	\$597.0
2037	-\$144.8	-\$248.9	\$571.5	\$422.6	\$426.6	\$173.7	\$600.3
2038	-\$145.3	-\$249.8	\$574.4	\$424.5	\$429.1	\$174.7	\$603.8
2039	-\$145.7	-\$250.6	\$577.4	\$426.2	\$431.7	\$175.6	\$607.3
2040	-\$146.3	-\$251.6	\$580.4	\$428.0	\$434.1	\$176.4	\$610.5
Average	-\$111.6	-\$192.4	\$471.3	\$351.9	\$359.6	\$159.5	\$519.1
Total	-\$2,122.3	-\$3,655.8	\$8,954.9	\$6,685.1	\$6,832.5	\$3,029.4	\$9,861.9

Overall, there will be significant upfront costs to all users of outdoor power equipment due to the Proposed Amendments to the SORE regulations. This increased cost is due to the estimated higher prices of cleaner SORE equipment that meets the 2023 and 2024 standards and ZEE as compared to SORE equipment currently on the market. There is an increased cost over the baseline each year modeled starting in 2023 when the more stringent emissions standards go into place. For 2023 and 2024, this cost is mostly borne by individuals because of the relatively greater increase in price of gasoline powered SORE equipment for households compared to professional end-users. For 2023 and 2024, individual purchasers of SORE equipment are expected to incur an added cost of about \$157 million per year, compared to about \$89 million per year for the professional side of the market.

That changes in 2025, when the emission standard for SORE equipment goes to zero. As the most economically conservative scenario, it was modeled that no new spark-ignition equipment being produced on or after January 1, 2025 would be sold in California. CARB recognizes this is a conservative assumption as the Proposed Amendments to the SORE regulations do allow for the use of credits to continue to sell SORE through the end of 2027. This modelling decision creates an upper bound on the one-year swing in costs incurred by professional and household outdoor power equipment users. If some SORE equipment is purchased in 2025, the cost burden would decrease. In 2025, 71% of the cost burden is borne by professional equipment purchasers, though they only make up 10% of the market. This is due to the, currently, high price of professional ZEE as compared to current SORE equipment.

The total increased cost associated with purchasing new compliant outdoor power equipment is on average \$519.1 million per year over the regulatory time horizon, totaling \$9.86 billion.

c. Fuel and Electricity

Fuel for SORE equipment, electricity to charge batteries on cordless ZEE, and electricity to power corded equipment were considered as ongoing costs of ownership. Power requirements for the equipment included are based on representative model data from manufacturers reported on sales websites and through direct contact with manufacturers. This data was then combined with an estimated mean use rate based on survey data. It was assumed that 2023 complaint SORE would have the same usage and power requirements. The resulting annual power consumption for current SORE, 2023 compliant SORE and ZEE for household and professional equipment are found in Tables C-4 and C-5. Fuel prices and electricity rates are based on the forecast from the California Energy Commission assuming a moderate level of demand going forward.³¹ These costs and rates are shown in Table C-6. All fuel is assumed to be California reformulated gasoline and the 2030 rates were used for modeled years between 2030 and 2040. Electricity rates were differentiated for business and residential users. Ongoing fuel and electricity costs as compared to a baseline scenario are shown in Table C-7. As with upfront

³¹ California Energy Commission staff. Final 2019 Integrated Energy Policy Report. California Energy Commission. 2019. Publication Number: CEC-100-2019-001-CMD. (Web link: <https://efiling.energy.ca.gov/getdocument.aspx?tn=232922>. Last accessed June 2020).

costs, to be most conservative, it is assumed all businesses use their equipment as frequently as landscapers.

Table C-4. Estimated Annual Energy Needs for Household Outdoor Power Equipment.

Equipment Type	Estimated Annual Gas Usage SORE (gal/year)	Estimated Annual Electricity Usage (kWh/year)
Chainsaws	1.67	8.51
Generator Sets	52.50	136.00
Lawn Mowers	5.75	10.02
Leaf Blowers/Vacuums	6.00	8.37
Pressure Washers	11.60	4.09
Pump <2hp	0.83	144.61
Riding Mowers	62.32	27.36
Snowblowers	5.75	10.02
Trimmers/Edgers/ Brush Cutters	0.88	3.37

Table C-5. Estimated Annual Energy Needs for Professional Outdoor Power Equipment.

Equipment Type	Estimated Annual Gas Usage SORE (gal/year)	Estimated Annual Electricity Usage (kWh/year)
Chainsaws	25.07	9.40
Generator Sets	146.00	225.76
Lawn Mowers	314.08	45.36
Leaf Blowers/Vacuums	151.25	74.18
Pressure Washers	34.20	335.88
Pump <2hp	604.80	482.22
Riding Mowers	194.70	82.51
Snowblowers	314.08	45.36
Trimmers/Edgers/ Brush Cutters	14.58	59.06

Table C-6. Gasoline and Electric Rates Use for Cost Modeling. Estimates were Calculated by the California Energy Commission.³² All values in 2018 dollars.

Year	Price of Gallon of Gasoline (\$/Gal)	Price for kWh of electricity for businesses (\$/kWh)	Price for kWh of electricity for households (\$/kWh)
2022	3.18	\$0.17	\$0.20
2023	3.20	\$0.18	\$0.21
2024	3.22	\$0.18	\$0.21
2025	3.23	\$0.18	\$0.21
2026	3.23	\$0.18	\$0.21
2027	3.26	\$0.19	\$0.21
2028	3.25	\$0.19	\$0.21
2029	3.30	\$0.19	\$0.22
2030*	3.27	\$0.19	\$0.22

*2030 rates were used for all subsequent years modeled

³² California Energy Commission staff. Final 2019 Integrated Energy Policy Report. California Energy Commission. 2019. Publication Number: CEC-100-2019-001-CMD. (Web link: <https://efiling.energy.ca.gov/getdocument.aspx?tn=232922>. Last accessed June 2020).

Table C-7. Modeled Outdoor Power Equipment Energy Costs in the Household and Professional Market per year Due to the Proposed Amendments to the SORE Regulations Relative to the Baseline Scenario. All values in millions of dollars

Year	Gasoline Costs - Professional	Gasoline Costs- Household	Electric Costs- Professional	Electric Costs- Household	Total Energy Costs- Professional	Total Energy Costs- Households	Total Energy Costs
2022	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
2023	-\$0.1	-\$0.3	\$0.0	\$0.0	-\$0.1	-\$0.3	-\$0.4
2024	-\$0.2	-\$0.5	\$0.0	\$0.1	-\$0.2	-\$0.4	-\$0.6
2025	-\$36.6	-\$20.4	\$2.1	\$2.5	-\$34.5	-\$17.9	-\$52.4
2026	-\$110.8	-\$70.3	\$6.1	\$9.5	-\$104.7	-\$60.8	-\$165.5
2027	-\$194.1	-\$130.3	\$10.9	\$18.0	-\$183.2	-\$112.3	-\$295.5
2028	-\$273.9	-\$188.4	\$15.7	\$26.7	-\$258.2	-\$161.7	-\$419.9
2029	-\$354.1	-\$248.2	\$20.3	\$35.5	-\$333.8	-\$212.7	-\$546.5
2030	-\$421.3	-\$300.4	\$24.7	\$44.4	-\$396.6	-\$256.0	-\$652.6
2031	-\$484.3	-\$351.0	\$28.4	\$51.9	-\$455.9	-\$299.1	-\$755.0
2032	-\$539.4	-\$396.9	\$31.5	\$58.7	-\$507.9	-\$338.2	-\$846.1
2033	-\$587.3	-\$437.1	\$34.2	\$64.7	-\$553.1	-\$372.4	-\$925.5
2034	-\$627.5	-\$471.9	\$36.4	\$69.8	-\$591.1	-\$402.1	-\$993.2
2035	-\$661.5	-\$502.1	\$38.2	\$74.3	-\$623.3	-\$427.8	-\$1,051.1
2036	-\$689.9	-\$527.7	\$39.8	\$78.0	-\$650.1	-\$449.7	-\$1,099.8
2037	-\$713.5	-\$548.7	\$41.0	\$81.1	-\$672.5	-\$467.6	-\$1,140.1
2038	-\$733.2	-\$566.2	\$41.9	\$83.7	-\$691.3	-\$482.5	-\$1,173.8
2039	-\$748.9	-\$580.8	\$42.7	\$85.8	-\$706.2	-\$495.0	-\$1,201.2
2040	-\$761.6	-\$592.7	\$43.3	\$87.5	-\$718.3	-\$505.2	-\$1,223.5
Average	-\$417.8	-\$312.3	\$24.1	\$45.9	-\$393.74	-\$266.4	-\$660.1
Total	-\$7,938.2	-\$5,933.8	\$457.2	\$872.2	-\$7,481.0	-\$5,061.7	-\$12,542.7

Overall, there is significant energy cost-savings to individuals and businesses in the state as a result of the switch to ZEE. This cost-savings is borne out due to the greater gasoline savings, relative to the lower electricity cost, at the same level of equipment utilization. The ratio of fuel cost-savings to electricity cost is relatively higher for Households than professionals due primarily to a three cents higher per kilowatt-hour electricity charge for residential users in addition to power draws that are more in line with professional ZEE.³³ The average annual cost over the regulatory horizon for energy for outdoor power equipment is -\$660.1 million, peaking at -\$1.22 billion in 2040. The total energy cost is estimated to be -\$12.54 billion over the regulatory horizon.

d. Maintenance

The final ongoing cost accounted for is that of maintenance of SORE equipment. By their nature, there is preventative maintenance that helps to ensure that the engines reach their useable lifetime. This cost applies mainly to professional equipment. The CSU, Fullerton survey of outdoor power equipment owners showed that residential owners do not frequently complete the factory recommended maintenance. The survey found that 63 percent of household SORE owners never do maintenance or only when the equipment breaks. The definition of maintenance was not specified, so it was assumed that all users still replaced oil in their lawn mowers and snow blowers, which was considered under maintenance costs, but do not do any other maintenance tasks. For professional equipment, maintenance costs were estimated using the manufacturers recommended preventative maintenance schedule listed in the equipment manual. Maintenance only accounted for the cost of replacement parts, as needed, as many end-users perform their own equipment maintenance. The costs to maintain both household and professional SORE per piece of equipment is shown in Table C-8. The statewide costs associated with maintenance each modeled year relative to baseline, due to the Proposed Amendments to the SORE regulations, are shown in Table C-9.

³³ California Energy Commission staff. Final 2019 Integrated Energy Policy Report. California Energy Commission. 2019. Publication Number: CEC-100-2019-001-CMD. (Web link: <https://efiling.energy.ca.gov/getdocument.aspx?tn=232922>. Last accessed June 2020).

Table C-8. Annual Maintenance Cost per Piece of Outdoor Power Equipment. All values are dollars per year.

Equipment Type	Professional SORE	Household SORE	Professional ZEE	Household ZEE	Professional Incremental Cost	Household Incremental Cost
Chainsaws	\$5	\$0	\$0	\$0	-\$5	\$0
Generator Sets	\$9	\$0	\$0	\$0	-\$9	\$0
Lawn Mowers	\$27	\$6	\$0	\$0	-\$27	-\$6
Leaf Blowers/Vacuums	\$120	\$0	\$0	\$0	-\$120	\$0
Pressure Washers	\$0	\$0	\$0	\$0	\$0	\$0
Pump <2hp	\$0	\$0	\$0	\$0	\$0	\$0
Riding Mowers	\$99	\$0	\$0	\$0	-\$99	\$0
Snowblowers	\$27	\$6	\$0	\$0	-\$27	-\$6
Trimmers/Edgers/Brush Cutters	\$32	\$0	\$0	\$0	-\$32	\$0

Table C-9. Modeled Statewide Outdoor Power Equipment Maintenance Costs in the Professional Equipment Market per Year Due to the Proposed Amendments to the SORE Regulations Relative to the Baseline Scenario. All values in millions of dollars

Year	Professional Engines-Maintenance Cost	Household Engines-Maintenance Cost	Total Engines-Maintenance Cost
2022	\$0.0	\$0.0	\$0.0
2023	\$0.0	\$0.0	\$0.0
2024	\$0.0	\$0.0	\$0.0
2025	-\$3.9	-\$1.4	-\$5.3
2026	-\$12.8	-\$3.4	-\$16.2
2027	-\$22.1	-\$5.5	-\$27.6
2028	-\$31.0	-\$7.7	-\$38.7
2029	-\$38.9	-\$9.8	-\$48.7
2030	-\$45.6	-\$11.8	-\$57.4
2031	-\$51.2	-\$13.7	-\$64.9
2032	-\$55.5	-\$15.6	-\$71.1
2033	-\$59.0	-\$17.3	-\$76.3
2034	-\$61.8	-\$18.8	-\$80.6
2035	-\$64.0	-\$20.1	-\$84.1
2036	-\$65.7	-\$21.1	-\$86.8
2037	-\$67.0	-\$22.0	-\$89.0
2038	-\$68.0	-\$22.8	-\$90.8
2039	-\$68.7	-\$23.4	-\$92.1
2040	-\$69.2	-\$23.9	-\$93.1
Average	-\$41.3	-\$12.5	-\$53.8
Total	-\$784.3	-\$238.3	-\$1,022.7

Overall, there is a cost-savings to both household and professional users from reduced maintenance costs. This comes from the switch to ZEE which has much lower maintenance requirements since there are no engines, which require frequent maintenance. The average annual cost is -\$53.8 million and totals -\$1.02 billion over the period of 2022-2040.

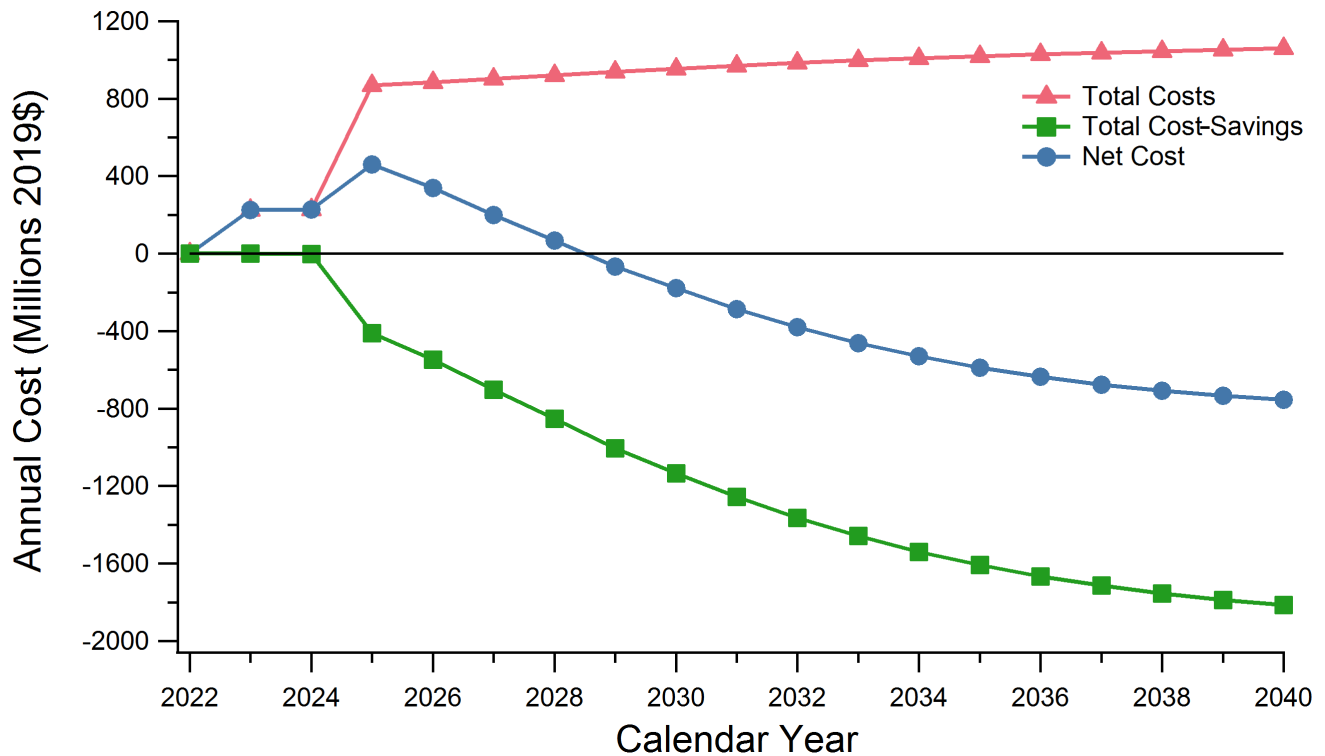
e. Total Costs

The total cost associated with individuals and businesses within the state of California due to the Proposed Amendments to SORE regulations are shown annually in Table C-10. The Proposed Amendments are estimated to lead to an average annual net cost of -\$194.9 million dollars, totaling -\$3.70 billion over the period of 2022-2040. The costs, cost-savings and overall net costs can be seen year over year in Figure C-2.

Table C-10. Modeled Costs to Businesses and Residents per Year Due to the Proposed Amendments to the SORE Regulations Relative to the Baseline Scenario. All values in millions of dollars. Total may differ slightly due to rounding.

Year	Gasoline Equipment Cost	Electric Equipment Cost	Gasoline Equipment Maintenance Cost	Fuel Costs	Electricity Costs	Total Cost-savings	Total Costs	Net Costs
2022	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
2023	\$212.9	\$33.1	\$0.0	-\$0.4	\$0.0	\$0.4	\$246.0	\$245.6
2024	\$213.9	\$33.6	\$0.0	-\$0.7	\$0.1	\$0.7	\$247.6	\$246.9
2025	-\$378.1	\$939.3	-\$5.0	-\$57.0	\$4.6	\$440.1	\$943.9	\$503.8
2026	-\$379.4	\$943.6	-\$16.0	-\$181.1	\$15.6	\$576.5	\$959.2	\$382.7
2027	-\$380.6	\$948.1	-\$28.0	-\$324.4	\$28.9	\$733.0	\$977.0	\$244.0
2028	-\$381.9	\$952.5	-\$39.0	-\$462.3	\$42.4	\$883.2	\$994.9	\$111.7
2029	-\$383.1	\$957.1	-\$49.0	-\$602.3	\$55.8	\$1,034.4	\$1,012.9	-\$21.5
2030	-\$384.4	\$961.6	-\$57.0	-\$721.7	\$69.1	\$1,163.1	\$1,030.7	-\$132.4
2031	-\$385.7	\$966.2	-\$65.0	-\$835.3	\$80.3	\$1,286.0	\$1,046.5	-\$239.5
2032	-\$387.0	\$970.7	-\$71.0	-\$936.3	\$90.2	\$1,394.3	\$1,060.9	-\$333.4
2033	-\$388.4	\$975.3	-\$76.0	-\$1,024.4	\$98.9	\$1,488.8	\$1,074.2	-\$414.6
2034	-\$389.7	\$980.0	-\$81.0	-\$1,099.4	\$106.2	\$1,570.1	\$1,086.2	-\$484.0
2035	-\$391.0	\$984.6	-\$84.0	-\$1,163.6	\$112.5	\$1,638.6	\$1,097.1	-\$541.5
2036	-\$392.3	\$989.3	-\$87.0	-\$1,217.6	\$117.8	\$1,696.9	\$1,107.1	-\$589.8
2037	-\$393.7	\$994.1	-\$89.0	-\$1,262.2	\$122.1	\$1,744.9	\$1,116.2	-\$628.8
2038	-\$395.0	\$998.9	-\$91.0	-\$1,299.4	\$125.6	\$1,785.4	\$1,124.5	-\$661.0
2039	-\$396.4	\$1,003.6	-\$92.0	-\$1,329.7	\$128.5	\$1,818.1	\$1,132.1	-\$685.9
2040	-\$397.9	\$1,008.4	-\$93.0	-\$1,354.3	\$130.8	\$1,845.2	\$1,139.2	-\$706.0
Average	-\$304.1	\$823.2	-\$53.8	-\$730.1	\$70.0	\$1,110.5	\$915.6	-\$194.9
Total	-\$5,778.2	\$15,640.1	-\$1,023.0	-\$13,872.1	\$1,329.4	\$21,100.0	\$17,396.2	-\$3,703.8

Figure C-2. Statewide Costs, Cost-savings, and Overall Net Costs as a Result of the Proposed Amendments



2. Direct Costs on Typical Businesses

Typical businesses are defined here as all affected establishments in the state that are not small businesses. As it relates to the Proposed Amendments the costs will be most heavily felt by landscapers who use SORE daily. Per the U.S. Census Bureau, 98% of all landscaping businesses in the state are small businesses and therefore deserve special attention.³⁴

A typical business therefore is one that that does not do landscaping work but owns outdoor power equipment to maintain their own property or conduct work outside using pumps and generators. Based on survey data, only 15% of all businesses in the state that are not landscaping vendors own at least one piece of lawn and garden equipment. Roughly 25% of all businesses surveyed had another piece of outdoor power equipment such as a generator or pump.³⁵ Therefore, a typical business likely will have no costs associated with the Proposed Amendments as they do not own any outdoor power equipment.

³⁴ U.S. Census Bureau. Annual Economic Surveys. 2018. (Web link: <https://data.census.gov/cedsci/table?q=Employment%20size&g=0400000US06&tid=CBP2018.CB1800CBP&t=Employment%20Size&vintage=2018&hidePreview=true&n=N0600.00>. Last accessed July 2020)

³⁵ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

As an example, to show the cost-savings on a microscale to a typical business that does own outdoor power equipment, take a business with a small outdoor area that needs to be kept tidy. This business likely has a leaf blower, walk-behind lawn mower and string trimmer as these are the three most commonly owned pieces of lawn and garden equipment by businesses.³⁶ To illustrate the cost-savings, it is assumed that the business will purchase all three pieces of equipment at the same time, either currently compliant SORE or ZEE. Because the statewide calculations assumed that typical businesses would purchase professional grade equipment and use that equipment with the regularity of a landscaper, the same assumptions were made for this business. The upfront and ongoing costs to this business are shown in Table C-11. In this scenario, while the upfront costs are higher for ZEE (\$586), the breakeven point comes less than a year in due to the difference between the cost of gasoline and electricity. This timeframe is well within the life of the equipment, so the savings are real. Further, this typical business could have more cost-savings if they purchase household equipment which would be more than sufficient to maintain a small outdoor area. The difference in price between household SORE and ZEE is much smaller than professional equipment as shown previously.

Table C-11. Cost Breakdown for a Typical Non-landscaping Business that has Purchased a Lawnmower, Leaf Blower, and a String Trimmer Including Annual Ongoing Costs

Cost Line Item	SORE Costs	ZEE Costs	Cost Difference
Equipment Price	\$3,774	\$4,360	\$586
Sales Tax	\$321	\$371	\$50
Maintenance	\$178	\$0	-\$178
Fuel Cost	\$1,526	\$0	-\$1,526
Electricity Cost	\$0	\$31	\$31
Upfront costs	\$4,095	\$4,731	\$636
Annual Operational Costs	\$1,704	\$31	-\$1,673
Total Cost after One Year	\$5,799	\$4,761	-\$1,038

To show the feasibility of compliance for a typical business, the \$586 increase in upfront costs was compared to the annual revenue of an typical business in the services industry (\$74,223,396).³⁷ This revenue value was chosen as the services industry has the most typical businesses in the state. The increase in upfront cost for this business is entirely negligible.

³⁶ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

³⁷ Estimated Based on revenues per employee by establishment size from the 2012 Economic Census: <https://www.census.gov/data/datasets/2012/econ/susb/2012-susb.html>

3. Direct Costs on Small Businesses

a. *Small Landscapers*

The cost to landscaping businesses, of which 98 percent in state are considered small businesses, based on the number of California based establishments with less than 100 employees, will be addressed in this section. Landscaping business (NAICS 561730) employ over 88,000 workers at about 8,600 establishments in California.³⁸ From the vendor portion of the CSUF survey, one third of all landscaping business owners responded that they do not have any employees. To illustrate the costs and cost-savings to a one-person landscaping business, a similar example as presented in the typical businesses section will be done. From the survey data, the five most common lawn garden tools that landscapers own and use are chainsaws, lawnmowers, leafblowers, string trimmers, and hedge trimmers. With these pieces of equipment, a one-person landscaping company, would be able to conduct a majority of jobs. For the sake of this example, it is assumed that the landscaper would be purchasing all of these pieces of equipment at once. This is a very conservative estimate, as it is highly unlikely that an existing landscaping business would need all new equipment at once. Pieces are replaced as they reach the end of their useable life. The cost breakdown for this landscaper is shown in Table C-12.

Table C-12. Cost Breakdown for a One Person Landscaping Business that has Purchased a Lawnmower, Leaf Blower, Hedge Trimmer, Chainsaw, and a String Trimmer Including Annual Ongoing Costs

Cost Line Item	SORE Costs	ZEE Costs	Cost Difference
Equipment Price	\$5014	\$6190	\$1,176
Sales Tax	\$426	\$526	\$100
Maintenance	\$215	\$0	-\$215
Fuel Cost	\$1652	\$0	-\$1652
Electricity Cost	\$0	\$43	\$43
Upfront costs	\$5440	\$6716	\$1276
Annual Operational Costs	\$1867	\$43	-\$1824
Total Cost after One Year	\$7307	\$6759	-\$548
Total Cost after Five Years	\$14,774	\$6,931	-\$7,843

Despite an increased upfront cost of \$1,276 for a complete suite of ZEE equipment, as with the typical business above, the example landscaping business comes out ahead after one year of use of ZEE equipment due to decreased fuel costs. Most professional lawn and garden equipment used by landscapers is less than 5 years old, so cost-savings within the first year of

³⁸ U.S. Census Bureau. Annual Economic Surveys. 2018. (Web link: <https://data.census.gov/cedsci/table?q=Employment%20size&g=0400000US06&tid=CBP2018.CB1800CBP&t=Employment%20Size&vintage=2018&hidePreview=true&n=N0600.00> Last accessed July 2020)

ownership is real savings for the landscaper.³⁹ Over the average 5 years lifespan of the equipment suite, the landscaper will see a cost-savings of \$7,843. The average small landscaping business has an annual revenue of \$633,578.⁴⁰ It is likely that one-person landscaping businesses have a lower annual revenue. The increased upfront cost difference of \$1,176 is likely less than 1% of their annual revenue.

The mean number of employees for landscaping businesses surveyed was 10.⁴¹ As an example of the cost breakdown of compliance with the Proposed Amendments, a similar example can be set up with a small landscaping business with 10 employees. Based on median populations from the survey data, this small landscaping business likely has three chainsaws, two lawnmowers, one riding mower, two leaf blowers, two string trimmers and two hedge trimmers. The cost breakdown including annual ongoing costs is seen in Table C-13. The same assumption as with the sole proprietor landscaping business, is made about purchasing all of this equipment at once.

Table C-13. Cost Breakdown for a Ten Person Landscaping Business that has Purchased Three Chainsaws, Two Lawnmowers, Two Leaf Blowers, Two Hedge Trimmers, Two String Trimmers and One Riding Mower Including Annual Ongoing Costs

Cost Line Item	SORE Costs	ZEE Costs	Cost Difference
Equipment Price	\$21,427	\$32,729	\$11,302
Sales Tax	\$1,821	\$2,782	\$961
Maintenance	\$533	\$0	-\$533
Fuel Cost	\$4002	\$0	-\$4002
Electricity Cost	\$0	\$120	-\$120
Upfront costs	\$23,248	\$35,510	\$12,262
Annual Operational Costs	\$4536	\$120	-\$4416
Total Cost after One Year	\$27,784	\$35,631	\$7,846
Total Cost after Two Years	\$32,320	\$35,750	\$3,430
Total Cost after Three Years	\$36,856	\$35,870	-\$987
Total Cost after Four Years	\$41,393	\$35,989	-\$5,403
Total Cost after Five Years	\$45,929	\$36,109	-\$9,820

This example landscaping business sees a cost-savings before three years of ownership of the equipment. The cost-savings after five years of ownership, the average life of professional lawn and garden equipment, is \$9,820. The average small landscaping business has an annual

³⁹ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

⁴⁰ Estimated Based on revenues per employee by establishment size from the 2012 Economic Census: <https://www.census.gov/data/datasets/2012/econ/susb/2012-susb.html>

⁴¹ Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

revenue of \$633,578. The added upfront cost of buying this suite of equipment for a ten employee crew represents less than 2% of their annual revenue but provides a net savings when considering the lifetime costs.

Starting in 2025, professional users of outdoor power equipment on a statewide level will incur a \$398 million increase in upfront cost each year over the baseline scenario. This accounts for 67% of the total statewide costs associated with buying new equipment despite professional equipment only accounting for less than 10% of the total population. This cost is due to the higher price point of professional grade ZEE relative to SORE equipment, as seen in Table C-2. Businesses will realize an overall cost-savings starting in 2030 due to these decreased ongoing costs. The five-year lag in savings as compared to the one-year lag with the typical landscaper example is due to the prices of ZEE pressure washers and generators, relative to SORE. It is unlikely that the typical small landscaping business has one of these items. However, these pieces of equipment generally have longer useable lifetimes than smaller equipment, and it can be shown that there is still a net cost-savings.

b. Other Small Businesses

As noted in the previous section only 15% of all businesses that are not landscapers own power lawn and garden equipment. It is assumed that the fraction of small businesses that own lawn and garden equipment is at best the same as all businesses but likely lower. Therefore, the typical small business incurs no cost to comply with the Proposed Amendments.

As an example, for the fraction of small businesses that do own lawn and garden equipment, take an example of a small business that has a parking lot that needs to be kept tidy. This business would own just a leafblower. This example is realistic as per survey data the most often owned piece of lawn and garden equipment by businesses is a leaf blower.⁴² Assuming that this business needs a new leaf blower, they have the option of ZEE or a currently compliant SORE. The upfront and ongoing costs associated with the SORE and ZEE leafblower are shown in Table C-14. In this scenario, while the upfront costs associated with the ZEE leafblower are greater (\$936), the breakeven point comes less than two years is due to the difference between the cost of gasoline and electricity. This timeframe is well within the life of the equipment, so the savings are real. Further, this typical business could have more cost-savings if they purchased a residential grade ZEE leafblower which would be more than sufficient to maintain a small parking lot. The difference in price between household SORE and ZEE is much smaller than professional equipment as shown previously.

⁴² Social Science Research Center at CSU, Fullerton. Survey of Small Off-Road Engines (SORE) Operating within California: Results from Surveys with Four Statewide Populations. May 15, 2019. (Web Link: <https://ww3.arb.ca.gov/msprog/offroad/sore/AbstractExecutiveSummary.pdf>. Last accessed July 2020)

Table C-14. Cost Breakdown for a Typical Small Non-Landscaping Business that has Purchased a Leaf Blower, Including Annual Ongoing Costs

Cost Line Item	SORE Costs	ZEE Costs	Cost Difference
Equipment Price	\$434	\$1,370	\$936
Sales Tax	\$37	\$116	\$79
Maintenance	\$120	\$0	-\$120
Fuel Cost	\$481	\$0	-\$481
Electricity Cost	\$0	\$13	\$13
Upfront costs	\$471	\$1,486	\$1,015
Annual Operational Costs	\$601	\$13	-\$588
Total Cost after One Year	\$1,072	\$1,499	\$427
Total Cost after Two Years	\$1,673	\$1,512	-\$161

To further show the feasibility of the Proposed Amendments, the \$936 increase in upfront costs was compared to the annual revenue of an average small business in the services industry (\$1,239,323).⁴³ This revenue value was chosen as it was the lowest for any of the major sectors of the economy. The increase in upfront cost is less than 1/10th of one percent of their annual revenue. The increased startup cost does not pose an issue to typical businesses both regular and small.

c. Dealers and Small-Engine Repair Shops

Dealers of SORE and small-engine repair shops will not see direct costs as a result of the Proposed Amendments but are expected to be indirectly impacted due to significant lost due to the reduced maintenance requirements for ZEE equipment. These indirect impacts are analyzed in the context of the California economy in Section E, but are also described here to provide further information to readers. As discussed previously, ZEE does not have the maintenance requirements that SORE outdoor power equipment does, so major reductions to engine repair are expected. In California, there are 78 establishments that are classified as “home and garden equipment repair.” These 78 businesses average \$1.7 million per year in revenue, for a total of \$132.5 million per year in total.⁴⁴ Based on the overall cost-savings on maintenance to outdoor power equipment purchasers due to the Proposed Amendments, there will be a total loss of \$54 million per year expected for repair of small off-road engines. This represents a 40% loss of revenue for small engine repair shops. The remaining revenue for these establishments likely comes from repair of equipment other than SORE, such as saws and hand tools, repair that would be conducted on both ZEE and SORE, including blade sharpening, as well as from sales of new equipment. Dealers and small-engine repair shops have many overlapping lines of

⁴³ U.S. Census Bureau. Annual Economic Surveys. 2018. (Web link: <https://data.census.gov/cedsci/table?q=Employment%20size&g=0400000US06&tid=CBP2018.CB1800CBP&t=Employment%20Size&vintage=2018&hidePreview=true&n=N0600.00> Last accessed July 2020)

⁴⁴ U.S. Census Bureau. Annual Economic Surveys. 2018. (Web link: <https://data.census.gov/cedsci/table?q=Employment%20size&g=0400000US06&tid=CBP2018.CB1800CBP&t=Employment%20Size&vintage=2018&hidePreview=true&n=N0600.00> Last accessed July 2020)

business, with many dealers also performing repairs and repair shops also selling equipment. Determination of whether a business is considered a dealer or repair shop is based on where the majority of its business falls. As a result, some of the \$54 million in lost revenue is expected to be borne by lawn and garden equipment dealers, which are also small businesses. No major impact is expected on revenue from equipment sales, as total equipment pieces sold is assumed to remain the same under the regulation.

4. Direct Costs on Individuals

While all individuals across the state may need to purchase a piece of outdoor power equipment, those most affected by the Proposed Amendments are homeowners who do their own landscaping. Over half (56%) of California households do not own any lawn and garden equipment and they will not be directly impacted by the Proposed Amendments. The remaining 44% of households owning equipment will be impacted. From survey data, the three most frequently owned pieces of household lawn and garden equipment are lawn mowers, leaf blowers, and string trimmers/edgers. As an example, a new homeowner is in need of these three pieces of equipment to maintain their yard. The cost breakdown of purchasing BAU SORE versus ZEE is shown in Table C-15.

Table C-15. Cost Breakdown for Typical Homeowner that has Purchased a Lawnmower, Leaf Blower, and a String Trimmer including Annual Ongoing Costs

Cost Line Item	SORE Costs	ZEE Costs	Cost Difference
Equipment Price	\$621	\$846	\$225
Sales Tax	\$53	\$72	\$19
Maintenance	\$6	\$0	-\$6
Fuel Cost	\$40	\$0	-\$40
Electricity Cost	\$0	\$4	\$4
Upfront costs	\$674	\$918	\$244
Annual Operational Costs	\$46	\$4	-\$42
Total Cost after One Year	\$721	\$922	\$201
Total Cost after Five Years	\$906	\$937	\$31
Total Cost after Ten Years	\$1138	\$956	-\$182

Based on needing to purchase all three pieces of equipment at once, it will take between 5 and 6 years after purchase for the homeowner to break even. This is a much longer timeframe than for professional users who see cost-savings more quickly due to more frequent use. The cost-savings for this homeowner is still real as household lawn and garden equipment owners go much longer between purchasing new equipment. From survey data, 79% of household string trimmer owners have had their piece of equipment for more than three years, with 25% responding that it is more than ten years old. For lawn mowers, 75% of households that responded as having one that is between 3 and 20 years old. A majority of household lawn and garden equipment owners surveyed respond that they plan on keeping their equipment until it

breaks or fails. At the rate they use these pieces of equipment, they will easily last more than ten years, and ZEE household lawn and garden equipment owners will see true cost-savings.

The upfront incremental cost to the example homeowner is \$244. Per U.S. Census data, the median income of homeowners in the state before taxes is \$99,245.⁴⁵ The incremental cost would therefore be 0.25% of their income representing a small change from the baseline. These upfront costs are more than offset by fuel and operational savings for the equipment. This suggests that a demand response to the slightly increased prices under the Proposed Amendments would be minimal and is not expected to have significant effect on the results presented in this section.

As shown in Table C-3, from 2025 until 2040, it is estimated that upfront costs associated with the Proposed Amendments to SORE regulations will cost individual households across the state a combined average of \$156 million dollars per year over the baseline scenario. This is more than offset by operational savings amounting to \$331 million dollars per year, yielding a net cost-savings of \$175 million.

The cost-savings to households comes from the lower cost to operate and maintain ZEE. Considering the lower cost of electricity relative to gasoline and the very low maintenance needs of ZEE, it is expected that the amendments to SORE regulations will yield the individuals in California a net overall savings, accounting for both upfront and ongoing costs, each year starting in 2028. The net annual cost-savings for individuals between 2028 and 2040 increases each year. This is due to the turnover of older SORE equipment to ZEE. Over the 18-year period modeled (2022-2040) the Proposed Amendments to SORE regulations will save individuals a total of \$2.51 billion.

D. FISCAL IMPACTS

1. Local government

a. Outdoor Power Equipment Cost

Local governments that utilize SORE equipment are expected to bear higher upfront costs for new equipment under the Proposed Amendments, but also realize fuel and operation savings. The net of these cost and cost-savings represents a fiscal impact to local governments. This fiscal impact on local governments is estimated based on the government entities portion of the inventory as shown in Table A-6, which is then apportioned to local government, based on its 77 percent share of total government employment in California.⁴⁶ Local governments, as a whole, will see a cost-savings beginning in 2032. Over the modeled lifetime there is \$0.13 million cost-savings.

⁴⁵ U.S. Census. Financial Characteristics. 2018 (Web link: <https://data.census.gov/cedsci/table?q=owner-occupied%20housing&g=0400000US06&hidePreview=true&tid=ACSS1Y2018.S2503&t=Housing&vintage=2018>. Last accessed July 2020).

⁴⁶ State and Local Government employment in 2018. Regional Economic Model's Inc. (REMI) Policy Insight+ v. 2.4.

b. Utility User Taxes

Many cities and counties in California levy a Utility User Tax on electricity usage. This tax varies from city to city and ranges from no tax to 11%. A value of 3.53% was used in this analysis, representing a population-weighted average.⁴⁷ By increasing the amount of electricity used, there will be an increase in the amount of the utility user tax revenue collected by cities and counties starting in 2025.

c. Gasoline Taxes

Fuel taxes on gasoline and diesel fund transportation improvements at the state, county, and local levels. The statewide local sales tax on gasoline is 2.25%.⁴⁸ Displacing gasoline SORE with ZEE will decrease the total amount of gasoline dispensed in the state, resulting in a reduction in fuel tax revenue collected by local governments starting in 2025.

d. Local Sales Taxes

Sales taxes are levied in California to fund a variety of programs at the state and local level. As discussed previously, the bulk of the SORE market is residential products, and ZEE are on average slightly cheaper than their gasoline counterparts. In the commercial market, this is not the case and ZEE are significantly more expensive to purchase. For this analysis, the CARB staff assumed an average of 4.56% local sales tax revenues based on how the state sales tax is divided up plus an average of local additional sales taxes.⁴⁹ This leads to a year over year net increase in local sales tax revenue totaling \$214.3 million over the modeled lifetime.

e. Fiscal Impacts on Local Government

Table D-1 shows the estimated fiscal impacts to local governments due to the proposed SORE amendments relative to baseline conditions. The fiscal impact to local governments is estimated to be \$42.5 million over the first three years of the regulation and \$150.1 million over the modeled lifetime. The initial annual gains due to increased sales tax revenue are eventually offset by losses in gas tax revenue as more of the population becomes ZEE.

⁴⁷ California State Controller's Office, User Utility Tax Revenue and Rates (web page: https://sco.ca.gov/Files-ARD-Local/LocRep/2016-17_Cities_UUT.pdf). Last accessed June 2020.

⁴⁸ California Department of Tax and Fee Administration. Sales Tax Rates for Fuels. <https://www.cdtfa.ca.gov/taxes-and-fees/sales-tax-rates-for-fuels.htm>. Accessed June 2020.

⁴⁹ California Department of Tax and Fee Administration. Tax Rates by County and City. <https://cdtfa.ca.gov/formspubs/cdtfa95.pdf>. Accessed June, 2020

Table D-1. Estimated Fiscal Impacts on Local Governments (millions 2019\$)

Calendar Year	Outdoor Power Equipment Costs	Utility User Tax Revenue	Gas Tax Revenue	Local Sales Tax Revenue	Total Fiscal Impact*
2022	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2023	-\$0.13	\$0.00	\$0.00	\$10.40	\$10.53
2024	-\$0.13	\$0.00	\$0.00	\$10.40	\$10.53
2025	-\$0.55	\$0.20	-\$1.30	\$23.60	\$23.05
2026	-\$0.46	\$0.60	-\$4.10	\$23.80	\$20.76
2027	-\$0.35	\$1.00	-\$7.30	\$23.90	\$17.95
2028	-\$0.26	\$1.50	-\$10.40	\$24.00	\$15.36
2029	-\$0.16	\$2.00	-\$13.60	\$24.20	\$12.76
2030	-\$0.08	\$2.40	-\$16.20	\$24.30	\$10.58
2031	\$0.00	\$2.80	-\$18.80	\$24.40	\$8.40
2032	\$0.07	\$3.20	-\$21.10	\$24.60	\$6.63
2033	\$0.12	\$3.50	-\$23.00	\$24.70	\$5.08
2034	\$0.17	\$3.70	-\$24.70	\$24.80	\$3.63
2035	\$0.21	\$4.00	-\$26.20	\$25.00	\$2.59
2036	\$0.24	\$4.20	-\$27.40	\$25.10	\$1.66
2037	\$0.26	\$4.30	-\$28.40	\$25.30	\$0.94
2038	\$0.29	\$4.40	-\$29.20	\$25.40	\$0.31
2039	\$0.30	\$4.50	-\$29.90	\$25.60	-\$0.10
2040	\$0.31	\$4.60	-\$30.50	\$25.70	-\$0.51
Total	-\$0.13	\$46.90	-\$312.10	\$415.20	\$150.13

*The Total Fiscal Impact is calculated as the change in revenue minus costs.

2. State Government

a. *SORE Cost*

The State Government utilizes SORE equipment across its operations and is expected to bear higher upfront costs for new equipment under the Proposed Amendments, but also realize fuel and operation savings. The net of these cost and cost-savings represents a fiscal impact to local governments. This fiscal impact on local governments is estimated based on the government entities portion of the inventory as shown in Table A-6, which is then apportioned to the State government, based on its 23 percent share of total government employment in California.⁵⁰ The State government will see a cost-savings beginning in 2032. Over the modeled lifetime there is -\$0.04 million cost.

b. *Certification Costs*

Zero-emission equipment does not require certification and no spark-ignited engines will be certified starting in 2025, so fewer CARB staff will be required for certification of SORE. These staff will be redirected to other CARB programs, so no cost savings will be realized.

c. *Gas Excise Tax*

⁵⁰ State and Local Government employment in 2018. Regional Economic Model's Inc. (REMI) Policy Insight+ v. 2.4.

Fuel taxes on gasoline and diesel fund transportation improvements at the state, county, and local levels. Displacing gasoline with electricity will decrease the total amount of gasoline dispensed in the state. The gas excise tax levied by the state was estimated to remain at its current rate of \$0.505/gal. There will be a reduction in revenue for the state from the gas tax starting in 2025 due to the switch to ZEE. In 2025, the decrease in revenue will be \$8.9 million and will reach a maximum decrease of \$209.1 million in 2040.

d. Energy Resources Fee

The Energy Resource Fee is a \$0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities. The revenue collected is deposited into the Energy Resources Programs Account of the General Fund which is used for ongoing energy programs and projects deemed appropriate by the Legislature, including but not limited to, activities of the California Energy Commission. The increase in ZEE post-2025 creates a small net gain in funds for the state through this fee per year. The total increase in Energy Resource Fee revenue over the modeled period is \$1.9 million.

e. State Sales Tax

Sales taxes are levied in California to fund a variety of programs at the state and local level. For this analysis, state sales tax was assumed to remain constant until 2040 with 3.53% being for state programs and the general fund. As discussed previously, the bulk of the SORE market is residential products, and ZEE are on average slightly cheaper than their gasoline counterparts. In the commercial market, ZEE is significantly more expensive. This leads to a net increase in state sales tax revenue starting in 2023 of \$9.0 million. Over the modeled life of the regulation, the state will gain \$358.7 million in sales tax over the baseline scenario.

f. Fiscal Impacts on State Government

Table D-2 shows the estimated fiscal impacts to the state government due to the proposed SORE amendments relative to baseline conditions. The fiscal impact to state government is estimated to be a net gain of \$29.1 million over the first three years of the regulation and a cost of -\$1.78 billion over the regulatory lifetime as there is a loss of funds from the gas excise tax due to the switch to ZEE.

Table D-2. Estimated Fiscal Impacts on State Government (millions 2019\$)

Calendar Year	Outdoor Power Equipment Costs	Gas Tax Revenue	Energy Resource Fee Revenue	State Sales Tax Revenue	Fiscal Impact*
2022	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
2023	-\$0.04	-\$0.10	\$0.00	\$9.00	\$8.94
2024	-\$0.04	-\$0.10	\$0.00	\$9.00	\$8.94
2025	-\$0.17	-\$8.90	\$0.00	\$20.40	\$11.67
2026	-\$0.14	-\$28.30	\$0.00	\$20.50	-\$7.66
2027	-\$0.11	-\$50.20	\$0.00	\$20.60	-\$29.49
2028	-\$0.08	-\$71.70	\$0.10	\$20.80	-\$50.72
2029	-\$0.05	-\$92.30	\$0.10	\$20.90	-\$71.25
2030	-\$0.02	-\$111.40	\$0.10	\$21.00	-\$90.28
2031	\$0.00	-\$129.00	\$0.10	\$21.10	-\$107.80
2032	\$0.02	-\$144.60	\$0.10	\$21.20	-\$123.32
2033	\$0.04	-\$158.20	\$0.10	\$21.30	-\$136.84
2034	\$0.05	-\$169.80	\$0.20	\$21.50	-\$148.15
2035	\$0.06	-\$179.70	\$0.20	\$21.60	-\$157.96
2036	\$0.07	-\$188.00	\$0.20	\$21.70	-\$166.17
2037	\$0.08	-\$194.90	\$0.20	\$21.80	-\$172.98
2038	\$0.09	-\$200.60	\$0.20	\$22.00	-\$178.49
2039	\$0.09	-\$205.30	\$0.20	\$22.10	-\$183.09
2040	\$0.09	-\$209.10	\$0.20	\$22.20	-\$186.79
Total	-\$0.04	-\$2,142.20	\$2.00	\$358.70	-\$1,781.46

*The Total Fiscal Impact is calculated as the change in revenue minus costs.

E. MACROECONOMIC IMPACTS

1. Methods for determining economic impacts

This section describes the estimated total impact of the Proposed Amendments on the California economy. The Proposed Amendments will result in incremental cost and cost-savings for businesses to comply with the regulation. These costs result in direct changes in expenditures in the economy as these costs are passed on to business and individual end-users. These changes in expenditures by end-users will indirectly affect employment, output, and investment in sectors that supply goods and provide services to affected businesses.

These direct and indirect effects lead to induced effects, such as changes in personal income that affect consumer expenditures across other spending categories. The total economic impact is the sum of these effects and are presented in this section. The total economic impacts of the Proposed Amendments are simulated relative to the baseline scenario using the cost estimates described in Section C. The analysis focuses on the changes in major macroeconomic indicators from 2020 to 2040 including employment, output, personal income, and gross state product (GSP). The years of the analysis are used to simulate the Proposed Amendments through more than 12 months post full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 2.4 is used to estimate the macroeconomic impacts of the Proposed Amendments on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.⁵¹ REMI Policy Insight Plus provides year-by-year estimates of the total economic impacts of the Proposed Amendments, pursuant to the requirements of SB 617 and the California Department of Finance.⁵² CARB uses the REMI single-region, 160-sector model. Several adjustments were made to the model reference case to reflect the impacts of COVID-19 and to reflect the Department of Finance conforming forecasts. First, the REMI model's National Control was updated with a short-term national forecast based on the U.S. Economic Outlook for 2020-2022 from the University of Michigan's Research Seminar in Quantitative Economics (RSQE)^[1] release on April 9th, 2020, which was made available in the latest REMI model. Second, the National and Regional Controls in REMI were updated to reflect the most recent Department of Finance conforming forecasts which include population projections dated January 2020 and U.S. real GDP forecasts, and California civilian employment growth numbers Dated May 2020. Because the Department of Finance forecasts only extended to 2023, CARB staff assumed that post-2023, U.S. income and employment would continue to grow at the same rate as projected in the RSQE forecast, while California civilian employment would continue to recover at the rate forecasted by the Department of Finance, until it returned to baseline levels.

2. Inputs of the assessment

The estimated economic impact of the Proposed Amendments is sensitive to modeling assumptions. This section provides a summary of the assumptions and inputs used to determine the suite of policy variables that best reflect the macroeconomic impacts of the Proposed Amendments. The direct costs and savings estimated in Section C and the non-mortality related health benefits estimated in Section B are translated into REMI policy variables and used as inputs for the macroeconomic analysis.⁵³

The initial requirements for lower exhaust and evaporative emission standards on spark-ignition engines will add an incremental cost to that equipment for both commercial and residential types of equipment as described in Section C. The requirements for zero-emissions equipment, which phase in by 2025, result in a shift in new purchases from spark-ignition based equipment to zero-emission, battery-electric equipment. The transition to use of zero-emission equipment will also result in ongoing incremental cost and cost-savings: end-users will realize fuel savings from reduced gasoline use, increased electricity costs from battery-electric equipment, and reduced equipment maintenance and repair. The upfront incremental costs of

⁵¹ For further information and model documentation see: <https://www.remi.com/model/pi/>.

⁵² Senate Bill 617 (Calderon, Stats. of 2011, Ch. 496; amending Gov. Code §§ 11346.2, 11346.3, 11346.5, 11346.9, 11347.3, 1139.1, 13401, 13402, 13403, 13404, 13405, 13406, 13407 and adding Gov. Code §§ 11342.548, 11346.36, 11349.1.5); Department of Finance Standardized Regulatory Impact Assessment For Major Regulations, Cal. Code Regs., tit. 1, §§ 2000 et seq.

^[1] This update assumes that the economic contraction is severe but that aggressive federal response to the pandemic maintains the possibility of a vigorous recovery: <https://lsa.umich.edu/econ/rsqe.html>.

⁵³ Refer to Section G: Macroeconomic Appendix for a full list of REMI inputs for this analysis.

the lower emission and zero-emission equipment is expected to be passed through to end-users (i.e. businesses and households), while also realizing net ongoing cost-savings.

The costs and cost-savings realized by businesses that use the affected equipment are input into the model as a change in production costs for the affected industry. The share of costs and cost-savings realized across different industries are estimated based on the baseline populations as described in Section A, where the primarily affected industry is Landscapers (5617). Also affected are all other businesses that use the equipment, the cost is assumed to be distribute to these industries according to their share of state employment.⁵⁴

These costs and costs-savings realized by business end-users correspond with changes in final demand for industries supplying those particular goods or services as shown in Table E-1. As the direct costs on SORE equipment manufacturers are incurred out of state, it is assumed here that the changes in demand for the SORE supply chain also occur out state. This change in demand is therefore omitted from evaluation in the economic model. All other changes in demand related to SORE equipment is included in this analysis. The reduced fuel costs for end-users correspond to a decrease in demand for petroleum products manufacturing (NAICS 324). The increased electricity use corresponds to an increase in demand for the electric power generation, transmission, and distribution industry (NAICS 2211). The decrease in expenditures on repair and maintenance corresponds to a decrease in demand for the personal and household goods repair and maintenance industry (NAICS 8114).

Table E-1. Sources of Changes in Production Costs or Prices and Final Demand by Industry

Source of Cost or Savings	Industries or Individuals with Change in Production Cost or Prices (NAICS)	Industries with Changes in Final Demand (NAICS)
Small Off-Road Equipment	Landscapers (5617) businesses & individuals	Upfront cost: SORE mfg. (3331, out of state)
Gasoline	Landscapers (5617) businesses & individuals	Recurring cost: Petroleum Products mfg. (324)
Electricity	Landscapers (5617) businesses & individuals	Recurring cost: Electric power generation, transmission, and distribution (2211)
Repair & Maintenance (savings)	Landscapers (5617) businesses & individuals	Recurring Savings: Personal and Household Goods Repair and Maintenance (8114)

The incremental equipment cost incurred by household end-users are input into the model as an increase in the consumer spending for Tools and Equipment for Home and Garden.⁵⁵ The

⁵⁴ Based on employment shares estimated for 159 industries from 2018 employment data from the REMI PI+ (v2.4) model.

⁵⁵ Tools and Equipment for Home and Garden is a component of Personal Consumption Expenditures as described by BEA <https://www.bea.gov/media/5711>. This PCE category within REMI best represents the types of equipment affected under this proposed regulation.

incremental changes in expenditures on fuel, electricity, and maintenance and repair are input into the model as a change in consumer spending for the relevant consumer categories: motor vehicles fuels and lubricants, electricity, and household maintenance, respectively. The consumer spending policy variable affects the economy through changes in expenditures on goods and services based on the relative increase or decrease of expenditures in the specified category, corresponding with an equivalent reallocation of the spending on all other consumption categories and savings.

In addition to these changes in production costs or prices and final demand, there will also be economic impacts as a result of the fiscal effects, primarily from reductions in tax and fee revenue, equipment costs, and passed-through compliance costs. These changes in government revenue and along with changes in costs are modeled as a change in state and local government spending, assuming these revenue decreases are not offset elsewhere.

3. Results of the assessment

The results from the REMI model provide estimates of the impact of the Proposed Amendments on the California economy. These results represent the annual incremental change from the implementation of the Proposed Amendments relative to the baseline scenario. The California economy is forecasted to grow post-2020, therefore, negative impacts reported here should be interpreted as a slowing of growth and positive impacts as an acceleration of growth resulting from the Proposed Amendments. The results are reported here in five-year intervals from 2020 through 2040.

a. California Employment Impacts

Table E-2 presents the impact of the Proposed Amendments on total employment in California across all private industries and the public sector. Employment comprises estimates of the number of jobs, full-time plus part-time, by place of work for all industries. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included. The employment impacts represent the net change in employment across the economy, which is composed of positive impacts for some industries and negative impacts for others. The Proposed Amendments are estimated to result in an initial decrease in employment growth that doesn't exceed 0.2% of baseline employment and diminishes over the course of the regulatory horizon. These changes in employment represent 0.01 percent of baseline California employment.

Table E-2. California Employment Impacts

Metric	2020	2025	2030	2035	2040
California Employment	20,946,451	23,781,456	24,751,250	25,011,315	25,693,353
% Change	0.00%	-0.02%	-0.01%	0.00%	0.00%
Change in Total Jobs	0	-4,090	-2,734	-778	-116

The total employment impacts presented above are net of changes at the industry level. The overall trend in employment changes by major sector are illustrated in Figure E-1 and Table E-3 show the changes in employment by industries that are directly impacted by the Proposed Amendments. As the requirements of the Proposed Amendments go into effect the industries generally realizing reductions in production cost or increases in final demand see an increase in employment growth. There is initially a decrease in job growth that corresponds with the higher SORE cost that is not immediately offset by fuel savings, prior to the zero-emission requirements going into effect. Over time as the zero-emission requirements phase in, business end-users begin to realize gasoline fuel cost-savings that more than offset the incremental equipment cost, resulting in lower production costs, diminishing the negative initial impact on job growth over the regulatory period. The oil and gas extraction industry and personal and household goods repair and maintenance industry see a decreased employment growth rate due to a reduction in final demand for their goods and services. The reduced fuel consumption also reduces tax revenues, resulting in lower state and local government spending and employment as seen in Table E-9.

Figure E-1. Job Impacts by Major Sector

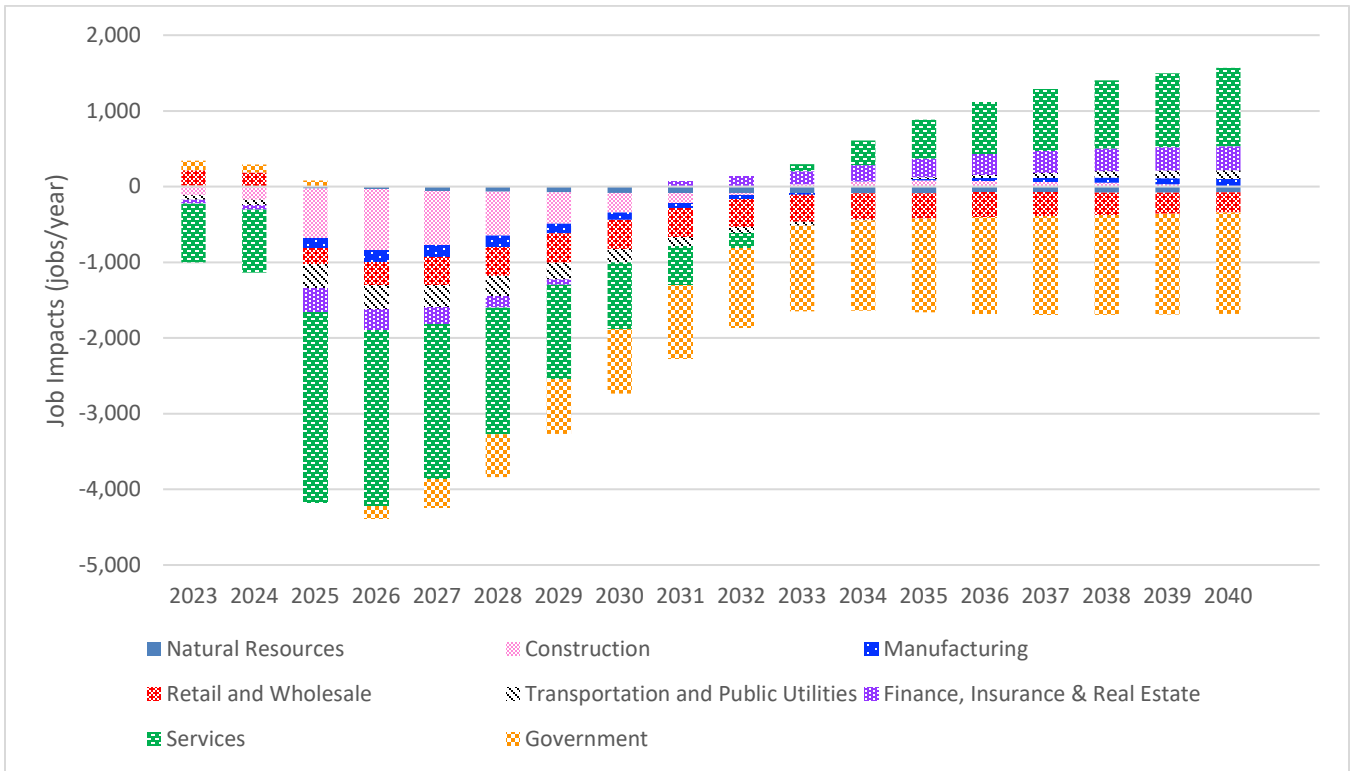


Table E-3. Job Impacts by Primary and Secondary Industries

Industry	Unit	2020	2025	2030	2035	2040
Electric power generation, distribution (2211)	% Change	0.00%	-0.01%	0.11%	0.17%	0.19%
Electric power generation, distribution (2211)	Change in Jobs	0	-2	40	66	72
Petroleum and coal products manufacturing (324)	% Change	0.00%	-0.05%	-0.48%	-0.70%	-0.74%
Petroleum and coal products manufacturing (324)	Change in Jobs	0	-6	-63	-87	-87
Agriculture, construction, and mining machinery manufacturing (3331)	% Change	0.00%	0.02%	0.02%	0.03%	0.03%
Agriculture, construction, and mining machinery manufacturing (3331)	Change in Jobs	0	1	1	1	1
Retail trade (44-45)	% Change	0.00%	-0.01%	-0.01%	-0.01%	-0.01%
Retail trade (44-45)	Change in Jobs	0	-161	-290	-269	-224
Services to buildings and dwellings (5617)	% Change	0.00%	-0.03%	-0.01%	0.02%	0.03%
Services to buildings and dwellings (5617)	Change in Jobs	0	-91	-23	64	106
Personal and household goods repair and maintenance (8114)	% Change	0.00%	-0.15%	-1.25%	-1.74%	-1.85%
Personal and household goods repair and maintenance (8114)	Change in Jobs	0	-28	-239	-317	-325
State & Local Government	% Change	0.00%	0.00%	-0.03%	-0.04%	-0.05%
State & Local Government	Change in Jobs	0	65	-687	-1,049	-1,148

b. California Business Impacts

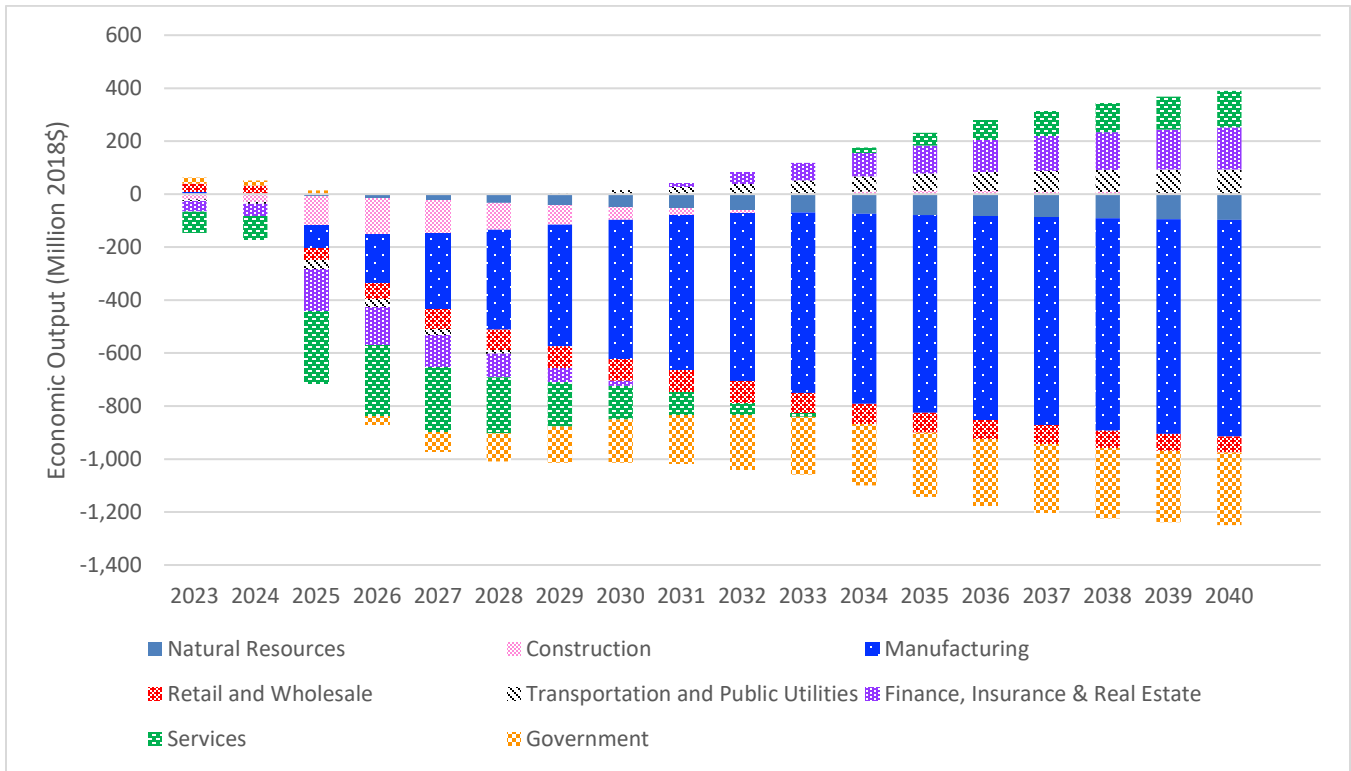
Gross output is used as a measure for business impacts because as it represents an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output is the sum of the amount of production, including all intermediate goods purchased as well as value added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

The results of the Proposed Amendments show a decrease in output of \$998 million in 2030 and a decrease of \$860 million in 2040 as shown in Table E-4, representing a change that doesn't exceed 0.02 percent of baseline output. The results for each impacted industry are shown in Table E-4. The trend in output changes is illustrated by major sector in Figure E-2. Similar to the employment impacts, there is an initial negative impact on the services sector that turns positive over time and negative impacts on oil and gas extraction, personal and household goods repair and maintenance. The public sector also experiences negative impacts as seen in Table E-4. The negative output impact on manufacturing is primarily driven by the petroleum and coal products manufacturing industry, which is estimated to see a sizeable decrease in final demand for gasoline and diesel.

Table E-4. Change in California Output Growth by Industry

Industry	Metric	2020	2025	2030	2035	2040
California Economy	Output (2019M\$)	4,276,749	5,222,462	5,725,678	6,209,827	6,948,815
California Economy	% Change	0.00%	-0.01%	-0.02%	-0.01%	-0.01%
California Economy	Change (2019M\$)	0	-702	-998	-911	-860
Electric power generation, transmission, and distribution (2211)	% Change	0.00%	-0.01%	0.11%	0.17%	0.19%
Electric power generation, transmission, and distribution (2211)	Change (2019M\$)	0	-2	46	81	96
Petroleum and coal products manufacturing (324)	% Change	0.00%	-0.05%	-0.48%	-0.70%	-0.74%
Petroleum and coal products manufacturing (324)	Change (2019M\$)	0	-46	-509	-795	-910
Agriculture, construction, and mining machinery manufacturing (3331)	% Change	0.00%	0.02%	0.02%	0.03%	0.03%
Agriculture, construction, and mining machinery manufacturing (3331)	Change (2019M\$)	0	1	1	1	1
Retail trade (44-45)	% Change	0.00%	-0.01%	-0.01%	-0.01%	-0.01%
Retail trade (44-45)	Change (2019M\$)	0	-20	-41	-41	-38
Services to buildings and dwellings (5617)	% Change	0.00%	-0.03%	-0.01%	0.02%	0.03%
Services to buildings and dwellings (5617)	Change (2019M\$)	0	-7	-2	5	10
Personal and household goods repair and maintenance (8114)	% Change	0.00%	-0.15%	-1.25%	-1.75%	-1.87%
Personal and household goods repair and maintenance (8114)	Change (2019M\$)	0	-4	-32	-44	-47
State & Local Government	% Change	0.00%	0.00%	-0.03%	-0.05%	-0.05%
State & Local Government	Change (2019M\$)	0	15	-163	-243	-274

Figure E-2. Change in Output in California by Major Sector



c. Impacts on Investments in California

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

The relative changes to growth in private investment for the Proposed Amendments are shown in Table E-5 and show a decrease of private investment by about \$177 million in 2030 and an increase of \$157 million in 2040, or less than 0.01 percent of baseline investment.

Table E-5. Change in Gross Domestic Private Investment Growth

Metric	2020	2025	2030	2035	2040
Private Investment (2019M\$)	306,853	420,607	483,159	525,926	592,601
% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2019M\$)	0	-177	-61	58	60

d. Impacts on Individuals in California

The Proposed Amendments result in impacts to individuals as the incremental costs of affected equipment is passed on to household end-users, who also realize fuel cost-savings. Additionally, the costs incurred by affected businesses and the public sector will cascade through the economy and impact individuals. One measure of this impact is the change in real personal income, which includes worker compensation and government and business transfer payments, adjusted for inflation.

Table E-6 shows the annual change in real personal income across all individuals in California. Total personal income growth initially decreases by about \$623 million in 2025, then subsequently begins an upward trend, with an increase of \$192 million in 2040. The change in personal income estimated here can also be divided by the California population to show the average or per capita impact on personal income. Personal income initially decreases by about \$12 per person in 2025 and increases by about \$5 per person in 2040.

Table E-6. Change in Personal Income Growth

Metric	2020	2025	2030	2035	2040
Personal Income (2019M\$)	2,421,561	2,838,674	3,119,606	3,428,717	3,814,071
% Change in Personal Income	0.00%	-0.02%	-0.01%	0.00%	0.01%
Change in Personal Income (2019M\$)	0	-623	-238	61	192
Personal Income per capita (2019\$)	60,345	68,557	73,469	79,074	86,540
% Change in Personal Income per capita	0.00%	-0.02%	0.00%	0.01%	0.01%
Change in Personal Income per capita (2019\$)	0	-12	2	6	5

e. Impacts on Gross State Product (GSP)

Gross State Product (GSP) is the market value of all goods and services produced in California and is one of the primary indicators used to gauge the health of an economy. Under the Proposed Amendments, GSP growth is anticipated to decrease by about \$408 million in 2030 and \$248 million in 2040 as shown in Table E-7. These changes represent less than 0.01 percent of baseline GSP.

Table E-7. Changes in Gross State Product (GSP) Growth

Metric	2020	2025	2030	2035	2040
GSP (2019M\$)	2,526,514	3,101,465	3,439,446	3,739,328	4,128,716
% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2019M\$)	0	-408	-450	-315	-248

f. Creation or Elimination of Businesses

The REMI model cannot directly estimate the creation or elimination of businesses. Changes in jobs and output for the California economy described above can be used to understand some potential impacts. The overall jobs and output impacts of the Proposed Amendments are very small relative to the total California economy, representing changes less than 0.03 percent. However, impacts in some specific sectors are larger as described in previous sections. The trend of decreasing production costs for the services to buildings and dwellings industry and the greater services sector has the potential to result in an expansion or increases in businesses in this industry if sustained over time. While, the decreasing trend in demand for gasoline and diesel fuel following from the Proposed Amendments has the potential to result in a decrease in businesses in this industry if sustained over time. The personal and household maintenance and repair sees the largest relative decrease in industry employment and output from the Proposed Amendments and may be indicative of potential business contraction or eliminations. In particular, we expect small-engine repair shops to see significant impacts to their business. Zero-emission equipment does not contain an engine and needs significantly less repair than SORE equipment. Some standard maintenance, such as sharpening lawnmower blades or replacing trimmer heads, will still be required on SORE, but this type of maintenance is more likely to be performed by the end-user or the dealer selling the equipment.

g. Incentives for Innovation

The amendments to SORE regulations are written to give maximum flexibility to manufacturers, while still meeting California's air quality goals. The regulations do not significantly incentivize innovation in gasoline-powered SORE, as the lower HC plus NOx emission standards in 2023 can be met by engines already certified for sale in California. Alternative fuel SORE, such as propane and liquefied natural gas, can exceed the emission standards set in 2023 and, therefore, be used to generate emission offset credits for continued production of gasoline SORE. Similarly, the zero-emission equipment program is being expanded to incentivize early conversion to ZEE by allowing credit generation to offset emission from gasoline engines.

h. Competitive Advantage or Disadvantage

The small off-road equipment manufacturers that must comply with requirements of the Proposed Amendments are based outside of California and therefore do not present any competitiveness impacts for this industry inside California. Small off-road equipment dealers may potentially find themselves at a competitive disadvantage as a result of the Proposed Amendments. Businesses, or individuals could purchase small off-road equipment out of state and bring it into California for use. Due to the small price differences on the household side of the market between SORE and ZEE, this is unlikely to happen at the individual level. However,

the high upfront costs associated with professional ZEE may make this enticing for large businesses. The additional costs of transportation for purchasing and repair may prevent some of this. In contrast, online sales of non-compliant equipment are expected to be low, as CARB staff search for such equipment and have initiated enforcement mechanisms against online retailers selling non-compliant SORE. The requirements result in an incremental net savings to business end-users of the equipment. These net savings are anticipated to be incurred generally across business end-users and are not anticipated to result in any competitive advantages or disadvantages within industries.

4. Summary and Agency Interpretation of the Assessment Results

As analyzed here, CARB estimates the Proposed Amendments are unlikely to have a significant impact on the California economy as summarized in Table E-8. Overall, the change in the growth of jobs, State GDP, and output is projected to not exceed 0.02 percent of the baseline. The Proposed Amendments result in fuel savings that grow over time, leading to eventual growth in the services sector, including landscaping. The fuel savings for business and household end-users represents decreased demand for gasoline, portending a decrease in growth for the oil and gas industry. The repair and maintenance cost-savings to end-users of electric powered equipment results in decreased sales to the household goods repair and maintenance industry, leading to relatively large declines in employment in the industry. This analysis also shows the negative impact estimated for state and local government output and employment due to fuel tax revenue decreases, without any offsetting revenues.

Table E-8. Summary of Macroeconomic Impacts of the Proposed Amendments

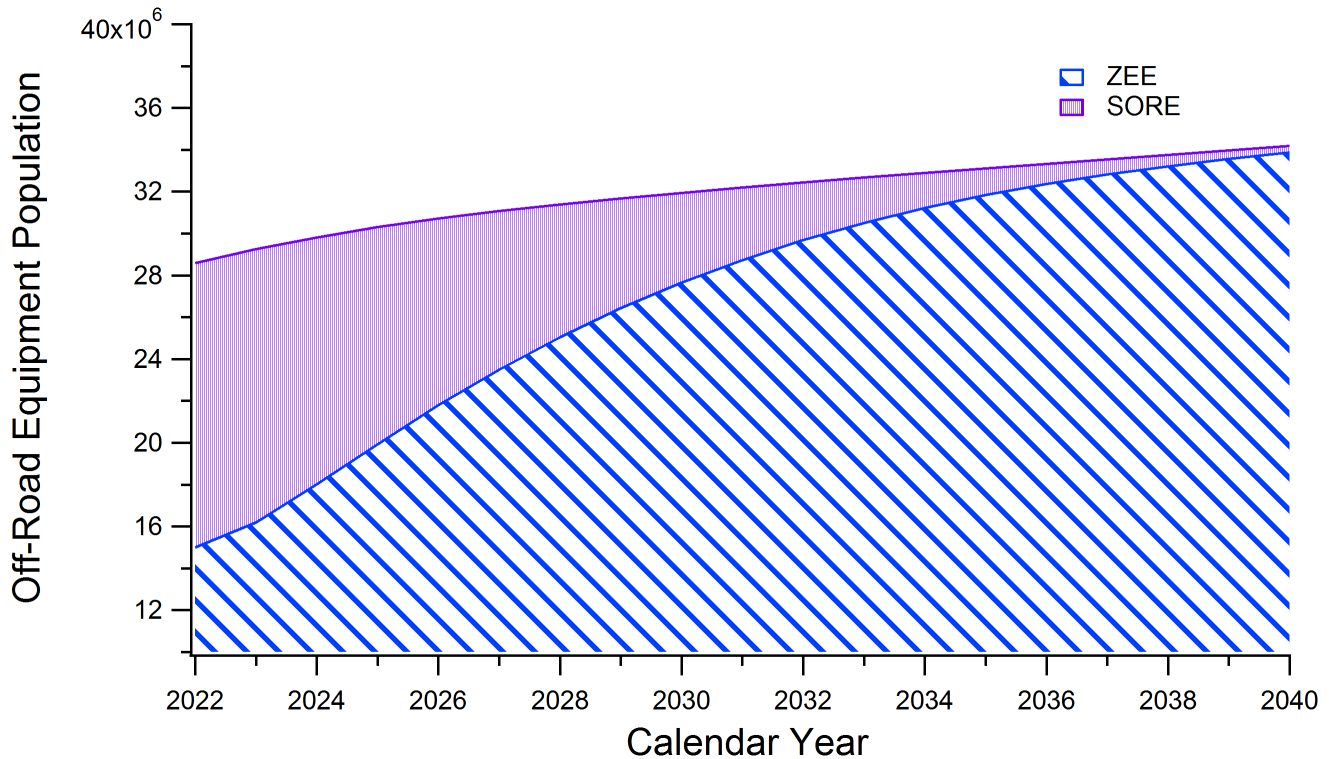
Indicator	Metric	2020	2025	2030	2035	2040
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
GSP	Change (2019M\$)	0	-408	-450	-315	-248
Personal Income	% Change	0.00%	-0.02%	-0.01%	0.00%	0.01%
Personal Income	Change (2019M\$)	0	-623	-238	61	192
Employment	% Change	0.00%	-0.02%	-0.01%	0.00%	0.00%
Employment	Change in Jobs	0	-4,090	-2,734	-778	-116
Output	% Change	0.00%	-0.01%	-0.02%	-0.01%	-0.01%
Output	Change (2019M\$)	0	-702	-998	-911	-860
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Private Investment	Change (2019M\$)	0	-177	-61	58	60

F. ALTERNATIVES

1. Alternative 1

Alternative 1 would transition equipment to ZEE more quickly than the Proposed Amendments and has been suggested by many environmental groups and members of the public. This alternative would prohibit the sales in California of new spark-ignition engines produced on or after January 1, 2023, by setting the emission standard to zero. All sales would be zero-emission equipment with no credit use allowed. The fraction of ZEE in the overall outdoor power equipment population would rise more quickly as seen in Figure F-1.

Figure F-1. Modeled Population of Outdoor Power Equipment in the Alternative 1 Scenario



a. Costs

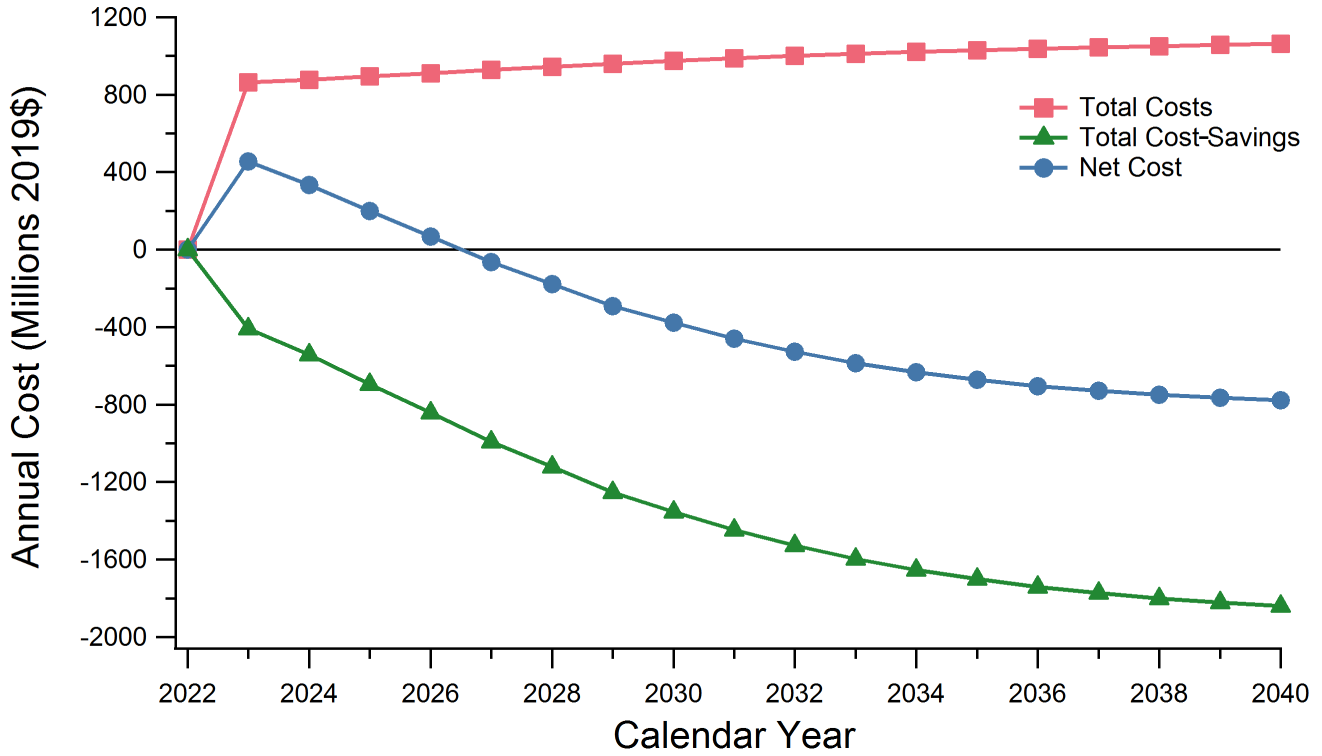
In Alternative 1, more ZEE would be purchased over the modeled time period. This would shift the increased upfront cost over baseline to start in 2023. Most of the costs of this scenario would be similar to those under the Proposed Amendments but occurring two years earlier. The major difference is the lack of two years of lower-emitting gasoline-powered equipment being sold. The 2023 compliant SORE are in several cases more expensive than the ZEE alternative for households. However, this is not the case for professional grade equipment and so there are larger upfront costs in the years 2023 and 2024 than the Proposed Amendments. Cost-savings would be seen statewide in the year 2027. The upfront and ongoing costs in this scenario each year are shown in Table F-1. The total costs and cost-savings are shown graphically in Figure F-2. The total cost-savings through 2040 is \$5.63 billion.

Year	Gasoline Equipment Costs	Electric Equipment Costs	Gasoline Equipment Maintenance Costs	Fuel Costs	Electricity Costs	Total Cost-savings	Total Costs	Net Costs
2022	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
2023	-\$375.6	\$931.4	-\$5.3	-\$55.7	\$4.4	\$436.5	\$935.8	\$499.3
2024	-\$376.9	\$935.8	-\$16.2	-\$178.8	\$15.1	\$571.9	\$950.9	\$379.0
2025	-\$378.1	\$940.2	-\$27.7	-\$318.3	\$27.9	\$724.1	\$968.1	\$244.0
2026	-\$379.4	\$944.6	-\$38.6	-\$454.9	\$40.8	\$872.9	\$985.4	\$112.5
2027	-\$380.6	\$949.0	-\$48.6	-\$591.5	\$53.5	\$1,020.7	\$1,002.5	-\$18.2
2028	-\$381.9	\$953.5	-\$57.3	-\$712.3	\$65.8	\$1,151.5	\$1,019.3	-\$132.2
2029	-\$383.2	\$958.0	-\$64.8	-\$834.8	\$77.8	\$1,282.8	\$1,035.8	-\$247.0
2030	-\$384.4	\$962.5	-\$71.1	-\$928.4	\$89.2	\$1,383.9	\$1,051.7	-\$332.3
2031	-\$385.7	\$967.0	-\$76.3	-\$1,015.9	\$97.7	\$1,478.0	\$1,064.7	-\$413.2
2032	-\$387.0	\$971.6	-\$80.5	-\$1,090.4	\$105.0	\$1,557.9	\$1,076.6	-\$481.3
2033	-\$388.4	\$976.2	-\$84.0	-\$1,154.0	\$111.2	\$1,626.3	\$1,087.5	-\$538.9
2034	-\$389.7	\$980.9	-\$86.8	-\$1,207.5	\$116.5	\$1,683.9	\$1,097.4	-\$586.5
2035	-\$391.0	\$985.6	-\$89.0	-\$1,251.6	\$120.7	\$1,731.6	\$1,106.2	-\$625.4
2036	-\$392.3	\$990.3	-\$90.8	-\$1,288.6	\$124.2	\$1,771.7	\$1,114.4	-\$657.3
2037	-\$393.7	\$995.0	-\$92.1	-\$1,318.6	\$127.0	\$1,804.4	\$1,122.0	-\$682.4
2038	-\$395.1	\$999.8	-\$93.1	-\$1,342.9	\$129.3	\$1,831.0	\$1,129.1	-\$702.0

2039	-\$396.4	\$1,004.6	-\$93.8	-\$1,362.7	\$131.1	\$1,852.9	\$1,135.7	-\$717.2
2040	-\$397.8	\$1,009.4	-\$94.3	-\$1,379.1	\$132.7	\$1,871.2	\$1,142.1	-\$729.2
Average	-\$366.2	\$918.7	-\$63.7	-\$867.7	\$82.6	\$1,297.5	\$1,001.3	-\$296.2
Total	-\$6,957.3	\$17,455.2	-\$1,210.0	-\$16,485.9	\$1,569.9	\$24,653.2	\$19,025.1	-\$5,628.1

Table F-1. Modeled Costs to Businesses and Residents per Year Due to Alternative 1 to the SORE Regulations Relative to the Baseline Scenario. All values in millions of dollars. Total may differ slightly due to rounding.

Figure F-2. Statewide Costs, Cost-savings, and Overall Net Costs as a Result of Alternative 1



b. Benefits

The most notable difference in benefits with Alternative 1 will be in emission reductions. For NO_x, ROG and CO₂ emission reductions for milestone years 2025 and 2031 are shown in Table F-2. The reductions for NO_x and ROG are seen for each modeled year in Figures F-3 and F-4.

Table F-2. Emissions Reductions for Milestone Years as a Result of Alternative 1.

Calendar Year	NO _x Reductions (tpd)	ROG Reductions (tpd)	CO ₂ reductions (tpd)
2025	2.81	22.51	815.17
2031	9.83	69.36	2416.03

Figure F-3. Emissions Reductions of NO_x as a Result of Alternative 1 for the Modeled Period

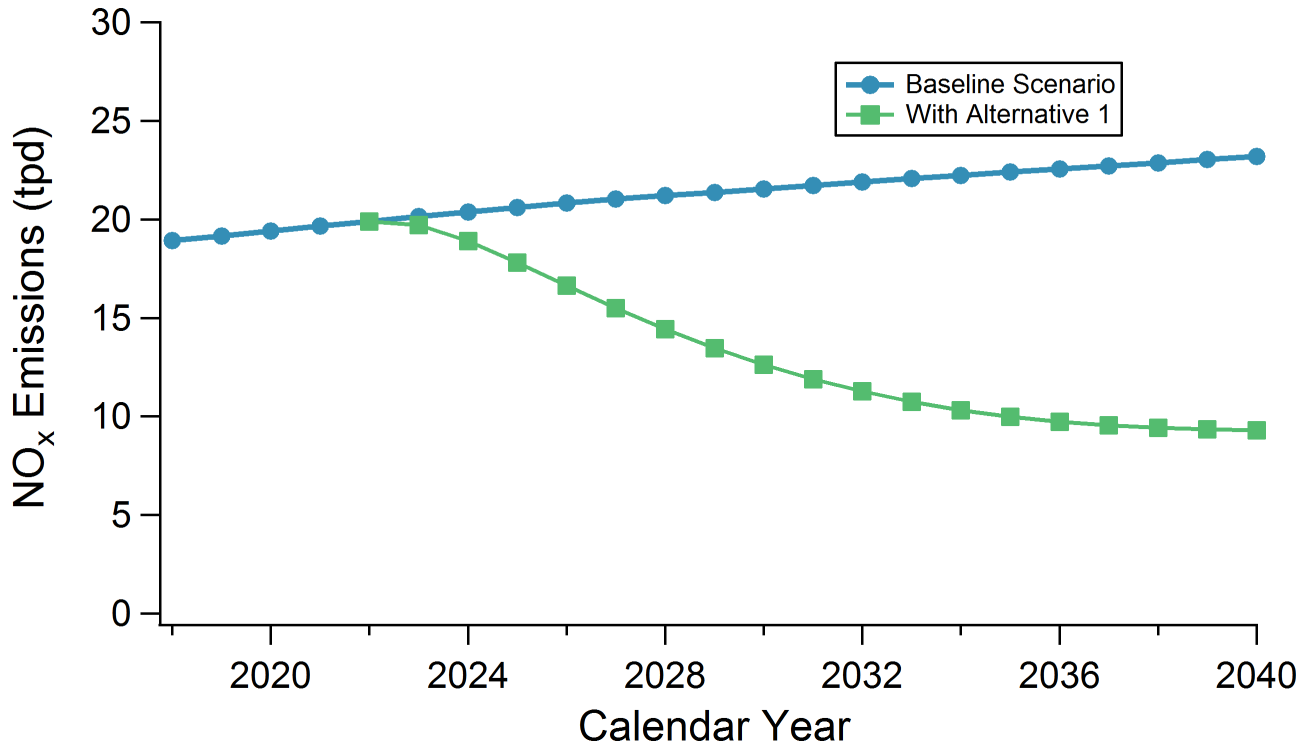
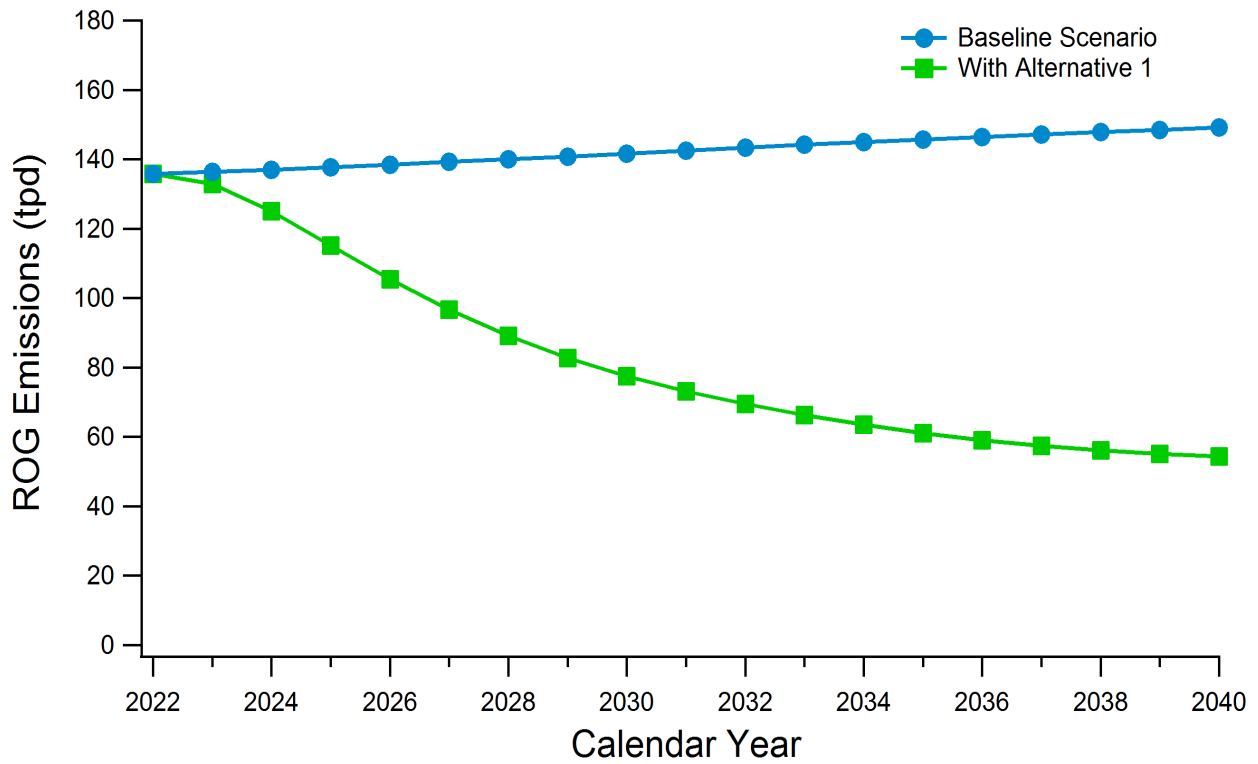


Figure F-4. Emission Reductions of ROG as a Result of Alternative 1 for the Modeled Period



Emission reductions occur earlier in Alternative 1 as compared to the Proposed Amendments but bottom out at the same point around 9 tons per day due to preempt equipment. Over the modelled period this leads to a total of 58,816 tons of NO_x and 412,761 tons of ROG saved from being emitted. This value is nearly identical to the saved emissions from the Proposed Amendments.

In terms of health benefits, the avoided negative health outcomes as a result of Alternative 1 are shown in Table F-3. The total of these avoided outcomes is slightly larger than that in the Proposed Amendments.

Table F-3. Avoided Health Outcomes as a Result of Alternative 1.

Endpoint	Avoided Incidents	Valuation (Million 2019\$)
Cardiopulmonary mortality	855	\$8,434.5
Hospitalizations for cardiovascular illness	134	\$7.8
Hospitalizations for respiratory illness	160	\$8.1
Emergency room visits	424	\$0.4
Total	1573	\$8,451

Alternative 1 results in an estimated 12.9 MMT of CO₂ emissions avoided. These emissions reductions represent a benefit of the avoided social cost of carbon valued between \$293 million and \$1.28 billion, depending on the discount rate.

c. Economic Impacts

Alternative 1 is a more stringent requirement with the zero-emission requirements for equipment going into effect in 2023. This results in greater incremental equipment cost as passed on to end-user, but also greater fuel cost-savings. The macroeconomic impacts analysis results are qualitatively similar to the results of the Proposed Amendments, but of a larger magnitude as shown in Tables F-4, Figure F-5, and Figure F-6 show the job impacts and output changes of Alternative 1, respectively.

Table F-4. Change in Growth of Economic Indicators for Alternative 1

Indicator	Metric	2020	2025	2030	2035	2040
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
GSP	Change (2019M\$)	0	-446	-236	-86	-15
Personal Income	% Change	0.00%	-0.02%	0.00%	0.01%	0.01%
Personal Income	Change (2019M\$)	0	-436	42	319	439
Employment	% Change	0.00%	-0.02%	0.00%	0.01%	0.01%
Employment	Change in Jobs	0	-3,785	-425	1,276	1,746
Output	% Change	0.00%	-0.02%	-0.01%	-0.01%	-0.01%
Output	Change (2019M\$)	0	-864	-729	-583	-499
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Private Investment	Change (2019M\$)	0	-189	45	106	92

Figure F-5. Job Impacts of Alternative 1 by Major Sector

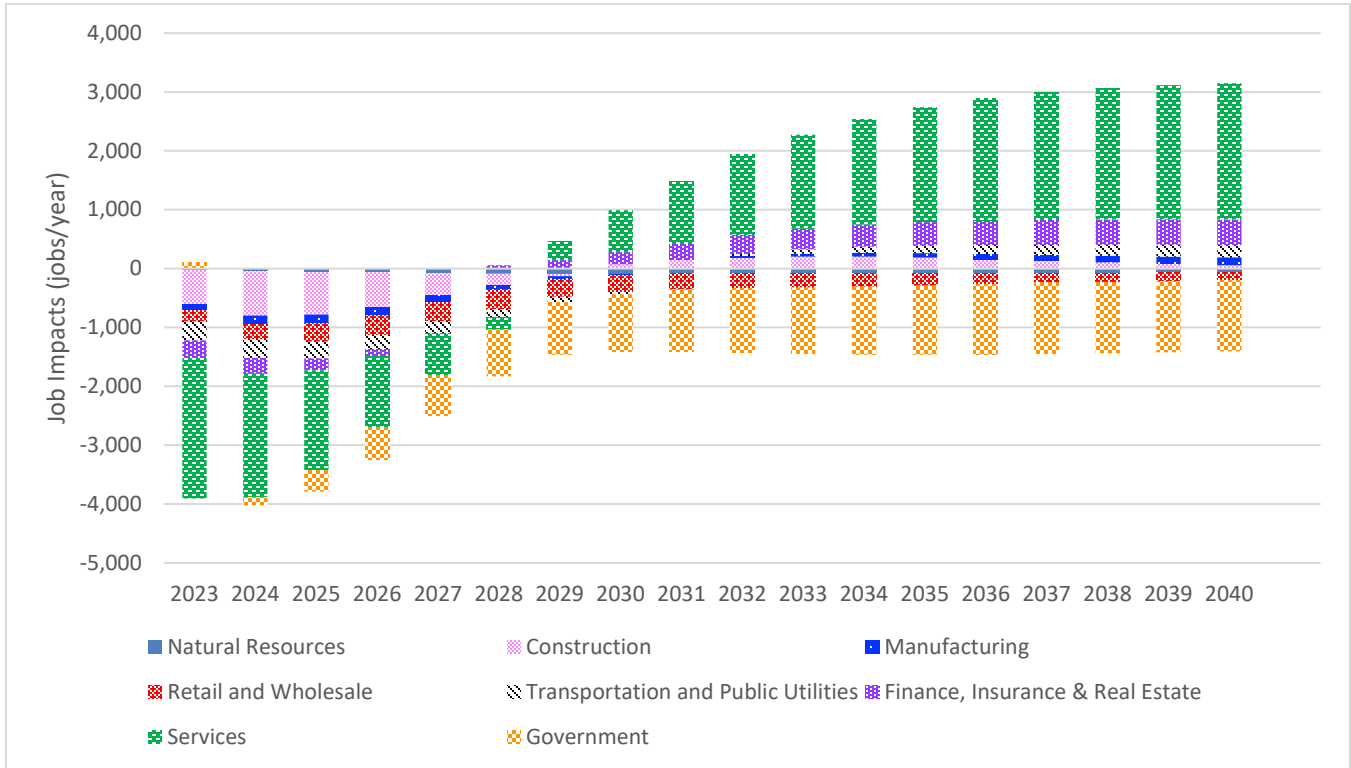
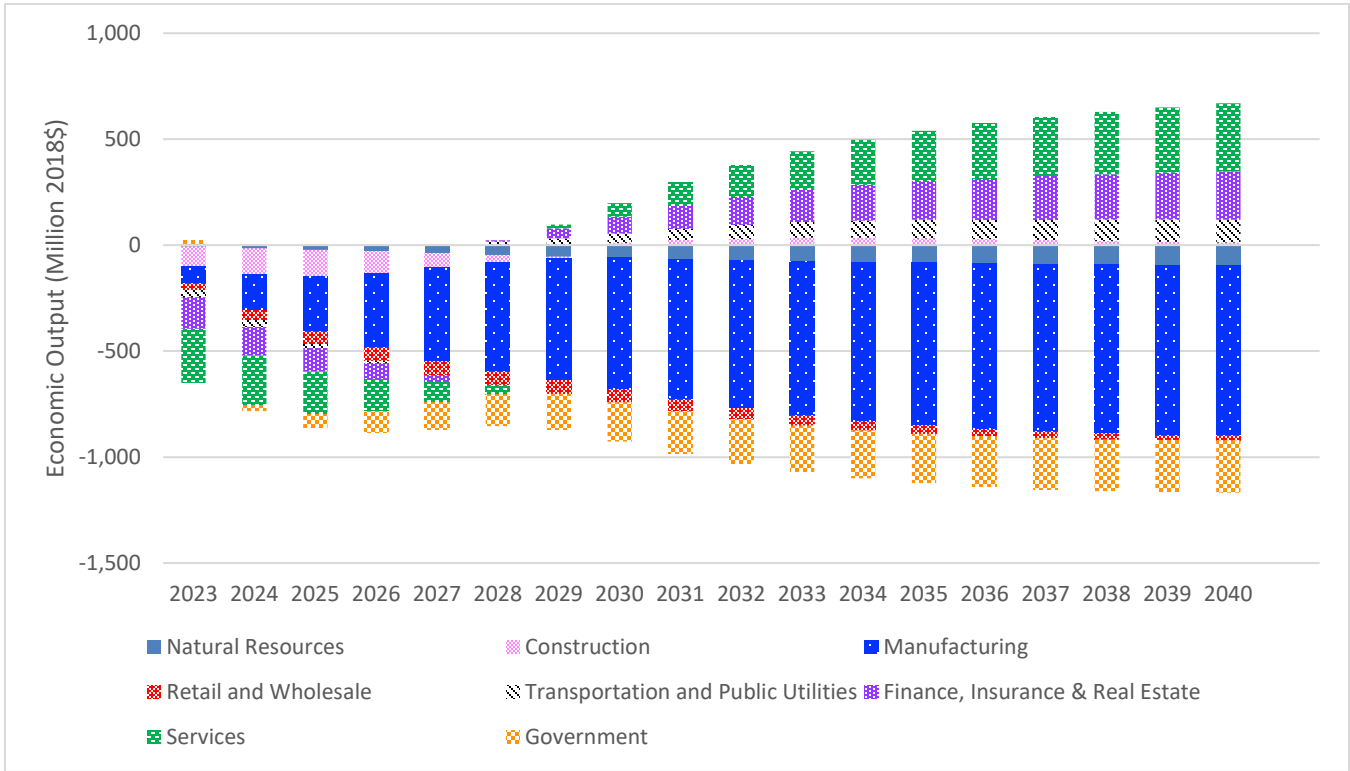


Figure F-6. Changes in Output from Alternative 1 by Major Sector



d. Cost-Effectiveness

The metric to quantify cost-effectiveness of the Proposed amendment and alternative 1 is the ratio of total monetized benefits divided by total monetized costs. A comparison of this type is an appropriate cost-effectiveness measure because the harm associated with increased emissions is captured in the estimates of monetized health impacts. A benefit-cost ratio greater than 1 implies that the benefits of the scenario are higher than its costs. Benefits includes both health benefits and cost-savings after subtracting tax and fee revenue impacts to State and local governments. Table F-5 indicates that the Proposed Amendments have a cumulative net benefit of \$9.9 billion and a benefit-cost ratio of 1.5, meaning benefits are more than costs during the analysis period between 2022 and 2040. Relative to the Proposed Amendments, Alternative 1 has a net benefit of \$12.0 billion, and a benefit-cost ratio of 1.6.

Table F-5. Cost-Benefit Comparison of Proposed Amendments and Alternative 1 (Billion 2019\$)

Scenario	Total Costs	Health Benefits	Cost-Savings (Benefit)	Tax & Fee Revenue	Total Benefit	Net Benefit	Benefit-Cost Ratio
Proposed Regulation	\$17.40	\$7.82	\$21.10	-\$1.63	\$28.92	\$9.89	1.5
Alternative 1	\$19.02	\$8.45	\$24.65	-\$2.04	\$33.10	\$12.04	1.6

e. Reason for Rejecting

The primary reason for not pursuing this alternative is to provide maximum flexibility to manufacturers and landscapers in implementation of tighter standards. The slightly slower enactment of the Proposed Amendments would give manufacturer more flexibility to reach zero-emissions and ramp up production of zero-emission alternatives to meet increased demand. Manufacturers could begin transitioning to cleaner technology immediately, where they are already capable of exceeding the standards, and bank credits, which would allow them to continue making gasoline-powered engines for equipment types, such as generators, where the zero-emission alternatives are most expensive and difficult to implement. This would provide additional transition time for both manufacturers and consumers to make any necessary adaptations to transition fully to ZEE. Additionally, this scenario would eliminate some of CARB’s opportunities to distribute incentive funds to be used for zero-emission equipment starting in 2023, which would result in larger effective costs for small businesses, particularly landscaping companies.

2. Alternative 2

Alternative 2 would transition equipment to ZEE more slowly than the Proposed Amendments. The 2023 standards from the Proposed Amendments would go into effect in 2025, and emission standards would be 0 across the board in 2027, while allowing the use of earned credits to still produce engines. All new equipment would be zero-emissions starting in 2032. Emission standards for model year 2023 would be an intermediate step between current regulations and the 2025 step. Again, it is simplest, and most conservative, to assume no carry-over of credits and all sales of spark-ignition engines end in 2027. The emission standards for this alternative are shown in Table F-6 through F-10. The fraction of ZEE in the statewide outdoor power equipment population in this alternative is shown in Figure F-7.

Table F-6. Exhaust Emission Standards for Displacement Range < 50 cc.

Model Year	Emission Standard Tier	Engine Class	Durability Periods (hours)	HC + NOx	CO	PM
2005-2022	3	3, 4	50/125/300	50	536	2.0
2023-2024	4	3, 4	1000	30	536	2
2025-2026	5	3, 4	1000	20	536	2
2027	6	3, 4	n.a.	0	536	2

Table F-7. Exhaust Emission Standards for Displacement Range 50-80 cc

Model Year	Emission Standard Tier	Engine Class	Durability Periods (hours)	HC + NOx	CO	PM
2005-2022	3	5	50/125/300	72	536	2.0
2023-2024	4	5	1000	43	536	2
2025-2026	5	5	1000	13	536	2
2027	6	5	n.a.	0	536	2

Table F-8. Exhaust Emission Standards for Displacement Range 80-225 cc

Model Year	Emission Standard Tier	Engine Class	Durability Periods (hours)	HC + NOx	CO
2007-2022	3	1	125/250/500	10	549
2023-2024	4	1	2000	8	549
2025-2026	5	1	2000	6	549
2027	6	1	2000	0	549

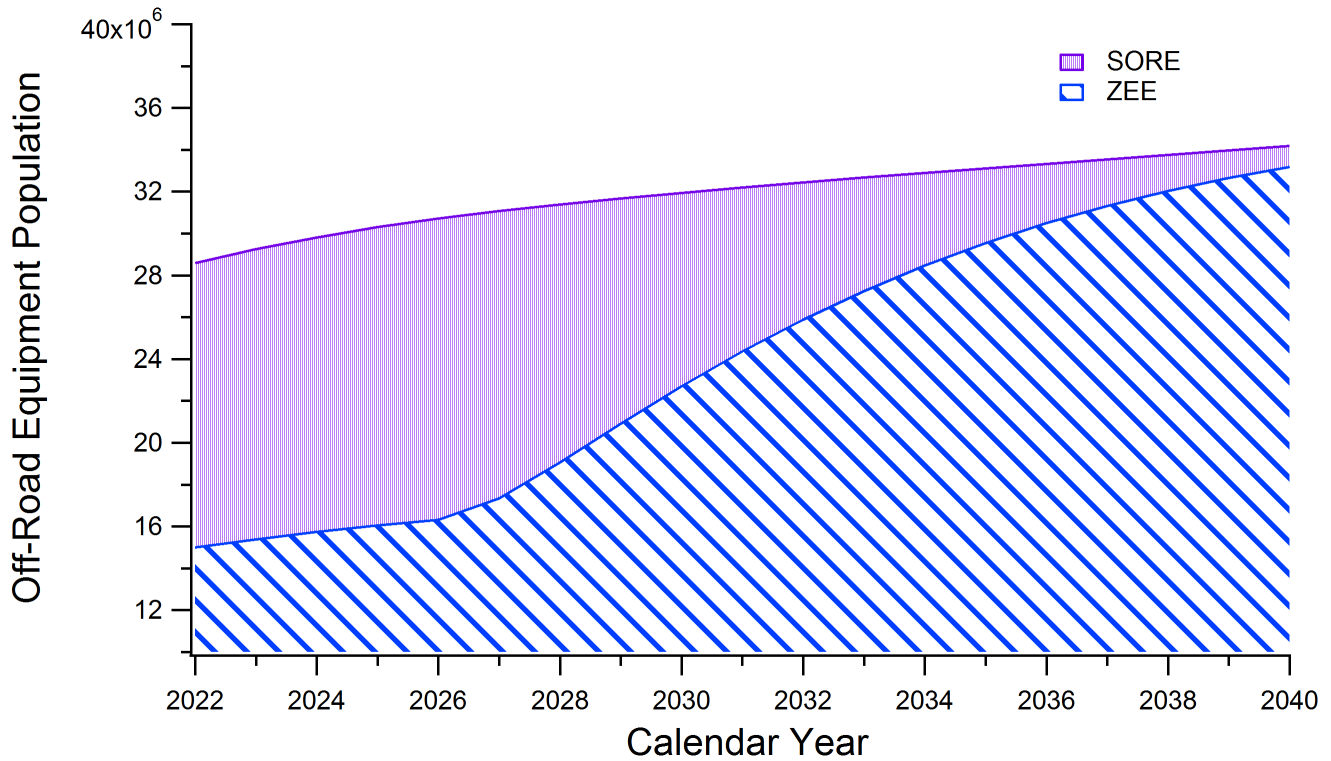
Table F-9. Exhaust Emission Standards for Displacement Range 225-825 cc

Model Year	Emission Standard Tier	Engine Class	Durability Periods (hours)	HC + NOx	CO
2008-2022	3	2	125/250/500/1000	8	549
2023-2024	4	2	5000	6	549
2025-2026	5	2	5000	3	549
2027	6	2	5000	0	549

Table F-10. Exhaust Emission Standards for Displacement Range >825 cc

Model Year	Emission Standard Tier	Engine Class	Durability Periods (hours)	HC + NOx	CO
2023-2024	4	2	5000	3	549
2025-2026	5	2	5000	0.8	549
2027	6	2	5000	0	549

Figure F-7. Modeled Population of Outdoor Power Equipment in the Alternative 2 Scenario



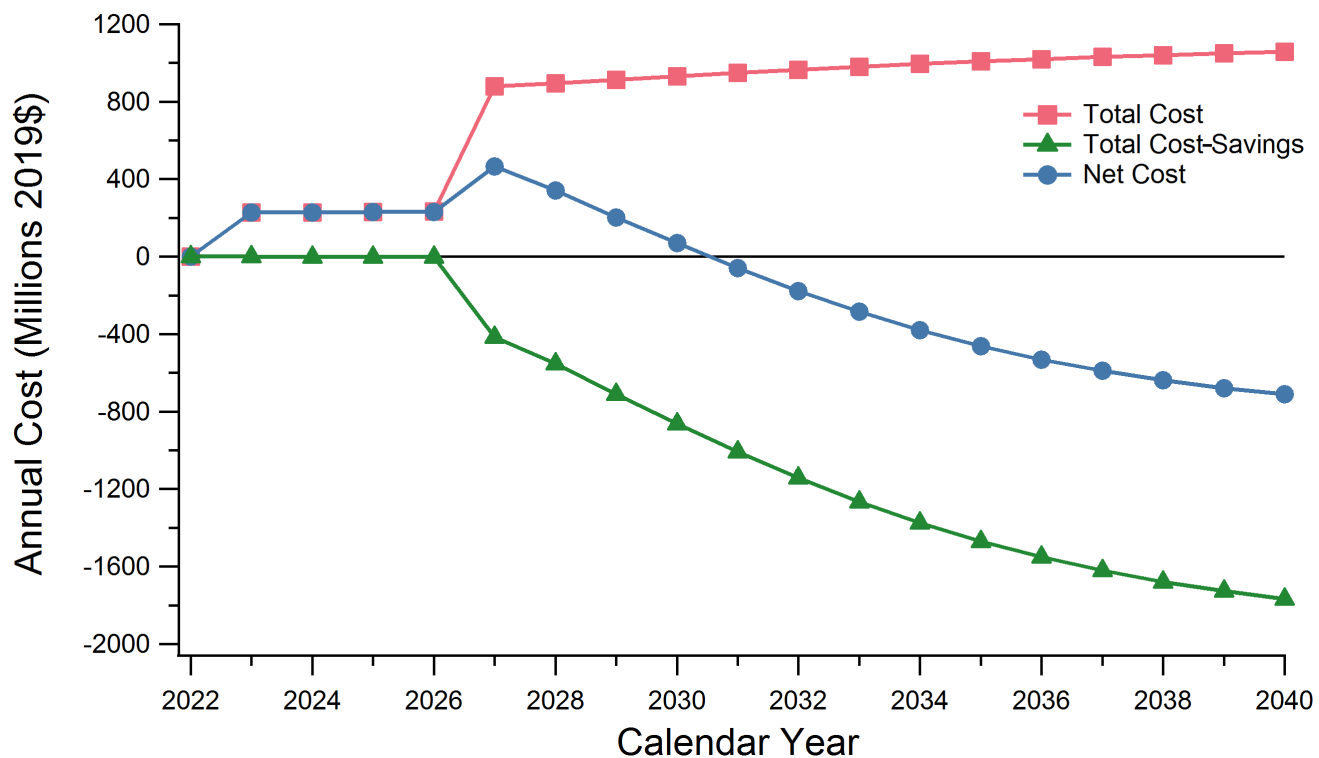
a. Costs

In Alternative 2, less ZEE would be purchased over the modeled time period. This would shift the increased upfront cost over baseline to start in 2025. Most of the costs of this scenario would be similar to those under the Proposed Amendments but occurring two years later. The major difference is the extension of the time period over which gasoline-powered equipment is sold. Cost-savings would be seen statewide in the year 2031. The upfront and ongoing costs in this scenario each year are shown in Table F-11. The total costs and cost-savings are shown graphically in Figure F-8. The total cost-savings through 2040 is \$2.51 billion. The cost-savings is lower as savings from fuel with cleaner SORE is marginal as compared to BAU scenario.

Table F-11. Modeled Costs to Businesses and Residents per Year Due to Alternative 2 to the SORE Regulations Relative to the Baseline Scenario. All values in millions of dollars. Total may differ slightly due to rounding.

Year	Gasoline equipment cost (upfront)	Electric equipment cost (upfront)	Gasoline equip maintenance cost (ongoing)	Gasoline equip gasoline cost (ongoing)	Electric equip ongoing cost	Total Cost-savings	Total Cost	Net Cost
2022	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
2023	\$212.8	\$34.0	\$0.0	-\$0.4	\$0.1	\$0.4	\$246.9	\$246.4
2024	\$213.9	\$34.5	\$0.0	-\$0.7	\$0.1	\$0.7	\$248.5	\$247.8
2025	\$215.0	\$35.0	\$0.0	-\$0.9	\$0.2	\$0.9	\$250.1	\$249.2
2026	\$216.0	\$35.6	\$0.0	-\$1.3	\$0.2	\$1.3	\$251.8	\$250.6
2027	-\$380.6	\$949.0	-\$5.3	-\$58.5	\$4.8	\$444.4	\$953.8	\$509.4
2028	-\$381.9	\$953.5	-\$16.2	-\$184.4	\$16.3	\$582.5	\$969.8	\$387.3
2029	-\$383.2	\$958.0	-\$27.7	-\$330.6	\$30.3	\$741.4	\$988.2	\$246.8
2030	-\$384.4	\$962.5	-\$38.7	-\$468.6	\$44.5	\$891.7	\$1,007.0	\$115.3
2031	-\$385.7	\$967.0	-\$48.6	-\$602.8	\$57.7	\$1,037.2	\$1,024.7	-\$12.4
2032	-\$387.0	\$971.6	-\$57.4	-\$727.9	\$69.9	\$1,172.3	\$1,041.6	-\$130.8
2033	-\$388.4	\$976.2	-\$64.9	-\$842.4	\$81.2	\$1,295.6	\$1,057.5	-\$238.2
2034	-\$389.7	\$980.9	-\$71.2	-\$944.1	\$91.3	\$1,404.9	\$1,072.2	-\$332.8
2035	-\$391.0	\$985.6	-\$76.4	-\$1,033.1	\$100.0	\$1,500.4	\$1,085.5	-\$414.9
2036	-\$392.3	\$990.3	-\$80.6	-\$1,108.7	\$107.4	\$1,581.7	\$1,097.7	-\$484.0
2037	-\$393.7	\$995.0	-\$84.1	-\$1,173.5	\$113.8	\$1,651.3	\$1,108.8	-\$542.4
2038	-\$395.1	\$999.8	-\$86.9	-\$1,227.8	\$119.2	\$1,709.8	\$1,118.9	-\$590.8
2039	-\$396.4	\$1,004.6	-\$89.1	-\$1,272.8	\$123.5	\$1,758.4	\$1,128.0	-\$630.3
2040	-\$397.8	\$1,009.4	-\$90.9	-\$1,310.4	\$127.0	\$1,799.1	\$1,136.4	-\$662.7
Average	-\$241.6	\$728.5	-\$44.1	-\$594.1	\$57.2	\$924.9	\$830.9	-\$94.0
Total	-\$4,589.6	\$13,842.4	-\$838.0	-\$11,288.8	\$1,087.5	\$17,574.0	\$15,787.5	-\$1,786.5

Figure F-8. Statewide Costs, Cost-savings, and Overall Net Costs as a Result of Alternative 2



b. Benefits

The most notable difference in benefits with Alternative 2 will be in emission reductions. For NO_x, and CO₂ emission reductions for milestone years 2025 and 2031 are shown in Table F-12. The reductions for NO_x and ROG are seen for each modeled year in Figures F-9 and F-10.

Table F-12. Emissions Reductions for Milestone Years as a Result of Alternative 1.

Calendar Year	NO _x Reductions (tpd)	ROG Reductions (tpd)	CO ₂ reductions (tpd)
2025	1.21	10.18	0
2031	8.23	57.23	1516

Figure F-9. Emissions Reductions of NO_x as a Result of Alternative 2 for the Modeled Period

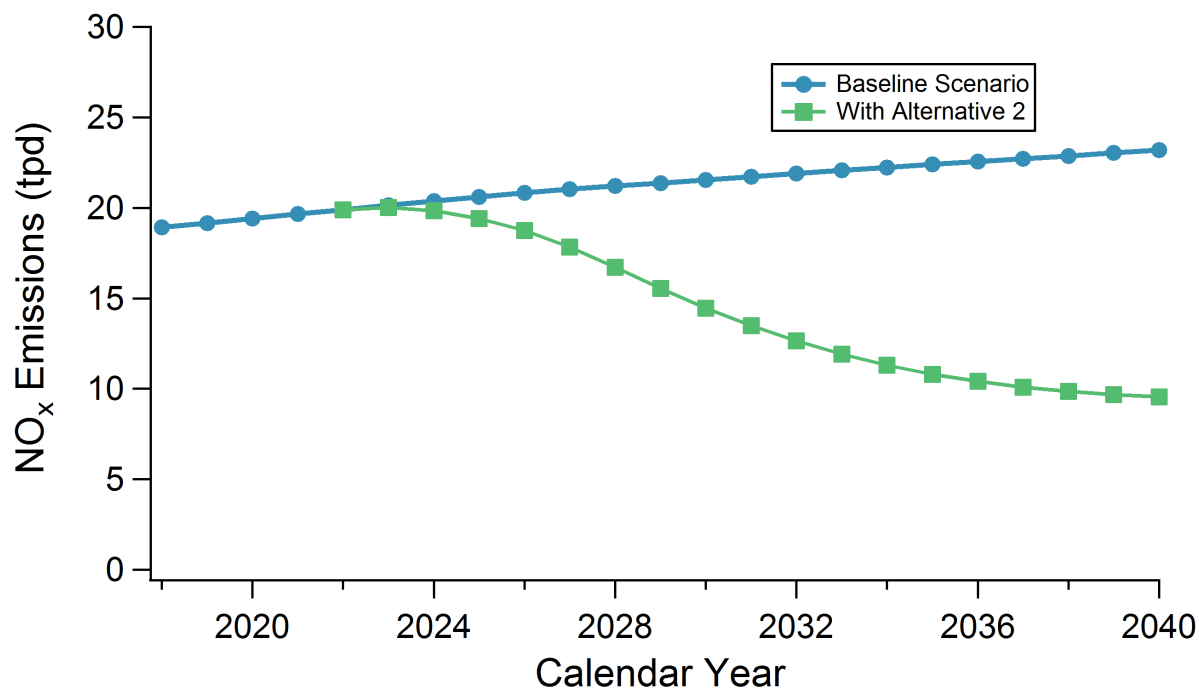
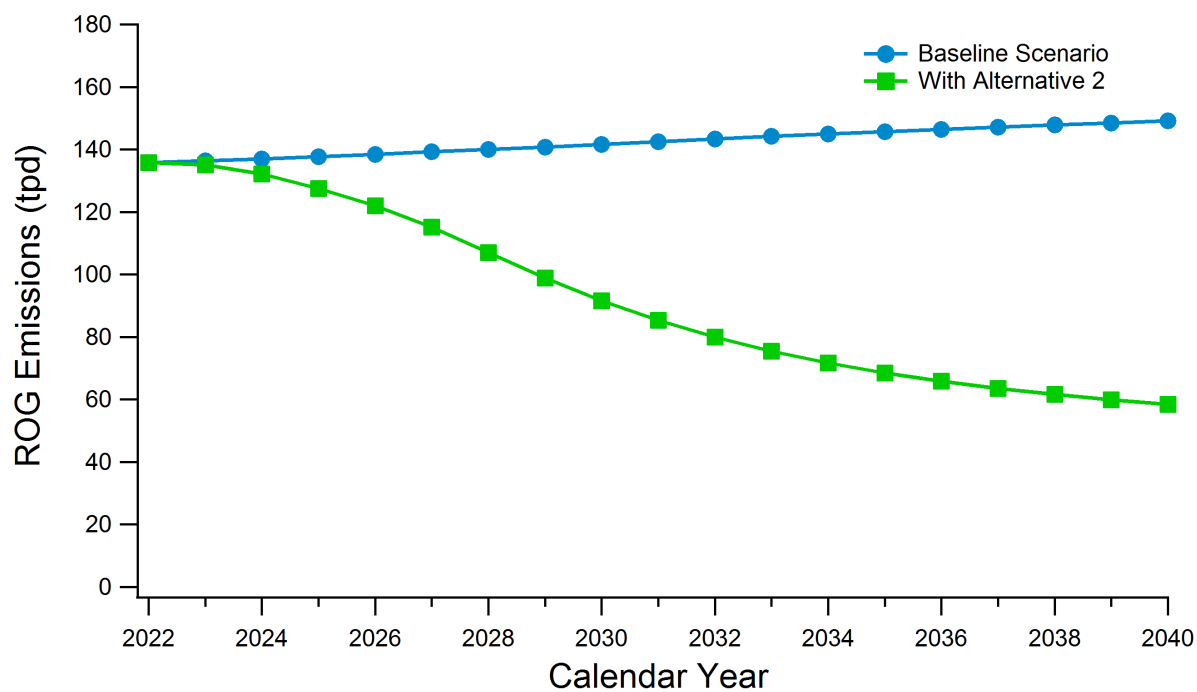


Figure F-10. Emissions Reductions of ROG as a Result of Alternative 2 for the Modeled Period



Emission reductions occur later in Alternative 2 as compared to the Proposed Amendments and bottom out at a higher point around 13 tons per day due to preempt equipment. Over the modelled period this leads to a total of 50,912 tons of NO_x and 347,362 tons of ROG saved from being emitted. This value is several thousand tons lower than the saved emissions from the Proposed Amendments.

In terms of health benefits, the avoided negative health outcomes as a result of Alternative 2 are shown in Table F-16. The total of these avoided outcomes is slightly smaller than that in the Proposed Amendments.

Table F-13. Avoided Health Outcomes as a Result of Alternative 2.

Endpoint	Avoided Incidents	Valuation (Million 2019\$)
Cardiopulmonary mortality	707	\$6,971.9
Hospitalizations for cardiovascular illness	112	\$6.5
Hospitalizations for respiratory illness	134	\$6.8
Emergency room visits	349	\$0.3
Total	1302	\$6,986

Alternative 2 results in an estimated 8.9 MMT of CO₂ emissions avoided. These emissions reductions represent a benefit of the avoided social cost of carbon valued between \$212 million and \$907 million, depending on the discount rate.

c. Economic Impacts

Alternative 2 is a less stringent requirement with the zero-emission requirements for equipment not going into effect until 2027. This results in lower incremental equipment cost as passed on to end-users, but also less fuel cost-savings. The macroeconomic impacts analysis results are qualitatively similar to the results of the Proposed Amendments, but of a larger magnitude as shown in Table F-14. Figure F-11 and Figure F-12 show the job impacts and output changes of Alternative 2, respectively.

Table F-14. Change in Growth of Economic Indicators for Alternative 2

Indicator	Metric	2020	2025	2030	2035	2040
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
GSP	Change (2019M\$)	0	-446	-236	-86	-15
Personal Income	% Change	0.00%	-0.02%	0.00%	0.01%	0.01%
Personal Income	Change (2019M\$)	0	-436	42	319	439
Employment	% Change	0.00%	-0.02%	0.00%	0.01%	0.01%
Employment	Change in Jobs	0	-3,785	-425	1,276	1,746
Output	% Change	0.00%	-0.02%	-0.01%	-0.01%	-0.01%
Output	Change (2019M\$)	0	-864	-729	-583	-499
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%
Private Investment	Change (2019M\$)	0	-189	45	106	92

Figure F-11. Job Impacts of Alternative 2 by Major Sector

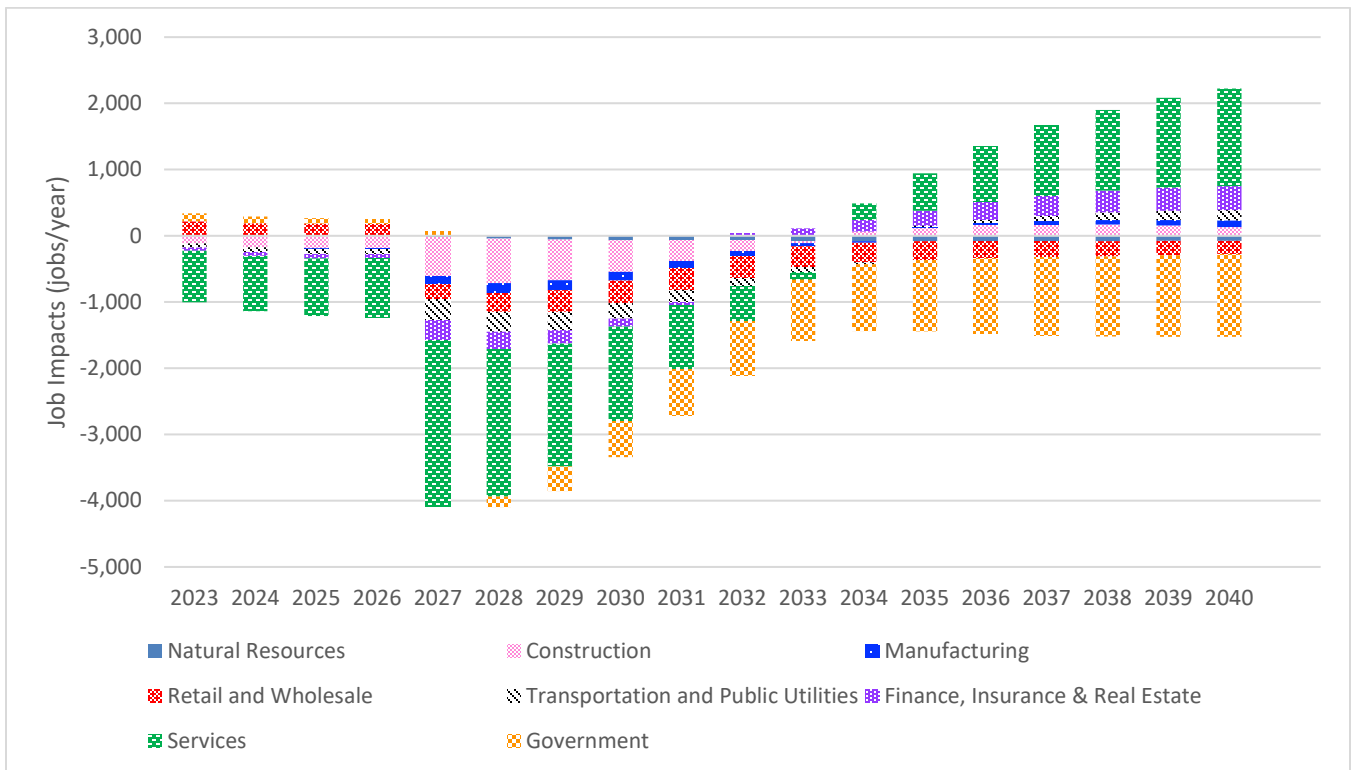
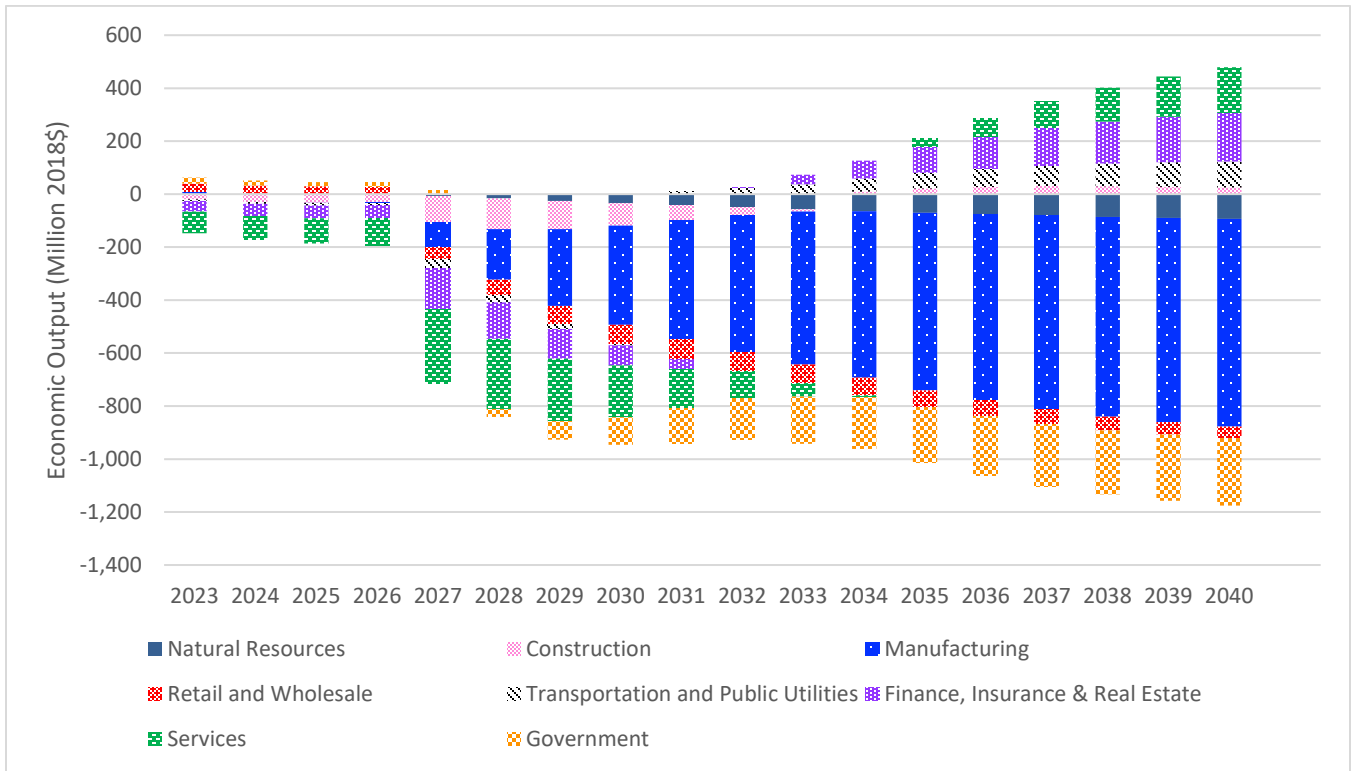


Figure F-12. Changes in Output from Alternative 2 by Major Sector



d. Cost-Effectiveness

Table F-15 indicates that the Proposed Amendments have a cumulative net benefit of \$9.9 billion and a benefit-cost ratio of 1.5, meaning benefits are more than costs during the analysis period between 2022 and 2040. Relative to the Proposed Amendments, Alternative 2 has a net benefit of \$7.5 billion, and a benefit-cost ratio of 1.4.

Table F-15. Cost-Benefit Comparison of Proposed Amendments and Alternative 2 (Billion 2019\$)

Scenario	Total Costs	Health Benefits	Cost-Savings (Benefit)	Tax & Fee Revenue	Total Benefit	Net Benefit	Benefit-Cost Ratio
Proposed Regulation	\$17.40	\$7.82	\$21.10	-\$1.63	\$28.92	\$9.89	1.5
Alternative 2	\$15.79	\$6.99	\$17.57	-\$1.24	\$24.56	\$7.53	1.4

e. Reason for Rejecting

This scenario is not as cost-effective as the Proposed Amendments or the first alternative. Additionally, the total emissions reductions through 2040 are lower and will make it more difficult for CARB to achieve its air quality goals under its SIP and the attendant health benefits for the public, which is the primary purpose of the proposed SORE regulation.

G. APPENDIX

1. Example Equipment Used in Economic Analysis

Shown in Tables G-1 through G-6 are the make and model of the median equipment price used in the economic analysis along with a web link to where the equipment can be purchased and the price found. This pricing exercise was conducted in early 2020, and so prices on the linked website may not exactly match the price shown as the market is subject to significant price volatility. Further, some equipment prices were scaled or estimated from other types of equipment as noted. This was done due to the equipment sharing the same engine and an inability to get enough prices to calculate a meaningful median. For professional grade ZEE, the cost of additional batteries and battery chargers not included in the purchase prices of the main unit were included such that the user would have enough battery power to make it through an eight hour work day without having to recharge batteries, The number of additional batteries and chargers needed is noted for the specific equipment.

Table G-1. Examples of Currently Compliant Household SORE Equipment Used in the Economic Analysis

Type of Equipment	Price Used in Analysis	Make and Model of Equipment	Citation (Web links were last accessed in March 2020)
Chainsaws	\$203	Ryobi RY5020	https://www.homedepot.com/p/RYOBI-20-in-50-cc-2-Cycle-Gas-Chainsaw-with-Heavy-Duty-Case-RY5020/303365779
Generator Sets	\$800	Briggs and Stratton #030744	https://www.homedepot.com/p/Briggs-Stratton-5500-Watt-Recoil-Start-Gasoline-Powered-Portable-Generator-with-OHV-Engine-030744/307723298
Lawn Mowers	\$280	Troy-Bilt TB170 XP Space Saver	https://www.homedepot.com/p/Troy-Bilt-XP-21-in-149-cc-Gas-Vertical-Storage-Walk-Behind-Push-Mower-with-3-in-1-TriAction-Cutting-System-TB170-XP-Space-Saver/311512185
Leaf Blowers/ Vacuums	\$150	Echo PB-2520	https://www.homedepot.com/p/ECHO-170-MPH-453-CFM-25-4-cc-Gas-2-Stroke-Cycle-Handheld-Leaf-Blower-PB-2520/303393700
Pressure Washers	\$399	Ryobi/RY803001	https://www.homedepot.com/p/RYOBI-3000-PSI-2-3-GPM-Honda-Gas-Pressure-Washer-RY803001/303316335
Pump <2hp	\$300	Powermate PP0100381 And Dirty Hand Tools 101099	Average of two pumps due to variety of pump uses. https://www.homedepot.com/p/Dirty-Hand-Tools-2-2-HP-Water-Pump-101099/206995316 https://www.amazon.com/PowerMate-pp0100381-Honda-Motor-Bomba/dp/B003TV8EHS?ref_=fsclp_pl_dp_12
Riding Mowers	\$1,899	John Deere BG21077	https://www.homedepot.com/p/John-Deere-E140-48-in-22-HP-V-Twin-Gas-Hydrostatic-Lawn-Tractor-California-Compliant-BG21077/303161820
Snowblowers	\$280	N/A	Assumed to be the same price as a lawnmower due to the same engine being used
Trimmers/ Edgers/ Brush Cutters	\$192	Toro 51978	https://www.homedepot.com/p/Toro-2-Cycle-25-4cc-Attachment-Capable-Straight-Shaft-Gas-String-Trim-mer-51978/202071363

Table G-2. Examples of 2023 Compliant Household SORE Equipment Used in the Economic Analysis

Type of Equipment	Price Used in Analysis	Make and Model	Citation (Web links last accessed in March 2020)
Chainsaws	\$211	N/A	Scaled from 2023 compliant household trimmer due to the same engine being used
Generator Sets	\$1,500	Kohler PA-PRO90-3001-PC	https://www.homedepot.com/p/KOHLER-9-000-Watt-Gasoline-Powered-Recoil-Start-Portable-Generator-with-Command-PRO-Commercial-Engine-PA-PRO90-3001-PC/303839886
Lawn Mowers	\$500	Mowox MNA152613	https://www.homedepot.com/p/MOWOX-21-in-3-n-1-Zero-Turn-Self-Propelled-Gas-High-Wheel-Walk-Behind-Mower-with-B-S-725is-163-cc-Engine-with-InStart-MNA152613/311148953
Leaf Blowers/ Vacuums	\$650	Stihl BR 800 X MAGNUM®	https://www.northerntool.com/shop/tools/product_200782044_200782044
Pressure Washers	\$326	Champion 100382 (2600-PSI Pressure Washer)	https://www.amazon.com/Champion-2600-PSI-2-2-GPM-Dolly-Style-Pressure/dp/B06XPCGSKT
Pump <2hp	\$450	Red Lion Semi-Trash Water Pump 6RLAG- 2LST 208cc	https://www.tractorsupply.com/tsc/product/red-lion-2-in-aluminum-semi-trash-pump-6rlag-2lst
Riding Mowers	\$3,561	N/A	Scaled from price of 2023 compliant generator due to the same engine being used.
Snowblowers	\$500	N/A	Assumed to be the same price as a lawnmower due to the same engine being used
Trimmers/ Edgers/ Brush Cutters	\$200	Craftsman/CMXGTAMD AXSC	https://www.lowes.com/pd/CRAFTSMAN-WS410-30-cc-4-Cycle-17-in-Straight-Shaft-Gas-String-Trimmer-with-Attachment-Capable-and-Edger-Capable/1002466480

Table G-3. Examples of Household ZEE Used in the Economic Analysis

Type of Equipment	Price Used in Analysis	Make and Model	Citation (Web links last accessed in March 2020)
Chainsaws	\$299	DEWALT DCCS670T1	https://www.homedepot.com/p/DEWALT-16-in-60-Volt-MAX-Lithium-Ion-Cordless-FLEXVOLT-Brushless-Chainsaw-with-One-2-0-Ah-Battery-and-Charger-DCCS670T1/307606876
Generator Sets	\$2,000	Goal Zero Yeti 1400	https://www.goalzero.com/shop/portable-power/goal-zero-yeti-1400-lithium-power-station-app/
Lawn Mowers	\$450	Ego LM2102SP	https://www.homedepot.com/p/EGO-21-in-56V-Lithium-Ion-Cordless-Electric-Walk-Behind-Self-Propelled-Mower-7-5-Ah-Battery-and-Charger-Included-LM2102SP/206515944
Leaf Blowers/ Vacuums	\$200	Ego LB6500	https://www.homedepot.com/p/EGO-180-MPH-650-CFM-56V-Lithium-Ion-Cordless-Electric-Variable-Speed-Blower-Tool-Only-LB6500/312263651
Pressure Washers	\$801	N/A	Scaled from ZEE welder which has the same power and battery requirements https://www.weldingoutfitter.com/products/ronius-107606-accupocket-150-battery-powered-stick-welder
Pump <2hp	\$319	Milwaukee 2771-21	https://www.homedepot.com/p/Milwaukee-M18-18-Volt-1-4-HP-Lithium-Ion-Cordless-Transfer-Pump-Kit-with-1-3-0Ah-Battery-and-Charger-2771-21/300510182
Riding Mowers	\$3,174	RYOBI- 48111	https://www.homedepot.com/p/RYOBI-38-in-100-Ah-Battery-Electric-Rear-Engine-Riding-Lawn-Mower-RY48111/300422546
Snowblowers	\$450	N/A	Assumed to be the same price as a lawnmower due to the same battery and power requirements
Trimmers/ Edgers/ Brush Cutters	\$197	DEWALT - DCST922P1	https://www.homedepot.com/p/DEWALT-20-Volt-MAX-Lithium-Ion-Brushless-Cordless-String-Trim-mer-with-One-5-Ah-Battery-and-Charger-DCST922P1/311222449

Table G-4. Examples of Currently Compliant Professional SORE Used in the Economic Analysis

Type of Equipment	Price Used in Analysis	Make and Model	Citation (Web links last accessed in March 2020)
Chainsaws	\$900	Stihl MS 362 R C-M And Stihl MS 462 R C-M	Average of two Stihl pieces. https://north40.com/stihl-ms-362-r-c-m-chainsaw https://rickssalesandservice.com/product/stihl-ms462-16-18-20-25-28-chainsaw/
Generator Sets	\$4,889	Honda EU700iS	https://powerequipment.honda.com/generators/models/eu700is
Lawn Mowers	\$3,000	Ferris FW15	https://www.ferrismowers.com/na/en_us/product-catalog/walk-behind-mowers/fw15-walk-behind-mower.html
Leaf Blowers/ Vacuums	\$434	Husqvarna 96714 43-01	https://www.leafblowersdirect.com/Husqvarna-967-14-43-01-Leaf-Blower/p96132.html
Pressure Washers	\$1,249	Simpson SW4035HADM	https://www.pressurewashersdirect.com/Simpson-65203-Pressure-Washer/p94378.html
Pump <2hp	\$300	Powermate PP0100381 And Dirty Hand Tools 101099	Average of two pumps due to variety of pump uses. https://www.homedepot.com/p/Dirty-Hand-Tools-2-2-HP-Water-Pump-101099/206995316 https://www.amazon.com/PowerMate-pp0100381-Honda-Motor-Bomba/dp/B003TV8EHS?ref_=fsclp_pl_dp_12
Riding Mowers	\$10,499	John Deere Z920M	https://www.deere.com/en/mowers/commercial-mowers/commercial-zero-turn-ztrak-mowers/z920m-mower/
Snowblowers	\$3,000	N/A	Assumed to be the same price as lawnmower due to using the same engine
Trimmers/ Edgers/ Brush Cutters	\$340	Husqvarna 525LST	https://www.husqvarna.com/us/products/trimmers/525lst/967175501/

Table G-5. Examples of 2023 Compliant Professional SORE Equipment Used in the Economic Analysis

Type of Equipment	Price Used in Analysis	Make and Model	Citation (Web links last accessed in March 2020)
Chainsaws	\$1,136	N/A	Scaled from 2023 compliant professional trimmer due to the same engine being used
Generator Sets	\$13,000	Westerbeke 5.0 MCG	https://citimarinestore.com/en/westerbeke-marine-generators/7537-westerbeke-mcga-5kw-marine-generator.html
Lawn Mowers	\$2,150	Toro 22215M	https://www.acmetools.com/shop/tools/toro-22215m?cm_mmc=Google-_-PRODUCTFEED-_-TORO-_-22215M&utm_id=go_cmp-732484532_adg-40556065149_ad-188049860360_pla-293946777986_dev-c_ext-_prd-22215M&gclid=EAlalQobChMI66qe8vPo6AIVDNlkCh1XkQOrEAQYASABEgIfG_D_BwE
Leaf Blowers/ Vacuums	\$650	Stihl BR 800 X MAGNUM®	https://www.sohars.com/stihl-br-800-x-magnum-79-9cc-912-cfm-commercial-backpack-blower/
Pressure Washers	\$3,321	N/A	Scaled from 2023 compliant professional generator due to the same engine being used
Pump <2hp	\$450	Red Lion Semi-Trash Water Pump 6RLAG- 2LST 208cc	https://www.tractorsupply.com/tsc/product/red-lion-2-in-aluminum-semi-trash-pump-6rlag-2lst
Riding Mowers	\$27,917	N/A	Scaled from 2023 compliant professional generator due to the same engine being used
Snowblowers	\$2,150	N/A	Assumed to be the same price as 2023 compliant professional lawnmower due to using the same engine
Trimmers/ Edgers/ Brush Cutters	\$429	Honda HHT35SUKAT	https://www.powerequipmentdirect.com/Honda-HHT35SUKAT/p6419.html

Table G-6. Examples of Professional ZEE Used in the Economic Analysis

Type of Equipment	Price Used in Analysis	Make and Model	Citation (Web links last accessed in March 2020)
Chainsaws	\$850	Stihl MSA 200	https://www.hutsoninc.com/stihl/chain-saws/battery-saws/msa200cbq/
Generator Sets	\$22,495	Goal Zero 38400 and Tesla Power Wall	Average of one Goal Zero and 6 Tesla packs plus installation https://www.homedepot.com/p/Goal-Zero-3-000-Watt-Lithium-Battery-Powered-Portable-Generator-38400/305504620 https://news.energysage.com/tesla-powerwall-battery-complete-review/#:~:text=Tesla%20lists%20the%20Powerwall%20at,components%20to%20%247%2C600%20before%20installation.
Lawn Mowers	\$2,010	HUSQVARNA LE221R, four extra batteries, and one extra battery charger	https://www.husqvarna.com/us/products/walk-behind-lawn-mowers/le221r/967820501/ https://www.amazon.com/Husqvarna-BLi20-40V-Lithium-Ion-Battery/dp/B07QW3DH45/ref=sr_1_1?dchild=1&keywords=BLi20+batteries&qid=1595276339&s=lawn-garden&sr=1-1 https://www.husqvarna.com/us/accessories/battery/qc80-battery-charger/967335641/
Leaf Blowers/ Vacuums	\$1,370	Stihl BGA 100 + AR 3000	https://www.stihlusa.com/products/batteries-and-accessories/batteries/ar3000/ https://www.stihlusa.com/products/blowers-and-shredder-vacs/battery-blowers/bga100/
Pressure Washers	\$19,499	N/A	Assumed to be the same as professional ZEE riding mowers due to power/battery needs
Pump <2hp	\$319	Milwaukee 2771-21	https://www.homedepot.com/p/Milwaukee-M18-18-Volt-1-4-HP-Lithium-Ion-Cordless-Transfer-Pump-Kit-with-1-3-0Ah-Battery-and-Charger-2771-21/300510182
Riding Mowers	\$19,499	Mean Green CXR-60	https://www.ecoequipmentsupply.com/products-high-performance-electric-lawnmowers/cxr-52/
Snowblowers	\$2,010	N/A	Assumed to be the same price as a lawnmower due to the same battery and power requirements

Trimmers/ Edgers/ Brush Cutters	\$980	Husqvarna 536 LiLx, two extra batteries and one extra battery charger	https://www.husqvarna.com/us/products/trimmers/536lilx/967326812/ https://www.amazon.com/Husqvarna-BLi20-40V-Lithium-Ion-Battery/dp/B07QW3DH45/ref=sr_1_1?dchild=1&keywords=BLi20+batteries&qid=1595276339&s=lawn-garden&sr=1-1 https://www.husqvarna.com/us/accessories/battery/qc80-battery-charger/967335641/
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2. Macroeconomic Appendix

Table G-7. REMI Inputs for the Main Proposal (Million 2018\$)

REMI Policy Variable	REMI Industry /Spending Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Production Cost	Services to buildings and dwellings	(0.0)	12.7	12.8	36.1	15.2	(6.4)	(26.4)	(45.6)	(60.2)	(74.3)	(86.2)	(96.5)	(104.9)	(111.7)	(117.1)	(121.7)	(125.4)	(128.0)	(129.9)
Production Cost	All industries (excluding 5617)	-	73.3	74.0	314.4	266.8	212.7	161.1	109.3	66.5	26.7	(7.7)	(36.9)	(61.1)	(81.3)	(97.7)	(111.0)	(121.8)	(130.0)	(136.2)
Consumer Spending (w/ reallocation)	Tools and equipment for house and garden	-	152.6	153.2	158.3	159.1	160.0	160.8	161.7	162.5	163.4	164.2	165.1	166.0	166.9	167.8	168.7	169.6	170.5	171.4
Exogenous Final Demand	electric power generation, transmission, and distribution	-	0.0	0.0	2.0	6.0	10.6	15.3	19.8	24.0	27.5	30.6	33.2	35.3	37.1	38.6	39.8	40.7	41.5	42.1
Exogenous Final Demand	Petroleum and coal products mfg.	-	(0.1)	(0.2)	(35.5)	(107.6)	(188.5)	(265.9)	(343.9)	(409.1)	(470.3)	(523.7)	(570.3)	(609.4)	(642.4)	(669.9)	(692.8)	(712.0)	(727.3)	(739.5)
Exogenous Final Demand	Personal and household goods repair	-	(0.0)	(0.0)	(3.8)	(12.4)	(21.5)	(30.1)	(37.7)	(44.3)	(49.7)	(53.9)	(57.3)	(60.0)	(62.1)	(63.8)	(65.1)	(66.1)	(66.7)	(67.2)
Consumer Spending (w/ reallocation)	motor vehicles fuels and lubricants	-	(0.3)	(0.5)	(19.8)	(68.3)	(126.5)	(182.9)	(241.0)	(291.7)	(340.8)	(385.4)	(424.5)	(458.3)	(487.6)	(512.4)	(532.8)	(549.8)	(563.9)	(575.5)
Consumer Spending (w/ reallocation)	electric power generation, transmission, and distribution	-	0.0	0.1	2.5	9.2	17.5	25.9	34.5	43.1	50.4	57.0	62.8	67.8	72.1	75.8	78.8	81.2	83.3	84.9
Consumer Spending (w/ reallocation)	Household maintenance and Repair	-	0.0	0.0	(1.3)	(3.3)	(5.4)	(7.4)	(9.5)	(11.4)	(13.3)	(15.1)	(16.8)	(18.3)	(19.5)	(20.5)	(21.4)	(22.2)	(22.8)	(23.2)
Government Spending	State Government	(0.0)	8.6	8.6	11.0	(7.7)	(28.8)	(49.5)	(69.3)	(87.8)	(104.6)	(119.6)	(132.7)	(143.8)	(153.3)	(161.2)	(167.8)	(173.2)	(177.7)	(181.2)
Government Spending	Local Government	(0.0)	9.9	10.0	21.3	19.2	16.8	14.4	12.1	10.1	8.2	6.6	5.1	3.9	2.9	2.1	1.4	0.9	0.5	0.2