State of California

AIR RESOURCES BOARD

Low Carbon Fuel Standard 2018 Amendments

Standardized Regulatory Impact Assessment (SRIA)

DATE OF SUBMISSION: November 16, 2017

Air Resources Board
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A. SUMMARY

Title 1, Division 3, Chapter 1 of the California Code of Regulations, sections 2000-2004 requires all State agencies that propose major regulations to complete a Standardized Regulatory Impact Assessment (SRIA). For the purposes of the SRIA, a major regulation is one that will result in an economic impact exceeding $50 million in any given 12 month period through 12 months after full implementation.

The California Air Resources Board (CARB/Board) initially approved the Low Carbon Fuel Standard (LCFS) regulation in 2009 to reduce greenhouse gas (GHG) emissions from the transportation sector. Throughout the nearly eight years since the Board's original adoption, the basic framework of the LCFS has worked well and continues to support growth in an increasingly diverse and low carbon transportation fuel pool.

This SRIA provides an economic assessment of new proposed amendments to the LCFS regulation for adoption in 2018. The proposed amendments reflect a range of potential changes including updates to improve the program's overall effectiveness and proposals for improving California's long-term ability to support the consumption of increasingly lower carbon intensity (CI) fuels.[1]

The most significant proposal change is the strengthening of CI reduction targets beyond 2020 in support of California's 2030 GHG reduction requirement enacted through Senate Bill (SB) 32 (Pavley, 2016). Other major proposed changes include allowing new fuel types, including alternative jet fuels, to generate credits and adding a system for third-party verification of the data reported in the LCFS. Staff began conceptually discussing many of these items during an informal public process initiated in March of 2016, hosting 18 workshops and fuel-specific working meetings through August of 2017.

The preliminary proposal for target setting and revisions to the LCFS was released as a concept paper on July 24, 2017, and discussed during workshops on August 7, September 22, and November 6, 2017, allowing stakeholders to submit comments and propose alternatives for consideration. Staff will present a formal package of proposed amendments for Board consideration in 2018. Continued interactions with stakeholders, external researchers, and other regulatory agencies will inform the proposal.

1. Background on the LCFS

In 2016, Californians used approximately 16 billion gallons of gasoline and 4 billion gallons of diesel fuel. The production, transport, and use of these fuels are responsible for nearly half of the State's GHG emissions, 80 percent of total emissions of oxides of

[1] The carbon intensity (CI) of a fuel refers to the amount of life cycle greenhouse gas emissions, per unit of fuel energy, expressed in grams of carbon dioxide equivalent per megajoule (gCO_2e/MJ). Lowering the average CI of fuels in California means that for the same amount of vehicle miles travelled in California, the transportation sector will emit less GHG overall.

nitrogen (NO_X), and 95 percent of diesel particulate matter (DPM) emissions. The LCFS is a key part of a comprehensive set of programs in California designed to reduce GHG emissions and other smog-forming and toxic air pollutants from the transportation sector. The proposed amendments are necessary for the LCFS to continue to contribute to California's long-term climate goals.

Executive Order S-01-07 ordered the establishment of the LCFS as a discrete early action item under the California Global Warming Solutions Act of 2006 (Assembly Bill (AB) 32, codified at Health and Safety Code section 38500 *et seq.*). In 2009, the Board approved the LCFS to achieve a 10 percent reduction in the CI of California transportation fuel by 2020, and in 2011 approved amendments to the regulation to clarify, streamline, and enhance certain provisions. In 2015, the Board re-adopted the LCFS in compliance with a court order arising from a challenge to the adoption of the original regulation.

The LCFS is designed to spur the steady introduction of lower carbon fuels. The framework establishes performance standards that fuel producers and importers must meet each year beginning in 2011. One standard is established for gasoline and the alternative fuels that can replace it. A second standard is set for diesel fuel and its replacements. Each standard is set to achieve an average 10 percent reduction in the CI of the statewide mix of transportation fuels by 2020. CI takes into account the GHG emissions associated with all of the steps of producing, transporting, and consuming a fuel—also known as a complete lifecycle of that fuel—and is expressed in units of grams of carbon dioxide equivalent per megajoule of energy supplied by the fuel. Fuels and fuel blendstocks introduced into the California fuel system that have a CI higher than the applicable standard generate deficits while fuels and fuel blendstocks with CIs lower than the standard generate credits. The LCFS also has provisions that allow refiners and crude oil producers to generate credits by implementing specific projects at refineries and oil fields that reduce the CI of fossil fuels, hereafter referred to in aggregate as petroleum projects. These projects may include carbon capture and sequestration (CCS) at refineries and oil fields, solar steam generation for thermally enhanced oil recovery, and use of hydrogen produced from renewable sources at refineries.

The LCFS is fuel-neutral and lets market forces determine the mix of fuels used to reach the CI reduction targets. Regulated parties, generally refiners in California and importers of fossil gasoline and diesel, demonstrate compliance by retiring one LCFS credit for each deficit generated (also known as a compliance obligation). The price of the LCFS credit depends on the demand and supply for credits in the LCFS market. The demand for credits is determined by the quantity of deficits, which are generated from the in-state use of high-carbon conventional fuels and blendstocks such as fossil CARBOB[2] and diesel. Regulated parties can obtain credits by blending low-CI liquid biofuels into the gasoline or diesel they produce or import, by investing in credit generating petroleum projects, or by purchasing LCFS credits from other parties. The

[2] CARBOB means California reformulated gasoline blendstock for oxygenate blending, which is produced from crude oil refining. Most of the finished motor gasoline sold in California consist of a blend of 90% CARBOB and 10% ethanol by volume.

LCFS encourages the production of low carbon fuels and investments in capital projects that reduce the CI of more traditional fuels.

The LCFS also has provisions that provide flexibility in achieving the CI standards. Regulated parties that acquire more credits than they need to cover their annual deficits can either sell credits in the open market or bank them for the future. Regulated parties that cannot meet their annual obligation by lowering the CI of their own fuel pool can purchase credits in the open market. If parties are unable to meet their annual compliance obligation through open market credit purchases, they are required to participate in the LCFS's credit clearance mechanism. Under this mechanism, regulated parties that did not meet their annual obligations are required to buy their pro-rata share of the credits offered by willing credit sellers. The price of the credit under this mechanism is restricted to a ceiling of $200 in 2016, which is adjusted annually for inflation thereafter. If a regulated party is still unable to meet its obligation, it can accumulate deficits for five years at an interest rate of five percent annually. A regulated party must repay its accumulated deficit plus the interest by the fifth year, otherwise it faces a penalty of up to $1,000 per deficit.

Since the LCFS went into effect in 2011, California has achieved a reduction of more than 2.5 percent in the average CI of the transportation fuel pool.[3] Regulated parties as a whole continue to over-comply with the LCFS regulation, providing a significant bank of almost ten million credits that are available for future compliance. The financial benefits are widely distributed among providers of various alternative fuels,[4] geographically across California,[5] and across the participating credit generators.[6]

The LCFS is contributing to the rapidly increasing use of low carbon fuels in California. Before the LCFS, the only alternative fuels with significant market share were fossil natural gas and ethanol. From 2011 to 2016, renewable diesel use has increased from less than 2 million gallons to 250 million gallons, biodiesel use has grown from 12 million gallons to 163 million gallons, and renewable natural gas use in vehicles has increased from 2 million gallons to 87 million diesel gallons equivalent. Credits in 2016 were generated primarily from ethanol (39 percent), renewable diesel (24 percent), biodiesel (19 percent), and to a lesser—but growing—extent, from biomethane (seven percent) and electricity (nine percent).

Figure A1 shows the LCFS credit price and the quantity of credits exchanged for years 2013 through August 2017. From 2013 through 2016, the LCFS credit price ranged from $22 to $122 per metric ton carbon dioxide equivalent (CO_2e).[7] Credit prices and

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[3] *Figure 1*, 2011-2016 Performance of the Low Carbon Fuel Standard (updated 08/02/2017). LCFS Data Dashboard: https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed Oct. 25th 2017.

[4] *Figure 2*, Alternative Fuel Volumes and Credit Generation (updated 08/02/2017). LCFS Data Dashboard: https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed Oct. 25th 2017.

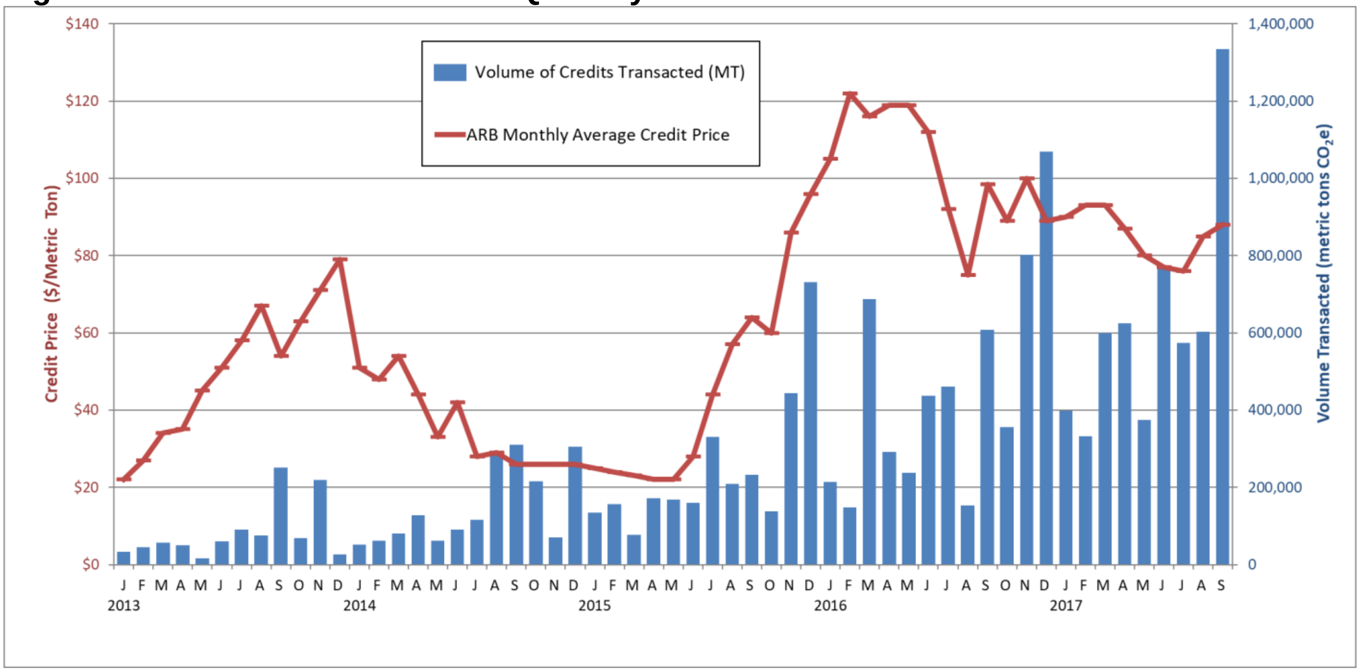
[5] *Figure 11*, Map of LCFS Beneficiaries (updated 08/02/2017). LCFS Data Dashboard: https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed Oct. 25th 2017.

[6] *Figure 9*, LCFS Credit Market Net Position Histogram (updated 08/02/2017). LCFS Data Dashboard: https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed Oct. 25th 2017.

[7] CARB, 2017. *Monthly LCFS Credit Transfer Activity Report for March 2017.* https://www.arb.ca.gov/fuels/lcfs/credit/20170411_marcreditreport.pdf. Accessed Oct. 25th 2017.

trading activity reached all-time highs in 2016. Over five million LCFS credits were sold or traded in approximately 929 transactions in 2016 with an average credit price of $101 per metric ton. Over the past 14 months, credit prices have remained within a range of $70 to $100.

Figure A1: LCFS Credit Price and Quantity of Credits Transacted



2. Statement of Need and Description of the Proposed Amendments

CARB staff is proposing to amend the LCFS regulation to reflect a range of objectives: from simple updates and revisions to improve the program's overall implementation, to broader program design proposals that will improve accuracy of the LCFS and further support California's long-term ability to diversify the State's fuel pool, support demand for increasingly lower CI fuels, and promote transformative innovation in the transportation sector. CARB staff is proposing amendments to the LCFS regulation to:

- Strengthen the carbon intensity benchmarks in order to help achieve California's 2030 GHG reduction requirement enacted through SB 32 and discussed in the Draft 2017 Climate Change Scoping Plan;
- Expand the fuel types and qualifying activities eligible to participate in the LCFS in order to recognize and incentivize GHG reductions in additional transportation fuel sectors;
- Require third-party verification of CI values and fuel transactions in order to enhance confidence in the LCFS program accounting;
- Update lifecycle analysis modeling tools to incorporate the most recent data and methodologies and streamline application and reporting requirements to encourage greater participation and reduce burden on participants; and

- Incorporate a protocol for carbon capture and sequestration projects that will specify the methods for both quantifying emission reductions and ensuring their permanent sequestration.

a) Establishing Appropriate Average Carbon Intensity Requirements Through 2030

The current LCFS requires a 10 percent reduction in average fuel carbon intensity by 2020 and maintains that target for all subsequent years. Strengthening the compliance targets of the LCFS regulation through 2030 is one of the primary objectives of this rulemaking.

In 2016, the California legislature adopted Senate Bill (SB) 32, which builds on the progress of AB 32 by codifying a statewide target to reduce GHG emissions by at least 40 percent below 1990 levels by 2030. California's Draft 2017 Climate Change Scoping Plan sets out the State's path to achieve this target through continuation of existing measures implemented under AB 32 and through the development of new strategies.[8] The Draft Climate Change Scoping Plan Update and the Mobile Source Strategy[9] identify increasing the ambition of the LCFS CI reduction target as one of the primary measures for achieving the State's 2030 GHG target and criteria pollutant reduction goals.

If adopted, the proposed amendments will extend the LCFS targets to meet an 18 percent reduction in fuel carbon intensity from a 2010 baseline by 2030, as shown in the proposed CI reduction schedule listed in Table A1:

Table A1. Proposed LCFS CI Reduction Schedule

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CI Reduction	10%	10%	11%	12%	13%	14%	15%	16%	17%	18%

b) Changes to Fuels Subject to the Regulation

The proposed amendments will broaden the list of fuels subject to the LCFS regulation by altering the opt-in and exempt status of particular fuels. CARB expects the most impactful of these changes is the removal of the exemption for alternative jet fuels (AJF), allowing producers or importers of these fuels to generate credits that would be used for compliance.

AJFs are "drop-in" fuels made from fossil or renewable sources that can replace conventional jet fuels without the need to modify aircraft engines or existing fuel distribution infrastructure. When used at approved blending levels, staff expects AJFs to have the same performance characteristics as conventional jet fuel. Staff is proposing amendments to allow low CI pathways for AJF to generate credits under the

[8] CARB, 2017. *The Draft 2017 Climate Change Scoping Plan.* https://www.arb.ca.gov/cc/scopingplan/revised2017spu.pdf. Accessed Oct. 30th 2017.

[9] CARB, 2016. 2016 Mobile Source Strategy. https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf. Accessed Oct. 25th 2017.

LCFS, but conventional jet fuel, in contrast to gasoline and diesel, would not be subject to the LCFS regulation and would therefore not generate deficits.

Including AJF in the LCFS may result in several benefits. First, incorporating AJF would clearly signal California's interest in addressing a significant and growing source of GHG emissions. Currently, GHG emissions from aviation contribute to approximately two percent of the total global emissions and are expected to grow in the future.[10] Second, because AJF and renewable diesel (RD) are often produced in the same facility using the same feedstock, inclusion of AJF may lead to increased investment in facilities, thereby increasing the production of both alternative fuels. The airline industry is developing a strong record for partnering with alternative fuel producers through direct investment and off-take agreements,[11] which provide the certainty necessary to get these advanced biofuel facilities built. Third, providing an incentive for the use of AJF may potentially reduce criteria pollutant emissions during taxi, takeoffs, and landings, which may result in positive health impacts, especially near airports. Recent studies have shown that there are significant reductions in particulate matter and sulfur oxide emissions[12] and a slight reduction or no change in nitrogen oxides (NO_X)[13] emissions when AJFs replace conventional jet fuel.

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[10] Center for Climate and Energy Solution. *Reducing Carbon Dioxide Emissions from Aircraft.* https://www.c2es.org/federal/executive/epa/reducing-aircraft-carbon-emissions. Accessed Oct. 25th 2017.

[11] CARB, 2017. *Low Carbon Fuel Standard: Evaluation of jet fuel inclusion.* Presentation at public working meeting on March 17th 2017. See Slides 27 and 28 at the following link for a list of examples: https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/031717presentation.pdf. Accessed Oct. 25th 2017.

[12] Boeing Company, UOP, U.S. Air Force Research Laboratory, 2011. *Evaluation of Bio-Derived Synthetic Paraffinic Kerosenes (Bio2SPK), Committee D02 on Petroleum Products and Lubricants, Subcommittee D02.J0.06 on Emerging Turbine Fuels, Research Report D02-1739, ASTM International, West Conshohocken, PA, 28 June 2011.*

Roland, O. and Garcia, F., 2014. *TOTAL New Energies, Amyris, Inc., U.S. Air Force Research Laboratory, Evaluation of Synthesized Iso-Paraffins Produced from Hydroprocessed Fermented Sugars (SIP Fuels), Final Version (3.), Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants, Subcommittee D02.J0 on Aviation Fuels, Research Report D02-1776, ASTM International, West Conshohocken, PA, 15 June 2014.*

Edwards, T., Meyer, D., Johnston, G., McCall, M., Rumizen, M., and Wright, M.,2016. *Evaluation of Alcohol to Jet Synthetic Paraffinic Kerosenes (ATK2SPK), Report Version (1.10), Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants, Subcommittee D02.J0 on Aviation Fuels, Research Report D02-1828, ASTM International, West Conshohocken, PA, 1 April 2016.*

[13] Corporan,E., DeWitt,M.J., Klingshirn,C.D., Anneken,D., 2010. *Alternative Fuels Tests on a C-17 Aircraft: Emissions Characteristics, Air Force Research Laboratory, Interim Report, AFRL-RZ-WP-TR-2011-2004, Wright-Patterson Air Force Base, OH, December 2010.*

Carter, Nicholas A., Stratton, R.W., Bredehoeft, M.K., and Hileman, 2011. J.I. *Energy and Environmental Viability of Select Alternative Jet Fuel Pathways, 47th AIAA/ASME, SAE, ASEE Joint Propulsion Conference & Exhibit, San Diego, CA, AIAA 2011I5968, 31 July – 03 August 2011.*

Lobo et al., 2012. *Impact of Alternative Fuels on Emissions Characteristics of a Gas Turbine Engine − Part 1: Gaseous and Particulate Matter Emissions. Environmental Science & Technology 2012 46 (19), 10805-10811. DOI: 10.1021/es301898u* *c) Addition of Third-party Verification*

A successful GHG reduction program requires a system to monitor, report, and verify GHG emissions that form the foundation of a reduction program. To date, the LCFS has relied upon a robust reporting program that includes CARB staff evaluation of fuel CI during the fuel pathway application process and random data audits for the reporting of quarterly fuel quantities per fuel pathway.[14]

CARB is proposing to supplement the existing work of staff with a verification system that would include independent third-party verifiers contracted by regulated entities reporting to CARB under the LCFS. Conceptually, LCFS third-party verifiers would perform GHG accounting checks in a role similar to the independent, objective evaluations conducted by financial auditors. CARB has extensive experience with an analogous system under the regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) pursuant to AB 32, and through the verification of GHG compliance offset projects under ARB's Cap-and-Trade Program.[15,16]

Under the proposed verification program, much of the fuel pathway CI and fuel quantity data submitted in the LCFS Data Management System (DMS)[17] would be subject to third-party review, including:

- Initial Validation of Fuel Pathway Applications: An initial third-party review of input values submitted for new fuel pathways, referred to as *validation*, would be conducted to reduce the amount of time CARB staff needs to take for the fuel CI certification process. The validation step would also assure that the calculated CI is based on valid, independently-reviewed, site-specific data.
- Ongoing Verification of Operational CI Calculation and Fuel Quantities: Ongoing third-party review of fuel quantities and fuel pathway CI calculations, referred to as *verification*, would be required to assure the validity of data used to assign credits and deficits.

[14] Fuel producers that want to market their products in California must submit a pathway application to obtain a CI for the fuel they intend to market. The CI is later used to calculate the amount of credits or deficits that the fuel will generate.
[15] AB 32 explicitly supported verification calling for CARB to "adopt regulations to require the reporting and verification of statewide greenhouse gas emissions and to monitor and enforce compliance…". California Health and Safety Code (H&SC), Sec 38530(a), 2017. Program information on MRR verification is available at: https://www.arb.ca.gov/cc/reporting/ghg-ver/ghg-ver.htm. Accessed Oct. 25th 2017.
[16] CARB. *Offset Verification Program.* https://www.arb.ca.gov/cc/capandtrade/offsets/verification/verification.htm. Accessed Oct. 25th 2017.
[17] The LCFS Data Management System (DMS) is an interactive, secured web-based system which comprises the following three modules: LCFS Reporting Tool (LRT), Credit Bank and Transfer System (CBTS) and the Alternative Fuels Portal (AFP). More information is available at: https://www.arb.ca.gov/fuels/lcfs/reportingtool/datamanagementsystem.htm#lrt-cbts. Accessed Oct. 25th 2017.

- Ongoing Verification of Petroleum Data: Data reported by project applicants to calculate innovative crude and refinery credits, quantity reports used for gasoline and diesel deficit claims, and crude oil volume reports would also be subject to verification.

d) CI Determination and Pathway Application

Staff is proposing revisions to the tools used to assess GHG emissions for crude oil and transportation fuels. These updates, which are made approximately every three years, incorporate the latest data and methodologies in order to ensure accurate determination of CI values. Staff is also proposing changes to the CI pathway application and certification process to enhance transparency and to reflect the inclusion of third-party verification process discussed above. Staff expects these changes to reduce application preparation time by the applicant as well as evaluation and processing time by ARB.

e) Carbon Capture and Sequestration Quantification and Permanence Protocol

CCS is a potentially significant technology for reducing carbon emissions from large stationary sources. In light of California's mid- and long-term climate goals, most importantly achieving GHG reductions of 40 percent below 1990 levels by 2030 and 80 percent below 1990 levels by 2050, CCS may grow in importance for California. In the 2015 LCFS rulemaking, CARB clarified that CCS projects would be eligible to produce LCFS credits upon the adoption of a Board-approved quantification methodology (QM) and regulatory requirements to ensure sequestration permanence.

Staff is proposing a "CCS Protocol" to address these issues and plans to incorporate the protocol into the LCFS through the proposed amendments. The CCS Protocol will lay out the methodology and assumptions to calculate the net amount of GHG emissions sequestered by a project over time and will ensure that CCS projects achieve the projected GHG reductions that are real, quantifiable, enforceable, permanent, additional, and verifiable.

3. Public Outreach and Input

Since the LCFS adoption, staff has been in frequent contact with stakeholders. Recently, the outreach has focused on clarifying certain provisions of the LCFS regulation and working to gather public feedback on proposals being considered for future target setting, pathway certification, and verification amendments. In 2016, staff conducted eight public workshops and stakeholder working meetings, and as of September 2017, staff has hosted an additional twelve public workshops and working meetings, with more workshops slated this fall to further discuss proposed regulatory language. Staff posted information regarding these workshops and any associated materials on the LCFS website[18] and distributed notice of these workshops through a public list serve that includes over 8,000 recipients. At the meetings, which are available by webcast and by teleconference, CARB solicits stakeholder feedback on the regulation and the regulatory process.

CARB has also sought public input regarding the alternatives for the proposed amendments analyzed for this SRIA including:

- July 24, 2017: Staff posted a notice for the August 7, 2017 Public Workshop,[19] which included a solicitation for alternatives as well as a pre-rulemaking concept paper describing each of the amendments under consideration.[20]
- August 7, 2017: Staff hosted a public workshop focused on the proposed amendments, which also included a solicitation from stakeholders for alternatives to the staff proposal.

4. Major Regulation Determination

The LCFS proposal is a major regulation because the annual direct cost of compliance exceeds $50 million during the period of analysis, 2019 through 2030.

5. Baseline and Scenario of Proposed Amendments

This section describes the assumptions and methodology used to estimate potential fuel volumes, credit generation, and LCFS credit prices through 2030. The analysis includes a projected baseline or 'business as usual' scenario and a scenario of the proposed amendments that represents one potential way to achieve the CI reductions outlined in Table A1. As the proposed amendments retain the market flexibility of the current LCFS, it is not possible to predict the exact path or fuels used for future compliance. The following section describes the general process, including the data and model used to develop the baseline and proposed amendments scenario.[21]

a) The Biofuel Supply Module (BFSM)

Staff developed the Biofuel Supply Module (BFSM) to model California transportation fuel supply in the 2017 Draft Climate Change Scoping Plan Update process. BFSM creates fuel supply curves to satisfy annual user supplied transportation demand. BFSM is an excel-based model that has been publicly available since September

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[18] CARB, 2017. *Meeting Notice for Public Workshop to Discuss Potential Low Carbon Fuel Standard Rulemaking Items.* https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/080717mtgnotice.pdf. Accessed Oct. 25th 2017.

[19] CARB, 2017. *Low Carbon Fuel Standard 2018 Amendments, Pre-Rulemaking Concept Paper.* https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/080717conceptpaper.pdf. Accessed Oct. 25th 2017.

[20] CARB, 2017. *Low Carbon Fuel Standard 2018 Amendments, Pre-Rulemaking Concept Paper.* https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/080717conceptpaper.pdf. Accessed Oct. 25th 2017.

[21] The projected volumes of alternative fuel and credits from refinery and crude oil provisions presented at the end of this section should be considered "illustrative" and only represent possible paths to achieve compliance under the given scenario conditions.

2016.[22] BFSM incorporates feedstock and technology cost data with projected incentives created by the price of LCFS credits and the federal Renewable Fuel Standard (RFS) to create a set of supply curves for each fuel technology pathway described in Table A2. BFSM selects the lowest cost fuel-technology pair that can satisfy transport fuel demand in a given year, subject to a set of constraints including global feedstock limitations and technology adoption rate. The model allows for the estimation of feasible biofuel volumes under various assumptions.

Rather than attempting to develop an exhaustive list of all future fuel pathways and combinations, CARB focused on established, near-term fuel production pathways for which technology and cost data is available. Table A2 presents each alternative fuel considered in this analysis including the feedstock from which the fuel is made and the conversion process used to produce fuel from the feedstock (there may be multiple conversions technologies for an alternative fuel).

[22] BFSM was initially presented at a Scoping Plan workshop on September 14, 2016. An updated version incorporating stakeholder feedback was posted in January, 2017. https://www.arb.ca.gov/cc/scopingplan/meetings/meetings.htm. Accessed Oct. 25th 2017.

Table A2: Fuel Technology Pathways Included in the Baseline and the Scenario of Proposed Amendments[23]

Alternative Fuel	Conversion Technology	Feedstock
Ethanol	Fermentation	Grains and sugar
Ethanol	Enzymatic hydrolysis	Cellulosic biomass
Biodiesel	Fatty acid methyl ester conversion (FAME)	Fats, oils, and greases
Renewable diesel, jet, and gasoline	Hydrotreating	Fats, oils, and greases
Renewable diesel, jet, and gasoline	Gasification and Fischer-Tropsch synthesis	Cellulosic biomass
Renewable diesel, jet, and gasoline	Pyrolysis, cracking, and hydrotreating	Cellulosic biomass
Renewable diesel, jet, and gasoline	Fischer-Tropsch	Natural gas
Renewable natural gas (CNG and LNG)	Anaerobic digestion	Landfills, dairy manure, wastewater, green waste
Renewable natural gas	Gasification	Cellulosic biomass
Hydrogen	Steam methane reforming	Natural gas
Hydrogen	Electrolysis	Water

In addition to technology uncertainty, there is also uncertainty in future feedstock availability, use, and supply-chain development. For biofuel pathways, CARB has primarily relied on data from the Department of Energy (DOE) and the Environmental Protection Agency (EPA) to determine the cost and availability of feedstocks as well as the potential supply for cellulosic materials and biomethane resource potential for the baseline and proposed amendment scenario. The main sources of data include:

- The Billion-Ton Report[24]

[23] For more information on the technology used to produce alternative fuels refer to CARB, *LCFS Staff Report: Initial Statement of Reason,* Appendix B. https://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15appb.pdf. Accessed Nov 15th 2017.
[24] Department of Energy, Office of Energy Efficiency and Renewable Energy, 2016. *2016 Billion Ton Report.* https://energy.gov/eere/bioenergy/2016-billion-ton-report. Accessed Oct. 30th 2017.

- The EPA Landfill Methane Outreach Program database[25]
- The EPA Livestock Anaerobic Digester Database[26]

CARB has also considered how quickly biofuel production capacity expansion can occur. Staff evaluated historical data for corn ethanol and biodiesel expansion in the U.S. to establish guidelines for the maximum feasible rate for expansion for liquid biofuel volumes within the BFSM. Staff also reviewed near-term low carbon biofuel supply projections from Bloomberg New Energy Finance and Lux Research to approximate technology development trajectories and market trends. Additional detail and references for data used are available in the technical documentation for the BFSM.[27]

b) The Baseline Condition for the LCFS Amendments

The LCFS is a flexible, market-based program that interacts with many different state and federal regulations. Estimating the baseline fuel demand requires accounting for compliance with existing regulations and standards, changes in fuel consumption due to natural fleet turnover to more efficient vehicles, and the expected price of fuels in the future.

In October 2017, CARB published the Draft 2017 Climate Change Scoping Plan[28] which outlines a proposed strategy for achieving California's 2030 greenhouse gas target. In this SRIA, staff uses transportation fuel demand values from the Scoping Plan reference scenario and the Scoping Plan scenario as a starting point for the baseline scenario. The most important policies that drive change in fossil fuel demand that are represented in the baseline are the following:

- Advanced Clean Cars (ACC): ACC incentivizes both improvements in GHG tailpipe performance of conventional vehicles (see description of CAFE below) and the adoption of alternative technology vehicles that consume fuels such as electricity, natural gas, and/or hydrogen.
- U.S. Environmental Protection Agency's (U.S. EPA) Renewable Fuel Standard (RFS): The U.S. EPA's RFS mandates minimum volumes of renewable fuels, which are required to be blended into transportation fuels. Staff assumes that the RFS will continue to operate through 2030, providing monetary incentive for biofuels such as ethanol, biodiesel, renewable diesel, and renewable natural gas.

[25] U.S. EPA. *Landfill Technical Data.* https://www.epa.gov/lmop/landfill-technical-data. Accessed Oct. 30th 2017.

[26] U.S. EPA, AgStar. *Livestock Anaerobic Digester Database.* https://www.epa.gov/agstar/livestock-anaerobic-digester-database. Accessed Oct. 30th 2017.

[27] CARB. *Biofuel Supply Module.* https://www.arb.ca.gov/cc/scopingplan/bfsm_tech_doc.pdf. Accessed Oct. 30th 2017.

[28] CARB, 2017. *The Draft 2017 Climate Change Scoping Plan.* https://www.arb.ca.gov/cc/scopingplan/revised2017spu.pdf. Accessed Oct. 30th 2017.

- U.S. EPA National Program for Vehicle GHG Performance Standards/Corporate Average Fuel Economy (CAFE) standards: This policy requires vehicle manufacturers to comply with new GHG vehicle performance standards/fuel economy standards through 2025. Post 2025, staff assumes GHG vehicle performance standards/fuel economy standards for new vehicles will be held constant through 2030. However, due to turnover introducing newer model vehicles with better GHG performance and fuel efficiency, the average vehicle fuel efficiency will continue to increase through 2030.
- The Sustainable Communities and Climate Protection Act of 2008 (SB 375): SB 375 supports the State's climate action goals to reduce greenhouse gas (GHG) emissions through coordinated transportation and land use planning with the goal of more sustainable communities. Under SB 375, CARB sets regional targets for GHG emissions reductions from passenger vehicle use and each of the State's metropolitan planning organizations prepares a sustainable communities strategy to meet its GHG reduction target.
- Cap-and-Trade Program: The Cap-and-Trade Program establishes a declining limit on major sources of GHG emissions, and it creates an economic incentive for major investment in cleaner, more efficient technologies. The Cap-and-Trade Program applies to emissions that cover about 85 percent of the State's GHG emissions. CARB creates allowances equal to the total amount of permissible emissions (i.e., the "cap") over a given compliance period. One allowance equals one metric ton of GHG emissions. Fewer allowances are created each year, thus the annual cap declines and statewide emissions are reduced over time. An increasing annual auction reserve (or floor) price for allowances and the reduction in annual allowance budgets creates a steady and sustained pressure for covered entities to reduce their GHGs---the Program is expected to lower the GHG emissions associated with the instate production of fuels and lower demand for high carbon fuels.
- California Phase 2 GHG Standards for On-Road Medium and Heavy Duty Vehicles: Under this program, medium and heavy duty vehicles are required to reduce GHG and criteria pollutants emissions by adopting more fuel efficient technologies.
- Low Carbon Fuel Standard: Under the current LCFS, a 10 percent reduction in average fuel CI will be achieved by 2020. This target then remains constant for years 2021 and beyond.
- Clean Energy & Pollution Reduction Act (SB 350): SB 350 requires 50 percent of California's electricity to come from renewable sources by 2030. While this requirement will not lower fuel demand directly, it will affect the carbon intensity of electricity.

c) *Comparison of Potential Compliance Responses under the Baseline and Proposed Amendments Scenario*

In this section, staff provides a comparison of potential compliance responses (e.g., volumes and credits generated by alternative fuels as well as credits generated through petroleum projects) under both the baseline and the proposed amendments scenario.

Staff first describes potential compliance responses under the baseline and then describes differences between the expected compliance responses under the proposed amendments and the baseline.

The baseline assumes that compliance targets are held at a 10 percent reduction from 2020 through 2030. Figures A2 and A3 show the estimated volumes of alternative fuels and credits generated by source for the baseline scenario.

Figure A2: Alternative Fuel Volumes in the Baseline Scenario[29]

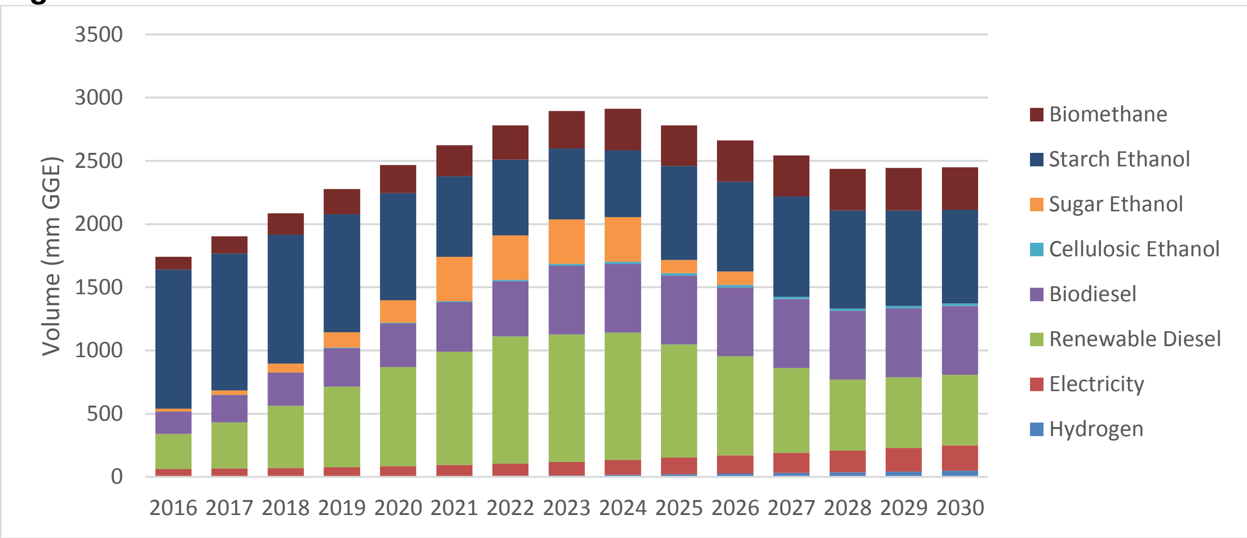
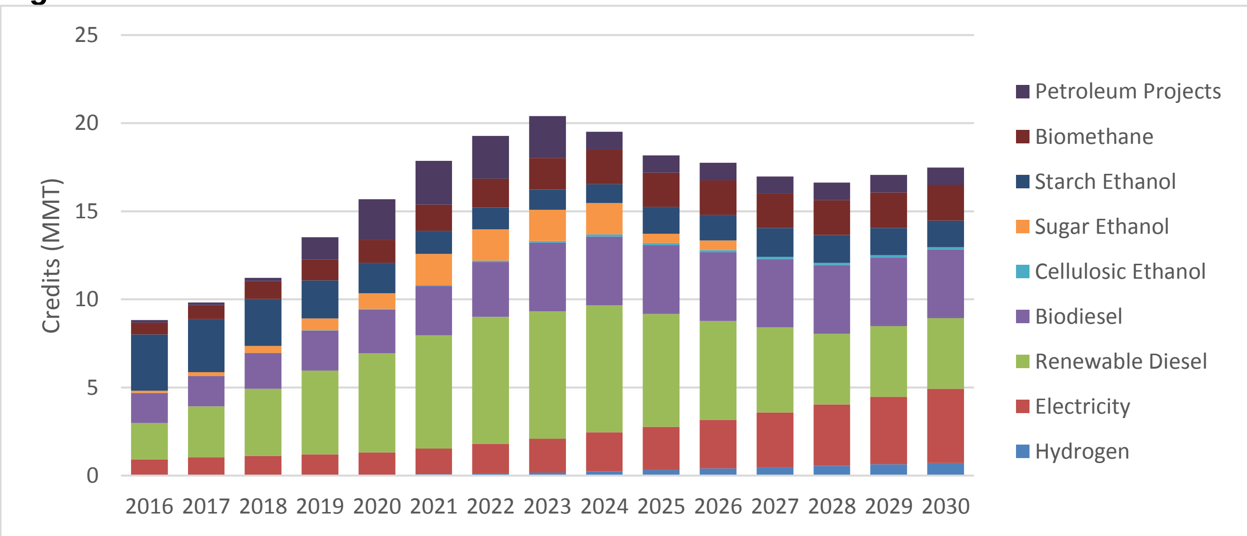


Figure A3: Credits Generated in the Baseline Scenario[30]



In the baseline, the following general trends are observed from current conditions through 2030:

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[29] Fuel volumes are reported in gasoline gallons equivalent (GGE).
[30] MMT stands for million metric tons CO_2 equivalent.

- Gasoline consumption decreases due to efficiency improvements across the vehicle fleet and due to adoption of Zero Emission Vehicles (ZEVs) including battery-electric vehicles, plug-in gasoline/electric hybrids, and hydrogen-fuel-cell electric vehicles. This results in a commensurate decrease in the volume of ethanol as the total volume of ethanol is determined by the 10 percent blending limit with CARBOB to produce gasoline. The reduction in gasoline consumption also results in a decrease in the total quantity of credits necessary for compliance with the 10 percent target between 2020 and 2030.
- Biodiesel, renewable diesel, and sugar ethanol consumption increase substantially to achieve a 10 percent reduction in carbon intensity in 2020. Credits from petroleum projects also increase substantially.
- Renewable natural gas, electricity, and hydrogen consumption continue to grow through 2030 as additional ZEVs and renewable natural gas powered vehicles are purchased. Because the compliance target is fixed at 10 percent beyond 2020, as credits generated by these fuels increase, the credits generated by renewable diesel, sugar ethanol, and petroleum projects decrease.

Figures A4 and A5 show the estimated volumes of alternative fuels and credits generated by source for the proposed amendments scenario.

Figure A4: Alternative Fuel Volumes in the Proposed Amendments Scenario

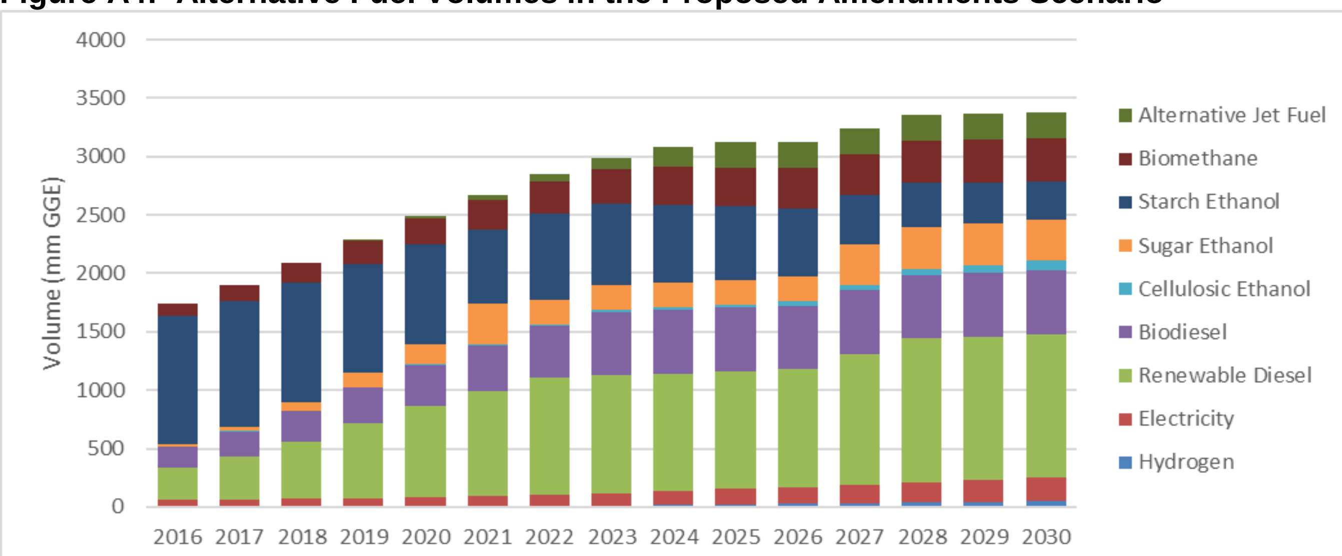
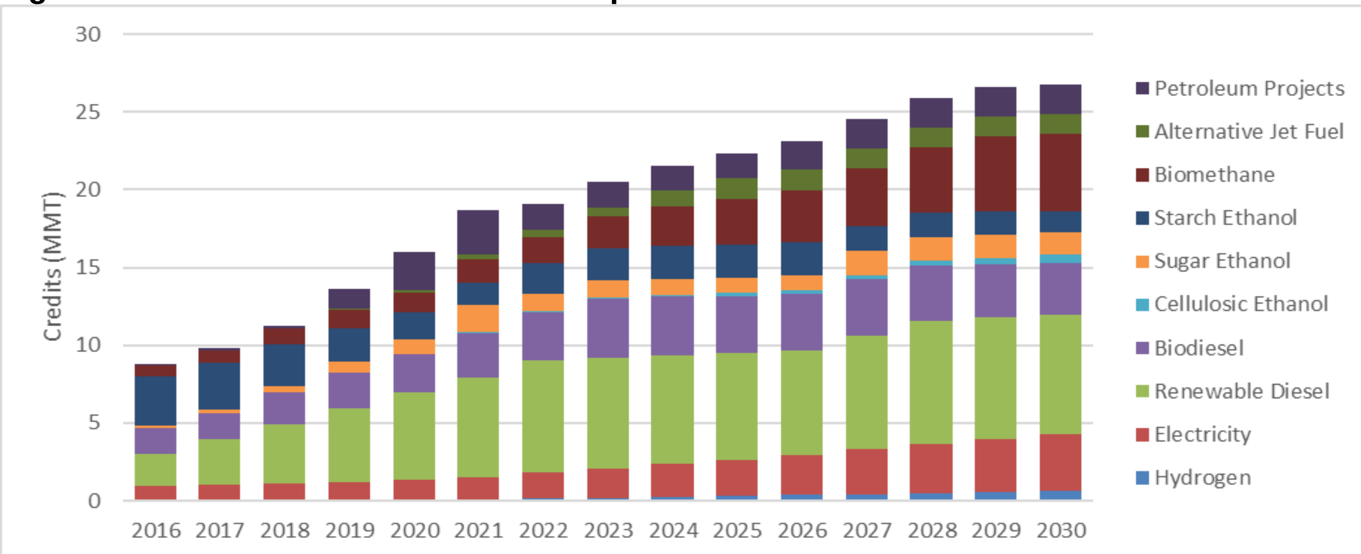


Figure A5: Credits Generated in the Proposed Amendments Scenario

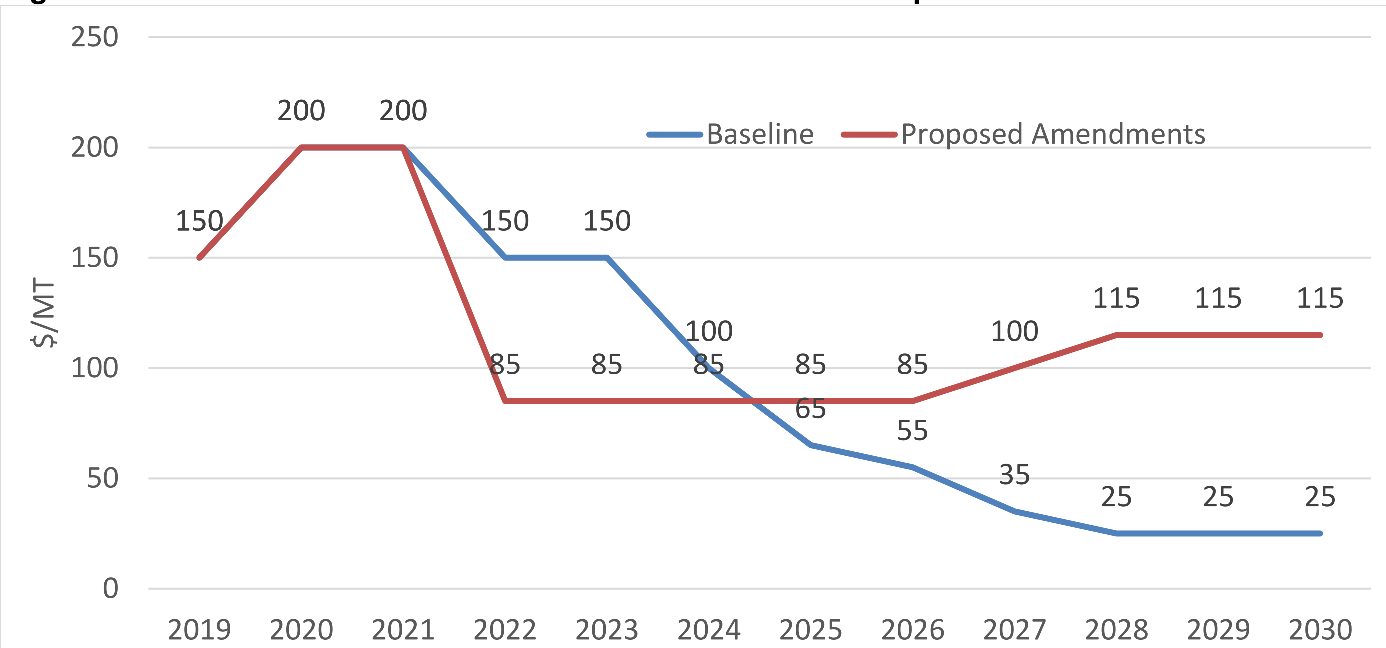


- When compared to the baseline scenario, the proposed amendments scenario reveals the following: Total credits necessary for compliance in 2030 increase from an estimated 18 MMT in the baseline to about 26 MMT in the proposed amendments. Because the proposed amendments require more credits for compliance, consumption of renewable diesel and sugar ethanol, and credits generated by petroleum projects are expected to continue increasing through 2030.
- There are more credits generated from renewable natural gas (RNG) in the proposed amendments scenario, reflecting a much greater use of RNG from dairy digesters rather than landfills. RNG from dairy digesters has a much lower CI than from landfills due to the currently uncontrolled methane emissions from dairies and therefore generates substantially more credits for the same volume of fuel relative to RNG from landfills.
- Credits are generated from use of alternative jet fuel, as the exemption for this fuel is removed under the proposed amendments. Credits are also generated by implementation of CCS at starch ethanol facilities as the CCS Protocol in the proposed amendments will allow for certification of these projects.

As will be shown later in Sections C through E, the estimated LCFS credit price plays a large role in the economic impact of the proposed amendments. As both the fuel mix and the implementation of petroleum projects is different in the baseline scenario and under the proposed amendments, the average annual LCFS credit price will also vary across the scenarios. The LCFS credit price for each scenario was estimated using the cost of obtaining the marginal, most expensive, credit in a given year.[31] Figure A6 shows the estimated credit price for each of the scenarios from 2019 through 2030.

[31] The method used by staff to estimate the LCFS credit price for the purpose of this analysis does not assume fully rational intertemporal pricing for the LCFS credit market. Instead it shows possible market behavior under each scenario based on CARB's best estimate of LCFS market dynamics. Specifically, the LCFS credit price trajectories include a higher near-term credit price to reflect possible market

Figure A6: Estimated Credit Prices for the Baseline and Proposed Amendments



CARB estimates that the annual LCFS credit price under the baseline scenario and proposed amendments will be the same from 2019 through 2022, after which point the credit prices will differ. From 2018 to 2020, the LCFS CI reduction target increases rapidly from five percent to ten percent. During this time period, it is expected that regulated parties will use banked allowances from over-complying in earlier years of the LCFS regulation to help with compliance. Figures A7 and A8 show the estimated annual credit balance and bank of credits for the baseline scenario and proposed amendments.

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behavior (and subsequent LCFS credit prices) during the period of steepest program target decline from 2018 through 2021, followed by a gradual settlement toward a longer-run equilibrium, that should reflect the long-run marginal cost of reducing the carbon intensity of the transportation fuel pool. These prices should be treated as illustrative rather than predictive.

Figure A7: Annual Net Credits and Credit Bank for the Baseline Scenario

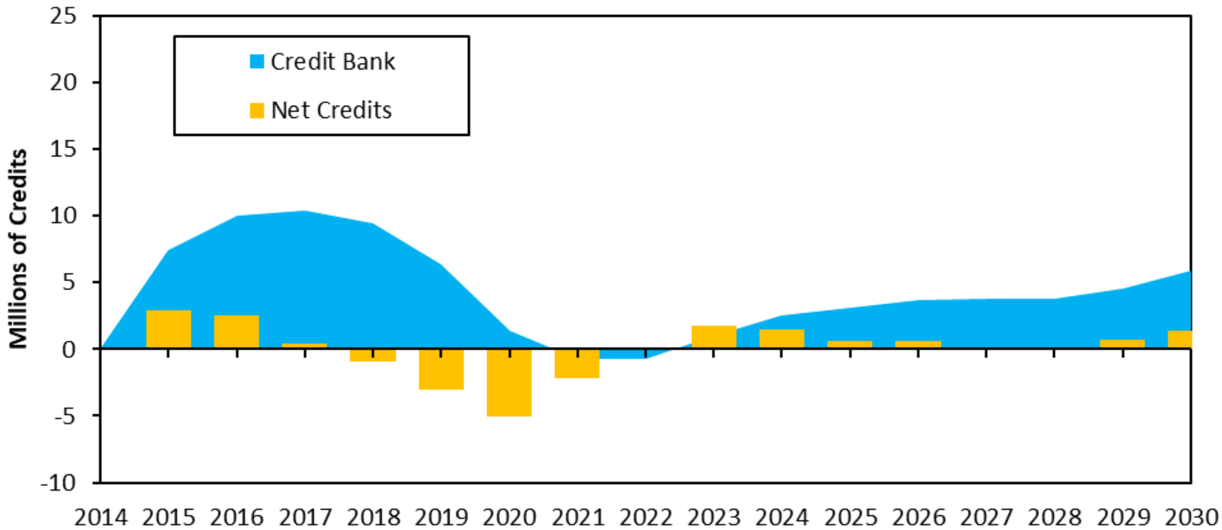
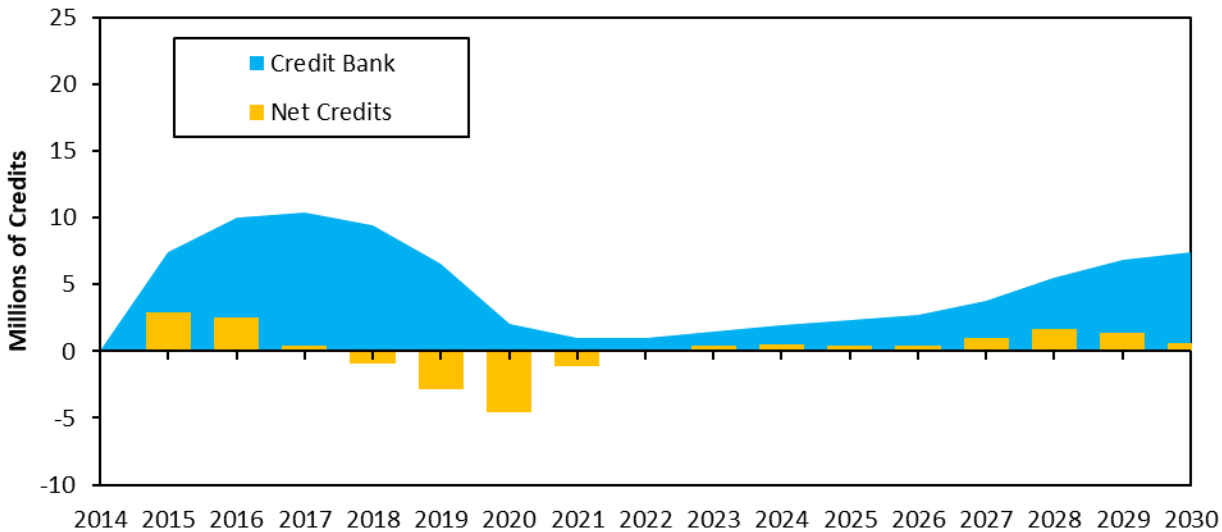


Figure A8: Annual Net Credits and Credit Bank for the Proposed Amendments



When the bank of estimated excess credits nears zero, as occurs in year 2020 of both scenarios, some regulated parties may not be able to obtain enough credits to offset their deficits and will be required to participate in the credit clearance mechanism.[32] If not enough credits are pledged into the credit clearance market to cover the net deficits, the LCFS credit prices could increase to the maximum price of $200 (plus an inflation

[32] Staff includes this behavior to illustrate a "near-term worst-case" cost impact due to concerns from some stakeholders about the potential for such a short-run dynamic (and to illustrate the expected mechanics of the credit clearance mechanism in such a circumstance).

adjustment).[33] Under this conservative scenario, CARB estimates that this high LCFS credit price could persist until 2021 in both the baseline scenario and under the proposed amendments.

From 2022 onwards, CARB estimates that alternative fuel production will increase and credit generation will equal or exceed deficit generation resulting in lower LCFS credit prices. From 2022 through 2024, the LCFS credit price under the baseline scenario is anticipated to be higher than under the proposed amendments scenario, mainly due to the availability of new lower-cost pathways under the proposed amendments, such as credit generation from alternative jet fuels and CCS projects. Additionally, with the less stringent long-term CI reduction target under the baseline scenario, credit investors may have a lower incentive to implement capital intensive projects such as dairy RNG production, cellulosic ethanol production, and solar steam projects at oilfields. This could result in fewer credits generated from these pathways.

After 2024 in the baseline scenario, additional LCFS credits are modeled through continued growth in renewable natural gas, electricity, and hydrogen. These credits coupled with continued decrease in gasoline consumption and the constant compliance target put downward pressure on LCFS credit prices in the baseline scenario from 2024 through 2030. Staff estimates that credit prices as low as $25 could occur by 2030 in the baseline scenario. This decline in credit prices substantially weakens the incentive for some of the more expensive pathways for credit generation, including cellulosic and sugarcane ethanol, renewable diesel, and renewable hydrogen for refineries (a petroleum project), resulting in a decline in use of these fuels over these years. The sharp decline in the long-term LCFS credit price would increase the risk of stranded assets under the 10% baseline, as some facilities would be unable to cover their operating costs.

Under the proposed amendments, CI targets continue to increase in ambition from 2022 to 2030, which results in increasing demand for low-CI fuels. This increasing demand may be met by higher volumes of low-CI biofuels such as renewable diesel and alternative jet fuel and by increased implementation of petroleum projects. Due to the more stringent CI reduction standard, LCFS credit prices remain at an estimated price of approximately $100 by 2030.

Unlike the baseline scenario, the likelihood of higher long-run credit prices in the proposed amendments scenario is expected to promote investment in capital intensive projects in the near term. First, as modeled for this analysis, more biomethane is sourced from dairy projects rather than landfills under the proposed amendments. In addition, a substantial increase in the number of credits generated from solar steam projects at oil fields may occur and more corn ethanol facilities may utilize CCS in this

[33] The credit clearance mechanism established a ceiling of $200 + an annual CPI adjustment from 2016 forward. Staff assumes that the credit clearance mechanism will be used in years where net credit generation is negative and the annual credit bank is less than 3 million credits. For more details on the credit clearance mechanism, refer to the LCFS current regulations, § 95485,(c): https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf Accessed Oct. 31st 2017.

scenario, which substantially lowers the CI of starch ethanol and generates additional credits from the same volume of starch ethanol used.

B. BENEFITS

CARB anticipates that the proposed amendments, including the CI reductions outlined in Table A1, will have the following general benefits to California businesses and individuals:

- Reduced GHG emissions. The LCFS is specifically designed to reduce GHG emissions in the transportation sector, which is responsible for nearly half of GHG emissions in California. This will contribute to California's efforts to address climate change.
- Increased use of lower CI alternative fuels and alternative fueled vehicles including biodiesel, renewable diesel, renewable jet fuel, low NO_X natural gas trucks, and electric and hydrogen zero emission vehicles. In addition to reducing GHG emissions, this may lower levels of localized air pollutants, which are the cause of many deleterious health effects on California residents.
- Greater opportunities for California businesses to invest in the production of alternative fuels and other credit generating opportunities at oil fields and refineries.
- Reduce the dependence on fossil fuel and crude oil imports and diversifying the transportation fuel pool, which may decrease the exposure of California to large swings in energy prices due to external economic shocks.

In the following sections, staff describes the estimated benefits of the proposed amendments to California businesses, small businesses, and individuals.

1. Benefits to California Businesses

The proposed amendments will increase the demand for low carbon fuels, which provides an opportunity for businesses, both in-state and out-of-state, to increase revenue from the sale of low carbon fuels in California. Table B1 shows the potential LCFS credit revenue for several low carbon fuels in 2020, 2025 and 2030. To allow comparison across fuels, the potential revenues are expressed on the basis of an equivalent gallon of either gasoline (gge) or diesel (dge) that the alternative fuel displaces. The sale of LCFS credits provides an additional revenue stream for these firms, enabling them to increase their market share and increase their competitiveness against high-CI fuels such as fossil gasoline or diesel.[34] In Table C4 in Section C, staff monetized the value of the revenues generated by both in-state and out-of-state low-CI fuels.

[34] The LCFS incentive is incremental to incentives created by federal biofuel/low carbon fuel policy, including the RFS.

Table B1: Value Added from LCFS Credit for Low Carbon Fuels under the Proposed Amendments

Fuel	Assumed CI Value (g/MJ)	2020	2025	2030	Units
Proposed Amendments Credit Price ($/MT)		*$200*	*$85*	*$115*	
Corn Ethanol	71	0.41	0.14	0.13	$/gge
Cellulosic Ethanol	30	1.36	0.55	0.68	$/gge
Hydrogen*	88	1.24	0.50	0.61	$/gge
Electricity*	84	1.48	0.60	0.75	$/gge
Biodiesel	30	1.66	0.67	0.83	$/dge
Renewable Diesel	30	1.66	0.67	0.83	$/dge
Landfill NG*	40	1.27	0.51	0.61	$/dge
Dairy NG*	-273	10.63	4.48	5.98	$/dge

* The following EERs were used for this calculation: 2.5 for hydrogen, 3.4 for electricity, and 0.9 for landfill NG and Dairy NG.[35]

Moreover, firms that are early investors in innovative, low-CI fuel technologies may be at a competitive advantage if other state, federal, or international jurisdictions adopt similar carbon intensity standards.[36] The proposed amendments will also help promote a wider range of clean fuels and vehicles for California businesses to choose from including vehicles operating on electricity, hydrogen and natural gas.

The proposed amendments also benefit California fuel providers that have compliance obligations under the Cap-and-Trade Program. As the LCFS reduces the carbon intensity of fuels, it changes the composition of the State's transportation fuel mix and dependence on traditional petroleum-based fuels. CARB designed the LCFS and Cap-and-Trade Program to complement one another. Investments made to comply with one of the programs will generally result in reduced compliance requirements for the other program. Increased use of low carbon fuel due to the LCFS will reduce fuel suppliers' GHG emissions covered by the Cap-and-Trade Program, reducing the Cap-and-Trade Program compliance obligation of these firms. Similarly, selling cleaner fuels or investing in emission reduction projects at California refineries and oil fields to comply with the Cap-and-Trade Program may help meet the project requirements of the LCFS.

2. Benefits to Small Businesses[37]

[35] "Energy Economy Ratio (EER)" means the dimensionless value that represents the efficiency of a fuel as used in a powertrain as compared to a reference fuel. EERs are often a comparison of miles per gasoline gallon equivalent (mpge) between two fuels.
[36] Currently both Oregon and British Columbia have LCFS-like policies in place and both Canada and Brazil are considering similar policies.
[37] Staff defines small businesses as independently owned businesses, with a revenue less than $10 million annually that are located in California.

In addition to the benefits already discussed for California businesses, CARB estimates that small businesses will see some benefits from the proposed amendments. Many of California's biodiesel producers, hydrogen producers, electric charging stations, hydrogen stations, and natural gas stations are small businesses. Staff identified the following small businesses in California, which represented 12% of the LCFS regulated parties registered in the LCFS reporting tool and credit banking transfer system (LRT-CBTS)[38] in September, 2017:

- Four biodiesel plants
- One landfill gas project
- One dairy gas project
- Fifteen natural gas (CNG and LNG) fueling station operators
- Two hydrogen fueling station operators
- Six electric charging station operators
- One electric vanpooling operation

In total, these small businesses generated 28,000 LCFS credits in 2016, which provided an estimated $2.8 million in credit revenue as estimated using the 2016 average LCFS credit price.

The proposed amendments will increase the demand for low-CI fuels and are anticipated to increase the prices for LCFS credits relative to the baseline, thereby increasing revenue to these small businesses. In addition, larger revenue potential as a result of the proposed amendments may allow other small businesses to enter the market.

3. Benefits to Individuals

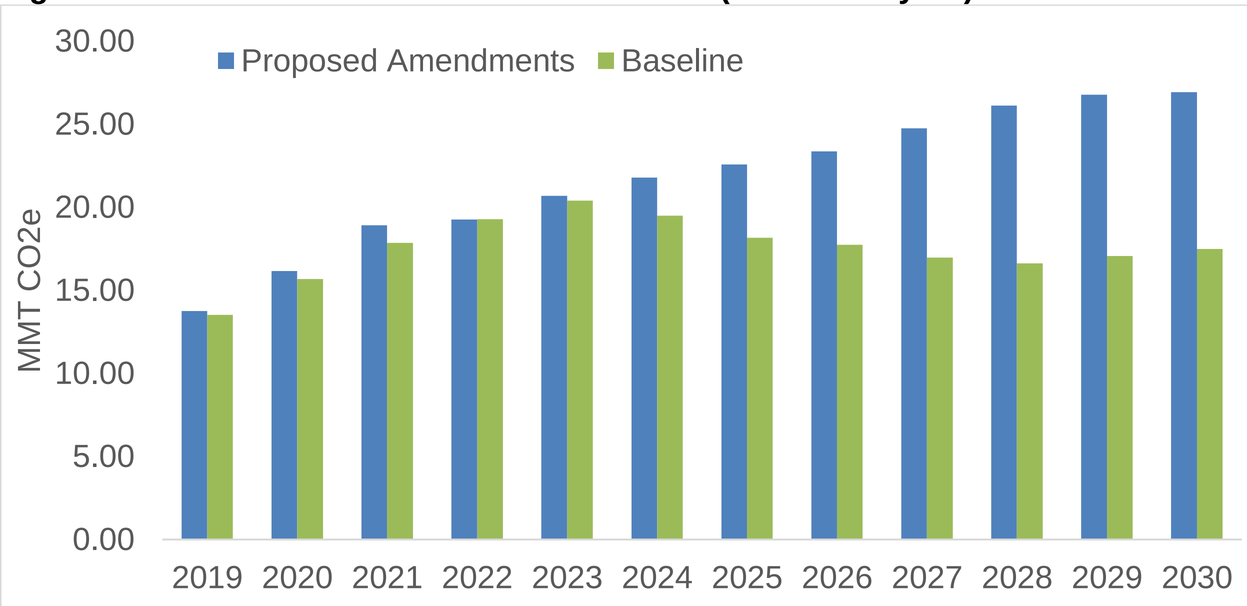
The proposed amendments will benefit California residents mainly from reductions in GHG emissions and from improvements in California air quality.

a) GHG Emissions Benefits of the Proposed Amendments

Figure B1 summarizes the annual GHG emissions reductions under the baseline and the proposed amendments scenario. Staff expects the proposed amendments to reduce GHG emissions relative to the baseline by almost 51 million metric tons in carbon dioxide equivalent (MMT CO_2e) from 2019 through 2030 (accounted for on a full fuel lifecycle basis).

[38] The list of registered in LRT-CBTS is available here: https://www.arb.ca.gov/fuels/lcfs/lcfs.htm. Accessed Oct. 30th 2017.

Figure B1: Annual GHG Emissions Reductions (MMT CO_2e/year)



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

In this analysis, CARB utilizes the current IWG supported SC-CO_2 values to consider the social costs of actions to reduce GHG emissions. This is consistent with the approach presented in the Revised 2017 Climate Change Scoping Plan [39] and is in line with Executive Orders including 12866 and the OMB Circular A-4 of September 17, 2003, and reflects the best available science in the estimation of the socio-economic impacts of carbon.[40]

The IWG describes the social costs of carbon as follows:

> *The social cost of carbon (SC-CO_2) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO_2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO_2 emissions by the same amount in that year. The SC-CO_2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts- from global climate change that result from an additional ton of CO_2.*
>
> *These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood*

[39] CARB, 2017. The Revised 2017 Climate Change Scoping Plan. https://www.arb.ca.gov/cc/scopingplan/revised2017spu.pdf. Accessed Oct. 30th 2017.
[40] OMB circular A-4 is available at: https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf.

risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO_2 emissions today will affect economic outcomes throughout the next several centuries.[41]

The SC-CO_2 is year specific, and is highly sensitive to the discount rate used to discount the value of the damages in the future due to CO_2. The SC-CO_2 increases over time as systems become more stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. A higher discount rate decreases the value today of future environmental damages. This analysis uses the Interagency Working Group (IWG) standardized range of discount rates from 2.5 to 5 percent to represent varying valuation of future damages. Table B2 presents the range of IWG SC-CO_2 values used in California's regulatory assessments.[42].

Table B2: SC-CO_2, 2015-2030 (in 2007$ per Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2015	$11	$36	$56
2020	$12	$42	$62
2025	$14	$46	$68
2030	$16	$50	$73

The benefit of methane reductions can also be estimated using the IWG Social Cost of Methane (SC-CH_4). Table B3 presents the range of IWG SC-CH_4 values used in monetizing the benefit of methane reductions.

Table B3: SC-CH_4, 2015-2030 (in 2007$ per Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2015	$450	$1000	$1400
2020	$540	$1200	$1600
2025	$650	$1400	$1800
2030	$760	$1600	$2000

The GHG reductions due to the proposed amendments are calculated in CO_2e which includes reductions in carbon, methane, and other GHGs. As the CI of a fuel is based on a lifecycle assessment of GHG emissions from the use of a fuel converted to CO_2e

[41] National Academies, 2017. *Valuing Climate Damages: Updating Estimation of Carbon Dioxide*. http://www.nap.edu/24651. Accessed Nov 14th 2017.
[42] The SC-CO_2 values are of July 2015 and are available at: https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf

units, there is not a simple way to assess the breakdown of emissions reduction by GHG (i.e. CO_2, methane, or other GHG) due to the proposed amendments.

As there is no Social Cost of CO_2e, there is not a straightforward metric to estimate the benefits of the proposed amendments. If all GHG reductions under the proposed amendments are assumed to be carbon reductions, in 2030 the estimated benefits from the proposed amendments would range from approximately $485 million to $2.5 billion (in 2016$).

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 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.

b) *Criteria Pollutant Emission Benefits of Proposed Amendments*

Improvements in California air quality under the proposed amendments are anticipated to result in health benefits for California individuals. These health benefits result in cost-savings to individuals, businesses, and government agencies due to fewer premature mortalities, fewer hospital and emergency room visits, and fewer lost days of work. The proposed amendments will affect air quality through three main categories: 1) tailpipe emissions reductions for on-road and off-road vehicles, 2) aircraft emissions reductions at airports, and 3) changes in emissions at stationary sources from fuel production and steam production at oil fields.

The methodology used to estimate the emissions impact of the proposed amendments is detailed in Appendix I.1. In the following section, the incremental impacts of the proposed amendments (relative to the baseline) are detailed. The net NO_X and $PM_{2.5}$ emissions impact of the proposed amendments are presented in Figures B2 and B3. By 2030, these reductions are estimated to represent a 0.3 percent and 1.3 percent reduction in tailpipe NO_X and $PM_{2.5}$ emissions respectively, 0.1 percent reduction in jet fuel NO_X and $PM_{2.5}$ emissions, 1.9 percent and 8.1 percent reduction in oil and gas production NO_X and $PM_{2.5}$ emissions respectively, and 0.1 percent and 0.3 percent increase in manufacturing and industrial NO_X and $PM_{2.5}$ emissions respectively due to increased production of alternative fuels.[43]

[43] These values were obtained by dividing the 2030 emissions reductions numbers by the NO_X and $PM_{2.5}$ emissions inventory values from the CEPAM: 2016 SIP – Standard Emissions Tool which can found here: https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php

Figure B2: Incremental NO_X Emission Reductions under the Proposed Amendment Scenario (tons per year)

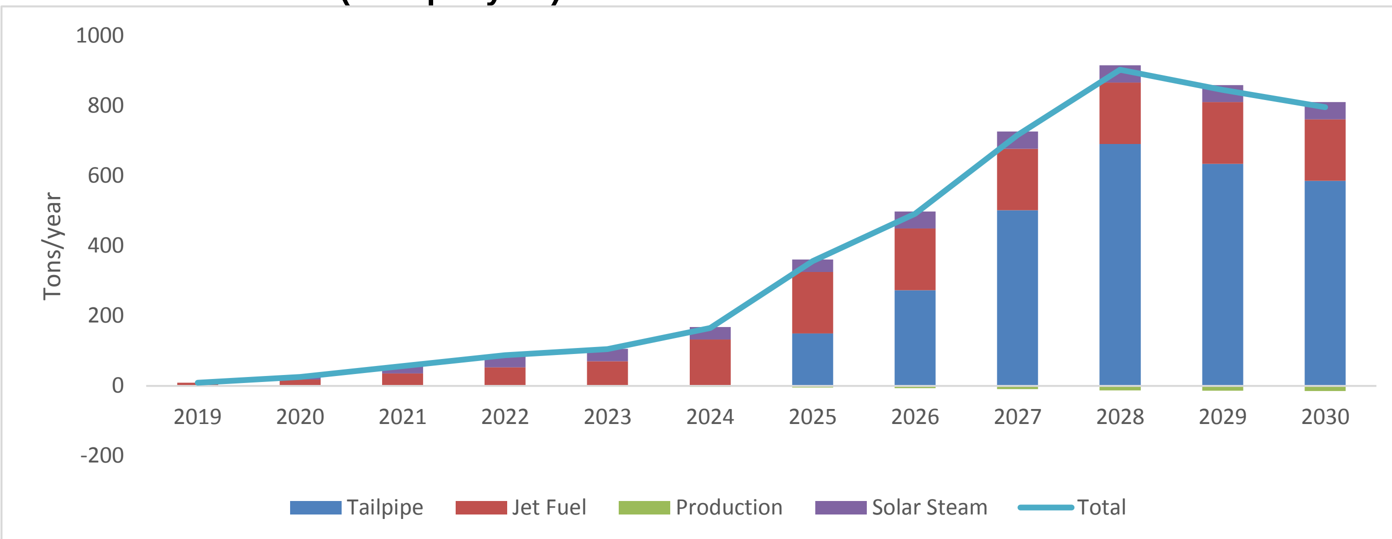
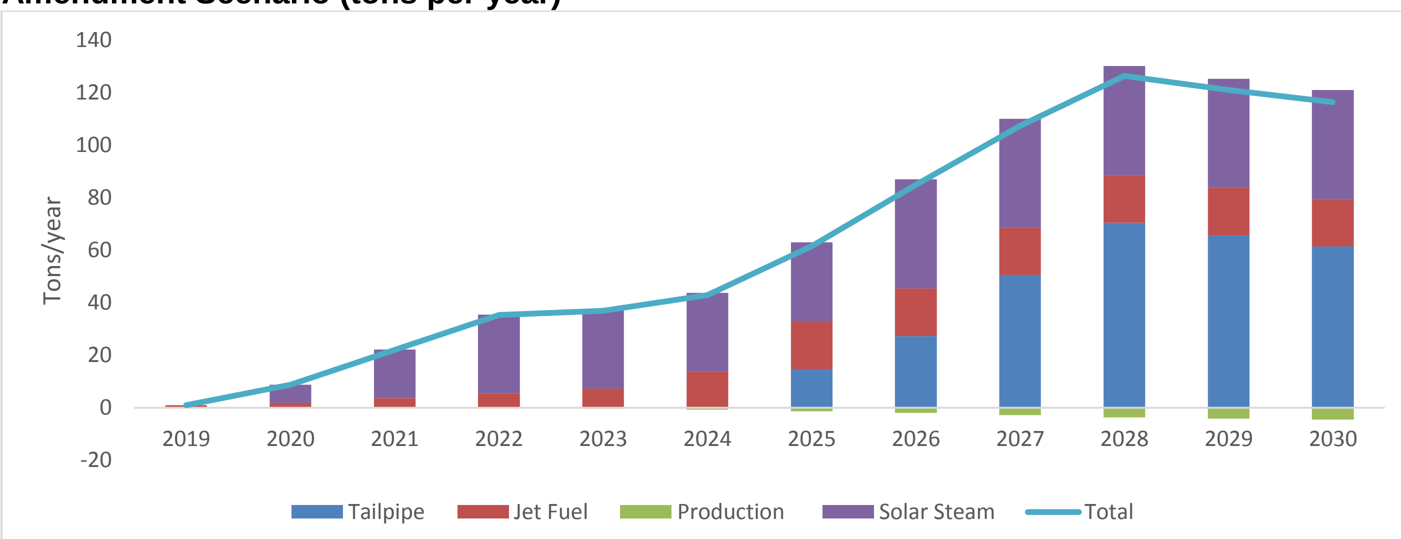


Figure B3: Incremental $PM_{2.5}$ Emission Reductions under the Proposed Amendment Scenario (tons per year)



Staff estimates reductions in tailpipe emissions of NO_X and $PM_{2.5}$ throughout the State due to increased use of diesel alternatives. Reductions in emissions of NO_X and $PM_{2.5}$ are also expected to occur in areas surrounding airports due to the switch to alternative jet fuels. Additionally, individuals living close to oil fields in the San Joaquin Valley may experience improved air quality, as solar power may be substituted for combustion of natural gas in steam generators. Small emission increases may occur near biofuel production facilities, including facilities that produce electricity, hydrogen, dairy digester gas, cellulosic ethanol, renewable diesel, and alternative jet fuel.

Potential emission increases near production facilities are estimated to be very small relative to total emission reductions from tailpipe, jet fuel, and solar steam. When considering the net effect at the California air basin level, the proposed amendments are estimated to result in a significant net decrease in emissions from 2018 through 2030, with all air basins experiencing net health benefits. However, CARB does acknowledge that small emission increases may occur at a localized level near production facilities and for some fuel/vehicle combinations, changing the impacts for some individuals. Emissions from these stationary sources will be monitored and controlled to minimize the negative impacts from the increased production. Under State Implementation Plans (SIPs), states are required to provide comprehensive plans to attain the national ambient air quality standards (NAAQS) set by the U.S. EPA. CARB reviews and approves local area districts and other agencies SIP elements and ensures they achieve the State's criteria pollution targets. Additionally, AB 617 directs CARB to cooperate with local air districts to implement criteria pollutants reduction program in non-attainment areas. AB 617 additionally requires CARB to establish and maintain a database of the best-available retrofit control technology for criteria area pollutants. The programs, standards and plans specified under the SIPs and AB 617 will ensure that any increase in criteria pollutants emissions from increased activity due to the proposed amendments will be controlled to minimize the impacts on California residents, especially in areas with poor air quality.

c) Health Benefits

As modeled, the proposed amendments reduce $PM_{2.5}$ and NO_X emissions, resulting in health benefits for individuals in California. The value of these health benefits are due to 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, the U.S. EPA quantifies the health risk from exposure to PM,[44] and CARB relies on the same health studies for this evaluation.[45]

The largest estimated health benefits correspond to regions in California with the most truck and air traffic such as the South Coast Air Basin and the San Joaquin Valley Air Basin. Additionally, health benefits are estimated to occur near airports, both commercial and military, as well as near oil producing regions in the San Joaquin Valley.

Table B4 shows the estimated avoided mortality and morbidity incidence as a result of the proposed amendments scenario for 2019 through 2030 by California air basin. Values in parenthesis represent the 95 percent confidence intervals of the central estimate. The proposed amendments scenario is estimated to reduce overall emissions

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[44] U.S. EPA, 2010. *Quantitative Health Risk Assessment for Particulate Matter (Final Report).* https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf. Accessed Oct. 30th 2017.

[45] See Appendix I.2. for further discussion.

of $PM_{2.5}$ and NO_X in most years, and leads to a net statewide health benefit relative to the baseline scenario.

The majority of health benefits estimated in the proposed amendments scenario are concentrated in the South Coast and San Joaquin Valley air basins, with minor health benefits distributed among other regions. The projections of the spatial distribution of emission reductions from the proposed amendments is highly uncertain. This source of uncertainty is not accounted for in the 95 percent confidence intervals.

Table B4: Incremental Regional and Statewide Avoided Mortality and Morbidity Incidences from 2019 to 2030 under the Proposed Amendments Scenario (Relative to the Baseline Scenario)*[46]

Region	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Great Basin Valleys	0 (0-0)	0 (0-0)	0 (0-0)
Lake County	0 (0-0)	0 (0-0)	0 (0-0)
Lake Tahoe	0 (0-0)	0 (0-0)	0 (0-0)
Mojave Desert	3 (2-3)	0 (0-1)	1 (1-2)
Mountain Counties	0 (0-0)	0 (0-0)	0 (0-0)
North Central Coast	0 (0-0)	0 (0-0)	0 (0-0)
North Coast	0 (0-0)	0 (0-0)	0 (0-0)
Northeast Plateau	0 (0-0)	0 (0-0)	0 (0-0)
Sacramento Valley	3 (2-4)	0 (0-1)	1 (1-2)
Salton Sea	2 (2-3)	0 (0-1)	1 (0-1)
San Diego County	6 (5-7)	1 (0-2)	3 (2-3)
San Francisco Bay	8 (7-10)	1 (0-3)	4 (2-5)
San Joaquin Valley	16 (12-19)	2 (0-5)	6 (4-9)
South Central Coast	1 (1-1)	0 (0-0)	0 (0-1)
South Coast	27 (21-33)	4 (0-9)	12 (7-16)
Statewide	67 (52-82)	10 (1-23)	28 (18-39)

*Values in parenthesis represent the 95% confidence interval. Totals may not add due to rounding

d) Valuation of Health Benefits

In accordance with U.S. EPA practice, health outcomes are monetized by multiplying incidence by a standard value derived from economic studies.[47] The value per incident is included in Table B5. The value for avoided premature mortality is based on

[46] The method used to quantify health benefits was used for CARB's on-road diesel regulations. Jet fuel emissions are treated the same as on-road diesel. This is an upper bound estimate. Fuel production emissions were discounted by a factor of 0.2 compared to diesel. In other words, PM emissions from this category were multiplied by 0.2. This factor is based on dispersion modeling work by Research Division, which suggests that the ratio of intake fractions of PM from refineries in Los Angeles to on-road diesel is approximately 1/5.

[47] U.S. EPA, National Center for Environmental Economics, Office of Policy Economics and Innovation, 2010. *Guidelines for Preparing Economic Analyses, Appendix B: Mortality Risk Valuation Estimates.* EPA 240-R-10-001. Washington, DC. December. Available at: http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-22.pdf/$file/EE-0568-22.pdf. Accessed Oct.31st 2017. Monetized heath impacts are not discounted.

willingness to pay[48] 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. While the cost-savings associated with premature mortality is important to account for in the analysis, the valuation of avoided premature mortality does not correspond to changes in expenditures, and is not included in the macroeconomic modeling (Section E). As avoided hospitalizations and ER visits do correspond to reductions in household expenditures on health care, these values are included in the macroeconomic modeling.

Unlike mortality valuation, the cost-savings for avoided hospitalizations and ER visits are based on a combination of typical costs associated with hospitalization and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, and lost earnings or 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).[49] These monetized benefits from avoided hospitalizations and ER visits are included in macroeconomic modeling (Section E).

Table B5: Valuation per Incident for Avoided Health Outcomes

Outcome	Cost-Savings per Incident (2016$)
Avoided Premature Mortality	$8,793,190
Avoided Acute Respiratory Hospitalizations	$52,826
Avoided Cardiovascular Hospitalizations	$46,078
Avoided ER Visits	$756

The total statewide valuation as a result of avoided health outcomes for the proposed amendments is summarized in Table B6. The spatial distribution of these cost-savings follow the distribution of emission reductions and avoided health outcomes, therefore most cost savings will occur in the South Coast and San Joaquin Valley air basins.

[48] U.S. EPA Science Advisory Board (U.S. EPA-SAB). 2000. "An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction." EPA-SAB-EEAC-00-013. July. Available at: http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf

[49] Chestnut, L. G., Thayer, M. A., Lazo, J. K. And Van Den Eeden, S. K.. 2006. "The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations." Contemporary Economic Policy, 24: 127–143. doi: 10.1093/cep/byj007 Available at: http://onlinelibrary.wiley.com/doi/10.1093/cep/byj007/full. Accessed Oct. 31st 2017.

Table B6: Estimated Incremental Valuation from Avoided Health Outcomes under the Proposed Amendments Scenario (2019 to 2030)

Outcome	Cumulative Cost-Savings (2016$)
Avoided Premature Mortality	$588,841,739
Avoided Hospitalizations	$483,211
Avoided ER Visits	$21,246
Total	**$589,346,197**

e) Qualitative Discussion of Other Pollutant Emissions and Health Outcomes

The proposed amendments could also change emissions of pollutants besides $PM_{2.5}$ and NO_X, but the magnitude and location of this impact (i.e., in-state versus out-of-state) depends on the pathways regulated entities use for compliance. Potential impacts under the proposed amendments scenario are discussed qualitatively in Appendix I.5.

f) Occupational Exposure

The proposed amendments may also change occupational exposure of California workers. Potential changes in pollutant types and emissions described in the previous sections (and in Appendix I.1.) would most heavily impact individuals who work in and around facilities that produce fuels or are exposed to heavy fuel use. Additional detail on potential changes in occupational exposure is presented in Appendix I.6.

C. DIRECT COSTS

1. Direct Cost Inputs

Estimated direct costs of the proposed amendments include costs of obtaining LCFS credits and third-party verification costs. Staff expects the more aggressive CI targets in the proposed amendments to result in an increase in the costs to regulated parties of obtaining LCFS credits by: (1) increasing the total quantity of LCFS credits required to be in compliance with the rule for every gallon of high-carbon fuel sold, and (2) increasing the price of LCFS credits. The addition of third party verification will also impose a small cost on the majority of regulated parties.

a) Cost of Obtaining LCFS Credits

To comply with the LCFS, regulated parties must retire an equivalent number of credits to cover the deficits that they generate. As discussed earlier in section A, the LCFS provides significant flexibility to regulated parties to obtain these credits. Broadly speaking, regulated parties can either: (1) self-generate credits by blending low-CI fuels with hydrocarbon blendstocks, invest in refinery and oil field improvements that lower emissions, or use renewable hydrogen in refinery operations; (2) purchase credits from the LCFS open market or the Credit Clearance Market; or (3) use credits banked from previous years.

Since the LCFS allows regulated parties to pursue a variety of strategies to comply with the standard, it is difficult to estimate the cost of obtaining the credits precisely. To quantify the direct cost of obtaining LCFS credits, CARB uses one annual uniform LCFS credit price for all firms. This methodology assumes that deficit generators will not pursue strategies themselves that cost more than the cost of obtaining credits from others through the LCFS market. However, some regulated entities may be able to generate LCFS credits at a cost lower than the assumed LCFS credit price, either through producing and blending alternative fuels themselves, investing in refinery and oil field projects, or producing renewable hydrogen for refinery use. Thus, using one annual LCFS market credit price as a proxy for the cost of compliance with the proposed amendments likely overstates the direct cost to deficit generating parties.

Alternatively, credit producers are able to sell their credits in the open market. The value of these credits is an important source of revenue to businesses producing and marketing low-carbon fuels, and allows them to compete against high-carbon fuels. In this section, staff also estimated the magnitude of these revenues to in-state and out-of-state businesses.

As discussed in Section A5, staff followed a multi-step process that uses the BFSM, stakeholder input, and external research to produce estimates of the mix of fuel use in California and credits from utilizing innovative methods at refineries and crude oil fields under each scenario. The LCFS credit price was then determined by estimating the cost of obtaining the most expensive (marginal) credit in that year. Table C1 shows the expected LCFS price trajectory under the baseline and proposed amendments scenarios.

Table C1: Estimated Annual Credit Price for Baseline and Proposed Amendments (2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	$150	$200	$200	$150	$150	$100	$65	$55	$35	$25	$25	$25
Proposed Amendments	$150	$200	$200	$85	$85	$85	$85	$85	$100	$115	$115	$115

Under the proposed amendments, parties in aggregate are expected to generate more deficits, and therefore are required to obtain more credits. Table C2 summarizes the number of deficits that all parties are expected to generate under the baseline and the proposed amendments scenarios. Cumulatively, approximately 50 million additional deficits are expected to be generated under the proposed amendments as compared to the baseline.

Table C2: Estimated Annual Deficits Generated under the Baseline and Proposed Amendments Scenarios (MMT)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	17	21	20	19	19	18	18	17	17	17	16	16
Proposed Amendments	17	21	20	19	20	21	22	23	24	24	25	26

Table C3 summarizes the change in the aggregate cost of obtaining LCFS credits due to the proposed amendments. The cost of compliance for the proposed amendments was calculated by multiplying the credit price in a given year by the projected number of deficits in that year and subtracting the same multiple from the baseline scenario. Negative numbers in Table C3 indicate a cost-savings compared to the baseline. Cumulatively, from 2019 through 2030, the proposed amendments are estimated to increase the total cost of obtaining LCFS credits by $8.8 billion relative to the baseline scenario.

Table C3: Estimated Direct Cost of Obtaining LCFS Credits under the Proposed Amendments Relative to Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$0	$0	$0	-$1250	-$1065	$7	$743	$1011	$1782	$2394	$2512	$2631

* Negative costs imply costs are lower under the proposed amendments than under the baseline for that year.

Table C4 summarizes the estimated increase in revenue to credit generating parties from the sale of LCFS credits, in-state and out-of-state, due to the proposed amendments. To apportion credits between in-state and out-of-state businesses, staff used an assumed percentage for production in-state and out-of-state for each fuel type, which is detailed in Table I1 in Appendix I. Cumulatively, from 2019 through 2030, the proposed amendments are estimated to increase total revenue for credit generating businesses as compared to the baseline scenario by $9.2 billion, of which $3.0 billion is estimated to accrue to California businesses.

Table C4: Estimated Increase in Revenue from LCFS Credit Sales under the Proposed Amendments Relative to Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
California businesses	$27	$72	$134	-$399	-$416	$28	$221	$316	$565	$795	$838	$867
Out-of-state businesses	$8	$24	$76	-$855	-$886	-$126	$516	$694	$1316	$1794	$1815	$1794
Total	$35	$96	$210	-$1254	-$1302	-$98	$737	$1010	$1881	$2589	$2653	$2661

*Negative revenues imply revenues are lower under the proposed amendments than under the baseline for that year.

b) Cost of Third-Party Verification

There will also be direct costs faced by regulated entities related to the third-party verification provisions of the proposed amendments. Staff estimated third-party verification costs by surveying fuel producers, fuel importers, and potential verifiers using a survey methodology similar to that used for the 2013 Amendments to the Regulation for Mandatory Greenhouse Gas Reporting, which included a similar verification program.[50] The third-party verification cost estimates are comprised of: (1) regulated party preparation and implementation costs obtained from survey results of fuel producers and importers and (2) contract costs for verification services obtained from qualified parties that regularly carry out third-party verifications or "audits". More details on the methodology used to estimate verification costs are presented in Appendix I.3.

c) Total Costs

The total direct cost to deficit generators (e.g., petroleum refiners) due to the proposed amendments is the summation of the cost of compliance and the cost of third-party verification. Table C5 provides a breakdown of the estimated annual direct costs to deficit generators.

The proposed amendments are projected to go into effect in 2019. From 2019 through 2030, the proposed amendments to the LCFS are estimated to result in direct costs to deficit generators of about $8.8 billion. The highest annual cost occurs in 2030 with an estimated direct cost of $2.6 billion.

Table C6: Estimated Total Direct Costs of the Proposed Amendments to Deficit Generators Relative to Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Obtaining Credits	$0	$0	$0	-$1250	-$1065	$7	$743	$1011	$1782	$2394	$2512	$2631
Third Party Verification	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3
TOTAL	**$0.3**	**$0.3**	**$0.3**	**-$1250**	**-$1065**	**$7**	**$743**	**$1012**	**$1782**	**$2395**	**$2512**	**$2631**

*Negative costs imply costs are lower under the proposed amendments than under the baseline for that year.

The total direct cost to credit generators (e.g., alternative fuel producers and petroleum project operators) under the proposed amendments is the summation of the revenue from LCFS credits and third-party verification. Table C7 provides a breakdown of the estimated annual direct costs to credit generators.

The proposed amendments are expected to go into effect in 2019. From 2019 through 2030, the proposed amendments to the LCFS are estimated to result in a decrease in the direct costs (i.e. an increase in revenue) to California credit generators of about $3.0 billion. This reduction in cost is due to the how the LCFS is structured; value is transferred from deficit generating parties to credit generating parties (e.g., from producers of high-CI fuels to producers of low-CI fuels), which covers the cost of

[50] CARB. *Proposed Amendments to the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions.* https://www.arb.ca.gov/regact/2013/ghg2013/ghgfro.pdf. Accessed Nov. 1st 2017.

verification, as well as increased indirect costs of upgrading or building new facilities, and obtaining higher volume and more expensive feedstock.

Table C7: Estimated Total Direct Costs of the Proposed Amendments to California Credit Generators Relative to Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Credit Value	-$27	-$72	-$134	$399	$416	-$28	-$221	-$316	-$565	-$795	-$838	-$867
Third Party Verification	$1	$1	$1	$1	$1	$1	$2	$2	$2	$2	$3	$3
TOTAL	**-$26**	**$-71**	**$133**	**$400**	**$417**	**-$27**	**-$219**	**-$314**	**-$563**	**-$793**	**-$835**	**-$864**

*Negative costs imply costs are lower under the proposed amendments than under the baseline for that year.

2. Direct Costs to Typical Businesses

Businesses involved in the LCFS vary greatly by size, geographic location and even by industry and there is no easily defined typical business. However, staff expects the costs of complying with proposed amendments will fall initially on oil refineries which are anticipated to pass these costs to consumers of high carbon conventional fuels, such as gasoline and diesel. In this section, staff estimated the annual costs for a typical California refinery to comply with the proposed amendments, detailed in Table C8. Section 5 discusses how these costs may be passed to consumers in the form of increased retail prices for both gasoline and diesel.

California has 15 refineries that currently produce transportation fuel.[51] The direct cost of the proposed amendments on a typical oil refinery consists of two components: increased cost of obtaining LCFS credits and increased verification cost. While a typical refinery might elect to invest in projects that generate credits (for example, direct production of low carbon fuels or petroleum projects to generate credits), they are only likely do so if the cost of the project is less than the cost of obtaining the LCFS credit through credit purchase. Therefore, estimating refinery costs using the market credit price may overestimate the costs of the proposed amendments on a typical refinery.

To calculate the average compliance cost for the typical refinery, staff divided the total annual compliance cost (total number of deficits multiplied by the LCFS credit price) by the number of major refineries (refineries with a capacity greater than 75,000 barrels a day).[52] In the early years, the direct cost is unchanged or lower under the proposed

[51] In California, there are currently 15 refineries that produce transportation fuels, of which 12 have a production capacity above 75,000. For more details, refer to the following: http://energy.ca.gov/almanac/petroleum_data/refineries.html. Accessed Nov. 1st 2017.
[52] Since the credit price is expected to represent the marginal costs of producing the last credit needed to achieve compliance in the system (i.e., the marginal GHG abatement needed to achieve the targeted CI benchmarks), each refiners' compliance cost is certain to be lower than staff's estimated value (because most abatement comes at a cost lower than the marginal abatement cost).

amendments due to identical or lower LCFS credit prices. In later years, the more stringent LCFS standard under the proposed amendments will lead to higher cost of obtaining LCFS credits due to increased price and quantity needed by the typical refinery. Note that verification costs are a small fraction of the total costs (an estimated average annual cost of $26,000) relative to the estimated cost of acquiring LCFS credits on the order of hundreds of millions of dollars in the out years.

Table C8: Estimated Direct Cost for a Typical Refinery under the Proposed Amendments Relative to Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$0	$0	$0	-$269	-$257	-$39	$117	$170	$337	$466	$481	$497

*Negative costs imply costs are lower under the proposed amendments than under the baseline for that year.

3. Direct Cost to Small Businesses

The change in the LCFS verification requirements will affect some low carbon fuel producers and dispensers that are small businesses.[53] Staff estimated the number of small businesses in California that will be impacted by the proposed amendments: four biodiesel producers, 15 natural gas fueling station owners, and one landfill biogas producer. No producers of conventional high carbon fuels (petroleum refiners) are small businesses and therefore no small businesses are expected to incur net compliance costs as the result of the proposed amendments. Some small businesses may also incur indirect costs related to facility expansion and higher feedstock purchases to meet the higher demand for their products due to the more stringent LCFS. Any cost of expansion is assumed to be offset by increased revenues from increased sales of LCFS credits. Under this assumption, a new small business would enter the market or an existing small business would expand only if the increased revenue from credit generation made the decision profitable. For this reason, verification is anticipated to be the only direct cost to small businesses.

The proposed amendments recognize the potential verification cost to small business, and provide more flexibility to small producers. Low carbon fuel producers that generate fewer than 6,000 credits annually are only required to verify the carbon intensity of their fuels every three years instead of annually, reducing their overall costs for verification. Currently, staff estimates that all small businesses in California that participate in the LCFS generate fewer than 6,000 credits annually. Moreover, small businesses that produce credits through lookup table hydrogen or electricity pathways will not incur third-party verification costs as CARB staff will perform verification of these hydrogen and electricity producers (as we would under the baseline scenario).

[53] Staff defines small businesses as independently owned businesses, with a revenue less than $10 million annually that are located in California.

Based on the estimated costs for verification shown in Table I4 of Appendix I.3., a small business owning fewer than 10 natural gas fueling stations would incur costs of $2,000 annually; a landfill biomethane producer would incur verification costs of $11,000 to $31,000 every three years; and a small biodiesel producer is estimated to incur costs at the low end of the $11,000 to $97,000 range every three years. These estimated verification costs are assumed to be recovered through revenue earned by sale of LCFS credits. For example, a small business that earns 2,000 LCFS credits annually will receive several hundred thousand dollars in revenue every three years assuming an LCFS credit value of greater than $50.

4. Direct Cost to Individuals

There are no direct regulatory costs incurred by individuals as a result of the proposed amendments. Businesses that incur costs may pass on costs to consumers, which could result in increased prices for gasoline and diesel. This indirect impact is discussed in the following section.

5. Estimated Cost Pass-Through

The proposed amendments will increase the costs to producers and importers of high carbon intensity fuels while producers of low carbon intensity fuels will see revenue increases. This will indirectly affect individuals in California that purchase transportation fuel, as staff assumes some portion of increased costs associated with production or import of high carbon intensity fuels will be passed on to consumers in the form of higher fuel prices. This section details the assumptions and methods used by staff to quantify the portion of the costs and revenues that may be passed to transportation fuel consumers.

The potential portion of the cost or revenue passed through to consumers can be approximated using bounding assumptions. To be conservative, staff assumed that cost increases faced by petroleum fuel producers and importers are completely passed-through to consumers. And, revenues generated by low carbon fuels are assumed to be passed through to fuel consumers only if the credits are generated by the consumer or dispenser of the fuel. When LCFS credit revenue is generated by a fuel producer, staff conservatively assumes that the producer will not share any of the revenue with fuel consumers, but rather use this revenue to cover the higher cost of producing these lower carbon fuels or retain this value to improve their firm's profitability. For example, in the case of biodiesel, producers receive the LCFS credits, thus staff assumes none of the value of the LCFS credit will be passed to consumers in the form of lower fuel prices. On the other hand, in the case of electricity used by a transit agency, the transit agency is the generator of credits, and thus the LCFS credits will effectively reduce the price of electricity used by the transit agency.

Staff expects that cost increases will fall exclusively on producers of high carbon intensity fuels, as discussed in Section B.1.b. The producers of conventional gasoline (CARBOB) and diesel (CARB diesel) generate deficits under the LCFS. Fuel producers must obtain credits to offset each deficit for compliance with the LCFS. Therefore, the quantity of deficits generated per gallon of fuel multiplied by the LCFS credit price can be used to estimate the increase in production cost of conventional fuels, which is assumed to be passed to consumers.

As discussed previously, this calculation assumes that all credits acquired by the high carbon intensity fuel producers are obtained at the price of the marginal LCFS credit (shown for the period 2019 through 2030 in Figure A6). This represents a reasonable upper bound of the cost to consumers at a given credit price, as the proposed amendments provide flexibility for regulated parties to meet the CI targets through a variety of compliance strategies(for example, increased blending of low-CI fuels or generating credits at production facilities). Regulated parities will therefore pursue actions that generate credits with costs less than or equal to the LCFS market price.

To estimate the LCFS credit price pass-through for diesel, staff used the following formula:

$$Diesel\ pass\ through\ (\$/gal)_t = \frac{CARB\ diesel\ deficits_t \times credit\ price_t}{gallons\ of\ CARB\ diesel\ sold_t}$$

where t indexes the year. This formula assumes that the cost of the deficit on diesel is fully passed through to consumers. It also assumes that biodiesel and renewable diesel producers price their retail products at the same price as CARB diesel.

To estimate the LCFS credit cost pass through for gasoline, staff assumes the current blend of gasoline, called E10, which is 90 percent CARBOB (which generates deficits) and 10 percent ethanol (which generates credits), persists through 2030.

To estimate the LCFS credit price pass through for CARBOB, staff used the following formula:

$$Gasoline\ pass\ through(\$/gal)_t = \frac{0.9 \times CARBOB\ deficits_t \times credit\ price_t}{gallons\ of\ CARBOB\ sold_t}$$

where t indexes the year. This formula assumes that the cost of the deficit generated by CARBOB is fully passed through to consumers of gasoline and that the ethanol credit value is not passed to consumers but rather kept by the ethanol producer.

Table C9 presents a range of potential LCFS credit price pass-through for gasoline and diesel due to the proposed amendments relative to the baseline. The range is based on staff's analysis described in the sections above, as well as two sensitivity analyses performed in Appendices G and H.[54] From 2019 through 2021, the proposed amendments are projected to have no incremental impact on the price of gasoline and

[54] The cost pass through shown in Table C9 are derived from CARB estimates of LCFS credit prices for each of the project scenarios (main and two sensitivity scenarios), and should be interpreted as illustrative rather than predictive.

diesel, as the proposed amendments do not lead to potential increases in credit price above the baseline scenario in these years. In 2022 and 2023, the proposed amendments are projected to reduce gasoline and diesel costs, as potentially lower LCFS credit prices are estimated for these years relative to the baseline scenario (see section A.5 for the credit price discussion that creates this trend). From 2025 onwards, the proposed amendments are projected to potentially increase the price of gasoline by up to $0.21 per gallon and potentially increase the price of diesel by up to $0.25 per gallon, based on the change in estimated annual LCFS credit price and annual deficits from 2025 through 2030.

Table C9: Range of Proposed Amendments Cost Pass Through (cents/gallon)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gasoline	0	0	0	(8)-(6)	(7)-(1)	0-4	3-5	7-10	10-13	9-18	10-19	10-21
Diesel	0	0	0	(9)-(7)	(8)-(1)	0-5	4-6	9-12	12-16	11-22	12-23	13-25

***Brackets indicate negative values**

Retail fuel prices are strongly influenced by many factors beyond LCFS credit prices (e.g., global events, holiday weekends, seasonal fluctuations, refinery disruptions, seasonal fuel blends, taxes, etc.) and fuel producer pricing strategies are complex and reflect local and regional market conditions.[55] Predicting how LCFS credit price changes impact these complex pricing strategies is beyond the scope of this work. Instead we provide the analysis above as an estimate of the upper bound of possible consumer price impacts based on the carbon content of fuel.

The proposed amendments scenario estimates use of conventional high carbon fuels (gasoline and diesel) will decrease by about 35 percent by 2030. This is due to increased vehicle efficiency, alternative fuel vehicles, sustainable land use design, and cleaner options for alternative modes of travel such as bicycling, increased mass transit, and walking. While, as discussed above, there may be a modest potential cost pass through to those still using high carbon fuels due to the proposed amendments, the reduction in total demand for these high carbon fuels driven by other portions of California's portfolio of GHG reduction policies is expected to at least partially offset these costs to high carbon fuel consumers. For example, if vehicle efficiency improves significantly, consumers of conventional fuels can travel much further on the same gallon of gasoline and diesel. Therefore, total expenditure on conventional fuel may decrease as the result of California's suite of GHG policies, even if the price per gallon of those conventional fuels increase slightly due to the LCFS amendments.

[55] Between 2012 and 2017, the retail price of gasoline fell as low as $2.30 and rose as high as $4.66, and similarly for diesel, the retail price ranged between $2.29 and $4.49. Source: United States Energy Information Administration. Weekly Retail Gasoline and Diesel Prices. www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_w.htm. Accessed Nov. 1st 2017.

Many transportation fuels will generate increased revenues from LCFS credit sales under the proposed amendments. In some cases producers or fuel importers will generate the LCFS credits, for example most of liquid biofuels credits are generated by the fuel producer or importer. In other cases the LCFS credits are generated by the fuel end user or the fuel dispenser, such as the case of many heavy duty users of fuels that operate their own refueling stations.

In the case where LCFS credits are generated by the fuel producer or importer, staff assumes that the value of these credits is not passed on to consumers, but is instead used to compensate these producers for creating low carbon fuels (either to cover the costs of producing more expensive low carbon fuels or to boost low carbon fuel producer profitability). This analysis assumes that alternative fuels are generally more costly to produce than fossil fuels and represent a small share of the total fuel market. In the future, it may be possible that alternative fuel producers might pass the value of the LCFS credit value to discount the price of their product to increase market share. If this were to occur, it could reduce the price of the estimated price increase to consumers. As it is difficult to predict future marketing behavior, staff elected to use the conservative assumption that LCFS credit revenue for most biofuels was not passed on to consumers.

For fuels where credits are generated by the end user or dispenser, as in the case of electricity, hydrogen, fossil natural gas, and fossil propane used in heavy duty applications, the full value of the credit is assumed to be passed on to consumers as a decrease in the price of these transportation fuels. In each year, the total value of credits are divided by the volume of fuel sold to calculate the per volume decrease in fuel prices. Specifically:

$$pass\ through_{ft} = \frac{credits_{ft} \times credit\ price_t}{volume\ sold_{ft}}$$

where f indexes the fuel type and t indexes the year.

D. FISCAL IMPACTS

1. State Government

Implementing the proposed amendments will affect state government finances through a change in State tax revenues due to the change in the fuel mix and prices, a change in the fuel expenditures for government fleets, and cost-savings from reduced health impacts.

a) Change in State Taxes

Table D1 summarizes the State and local tax rates and fees on different fuels used to calculate the fiscal impact of the proposed amendments on State and local government.

Table D1: State and Local Taxes in California 2019 – 2030

	Gasoline[56]	Diesel[57]	CNG	Hydrogen	Electricity
Excise Tax	$0.473/gallon [58]+ Annual CPI Adjustment	$0.36/gallon + Annual CPI Adjustment	$0.0887per 126.67 scf[59]	-	-
Underground storage tank fee[60]	$0.02/gallon	$0.02/gallon	-	-	-
Road Improvement Fee				$100/vehicle (2020 and later) + Annual CPI Adjustment	$100/vehicle (2020 and later) + Annual CPI Adjustment
Sales Tax[61]	4.5%	13.00%	8.5%	8.5%	8.5%
State portion	0%	8.5%	4.00%	4.00%	4.00%
Local portion	4.5%	4.5%	4.5%	4.5%	4.5%

Table D2 shows the changes in California's State tax revenues due to the proposed amendments. Cumulatively over the time period from 2019 through 2030, State revenues are estimated to increase by $315 million due to higher sales taxes resulting from higher fuel prices.

Table D2: Estimated Changes in State Government Tax Revenue under the Proposed Amendments Relative to Baseline (million $)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Change in Excise Tax	$0	$0	$0	$0	$0	$0	$1	$3	$5	$8	$8	$8
Change in Sales Tax	$0	$0	$0	-$27	-$24	$1	$21	$29	$52	$72	$77	$81

*Negative costs imply tax revenues are lower than under the proposed amendments than under the baseline for that year.

b) Change in Costs to State Government Fuel Purchases

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56 Senate Bill 1. SEC. 25. 2017-2018. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1. Accessed Oct. 31st 2017.

57 Senate Bill 1. SEC. 32. 2017-2018. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1. Accessed Oct. 31st 2017.

58 The gasoline tax rate has not yet been finalized For Jan 2019 – June 30 2019. This does not materially influence staff's calculations, as volumes and prices are the same under project scenarios and the baseline scenario.

59 California State Board of Equalization. *Tax Rates and Fees.* http://www.boe.ca.gov/sptaxprog/tax_rates_stfd.htm. Accessed Oct. 31st 2017.

60 California State Board of Equalization. *Tax Rates and Fees.* http://www.boe.ca.gov/sptaxprog/tax_rates_stfd.htm. Accessed Oct. 31st 2017.

61 California's basic sales tax rate is 7.25%, with 3.94% going to the State and the rest to local authorities. In addition to the basic sales tax, districts levy special taxes that differ amongst districts. The BOE calculated a weighted average special district tax which amounted to 1.23% in July 2017, increasing the average sales tax rate to 8.48%. For this analysis, staff assumes that sales tax rates will remain at July 2017 levels.

Table D3 summarizes the estimate of changes in cost for fuel purchases by the California government. To calculate the change in the cost of fuel purchases, staff obtained the most recently available fuel purchase data from the Department of General Services.[62] It is assumed that the consumption of gasoline and diesel by the State's fleet will change by the same rate as the assumed overall statewide change in gasoline and diesel consumption.[63]

Based on these assumptions, staff estimated the gasoline and diesel fuel purchases from 2019 through 2030 by state fleets. The maximum cost pass through for gasoline and diesel for each year of the proposed amendments was multiplied by the total gasoline and diesel purchases to estimate the effect of the proposed amendments on fuel purchases by the state government. As this calculation assumes gasoline and diesel prices will increase by the cost of obtaining the marginal credit and that the state government's rate of adoption of ZEVs is no greater than the rate for all of California, the cost values may overestimate the realized cost to state government.

Table D3: Estimated Changes in State Government High Carbon Fuel Purchases under the Proposed Amendments Relative to Baseline (million $)

	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Gasoline	$0	$0	$0	-$2	-$2	$0	$1	$2	$3	$4	$4	$4
Diesel	$0	$0	$0	-$1	-$1	$0	$1	$1	$1	$2	$2	$2
Total	**$0**	**$0**	**$0**	**-$3**	**-$2**	**$0**	**$2**	**$2**	**$4**	**$5**	**$6**	**$6**

*Negative costs imply costs are lower than under the proposed amendments than under the baseline for that year.

c) Cost-Savings from Avoided Health Incidence

The California government will likely see cost-savings through reduced hospital visits at state run hospitals and reduced sick days for state employees as a result of the proposed amendments. The projected changes in hospital visits and ER visits will also affect general fund costs through changes in State Medi-Cal expenditures. Medi-Cal, California's version of Medicaid, provides health coverage for children and adults with limited resources and is funded both by federal and state funds. A potential method to estimate the changes in general fund costs is multiplying the change in hospital

[62] California Department of General Services. *Progress Report for Reducing or Displacing the Consumption of Petroleum Products by the State Fleet*. https://www.documents.dgs.ca.gov/ofa/ab236/ab2362016report(final).pdf. Accessed: 09/12/17.

[63] Recent legislation and executive actions may drive higher rates of ZEV adoption by the State's fleet. SB 498 (2017-2018) requires at least 50% of the light-duty vehicles purchased for the state vehicle fleet each fiscal year to be zero-emission vehicles, except for vehicles that require special performance requirements for the protection of public safety. AB 739 (2017-2018) establishes ZEV heavy duty vehicles purchase requirements for the Department of General Services (DGS) and other State entities. AB 236 (2007-2008) requires DGS to implement a petroleum reduction plan to reduce the use of petroleum products to fuel the State's fleet. Executive Order B-16-12 requires the State's fleet to increase ZEV adoption through regular fleet replacement as to increase the percentage of ZEVs to be at least 10% of the light duty vehicles by 2015 and 25% of the light duty vehicles by 2020, except for vehicles that have special performance requirements for the protection of public safety.

expenditures by the Medi-Cal's share of California's hospital care expenditures and by the state's share of Medi-Cal spending. The method is discussed in more detail in Appendix I.4.

Using the values of the state share of Medi-Cal expenditures from 2014 to 2016, and the observed and forecasted ratio of Medi-Cal expenditures to total expenditures on hospital care, an estimated 8.2 to 11.6 percent of the cost savings for hospital care and emergency room visits from the proposed amendments would go to the State General Fund. The magnitude of cost savings from the proposed amendments, however, is very small compared to total State spending on medical care.

2. Local Government

Four separate impacts related to the proposed amendments affect local government finances: revenue generated from the sale of credits from transit fleets that use low-CI fuels, change in local tax revenues due to the change in the fuel mix and prices, the change in the expenditure on fuels for government fleets, and the cost-savings from reduced health impacts.

Many local governments are already generating credits from the LCFS program, which generate revenue. As discussed above, the proposed amendments will increase the demand, and subsequently the price, for LCFS credits relative to the baseline scenario, which can increase local government revenues.

a) Revenue from the LCFS Credits

In 2016, local governments earned 312,092 credits from the LCFS, which were primarily generated from low-CI fuel use in public transit systems. This sum does not include credits generated by public-owned utilities (POU) for the use of electricity in electric vehicles, since the utilities are obligated to pass the value of these credits to the electric vehicle owners. Of the credits generated by local governments, 44 percent were generated from the use of natural gas, from either fossil or renewable sources, and 56 percent were generated from the use of electricity for transportation from non-POU sources. The average price of LCFS credits in 2016 was $103, and thus the LCFS program is estimated to have contributed over $32 million to local governments.

Staff conducted an analysis to project the number of credits generated by local governments under the proposed amendments making the following assumptions:

- Electricity for non-bus use such as light rail service will stay at 2016 levels. This assumption conservatively awards local governments less credits than expected, as many municipalities in California will expand light rail service by 2030.

- Estimates of the number of buses and their type (diesel, gasoline, natural gas, or electricity) were obtained from the Draft 2017 Climate Change Scoping Plan Update.[64]
- The natural gas used by local authorities will have the same average mix (i.e. fossil, landfill, and dairy) as the projected annual State's average for the baseline and proposed amendments.

Table D4 shows the estimated increase in revenue generated local governments under the proposed amendments. Increased revenues for local governments are expected to be driven largely by higher use of dairy RNG, a very low-CI fuel, and the higher annual LCFS credit prices in the project scenario. It is important to note that the values in Table D4 represent the gross revenue for local governments from using alternative fuels and not the total reduction in fueling costs to local governments. Some of the increased revenues from selling LCFS credits may be used to purchase more expensive low-CI fuels or as an investment in fueling infrastructure or equipment to utilize these low-CI fuels.

Table D4: Estimated Changes in Revenue Generated by Local Governments from the Sale of LCFS Credits under the Proposed Amendments Relative to Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$56	$75	$78	$34	$35	$36	$38	$41	$51	$63	$67	$66

b) Change in Local Tax Revenue

Similar to changes in tax revenue for the State government, tax revenue for local governments will be affected by the proposed amendments. The primary factors affecting fuel tax revenue are the changes in price of gasoline and diesel. Table D1 summarizes the State and local taxes on different fuels that were used to calculate the fiscal impact of the proposed amendments on State and local government. Table D5 shows the changes in the local government tax revenues due to the proposed amendments. Cumulatively over the time period from 2019 through 2030, local government revenues are estimated to increase by $462 million due to higher sales taxes resulting from higher fuel prices.

Table D5: Estimated Changes in Local Government Tax Revenue under the Proposed Amendments Relative to Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$0	$0	$0	-$60	-$51	$1	$38	$52	$92	$124	$130	$136

*Negative values imply revenues are lower than under the proposed amendments than under the baseline for that year.

[64] The PATHWAYS model was used to produce an estimate of the number of buses and their types. PATHWAYS output can be found at www.arb.ca.gov/cc/scopingplan/meetings/meetings.htm, under Modelling Information/PATHWAYS Output tool. Accessed Nov. 1st 2017.

c) *Change in Costs to Local Government from Fuel Purchases*

Table D6 summarizes the estimated change in fuel purchases by local California government. To analyze the effects of the proposed amendments on the cost of fuel purchases, staff obtained the most recently available fuel purchasing data from the Department of General Services,[65] and the number of State and local government fleet vehicles from the California Energy Commission.[66] The available fuel data from the State fuel purchases is scaled by the ratio of local fleet vehicles to the State government fleet vehicles in 2015, to get an estimate of the fuel use by the local fleet vehicles. It is further assumed that the fuel economy ratings of the local government fleets for passenger and light-duty trucks are similar to the fuel economy ratings for the State as a whole. The maximum pass through cost for each year of the proposed amendments was multiplied by the total gasoline and diesel purchases to estimate the effect of the proposed amendments on fuel purchases by the local governments.

Table D6: Estimated Changes in Local Government High Carbon Fuel Purchases under the Proposed Amendments Relative to Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gasoline	$0	$0	$0	-$9	-$8	$0	$5	$7	$13	$17	$18	$19
Diesel	$0	$0	$0	-$4	-$3	$0	$3	$4	$7	$9	$10	$11
Total	$0	$0	$0	-$13	-$11	$0	$8	$11	$20	$27	$28	$29

*Negative values imply costs are lower than under the proposed amendments than under the baseline for that year.

d) *Cost-Savings from Avoided Health Impacts*

With the reduction in $PM_{2.5}$ and NO_X emissions and improvement in air quality, it is expected that local governments will benefit from fewer employee sick days and a reduction in public hospital and emergency room visits. The proposed amendments will lead to some cost-savings, but the share of cost savings attributable to local government are not easily quantified. Based on the spatial distribution of emission reductions and associated health benefits (Table B4), most avoided hospitalizations and ER visit cost-savings will occur in the South Coast and San Joaquin air basins. Local governments will also benefit from a greater ability to attain regional air quality goals.

3. CARB

Implementing the proposed amendments will not result in the need for additional personnel at CARB. CARB staff time that is currently devoted to processing pathway applications and verifying data will be reallocated to training and supporting third-party verifiers.

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[65] California Department of General Services. *Progress Report for Reducing or Displacing the Consumption of Petroleum Products by the State Fleet*. https://www.documents.dgs.ca.gov/ofa/ab236/ab2362016report(final).pdf. Accessed: 09/12/17.

[66] Communication with the California Energy Commission, June 14, 2017.

E. MACROECONOMIC IMPACTS

This section estimates the cumulative impact of the proposed amendments on the California economy. The proposed amendments are expected to have a broad impact on the California economy. For example, along with direct impacts to alternative and conventional fuel producing industries, there will also be changes in employment, output, and investment in sectors that supply goods and services to the fuel producing industries. Costs and benefits that are borne by directly affected industries will also affect the personal income of individuals in California. These changes in income lead to additional induced effects, like the change in consumer expenditures across other spending categories. The following analysis focuses on the resulting incremental changes in major macroeconomic indicators including employment, growth, and gross domestic product (GDP).

The direct costs discussed in Section C are input into Regional Economic Models, Inc. (REMI), Policy Insight Plus Version 2.1.1 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.

REMI provides year-by-year estimates of the total economic impacts of the proposed amendments, meeting the requirements of the Administrative Procedure Act and its implementing regulations.[67] CARB uses the REMI 2.1 single-region, 160-sector model with the model Reference case adjusted to reflect the California Department of Finance conforming forecast dated June 2017. These forecasts include California population figures, U.S. real GDP forecast, and civilian employment growth numbers.

1. REMI Inputs

The estimated economic impacts of the proposed amendments are sensitive to modeling assumptions. This section provides a summary of the assumptions used to determine the suite of policy variables that best reflect the macroeconomic impacts of the proposed amendments. The direct and indirect costs and benefits of the proposed amendments estimated in previous sections are translated into REMI variables and used as inputs for the macroeconomic analysis. Direct impacts include the cost of acquiring credits to cover deficits, credit revenue, changes in demand for fuels and third-party verification costs (described in Section C – Direct Costs). Indirect impacts calculated in previous sections include changes in fuel expenditures (described in Section C – Direct Cost Pass-Through), changes in state and local tax revenues (described in Section D – Fiscal Impacts), capacity expansion costs (described in Appendix J – Capacity Expansion Costs), and reduced spending on healthcare-related

[67] Gov. Code, §§ 11346.3, 11346.36; 1 Cal. Code Regs., tit. 1 §§ 2000-2004;see also: http://dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Order_of_Adoption-1.pdf

services from health benefits (described in Section B – Benefits). The model uses the inputs to calculate additional indirect and induced effects. The additional indirect effects are the changes in sales, income, or employment within California that supplies goods or services to the directly affected industries. Induced effects capture changes within California that result from changes in household spending.

The following two sections provide an overview of the direct and indirect REMI inputs. Additional detailed methodology and full REMI input data tables are included in Appendix J – Macroeconomic Modeling Appendix.

i. Direct Impacts

The proposed amendments will increase the number of deficits and credits generated. Industries that generate deficits will incur costs in acquiring credits to cover those deficits, while industries that generate credits will obtain revenue. These impacts are input into REMI as a change in production costs. The REMI analysis requires aggregated input data by North American Industry Classification System (NAICS) code. Each NAICS code is a broad category which aggregates costs among multiple fuel types. Thus, the final REMI inputs net multiple effects, which may obscure trends across fuel types.

Table E1 summarizes deficits and credits that are generated for each fuel type nested within a NAICS code to illustrate the pre-netted impacts of transfers of costs and revenues within NAICS codes. Positive values represent net costs, while negative values represent net revenues from credit generation. The input data shows that, in general, fossil fuels such as gasoline and diesel will generate deficits and incur costs, while low-CI fuels such as biodiesel, alternative jet fuel and dairy biogas will generate credits and obtain revenue.

Table E1. Estimated Net Deficits or Credits for California Facilities by Fuel Type for 2019 through 2030 (Million 2016$)

NAICS Industry	Fuel	Deficits or Credit Revenue*	Net Cost by NAICS Industry
Petroleum and coal products manufacturing (324)	CARBOB Gasoline	$7,085	$8,129
	Diesel	$1,678	
	Conventional Propane	-$3	
	Refinery Credits	-$631	
Basic chemical manufacturing (3251)	Starch Ethanol	-$90	-$1,151
	Sugar Ethanol	$0	
	Cellulosic Ethanol	-$19	
	Renewable Gasoline	$0	
	Hydrogen for LDVs	-$152	
	Biodiesel	-$181	
	Renewable Diesel	-$286	
	Hydrogen for HDVs	-$8	
	Renewable Propane	-$285	

	Alternative Jet Fuel*	-$130	
Natural gas distribution (2212)	Conv. Natural Gas	$0	-$564
	Dairy Natural Gas	-$564	
Waste management and remediation services (562)	Landfill Natural Gas	-$2	-$2
Electric power generation, transmission, and distribution (2211)	Electricity for LDVs**	-$545	-$699
	Electricity for HDV	-$105	
	Electricity for Rail/Forklift/etc.	-$49	
Local Government Spending***	Natural Gas	-$186	-$203
	Hydrogen	$0	
	Electricity	-$17	

* A positive value indicates increased cost, while a negative value indicates increased revenue.
** Credits from LDVs are rebated to consumers two years after they are generated and modeled as an increased spending in all consumer categories.
*** Credits generated by local government are a subset of credits generated by industry

The proposed amendments are designed to increase penetration of low-CI fuels in the California market. As such, the proposed amendments will impact the volumes of fuels sold which affects the output of fuel-producing industries. In addition, the proposed amendments will affect the price of fuels, natural gas used for transportation, and electricity used for transportation. These fuel volume impacts described in Section A and fuel price impacts described in Section C result in a change in revenue from the sale of fuel for the fuel-producing industries.[68]

Table E2 summarizes the change in revenue by fuel type input into REMI. The change in revenue depends on the projected changes in fuel price and the projected changes in fuel volumes. These two effects may have different signs, and can provide unexpected results. For example, producers of CARBOB gasoline see an increase in revenue because the fuel price increases but production volumes do not change.[69] Changes in revenue for other fuel producers are more intuitive. Fossil diesel and starch ethanol producers experience a fuel price increase but the decrease in production volume results in an overall decrease in revenue to the industries.[70] Fuels that substitute for diesel and starch ethanol, such as sugar ethanol, cellulosic ethanol, and renewable diesel see fuel price increases and higher volumes, resulting in an increase in revenues for the industry. The volume of renewable diesel under the proposed amendments is anticipated to be approximately twice as large as under the baseline in 2030, resulting in the substantial increase in revenues. For natural gas the change in revenue reflects, increases in volumes of dairy natural gas displacing conventional natural gas and landfill natural gas. These changes in revenues to fuel producers are modeled in REMI as a change in exogenous final demand to affected NAICS industries.

[68] Revenue generated by a fuel producer is defined as the price of the fuel multiplied by the volume sold.
[69] The increase in revenue to producers of fossil gasoline are used to offset the cost of credit acquisition.
[70] Fossil gasoline volumes do not change relative to the baseline because there are no drop-in substitutes for fossil gasoline. Fossil diesel and starch ethanol volumes decrease due to the availability of low-CI substitutes.

Table E2: Change in Revenue by Fuel Type for 2019 through 2030 (Million 2016$)

NAICS Industry	Fuel	Change in Revenue
Petroleum and coal products manufacturing (324)	CARBOB Gasoline	$6,376
	Diesel	-$7,879
	Conventional Propane	$32
Basic chemical manufacturing (3251)	Starch Ethanol	-$6,550
	Sugar Ethanol	$6,208
	Cellulosic Ethanol	$1,084
	Renewable Gasoline	$0
	Hydrogen for LDVs	-$149
	Biodiesel	$432
	Renewable Diesel	$10,935
	Hydrogen for HDVs	-$11
	Renewable Propane	$838
	Alternative Jet Fuel	$3,800
Natural gas distribution (2212)	Conv. Natural Gas	-$241
	Dairy Natural Gas	$608
Waste management and remediation services (562)	Landfill Natural Gas	-$359
Electric power generation, transmission, and distribution (2211)	Electricity for LDVs**	$0
	Electricity for HDV	-$95
	Electricity for Rail/Forklift/etc.	-$103

Industries required to obtain third-party verification will incur additional costs, modeled as an increase in production costs. The third-party verification requirements will also trigger demand for third-party verification services, modeled as an increase in demand for management, scientific, and technical consulting services in REMI.

ii. *Indirect Impacts*

The proposed amendments are anticipated to change the expenditures for households, businesses, and government agencies on fuel, electricity for transportation, and natural gas for transportation. This mirrors the change in value of fuel demand described in the previous section (Table E2). For example, an increase in gasoline prices results in increased spending by consumers and increased revenue to the fuel producer.[71] Impacts to households are input in REMI as a change in consumer spending on motor vehicle fuels, electricity, or natural gas. Impacts to businesses that consume fuel, electricity, or natural gas are input in REMI as a change in production cost by industry.

[71] Changes in expenditures by fuel consumers mirror the changes in revenue to fuel producers with one exception. Alternative jet fuel is assumed to substitute one-for-one with conventional jet fuel so that there is no change in consumer expenditures on air transportation.

Impacts to government agencies are input into REMI as changes to state or local government spending.

State and local agencies collect taxes and fees which will be impacted by the proposed amendments. For example, a change in fuel price will change State and local sales tax revenue. Changes in State and local revenue is estimated in Section D – Fiscal Impacts. From 2019 through 2030, the proposed amendments are anticipated to generate an additional $462 million in local government tax revenue and $323 million in state government tax revenue relative to the baseline. These data are input into REMI as a change in state or local government spending.

The proposed amendments are also anticipated to reduce hospitalizations and emergency room visits through estimated reductions in $PM_{2.5}$ and NOx emissions. The cost-savings from reduced hospital and emergency room visits is calculated in Section B – Benefits. The cumulative monetized health saving from 2019 through 2030 is $1 million, and is input into REMI as a reduction in consumer spending on hospitals.

The proposed amendments also provide benefits in the form of avoided climate damages from reduced GHG emissions and avoided deaths from reductions in $PM_{2.5}$ and NOx emissions. Benefits from avoided deaths are estimated based on how much people are willing to pay for small reduction in their risks of dying from adverse health conditions that may be caused by environmental problems. These valuations are not direct expenditures that would result in further macroeconomic impacts. Therefore, they are omitted from the macroeconomic analysis.

Some industries are expected to expand existing facilities or build new facilities to increase fuels production in response to the proposed amendments. Facilities anticipated to expand include dairy digesters producing renewable natural gas and cellulosic ethanol facilities. Fossil fuel refineries are also anticipated make investments in solar steam generation and carbon capture and sequestration projects to generate credits. These industries will incur additional costs, modeled as an increase in production cost. More details on the magnitude of the staff's methodology of accounting for these indirect costs are detailed in Appendix J – Macroeconomics Appendix. These actions also trigger demand for construction services, modeled as an increase in demand for construction in REMI.

2. **Results of the Assessment**

The REMI output provides the impact of the proposed amendments on the California economy, and is presented as the annual incremental change from the proposed amendment scenario relative to the baseline. The California economy is anticipated to grow through 2030 in all scenarios, therefore, negative impacts reported here should be interpreted as a slowing of growth and positive impacts as an increase in the rate of growth of the proposed amendments relative to the baseline *a) California Employment Impacts*

The California economy is growing, therefore the REMI baseline shows an increase in employment through 2030. Changes in employment growth as a result of the proposed amendments are not declines relative to today, but incremental results from growth forecasts in future years. Some industries experience job growth that is slightly higher than the baseline while other industries take slightly longer to reach baseline employment levels. Table E3 presents employment levels under the proposed amendments and the impact of the proposed amendments on total employment in California across all industries. As modeled, the proposed amendments are anticipated to result in a negligible decrease in total employment growth in 2019, then a modest growth in total employment from 2020 through 2024 as demand increases for the services of secondary industries such as construction and expansion of low carbon fuel production facilities and third-party verification services. Slowing of employment growth, relative to the baseline, begins in 2025 as the employment benefits of the proposed amendments are offset by the employment impacts on conventional high carbon fuel producers (and the employers that use these fossil fuels) and as the CI reduction targets decline through 2030.

Table E3: Estimated Change in California Employment Growth Relative to Baseline

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Employ-ment (Million Jobs)	23.1	23.3	23.5	23.7	23.9	24.1	24.3	24.5	24.7	24.9	25.1	25.3
% Change	0.00%	0.01%	0.02%	0.03%	0.01%	0.00%	-0.02%	-0.01%	-0.05%	-0.07%	-0.08%	-0.08%
Change in Total Jobs	-700	3500	4300	8200	3300	300	-3900	-3500	-12400	-17100	-19400	-21300

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 100.

Table E4 presents changes in employment growth for industries impacted by the proposed amendments. REMI output data can only be analyzed by NAICS code, which nets the effects of multiple fuel categories as demonstrated in Table E1 and E2, which can complicate interpretation of the REMI results.

Employment growth slows in the petroleum and coal products manufacturing industry between 2025 and 2030, likely resulting from the deficit generation by CARBOB gasoline and diesel fuels that are included in this NAICS code (Table E1). The slowing in growth reaches its peak in 2030 with a 4 percent reduction in employment under the proposed amendments relative to the baseline.

This slowing in growth in employment of high carbon fuel producers is countered by increases in employment growth in industries representing producers of alternative fuels. The basic chemical manufacturing industry, representing producers of fuels such as ethanol, biodiesel, and renewable diesel see increases in employment growth in 2030 of 8 percent, reflecting reduced operating costs from credit generation, higher revenue from pricing fuels at parity with conventional gasoline or diesel, and higher production volumes as these fuels substitute for their higher CI counterparts.

There are opposite trends in employment growth in the natural gas distribution sector and the waste management and remediation services sector. This reflects the anticipated increased demand for dairy natural gas, represented under the natural gas distribution sector, under the proposed amendments that replaces demand for landfill natural gas, represented under the waste management and remediation services sector.

Secondary industries include construction and third-party verification services. These industries experience an increase in demand for services, but are also affected by changing fuel prices as a result of the proposed amendments. Increased demand drives employment growth through about 2024. Small reductions in employment growth in later years are likely a result of increased fuel costs. The employment impacts in these industries represents less than a one percent change in growth through all years of the assessment, relative to the baseline, therefore are negligible.

Table E4: Estimated Change in California Employment Growth Relative to Baseline: Regulated Parties and Secondary Industries

		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel Producers													
Petroleum and coal products manufacturing (324)	% Change	0.02%	-0.19%	-0.42%	-0.69%	-0.09%	0.36%	-0.06%	-0.92%	-1.88%	-3.03%	-3.72%	-4.32%
	Change in Jobs	0	-20	-50	-90	-10	50	-10	-120	-240	-390	-470	-540
Basic chemical manufacturing (3251)	% Change	0.18%	0.29%	0.44%	-0.09%	-0.25%	0.39%	1.81%	2.90%	4.98%	7.07%	7.57%	8.00%
	Change in Jobs	10	20	30	-10	-20	20	110	170	290	410	440	460
Natural gas distribution (2212)	% Change	0.00%	0.01%	0.01%	0.02%	0.06%	0.16%	0.18%	0.32%	0.41%	0.69%	0.97%	1.07%
	Change in Jobs	0	0	0	0	10	20	20	40	50	80	110	120
Waste management and remediation services (562)	% Change	0.00%	0.01%	0.01%	-0.02%	-0.10%	-0.15%	-0.15%	-0.23%	-0.24%	-0.40%	-0.56%	-0.53%
	Change in Jobs	0	0	0	-10	-50	-80	-80	-120	-130	-220	-310	-290
Electric power generation, transmission, and distribution (2211)	% Change	0.00%	0.00%	0.00%	0.02%	-0.02%	-0.05%	-0.06%	-0.04%	-0.03%	0.02%	0.07%	0.12%
	Change in Jobs	0	0	0	10	-10	-20	-20	-10	-10	0	20	40
Secondary Industries													
Construction (23)	% Change	-0.01%	0.20%	0.26%	0.31%	0.06%	0.04%	-0.03%	0.08%	-0.17%	-0.24%	-0.27%	-0.30%
	Change in Jobs	-120	2,350	3,080	3,620	730	460	-300	930	-2,130	-2,950	-3,470	-3,820
Management, scientific, and technical consulting services (5416)	% Change	0.00%	0.01%	0.01%	0.01%	0.01%	0.00%	-0.01%	-0.01%	-0.03%	-0.04%	-0.04%	-0.05%
	Change in Jobs	0	20	20	40	30	10	-20	-30	-90	-130	-150	-170

The value in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 10.

b) California Business Impacts

Gross output is used as a proxy for business impacts because it is principally a measure of an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output growth, as defined in REMI, is the sum of output of each private industry and State and local government as it contributes to the state's gross domestic product (GDP), and is affected by production cost and demand changes. As production costs increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth. Table E5 presents the estimated changes to output growth resulting from the proposed amendments.

The transportation fuel CI target reductions, outlined in Section A, increases production costs and contributes to the slowing of output growth in sectors that produce high CI fuels and increases output growth in sectors producing low-CI fuels through the lower cost of production resulting in credit generation. The petroleum and coal products industry, representative of CARBOB gasoline, diesel, and conventional propane producers, sees a slowing of output growth of more than four percent by 2030 as a result of deficit generation exceeding the increase in fuel demand changes, as outlined in Table E1 and Table E2. The decrease in petroleum products output growth is offset by increases in output growth by industries producing renewable fuels. For example, the model results show an increase of more than eight percent in output growth in the basic chemical manufacturing industry, relative to the baseline. As shown in Table E2, the basic chemical manufacturing industry nets effects from a variety of fuel producers. The increase in output growth for this industry includes the effect of large decreases in the value of demand for starch ethanol, which is netted in the basic chemical manufacturing industry.

Changes in output growth follow similar trends to those in employment growth in the secondary industries. There are increases in output growth in early years due to increased demand for construction to expand facilities producing low carbon fuels and for third-party verification services. In later years, the slight slowing of output growth among secondary industries likely results from the impact of fuel price changes.

Table E5: Estimated Change in California Output Growth Relative to Baseline

		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Regulated Parties													
Petroleum and coal products manufacturing (324)	% Change	0.02%	-0.19%	-0.42%	-0.69%	-0.09%	0.36%	-0.06%	-0.92%	-1.88%	-3.04%	-3.74%	-4.33%
	Change (2016M$)	15	-143	-320	-543	-71	302	-49	-803	-1683	-2782	-3496	-4146
Basic chemical manufacturing (3251)	% Change	0.18%	0.29%	0.44%	-0.09%	-0.25%	0.39%	1.81%	2.91%	4.99%	7.09%	7.60%	8.04%
	Change (2016M$)	37.0	60.7	94.8	-19.7	-57.4	91.3	430.4	706.9	1,244.4	1,811.8	1,983.9	2,145.6
Natural gas distribution (2212)	% Change	0.00%	0.01%	0.01%	0.02%	0.06%	0.16%	0.18%	0.32%	0.41%	0.69%	0.97%	1.07%
	Change (2016M$)	0.2	0.7	0.7	1.6	5.6	14.7	16.5	29.4	37.7	64.7	90.8	100.7
Waste management and remediation services (562)	% Change	0.00%	0.01%	0.01%	-0.02%	-0.10%	-0.15%	-0.15%	-0.23%	-0.25%	-0.41%	-0.57%	-0.54%
	Change (2016M$)	0.0	1.1	1.1	-2.8	-13.1	-19.6	-20.0	-31.8	-34.8	-59.0	-83.9	-82.0
Electric power generation, transmission, and distribution (2211)	% Change	0.00%	0.00%	0.00%	0.02%	-0.02%	-0.05%	-0.06%	-0.04%	-0.03%	0.01%	0.06%	0.12%
	Change (2016M$)	-0.4	0.8	0.3	4.2	-5.9	-14.0	-15.6	-11.2	-8.0	3.2	17.4	32.0
Secondary Industries													
Construction (23)	% Change	-0.01%	0.20%	0.27%	0.31%	0.07%	0.04%	-0.02%	0.08%	-0.17%	-0.24%	-0.28%	-0.30%
	Change (2016M$)	-16.7	327.7	438.1	526.4	114.5	74.8	-39.6	146.8	-324.3	-461.4	-555.9	-624.4
Management, scientific, and technical consulting services (5416)	% Change	0.00%	0.01%	0.01%	0.01%	0.01%	0.00%	-0.01%	-0.01%	-0.03%	-0.04%	-0.05%	-0.05%
	Change (2016M$)	0.2	2.1	2.1	4.8	2.9	1.0	-2.4	-3.4	-10.4	-15.3	-18.3	-20.9

The value in each year is interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

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. Table E6 presents gross private domestic investment levels in California under the proposed amendments and the impact of the proposed amendments on gross private domestic investment growth. As modeled, the proposed amendments will have negligible impacts on private investment growth, resulting in less than a one percent change in private investment growth relative to the baseline. The model results show a slight slowing of investment growth, likely driven by increases in fuel prices, and as deficit generation occurs across conventional fuel producing industries.

Table E6: Estimated Change in Gross Domestic Private Investment Growth Relative to Baseline

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Investment (2016B$)	379.1	391.5	404.2	417.9	428.3	441.7	454.2	462.3	474.2	487.9	502.2	516.4
% Change	-0.01%	0.00%	-0.01%	0.03%	0.04%	0.01%	-0.04%	-0.08%	-0.16%	-0.23%	-0.26%	-0.28%
Change (2016M$)	-27.8	-9.5	-29.9	134.2	164.3	57.2	-182.6	-388.8	-762.5	-1109.6	-1319.1	-1457.1

The values for changes in each year are interpreted as the referenced year value less the baseline value in the same year. The values presented above are rounded to the nearest $100,000.

d) *Impacts on Individuals in California*

Table E7 shows that the annual change in growth of personal income through 2030 is less than 0.1 percent relative to the baseline. This amounts to a $33 per person decrease in personal income under the proposed amendments in 2030, relative to the baseline.[72] The minimal reduction in personal income growth after 2025 is likely the result of increased consumer spending on gasoline in diesel fuels. The REMI model shows that on average, personal income grows by $57.9 million each year. This means that as modeled, it would take less than 1 year for personal income under the proposed amendments to reach personal income levels under the baseline.

Table E7: Change in Personal Income Growth Relative to Baseline

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Personal Income (2016B$)	2281.7	2337.9	2392.4	2458.6	2506.5	2556.6	2616.2	2672.4	2730.7	2788.1	2847.7	2909.6
% Change	0.00%	0.00%	0.00%	0.03%	0.02%	0.00%	-0.03%	-0.03%	-0.06%	-0.08%	-0.09%	-0.09%
Change (2016M$)	-100.5	46.3	18.5	711.6	442.1	-80.0	-673.9	-875.9	-1746.0	-2264.4	-2485.9	-2704.0

The values for changes in each year are interpreted as the referenced year value less the baseline value in the same year. The values presented above are rounded to the nearest $100,000.

[72] Based on California Department of Finance State population projections. http://www.dof.ca.gov/Forecasting/Demographics/projections/documents/P1_Race_Ethnicity.xlsx. Accessed Nov. 1st 2017.

e) Impacts to Gross State Product (GSP)

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 is anticipated to have an average growth rate of 2.4 percent per year. As presented in Table E8, GSP growth is estimated to be slower, relative to the baseline, beginning in 2025, likely due to the fuel price changes and deficit generation resulting from the proposed amendments. CARB interprets the impact of the proposed amendments on GSP as being indiscernible in California's $3.4 trillion economy in 2030.[73] As modeled, it would take less than 1 year for GSP under the proposed amendments to reach GSP levels under the baseline.

Table E8: Change in Gross State Product Growth Relative to Baseline

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GSP (2016B$)	2584.5	2648.0	2712.0	2790.0	2860.3	2932.6	3002.7	3071.2	3142.9	3219.8	3299.0	3379.8
% Change	0.00%	0.01%	0.01%	0.02%	0.01%	0.00%	-0.01%	-0.02%	-0.05%	-0.07%	-0.08%	-0.09%
Change (2016M$)	-53.6	269.4	283.7	578.8	275.6	124.0	-330.3	-465.1	-1494.2	-2149.9	-2562.4	-2922.0

The values for changes in each year are interpreted as the referenced year value less the baseline value in the same year. The values presented above are rounded to the nearest $100,000.

f) Incentives for Innovation

The proposed amendments will lead to an overall higher price for LCFS credits relative to the baseline, which will send a signal for research and development, and deployment of innovative technologies and fuels that support California's long-term GHG emissions reduction goals. All fuel producers will have an increased incentive to innovate and deploy new methods that reduce the CI of their fuels. The proposed amendments will additionally provide long term price stability for LCFS credits, which is essential for low-CI fuel producers to make investments in long-term capital projects and research and development. Additionally, the proposed amendments include a protocol that will pave the road for CCS projects, a technology area with a high potential for innovation and development.

Some of the innovations staff is expecting to see in the next five to ten years include:

- Implementing processes that substitute low carbon sources of process energy, such as residual biomass, renewable natural gas and renewable electricity, in place of fossil fuel sources.

[73] U.S. Bureau of Economic Analysis, updated May 11, 2017. http://www.dof.ca.gov/Forecasting/Economics/Indicators/Gross_State_Product/. Accessed Nov. 1st 2017.

- Producing cellulosic ethanol from residual corn kernel fiber and sugarcane bagasse at conventional corn and sugarcane ethanol facilities, thereby improving production yields and energy efficiency.
- Deployment of advanced EV charging and hydrogen production technologies that take advantage of the availability of intermittent renewable power generation to lower CI scores.
- Producing solar-generated steam in place of fossil generated steam at oil fields for thermally enhanced oil recovery.
- Utilizing CCS, especially at ethanol production facilities.

g) Competitive Advantage or Disadvantage

The proposed amendments are designed to increase the competitiveness of low-CI fuels in California, therefore California businesses that produce low-CI fuels may become more competitive. Petroleum fuel producers, however, may be negatively impacted by the proposed amendments.

California sectors that rely heavily on transportation fuel may also face higher prices, resulting in a competitive disadvantage relative to out of state entities that are not subject to the LCFS. However, due to the 2015 Paris Agreement reached by the Conference of Parties in Paris, which is aimed at keeping the global temperature rise below 2ºC, staff expects signatories (which include all of the U.S.'s trading partners) to take action to reduce GHG emissions.[74] As these policies come online, businesses outside of the state will begin to face similar carbon costs in order to reduce GHGs, reducing the relative impact of the proposed amendments on California businesses.

Low carbon fuel mandates similar to California's LCFS have been adopted by the United States Environmental Protection Agency (U.S. EPA) and by other jurisdictions including Oregon, British Columbia, the European Union, and the United Kingdom.[75] Canada has also proposed a Federal Clean Fuel Standard to help achieve its 2030 GHG target.[76]

h) Creation or Elimination of Businesses

Staff expects the proposed amendments to provide substantial incentive to low-CI fuel producers, spurring existing businesses to grow and new businesses to be created to meet the expanding demand for these fuels. Business creation can occur either in-state or out-of-state, as the LCFS is neutral to the location of production.

[74] https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&lang=_en&clang=_en
[75] https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/clean-fuel-standard-discussion-paper.html
[76] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html

3. Summary and Agency Interpretation of the Results of the Economic Impact Assessment

As modeled, CARB estimates the proposed amendments will have a minor net impact on the California economy. The economic modeling results show that the low carbon fuel producing sectors of the economy gain from implementing the proposed amendments at the expense of high carbon fuel producing sectors. The proposed amendments provides a larger market share for innovative alternative fuels, and shift California's consumption towards cleaner fuels at a small cost to the California economy.

F. ALTERNATIVES

CARB solicited public input regarding alternatives to the proposed amendments. This solicitation was presented both in a concept paper posted at the LCFS webpage on July 24, 2017[77] and discussed at a workshop held on August 7, 2017.[78] In the solicitation, staff requested that alternatives be submitted by August 21, 2017. Several stakeholders responded to the solicitation by proposing alternatives.

Staff analyzed two alternatives to the proposed regulations. The first alternative is more aggressive than the proposed amendments and achieves a 25 percent CI reduction in 2030. The second alternative achieves the same overall CI reduction target of 18 percent by 2030 but does not include proposed amendments that allow the generation of LCFS credits through the use of alternative jet fuels, propane or CCS technologies. Figure F1 shows the compliance target trajectories under the 10 percent baseline scenario, the proposed amendments, and the two alternatives.

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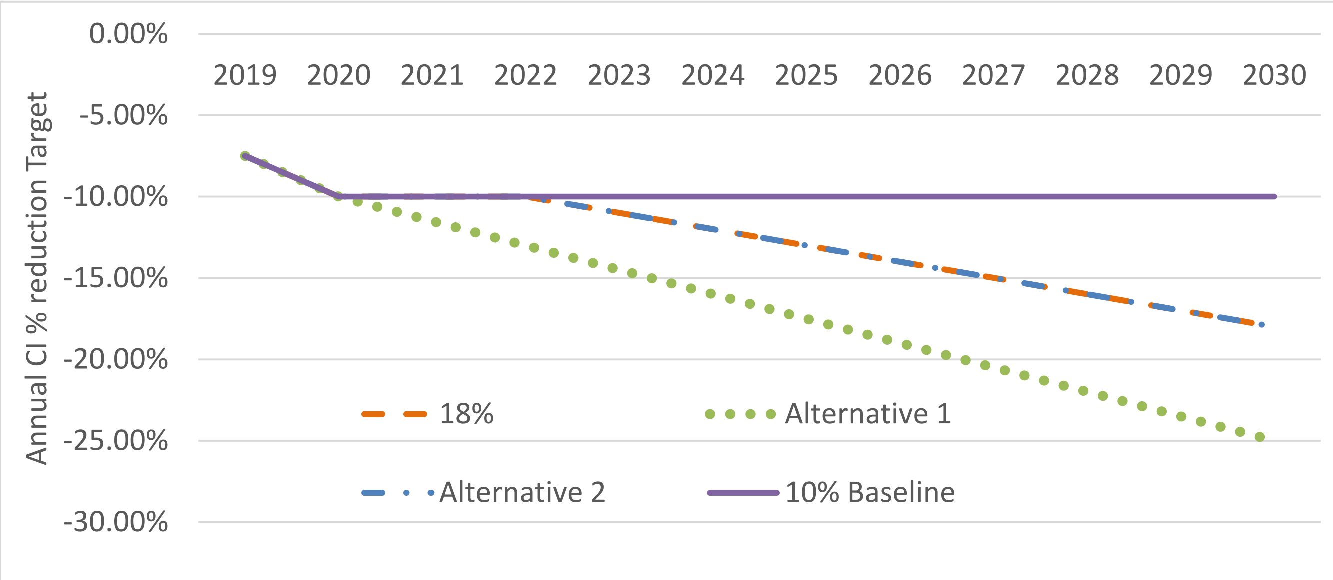
[77] CARB, 2017. *Low Carbon Fuel Standard 2018 Amendments, Pre-Rulemaking Concept Paper.* https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/080717conceptpaper.pdf. Accessed Oct. 25th 2017.
[78] CARB, 2017. *Meeting Notice for Public Workshop to Discuss Potential Low Carbon Fuel Standard Rulemaking Items.* https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/080717mtgnotice.pdf. Accessed Oct. 25th 2017.

Figure F1: Proposed Compliance Targets under the Baseline Scenario, Proposed Amendments and Alternatives



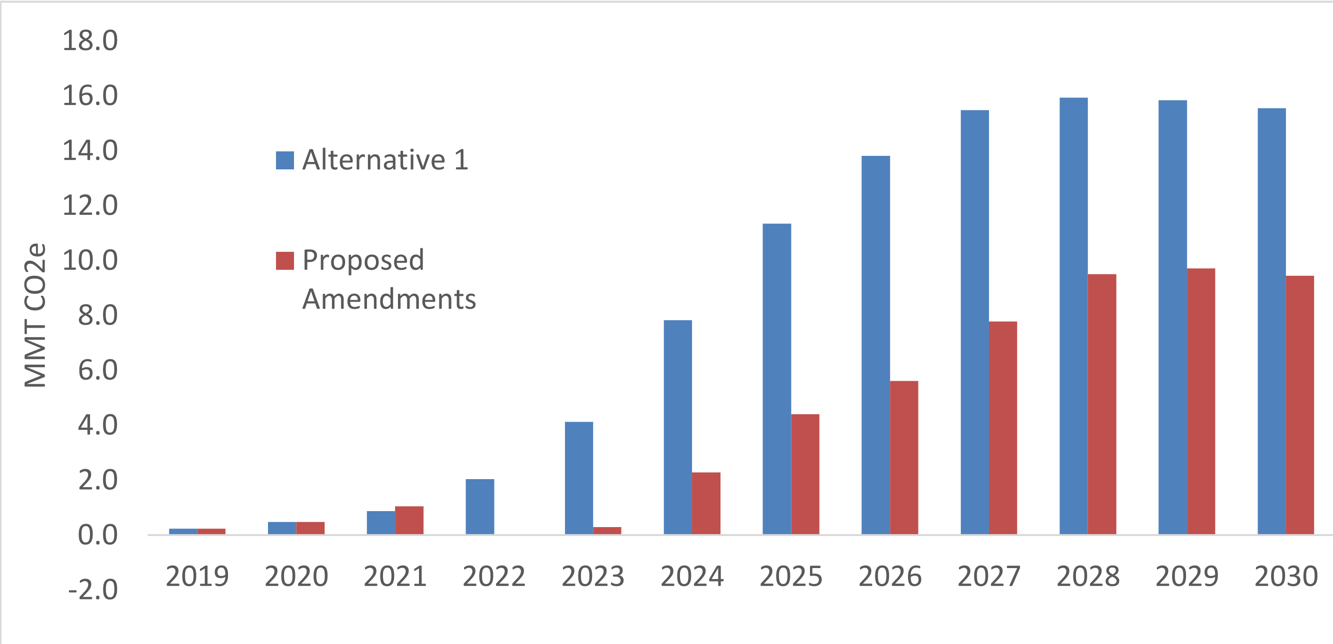
1. Alternative 1: CI reduction of 25 percent in 2030

Alternative 1 includes more aggressive CI reduction targets than the proposed amendments. Under this alternative, the required annual CI reduction will be higher post 2022 and the State will achieve higher GHG reductions, greater supply of alternative fuels, and increased air quality benefits. These benefits, however, will be achieved at a higher cost to the California economy and California consumers, through higher gasoline and diesel prices, relative to the proposed amendments.

a) *Benefits*

Alternative 1 provides additional GHG emissions reductions and additional improvements in local air quality compared to the proposed amendments, which will lead to additional health benefits. Figure F2 summarizes the total GHG emission reductions under this alternative relative to the baseline scenario. Staff expects cumulative GHG emission reductions for Alternative 1 to be 103.6 MMT CO_2e above the baseline. Compared to the proposed amendments, this is an increase in anticipated cumulative GHG reductions of 52.8 MMTCO_2e.

Figure F2: Estimated Incremental (Relative to Baseline) GHG Emissions Reductions under Alternative 1 and the Proposed Amendments (MMT CO2e/year)



Similarly, staff expects additional NO_X and $PM_{2.5}$ emissions reductions under Alternative 1 relative to the baseline and proposed amendments. Figures F3 and F4 summarize the statewide reductions in NO_X and $PM_{2.5}$ emissions under Alternative 1 and the proposed amendments relative to the baseline scenario. Alternative 1 is expected to further reduce NO_X emissions by about 7900 tons and $PM_{2.5}$ emissions by about 1000 tons cumulatively from 2019 to 2030, relative to the reductions achieved under the proposed amendments.

Figure F3: Incremental (Relative to Baseline) NO_X Emissions Reductions under Alternative 1 and the Proposed Amendments (tons/year)

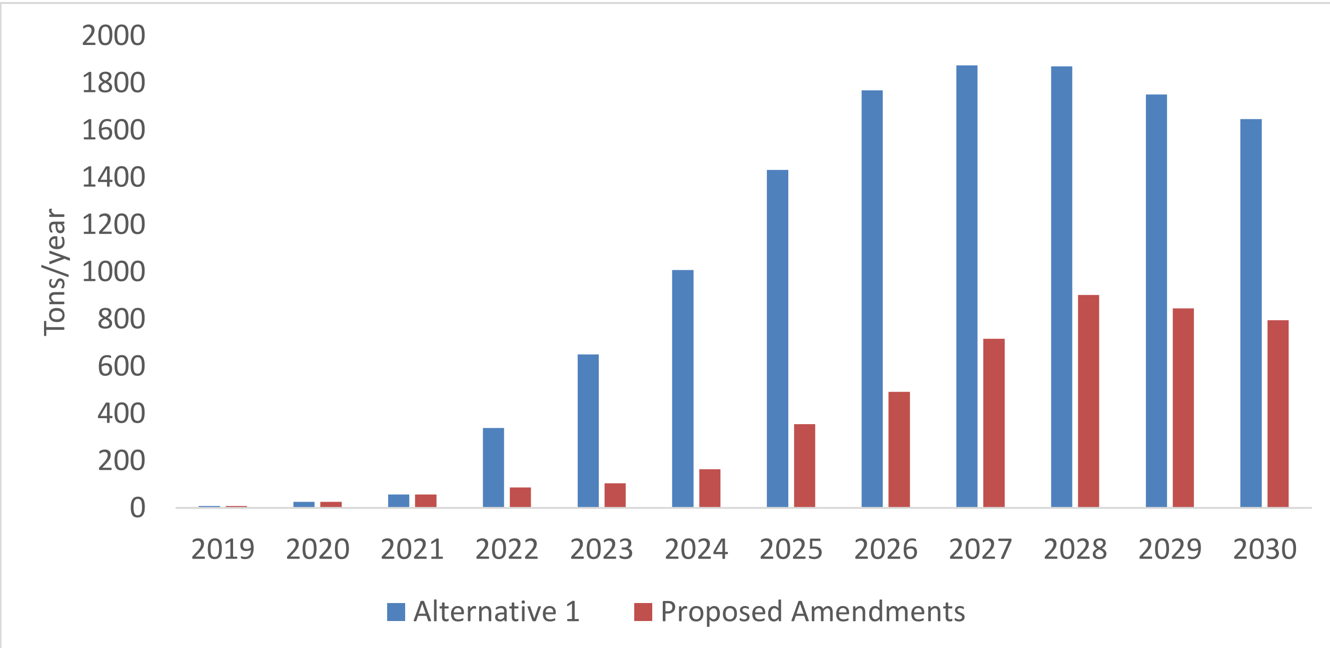


Figure F4: Incremental (Relative to Baseline) $PM_{2.5}$ Emissions Reductions under Alternative 1 and the Proposed Amendments (tons/year)

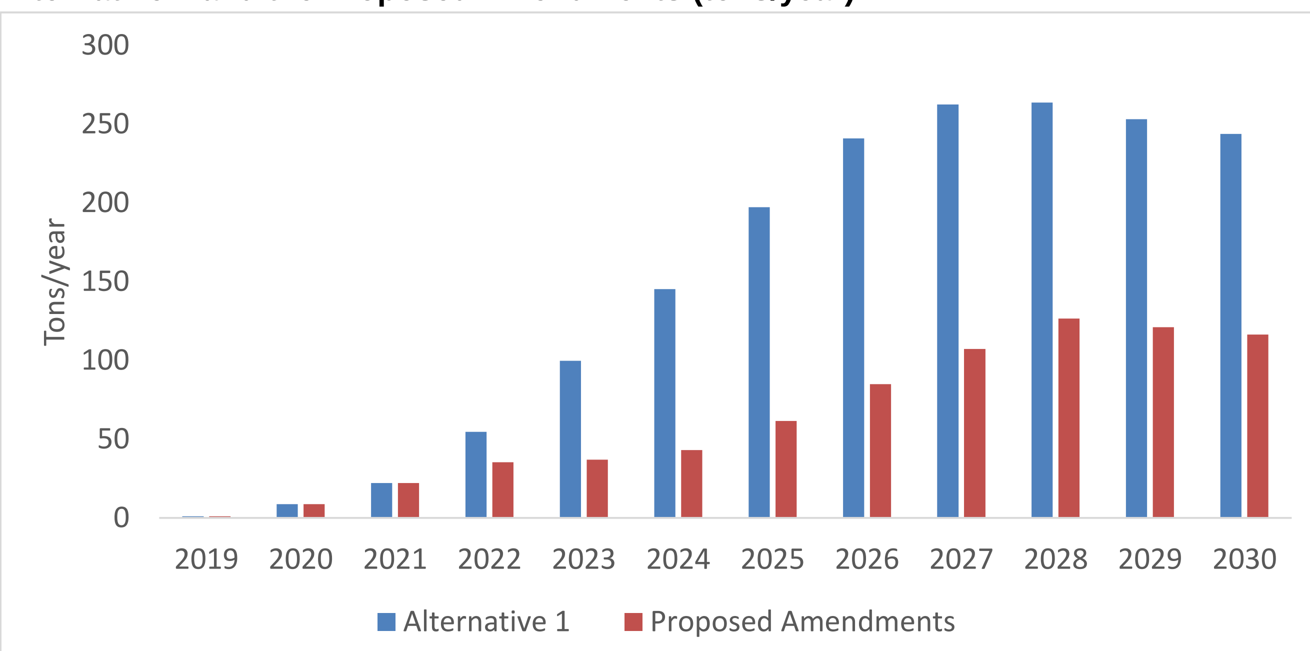


Table F1 shows the estimated avoided health impacts by California air basin under Alternative 1. Values in parenthesis represent the 95 percent confidence intervals of the central estimate. Alternative 1 will reduce overall emissions of $PM_{2.5}$ and NO_X in most years, and will lead to a net statewide health benefits relative to both the baseline scenario and the proposed amendments. Relative to the proposed amendments, 116 premature deaths, 17 hospitalizations, and 49 emergency room visits are expected to be avoided.

Similar to the proposed amendments, the majority of health benefits are concentrated in the South Coast and San Joaquin Valley air basins, with minor health benefits distributed among other regions.

Table F1: Estimated Cumulative Incremental (Relative to Baseline) Regional and Statewide Avoided Health Incidences from 2019 to 2030 under Alternative 1*

Region	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Great Basin Valleys	0 (0-0)	0 (0-0)	0 (0-0)
Lake County	0 (0-0)	0 (0-0)	0 (0-0)
Lake Tahoe	0 (0-0)	0 (0-0)	0 (0-0)
Mojave Desert	6 (4-7)	1 (0-2)	2 (2-3)
Mountain Counties	1 (1-1)	0 (0-0)	0 (0-0)
North Central Coast	1 (1-1)	0 (0-0)	0 (0-1)
North Coast	0 (0-1)	0 (0-0)	0 (0-0)
Northeast Plateau	0 (0-0)	0 (0-0)	0 (0-0)
Sacramento Valley	10 (7-12)	1 (0-3)	4 (2-5)
Salton Sea	5 (4-6)	1 (0-2)	2 (1-2)
San Diego County	13 (10-16)	2 (0-5)	6 (4-8)
San Francisco Bay	24 (19-29)	4 (1-10)	10 (7-14)
San Joaquin Valley	40 (31-49)	5 (1-12)	17 (10-23)
South Central Coast	3 (3-4)	1 (0-1)	1 (1-2)
South Coast	81 (63-99)	12 (1-27)	35 (22-47)
Statewide	183 (143-225)	27 (3-62)	77 (48-106)

*Values in parenthesis represent the 95% confidence interval. Totals may not add due to rounding

b) Costs

The more aggressive CI reduction targets under Alternative 1 result in higher costs of obtaining LCFS credits. Additionally, more alternative fuel facilities will need to be expanded or new facilities built (both in-state and out-of-state) to meet the higher demand for LCFS credits. In-state verification costs may increase slightly as a larger number of firms might participate in the LCFS due to the higher demand for low-carbon fuels. Because verification costs are very small compared to other direct costs (as detailed in Section C.1.d for the proposed amendments) staff did not estimate verification costs under Alternative 1.

The more aggressive targets in Alternative 1 will increase the number of deficits generated. Under Alternative 1, regulated parties are (in aggregate) are expected to generate between 17 and 34 million deficits annually, as shown in Table F2, resulting in a cumulative increase of 106 million and 57 million deficits over the baseline scenario and the proposed amendments, respectively.

Table F2: Estimated Annual Deficits Generated under the Alternative 1 (MMT)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	17	21	20	19	19	18	18	17	17	17	16	16
Alternative 1	17	21	23	24	26	27	28	29	30	31	33	34

Using the same approach as discussed in Section C, staff produced estimates of the annual price of LCFS credits under Alternative 1. Table F3 shows a comparison of credit prices between the proposed amendments and Alternative 1. The price of LCFS credits is expected to be higher under Alternative 1 than the proposed amendments as the higher demand for credits necessary to offset the generated deficits will necessitate the use of more expensive credit-generating options.

Table F3: Estimated Annual LCFS Credit Price under the Proposed Amendments and Alternative 1 (2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Proposed Amendments (18%)	$150	$200	$200	$85	$85	$85	$85	$85	$100	$115	$115	$115
Alternative 1 (25%)	$150	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200

The cost of compliance for Alternative 1 is calculated by multiplying the projected LCFS credit price by the number of deficits generated and subtracting the same multiple for the baseline scenario. Table F4 shows the annual compliance costs for Alternative 1, which are estimated at $41.2 billion (relative to the baseline). The cost of Alternative 1 is $32.4 billion more expensive than the proposed amendments.

Table F4: Estimated Total Direct Cost of Obtaining LCFS Credits under Alternative 1 Relative to Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$0	$0	$542	$1970	$2327	$3543	$4389	$4757	$5371	$5812	$6094	$6381

Under Alternative 1, the amount of low-carbon fuels will increase, and hence credit generation will also increase. Table F5 summarizes the estimated increased value to California businesses under Alternative 1 compared to the baseline. Cumulatively from 2019 through 2030, low carbon fuel producers and projects are estimated to generate an extra $41 billion in total, of which $13 billion will be generated by California businesses.

Table F5: Estimate of Increase in Revenue from LCFS Credit Sales for Alternative 1 Relative to Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
California businesses	$27	$72	$134	$204	$317	$1048	$1492	$1679	$1914	$2061	$2163	$2232
Out-of-state businesses	$8	$24	$41	$1169	$1528	$2469	$3231	$3657	$3985	$4034	$3992	$3938
Total	$35	$96	$175	$1373	$1845	$3517	$4723	$5336	$5899	$6095	$6155	$6170

c) Economic Impacts

The costs described in Tables F5 and F6 are input into REMI to assess the macroeconomic impact of Alternative 1 and are summarized in Table F7. Alternative 1 is estimated to have a moderate impact on the California economy, relative to the baseline. Under Alternative 1, GSP growth is estimated to be slower than growth under the baseline in almost all years. This is likely due to fuel price changes and deficit generation resulting from the proposed amendments. When compared to the proposed amendments, Alternative 1 is anticipated to slow GSP by an additional $2.7 billion each year. While the impacts of Alternative 1 on GSP are anticipated to be proportionally much larger than the proposed amendments, the impacts are still small when compared to California's large economy. Under Alternative 1, it would take less than one year for GSP to reach the levels reflected under the baseline. The trends in other macroeconomic indicators follow similar trends as GSP. Growth in personal income, employment, and private investment are estimated to be slower than under the baseline in almost all years. In 2030, the magnitude of these impacts are more than twice the impacts estimated under the proposed amendments.

Table F7: Change in Growth of Economic Indicators for Alternative 1 Compared to Baseline (25% CI Reduction)

		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GSP	% Change	0.00%	0.01%	0.00%	-0.04%	-0.07%	-0.11%	-0.14%	-0.16%	-0.18%	-0.20%	-0.21%	-0.22%
	Change (2016M$)	-53.8	269.4	-71.7	-1,072.3	-2,100.9	-3,085.4	-4,142.0	-4,856.2	-5,593.4	-6,521.4	-6,868.4	-7,275.9
Personal Income	% Change	0.00%	0.00%	-0.02%	-0.07%	-0.10%	-0.14%	-0.17%	-0.18%	-0.20%	-0.22%	-0.23%	-0.24%
	Change (2016M$)	-100.7	46.3	-553.4	-1,828.4	-2,508.4	-3,483.2	-4,404.6	-4,931.6	-5,571.1	-6,218.3	-6,502.7	-6,880.2
Employ ment	% Change	0.00%	0.01%	0.00%	-0.04%	-0.07%	-0.10%	-0.13%	-0.15%	-0.17%	-0.20%	-0.20%	-0.21%
	Change in Jobs	-700	3,500	600	-8,600	-16,900	-25,000	-32,900	-37,600	-43,000	-50,300	-51,700	-53,700
Private Investmen	% Change	-0.01%	0.00%	-0.05%	-0.16%	-0.27%	-0.38%	-0.49%	-0.57%	-0.62%	-0.66%	-0.67%	-0.67%
	Change (2016M$)	-27.8	-9.6	-189.7	-670.6	-1,146.6	-1,671.5	-2,211.7	-2,615.3	-2,952.9	-3,239.2	-3,378.1	-3,481.5

The value in each year is interpreted as the referenced year value less the baseline value in the same year. The change in jobs is rounded to the nearest 100, while the dollar value is rounded to the nearest $100,000.

d) Cost-Effectiveness

Increasing the CI to 25 percent by 2030 will result in additional GHG and criteria and toxic air pollutant emission reductions, but at higher cost to the California economy and consumers. The cost effectiveness for Alternative 2, calculated as the cumulative cost of obtaining credits divided by the cumulative GHG reductions, is $398 per MT CO_2e as compared to $173 per MT CO_2e for the proposed amendments.

a) Reason for Rejection

Requiring a 25 percent CI reduction will result in increased GHG emission reductions and improvement in air quality, but at cost much greater than the proposed amendments. The cost effectiveness of this alternative is more than double that of the proposed amendments.

2. Alternative 2: 18% target in 2030, no alternative jet fuel, no CCS, and no propane

Alternative 2 proposes similar CI reduction targets to the proposed amendments, but does not include proposed amendments that allow the generation of LCFS credits through the use of alternative jet fuels, propane or CCS technologies. Although the near term GHG and criteria pollutant reductions are similar to the proposed amendments, this alternative is significantly less likely to have as many benefits in terms of driving the innovation desired and needed to continue decarbonizing transportation fuel in the future. Studies by the Intergovernmental Panel on Climate Change[79] and the California Council on Science and Technology[80] have shown that CCS has the potential to reduce carbon emissions by millions of metric tons, and may be an integral part of meeting California's long term climate goals. It is also expected that long-term decarbonization in the aviation industry will rely heavily on biofuels, as there are few other options to reduce GHG emissions for aviation.

a) Benefits

Alternative 2 provides similar GHG emissions and criteria pollutants reductions compared to the proposed amendments. Figure F5 summarizes the total GHG emission reductions under Alternative 2 relative to the baseline scenario. Staff expects cumulative GHG emission reductions for Alternative 2 to be 47 MMT CO_2e more than for the baseline. Compared to the proposed amendments, this represents a decrease in anticipated GHG reductions of 4 MMT CO_2e from 2019 through 2030.

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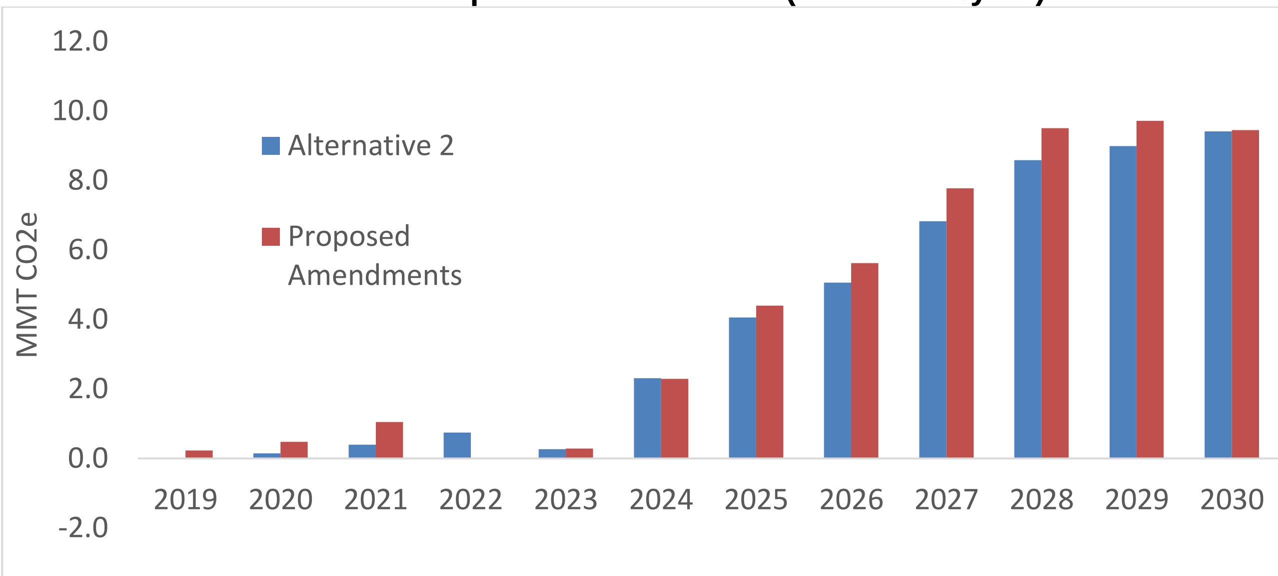
[79] IPCC Special Report. *Carbon Dioxide Capture and Storage*. http://www.ipcc.ch/report/srccs/. Accessed Nov 14th 2017.

[80] CCST Publications. *Policies for California's Energy Future - Electricity from Natural Gas with CO2 Capture for Enhanced Oil Recovery*. http://ccst.us/publications/2015/2015ccs.php. Accessed Nov 14th 2017.

Figure F5: Estimated Incremental (Relative to Baseline) GHG Emissions Reductions under Alternative 2 and the Proposed Amendments (MMT CO2e/year)



Similarly, staff expects NO_X and $PM_{2.5}$ emissions reductions under Alternative 2 to be similar to the proposed amendments. Figures F6 and F7 summarize the statewide reductions in NO_X and $PM_{2.5}$ emissions under Alternative 2 and the proposed amendments relative to the baseline scenario.

Figure F6: Incremental (Relative to Baseline) NO_X Emissions Reductions under Alternative 2 and the Proposed Amendments (tons/year)

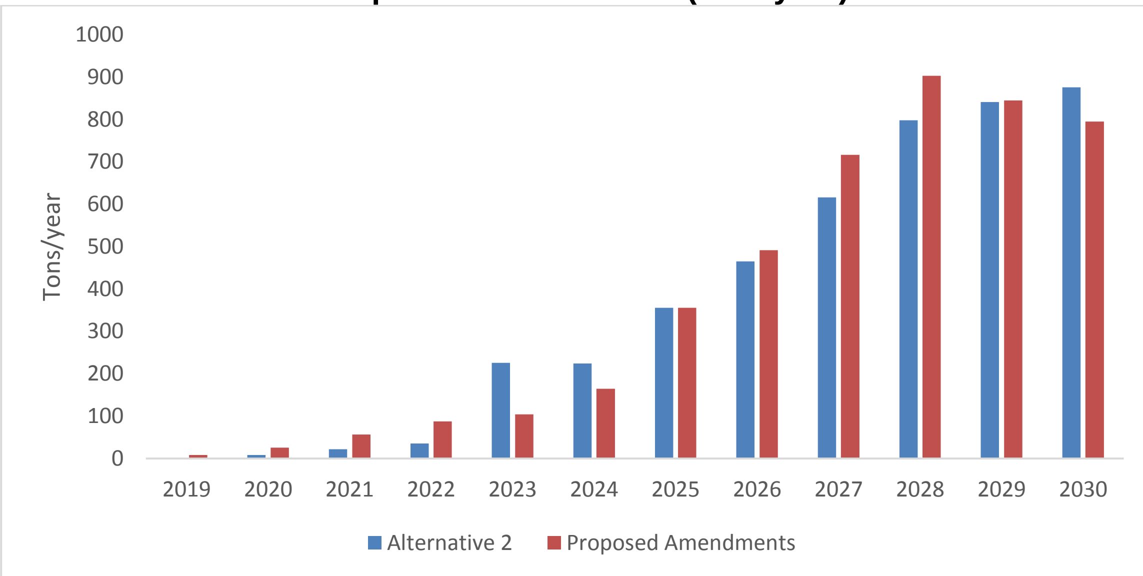


Figure F7: Incremental (Relative to Baseline) $PM_{2.5}$ Emissions Reductions under Alternative 2 and the Proposed Amendments (tons/year)

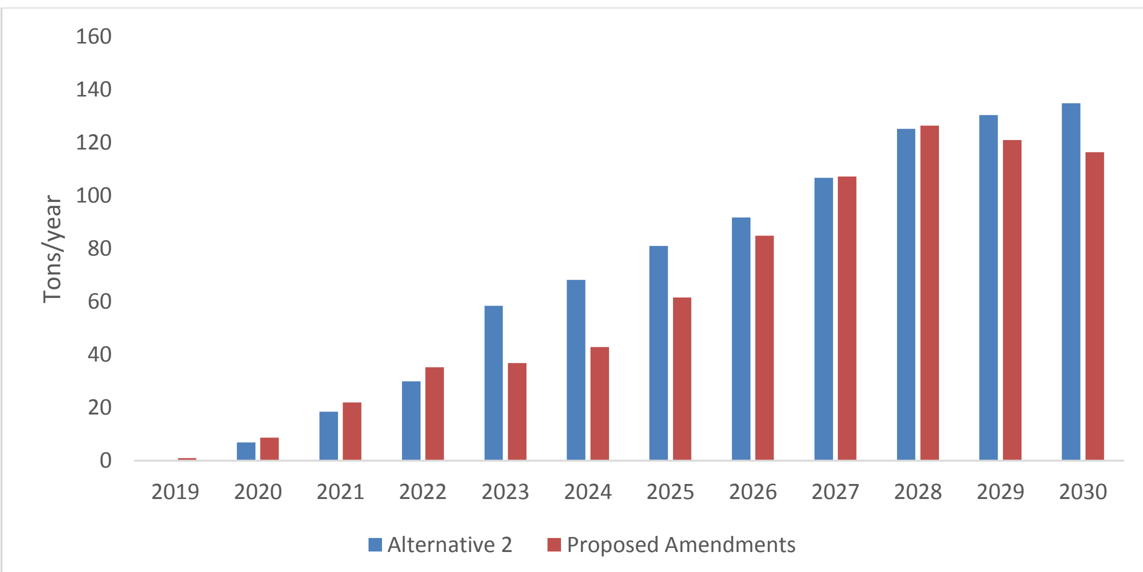


Table F8 shows the avoided health incidences as a result of Alternative 2 for 2019 through 2030 by California air basin relative to the baseline. Values in parenthesis represent the 95 percent confidence intervals of the central estimate. Relative to the proposed amendments, 24 fewer premature deaths, 3 fewer hospitalizations, and 10 fewer ER visits are expected to occur.

Table F8: Cumulative Regional and Statewide Avoided Health Incidences from 2019 to 2030 under Alternative 2* as compared to the Baseline

Region	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Great Basin Valleys	0 (0-0)	0 (0-0)	0 (0-0)
Lake County	0 (0-0)	0 (0-0)	0 (0-0)
Lake Tahoe	0 (0-0)	0 (0-0)	0 (0-0)
Mojave Desert	1 (1-2)	0 (0-0)	1 (0-1)
Mountain Counties	1 (0-1)	0 (0-0)	0 (0-0)
North Central Coast	0 (0-1)	0 (0-0)	0 (0-0)
North Coast	0 (0-0)	0 (0-0)	0 (0-0)
Northeast Plateau	0 (0-0)	0 (0-0)	0 (0-0)
Sacramento Valley	5 (4-6)	1 (0-2)	2 (1-3)
Salton Sea	1 (1-1)	0 (0-0)	0 (0-1)
San Diego County	5 (4-6)	1 (0-2)	2 (1-3)
San Francisco Bay	11 (9-14)	2 (0-5)	5 (3-7)
San Joaquin Valley	24 (19-30)	3 (0-7)	10 (6-14)
South Central Coast	2 (1-2)	0 (0-1)	1 (0-1)
South Coast	40 (31-49)	6 (1-13)	17 (11-23)
Statewide	91 (71-112)	13 (2-31)	38 (24-52)

*Values in parenthesis represent the 95% confidence interval. Totals may not add due to rounding

b) Costs

Under Alternative 2, regulated parties are (in aggregate) expected to generate between 17 and 26 million deficits annually, as shown in Table F9. By eliminating the ability to generate credits from alternative jet fuels, propane and CCS projects, Alternative 2 result in higher overall costs of obtaining LCFS credits, as the supply of LCFS credits is constrained.

Table F9: Annual Deficits Generated under Alternative 2 (MMT)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	17	21	20	19	19	18	18	17	17	17	16	16
Alternative 2	17	21	20	19	20	21	22	23	24	24	25	26

Using the same approach as discussed in Section C, staff produced estimates of the annual price of the LCFS credit under each scenario in Alternative 2. Table F10 shows a comparison of credit prices between the proposed amendments and Alternative 2. The price of LCFS credits is expected to be generally higher under Alternative 2 than the proposed amendments as the exclusion of credit generation through alternative jet fuel, propane, and CCS projects will necessitate the use of more expensive credit-generating options.

Table F10: Estimated Annual LCFS Credit Price under the Proposed Amendments and Alternative 2 (2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Proposed Amendments	$150	$200	$200	$85	$85	$85	$85	$85	$100	$115	$115	$115
Alternative 2	$150	$200	$200	$150	$100	$100	$100	$100	$115	$125	$125	$125

The cost of compliance for Alternative 2 is calculated by multiplying the projected LCFS credit price by the number of generated deficits and subtracting the same multiple for the baseline scenario. Table F11 shows the annual compliance costs for Alternative 2 relative to the baseline. Cumulatively the cost of compliance under Alternative 2 is expected to be $12 billion more expensive than the baseline, and $3.4 billion more expensive than the proposed amendments.

Table F11: Total Direct Cost of Obtaining LCFS Credits under Alternative 2 Relative to Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$0	$0	$0	$0	-$776	$310	$1058	$1338	$2126	$2625	$2723	$2820

Table F12 summarizes the value of credits to California and out-of-state businesses under Alternative 2 relative to the baseline. Cumulatively from 2019 to 2030, low carbon fuel producers and projects are expected to generate $12 billion in extra revenue and California low carbon fuel producers are expected to generate $4 billion in extra revenue as compared to the baseline.

Table F12: Estimate of Increase in Revenue from LCFS Credit Sales for Alternative 2 Relative to Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
California businesses	$0	$30	$80	$107	-$334	$151	$349	$433	$697	$896	$933	$971
Out-of-state businesses	$0	$0	$0	$9	-$654	$80	$693	$871	$1447	$1839	$1897	$1954
Total	$0	$30	$80	$112	-$994	$231	$1042	$1305	$2144	$2735	$2830	$2925

c) Economic Impacts

The costs described in Tables F11 and F12 are input into REMI to assess the macroeconomic impact of Alterative 2 and are summarized in Table F13. Alternative 2 is estimated to have similar impacts on the California economy as the proposed amendments. Under Alternative 2, GSP is estimated to grow slightly faster than under the baseline from 2019 through 2023 and then grow slightly slower than under the baseline from 2028 through 2030. In 2030, the impact of Alternative 2 on GSP is 0.01 percentage points larger than under the proposed amendments. It would take less than 1 month for GSP to reach levels reflected under the baseline. The trends in other macroeconomic indicators follow similar trends as GSP. Growth in personal income and employment are estimated to be faster than under the baseline from 2019 through 2024, followed by slight slowing in growth from 2025 through 2030. Private investment follows a similar trend with faster growth, relative to the baseline from 2019 through 2021, followed by slower growth starting in 2022. The impacts are approximately 1 percent larger than those found under the proposed amendments.

Table F13: Change in Growth of Economic Indicators for Alternative 1 Compared to the Baseline

		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GSP	% Change	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	-0.03%	-0.04%	-0.06%	-0.08%	-0.09%	-0.10%
	Change (2016M$)	-0.5	322.4	323.4	218.2	142.7	-67.1	-983.2	-1,300.3	-1,882.5	-2,512.9	-2,977.0	-3,301.3
Personal Income	% Change	0.00%	0.01%	0.00%	0.00%	0.01%	-0.01%	-0.04%	-0.05%	-0.07%	-0.09%	-0.09%	-0.10%
	Change (2016M$)	-0.6	136.5	101.4	64.0	315.1	-272.3	-1,056.9	-1,277.7	-1,932.1	-2,440.2	-2,671.1	-2,870.0
Employment	% Change	0.00%	0.02%	0.02%	0.02%	0.02%	0.01%	-0.03%	-0.04%	-0.06%	-0.08%	-0.09%	-0.09%
	Change (2016M$)	0	4,300	4,900	4,200	4,100	1,200	-7,900	-10,200	-14,700	-19,000	-21,800	-23,200
Private Investment	% Change	0.00%	0.01%	0.00%	-0.01%	0.00%	-0.03%	-0.10%	-0.14%	-0.20%	-0.25%	-0.29%	-0.31%
	Change (2016M$)	-0.2	26.4	4.6	-33.8	-11.4	-147.7	-442.4	-648.1	-941.0	-1,242.6	-1,450.1	-1,603.1

d) Cost-Effectiveness

Alternative 2 provides similar environmental benefits and availability of alternative fuels as compared to the proposed amendments. However, this alternative also results in a higher economic cost. The cost effectiveness for Alternative 2, calculated as the cumulative cost of obtaining credits divided by the cumulative GHG reductions, is $261 per MT CO_2e as compared to $173 per MT CO_2e for the proposed amendments.

e) Reason for Rejection

This alternative achieves similar GHG and criteria pollutants reduction but at a substantially higher economic cost. Additionally, it reduces the incentive to invest in emissions reduction opportunities in the aviation sector and in cutting-edge technologies (e.g. CCS) that have a large potential to spur innovations in the GHG reduction space, and which may be necessary for meeting long-term GHG emission reduction goals.

G. APPENDIX: HIGH ZERO EMISSION VEHICLE (ZEV) SENSITIVITY

In this Appendix, CARB presents the results of a sensitivity analysis that estimates the impact of a higher adoption rate of ZEVs relative to the proposed amendments scenario analyzed in the main SRIA analysis.[81] Since adoption of higher ZEV mandate is a likely event before 2030, staff performed a sensitivity analysis to explore the effects of the adoption of increased purchase of ZEVs on the LCFS proposed amendments. Overall, the results show that a higher rate of ZEV adoption will lead to similar cumulative GHG emissions reductions at a slightly reduced economic cost relative to the proposed amendments scenario. In this Appendix, the scenario described in the main body of the SRIA is referred to as the main scenario (and main baseline), while the sensitivity scenario described in this Appendix is referred to as the high ZEV scenario (and high ZEV baseline).

The higher ZEV adoption values shown in Tables G1 and G2 are consistent with the 4.2 million ZEVs by 2030 included in the Draft 2017 Climate Change Scoping Plan.[82] Achieving this higher level of ZEVs will likely require the development of new regulations or amendments to existing regulations (e.g., Advanced Clean Cars) that promote the purchase of ZEVs. For the high ZEV scenario, staff assumes that these additional or amended incentive programs are in place by the end of 2022, resulting in an increase in ZEVs as compared to the main scenario starting in 2023. Because the development and approval of these future incentive programs is exogenous to the proposed LCFS amendments, staff applied the higher ZEV adoption rate to both the project scenario and the baseline scenario. The higher ZEV adoption rate was not included in the main scenario because the Scoping Plan targets for ZEVs are not a part of any existing legislation or mandate.

Table G1: Number of Electric Vehicles under the Main Scenario and the High ZEV Scenario (thousand vehicles)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Main Scenario	453	529	619	715	821	935	1059	1182	1306	1429	1553	1676
High ZEV Scenario	453	529	619	715	972	1228	1485	1775	2122	2530	2997	3524

[81] ZEVs, or zero emission vehicles, are vehicles that do not emit any criteria pollutants or greenhouse gas. ZEVs are either fueled with electricity, as in the case of battery-electric vehicles and plug-in hybrid vehicles, or hydrogen, as in the case of fuel cell vehicles.

[82] Output from the PATHWAYS modeling for the proposed scoping plan scenario was used to produce an estimate of ZEVs. PATHWAYS output can be found at www.arb.ca.gov/cc/scopingplan/meetings/meetings.htm, under Materials/Modelling Information/PATHWAYS Output tool

Table G2: Number of Fuel Cell Vehicles under the Main Scenario and the High ZEV Scenario (thousand vehicles)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Main Scenario	9	15	24	38	55	74	97	119	142	164	187	209
High ZEV Scenario	9	15	24	38	92	146	201	264	340	429	530	644

Figure G1 compares the cumulative credits generated by each fuel type for the main and high ZEV scenarios. Because of the larger amount of credits generated by hydrogen and electricity consumed in ZEVs, fewer credits are required from biofuels and petroleum-based projects. As discussed previously, the LCFS is a market-based program and therefore any estimates of fuel volumes and credits generated are illustrative of one of many potential paths to compliance.

Figure G1: Comparison of Estimates of Cumulative Credits Generated under the Main and High ZEV Scenarios

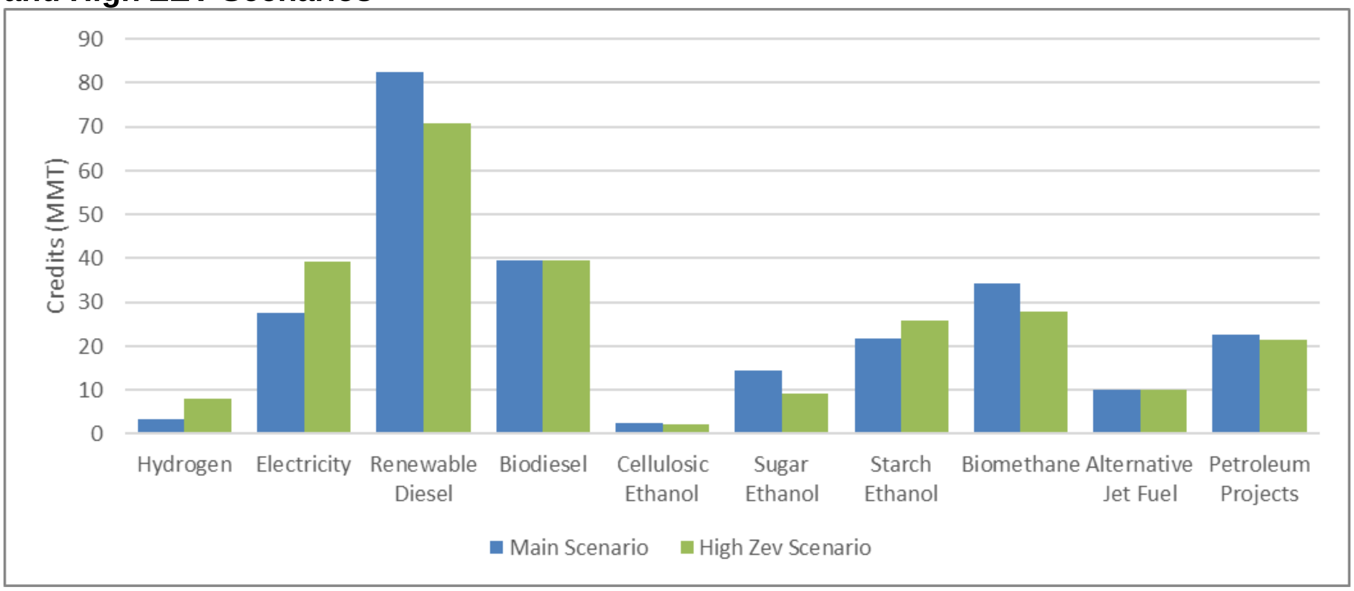


Table G3 shows deficits generated under the high ZEV scenario and the high ZEV baseline. Because of the increased penetration of ZEVs, slightly less gasoline will be consumed and therefore slightly fewer deficits are generated as compared to the main scenario (see Table C2 for comparison).

Table G3: Annual Deficits Generated under the High ZEV Scenario (MMT)

	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
High ZEV Baseline	17	21	20	19	19	18	18	17	17	16	16	16
High ZEV Scenario	17	21	20	19	20	21	22	23	24	24	25	26

Using the same approach as discussed in Section C, staff estimated the annual price of LCFS credits under the high ZEV scenario and high ZEV baseline which is shown in Table G4. Because of the higher supply of credits generated by electricity and hydrogen used in ZEVs, staff estimates that credit prices will be lower by $0 to $50 in the high ZEV scenario as compared to the main scenario (see Table C1 for comparison).

Table G4: Estimated Annual LCFS Credit Price under the High ZEV Scenario (2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High ZEV Baseline	150	200	200	150	100	65	65	35	25	25	25	25
High ZEV Scenario	150	200	200	85	85	85	75	75	75	65	65	65

The estimated cost to deficit generating parties of obtaining credits in each year is calculated by multiplying the estimated LCFS credit price by the number of deficits generated and subtracting the same multiple from the baseline scenario. Table G5 shows the annual compliance costs for the high ZEV and the main scenarios. For the high ZEV scenario, the cumulative costs are estimated at $5.9 billion (relative to the high ZEV baseline), an incremental cost which is $2.8 billion less expensive than the incremental cost of the main scenario. As in the main scenario, the increased direct cost will fall mostly on fossil gasoline and fossil diesel producers, as they are expected to be the only sector that will earn deficits under the proposed amendments

Table G5: Estimated Direct Cost of Obtaining LCFS Credits Relative to Baseline for Both the Main Scenario and the High ZEV Scenario (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Main Scenario	$0	$0	$0	-$1250	-$1065	$7	$743	$1011	$1782	$2394	$2512	$2631
High ZEV Scenario	$0	$0	$0	-$1250	-$136	$624	$528	$1115	$1352	$1181	$1237	$1290

The lower cost of credits under the high ZEV scenario also translates to a potentially smaller cost pass through to liquid fuel consumers than the main scenario. Using the calculation discussed in section C, staff calculated a potential cost pass through of $0.10 per gallon of gasoline and $0.13 per gallon of diesel by 2030.

GHG emissions reductions are expected to be similar under the high ZEV scenario and the main scenario, but they come at a lower economic cost under the high ZEV scenario. The estimated cost effectiveness under the high ZEV scenario, calculated as the cumulative cost of obtaining credits divided by the cumulative GHG reductions, is $127 per MT CO_2e as compared to $173 per MT CO_2e for the main scenario.

H. APPENDIX: HIGH LIGHT-DUTY VEHICLE DEMAND SENSITIVITY

CARB also analyzed the impact of changing assumptions related to the demand for gasoline for light duty vehicles (LDVs). Staff finds that a higher LDV fuel demand will result in similar GHG emissions reductions at a slightly higher economic cost when compared to the main scenario. The sensitivity scenario described in this section is referred to as the high demand scenario (and high demand baseline).

In the high demand scenario, staff assumed that LDV fuel demand will decline 15 percent by 2030 (from 2016 levels), this is relative to the 30 percent demand reduction assumed in the main scenario. As discussed in section A.5.b, LDV fuel demand in California is dependent on a number of State and federal policies (including CAFÉ vehicle standards, ACC, and SB 375). The demand reduction in the main scenario assumes success in achieving the goals of each of these policies. The sensitivity accounts for uncertainty due to lack of federal action in future years or because VMT reductions goals recommended in the Scoping Plan for SB 375 are not achieved. Because success in achieving the LDV demand reduction is exogenous to the LCFS amendments, staff applied the higher LDV demand to both the project scenario and the baseline scenario. Table H1 summarizes the annual LDV demand reduction relative to year 2016 for both the main scenario and the high demand scenario.

Table H1: LDV Demand Reduction under the Main Scenario and the High Demand Scenario (% reduction relative to 2016 demand level)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Main Scenario	6%	8%	11%	14%	17%	19%	22%	24%	26%	28%	29%	30%
High Demand Scenario	3%	4%	6%	7%	8%	10%	11%	12%	13%	14%	15%	15%

The higher LDV fuel demand (or lower LVD fuel reduction) will lead to higher deficit generation, and therefore higher demand for credits to comply with the policy. Figure H1 compares cumulative credits generated by fuel type for the main scenario and the high demand scenario. As discussed previously, the LCFS is a market-based program and therefore any estimates of fuel volumes and credits generated are illustrative of one of many potential paths to compliance.

Figure H1: Comparison of Estimates of Cumulative Credits Generated under the High Demand and Main Scenarios

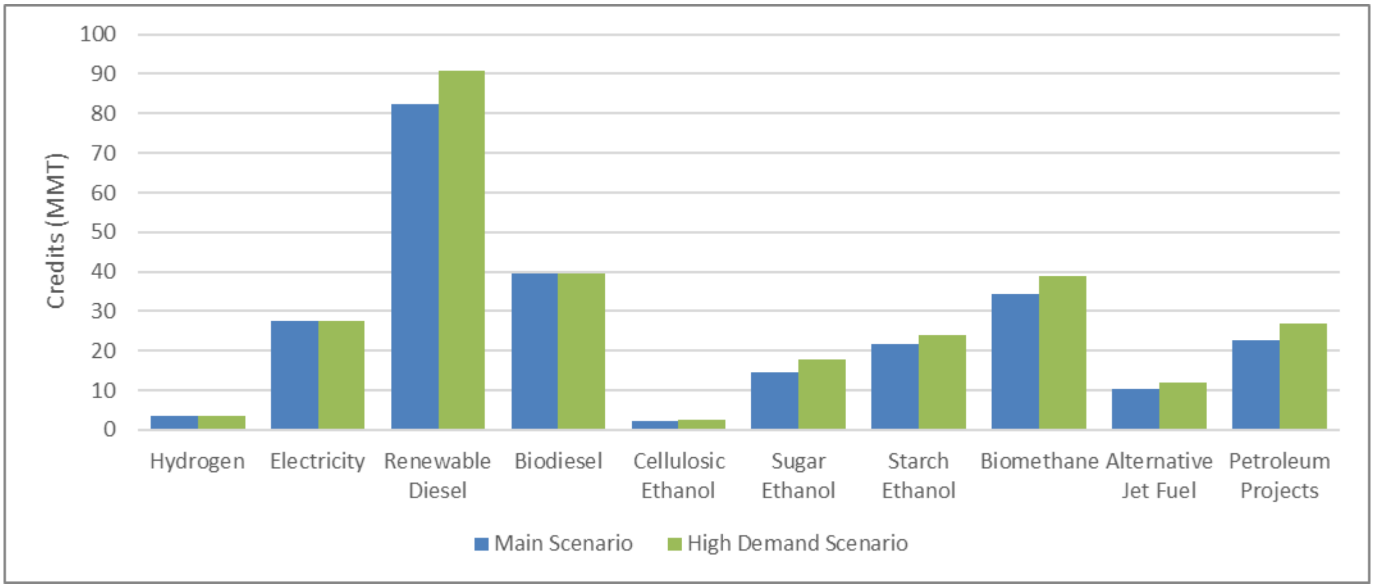


Table H2 shows deficits generated under the high demand scenario and the high demand baseline. Because of the much higher LDV demand, more gasoline will be consumed and therefore greater deficits are generated as compared to the main scenario (see Table C2 for comparison). Cumulatively through 2030 there are 291 million deficits generated under the high demand scenario as compared to 263 million under the main scenario.

Table H2: Annual Deficits Generated under the High Demand Scenario (MMT)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High Demand Baseline	17	21	21	21	20	20	20	19	19	19	19	19
High Demand Scenario	17	21	21	21	22	23	25	26	27	28	29	30

Using the same approach as discussed in Section C, staff produced estimates of the annual price of LCFS credits under the high demand scenario and high demand baseline, as shown in Table H3. The greater demand for credits to offset deficits results in higher estimated credit price for the high demand scenario as compared to the main scenario (see Table C1 for comparison).

Table H3: Estimated Annual LCFS Credit Price under the High Demand Scenario (2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High Demand Baseline	150	200	200	200	150	100	100	75	75	55	55	55
High Demand Scenario	150	200	200	150	100	100	100	115	125	125	125	125

The estimated cost to deficit generating parties of obtaining credits in each year is calculated by multiplying the estimated LCFS credit price by the number of deficits generated and subtracting the same multiple for the baseline scenario, as done in Section C. Table H4 shows the annual compliance costs under the high demand scenario and the main scenario. For the high demand scenario, the costs are estimated at $10.3 billion (relative to the baseline), which is $1.5 billion more expensive than under the main scenario. As in the main scenario, the increased direct cost will fall mostly on fossil gasoline and fossil diesel producers, as they are expected to be the only sector that will earn deficits under the proposed amendments.

Table H4: Total Direct Cost of Obtaining LCFS Credits under the Main Scenario and High Demand Scenario Relative to the Baseline (million 2016$)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Main Scenario	$0	$0	$0	-$1250	-$1065	$7	$743	$1011	$1782	$2394	$2512	$2631
High Demand Scenario	$0	$0	$0	-$1028	-$841	$342	$511	$1521	$1954	$2479	$2631	$2780

Using the calculation discussed in section C, staff calculated a potential cost pass through of $0.19 per gallon of gasoline and $0.23 per gallon of diesel by 2030, which is similar to the estimated cost pass through for the main scenario.

GHG emissions reductions are expected to be similar under the high demand scenario and the main scenario, but they come at a higher economic cost under the high demand scenario. The cost effectiveness under the high demand scenario, calculated as the cumulative cost of obtaining credits divided by the cumulative GHG reductions, is estimated as $192 per MT CO_2e as compared to $173 per MT CO_2e for the main scenario.

I. APPENDIX: METHODOLOGIES AND ADDITIONAL DISCUSSIONS

This appendix contains a description of the methodologies used to quantify and monetize the potential impacts of the proposed amendments and alternatives. The following methodologies are described:

- Estimating Changes in NO_X and $PM_{2.5}$ Emissions
- Estimating Health Impacts
- Estimating Verification Costs
- Estimating the Effect of Health Benefits on State Finances
- Qualitative Discussion of Other Pollutant Emissions and Health Outcomes
- Occupational Exposure

1. Methodology for Estimating Changes in NO_X and $PM_{2.5}$ Emissions

This section contains a description of staff's method of calculating changes in NO_X and $PM_{2.5}$ emission due to the proposed amendments. Staff identified three sources of emissions that might be substantially affected by the proposed amendments (relative to the baseline): 1) changes in tailpipe emissions due to increased use of renewable diesel, 2) changes in aircraft emission due to the use of alternative jet fuel, 3) changes in emissions at production facilities due to increased or changed method of production.

a) Tailpipe Emissions

Substitution of certain fuel types can lead to a reduction in vehicle tailpipe emissions. Staff expects lower NO_X and $PM_{2.5}$ emissions from the increased use of renewable diesel due to the proposed amendments. Table I1 summarizes the additional fuel volume of renewable diesel, relative to the baseline, projected each year through 2030.

Other changes in the fuel mix, such as a switch from starch to sugarcane or cellulosic ethanol as well as changes from fossil natural gas to renewable natural gas are not expected to affect tailpipe emissions, as these fuels are very similar chemically, and hence their combustion will produce similar tailpipe emissions.

Table I1: Estimated Additional Renewable Diesel Used in California under the Proposed Amendments (million gallons)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	0	0	0	0	0	100	200	400	600	600	600

To calculate NO_X and $PM_{2.5}$ emissions change for renewable diesel use, staff used emissions projections from California Emissions Projection Analysis Model (CEPAM): 2016 SIP[83] and fuel volume estimates from CARB's on-road and off-road modeling tools.[84] Staff assumed that

[83] CARB. *CEPAM: 2016 SIP – Standard Emissions tool* https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php. Accessed Nov. 3rd 2017.
[84] CARB. *Mobile Source Inventory.* https://www.arb.ca.gov/msei/msei.htm. Accessed Nov. 3rd 2017.

pure renewable diesel reduces NO_X emissions by 10 percent for older engines not equipped with selective catalytic reduction (SCR) and reduces $PM_{2.5}$ emissions by 30 percent.[85]

To estimate the statewide reduction in NO_X and $PM_{2.5}$ emissions, staff multiplied the difference between the emission factors for fossil and renewable diesel by the amount of fossil fuel displaced. The total statewide reduction in NO_X and $PM_{2.5}$ emissions was then proportioned to each air basin on the basis of overall diesel exhaust emissions in each air basin. Thus, emissions changes due to renewable diesel substituting for diesel will weigh more heavily in air basins with higher projected emissions from diesel.

b) Aircraft Emissions

In addition to reductions in tailpipe emissions, the proposed amendments would allow alternative jet producers to receive LCFS credits, resulting in increased substitution of alternative jet fuel for fossil jet fuel. Staff estimated that alternative jet fuel emits 10 percent less NO_X and 45 percent less $PM_{2.5}$ compared to fossil jet fuel.[86] Staff estimated emissions reductions during taxi, take-off, and landing operations at California airports using the projected volumes of alternative jet fuel used in each project scenario. Only jet fuel consumed below 3,000 feet was included, as emissions occurring above this altitude are not likely to affect air quality. The total statewide reduction in NO_X and $PM_{2.5}$ emissions was then proportioned to each air basin on the basis of overall jet exhaust emissions in each air basin.

c) Stationary source emissions

The LCFS also includes a provision to incentivize the use of innovative production methods in oil fields. Solar steam projects in California's San Joaquin Valley, in particular, may be a significant source of LCFS credits through 2030. Staff estimated NO_X and $PM_{2.5}$ emission reductions in the San Joaquin air basin by assuming that solar steam generation would displace generation of steam using natural gas fired steam generators. Staff estimated NO_X and $PM_{2.5}$ emission factors for natural gas fired steam generators using 2015 emissions data from CEPAM and 2015 steam generation volumes from the Division of Oil, Gas, and Geothermal Research (DOGGR).[87]

CARB also expects the proposed amendments will increase the production of low carbon fuels in California, which will result in increased emissions at these production facilities. To estimate the in-state low-carbon fuel production, staff estimated the proportion of low-CI production that

[85] CARB, 2015. *Staff Report – Multimedia Evaluation of Renewable Diesel.* Available at: https://www.arb.ca.gov/fuels/diesel/altdiesel/20150521RD_StaffReport.pdf. (p. 8). Accessed Nov. 1st 2017.

[86] For $PM_{2.5}$ emissions: Table 6 from Carter, Nicholas A., Stratton, R.W., Bredehoeft, M.K., and Hileman, J.I., Energy and Environmental Viability of Select Alternative Jet Fuel Pathways, 47th AIAA/ASME, SAE, ASEE Joint Propulsion Conference & Exhibit, San Diego, CA, AIAA 2011I5968, 31 July – 03 August 2011, Table 6.
For NO_X emissions: Staff calculated the NO_X emissions change using The NASA's Langley Aerosol Research Group data: https://science.larc.nasa.gov/large/data/

[87] Steam injection rates for California oil fields were obtained from monthly production and injection reports at ftp://ftp.consrv.ca.gov/pub/oil/monthly_production_reports/. Staff assumed that 73 percent of steam was produced using steam generators and 27 percent in cogeneration units.

will occur in-state (Table I2), and multiplied this by the estimated change in total production for each fuel.

Table I2: Assumed Proportion of Alternative Fuels Production in California

Fuel	Percentage	Notes
Starch Ethanol	12%	Based on 2016 California proportion, obtained from LCFS data.
Cellulosic Ethanol	12%	Assumed the same percentage as starch ethanol, as staff believes most cellulosic will come from bolt-on upgrades to convert corn kernel fiber or other cellulosic materials at existing starch ethanol plants.
Renewable Diesel, Gasoline, Propane, and Jet Fuel	12%	Based on 2016 California proportion for renewable diesel, obtained from LCFS data. [88]
Biodiesel	24%	Based on 2016 California proportion, obtained from LCFS data.
Dairy RNG	33%	Assumed[89]

Staff calculated increases in NO_X and $PM_{2.5}$ emissions associated with the production increases by multiplying facility emission factors, summarized in Table I3, by the assumed increase in in-state production.

[88] Hydrotreating of fats, oils and greases results in the production of renewable diesel, renewable gasoline, renewable jet fuel, and renewable propane. Because all four alternative fuels are produced at the same facilities, staff assumed the same proportion would be produced in California.
[89] In the period of 2012-2016, California dairies account on average 20% of the national milk production. Since the State is actively pursuing policies to incent California dairies to mitigate GHG emissions, by providing grants and other programs, staff assumes that the ratio of in-state production will be higher than California's share of milk production. Source: USDA. *Dairy Data, Milk cows and production by state and region(Annual).* https://www.ers.usda.gov/webdocs/DataFiles/48685/milkcowsandprod_1_.xlsx?v=42866. Accessed Nov. 1st 2017.

Table I3: Assumed Facility Emission Factors

Fuel Production	NO_X Emission Factor	$PM_{2.5}$ Emission Factor	Emission Factor Estimation Method
Starch Ethanol and Cellulosic Ethanol	0.068 tons/million gallons	0.084 tons/million gallons	Estimated using 2015 emissions of Pacific Ethanol's Madera and Stockton facilities,[90] and assuming production at 80% of capacity.
Renewable Diesel, Gasoline, Propane, and Jet Fuel	0.079 tons/million gallons	0.0178 tons/million gallons	Assumed to be the same as a simple oil refinery. Estimated using Kern oil refinery 2015 emissions,[91] and assuming production at 80% of capacity.
Biodiesel	0.008 tons/million gallons	0.007 tons/million gallons	Estimated using 2015 emissions of Crimson and American Biodiesel facilities,[92] and assuming production at 60% of capacity.
Dairy RNG	0.25 tons/ million DGE	0.079 tons/ million DGE	Assumed 10% of dairy digester gas is flared. Flaring emission factors from GREET 2016

[90] Facility emissions were obtained from CARB's Facility Search Engine: https://www.arb.ca.gov/app/emsinv/facinfo/facinfo.php?dd=. Accessed Nov 1st. 2017.
[91] Facility emissions were obtained from CARB's Facility Search Engine: https://www.arb.ca.gov/app/emsinv/facinfo/facinfo.php?dd=
[92] Facility emissions were obtained from CARB's Facility Search Engine: https://www.arb.ca.gov/app/emsinv/facinfo/facinfo.php?dd=

2. Methodology for Estimating Health Impacts

CARB analyzed the value associated with five health outcomes: cardiopulmonary[93] mortality, hospitalizations for cardiovascular[94] illness, hospitalizations for respiratory[95] illness, emergency room (ER) visits for respiratory illness, and ER visits for asthma.

Staff selected these health outcomes because U.S. EPA has identified these as having a *causal* or *likely causal* relationship with exposure to $PM_{2.5}$.[96] The 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.

The 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.[97] While other mortality endpoints could be analyzed, the strongest evidence exists for cardiopulmonary mortality.[98] 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.[99]

The US EPA has also determined a *causal* relationship between non-mortality cardiovascular effects and short and long-term exposure to $PM_{2.5}$, and a *likely causal* relationship between non-mortality respiratory effects (including worsening asthma) and short and long-term $PM_{2.5}$ exposure.[100] These outcomes lead to hospitalizations and ER visits, and are included in this analysis.

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[93] Outcomes related to the heart or lungs

[94] Outcomes related to the heart or blood vessels

[95] Respiratory illness such as chronic obstructive pulmonary disease, and respiratory infection

[96] U.S. EPA, 2010. *Quantitative Health Risk Assessment for Particulate Matter (Final Report).* https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf. Accessed Oct. 30th 2017.

[97] U.S. EPA, 2009. *Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009)*. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959. Accessed Oct. 30th 2017.

[98] U.S. EPA, 2009. *Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009)*. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959. Accessed Oct. 30th 2017.

[99] CARB, 2010. *Estimate of Premature Deaths Associated with Fine Particle Pollution ($PM_{2.5}$) in California Using a U.S. Environmental Protection Agency Methodology.* https://www.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf. Accessed Oct 31st 2017.

[100] U.S. EPA, 2009. *Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009)*. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959. Accessed Oct. 30th 2017.

In general, health studies have shown that populations with low socioeconomic standings are more susceptible to health problems from exposure to air pollution.[101,102] However, the models currently used by U.S. EPA and CARB do not have the granularity to account for this impact. The location and magnitude of projected emission reductions resulting from many proposed regulations are not known with sufficient accuracy to account for socioeconomic impacts, and an attempt to do so would produce uncertainty ranges so large as to make conclusions difficult. CARB acknowledges this limitation.

A detailed summary of the health modeling methodology is included in Appendix A of the CARB Proposed Regulatory Amendments to the Heavy-Duty Vehicle Inspection Program and Periodic Smoke Inspection Program SRIA.[103]

Emissions from alternative fuel production facilities and other stationary sources were multiplied by 0.2 to account for the difference in the way those emissions affect exposed populations compared to on-road vehicle emissions. Emissions from production facilities, which are released from tall stacks relatively distant from residential areas, are expected to result in lower impacts than emissions from motor vehicles at ground level, on roadways that run through residential neighborhoods. The factor of 0.2 was derived by comparing the intake fraction (IF) of the two sources.

IF is the fraction of total emissions of air pollutant that is inhaled by a receptor population during a certain time period, and is estimated by combining air pollutant concentration enhancement and population distribution near the source. The current study estimates IF of $PM_{2.5}$ from three major refineries located in Los Angeles County using the US EPA approved AERMOD model. The IF for refineries is then compared against published estimates of the IF of on-road diesel vehicles in the South Coast Air Basin to obtain the ratio of 20 percent.[104]

3. Methodology for Estimating Verification Costs

This section contains greater details on how staff estimated the cost of implementing the proposed third-party verification for different types of regulated parties.

a) Cost Surveys

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[101] Krewski et al., 2009. *Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality.* Health Effects Institute Research Report 140. https://ephtracking.cdc.gov/docs/RR140-Krewski.pdf.

[102] Gwynn, RC and Thurston, GD.,2001. *The burden of air pollution: impacts among racial minorities*. Environmental Health Perspectives;109(4):501–6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240572/. Accessed Oct. 31st 2017.

[103] CARB, 2017. *Proposed Regulatory Amendments to the Heavy-Duty Vehicle Inspection Program and Periodic Smoke Inspection Program SRIA.* http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/documents/CARB%20HDVIP%20PSIP%20SRIA.pdf. Accessed Oct. 31st 2017.

[104] Marshall, J.D., Teoh, S., and Nazaroff, W. 2003. *Intake fraction of primary pollutants: motor vehicle emissions in the South Coast Air Basin.* Atmospheric Environment 37 (2003) 3455–3468. http://uctc.berkeley.edu/research/papers/772.pdf. Accessed Oct. 31st 2017.

The cost survey asked each producer, importer, and verifier to identify potential activities, equipment, or data management systems that would be necessary for third-party verification, based on draft regulatory requirements discussed in stakeholder workshops held in 2016 and 2017. The survey asked for incremental costs – only those costs associated with the LCFS third-party verification program that would be additional to current costs for complying with other programs or regulations.

Using a spreadsheet supplied by CARB, respondents provided the number of hours by staff type (e.g., management, administrative, legal) that will be required to complete specific tasks to prepare for and conduct third-party verification. The number of hours for each staff category was then multiplied by the estimates of the cost for each staff category obtained from the Bureau of Labor Statistics (BLS) 2016 California data.[105] Staff calculated the labor costs using the sum of the total loaded staff time required to prepare for and conduct third party verification. In addition to the labor cost, staff included the cost of additional contractor and/or equipment costs that stakeholders anticipated would be needed to prepare for and conduct third party verifications and maintenance of any additional required equipment.

b) Producer Survey Binning

Fuel producers that participate in the LCFS program are heterogeneous, ranging from small facilities with fairly simple supply chains to large fuel producers with complex supply chains. To capture the cost of the verification program, staff categorized production facilities into small, medium, and large facilities and also by low, moderate, and high complexity fuel production processes. This categorization is important because process complexity will have a large impact on contracted cost for a third-party verifier. A low complexity facility would be one with a short chain of custody, an easily verifiable feedstock source and identity, and one or two fuel pathway codes[106] with few modes of transport. A moderate complexity facility would be a facility with a longer chain of custody and moderately challenging feedstock source and identity, three to five fuel pathway codes with more varied modes of transport. A highly complex facility would be one with a long chain of custody, challenging confirmation of feedstock source and identity, and six or more fuel pathway codes with complicated modes of transport.

An example of a high complexity facility would be one producing biodiesel from used cooking oils—collected from potentially hundreds of individual restaurants as well as aggregators and brokers, animal fats, and crop-based oils. Because of the use of multiple feedstocks, the producer may have ten to 15 different fuel pathway codes (FPCs). A low complexity facility example is ethanol from corn starch. The corn source will not require verification, and the process of fermenting corn starch to produce ethanol is well established and fairly straightforward. Such a facility may have only one or two FPCs.

c) Estimates of Verification Costs

[105] Bureau of Labor Statistics Occupational Employment Statistics May 2016 Occupational Profiles, https://www.bls.gov/oes/current/oes_stru.htm#11-0000, Accessed 6/16/2017.
[106] A fuel pathway code represents a given fuel with a distinct CI value. Under the LCFS, a producer of fuel that uses several different feedstocks will receive a separate CI value for fuel produced from each feedstock.

Table I4 provides representative ranges in estimated total verification costs for different fuel types. In general, large facilities with complex fuel production processes are estimated to have the highest costs for verification. The highest facility verification cost was approximately $97,000 per year. Across all fuel types the initial verification costs are the same as the on-going costs. Facilities participating in the voluntary third-party verification program developed by the U.S. EPA under its Renewable Fuel Standard Quality Assurance Plan (QAP) Program had lower verification costs as only the incremental verification activities and costs would be attributable to the LCFS.[107]

Table I4: Estimated Verification Costs for Fuel or Credit Generating Projects

Fuel or Credit Type	**Verification Cost Range**
Biodiesel and Renewable Diesel	$11,000 to $97,000
Starch Ethanol	$30,000 to $54,000
NG Fueling Stations	$2,000 for 1 to 10 stations $6,000 for 11 to 50 stations $8,000 for >50 stations
Landfill RNG	$16,000 to $36,000 plus verification for NG Fueling Stations (see above)
Dairy Digester RNG	$11,000 to $31,000
Hydrogen	$0 (CARB staff will conduct audits)
Electricity	$0 (CARB staff will conduct audits)
Innovative Crude	$7,000 per project
Refineries	$26,000
Liquid fuel importers and exporters	$8000 to $12,000

4. Methodology for Estimating the Effect of Health Benefits on State Finances.

This section contains a discussion on how staff calculated the effect of health benefits on State finances. Staff expects modest decreases in the State's expenditure on health care due to improved air quality in the State from implementing the proposed amendments.

The projected changes in hospital visits affect general fund costs through changes in State Medi-Cal expenditures. A potential method to estimate the changes in general fund costs is multiplying the change in hospital expenditures by the Medi-Cal's share of California's hospital care expenditures and by the State's share of Medi-Cal spending.

[107] The Quality Assurance Plan (QAP) is a voluntary program where independent third-parties may audit and verify that RINs have been properly generated and are valid for compliance purposes. RINs verified under a QAP may be purchased by regulated parties. Renewable identification numbers (RINs) are credits used for compliance, and are the "currency" of the RFS program. https://www.epa.gov/renewable-fuel-standard-program/renewable-identification-numbers-rins-under-renewable-fuel-standard. Accessed: Nov 1st, 2017

Specifically,

$$\Delta General\ Fund\ Costs = \Delta Hosptial\ Expenditures \times \left(\frac{M}{C}\right) \times S$$

where M is the value of Medi-Cal hospital care spending in California (including both State and federal funds), C is the total value of hospital care expenditures in California, and S is the State share of Medi-Cal spending. This approach assumes that hospitalizations and ER visits due to respiratory conditions and asthma will fall under the expenditure classification of hospital care as categorized by the Centers for Medicare and Medicaid Services. In addition, this methodology assumes that individuals utilizing hospital care due to asthma or respiratory conditions are no more or no less likely to be insured through Medi-Cal than individuals in the general population. Finally, the methodology assumes that the State share of Medi-Cal spending on hospital care is the same as the share of State spending on Medi-Cal as a whole. There is insufficient information about the distribution of health impacts and year to year budget details to further refine these assumptions.

Data on hospital care spending in California is available from the Centers for Medicare and Medicaid Services, Office of the Actuary, National Health Statistics Group. From 2010 through 2014 (the most recent year with reported data), the ratio of Medi-Cal expenditures on hospital care to total expenditures on hospital care has increased from 19.6 to 23.1 percent, an average annual growth rate of 4.8 percent.[108] Extrapolating this out to 2016 would imply a ratio of 25.4 percent.

In 2014, the State share of Medi-Cal expenditures was 43.6 percent.[109] This percentage has increased in the past few years, in part due to the Affordable Care Act (ACA) optional expansion and the federal medical assistance percentages assigned to the ACA optional expansion population.[110] In 2016, the State share of Medi-Cal expenditures was 35.9 percent.[111] This share may increase over the next several years as the federal medical assistance percentages assigned to the ACA optional expansion population declines.

5. Qualitative Discussion of Other Pollutant Emissions and Health Outcomes

The potential substitution from fossil fuels to electricity, hydrogen, natural gas and liquid biofuels may result in decreases in other criteria pollutants and toxics associated with gasoline tailpipe emissions and refueling infrastructure. Fossil fuels contain BTEX compounds, benzene, toluene, ethyl benzene, and xylenes, which can be emitted to the air and also contaminate soil and water. Gasoline-engine exhaust contains benzene, 1,3-butadiene,

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[108] Centers for Medicare & Medicaid Services, 2017. *Health Expenditures by State of Provider*. http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/provider-state2014.zip. Accessed Jul. 11th 2017.

[109] Medicaid. https://www.medicaid.gov/medicaid/financing-and-reimbursement/state-expenditure-reporting/expenditure-reports/index.html. Accessed Nov. 1st 2017.

[110] Legistlative Analyst's Office. *Analysis of the Medi-cal Budget/* http://www.lao.ca.gov/Publications/Report/3612#Governor.2019s_Budget_Caseload_Projections. Accessed Nov. 1st 2017.

[111] The Henry J. Kaiser Family Foundation. *Federal and State Share of Medicaid Spending* http://www.kff.org/medicaid/state-indicator/federalstate-share-of-spending/?currentTimeframe=0&selectedRows=%7B%22states%22:%7B%22california%22:%7B%7D%7D%7D&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D#notes

formaldehyde, and acetaldehyde. Diesel-engine exhaust contains not only diesel particulate matter, which is a toxic air contaminant (TAC), but also poly-nuclear (polycyclic) aromatic hydrocarbons (PAHs). Generally, all exhaust from the combustion of hydrocarbon fuels contains benzene as a product of incomplete combustion (PIC). Staff expects decreases in these criteria pollutants and toxics due to decreased use of fossil fuels to occur in regions with heavy use of motor vehicles and diesel engines, such as big population centers (e.g., South Coast) and areas with heavy truck use (San Joaquin Valley).

The substitution from fossil jet fuel to alternative jet fuel might also contribute to a decrease in the emission of criteria pollutants and toxics, especially around airports with heavy air traffic. Alternative jet fuels derived from hydrotreating of vegetable oils and animal fats do not contain any aromatic compounds (benzene, naphthalene, and methylnaphthalene),[112] and emit less sulfur oxides (SOx) when compared to fossil jet fuel. However, it is unclear whether alternative jet fuels emit less or more carbon monoxide (CO) or unburned hydrocarbons than fossil jet fuels. The U.S. EPA National Ambient Air Quality Standards (NAAQS) include standards for CO, and California is in attainment for all air basins. Given California is in attainment and the small volumes of alternative jet fuel anticipated to be used as a result of the proposed amendments, any impacts on CO emissions are expected to be negligible.

The proposed amendments might result in the increased production of ethanol, biodiesel and renewable diesel and biomethane in California. This may lead to an increase in emissions associated with the production of these fuels. Any new facilities would be required to follow all State and local emission standards to protect public health and the environment.

The proposed amendments might lead to the investment in solar steam generation projects, which will substitute for steam generation using natural gas boilers. This is likely to lead to a net reduction in local pollutant emissions. The potential reduction in these criteria pollutants will mostly affect regions with a high concentration of oil fields that require steam, such as the San Joaquin Valley air basin.

6. Occupational Exposure

Increased use of alternative jet fuels might decrease the occupational exposure of airport workers and frequent fliers to many criteria pollutants and toxics, but may slightly increase exposure to CO. Workers in ethanol, biodiesel, renewable diesel, and dairy digester facilities may be exposed to slightly higher levels of pollutants than if they worked at alternative sites not substantially impacted by air pollutants. Increased use of renewable diesel and biodiesel as transportation fuels might lead to a decrease emissions from vehicles, which will benefit those who work around truck traffic, such as dockworkers, truck drivers, railyard workers, and construction workers. Staff cannot quantify the potential effect on occupational exposure due to lack of data on the typical occupational exposure for these types of workers and uncertainty in geographic location of alternative fuel production and use.

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[112] Boeing Company, UOP, U.S. Air Force Research Laboratory, 2011. *Evaluation of Bio-Derived Synthetic Paraffinic Kerosenes (Bio2SPK), Committee D02 on Petroleum Products and Lubricants, Subcommittee D02.J0.06 on Emerging Turbine Fuels, Research Report D02-1739, ASTM International, West Conshohocken, PA, 28 June 2011.*

The California Division of Occupational Safety and Health (Cal/OSHA) does not have a permissible exposure limit (PEL) specifically for diesel PM. Still, CARB recognizes that workers that use portable diesel-powered equipment, such as power generators, pumps, compressors, pile-driving hammers, welders, cranes, wood chippers and dredgers, may be at risk to occupational diesel particulate matter exposure. Studies have shown occupational exposure to be lower when diesel engines meet higher emissions standards. The Proposed Amendments Scenario results in lower emissions in most years, which will reduce occupational exposure to diesel PM. Staff cannot quantify this effect due to lack of data on the typical occupational exposure for these types of portable equipment.

J. MACROECONOMICS APPENDIX

1. Fuel Expenditure Assumptions and Methodology

Fuel prices and the quantity of fuels consumed in California are both projected to change as a result of the proposed amendments. Fuel prices change as a result of pass through of deficit costs or credit revenue as described in Section C5: Direct Cost Pass-Through. Fuel volumes change as a result of changing demand for low carbon intensity fuels, estimated using the BFSM model as described in Section A5: Baseline and Proposed Amendments Scenarios. These changes will affect fuel expenditures for all households, businesses, and government fleets in the California economy.

To model the effect of these expenditure changes on the economy, the changes in expenditures for each fuel are split between households, businesses, and government agencies before being input into the REMI model. Fuels that are classified as gasoline substitutes are starch ethanol, sugar ethanol, cellulosic ethanol, renewable gasoline, hydrogen used for light duty vehicles, and electricity used for light duty vehicles. Expenditures on these fuels are allocated to households, businesses, and government based on estimates of relative gasoline and ethanol use. Fuels that are classified as diesel substitutes are biodiesel, renewable diesel, conventional and renewable natural gas, hydrogen used in heavy duty vehicles, electricity used in heavy duty vehicles, electricity used in rail and forklift applications, renewable propane, and conventional propane. Expenditures on these fuels are allocated among households, businesses, and government based on estimates of relative diesel fuel use.

The proportion of fuel used by households is estimated using 2015 fuel combustion volumes by sector from the CARB Greenhouse Gas Emission Inventory.[113] Household use of gasoline and its substitutes is assumed to be proportional to the volume of gasoline and ethanol used in motorhomes, light-duty trucks and SUVs, motorcycles, and passenger cars, relative to the total volumes of in-state gasoline and ethanol used.[114] Household use of diesel and its substitutes is assumed to be proportional to the volume of diesel fuel used in motorhomes, light-duty trucks, passenger cars, and residential applications relative to the total volumes of diesel used.

The proportion of gasoline and diesel used by the State government is based on the most recently available fuel purchasing data from the Department of General Services.[115] The ratio of State government consumption to total consumption is estimated by comparing gasoline and diesel volumes consumed by the State in 2012 to total gasoline and diesel volumes consumed in California in 2012. This ratio is used for each year in the analysis.

The proportion of gasoline and diesel used by local government is estimated by scaling State government fuel use by the ratio of local government fleet size to State government fleet size.

[113] CARB, 2017. *2017 Edition of CARB's GHG Emission Inventory, fuel combustion activity data.* https://www.arb.ca.gov/cc/inventory/data/tables/fuel_activity_inventory_by_sector_all_00-15.xlsx

[114] Business and government also uses light-duty vehicles and passenger cars. Assigning all of this activity to households may overestimate expenditures to households.

[115] California Department of General Services. *Progress Report for Reducing or Displacing the Consumption of Petroleum Products by the State Fleet*. https://www.documents.dgs.ca.gov/ofa/ab236/ab2362016report(final).pdf. Accessed: 09/12/17.

Data for this calculation is based on 2015 California Energy Commission records.[116] In 2015, local government owned 4.84 times more vehicles than State government.

The remaining proportion of in-state gasoline and diesel is assumed to be used by business. This includes agriculture and forestry applications, commercial and industrial applications, fuel used in heavy duty transportation, and fuel used in aviation and water-borne crafts. The resulting proportions of gasoline and diesel fuel use by households, business, local government, and State government are reported Table J1.

Table J1: Households, Business, and Government Share of Fuel Use*

	Households	Business	Local Government	State Government
Gasoline and its substitutes	93%	6%	1%	<1%
Diesel and its substitutes	2%	97%	1%	<1%

** Totals may not add due to rounding*

Household fuel expenditures are modeled as a change in consumer spending in the categories of motor vehicle fuels, lubricants, and fluids, electricity, and natural gas. Changes in fuel expenditures by State and local government fleets for each fuel category are aggregated together and modeled as a change in State government spending or local government spending.

Changes in fuel expenditures for businesses and industrial operations within California are modeled as a change in production costs. These expenditures are spread across 156 private non-farm[117] industries based on REMI's input-output (IO) table and estimates of total output for each industry. The total expenditures on fuels is allocated based on each industries' use of petroleum and truck transportation relative to the total for all 156 industries, as estimated in the REMI IO table. Some fuels are not used exclusively for transportation purposes, but may instead be used in commercial and industrial applications. Therefore, petroleum as an intermediate input, which is not restricted to transportation fuels, is used as a proxy for gasoline, ethanol, renewable gasoline, diesel, biodiesel, and renewable diesel fuel use.[118] Truck transportation as an intermediate input is used as a proxy for the use of hydrogen, natural gas, electricity, and propane fuel expenditures because these fuels are anticipated to be used exclusively for transportation.

[116] CEC Communication, June 14, 2017.

[117] The Farm sector is also a user of fuel. However, the REMI model does not include the ability to change production costs in this sector and intermediate purchases from the Farm sector to other industries are not included in the model's inter-industry transactions. Excluding the Farm sector when spreading expenditures across the remaining industries will overestimate in the changes in expenditures to all other industries and underestimate the impact of the proposed amendments on farm employment and farm output.

[118] The REMI model does not distinguish between petroleum used for aviation purposes, such as aviation gasoline and jet fuel, and other uses of petroleum, such as gasoline or diesel used in ground support equipment. Because aviation gasoline and jet fuel prices are not anticipated to change as a result of the LCFS, the value of petroleum used in the air transportation industry is adjusted to exclude aviation fuel and jet fuel. CARB's 2017 GHG Emission Inventory indicates that on average, jet fuel and aviation gasoline make up 75 percent of air transportation industries' fuel use. The value of petroleum as an intermediate input is scaled down to only reflect that only 25 percent of total fuel used will be petroleum that would be impacted by the LCFS.

An input-output (IO) table is a matrix that describes the value of capital, labor, energy, and intermediate inputs that is required to create one dollar of output in a specific industry.[119] The REMI model's IO table describes the value of intermediate inputs needed to create one dollar of output for each industry.[120] For example, the IO table includes the value of petroleum and truck transportation that is needed to produce one dollar of output. The intermediate input is then multiplied by the total output for each industry to get the total expenditure on petroleum and truck transportation by industry. The sum of all industries gives the total value of petroleum and truck transportation used by all 156 industries, and the relative proportion used by each industry can be calculated. The percentage of petroleum and truck transportation based on this methodology are include in Table J2.

Each industries' change in expenditures on fuels is then estimated as:

$$E_{i,t} = P_{i,petroleum} \times E_{F1,t} + P_{i,truck} \times E_{F2,t}$$

Where $E_{i,t}$ is the change in expenditures on fuels by industry i at time t, $P_{i,petroleum}$ is industry i's percent of total spending on petroleum relative to all 156 industries, $P_{i,truck}$ is industry i's percent of total spending on truck transportation relative to the all 156 industries, $E_{F1,t}$ is the total change in expenditures by all businesses on gasoline, ethanol, renewable gasoline, diesel, biodiesel, and renewable diesel, and $E_{F2,t}$ is the total change in expenditures by all businesses on hydrogen, natural gas, electricity, and propane.

Table J2. Estimated Proportion of Petroleum and Truck Transportation Expenditures

Sector	NAICS Code	$P_{i,petroleum}$	$P_{i,truck}$
Forestry; Fishing, hunting, trapping	1131, 1132, 114	0.15%	0.03%
Logging	1133	0.08%	0.12%
Support activities for agriculture and forestry	115	0.13%	0.33%
Oil and gas extraction	211	0.00%	0.07%
Coal mining	2121	0.00%	0.00%
Metal ore mining	2122	0.06%	0.02%
Nonmetallic mineral mining and quarrying	2123	0.32%	0.05%
Support activities for mining	213	0.18%	0.08%
Electric power generation, transmission, and distribution	2211	0.00%	0.20%
Natural gas distribution	2212	0.00%	0.01%
Water, sewage, and other systems	2213	0.06%	0.01%
Construction	23	20.83%	12.63%
Sawmills and wood preservation	3211	0.04%	0.18%
Veneer, plywood, and engineered wood product manufacturing	3212	0.05%	0.10%
Other wood product manufacturing	3219	0.10%	0.50%
Clay product and refractory manufacturing	3271	0.02%	0.03%
Glass and glass product manufacturing	3272	0.13%	0.30%
Cement and concrete product manufacturing	3273	0.19%	0.93%
Lime, gypsum and other nonmetallic mineral product manufacturing	3274, 3279	0.10%	0.25%
Iron and steel mills and ferroalloy manufacturing	3311	0.12%	0.43%
Steel product manufacturing from purchased steel	3312	0.03%	0.07%

[119] For more information on input-output methodologies in general, see Horowtiz, Karen J. and Planting, Mark ,A., 2009. *Concepts and Methods of the Input-Output Account.* U.S. Department of Commerce, Bureau of Economic Analysis https://www.bea.gov/papers/pdf/IOmanual_092906.pdf. Accessed Nov. 9th 2017.
[120] Documentation of data sources and methodology behind REMI's IO table can be found at: http://www.remi.com/resources/documentation. Accessed Nov. 1st 2017.

Sector	NAICS Code	$P_{i,petroleum}$	$P_{i,truck}$
Alumina and aluminum production and processing	3313	0.03%	0.20%
Nonferrous metal (except aluminum) production and processing	3314	0.02%	0.59%
Foundries	3315	0.01%	0.07%
Forging and stamping	3321	0.05%	0.20%
Cutlery and handtool manufacturing	3322	0.01%	0.03%
Architectural and structural metals manufacturing	3323	0.09%	0.58%
Boiler, tank, and shipping container manufacturing	3324	0.02%	0.15%
Hardware manufacturing	3325	0.01%	0.06%
Spring and wire product manufacturing	3326	0.00%	0.03%
Machine shops; turned product; and screw, nut, and bolt manufacturing	3327	0.09%	0.37%
Coating, engraving, heat treating, and allied activities	3328	0.14%	0.17%
Other fabricated metal product manufacturing	3329	0.06%	0.28%
Agriculture, construction, and mining machinery manufacturing	3331	0.03%	0.17%
Industrial machinery manufacturing	3332	0.05%	0.50%
Commercial and service industry machinery manufacturing	3333	0.70%	0.22%
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	3334	0.03%	0.19%
Metalworking machinery manufacturing	3335	0.01%	0.08%
Engine, turbine, power transmission equipment manufacturing	3336	0.06%	0.55%
Other general purpose machinery manufacturing	3339	0.09%	0.40%
Computer and peripheral equipment manufacturing	3341	0.08%	0.50%
Communications equipment manufacturing	3342	0.05%	0.38%
Audio and video equipment manufacturing	3343	0.01%	0.13%
Semiconductor and other electronic component manufacturing	3344	0.18%	0.50%
Navigational, measuring, electromedical, and control instruments manufacturing	3345	0.12%	0.68%
Manufacturing and reproducing magnetic and optical media	3346	0.00%	0.02%
Electric lighting equipment manufacturing	3351	0.07%	0.08%
Household appliance manufacturing	3352	0.01%	0.04%
Electrical equipment manufacturing	3353	0.07%	0.10%
Other electrical equipment and component manufacturing	3359	0.18%	0.34%
Motor vehicle manufacturing	3361	0.02%	0.59%
Motor vehicle body and trailer manufacturing	3362	0.00%	0.03%
Motor vehicle parts manufacturing	3363	0.05%	0.41%
Aerospace product and parts manufacturing	3364	0.27%	1.15%
Railroad rolling stock manufacturing	3365	0.01%	0.06%
Ship and boat building	3366	0.01%	0.05%
Other transportation equipment manufacturing	3369	0.05%	0.50%
Household and institutional furniture and kitchen cabinet manufacturing	3371	0.07%	0.48%
Office furniture (including fixtures) manufacturing; Other furniture related product manufacturing	3372, 3379	0.05%	0.33%
Medical equipment and supplies manufacturing	3391	0.25%	0.84%
Other miscellaneous manufacturing	3399	0.25%	1.01%
Animal food manufacturing	3111	0.04%	0.56%
Grain and oilseed milling	3112	0.17%	1.90%
Sugar and confectionery product manufacturing	3113	0.20%	0.39%
Fruit and vegetable preserving and specialty food manufacturing	3114	0.28%	1.50%
Dairy product manufacturing	3115	0.21%	3.34%
Animal slaughtering and processing	3116	0.03%	1.80%
Seafood product preparation and packaging	3117	0.01%	0.11%

Sector	NAICS Code	$P_{i,petroleum}$	$P_{i,truck}$
Bakeries and tortilla manufacturing	3118	0.15%	0.42%
Other food manufacturing	3119	0.25%	1.84%
Beverage manufacturing	3121	0.63%	2.82%
Tobacco manufacturing	3122	0.01%	0.06%
Textile mills and textile product mills	313, 314	0.08%	0.44%
Apparel manufacturing; Leather and allied product manufacturing	315, 316	0.08%	1.07%
Pulp, paper, and paperboard mills	3221	0.22%	0.17%
Converted paper product manufacturing	3222	0.23%	0.88%
Printing and related support activities	323	0.79%	0.45%
Petroleum and coal products manufacturing	324	0.00%	2.72%
Basic chemical manufacturing	3251	4.65%	1.32%
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	3252	1.96%	0.53%
Pesticide, fertilizer, and other agricultural chemical manufacturing	3253	0.86%	0.31%
Pharmaceutical and medicine manufacturing	3254	0.65%	1.11%
Paint, coating, and adhesive manufacturing	3255	0.46%	0.22%
Soap, cleaning compound, and toilet preparation manufacturing	3256	0.58%	0.50%
Other chemical product and preparation manufacturing	3259	0.79%	0.30%
Plastics product manufacturing	3261	0.49%	1.04%
Rubber product manufacturing	3262	0.06%	0.13%
Wholesale trade	42	1.70%	4.03%
Retail trade	44-45	1.74%	12.57%
Air transportation*	481	4.16%	0.37%
Rail transportation	482	1.20%	0.09%
Water transportation	483	3.09%	0.29%
Truck transportation	484	23.17%	2.99%
Couriers and messengers	492	3.21%	0.43%
Transit and ground passenger transportation	485	1.91%	0.12%
Pipeline transportation	486	0.08%	0.01%
Scenic and sightseeing transportation and support activities	487, 488	1.14%	1.09%
Warehousing and storage	493	0.39%	0.30%
Newspaper, periodical, book, and directory publishers	5111	0.03%	0.33%
Software publishers	5112	0.07%	0.30%
Motion picture, video, and sound recording industries	512	0.10%	0.34%
Data processing, hosting, related services, and other information services	518, 519	0.33%	1.98%
Broadcasting (except internet)	515	0.07%	0.24%
Telecommunications	517	0.34%	1.31%
Monetary authorities, credit intermediation, and related activities	521, 522	0.40%	0.06%
Funds, trusts, and other financial vehicles	525	0.00%	0.00%
Securities, commodity contracts, and other financial investments and related activities	523	0.11%	0.29%
Insurance carriers	5241	0.00%	0.06%
Agencies, brokerages, and other insurance related activities	5242	0.01%	0.10%
Real estate	531	1.29%	1.33%
Automotive equipment rental and leasing	5321	0.59%	0.08%
Consumer goods rental and general rental centers	5322, 5323	0.07%	0.06%
Commercial and industrial machinery and equipment rental and leasing	5324	0.09%	0.11%
Lessors of nonfinancial intangible assets (except copyrighted works)	533	0.03%	0.25%
Legal services	5411	0.05%	0.14%

Sector	NAICS Code	$P_{i,petroleum}$	$P_{i,truck}$
Accounting, tax preparation, bookkeeping, and payroll services	5412	0.05%	0.19%
Architectural, engineering, and related services	5413	0.35%	0.65%
Specialized design services	5414	0.04%	0.21%
Computer systems design and related services	5415	0.24%	0.22%
Management, scientific, and technical consulting services	5416	0.07%	0.74%
Scientific research and development services	5417	0.72%	1.08%
Advertising and related services	5418	0.13%	0.53%
Other professional, scientific, and technical services	5419	0.10%	0.22%
Management of companies and enterprises	55	0.68%	0.36%
Office administrative services; Facilities support services	5611, 5612	0.10%	0.10%
Employment services	5613	0.01%	0.05%
Business support services; Investigation and security services; Other support services	5614, 5616, 5619	0.18%	0.32%
Travel arrangement and reservation services	5615	0.02%	0.06%
Services to buildings and dwellings	5617	2.10%	0.39%
Waste management and remediation services	562	0.90%	0.60%
Educational services	61	0.61%	0.59%
Offices of health practitioners	6211-6213	0.45%	0.69%
Outpatient, laboratory, and other ambulatory care services	6214, 6215, 6219	0.21%	0.42%
Home health care services	6216	0.05%	0.08%
Hospitals	622	1.95%	0.88%
Nursing and residential care facilities	623	0.52%	0.29%
Individual and family services; Community and vocational rehabilitation services	6241-6243	0.31%	0.43%
Child day care services	6244	0.18%	0.13%
Performing arts companies; Promoters of events, and agents and managers	7111, 7113, 7114	0.13%	0.12%
Spectator sports	7112	0.03%	0.02%
Independent artists, writers, and performers	7115	0.04%	0.17%
Museums, historical sites, and similar institutions	712	0.06%	0.06%
Amusement, gambling, and recreation industries	713	0.73%	0.52%
Accommodation	721	0.47%	0.41%
Food services and drinking places	722	1.67%	3.39%
Automotive repair and maintenance	8111	0.34%	0.49%
Electronic and precision equipment repair and maintenance	8112	0.06%	0.08%
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	8113	0.05%	0.07%
Personal and household goods repair and maintenance	8114	0.05%	0.12%
Personal care services	8121	0.10%	0.15%
Death care services	8122	0.01%	0.05%
Drycleaning and laundry services	8123	0.53%	0.09%
Other personal services	8129	0.11%	0.22%
Religious organizations; Grantmaking and giving services, and social advocacy organizations	8131-8133	0.25%	0.10%
Civic, social, professional, and similar organizations	8134, 8139	0.21%	0.06%

* The air transportation sector's proportion of petroleum has been adjusted exclude petroleum used in jet fuel and aviation gasoline. See Section J1, footnote 130 for details.

2. Detailed REMI Input Data

To best reflect the interaction of economic variables using REMI, CARB has employed the production cost variable to reflect credits and deficits generated by regulated parties, capacity expansion costs, verification requirement costs, and changes in business fuel expenditures. The consumer spending variable is used to mimic changes in household fuel expenditures and to model health benefits due to the proposed amendments' contributions to reduced NOx and PM2.5 emissions. The State and local spending variables are used to simulate the impact of the proposed amendments on State and local tax revenue, fuel expenditures, and LCFS credit revenue generated by local government entities. The exogenous final demand variable is used to emulate increased demand for construction services to meet capacity expansion needs, increased demand for verification services to meet verification requirements, and changes in demand for different fuels as the LCFS incentivizes higher volumes of low-CI fuels and disincentives consumption of high-CI fuels in California.

This section includes the detailed REMI input data used to model the macroeconomic impacts of the proposed amendments. All inputs are presented as the annual incremental change relative to the baseline.

a) Baseline Adjustments

The baseline established by REMI is adjusted with the California Department of Finance conforming forecast dated June 2017, which includes California population figures, a U.S. real GDP forecast, and civilian employment growth numbers. In addition, the national baseline is adjusted to account for credit revenue and deficit cost that is generated by industries outside of California. The policy variables and industries chosen for this additional adjustment are the same as those described in the next section.

b) Direct Impacts of the Proposed Amendments

i. <u>LCFS Compliance: Credit or Deficit Generation and Change in Demand for Fuels</u>

Both conventional and alternative fuel producers will experience changes in demand for fuels which affect production volumes and will either face production costs associated with deficit generation or face increased revenues from credit generation. The detailed REMI inputs used to estimate these impacts to fuel producers are included in Table J3.

The production cost policy variable is used to account for a change in operating costs for industries that generate LCFS deficits or credits. Table E2 illustrates the value of credits revenue and deficit cost that is generated by industries within California.[121] REMI organizes industries by NAICS codes and each code nets the effects to several fuel producers. The NAICS code representing petroleum and coal products manufacturing (324) is used to represent deficits generated by CARBOB gasoline and diesel and to represent credits generated by conventional propane, refinery investments, refinery renewable hydrogen, and innovative crude. This industry typically sees a decrease in operating costs in early years of

[121] Credit revenue and deficit cost that is generated by industries outside of California is accounted for with an additional adjustment to REMI's national baseline to reflect production cost changes in the same industries discussed below.

both scenarios. From 2019 to 2021, the decrease in operating costs is associated with more credits from propane and innovative crude. From 2022 to 2024, the decrease in operating costs is associated with lower credit prices in the scenarios relative to baseline.

Low-CI fuel producers that generate credits are grouped into four NAICS codes: basic chemical manufacturing (3251), natural gas distribution (2212), waste management and remediation services (562), and electric power generation, transmission, and distribution (2211). Changes in the production costs to basic chemical manufacturing industry is used to represent credits generated from: starch ethanol, sugar ethanol, cellulosic ethanol, renewable gasoline, hydrogen, biodiesel, renewable diesel, renewable propane, and alternative jet fuel. Changes in the production costs to the natural gas distribution industry is used to represent credits generated from conventional natural gas and dairy natural gas. Changes in production costs to the waste management and remediation service industry is used to represent credits generated from landfill natural gas. Changes in the production costs to the electric power generation, transmission, and distribution industry is used to represent credits generated from electricity used in transportation.

The producers of low-CI fuel typically see a reduction in production costs in the later years of the policy due to higher credit revenue. However, from 2022 to 2024, these fuel producers see an increase in production costs relative to the baseline. This reflects higher credit prices in the baseline from 2022 to 2024 which provides more credit revenues.

The exogenous final demand REMI variable is used to represent changes in value of production for each fuel type that results from changes in business and government expenditures on the fuels.[122] This change in the value of production represents both changes in the volumes of fuel consumed in California and the changes in the price of fuel due to the proposed amendments. The change in production value due to household expenditures on fuels is accounted for through the consumer spending variable and is detailed in Section J6.

Table A2 shows decreases in exogenous final demand to the petroleum and coal products manufacturing industry. This reflects decreases in volume of diesel fuel consumed under the proposed amendments. The decrease in demand to the petroleum and coal products manufacturing industry is mirrored by increases in demand in the basic chemicals manufacturing industry and natural gas distribution industry. This reflects increased volumes of low-CI alternative fuels that substitute for fossil diesel gasoline.

The increases in demand for the natural gas distribution industry reflects increases in production volumes of dairy natural gas. This is mirrored by a decrease in demand in the waste management and remediation services industry, reflecting decreased production of landfill natural gas. In addition, within the natural gas distribution industry, there is a transfer of production value from conventional natural gas producers to dairy natural gas producers. These effects net to zero when combined in the same NAICS code.

[122] For fossil gasoline specifically, the change in the value of demand is instead modeled as a decrease in production costs. This reflects the assumption that higher fuel prices will be used to offset deficits generated by fossil gasoline producers.

Decreases in the value of demand in the electric power generation, transmission, and distribution industry reflects decreased prices of electricity used in heavy duty applications due to pass through of the LCFS credits.

Table J3: REMI Inputs to Simulate LCFS Compliance (Million 2016$)

REMI Category	Industry (NAICS)	Explanation	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Production Cost	Petroleum and coal products manufacturing (324)	Deficits from fuel production and refinery credits	-1.78	-30.87	-80.16	-1030.23	-852.61	-33.75	667.60	905.25	1627.19	2201.59	2318.94	2438.00
Production Cost	Basic chemical manufacturing (3251)	Credit generation	-25.55	-41.47	-53.85	94.45	110.12	-0.32	-83.20	-110.14	-201.70	-279.56	-280.35	-279.38
Production Cost	Natural gas distribution (2212)	Credit generation	-	-	-	4.07	-2.36	-16.94	-33.65	-47.50	-75.26	-111.98	-136.05	-144.08
Production Cost	Waste management and remediation services (562)	Credit generation	-	-	-	0.86	0.98	0.35	-0.17	-0.27	-0.74	-1.00	-0.91	-0.89
Production Cost	Electric power generation, transmission, and distribution (2211)	Credit generation	0.00	0.00	0.00	79.47	94.29	29.35	-29.20	-52.01	-133.40	-209.41	-228.58	-249.66
Exogenous Final Demand	Petroleum and coal products manufacturing (324)	Change in production volumes*	19.91	9.63	1.77	-218.55	-185.34	6.45	-226.46	-548.85	-1162.72	-1807.24	-1800.38	-1807.94
Exogenous Final Demand	Basic chemical manufacturing (3251)	Change in production volumes*	65.20	97.21	149.95	85.27	143.31	425.26	1025.47	1465.53	2374.82	3268.92	3327.16	3406.36
Exogenous Final Demand	Natural gas distribution (2212)	Change in production volumes*	-	-	-	4.53	14.63	24.22	23.34	35.15	35.61	59.44	83.63	80.35
Exogenous Final Demand	Waste management and remediation services (562)	Change in production volumes*	-	-	-	-4.53	-14.63	-21.87	-21.78	-33.81	-34.73	-58.80	-82.98	-79.69
Exogenous Final Demand	Electric power generation, transmission, and distribution (2211)	Change in production volumes*	-	-	-	23.76	26.28	7.99	-7.89	-14.09	-37.62	-59.01	-64.26	-69.56

* This change in production volume is due to business and government expenditures only. Changes in production volumes due to consumer expenditures on fuels are accounted for by REMI when adjusting the consumer spending variable. Changes in consumer spending are detailed in Table J6.

ii. Third-Party Verification

As outlined in Section C - Direct Costs, third-parity verification requirements will increase operating costs for fuel producing industries. Higher verification costs are modeled as an increase in production cost to the three industry NAICS codes anticipated to bear these costs: petroleum and coal products manufacturing (324), basic chemical manufacturing (3251), and natural gas distribution (2212).

Demand for verification services will also grow as a result of the proposed verification requirements. This demand is modeled as an increase in exogenous final demand for management, scientific, and technical consulting services (NAICS 5416). Aggregated costs for third-party verification services, and the corresponding increase in demand, are outlined in Table J4.

Table J4: REMI Inputs to Simulate Third-Party Verification Requirements (Million 2016$)

REMI Category	Industry (NAICS)	Explanation	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Production Cost	Petroleum and coal products manufacturing (324)	Third-party verification costs	0.31	0.33	0.34	0.35	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Production Cost	Basic chemical manufacturing (3251)	Third-party verification costs	0.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Production Cost	Natural gas distribution (2212)	Third-party verification costs	0.25	0.27	0.31	0.33	0.40	0.54	0.69	0.90	0.92	0.92	0.94	0.96
Production Cost	Management, Scientific, and Technical Consulting Services (5416)	Demand for third-party verification services	0.85	0.90	0.96	0.99	1.07	1.21	1.36	1.57	1.59	1.59	1.61	1.63

c) Changes in Fuel Expenditures

As detailed in Section J1 (Macro appendix section 1), Consumers, government fleets, and businesses will face changes in expenditures on fuels due to changes in the prices and quantities of fuels consumed as a result of the proposed amendments.

Changes in consumer expenditures on fuel are modeled through the consumer spending category in the areas of motor vehicle fuels and lubricants, natural gas, and electricity. The total consumer budget will remain the same, but the changes in consumer spending on these three categories are offset by and increase or decrease in spending in all other consumption categories. The REMI model adjusts production and the resulting intermediate demand in for these categories to account for the changes in consumer spending. In addition, electricity credits generated from light duty vehicle use are assumed to be rebated to consumers two years after they are generated. This transfer is modeled as an increase in all consumer spending categories.

Changes in expenditures on fuel by State and local government are modeled as changes in State and local government spending. Changes in business expenditures on fuel are modeled as a change in production costs.

REMI inputs for businesses are described in Table J5. REMI inputs for consumers and government spending are described in Table J6.

Table J5: REMI Inputs to Simulate Change in Fuel Expenditures by Industry (Million 2016$). All Values Modeled as a Production Cost.

Detail	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forestry; Fishing, hunting, trapping (1131, 1132, 114)	0.02	0.02	0.02	-0.56	-0.49	0.04	0.45	0.62	1.1	1.5	1.6	1.7
Logging (1133)	0.08	0.08	0.08	-0.19	-0.15	0.11	0.30	0.38	0.60	0.78	0.82	0.87
Support activities for agriculture and forestry (115)	0.21	0.21	0.21	-0.21	-0.13	0.28	0.58	0.72	1.1	1.3	1.4	1.5
Oil and gas extraction (211)	0.05	0.05	0.05	0.07	0.07	0.06	0.05	0.04	0.03	0.01	0	0
Coal mining (2121)	0	0	0	0	0	0	0	0	0	0	0	0
Metal ore mining (2122)	0.01	0.01	0.01	-0.21	-0.18	0.02	0.17	0.24	0.43	0.58	0.62	0.65
Nonmetallic mineral mining and quarrying (2123)	0.03	0.03	0.03	-1.2	-1	0.08	0.91	1.3	2.3	3.1	3.3	3.5
Support activities for mining (213)	0.05	0.05	0.05	-0.63	-0.54	0.08	0.55	0.76	1.3	1.8	1.9	2
Electric power generation, transmission, and distribution (2211)	0.13	0.13	0.13	0.19	0.2	0.17	0.13	0.12	0.07	0.02	0.01	0
Natural gas distribution (2212)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0
Water, sewage, and other systems (2213)	0.01	0.01	0.01	-0.22	-0.19	0.02	0.18	0.25	0.44	0.6	0.64	0.67
Construction (23)	8.1	8	8.1	-68	-58	13	66	89	151	205	217	229
Sawmills and wood preservation (3211)	0.11	0.11	0.11	0.03	0.06	0.15	0.22	0.25	0.31	0.37	0.38	0.39
Veneer, plywood, and engineered wood product manufacturing (3212)	0.06	0.06	0.06	-0.11	-0.08	0.08	0.21	0.26	0.41	0.53	0.56	0.58
Other wood product manufacturing (3219)	0.32	0.32	0.32	0.09	0.16	0.42	0.59	0.68	0.86	1	1	1.1
Clay product and refractory manufacturing (3271)	0.02	0.02	0.02	-0.04	-0.03	0.03	0.07	0.09	0.14	0.18	0.19	0.2
Glass and glass product manufacturing (3272)	0.19	0.19	0.19	-0.22	-0.15	0.26	0.56	0.69	1	1.3	1.4	1.4
Cement and concrete product manufacturing (3273)	0.59	0.59	0.59	0.15	0.28	0.78	1.1	1.3	1.6	1.9	2	2.1
Lime, gypsum and other nonmetallic mineral product manufacturing (3274, 3279)	0.16	0.16	0.16	-0.16	-0.1	0.22	0.45	0.55	0.82	1	1.1	1.1
Iron and steel mills and ferroalloy manufacturing (3311)	0.27	0.27	0.27	-0.04	0.03	0.36	0.6	0.71	0.97	1.2	1.2	1.3
Steel product manufacturing from purchased steel (3312)	0.05	0.05	0.05	-0.06	-0.04	0.06	0.14	0.17	0.26	0.33	0.35	0.37
Alumina and aluminum production and processing (3313)	0.13	0.13	0.13	0.09	0.11	0.17	0.21	0.22	0.26	0.28	0.29	0.29
Nonferrous metal (except aluminum) production and processing (3314)	0.38	0.37	0.38	0.5	0.53	0.49	0.43	0.41	0.31	0.22	0.2	0.17
Foundries (3315)	0.05	0.05	0.05	0.04	0.04	0.06	0.07	0.07	0.08	0.09	0.09	0.09
Forging and stamping (3321)	0.13	0.13	0.13	0	0.03	0.17	0.27	0.32	0.42	0.51	0.53	0.55
Cutlery and handtool manufacturing (3322)	0.02	0.02	0.02	0	0.01	0.02	0.04	0.04	0.06	0.07	0.07	0.07
Architectural and structural metals manufacturing (3323)	0.37	0.37	0.37	0.2	0.27	0.49	0.63	0.7	0.84	0.95	0.97	0.99
Boiler, tank, and shipping container manufacturing (3324)	0.1	0.1	0.1	0.06	0.08	0.13	0.16	0.18	0.2	0.23	0.23	0.24
Hardware manufacturing (3325)	0.04	0.04	0.04	0.01	0.01	0.05	0.07	0.08	0.11	0.13	0.13	0.13
Spring and wire product manufacturing (3326)	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Machine shops; turned product; and screw, nut, and bolt manufacturing (3327)	0.24	0.24	0.24	0	0.06	0.31	0.49	0.57	0.77	0.93	0.97	1

Detail	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Coating, engraving, heat treating, and allied activities (3328)	0.11	0.11	0.11	-0.39	-0.32	0.15	0.5	0.66	1.1	1.4	1.5	1.6
Other fabricated metal product manufacturing (3329)	0.18	0.18	0.18	0.02	0.06	0.24	0.36	0.41	0.55	0.66	0.68	0.7
Agriculture, construction, and mining machinery manufacturing (3331)	0.11	0.11	0.11	0.05	0.07	0.15	0.2	0.22	0.28	0.32	0.33	0.34
Industrial machinery manufacturing (3332)	0.32	0.32	0.32	0.3	0.34	0.42	0.46	0.48	0.5	0.51	0.51	0.51
Com. and service industry machinery manufact., incl. digital camera manufact. (3333)	0.14	0.14	0.14	-2.5	-2.2	0.25	2.1	2.9	5	6.9	7.3	7.8
Ventilation, heating, AC, and commercial refrigeration equip. manufacturing (3334)	0.12	0.12	0.12	0.06	0.08	0.16	0.21	0.24	0.29	0.33	0.34	0.35
Metalworking machinery manufacturing (3335)	0.05	0.05	0.05	0.04	0.04	0.07	0.08	0.09	0.1	0.11	0.11	0.11
Engine, turbine, power transmission equipment manufacturing (3336)	0.35	0.35	0.35	0.29	0.34	0.46	0.53	0.57	0.62	0.66	0.67	0.68
Other general purpose machinery manufacturing (3339)	0.26	0.25	0.25	0.03	0.09	0.34	0.51	0.59	0.77	0.92	0.95	0.99
Computer and peripheral equip. manufacturing, excl. digital camera manufact. (3341)	0.32	0.32	0.32	0.18	0.24	0.42	0.53	0.59	0.7	0.79	0.81	0.82
Communications equipment manufacturing (3342)	0.24	0.24	0.24	0.17	0.21	0.32	0.38	0.42	0.48	0.52	0.53	0.54
Audio and video equipment manufacturing (3343)	0.08	0.08	0.08	0.1	0.11	0.11	0.1	0.1	0.09	0.08	0.07	0.07
Semiconductor and other electronic component manufacturing (3344)	0.32	0.32	0.32	-0.24	-0.13	0.43	0.83	1	1.5	1.9	1.9	2
Navigational, measuring, electromedical, and control inst. manufacturing (3345)	0.44	0.44	0.44	0.18	0.26	0.58	0.79	0.88	1.1	1.3	1.3	1.3
Manufacturing and reproducing magnetic and optical media (3346)	0.02	0.02	0.02	0	0.01	0.02	0.03	0.03	0.04	0.05	0.05	0.05
Electric lighting equipment manufacturing (3351)	0.05	0.05	0.05	-0.19	-0.15	0.08	0.25	0.32	0.52	0.69	0.73	0.77
Household appliance manufacturing (3352)	0.03	0.03	0.03	0.01	0.02	0.04	0.05	0.05	0.07	0.07	0.08	0.08
Electrical equipment manufacturing (3353)	0.07	0.07	0.07	-0.16	-0.13	0.09	0.25	0.33	0.51	0.67	0.71	0.75
Other electrical equipment and component manufacturing (3359)	0.22	0.22	0.22	-0.36	-0.26	0.3	0.71	0.89	1.4	1.8	1.9	1.9
Motor vehicle manufacturing (3361)	0.38	0.37	0.38	0.48	0.51	0.49	0.44	0.43	0.35	0.27	0.25	0.23
Motor vehicle body and trailer manufacturing (3362)	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Motor vehicle parts manufacturing (3363)	0.27	0.26	0.26	0.21	0.25	0.35	0.4	0.43	0.48	0.51	0.52	0.52
Aerospace product and parts manufacturing (3364)	0.74	0.73	0.74	0.04	0.22	0.98	1.5	1.7	2.3	2.8	2.9	3
Railroad rolling stock manufacturing (3365)	0.04	0.04	0.04	0.03	0.04	0.05	0.06	0.06	0.07	0.07	0.07	0.07
Ship and boat building (3366)	0.04	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06
Other transportation equipment manufacturing (3369)	0.32	0.32	0.32	0.29	0.33	0.41	0.45	0.48	0.5	0.52	0.52	0.52
Household and institutional furniture and kitchen cabinet manufacturing (3371)	0.31	0.31	0.31	0.21	0.26	0.41	0.5	0.54	0.63	0.69	0.71	0.72
Office furniture (incl. fixtures) mfg.; Other furniture product mfg. (3372, 3379)	0.21	0.21	0.21	0.11	0.15	0.28	0.36	0.4	0.48	0.55	0.56	0.58

Detail	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Medical equipment and supplies manufacturing (3391)	0.54	0.54	0.54	-0.18	-0.02	0.72	1.3	1.5	2.1	2.6	2.7	2.8
Other miscellaneous manufacturing (3399)	0.65	0.64	0.65	-0.01	0.15	0.86	1.4	1.6	2.1	2.6	2.7	2.8
Animal food manufacturing (3111)	0.36	0.35	0.36	0.36	0.41	0.47	0.48	0.5	0.49	0.48	0.47	0.47
Grain and oilseed milling (3112)	1.2	1.2	1.2	1.1	1.3	1.6	1.7	1.8	1.9	1.9	1.9	1.9
Sugar and confectionery product manufacturing (3113)	0.25	0.25	0.25	-0.41	-0.3	0.34	0.82	1	1.6	2	2.1	2.2
Fruit and vegetable preserving and specialty food manufacturing (3114)	0.96	0.95	0.96	0.36	0.55	1.3	1.7	2	2.4	2.9	2.9	3
Dairy product manufacturing (3115)	2.1	2.1	2.1	2.4	2.6	2.8	2.8	2.8	2.6	2.4	2.4	2.3
Animal slaughtering and processing (3116)	1.2	1.1	1.2	1.6	1.7	1.5	1.2	1.2	0.79	0.45	0.36	0.27
Seafood product preparation and packaging (3117)	0.07	0.07	0.07	0.08	0.09	0.1	0.1	0.1	0.09	0.08	0.08	0.08
Bakeries and tortilla manufacturing (3118)	0.27	0.27	0.27	-0.17	-0.08	0.36	0.68	0.82	1.2	1.5	1.6	1.6
Other food manufacturing (3119)	1.2	1.2	1.2	0.78	0.97	1.5	1.9	2.1	2.4	2.6	2.7	2.7
Beverage manufacturing (3121)	1.8	1.8	1.8	0.23	0.65	2.4	3.6	4.1	5.4	6.5	6.7	7
Tobacco manufacturing (3122)	0.04	0.04	0.04	0.01	0.02	0.05	0.08	0.09	0.11	0.13	0.14	0.14
Textile mills and textile product mills (313, 314)	0.28	0.28	0.28	0.12	0.17	0.37	0.5	0.56	0.69	0.8	0.83	0.85
Apparel, leather and allied product manufacturing (315, 316)	0.68	0.68	0.68	0.71	0.79	0.89	0.92	0.94	0.92	0.89	0.88	0.87
Pulp, paper, and paperboard mills (3221)	0.11	0.11	0.11	-0.7	-0.59	0.16	0.73	0.98	1.6	2.2	2.3	2.5
Converted paper product manufacturing (3222)	0.56	0.56	0.56	-0.06	0.08	0.75	1.2	1.4	1.9	2.4	2.5	2.6
Printing and related support activities (323)	0.29	0.29	0.29	-2.6	-2.2	0.45	2.5	3.4	5.7	7.8	8.3	8.7
Petroleum and coal products manufacturing (324)	1.7	1.7	1.7	2.6	2.7	2.2	1.8	1.6	0.92	0.29	0.13	-0.02
Basic chemical manufacturing (3251)	0.84	0.84	0.84	-17	-14	1.6	14	19	33	46	48	51
Resin, synthetic rubber, and artificial synth. fibers and filaments manufacturing (3252)	0.34	0.34	0.34	-7	-6.1	0.64	5.7	8	14	19	20	22
Pesticide, fertilizer, and other agricultural chemical manufacturing (3253)	0.2	0.2	0.2	-3	-2.6	0.35	2.6	3.6	6.2	8.5	9	9.5
Pharmaceutical and medicine manufacturing (3254)	0.71	0.71	0.71	-1.5	-1.1	0.99	2.5	3.2	5	6.5	6.8	7.2
Paint, coating, and adhesive manufacturing (3255)	0.14	0.14	0.14	-1.5	-1.3	0.23	1.4	1.9	3.3	4.5	4.8	5
Soap, cleaning compound, and toilet preparation manufacturing (3256)	0.32	0.32	0.32	-1.8	-1.5	0.47	1.9	2.6	4.3	5.7	6	6.4
Other chemical product and preparation manufacturing (3259)	0.19	0.19	0.19	-2.8	-2.4	0.33	2.4	3.3	5.7	7.8	8.3	8.7
Plastics product manufacturing (3261)	0.66	0.66	0.66	-0.92	-0.64	0.91	2	2.5	3.8	4.9	5.2	5.4
Rubber product manufacturing (3262)	0.09	0.09	0.09	-0.1	-0.07	0.12	0.25	0.31	0.47	0.6	0.63	0.66
Wholesale trade (42)	2.6	2.6	2.6	-2.7	-1.7	3.5	7.3	9	13	17	18	19
Retail trade (44-45)	8	8	8	5.2	6.5	11	13	14	17	18	19	19
Air transportation (481)	0.24	0.23	0.23	-16	-14	0.72	12	17	29	41	43	46
Rail transportation (482)	0.06	0.06	0.06	-4.5	-4	0.19	3.4	4.8	8.5	12	12	13
Water transportation (483)	0.18	0.18	0.18	-12	-10	0.55	8.7	12	22	30	32	34
Truck transportation (484)	1.9	1.9	1.9	-86	-75	4.8	66	92	165	227	241	255

Detail	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Couriers and messengers (492)	0.28	0.28	0.28	-12	-10	0.68	9.1	13	23	31	33	35
Transit and ground passenger transportation (485)	0.08	0.08	0.08	-7.2	-6.3	0.29	5.3	7.5	14	19	20	21
Pipeline transportation (486)	0.01	0.01	0.01	-0.28	-0.24	0.02	0.22	0.3	0.54	0.74	0.79	0.84
Scenic and sightseeing transp. and support activities for transportation (487, 488)	0.69	0.69	0.69	-3.4	-2.8	1	3.9	5.1	8.4	11	12	13
Warehousing and storage (493)	0.19	0.19	0.19	-1.2	-1	0.29	1.3	1.7	2.9	3.9	4.1	4.3
Newspaper, periodical, book, and directory publishers (5111)	0.21	0.21	0.21	0.19	0.22	0.27	0.29	0.31	0.32	0.33	0.33	0.33
Software publishers (5112)	0.19	0.19	0.19	0.01	0.06	0.26	0.4	0.46	0.61	0.73	0.76	0.79
Motion picture, video, and sound recording industries (512)	0.22	0.22	0.22	-0.04	0.02	0.29	0.48	0.57	0.79	0.97	1	1
Data processing, hosting, related services, and other information services (518, 519)	1.3	1.3	1.3	0.61	0.84	1.7	2.2	2.5	3	3.5	3.5	3.6
Broadcasting (except internet) (515)	0.16	0.15	0.16	-0.04	0	0.21	0.35	0.42	0.58	0.72	0.75	0.78
Telecommunications (517)	0.84	0.83	0.84	-0.07	0.15	1.1	1.8	2.1	2.8	3.5	3.6	3.7
Monetary authorities, credit intermediation, and related activities (521, 522)	0.04	0.04	0.04	-1.5	-1.3	0.09	1.1	1.6	2.8	3.9	4.1	4.4
Funds, trusts, and other financial vehicles (525)	0	0	0	-0.01	-0.01	0	0.01	0.02	0.03	0.04	0.04	0.04
Securities, commodity contracts, and other financial investments and related (523)	0.18	0.18	0.18	-0.15	-0.09	0.25	0.49	0.6	0.87	1.1	1.2	1.2
Insurance carriers (5241)	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04
Agencies, brokerages, and other insurance related activities (5242)	0.06	0.06	0.06	0.05	0.06	0.08	0.09	0.1	0.11	0.12	0.12	0.12
Real estate (531)	0.85	0.85	0.85	-3.7	-3	1.2	4.4	5.8	9.5	13	13	14
Automotive equipment rental and leasing (5321)	0.05	0.05	0.05	-2.2	-1.9	0.13	1.7	2.4	4.2	5.8	6.1	6.5
Consumer goods rental and general rental centers (5322, 5323)	0.04	0.04	0.04	-0.23	-0.19	0.06	0.24	0.32	0.54	0.73	0.77	0.81
Commercial and industrial machinery and equipment rental and leasing (5324)	0.07	0.07	0.07	-0.22	-0.18	0.1	0.31	0.4	0.64	0.85	0.89	0.94
Lessors of nonfinancial intangible assets (except copyrighted works) (533)	0.16	0.16	0.16	0.11	0.13	0.21	0.26	0.29	0.33	0.37	0.38	0.38
Legal services (5411)	0.09	0.09	0.09	-0.06	-0.03	0.12	0.23	0.28	0.41	0.52	0.54	0.57
Accounting, tax preparation, bookkeeping, and payroll services (5412)	0.12	0.12	0.12	-0.01	0.02	0.17	0.26	0.31	0.42	0.51	0.53	0.55
Architectural, engineering, and related services (5413)	0.41	0.41	0.41	-0.74	-0.54	0.57	1.4	1.7	2.7	3.5	3.7	3.8
Specialized design services (5414)	0.13	0.13	0.13	0.04	0.07	0.18	0.25	0.29	0.36	0.43	0.44	0.45
Computer systems design and related services (5415)	0.14	0.14	0.14	-0.7	-0.58	0.21	0.8	1.1	1.8	2.3	2.5	2.6
Management, scientific, and technical consulting services (5416)	0.48	0.47	0.47	0.43	0.5	0.62	0.68	0.71	0.75	0.77	0.77	0.78
Scientific research and development services (5417)	0.69	0.69	0.69	-1.8	-1.4	0.96	2.7	3.5	5.5	7.2	7.5	7.9

Detail	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Advertising, public relations, and related services (5418)	0.34	0.34	0.34	0.01	0.09	0.46	0.7	0.82	1.1	1.3	1.4	1.4
Other professional, scientific, and technical services (5419)	0.14	0.14	0.14	-0.19	-0.13	0.19	0.42	0.53	0.8	1	1.1	1.1
Management of companies and enterprises (55)	0.23	0.23	0.23	-2.3	-1.9	0.37	2.1	2.9	4.9	6.7	7.1	7.5
Office administrative services; Facilities support services (5611, 5612)	0.06	0.06	0.06	-0.28	-0.23	0.09	0.33	0.44	0.72	0.97	1	1.1
Employment services (5613)	0.03	0.03	0.03	0	0.01	0.05	0.07	0.08	0.11	0.14	0.14	0.15
Business, Investigation and security, and Other support services (5614, 5616, 5619)	0.21	0.21	0.21	-0.39	-0.29	0.29	0.71	0.9	1.4	1.8	1.9	2
Travel arrangement and reservation services (5615)	0.04	0.04	0.04	-0.03	-0.02	0.05	0.1	0.12	0.18	0.23	0.24	0.25
Services to buildings and dwellings (5617)	0.25	0.25	0.25	-7.7	-6.7	0.54	6	8.5	15	21	22	23
Waste management and remediation services (562)	0.38	0.38	0.38	-2.9	-2.4	0.59	2.9	3.9	6.6	8.9	9.4	9.9
Educational services; private (61)	0.38	0.38	0.38	-1.8	-1.5	0.55	2.1	2.7	4.5	6	6.3	6.7
Offices of health practitioners (6211-6213)	0.44	0.44	0.44	-1.1	-0.86	0.61	1.7	2.2	3.4	4.5	4.8	5
Outpatient, laboratory, and other ambulatory care services (6214, 6215, 6219)	0.27	0.27	0.27	-0.42	-0.3	0.37	0.86	1.1	1.7	2.1	2.2	2.4
Home health care services (6216)	0.05	0.05	0.05	-0.12	-0.09	0.07	0.19	0.24	0.38	0.5	0.53	0.56
Hospitals; private (622)	0.56	0.56	0.56	-6.7	-5.7	0.93	5.9	8.2	14	19	20	21
Nursing and residential care facilities (623)	0.18	0.18	0.18	-1.7	-1.5	0.29	1.6	2.2	3.8	5.1	5.4	5.7
Ind. and family services; Community and vocational rehab. services (6241-6243)	0.27	0.27	0.27	-0.78	-0.62	0.39	1.1	1.5	2.3	3.1	3.2	3.4
Child day care services (6244)	0.08	0.08	0.08	-0.57	-0.48	0.13	0.58	0.78	1.3	1.8	1.9	2
Performing arts companies; Promoters of events, and agents and managers (7111, 7113, 7114)	0.08	0.08	0.08	-0.36	-0.3	0.12	0.43	0.56	0.93	1.2	1.3	1.4
Spectator sports (7112)	0.01	0.01	0.01	-0.08	-0.06	0.02	0.08	0.11	0.19	0.25	0.26	0.28
Independent artists, writers, and performers (7115)	0.11	0.11	0.11	0	0.03	0.15	0.23	0.27	0.36	0.43	0.44	0.46
Museums, historical sites, and similar institutions (712)	0.04	0.04	0.04	-0.19	-0.15	0.06	0.21	0.28	0.47	0.63	0.66	0.7
Amusement, gambling, and recreation industries (713)	0.33	0.33	0.33	-2.3	-1.9	0.5	2.3	3.2	5.3	7.2	7.6	8
Accommodation (721)	0.26	0.26	0.26	-1.4	-1.2	0.38	1.6	2.1	3.5	4.7	4.9	5.2
Food services and drinking places (722)	2.2	2.2	2.2	-3.2	-2.3	3	6.8	8.5	13	17	18	18
Automotive repair and maintenance (8111)	0.32	0.31	0.31	-0.85	-0.66	0.44	1.3	1.6	2.6	3.4	3.6	3.8
Electronic and precision equipment repair and maintenance (8112)	0.05	0.05	0.05	-0.17	-0.13	0.07	0.22	0.29	0.46	0.61	0.65	0.68
Comm. and indust. Machin. and equip. (excl. auto and electronic) repair and maintenance (8113)	0.04	0.04	0.04	-0.12	-0.1	0.06	0.18	0.23	0.37	0.48	0.51	0.53
Personal and household goods repair and maintenance (8114)	0.08	0.08	0.08	-0.07	-0.04	0.11	0.21	0.26	0.38	0.48	0.5	0.52
Personal care services (8121)	0.1	0.09	0.09	-0.23	-0.18	0.13	0.36	0.46	0.73	0.95	1	1.1
Death care services (8122)	0.03	0.03	0.03	0	0.01	0.04	0.07	0.08	0.1	0.12	0.13	0.13
Drycleaning and laundry services (8123)	0.06	0.06	0.06	-1.9	-1.7	0.13	1.5	2.1	3.7	5.1	5.5	5.8

Detail	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Other personal services (8129)	0.14	0.14	0.14	-0.23	-0.17	0.2	0.46	0.58	0.89	1.1	1.2	1.3
Relig. org.; Grantmaking and giving services, and social advocacy org. (8131-8133)	0.07	0.07	0.07	-0.88	-0.75	0.11	0.76	1.1	1.8	2.5	2.6	2.8
Civic, social, professional, and similar organizations (8134, 8139)	0.04	0.04	0.04	-0.77	-0.67	0.07	0.62	0.87	1.5	2.1	2.2	2.4

Table J6: REMI Inputs to Simulate Change in Fuel Expenditures by Households and Government (Million 2016$)

REMI Category	Detail	Explanation	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Consumer Spending	Motor vehicle fuels and lubricants	Change in consumer expenditures	1.07	1.07	1.07	-960.42	-814.73	5.51	566.72	768.06	1347.27	1809.84	1886.82	1964.97
Consumer Spending	Natural Gas	Change in consumer expenditures	-	-	-	-	-	0.04	0.03	0.02	0.01	0.01	0.01	0.01
Consumer Spending	Electricity	Change in consumer expenditures	-	-	-	0.39	0.43	0.13	-0.13	-0.23	-0.62	-0.98	-1.06	-1.15
Consumer Spending	Consumption Reallocation	Electricity credits rebated to consumers	-	-	-	-	-	-84.74	-100.68	-31.04	30.45	53.39	139.09	214.95
State and Local Government Spending	State Government	Change in fuel expenditures for fleets	-	-	-	-1.75	-1.48	0.01	1.03	1.40	2.46	3.30	3.44	3.58
State and Local Government Spending	Local Government	Change in fuel expenditures for fleets	0.77	0.77	0.77	-11.82	-9.93	1.15	8.99	12.05	20.54	27.52	28.85	30.22

d) Other Indirect Impacts

i. <u>State and Local Tax Revenue and Local Spending</u>

State and local government spending and tax revenues will be impacted by the proposed amendments. In addition to tax revenue impacts, local government is able to generate LCFS credits, primarily through the use of low-CI fuel use in public transit systems. A detailed discussion of the fiscal impacts of the proposed amendments is included in Section D: Fiscal Impacts. All monetary impacts to State and local governments are modeled as changes in government spending, as outlined in Table J7.

Table J7: REMI Inputs to Simulate Change in Tax Revenue and Local Spending (Million 2016$)

REMI Category	Explanation	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
State Government Spending	Tax Revenue	0.00	0.00	0.00	-27.45	-23.69	1.48	22.24	32.52	58.53	81.67	86.43	91.31
Local Government Spending	Tax Revenue	0.00	0.00	0.00	-60.20	-51.24	1.15	37.97	52.13	91.62	123.97	130.00	136.14
Local Government Spending	LCFS Credit Generation	-0.56	-0.71	-0.73	-24.05	-21.38	-0.41	15.82	22.23	39.59	55.17	59.26	58.30

ii. *Health Benefits*

As discussed in Section B3, The decrease in acute respiratory, cardiovascular, and asthma related hospital and emergency room visits results in less household spending in the healthcare industry as a result of PM2.5 and NOx reductions. This decrease in consumer spending for hospitals allows for an increase in spending in all other consumption categories. REMI inputs are described in Table J8.

Table J8: REMI Inputs to Simulate Monetized Health Benefits (Million 2016$)

REMI Category	Explanation	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Consumer Spending on Hospitals	Health benefits savings	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.04	-0.05	-0.08	-0.10	-0.10	-0.09

iii. *Expansion of Facilities*

Under the proposed amendments, staff expects investments will be made in expanding or upgrading existing alternative fuel production facilities or building new facilities to meet the increased demand for low-CI fuels. Because the LCFS is structured to transfer money from deficit generating parties to credit generating parties (e.g., from producers of high-CI fuels to producers of low-CI fuels), the cost of upgrading or building new facilities will at least partially be recovered through this transfer. Whether these expansions will occur in-state or out-of-state will depend on many factors, such as the availability of feedstock, other policies that incentivize production and investment in certain fuels, technical considerations, transportation costs, and existing infrastructure. The direct cost of expanding facilities included in this analysis, therefore, is based on the portion of low-CI fuel supply estimated to occur in California. Table J9 summarizes the annual cost of capacity expansion[123] under the proposed amendments, relative to the baseline.

Table J9: Estimate of the In-State Cost of Capacity Expansion Relative to the Baseline (million 2016$)

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
$0	$367	$504	$515	$31	$50	$68	$406	$74	$100	$89	$60

Additions or expansions are assumed for renewable diesel, dairy natural gas, and cellulosic ethanol as a result of increased demand under the proposed amendments. There are also anticipated to be new projects associated with solar steam generation and carbon capture and sequestration. In-state facility expansion costs are modeled as an increase in production cost for these fuel producers, represented in REMI under basic chemical manufacturing (NACIS 3251) for ethanol, and renewable diesel, natural gas distribution (NAICS 2212) for dairy natural gas, electric power generation, transmission, and distribution, and (NAICS 324) for solar steam and carbon capture sequestration projects.

[123] This does not include the operational expenditures of running facilities or the feedstock costs.

An increase in the exogenous final demand variable is also applied to the construction industry (NAICS 23) to simulate the demand for facility construction, expansion of existing facilities, and new projects. REMI model inputs simulating facility expansion are outlined in Table J10.

Table J10: REMI Inputs to Simulate Facility Expansion (Million 2016$)

REMI Category	Industry (NAICS)	Explanation	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Production Cost	Petroleum and coal products manufacturing (324)	Facility capacity expansion	-	$368	$506	$506	-	-	-	$346	-	-	-	-
Production Cost	Basic chemical manufacturing (3251)	Facility capacity expansion	-	-	-	$5	$2	$12	$20	$14	$26	$33	$22	$36
Production Cost	Natural gas distribution (2212)	Facility capacity expansion	-	-	-	$5	$29	$38	$48	$48	$48	$67	$67	$24
Exogenous Final Demand	Construction (23)	Demand for construction services	-	$368	$506	$517	$31	$50	$68	$408	$74	$100	$89	$60

To estimate the proportion of production that will occur in-state versus out-of-state, staff made the following assumptions categorized by fuel type.

- Conventional biofuels (starch ethanol, sugarcane ethanol, biodiesel and renewable diesel, landfill gas): In-state percentage of overall production will remain at 2016 levels.
- Cellulosic ethanol: In-state percentage is assumed to be equal to that of starch ethanol. Most cellulosic ethanol production will occur in starch ethanol facilities that will use bolt-on technologies.
- Alternative jet fuel, renewable gasoline, and renewable propane: In-state percentage will equal the in-state percentage of renewable diesel. Renewable diesel, gasoline, propane, and jet fuel are all produced at the same facilities that hydrotreat fats, oils, and greases.
- Dairy renewable natural gas: In-state generation represents a third of dairy renewable natural gas. While California produces approximately 20 percent of the milk in the U.S.,[124] the state has committed to reduce methane emissions from dairies through requirements mandated in Senate Bill 1383 (Lara),[125] therefore will produce a larger share of total diary natural gas.
- Solar steam generation at oil fields: In-state generation represents 100 percent of production as the innovative crude provision requires that the crude produced using solar steam be supplied to California refineries.

Using these assumptions, staff estimated the incremental capacity needed under the proposed amendments as the difference between the annual in-state production quantities under each project scenario and the maximum annual amount produced under the baseline. The incremental capacity was then multiplied by the cost of facility expansion or new facility construction.

The following data were used to estimate the cost of facility expansion or new facility construction:

- Renewable diesel: Cost estimate is based on Lux Research's estimate of the cost of the expansion of Diamond Green's renewable diesel facility in Louisiana.[126]
- Dairy RNG: Cost estimate is based on the CARB's Short-Lived Climate Pollutant (SLCP) report estimate of the cost of an illustrative typical 2,000-cow dairy.[127]

[124] USDA. *Dairy Data, Milk cows and production by state and region(Annual).* https://www.ers.usda.gov/webdocs/DataFiles/48685/milkcowsandprod_1_.xlsx?v=42866. Accessed Nov. 1st 2017.
[125] Senate Bill 1383. 2017-2018. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1383. Accessed Nov. 1st 2017.
[126] Yu, Yuan-Sheng, Apr. 19th 2016. *Diamond Green Diesel expanding production capacity to 275 million gallons per year.* Lux Research. Accessed Aug. 11th 2017.
[127] CARB. SLCP Final Report – Appendix F, Table 14. https://www.arb.ca.gov/cc/shortlived/meetings/03142017/appendixf.pdf

- Cellulosic ethanol: Cost estimate is based on the average cost of building the Dupont cellulosic plant in Iowa, Abengoa's cellulosic plant in Kansas,[128] and the estimated cost of upgrading Aemetis starch ethanol plant in California to cellulosic ethanol production.[129]
- Steam generation: Cost estimate is based on an ICF international study, commissioned by GlassPoint, a leading provider of solar steam for oil fields.[130]
- CCS: Cost estimate is based on the installation of CCS technology at ethanol facilities.[131]

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128 Yu, Yuan-Sheng, Oh, Victor, & Giles, Brent. Jan 19th 2016. *Uncovering the Cost of Cellulosic Ethanol Production.* Lux Research. Accessed Aug. 11th 2017.

129 Aemetis. *The Aemetis Biorefinery: Low Carbon Renewable Fuel for California.* Presentation for ARB.

130 ICF International, 2015. *The Impact of Solar Powered Oil Production on California's Economy An economic analysis of Innovative Crude Production Methods under the LCFS.* https://www.seia.org/sites/default/files/resources/Solar_Powered_Oil_Production_California_Economy_0.pdf Accessed Nov. 3rd 2017.

131 U.S. Department of Energy Contract: DE-FC26-05NT42588, *Illinois State Geological Survey, Evaluation of CO_2 Capture Options from Ethanol Plants.* The values were adjusted by staff to reflect different electricity prices across states. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/DE20131036302.xhtml. Accessed Nov. 3rd 2017.