

This Preliminary Draft may not be the version that will be considered as part of the formal rulemaking.

### **Preliminary Draft Proposed Regulation Order and Staff Report**

**Draft release:** In follow-up to the California Air Resources Board (CARB) listserv released on February 16, 2018, CARB is posting this preliminary draft Proposed Regulation Order and portions of the draft Staff Report: Initial Statement of Reasons (ISOR) (Executive Summary, Chapter 1, and Chapter 2) to the Low Carbon Fuel Standard webpage to ensure all market participants and other interested stakeholders have access to the content of this regulatory proposal at the same time.

***This draft does not initiate the formal comment period.***

**Office of Administrative Law Schedule:** The schedule to commence the formal rulemaking process pursuant to the Administrative Procedure Act is as follows:

- |                   |   |
|-------------------|---|
| Feb. 20, 2018     | CARB will provide a draft of the formal regulatory package, including the full Staff Report: Initial Statement of Reasons (ISOR) (including appendices), and the Proposed Regulation Order, to the Office of Administrative Law (OAL). This submittal initiates a review by OAL prior to opening the formal comment period.   |
| Mar. 6, 2018      | Based on OAL's review, CARB may revise the draft documents and will post final versions of all documents related to the rulemaking (including the Notice of Public Hearing, ISOR, Proposed Regulation Order, and other Appendices) to CARB's LCFS Rulemaking webpage. CARB will also make a rulemaking file for the proposed amendments available to the public on this date. |
| Mar. 9, 2018      | The formal public comment period will begin when OAL publishes CARB's Notice of Public Hearing.   |
| Apr. 23, 2018     | The formal comment period will close.   |
| Apr. 27, 2018     | CARB Board Hearing to consider proposed amendments.   |
| May–Sept. 2018    | Continued stakeholder engagement and 15-day formal comment periods for any changes to the proposed amendments.  |
| Sept. 27–28, 2018 | Second Board Hearing to vote on proposed amendments.  |

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**Staff Report: Initial Statement of Reasons for the Proposed Amendments to the Low Carbon Fuel Standard Regulation**

**PUBLIC HEARING TO CONSIDER PROPOSED AMENDMENTS TO THE LOW CARBON FUEL STANDARD REGULATION AND TO THE REGULATION ON COMMERCIALIZATION OF ALTERNATIVE DIESEL FUELS**

Date of Release: **March 6, 2018**  
Scheduled for Consideration: **April 26, 2018**

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## Executive Summary

### Purpose of Proposed Rulemaking

In this rulemaking, the California Air Resources Board (Board or CARB) staff is proposing to amend the Low Carbon Fuel Standard (LCFS) regulation. Since the Board's original adoption of the LCFS in 2009, the basic framework of the program has worked well and the use of alternative fuels with low greenhouse gas (GHG) performance is becoming widespread throughout California.

Before the LCFS, the only alternative fuels for transportation with any significant market share were natural gas and ethanol. Between the first year of LCFS compliance (2011) and 2016, a wide variety of low carbon fuels proved their commercial feasibility and began to be deployed in large volumes. In the most recent quarter for which LCFS data are available (Q3 2017), the carbon intensity (CI) of all transportation fuels used in the state has decreased 3.7 percent relative to a 2010 baseline, generating nearly 2.5 million metric tons (MT) of LCFS credits.<sup>1</sup> During this quarter, biomass-based diesel averaged 14 percent of every gallon of diesel sold in the state; renewable natural gas was 68 percent of all fuel used in natural gas vehicles; and ethanol, electricity<sup>2</sup> and hydrogen used in passenger vehicles displaced 303 million gallons of gasoline.

In 2016, the California legislature adopted Senate Bill (SB) 32 (Pavley, 2016), which codifies a statewide GHG target of at least 40 percent below 1990 levels by 2030. In December of 2017, the Board adopted a strategy for achieving this target known as *California's 2017 Climate Change Scoping Plan* (Scoping Plan). The Scoping Plan made it clear that developing a more ambitious LCFS is a critical part of the state's efforts to achieve the SB 32 goal and to:

- Lower GHG emissions on a trajectory to avoid the worst impacts of climate change;
- Support a clean energy economy which provides more opportunities for all Californians;
- Reduce our reliance on fuels derived from petroleum;
- Advance the necessary technologies to achieve deep decarbonization across the Californian economy in the long run.

This rulemaking will set ambitious targets for low carbon fuel use from the transportation sector—the proposed amendments target a 20 percent reduction in fuel CI from a 2010 baseline by 2030. Staff's proposed amendments will also improve the efficiency of the program—reducing application time, streamlining and further clarifying reporting

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<sup>1</sup> As described in more detail below, carbon intensity is a measure of the GHG emissions associated with the various production, distribution, and consumption steps in the "life cycle" of a transportation fuel.

<sup>2</sup> The electricity data include staff's projected estimates for non-metered residential charging which is off-cycle relative to the other credit generation in the LCFS system.

requirements, creating additional flexibility for program participants, and creating more opportunities for low carbon fuel providers.

## **Background and Program Overview**

The LCFS program uses life cycle assessment (LCA) to examine the GHG emissions associated with the production, distribution, and end use of all transportation fuels used in California. The carbon intensity scores assessed in the LCFS to each fuel are compared to a declining CI benchmark for each year. Low carbon fuels below the benchmark generate credits. Fuels above the CI standard generate deficits.

Each year, a supplier of fuel must match all deficits created from supply of high carbon fuels with credits associated with the supply of low carbon fuel. A tradeable system for these credits ensures entities who do not choose to make low carbon fuel themselves can fund the production of low carbon fuels by other program participants.

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). Credit prices and trading activity reached all-time highs in 2017. Over five million LCFS credits were sold or traded in approximately 929 transactions in 2016 with an average credit price of \$101/metric ton carbon dioxide equivalent (CO<sub>2</sub>e), demonstrating a robust credit market.

Many of the alternative fuels that have low carbon intensity also have one or more of the following co-benefits: (1) improved performance with respect to conventional air pollutants, (2) the ability to be used in efficient advanced vehicles, which leads to fuel savings, and (3) reduced petroleum dependency, such that California consumers have more fuel choices and are less exposed to fluctuations in world oil prices.

## **Summary of Proposal**

### 2019 through 2030 Carbon Intensity Decline

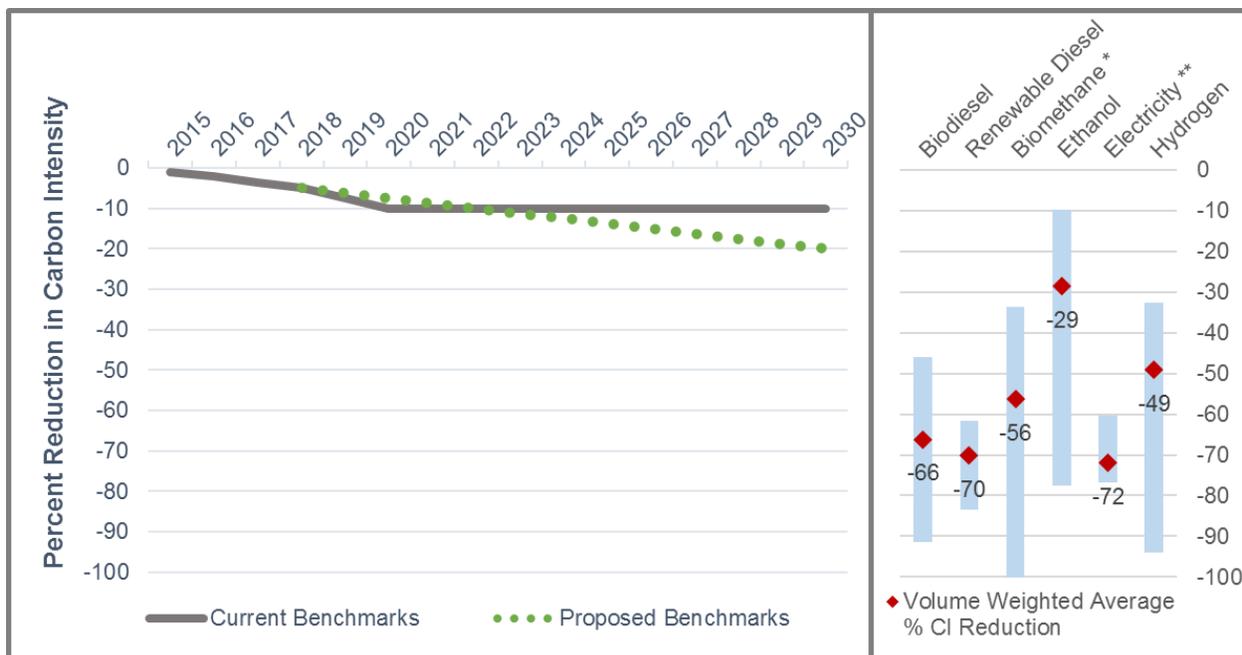
The most significant change under consideration in this rulemaking is how to strengthen the CI reduction targets through 2030 in-line with the SB 32 goals. The proposed amendments target a 20 percent reduction in fuel carbon intensity (CI) from a 2010 baseline by 2030. The amendments also propose smoothing the near-term benchmark schedule by linearly reducing by 1.25 percent annually from a 5 percent reduction in 2018 to the 20 percent value in 2030.

Increasing the stringency of the LCFS carbon intensity targets is necessary to achieve California's 2030 GHG target. The 2017 Scoping Plan considered an 18 percent reduction target for 2030. After the conclusion of the Scoping Plan analysis, staff solicited additional stakeholder feedback through LCFS workshops. Based on stakeholder data received in these LCFS workshops and staff's additional analysis of

possible compliance scenarios building off the Scoping Plan analytics, staff believes that a 20 percent by 2030 CI target is achievable and appropriate.

Staff is also recommending smoothing the CI trajectory by adjusting the benchmarks for years 2019 through 2021. Figure EX-1 shows staff’s proposed benchmarks as compared to the benchmarks in the current regulation for years 2015 through 2030. All else equal, staff’s proposal achieves additional long-run GHG reductions while reducing the probability of unnecessarily high short-run credit prices, which staff’s analysis indicated may occur if the current regulation’s benchmarks are retained.

**Figure EX-1: Current and Proposed Annual Carbon Intensity Benchmarks as Compared to CI Reductions Achieved in 2017 by the Most Common Alternative Fuels**



\* Negative CIs have been achieved for some fuel pathways but are not shown.

\*\* The average percent CI reduction for electricity shown represents Light-Duty Electric Vehicle charging.

### Changes to Fuels Subject to the Regulation

Staff is proposing amendments that would broaden the list of fuels subject to the LCFS regulation and alter the opt-in and/or exempt status of particular fuels. The major potential changes include:

- The addition of alternative jet fuels (AJF) as opt-in credit-generating fuels:** 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. 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.

- **Removing the opt-in status for fossil compressed natural gas (CNG), hydrogen, and the exemption for propane:** In the current regulation, hydrogen and CNG from fossil natural gas are opt-in fuels because they are presumed to have a CI that meets the benchmarks in every year. As staff is proposing more ambitious CI benchmarks, however, staff anticipates some pathways for these fuels will have a CI that exceeds the benchmarks and become deficit-generating fuels. Liquefied petroleum gas (LPG or “propane”), including renewable propane, is exempt from the current regulation, meaning its use as a transportation fuel generates neither credits nor deficits. Staff is proposing to include this fuel in the LCFS.
- **Allowing alternative fuels used in military vehicles to opt in:** The LCFS currently exempts all fuels supplied for use in military tactical vehicles and support equipment from both credit and deficit generation. Producers of renewable fuels used in these applications have expressed concern that this provision reduces their incentives to sell low carbon fuels to the military. These producers have requested opt-in status for the alternative fuels sold for use in these military applications. Staff is supportive of this approach because it simplifies the decision-making framework created by the LCFS for low carbon fuel producers.

#### Carbon Capture and Sequestration Protocol

Carbon Capture and Sequestration (CCS) is a potentially significant technology for reducing CO<sub>2</sub> emissions from large stationary sources. In light of California’s mid- and long-term climate goals, CCS is likely to grow in importance. 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 relevant regulatory requirements that ensure sequestration permanence. The proposed amendments in this rulemaking include a fully developed CCS Protocol.

#### Promote Zero Emission Vehicle Infrastructure and Renewable Electricity to ZEVs

Staff is proposing amendments that expand opportunities for accounting for renewable/low-CI electricity used in zero emission vehicle (ZEV) applications, such as electric vehicle charging and hydrogen production via electrolysis. Electricity is the primary—if not the sole—factor in determining the CI of these fuel pathways and the combination of renewable electricity and ZEVs offers significant opportunity for CI reductions.

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However, we have seen very little interest in such pathways under the current rule. Staff believes that the lack of fuel pathways that combine zero carbon electricity and ZEV fueling technology is due to the small geographic footprint of ZEV infrastructure—which is often located in dense urban areas—making it difficult to co-locate renewable power generation with fueling stations.

To address this issue, staff proposes to allow renewable power generated in the same balancing authority as the ZEV load to be used in EV charging and H<sub>2</sub> production. Staff's goal is to incent the installation of additional low carbon electricity supply coupled with additional ZEV fueling infrastructure. Staff modelled these amendments off the existing flexibility for renewable natural gas used in natural gas vehicles—the main other alternative fuel that requires new fueling infrastructure.

Additionally, staff is proposing an option to recognize and reward the GHG benefits of shifting EV charging and electrolytic hydrogen load to the periods of time when intermittent renewable electricity might otherwise be wasted (curtailed). These amendments would allow the LCFS to increase its effectiveness as a tool for promoting the integration of renewable power and ZEV-related load and help make these vehicles truly “zero emission” on a life cycle basis.

These amendments are intended to promote the expansion of zero-emission vehicle infrastructure through the Low Carbon Fuel Standard Program as directed by Executive Order B-48-18.<sup>3</sup>

### Improve Crediting for Innovative Actions at Conventional Fuel Refineries

The 2015 LCFS rulemaking introduced a pilot program for crediting conventional petroleum refineries for GHG reduction projects performed within the boundary of the refinery. The current Refinery Investment Credit Pilot Program (RICPP) allows refineries to generate credits for projects that reduce refinery GHG emissions by at least 0.1 grams carbon dioxide equivalent per mega joule (gCO<sub>2</sub>e/MJ), calculated based on pre- and post-project GHG emissions at the refinery level. To date the LCFS program has not issued any credits under this provision, in part due to the uncertainty of the eligibility threshold and credit calculation using the refinery's entire emissions, which fluctuate due to confounding factors beyond the impacts of the project in question.

Staff is proposing to make changes to the RICPP with the goals of: (1) focusing the provision on innovative changes at refineries, (2) simplifying the eligibility threshold and credit calculation method by focusing on project-level rather than refinery-wide emission changes.<sup>4</sup> Example of innovative projects that would be eligible under the proposed amendments include carbon capture and sequestration, the use of renewable electricity,

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<sup>3</sup> Available at <https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/>

<sup>4</sup> Staff is proposing a new eligibility threshold whereby the GHG reduction in project life cycle emissions would need to be at least one percent of to the pre-project on-site refinery level GHG emissions.

fossil fuel substitution by renewable fuels for process energy, and electrification. Focusing this provision on innovative technologies would align it with the more successful provision for crediting production of crude using innovative methods and the overall technology-advancement goals at the core of the LCFS.

Relative to the current provision, these amendments would clearly signal the types of technological changes CARB would like to see the conventional petroleum refineries adopt. Simultaneously it will make the eligibility threshold more achievable, easier to estimate, and equitable to all refineries.

#### Addition of Third-party Verification

A successful GHG reduction program requires a system to monitor, report, and verify GHG emissions to support implementation and tracking of the effectiveness of emission reduction strategies. 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 audits of the reporting of quarterly fuel quantities. Staff is now proposing to supplement the work of CARB staff with a verification system that would require regulated entities reporting to CARB under the LCFS to retain the services of independent third-party verifiers. LCFS verifiers would perform GHG accounting checks in a role similar to the independent, objective evaluations of organizations' financial reports by financial auditors.

#### Pathway Application and CI Determination

Staff is proposing changes to the CI pathway application and certification process to better integrate with the system for third-party verification discussed above. Staff expects these changes would reduce application preparation time by the applicant as well as evaluation and processing time by CARB. Our goal is to enhance transparency and simplicity of CI calculations while ensuring accuracy of raw data inputs and basic pathway information through independent third-party verification.

#### *Adjust ADF Biodiesel in-use NOx Mitigation Sunset to Ensure Long Term NOx Mitigation*

On July 15, 2013, the State of California Court of Appeal, Fifth Appellate District (Court) issued an opinion in *POET, LLC versus California Air Resources Board* (2013) 218 Cal.App.4th 681. The Court held that CARB needed to remedy California Environmental Quality Act (CEQA) and Administrative Procedure Act (APA) issues, relating to the adoption of the original LCFS, including concerns about CARB's analysis of the environmental impacts of biodiesel.

CARB readopted the LCFS in 2015 to address the Court's concerns. At the same hearing, the Board also adopted the Alternative Diesel Fuels (ADF) regulation. The ADF regulation imposed restrictions to prevent certain biodiesels, which LCFS might incent, from causing any significant new emissions. A 2017 Court of Appeal opinion

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concluded that CARB, in the 2015 re-adoption, had failed to adequately analyze potential NOx impacts that may have been caused by increased use of biodiesel driven by the LCFS. On October 18, 2017, the Superior Court issued a writ of mandate pursuant to the direction of the Court of Appeal.

In response to this writ of mandate, CARB set aside the portions of the 2015 LCFS environmental analysis addressing NOx emissions from biodiesel on November 17, 2017, and has developed a supplemental environmental analysis to the 2015 Environmental Analysis to more comprehensively address potential LCFS-driven biodiesel NOx emissions impacts. A draft of that supplemental analysis is included as Appendix G to this Staff Report.

Based on this updated analysis, staff proposes to add an additional requirement to the sunset provision of the ADF regulation such that the ADF sunset would not occur for biodiesel until the hours of operation of off-road New Technology Diesel Engines (NTDEs) are 90 percent of the total hours of operation of off-road diesel engines. This is in addition to the current provision requiring 90 percent of vehicle miles travelled by on-road heavy-duty diesel vehicles to be from on-road heavy-duty NTDEs.

## **Potential Impacts of the Proposal**

### Potential Environmental Impacts

The existing LCFS regulation, established in previous rulemakings, defines the current requirements for the CI of fuels in California. CEQA states the baseline for determining the significance of environmental impacts will normally be the existing conditions at the time the environmental review is initiated. Therefore, significance determinations reflected in the Draft EA are based on a comparison of the potential environmental consequences of the proposed LCFS amendments with the LCFS at the 2016 regulatory standards.

Cumulatively, from 2019 through 2030, staff expects the proposed amendments to achieve 70 MMT CO<sub>2</sub>e additional GHG reductions beyond a business-as-usual scenario in which the current regulation is not amended.<sup>5</sup>

The proposed amendments are also expected to result in slight improvements to California's statewide air quality relative to both the current (2016) conditions and relative to the business-as-usual scenario. The total statewide NOx and PM<sub>2.5</sub> emissions are estimated to be lower in each year from 2019 through 2030 as the result

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<sup>5</sup> CEQA states the baseline for determining the significance of environmental impacts will normally be the existing conditions at the time the environmental review is initiated. Therefore, significance determinations reflected in the Draft EA are based on a comparison of the potential environmental consequences of the proposed amendments with the existing regulatory setting and physical conditions in 2016. However, to provide additional context and transparency in some portions of this ISOR staff also compares the impacts of the amendments to a scenario where the current regulation is retained and changes result from the current conditions (a "business as usual" scenario).

of the amendments. The annual NO<sub>x</sub> and PM<sub>2.5</sub> emission reductions represent less than one percent of total statewide emissions.

For the purpose of determining whether the proposed regulations have a potential adverse effect on other aspects of the environment, CARB evaluated the potential physical changes to the environment resulting from a reasonable foreseeable compliance scenario for the proposed LCFS amendments. The environmental effects of the proposed LCFS amendments would build upon the compliance responses of the current LCFS regulation. In many instances, compliance responses associated with the proposed LCFS amendments would be an intensification of actions that are already occurring.

Given the small magnitude of the statewide criteria pollutant improvements in staff's scenarios, and the complexity of compliance responses to the LCFS, local air quality increases in some local jurisdictions cannot be ruled out. Because the authority to determine project-level impacts and required project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with the Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, the Draft EA takes the conservative approach in its post-mitigation significance conclusions and discloses, for CEQA compliance purposes, that impacts from the development of new facilities or modification of existing facilities associated with reasonably foreseeable compliance responses to the proposed LCFS regulation could be potentially significant and unavoidable.

The Draft EA concluded implementation of these proposed LCFS amendments could result in the following short-term and long-term beneficial and adverse impacts: beneficial impacts to energy demand and greenhouse gases; less-than-significant impacts to cultural resources, energy demand, greenhouse gases, hazards and hazardous materials, mineral resources, population employment, and housing, public services, and recreation; and potentially significant and unavoidable adverse impacts to aesthetics, agriculture and forest resources, air quality, biological resources, cultural resources, energy demand, geology and soils, hazards and hazardous materials, hydrology and water quality, land use and planning, mineral resources, noise, transportation/traffic and utilities and service systems. The potentially significant and unavoidable adverse impacts are primarily related to short-term, construction-related activities. This explains why some resource areas are identified above as having both less-than-significant impacts and potentially significant impacts. Please refer to the Draft EA for further details.

## Potential Economic Impacts

The LCFS has a range of potential economic impacts. They include direct costs to high carbon fuel producers, which are described below, and a broader set of macroeconomic impacts across California's economy. For example, the LCFS supports the growth of businesses and industries in California and elsewhere that are supplying lower carbon fuels, including renewable natural gas, advanced biofuels and others.

The LCFS also has interactive effects with other policies, for example it reduces compliance costs under California's Cap-and-Trade program for fuel sold by regulated entities that are subject to both regulations. Conversely, ZEVs sales are strongly promoted by the Advanced Clean Car package of rules, and the sale of these vehicles makes low carbon fuel use more likely. Similarly, the federal Renewable Fuels Standard creates a strong incentive for the use of some fuels that the LCFS also rewards. Because the impact of these interacting incentives are at times difficult to disentangle quantitatively, staff has endeavored to explain these interaction effects and to adopt a straightforward method to attribute abatement actions either to the LCFS or to other policies for the purpose of economic and air quality analyses.

### *Cost and Benefits to Regulated Parties*

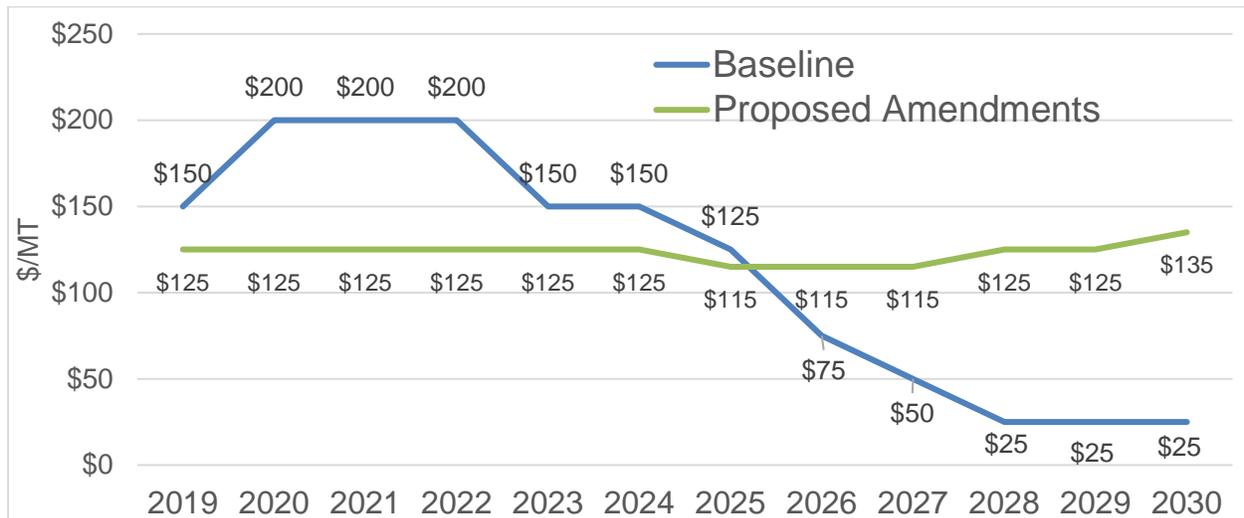
Staff believes the proposed CI benchmark schedule is more likely to produce strong and stable incentives for long-term decarbonization of California's transportation fuels.<sup>6</sup>

Figure EX-2 shows the estimated credit price for the projected baseline and proposed amendments scenarios from 2019 through 2030. Staff's analysis establishes the LCFS credit price for each scenario using the cost of obtaining the marginal (most expensive) credit in a given year. Given the high-level of uncertainty related to marginal abatement each year, these prices should be treated as illustrative rather than predictive. The availability of new lower-cost pathways, such as credit generation from alternative jet fuels and CCS projects, and the reduction trajectory being more closely aligned with the turnover of the vehicle fleet to alternative fuel vehicles, are expected to increase the likelihood of long-term stable LCFS credit prices under the proposed amendments.

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<sup>6</sup> Prices are expected to decrease in the short-run but increase in the long-run due to the smoother near-term benchmarks and long-run ambition of the proposed amendments.

**Figure EX-2: Estimated Credit Prices for the Baseline and Proposed Amendments Scenarios**



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 total direct costs to deficit generators of about \$9.0 billion. The highest annual cost occurs in 2030 with an estimated direct cost of \$3.7 billion.

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 \$3.8 billion. Many of California’s biodiesel producers, hydrogen producers, electric charging stations, hydrogen stations, and natural gas stations are small businesses who will benefit from these amendments.

### *Macroeconomic Effects*

For a major regulation proposed on or after January 1, 2014, a standardized regulatory impact analysis (SRIA) is required. A major regulation is one “that will have an economic impact on California business enterprises and individuals in an amount exceeding fifty million dollars (\$50,000,000), as estimated by the agency.” (Govt. Code Section 11342.548). The LCFS amendments were determined to be a major regulation; therefore, CARB prepared a SRIA and submitted it to the Department of Finance (DOF) in November of 2017. DOF provided feedback and CARB staff have updated the SRIA and responded to DOF’s comments as shown in Appendix E of this ISOR.

The macroeconomic impacts of the proposed amendments are negligible, considering the size and diversity of California’s economy. As one example, Gross State Product is the market value of all goods and services produced in California and is one of the primary macroeconomic 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. Under the proposed amendments, GSP growth is estimated to be

slightly faster, relative to the baseline, from 2019-2025 and then slightly slower from 2026-2030.<sup>7</sup> CARB interprets the impact of the proposed amendments on GSP as being indiscernible in California's \$3.4 trillion economy in 2030.

### *Other Highlighted Benefits*

CARB anticipates that the proposed amendments, including the CI reductions outlined in Figure EX-1, 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. If all GHG reductions under the proposed amendments are assumed to be carbon dioxide reductions, in 2030 the estimated benefits from the proposed amendments would range from approximately \$555 million to \$2.5 billion (in 2016\$).
- **Increased use of lower CI alternative fuels** and alternative fueled vehicles including biodiesel, renewable diesel, renewable jet fuel, low NO<sub>x</sub> natural gas trucks, and electric and hydrogen zero emission vehicles. In addition to reducing GHG emissions, this will lower levels of localized air pollutants, which are the cause of many deleterious health effects on California residents. As modeled, the proposed amendments would reduce PM<sub>2.5</sub> and NO<sub>x</sub> emissions, resulting in cumulative health benefits for individuals in California of approximately \$900 million over the period of 2019 to 2030 relative to business-as-usual. 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.
- **Greater opportunities for California businesses to invest** in the production of alternative fuels and other credit generating opportunities at oil fields and refineries.
- **Reduced dependence on fossil fuel and crude oil imports** and diversification of the transportation fuel pool, which may decrease the exposure of California to large swings in energy prices due to external economic shocks.

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<sup>7</sup> All of these GSP variations are less than 0.1% of a change from the baseline on an annual basis.

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Some of these benefits are beyond the scope of staff's analysis in this rulemaking, but some studies suggest they are significant.<sup>8,9,10,11,12</sup>

Furthermore, while the LCFS is designed to increase the supply of alternative fuels in California and drive existing supply chains to reduce emissions, perhaps a larger measure of its impact is evidenced by the development of similar programs, using a life cycle GHG performance-based approach, in other jurisdictions. Oregon and British Columbia have implemented similar regulations, and such programs are also under consideration at the national level in Brazil<sup>13</sup> and Canada.<sup>14</sup>

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<sup>8</sup> Petroleum Market Advisory Committee, California Energy Commission, September 2017. Available at: [http://docketpublic.energy.ca.gov/PublicDocuments/15-PMAC-01/TN221306\\_20170925T092536\\_Petroleum\\_Market\\_Advisory\\_Committee\\_Final\\_Report.pdf](http://docketpublic.energy.ca.gov/PublicDocuments/15-PMAC-01/TN221306_20170925T092536_Petroleum_Market_Advisory_Committee_Final_Report.pdf)

<sup>9</sup> National Research Council, Transitions to Alternative Vehicles and Fuels. (2013) National Academy of Sciences. Available at: [http://www.nap.edu/catalog.php?record\\_id=18264](http://www.nap.edu/catalog.php?record_id=18264)

<sup>10</sup> Fine, J., et al. The upside hedge value of California's global warming policy given uncertain future oil prices. Energy Policy (2012) doi 10.1016/j.enpol.2012.01.010

<sup>11</sup> Greene, D.L., Roderick, S.L., Hopson, J.L. OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010, (2013) Howard H. Baker Jr. Center for Public Policy.

<sup>12</sup> Greene, D.L., Tishchishyna, N.I. Costs of Oil Dependence: A 2010 Update. (2000) Oak Ridge National Laboratory.

<sup>13</sup> Temer sanctions incentive policy for biofuels. BrazilGovNews, Federal Government of Brazil. December 28, 2017. <http://www.brazilgovnews.gov.br/news/2017/12/temer-sanctions-incentive-policy-for-biofuels>

Brazil to Launch Ambitious Biofuels Program. Ethanol Producer Magazine. November 17, 2017 <http://ethanolproducer.com/articles/14803/brazil-to-launch-ambitious-biofuels-program>

<sup>14</sup> Environment and Climate Change Canada. Clean Fuel Standard Discussion Paper. February 2017. [http://ec.gc.ca/lcpe-cepa/D7C913BB-13D0-42AF-9BC7-FBC1580C2F4B/CFS\\_discussion\\_paper\\_2017-02-24-eng.pdf](http://ec.gc.ca/lcpe-cepa/D7C913BB-13D0-42AF-9BC7-FBC1580C2F4B/CFS_discussion_paper_2017-02-24-eng.pdf)

## **I. INTRODUCTION AND BACKGROUND**

In this chapter, the California Air Resources Board (CARB or Board) staff provides a brief overview of the Low Carbon Fuel Standard (LCFS), information on the history and current status of the LCFS program, and an overview of the proposed revisions to the program.

The Board approved the LCFS regulation in 2009 as a discrete early action measure under the California Global Warming Solutions Act of 2006 (AB 32). The purpose of the LCFS regulation is to reduce the carbon intensity of transportation fuels used in California, thereby reducing greenhouse gas (GHG) emissions, and to diversify the fuel pool to enable long-term dramatic decarbonization of the transportation sector. The regulation provides co-benefits in addition to these primary objectives, as discussed in this Staff Report.

Through this proposed rulemaking to amend the regulation, staff seeks to strengthen the LCFS targets. In 2016, the California legislature adopted Senate Bill (SB) 32 (Pavley, 2016), which codifies a statewide GHG target of at least 40 percent below 1990 levels by 2030. To encourage additional GHG reductions in key areas where decarbonization will be important to meet long-term climate goals, staff proposes to recognize eligibility of new fuels and vehicle applications for generating credits under the program. To enhance the integrity of the emission reduction claims in the program, the amendments include a proposal to establish an independent third-party verification and verifier accreditation program for ensuring the accuracy of data reported under LCFS. Finally, the proposed amendments include a number of changes that would integrate the verification system, update program data, quantification methods and analysis tools, and other changes to improve, streamline, and further clarify application and reporting processes.

### **A. Overview of the LCFS**

Transportation plays a key role in California's economy and lifestyle. The production and use of traditional petroleum-derived transportation fuels—such as gasoline and diesel—is responsible for almost half of the State's GHG emissions. The LCFS is a key part of a comprehensive set of California programs to cut GHG emissions by improving vehicle technology, reducing fossil fuel consumption, and implementing sustainable land-use policies.<sup>15</sup> The LCFS is designed to decrease the carbon intensity (CI) of California's transportation pool and provide an increasing range of low-carbon and renewable alternatives to conventional petroleum-derived fuels.<sup>16</sup>

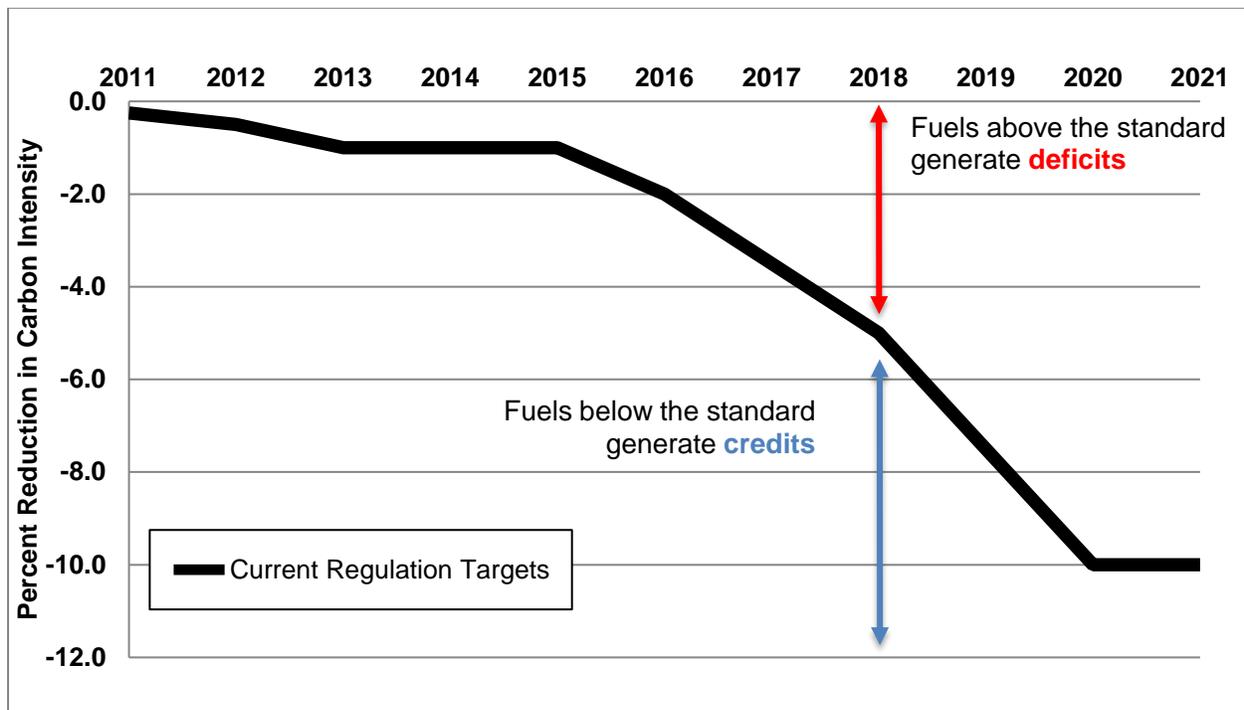
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<sup>15</sup> The Climate Change Scoping Plan explains the overarching framework of California's GHG policies. The current Draft 2017 Climate Change Scoping Plan Update is available from: <https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm>

<sup>16</sup> Carbon intensity (CI) is a measure of the GHG emissions associated with the various production, distribution, and consumption steps in the "life cycle" of a transportation fuel.

Providers of transportation fuels must demonstrate that the mix of fuels they supply for use in California meets the LCFS carbon intensity standards, or benchmarks, for each annual compliance period. They must report all fuels provided, and track the fuels' carbon intensity through a system of "credits" and "deficits." Credits are generated by supplying fuels with lower carbon intensity than the benchmark. Deficits result from supplying fuels with higher carbon intensity than the benchmark. This concept is illustrated in Figure I-1. A deficit generator meets its compliance obligation by ensuring that the amount of credits it earns or otherwise acquires from another party is equal to, or greater than, the deficits it has incurred. Credits and deficits are generally determined based on the quantity of fuel sold, the carbon intensity of the fuel, and the efficiency by which a vehicle converts the fuel into useable energy. Additionally, there are CARB-approved LCFS project-based actions that may generate credits, such as by demonstrating carbon capture and sequestration, using solar-generated steam at oil and gas extraction sites, and investing in refinery improvements that reduce emissions. Credits and deficits are denominated in metric tons of GHG emissions. Credits may be banked and traded within the LCFS market to meet compliance obligations.

**Figure I-1: Illustration of LCFS Mechanics: How Credits and Deficits are Calculated**



The LCFS carbon intensity benchmarks are an annually-declining standard, which are defined in the LCFS regulation as a percentage reduction from the historical average carbon intensity of gasoline and diesel fuel in the year 2010. To determine the carbon intensity value of a particular fuel, the GHG emissions from all steps in the fuel's life cycle are summed and divided by the fuel's energy content (in megajoules). GHG emissions from each step can include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous

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oxide (N<sub>2</sub>O), volatile organic compounds (VOC) and carbon monoxide (CO), which are adjusted by their Intergovernmental Panel on Climate Change (IPCC) global warming potentials to their CO<sub>2</sub> equivalent. Thus, carbon intensity is expressed in terms of grams of CO<sub>2</sub> equivalent per megajoule (gCO<sub>2e</sub>/MJ).

The LCFS is based on the principle that each fuel has life cycle GHG emissions. This life cycle analysis (LCA) examines the GHG emissions associated with the production, transportation, and use of a given fuel. The LCA includes direct emissions from the energy and material inputs to production, transport, and use of the fuels, as well as significant GHG emissions from market-driven changes, such as changes in land use for some crop-derived biofuels, and emissions that may result from market displacement effects (e.g., when a material is diverted from its historic use in order to produce a fuel, causing increased demand for another material to substitute the for fuel feedstock). The system of declining benchmarks that is used to calculate credits and deficits, and the obligation of deficit-generating fuels to be canceled out by credits, result in a decrease in the total life cycle GHG emissions from the transportation fuel pool in California.

The LCFS is designed to encourage the use of low carbon fuels in California, to encourage the lowest-carbon production of those fuels in California and elsewhere, thereby, reducing GHG emissions and advancing the technology underlying these low carbon fuels. The LCFS is performance-based and the flexibility of the credit market allows many possible low carbon fuels to contribute to the carbon intensity reductions.

A more complete description of how the LCFS regulation is designed to work, as well as its underlying scientific and economic principles, can be found in the initial and final statements of reasons for the original 2009 rulemaking,<sup>17</sup> the 2011 and 2015 Staff Reports.<sup>18,19</sup>

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<sup>17</sup> See "Staff Report: Initial Statement of Reasons: Proposed Regulation to Implement the Low Carbon Fuel Standard." March 5 (2009); Staff Report: Initial Statement of Reasons: Proposed Regulation to Implement the Low Carbon Fuel Standard Volume II." March 5 (2009); and "Final Statement of Reasons for Rulemaking, Including Summary of Public Comments and Agency Responses." December (2009). Available at: <https://www.arb.ca.gov/regact/2009/lcfs09/lcfs09.htm>.

<sup>18</sup> See "Staff Report: Initial Statement of Reasons for Rulemaking: Proposed Amendments to the Low Carbon Fuel Standard." October 26 (2011); and "Final Statement of Reasons: Amendments to the Low Carbon Fuel Standard Regulation." October 11 (2012). Available at: <https://www.arb.ca.gov/regact/2011/lcfs2011/lcfs2011.htm>.

<sup>19</sup> See "Staff Report: Initial Statement of Reasons for Rulemaking: Proposed Re-adoption of the Low Carbon Fuel Standard Regulation." December 31 (2014); and "Final Statement of Reasons for Rulemaking, Including Summary of Comments and Agency Response: Re-adoption of the Low Carbon Fuel Standard Regulation." October 2 (2015). Available at: <https://www.arb.ca.gov/regact/2015/lcfs2015/lcfs2015.htm>.

## **B. History and Current Status of the LCFS**

CARB initially approved the LCFS regulation in 2009. Throughout the nearly eight years since the Board's original adoption, the basic framework of the current LCFS—including the use of life cycle analysis, the LCFS credit market, and the electronic registry for fuel reporting—has worked well and continues to support growth in an increasingly diverse and low-carbon transportation fuel pool.<sup>20</sup>

CARB approved revisions to the LCFS in December 2011, which became effective on November 26, 2012, and were implemented by CARB on January 1, 2013. On July 15, 2013, the State of California Court of Appeal, Fifth Appellate District (Court) issued its opinion in *POET, LLC versus California Air Resources Board* (2013) 218 Cal.App.4th 681, resulting in a stay of the LCFS. The Court held that the LCFS adopted in 2009 and implemented in 2010 (referred to as 2010 LCFS) would remain in effect and that CARB could continue to implement and enforce the 2013 regulatory standards while taking steps to remedy California Environmental Quality Act (CEQA) and Administrative Procedure Act (APA) issues as required in the ruling.

To address the court ruling, CARB brought a revised LCFS regulation to the Board for re-adoption in February 2015. The 2015 rulemaking included many amendments, updates and improvements to the program, including a compliance schedule that maintained the 2009 LCFS regulation's target of a 10 percent reduction in average carbon intensity by 2020 from a 2010 baseline. On September 24, 2015, the Board approved the current LCFS regulation. The current regulation became effective on January 1, 2016.<sup>21</sup>

When readopting the LCFS in 2015 the Board also adopted the Alternative Diesel Fuels (ADF) regulation, clarifying an approval process for such fuels. The ADF regulation also imposed restrictions to prevent certain biodiesels from causing any significant new emissions.

After the Fresno County Superior Court initially discharged the writ of mandate directing CARB to take corrective action pursuant to the 2013 Court of Appeal ruling in January 2016, the Court of Appeal reversed the discharge of the writ of mandate in a May 30, 2017 opinion. (*POET, LLC v. California Air Resources Board* (2017) 12 Cal.App.5th 52, 58 (as modified).) The 2017 Court of Appeal opinion concluded that CARB had failed to adequately analyze potential NOx impacts that may have been caused by increased use of biodiesel driven by the LCFS. On October 18, 2017, the Superior Court issued a writ of mandate pursuant to the direction of the Court of Appeal. In response to this writ of mandate, CARB set aside the portions of the 2015 LCFS environmental analysis addressing NOx emissions from biodiesel on November 17, 2017, and has developed supplemental environmental analysis to more comprehensively address potential LCFS

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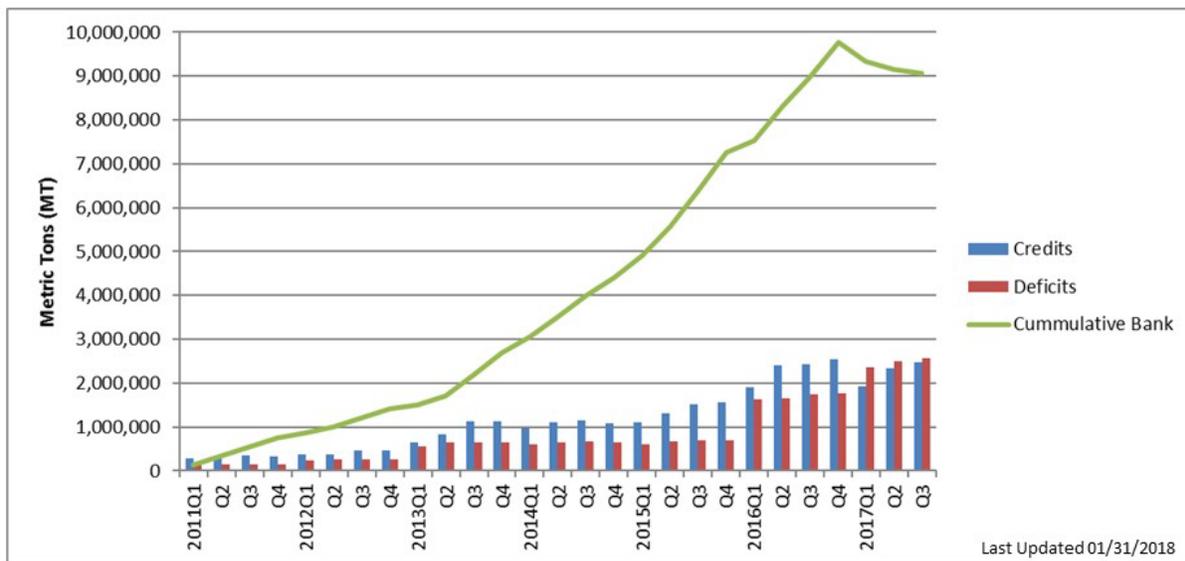
<sup>20</sup> Staff presented a progress report on the LCFS program to the Board on June 22, 2017. Available at: <https://www.arb.ca.gov/board/books/2017/062217/17-6-4pres.pdf> The record created in this rulemaking fulfills the requirement to conduct a program review in section 95496(b) of the current regulation.

<sup>21</sup> Title 17, California Code of Regulations (CCR), sections 95480-95497.

biodiesel NOx emissions impacts. A draft of that supplemental analysis is included as Appendix G to this ISOR. From the results of that supplemental analysis, staff's proposed amendments now include a proposed amendment to the ADF sunset provision designed to create greater certainty with respect to mitigation of potential future NOx emissions impacts from biodiesel use in off-road diesel engines. The writ of mandate orders CARB to maintain the 2017 LCFS CI reduction level for diesel and diesel substitutes until the writ is discharged.

Through the end of 2016 (the most recent full data year available), California had achieved a reduction of more than 2.5 percent in the average carbon intensity of the overall transportation fuel pool, as compared to a target reduction of 2 percent. Regulated parties have historically over-complied with the regulation, providing a bank of about nine million excess credits that are available for future compliance, as shown in Figure I-2. The financial benefits are distributed among providers of various alternative fuels (as illustrated in Figure I-3), geographically across California,<sup>22</sup> and across the participating credit generators.<sup>23</sup>

**Figure I-2: Total Credits and Deficits for All Fuels Reported and Cumulative Credit Bank**



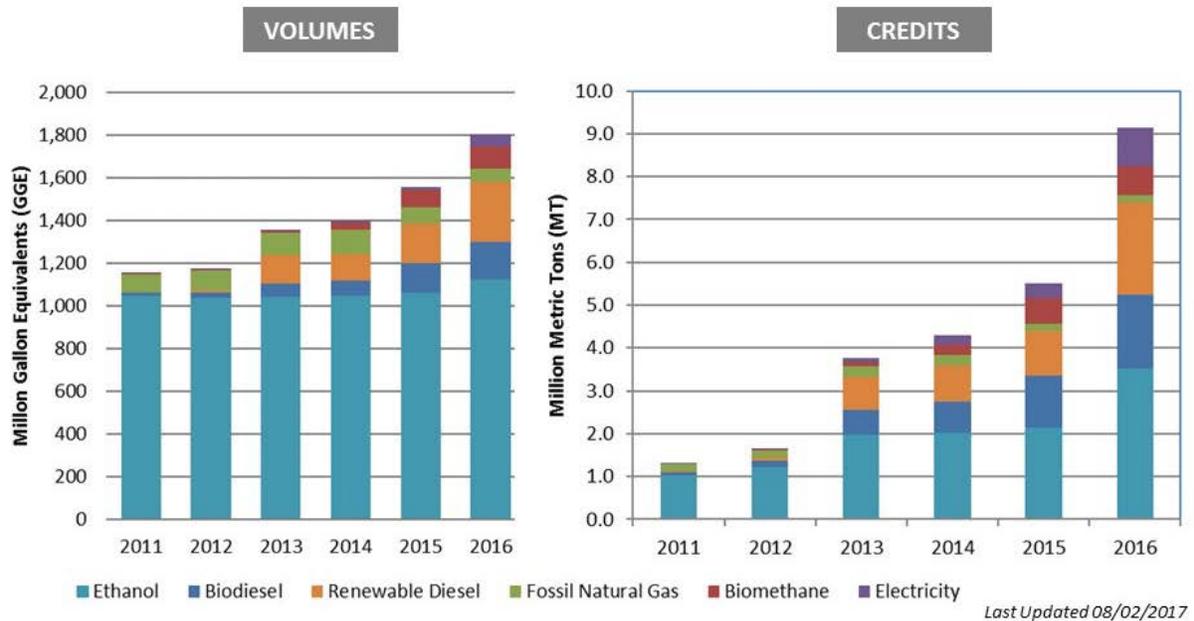
The LCFS is driving rapidly increasing use of low carbon fuels in California. Before the LCFS, the only alternative fuels with market share were natural gas and ethanol. Between 2011 and 2016, renewable diesel use has increased from less than 2 million to

<sup>22</sup> LCFS Data Dashboard. Figure 11 Map of LCFS Beneficiaries Are Dispersed Throughout California (accessed 04/21/2017). Beneficiaries include California municipal transit agencies, fueling facilities, equipment service providers, utilities, as well as fuel producers and project developers across the U.S. and abroad. Available at: <https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm>.

<sup>23</sup> LCFS Data Dashboard. Figure 9 LCFS Credit Market Net Position Histogram (accessed 02/06/2018). Available at: <https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm>.

250 million gallons per year, as shown in Figure I-3. Biodiesel use has grown from 12 million to 163 million gallons. Renewable natural gas use in vehicles has increased from 2 million 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 I-3: Annual Growth in Alternative Fuel Volumes and Credit Generation by Fuel Type**



Through ongoing innovation, fuel producers are achieving significant reductions in the carbon intensities of their fuel pathways. New projects with the potential to generate significant credits are being explored at biofuel production facilities, waste management operations (e.g., landfills, livestock manure and wastewater treatment plants), crude production fields (e.g., solar-generated electricity and steam) and petroleum refineries (e.g., production of renewable hydrogen and co-processing of renewable feedstocks). Providers of electricity and hydrogen for battery electric and fuel cell vehicles are also increasing participation in the program.

Credit prices and trading activity reached all-time highs in 2017. Over eight million LCFS credits were sold or traded in approximately 940 transactions in 2017 with a weighted average credit price of \$89/metric ton carbon dioxide equivalent (MTCO<sub>2e</sub>),<sup>24</sup> demonstrating an active credit market with an annual transactional value of over \$700 million. More than 255 active entities are registered for reporting in the LCFS Reporting Tool and Credit Bank & Transfer System (LRT-CBTS), and 459 individual alternative

<sup>24</sup> Weekly LCFS Credit Transfer Activity Report Activity Log (accessed 02/13/18). Available at: <https://www.arb.ca.gov/fuels/lcfs/credit/lrtweeklycreditreports.htm>.

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fuel pathways have been certified with carbon intensities below the current benchmarks. About 180 biofuel facilities are registered under the LCFS as supplying low carbon fuels to California.

In a June 22, 2017 LCFS Progress Report on the Low Carbon Fuel Standard<sup>25</sup> to the Board, staff compared actual data from 2016 to the illustrative compliance scenarios that were developed in the 2015 rulemaking process, alongside projections developed by Boston Consulting Group (BCG) for the Western States Petroleum Association, and by Chevron. The comparison showed that actual consumption of alternative fuels exceeded all parties' projections, and CARB's forecasted credit generation potential was reasonable in spite of unanticipated increases in gasoline demand.

The current regulation requires staff to conduct a program review and present results to the Board by January 1, 2019.<sup>26</sup> The record created in the 2018 amendments rulemaking, including the information presented in this Staff Report, at Board Hearings, and through responses to public comments in staff's Final Statement of Reasons, fulfills this requirement.

The current LCFS targets a 10 percent reduction in average fuel carbon intensity by 2020 and maintains that target for all subsequent years. A primary objective of this rulemaking is to strengthen the compliance targets of the LCFS regulation through 2030 so that the LCFS continues to serve as a key policy to reduce GHG emissions from the transportation sector. Achieving the GHG reduction goals of SB 32 will require significant changes in all economic sectors. California's transportation industry remains the largest contributing sector to the GHG Inventory,<sup>27</sup> yet many alternative fuels with demonstrated feasibility are available today at scale. The proposed LCFS targets will signal the market to identify the most promising long-term ultra-low carbon fuels solutions and invest in these alternatives to ensure greater reductions beyond the next decade in efforts to avoid the most catastrophic impacts of climate change. Specifically, the proposed regulation will support California's progress toward decarbonization and diversification of the transportation fuel pool.

### **C. Overview of the Proposed Amendments**

This section provides a broad overview of amendments staff is proposing for adoption in 2018. Chapter II provides a more in-depth description of the purpose for the rulemaking and the problems that the proposal is intended to address. Chapter III provides a summary, purpose and rationale for each change to the regulation order. The proposed changes reflect a range of intentions: from simple updates to improve the

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<sup>25</sup> Board Agenda Item # 17-6-4. Staff presentation available at: <https://www.arb.ca.gov/board/books/2017/062217/17-6-4pres.pdf>

<sup>26</sup> Section 95496(b) of the current regulation. Available at: <https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf>.

<sup>27</sup> California Greenhouse Gas Emission Inventory - 2017 Edition. Available at: <https://www.arb.ca.gov/cc/inventory/data/data.htm>

program's overall effectiveness, to more significant proposals for improving California's long-term ability to support the supply of increasingly lower-CI fuels.

The most significant change in this proposal is to both strengthen and smooth the CI reduction benchmarks through 2030 in-line with the California's 2030 GHG target enacted through SB 32 (Pavley, 2016). These benchmarks provide the basis of calculating credits for low carbon fuels and deficits for high carbon fuels.

If adopted, the proposed amendments would require a 20 percent reduction in fuel CI from a 2010 baseline by 2030, as shown in the proposed CI benchmark schedule listed in Table I-1 and shown in Figure II-1. The proposed amendments will also smooth the schedule by linearly reducing by 1.25 percent annually from a 5 percent reduction in 2018 to the 20 percent value in 2030.

**Table I-1: Proposed LCFS Schedule for Percentage Reduction in CI**

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	16.25	17.50	18.75	20.00

The process for determining the annual carbon intensity benchmarks is detailed in Chapter 8 and Appendix E. Other proposed changes include allowing new fuel types to generate credits and adding an independent third-party verification program for data reported under LCFS, including an accreditation program for verifiers.

Additionally, amendments are proposed to further streamline and clarify existing requirements of the LCFS regulation, to update program tools and data, and to integrate existing processes (such as fuel pathway application, CI determination, and reporting of quarterly and annual fuel transactions) with the proposed third-party verification program.

Table I-2 provides a summary of the proposed changes to the regulation. Staff began conceptually discussing many of these items during an informal public process initiated in March of 2016, hosting 22 workshops and fuel-specific working meetings through December of 2017. The informal public process is detailed in Chapter XI.

**Table I-2: Summary of Proposed Regulatory Amendments to the LCFS Regulation**

Topic	Proposed Regulatory Updates
<b>General</b>	<ul style="list-style-type: none"> <li>• Definition updates and additions, as needed</li> <li>• Improve consistency and clarity in referring to specific entities affected by the regulation and the types of data reports</li> <li>• Ensure accuracy and support better accounting through addition of recordkeeping and reporting requirements</li> <li>• Minor updates for typographical errors, clarifications, and organization of the rule, that do not materially affect requirements</li> </ul>
<b>Compliance, Program Targets &amp; Credit Generation</b>	<ul style="list-style-type: none"> <li>• Strengthen the targets through 2030: revise benchmarks for gasoline, diesel, and jet fuel substitutes from 2019 to 2030</li> <li>• Add new credit generating fuels and vehicle categories to incent further reductions, including alternative jet fuels</li> <li>• Adopt accounting and permanence protocols to enable credit generation for carbon capture and sequestration projects</li> <li>• Establish a Buffer Account to mitigate risk of credit invalidation</li> <li>• Shift credit generation to the end of each quarter and require business partner reconciliation in order to limit the scope of verification</li> </ul>
<b>Entities and Eligibility</b>	<ul style="list-style-type: none"> <li>• Enable trading exchanges to participate in the LCFS market to facilitate investment in new credit-generating projects and alternative fuels production</li> <li>• Enable account holders to designate a representative to manage fuel transactions reporting and credit transfers</li> <li>• Modify eligibility to provide flexibility while further clarifying the responsibilities of program participants</li> </ul>
<b>Fuel Pathways Applications and CI Determination</b>	<ul style="list-style-type: none"> <li>• Integrate third-party validation step into the certification process</li> <li>• Update LCA modeling tools and eliminate need for most producers to have familiarity with the CA-GREET model</li> <li>• Add new Lookup Table pathways, allow for updates to electricity pathways</li> <li>• Expand flexibility to recognize GHG benefits of low-CI electricity coupled with ZEV fueling infrastructure</li> <li>• Add ongoing responsibilities for submittal of Fuel Pathway Reports to ensure CI conformance</li> <li>• Extend the time period over which conformance with a certified CI score is evaluated</li> <li>• Add a process for innovative pathways to be evaluated before operation commencement</li> </ul>

	<ul style="list-style-type: none"> <li>• Reorganize text to improve readability</li> </ul>
<p><b>Fuel Transactions Reporting and Data Management</b></p>	<ul style="list-style-type: none"> <li>• Limit period of time that fuel can be transferred with credits/deficits attached</li> <li>• Add Verification Portal to the data management system for verifiers to have access to relevant applicant information</li> <li>• Require Fueling Supply Equipment registration for some fuels to avoid potential double counting of transactions reported at a distributed level</li> <li>• Further clarify requirements for reporting fuel exports</li> </ul>
<p><b>Petroleum and Project-based Credits</b></p>	<ul style="list-style-type: none"> <li>• Update Crude Oil Lookup Table</li> <li>• Improve accounting mechanisms for refinery hydrogen and investment credit pilot projects</li> <li>• Expand steam quality ranges for solar steam to improve accuracy of innovative crude crediting provisions</li> </ul>
<p><b>Verification Program</b></p>	<ul style="list-style-type: none"> <li>• Change reporting responsibilities for fuel transactions, CI data, and projects to integrate a system for verification by accredited third-parties and the Board’s staff</li> <li>• Identify entities responsible for reporting and recordkeeping to enable verification</li> <li>• Establish requirements for verification process, including: frequency and deadlines for verification; verification body selection and rotation requirements; requirements for site visits, sampling plans, data checks, assessing conformance and material misstatement, and completion of verification services.</li> <li>• Establish accreditation requirements for third parties providing verification services</li> <li>• Require demonstration to CARB of no conflict of interest</li> </ul>

## **II. THE PROBLEM THAT THE PROPOSAL IS INTENDED TO ADDRESS**

California needs to diversify the state's fuel pool, support demand for increasingly lower-CI fuels, and promote transformative innovation in the transportation sector to achieve our mid- and long-term greenhouse gas (GHG) targets. In this chapter, staff provides a description of the purpose for the rulemaking and the problems the proposed amendments are intended to address. A description, purpose and rationale for each of the proposed updates and revisions are provided in Chapter III.

Staff is proposing amendments to the regulation in order to:

- Strengthen the carbon intensity benchmarks through 2030 in order to help achieve the SB 32 2030 GHG target;
- Expand the fuel types to which the LCFS regulation applies in order to encourage additional actions in areas where reductions will be needed to meet long-term GHG goals;
- Improve accuracy and add flexibility to incent the installation of additional low carbon electricity supply coupled with expansion of ZEV fueling infrastructure;
- Adopt accounting and permanence protocols to enable credit generation for carbon capture and sequestration projects;
- Improve crediting for innovative actions at conventional fuel refineries;
- Further ensure accuracy of the data that underlies the LCFS program and associated market;
- Simplify and streamline application and reporting requirements for regulated entities to encourage greater participation and assist participant compliance;
- Update regulatory values (e.g., EER, energy densities) and LCA modeling tools to use more detailed or recent data;
- Include an independent third-party verification and verifier accreditation program to ensure accuracy of LCFS reported data, and reduce requirements for regulated entities to submit demonstrations and documents to CARB for staff review;
- Address the Court's direction from POET's legal challenge; and
- Make minor updates for typographical errors, clarifications, and organization of the rule that do not materially affect requirements.

## **A. Strengthen the Average Carbon Intensity Requirements Through 2030**

Increasing the stringency of the LCFS carbon intensity targets is necessary to achieve California's 2030 GHG target. Maintaining steady carbon intensity reductions through 2030 will ensure that low-carbon alternatives to petroleum fuel are available in sufficient quantities in the long-term.

Achieving California's mid- and long-term GHG and air quality goals will require a renewable portfolio of transportation fuels—including electricity and hydrogen—in amounts well beyond the current estimated trajectories. The transportation sector remains the largest contributing source of GHG emissions in the state inventory. The LCFS has been an effective measure for increasing the use of low carbon alternatives to fossil fuels in California, by providing significant economic benefits to the credit generating entities who participate in the program, including municipal transit agencies, alternative fueling facilities, equipment service providers, fuel producers and project developers across the U.S. and abroad.

In addition to other state and federal GHG-reduction programs, the proposed amendments are expected to reduce life cycle GHG emissions of transportation fuels consumed in California by about 70 million metric tons (MMT) between 2019 and 2030 as compared to business as usual (see Chapter IV of this Staff Report for additional discussion of the projected GHG benefits). Greater diversification of the State's fuel portfolio will also support California's ongoing efforts to improve ambient air quality. Chapter V of this Staff Report summarizes the air quality and public health benefits of the proposed regulation.

The LCFS plays a role in supporting other state GHG reduction efforts; notably, the Short-Lived Climate Pollutant (SLCP) Strategy, Advanced Clean Cars (ACC), Mobile Source Strategy (MSS), Sustainable Freight Action Plan (SFAP), and Renewable Portfolio Standard (RPS). The SLCP leverages the potential high value of LCFS credits to incentivize methane reductions from dairy and livestock waste management operations. The goals of the ACC are advanced by directing the proceeds from LCFS credit sales earned by electric utilities to offer rebates for EV charging; similarly, the opportunity to generate LCFS credits helps to reduce the upfront costs for fleets to purchase new zero-emission trucks and equipment to achieve the SFAP goals. By recognizing the carbon intensity of renewable electricity used to produce transportation fuels, the LCFS rewards fuel providers across the supply chain for the displacement of fossil fuel consumption by biomethane, wind, solar, and other lower carbon technologies, and offering further reward for renewable power to fuel above and beyond the RPS.<sup>28</sup>

California's 2017 Climate Change Scoping Plan Update sets out the State's path to achieve the SB 32 target. The 2017 Climate Change Scoping Plan Update proposes strengthening the LCFS benchmarks through 2030 as one of the key measures for

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<sup>28</sup> These amendments increase the flexibility of accounting for the use of such power.

achieving the State's GHG 2030 target.

The LCFS regulation defines a carbon intensity reduction target (or benchmark) for each year, which the current regulation refers to as the "compliance schedule." Achieving the SB 32 GHG target will require the use of a portfolio of low carbon transportation fuels beyond the amount expected to result from the current compliance schedule. Using market data alongside techno-economic models to evaluate a variety of transportation fuel pathways, staff has conducted an in-depth scenario analysis that informed the 2030 target and annual benchmarks for carbon intensity reduction from 2019 through 2030. This analysis helps explore possible compliance outcomes and facilitates improved understanding of LCFS economics and compliance feasibility.

Staff has developed several modeling tools that take into account feedstock supply, fuel prices, fuel incentives, and capacity constraints to assess the technical and economic feasibility of bringing low carbon fuels to California. Staff used these modeling tools, together with stakeholder feedback and information obtained from market reports on alternative fuel technology development, to assess fuel supply variability and sensitivity to LCFS credit prices and other uncertain market effects on a year-by-year basis. Model results provide staff with a better understanding of key variables and assumptions that ultimately affect compliance. While a 20 percent target may be conservative under some possible techno-economic assumptions, there are many market-based variables, such as growth in transportation fuel demand, which may make more aggressive compliance targets difficult to meet. Across most modeled scenarios, a 20 percent target is feasible with sufficient electrification (including hydrogen vehicles), increased use of commercially available low-CI fuels like renewable diesel, biodiesel, ethanol, and biomethane, and some reduction in the carbon intensity of the conventional fuel supply chain through project-based credits.

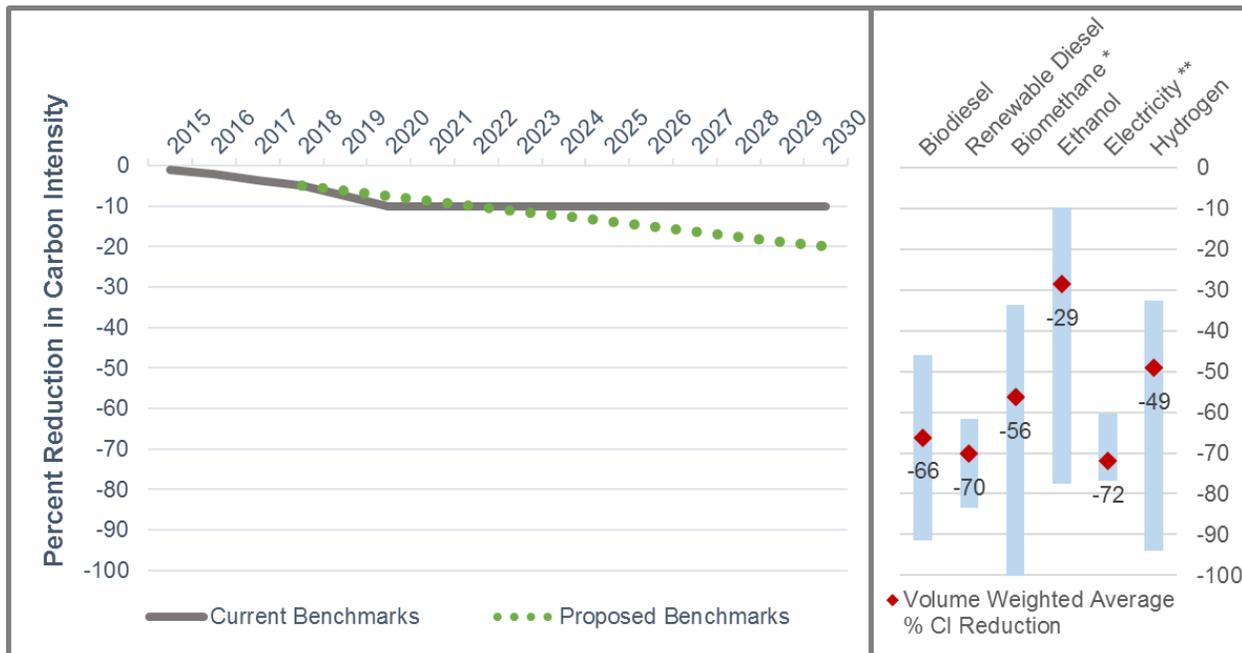
Based on comments received, staff evaluated a wide range of CI benchmark trajectories. Some scenarios indicated that a reduction greater than the 18 percent by 2030 included in the 2017 Climate Change Scoping Plan Update was achievable. Ultimately, staff determined a more stringent CI target of 20 percent is both achievable and necessary to promote the low carbon fuel technology advancement expected of the LCFS in the SB 32 framework.

Also, based on stakeholder feedback and additional analysis, staff recognized that the near-term benchmarks in the current regulation could, in some scenarios, lead to a draw-down of the credit bank in the next few years. In some scenarios, this leads to an unnecessary short-run jump in credit prices. Therefore, staff determined that adjusting the benchmarks for years 2019 through 2021 would be appropriate.

Figure II-1 shows staff's proposed benchmarks as compared to the benchmarks in the current regulation for years 2015 through 2030. When considering the full period from 2019-2030, staff's proposal achieves 70 MMT more cumulative reductions relative to current regulation. The right-hand side of Figure II-1 shows the range and volume-weighted average percentage reduction in carbon intensity that was achieved in the first

three quarters of 2017, per alternative fuel type as a point of comparison. These values supply a useful comparison as we begin to plan for a decarbonized economy.

**Figure II-1: Current and Proposed Annual Carbon Intensity Benchmarks as Compared to CI Reductions Achieved in 2017 by the Most Common Alternative Fuels**



\* Negative CIs have been achieved for some fuel pathways but are not shown.

\*\* The average percent CI reduction for electricity shown represents Light-Duty Electric Vehicle charging.

Chapter 8 and Appendix E of this Staff Report provide additional details on the data sources and methodology that staff has relied on to evaluate feasible LCFS compliance scenarios.

## B. New Fuels Subject to the Regulation

Staff is proposing amendments that would broaden the list of fuels subject to the LCFS regulation and alter the opt-in and/or exempt status of particular fuels. The objective is to encourage additional GHG reductions in specific areas where decarbonization will be important to meet California's long-term climate goals. The proposed changes include:

- The addition of alternative jet fuels (AJF) as opt-in credit-generating fuels;
- Requiring fossil compressed natural gas (CNG) to be covered under the program;
- Requiring hydrogen to be covered under the program;
- Removing the exemption for propane and, instead, requiring this fuel to be covered under the program; and
- Allowing alternative fuels used in military tactical vehicles and aircraft to opt-in to receive credit in the program.

### Alternative Jet Fuel

AJFs are “drop-in” fuels made from fossil or renewable sources, which can replace conventional jet fuels without the need to modify aircraft engines and existing fuel distribution infrastructure. When used at approved blending levels, staff expects AJFs to have the same performance characteristics as conventional jet fuel.

Staff’s proposal includes amendments to allow AJF to generate credits as an opt-in fuel under the LCFS. Under this proposal, conventional jet fuel, in contrast to gasoline and diesel, would not be subject to the LCFS regulation and would therefore not generate deficits. Similar to other liquid alternative fuels under the LCFS, the amended rule would designate the AJF producer or importer as the first fuel reporting entity eligible to generate credits. Opt-in AJF pathways would be eligible to generate credits for the total volume loaded to planes in California, whether the destinations are in California or out of the state.

The proposed amendments include an annual compliance schedule determined specifically for calculating credit from alternative jet fuels. The AJF annual benchmarks are anchored to the 2010 baseline CI for conventional jet fuel and incorporate the same annual percent reductions as the benchmarks for gasoline and diesel. The CI of AJF pathways, as well as the 2010 baseline CI for conventional jet fuel, were determined using the CA-GREET3.0 model. AJF would generate credits based on the difference between the AJF pathway’s CI and that of the jet fuel benchmark for the given year.

Including AJF in the LCFS would result in several benefits. First, greater use of AJFs would lead to a reduction in global GHG emissions. LCFS crediting of AJFs would signal California’s interest in addressing a significant and growing source of GHG emissions—the aviation sector. GHG emissions from aviation contribute to approximately two percent of current total global emissions and are expected to grow.<sup>29</sup>

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 such 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,<sup>30</sup> which assist in providing the certainty necessary to get these advanced biofuel facilities built.

Third, providing incentive for use of AJFs may reduce criteria pollutant emissions during taxi, takeoffs, and landings, which could improve air quality and thereby reduce health

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<sup>29</sup> <https://www.icao.int/environmental-protection/Pages/aircraft-engine-emissions.aspx> (accessed 12/24/17).

<sup>30</sup> Hileman, Jim. ICAO Seminar on Alternative Fuels 2017. February 8-9, 2017. Presentation on Alternative Jet Fuels: Factors that have Enabled Success. Slides 3-5.

impacts, especially near airports. Recent studies have shown that there are significant reductions in particulate matter and sulfur oxide emissions and a slight reduction or no change in nitrogen oxides (NOx) emissions when AJFs replace conventional jet fuel.<sup>31</sup>

### Fossil CNG

In the current regulation, North American fossil CNG is an opt-in fuel because this fuel is presumed to have a CI that meets the standard in every year through 2020. As the CI standard continues to decline beyond 2020, however, staff anticipates that the average CI of fossil CNG will exceed the standard and become a deficit generating fuel.

Therefore, staff proposes to remove the opt-in status of fossil CNG, thereby requiring all quantities of fossil CNG dispensed to vehicles in California to be reported under the LCFS. Liquefied natural gas (LNG), and L-CNG (LNG that is regasified and compressed for dispensing to CNG vehicles) are already required to report under the LCFS; the result is a requirement that all transportation fuel derived from fossil natural gas would be covered by the program.

Renewable natural gas pathways, which staff anticipates will continue to have CIs below the declining standards, would maintain their opt-in status. Given the rapid rate at which renewable natural gas has replaced fossil natural gas in CNG vehicles, staff expects that CNG providers will be able to comply with these requirements.

### Hydrogen

Similar to North American CNG, hydrogen is an opt-in fuel under the current regulation because this fuel is presumed to have a CI that meets the compliance standard in every year through 2020. Although it is possible to produce hydrogen in a high-CI way, hydrogen is not expected to become a deficit generating fuel given the efficiency of fuel cell vehicles and the focus of the industry on CI performance. However, staff is proposing changing the opt-in status of hydrogen to allow CARB to use the LCFS reporting framework to monitor statewide compliance with the greenhouse gas emission and renewable energy resource requirements of California SB 1505.<sup>32</sup> The low volume threshold exemption that exists in the current regulation (an aggregated 420 million megajoules (MJ) of fuel per year by all providers of a particular fuel, equivalent to 3,500 metric tons per year of hydrogen) remains in place under this proposal, thereby requiring the reporting of all hydrogen dispensed for transportation purposes only after statewide use grows to reach this threshold.

The proposed amendments also clarify who is eligible to generate credits in the situation where an upstream party, such as an industrial gas producer, supplies hydrogen to a refueling station, where it is compressed and cooled prior to being

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<sup>31</sup> Corporan, Edwin. December 2010. Alternative Fuels Test on a C-17 Aircraft: Emissions Characteristics. <http://www.dtic.mil/dtic/tr/fulltext/u2/a536842.pdf>

<sup>32</sup> California Senate Bill 1505, Lowenthal, 2006. Available at: <https://www.arb.ca.gov/msprog/hydprod/hydprod.htm>

dispensed. The fueling facility owner is designated as the first fuel reporting entity eligible to generate the credits. This entity would have the ability to contractually pass the reporting responsibilities (with the attendant opportunity to generate credits) to the upstream producer or a designee.

### Propane

Liquefied petroleum gas (LPG or “propane”), including renewable propane, is exempt from the current regulation, meaning its use as a transportation fuel generates neither credits nor deficits. Staff is considering removing this exemption for propane, which would require the reporting of fossil propane used in transportation, and allow renewable propane to opt-in to report and generate credits under the LCFS.

As of 2015, more than 32 million gasoline gallon equivalent (GGE) of propane were used in California as a transportation fuel, almost tripling over the past 15 years.<sup>33</sup> Propane on-road use is expected to grow continuously through 2030.

Tailpipe emissions from most propane vehicles are expected to be comparable to those of gasoline and diesel vehicles with modern emission controls.<sup>34,35</sup> However, the development of low NOx propane engines may provide additional NOx emission reduction benefits as compared to gasoline engines.<sup>36</sup> Propane vehicles are an economical option for a broad variety of markets, including school buses, municipal buses, shuttle vans, forklifts, delivery trucks, taxis, and pickups.

The CI performance of fossil propane varies depending on how it is produced, but generally fossil propane is expected to provide only a small CI benefit relative to displacing fossil gasoline or diesel. Renewable propane offers greater opportunities for CI reduction. Renewable propane can be produced using a number of production pathways and from a number of low-CI feedstocks. Removal of the propane exemption is expected to result in displacement of fossil-based propane currently used for transportation in California by lower CI renewable sources. Renewable propane is co-produced in the renewable diesel and jet production process from hydrotreating of renewable oils. Renewable propane can also be produced from catalytic dehydration of glycerol, a by-product of biodiesel production process. Currently, nearly 41 million

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<sup>33</sup> California Transportation Data for Alternative Fuels and Vehicles. U.S DOE Alternative Fuels Data Center. <https://www.afdc.energy.gov/states/ca>. (accessed 12/26/2017).

<sup>34</sup> Alternative Fuel Guidelines for Alternative Transportation Systems. John A. Volpe National Transportation Systems Center. January 2011

<sup>35</sup> Propane Vehicle Emissions. U.S DOE Alternative Fuels Data Center. [https://www.afdc.energy.gov/vehicles/propane\\_emissions.html](https://www.afdc.energy.gov/vehicles/propane_emissions.html). (accessed 02/07/2018).

<sup>36</sup> Public Workshop on Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives 2017 Available at: [https://www.arb.ca.gov/msprog/aqip/fundplan/1718\\_draft\\_funding\\_plan\\_workshop\\_100417.pdf?\\_ga=2.94821848.539688609.1508425887-114512377.1497044099](https://www.arb.ca.gov/msprog/aqip/fundplan/1718_draft_funding_plan_workshop_100417.pdf?_ga=2.94821848.539688609.1508425887-114512377.1497044099).

gallons of biodiesel are produced annually in California, so significant quantities of bio-glycerol should be available and at low cost. Pyrolysis oils, hydrotreated pyrolysis oil, and vegetable oils can be co-processed with vacuum gas oil (VGO) in fluid catalytic crackers (FCC) at refinery to produce gasoline and light cycle oil. Light gases from the FCC could contain significant propane (up to 18 percent by weight) as a by-product.<sup>37</sup>

Similar to fossil CNG, staff anticipates that the average fossil propane pathway may generate deficits as the CI standard declines beyond 2020, as proposed in this rulemaking. Therefore, reporting of dispensed volumes for fossil propane would be required. A Lookup Table CI value for fossil propane is provided in the proposed regulation for convenience of station owners, who would be designated as the first fuel reporting entity. Renewable propane pathways; however, will likely have a CI value that meets the compliance standard for each year, and under staff's proposal it is classified as an opt-in fuel.

### Military Vehicle Applications

The LCFS currently exempts all fuels supplied for use in military tactical vehicles and support equipment from both credit and deficit generation. Producers of renewable fuels used in these applications have expressed concern that this provision reduces their incentives to sell low carbon fuels to the military. These producers have requested opt-in status for the alternative fuels sold for use in these military applications. Staff is supportive of this approach because it simplifies the decision-making framework created by the LCFS for low carbon fuel producers.

Staff proposes to remove the current provision exempting military vehicle applications (vehicles and tactical equipment as defined in title 13, CCR section 1905(a) and CCR, title 17, section 93116.2(a)(38)), and to add an exemption specifically for conventional fuels used in these applications. This will allow alternative fuels to earn credit for use in these applications, while continuing to exempt conventional fuels used in these applications from generating deficits.

### Other New Applications

Staff proposes changes that would enable several other new applications, such as electric transport refrigeration units and electric motorbikes, to earn credits, as well as expanding the flexibility to allow low-CI electricity to be attributed to serve electric vehicle and hydrogen electrolyzer loads. Many of these applications are proposed to support measures investigated in the California Sustainable Freight Action Plan.<sup>38</sup> These specific changes are discussed further in Chapter III.

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<sup>37</sup> Wang, C.; Li, M.; Fang, Y. Coprocessing of Catalytic-Pyrolysis-Derived Bio-Oil with VGO in a Pilot-Scale FCC Riser. *Industrial & Engineering Chemistry Research* 2016 55 (12), 3525-3534 DOI: 10.1021/acs.iecr.5b03008

<sup>38</sup> State of California. California Sustainable Freight Action Plan. July 2016. Available at: [http://dot.ca.gov/hq/tpp/offices/ogm/cs\\_freight\\_action\\_plan/Documents/CSFAP\\_FINAL\\_07272016.pdf](http://dot.ca.gov/hq/tpp/offices/ogm/cs_freight_action_plan/Documents/CSFAP_FINAL_07272016.pdf)

### **C. Addition of Third-party Verification**

The third primary objective of the proposed amendments is to add an independent third-party verification program to support the accuracy of data reported to the LCFS. A key element of a credible reporting program is independent verification of the reported data to ensure completeness and accuracy, and conformance with the regulation. To date, the LCFS has relied upon a robust reporting program that includes staff evaluation of fuel CI during the fuel pathway application process and audits of the reporting of quarterly fuel quantities. Under the proposed regulation, verification would be performed by qualified and trained third-party verifiers that meet specifications for education and experience, and demonstrate that there is no conflict of interest for verifying the reported data due to current or previous relationships with the facility operator. Verifiers would be required to attend a multi-day CARB approved verifier training course and successfully complete an exit exam prior to being accredited to provide verification services for the LCFS program.

The proposed verification program would increase confidence in LCFS program data and streamline the use of staff resources. The basic mechanics of the program—credit and deficit generation—rely on a considerable amount of information to be supplied to CARB and reviewed by its staff. The determination of carbon intensity for a given fuel pathway, or emission reductions achieved by a project, dictates the number of credits or deficits generated per unit of fuel. The quantities of alternative fuel that are reported as fuel transactions result in credit or deficit generation. Thus, CARB and program participants must be able to rely on the accuracy of the underlying information. 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 CARB's Cap-and-Trade Regulation.<sup>39,40</sup>

Elements of verification proposed in the regulation include (1) annual site visits to ensure that all required sources and processes are included in the emissions estimates and that the data report is complete, (2) development of a plan for specific verification activities, including site visits and document reviews, (3) development of a sampling plan to conduct data checks on the reported data, that considers source contributions with the highest emissions and greatest uncertainty, and (4) a verification opinion submitted to CARB and the reporting entity. In addition, staff is proposing triennial verification for alternative liquid fuel production facilities that generate no more than

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<sup>39</sup> 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...” Health and Safety Code (H&SC) section 38530(a). Program information on MRR verification is available at: <https://www.arb.ca.gov/cc/reporting/ghg-ver/ghg-ver.htm>.

<sup>40</sup> Offset Verification Program. Available at: <https://www.arb.ca.gov/cc/capandtrade/offsets/verification/verification.htm>.

6,000 credits, due to the low risk to the LCFS credit market and to reduce the costs associated with verification for smaller projects.

In October of 2016, CARB released a white paper presenting initial thoughts on a framework for Low Carbon Fuel Standard Verification.<sup>41</sup> Staff's proposal builds off many of the concepts explained in that document and subsequent stakeholder feedback.

#### **D. Other Proposed Amendments**

Additional proposed changes are summarized in Table I-2, and detailed in Chapter III. Many of these amendments serve to support the primary objectives of the rulemaking, namely: strengthening the 2030 target and annual benchmarks for carbon intensity reduction from 2019 through 2030, adding fuels that participate in the program, and requiring third-party verification. For example, expanded flexibility to recognize use of low-CI electricity for EV charging and hydrogen production would promote decarbonization of these fuels and make these vehicles truly "zero emission" on a life cycle basis; modification of the fuel pathway application process would accommodate the process of obtaining verification services; the proposed revision to entity names would further clarify responsibilities of various parties who are subject to the regulation, a change that is necessary in conjunction with the third-party verification system; the development of new benchmarks for jet fuel would support the calculation of credits for AJF; and the addition of Lookup Table pathways for fossil CNG and LPG would facilitate the obligation of these fuels to be reported in the program.

Other amendments have been proposed that do not directly support those three changes, but do support the regulation's underlying purposes. For example, the verification system is not the sole means by which staff seeks to improve accuracy and data quality; the requirement for Fueling Supply Equipment registration serves this end by enabling staff to monitor risk of double counting by two entities for the same quantity of fuel. The update of modeling tools, conversion factors, and standard values also improves accuracy in the quantification of GHG reductions. The proposed adoption of an accounting and permanence protocol for carbon capture and sequestration allows such projects to generate credits. Some changes encourage modest reductions in areas that may later become critical to meet long-term climate stabilization goals.

Finally, a number of amendments are proposed to achieve secondary objectives, such as simplifying and streamlining application and reporting requirements in order to encourage greater participation and improve administrative efficiency. An example is the proposed option for some fuel providers to authorize a designee to report on their behalf. Staff expects that this provision will support the participation of smaller fueling facility operators, transit agencies, and EV charging services providers, allowing them to benefit from the program more efficiently with less administrative effort. The use of new Simplified CI Calculators for Tier 1 fuel pathway applications will reduce application

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<sup>41</sup> Available at: [https://www.arb.ca.gov/fuels/lcfs/lcfs\\_meetings/verification\\_whitepaper\\_102116.pdf](https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/verification_whitepaper_102116.pdf)

preparation time by the applicant; reduce evaluation and processing time by the Board staff; and enhance transparency by establishing a standard set of raw data inputs, whose accuracy is ensured through independent third-party verification. When staff has been made aware of a federal or other program with a similar reporting or verification requirement, harmonization was sought to minimize duplicative efforts. Staff has revised the regulation extensively order to improve the organization, in hopes that this will aid stakeholders and those subject to the regulation in clearly interpreting their obligations. Many changes, particularly in new sections 94588.1 to 95488.10, do not materially affect requirements, but rather are intended to improve organization and readability.