# OVERVIEW OF CALIFORNIA AND OREGON LOW CARBON FUEL PROGRAMS: AIR QUALITY AND GHG EMISSIONS IMPACTS

Prepared For:

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# 1. INTRODUCTION

The California Low Carbon Fuel Standard (LCFS) was the first state-level “clean fuels program” in the United States. The California Air Resources Board implemented its LCFS in 2011 with the intent of reducing lifecycle greenhouse gas (GHG) emissions by lowering the average carbon intensity (CI) of the statewide fuel supply on an annual basis, with a targeted 20% reduction by 2030 from a 2010 baseline. CI is assessed in terms of carbon dioxide equivalent per megajoule of energy, or $gCO_2e/MJ$. Compliance is achieved by blending low-CI fuels (e.g., ethanol, biodiesel, renewable diesel) in the conventional gasoline and diesel fuel streams or purchasing LCFS credits on the market. The design of the California LCFS program allows alternative fuels such as electricity, hydrogen, and natural gas used for transportation to generate credits under the program.

Following California’s lead, the Oregon Department of Environmental Quality (DEQ) implemented a Clean Fuels Program (CFP) in 2016 requiring a 10% reduction by 2025 from 2015 levels. The Oregon program essentially mirrors its California counterpart with some minor reporting and programmatic changes. Perhaps the biggest difference is the CFP deferral provision, which allows DEQ to suspend program compliance if sufficient alternative fuel volumes are not realized in the state. Table 1 compares features of the California and Oregon LCFS programs.

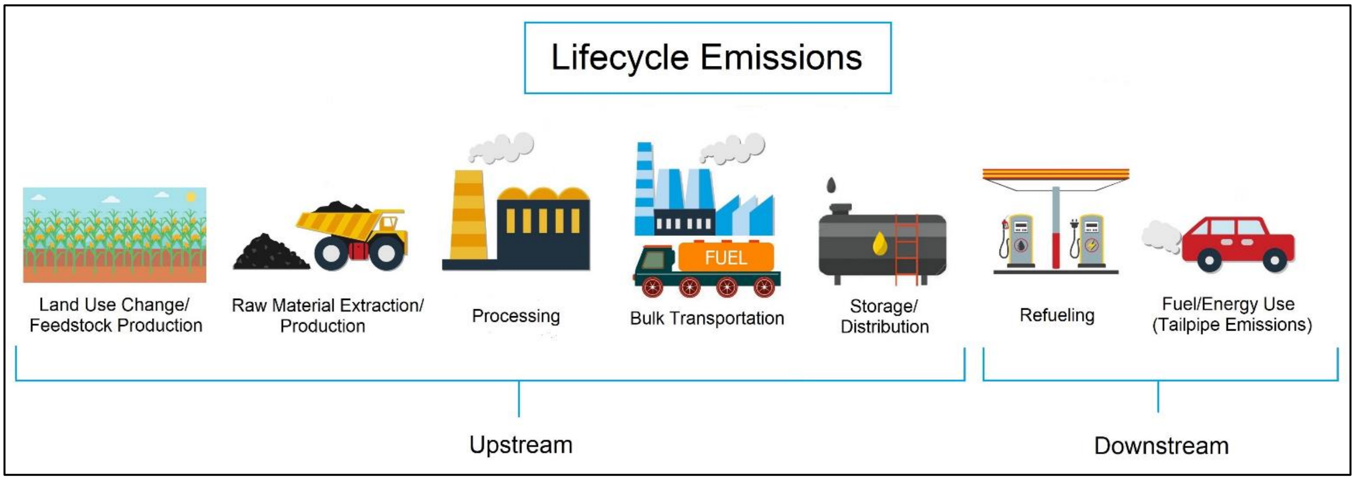
As CI standards tighten each year, future compliance with and the success of any clean fuels program will depend on the availability of low-CI fuels and alternative fuel vehicles and their supporting infrastructure. Furthermore, as new clean fuels programs come online, states and regions will have to compete for low-CI fuels by providing financial incentives in terms of credit prices. This results in fuels like ethanol costing more in states with a LCFS program compared to states without such a program.

**Table 1: California and Oregon LCFS**

| | California's LCFS | Oregon's CFP |
|---|---|---|
| Status | Adopted in 2009, revised in 2011, re-adopted in 2015, revised in 2018 | Adopted in 2012, revised in 2016 and 2018 |
| Standards / Requirements | CI 20% below 2010 baseline by 2030 | CI 10% below 2015 baseline by 2025 |
| CI Assessment | CA-GREET 3.0 model | OR-GREET3.0 or OR-adjusted CA-GREET pathways |
| Compliance and Reporting | Must offset deficits by generating credits or purchasing credits from suppliers. Quarterly and annual reporting requirements. | Same as in California |
| Third Party Verification | Yes | Being considered for the next set of amendments |
| Credit Generation | • Low-CI biofuels for blending<br>• Renewable and fossil natural gas supplied to vehicles<br>• Electricity/hydrogen supplied to vehicles<br>• Infrastructure credits for EVs/FCVs<br>• Propane<br>• Zero-CI and time-of-use incremental electricity credits<br>• Refinery projects and "innovative" crude oil production | • Low-CI biofuels for blending<br>• Renewable natural gas supplied to vehicles<br>• Electricity/hydrogen supplied to vehicles<br>• Propane |
| Cost Containment | Credit Clearance Market<br>Deficit carry forward up to 5 years with interest<br>"Borrowed" credits up to 10MMT (proposed) | Credit Clearance Market<br>Deficit carry forward up to 5 years with interest |
| **Exemptions** | None | Small-volume suppliers (< 500,000 gallons) |
| **Deferral Provision** | No | Yes |

When assessing environmental impacts for any new proposed regulatory program, it is important to distinguish between GHG emissions (climate change) and criteria pollutant emissions (air quality). GHG emissions are assessed on a lifecycle basis and include carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and other GHG contributors. As shown in Figure 1 below, lifecycle emissions include the entire fuel cycle from feedstock production, fuel transport, distribution, to end use in vehicle (tailpipe emissions).

**Figure 1: Lifecycle Emissions**




Both the California LCFS and Oregon CFP measure their environmental "successes" utilizing the GHG lifecycle analysis approach through the use of a state-level GREET model. The GREET life cycle assessment includes direct emissions associated with producing, transporting, and using a given transportation fuel, as well as indirect effects on GHG emissions, such as changes in land use due to biofuels.

Air quality analysis refers to assessing emissions increases or benefits for criteria pollutants known for their negative exposure impacts on human health. Most pollutants of concern are regulated under the Clean Air Act of 1970 through the passage of National Ambient Air Quality Standards (NAAQS). NAAQS are set for NOx, $PM_{10}$, $PM_{2.5}$, Ozone (ROG+NOx), Lead, $NO_2$, and $SO_2$. In addition, many states have passed additional controls on mobile source air toxics like benzene and acrolein, which are by-products of gasoline combustion.

In contrast to GHG emissions, air quality impacts are typically assessed for the downstream portion of the fuel cycle only. However, in order to completely understand air quality impacts for an LCFS program, the correct approach is to include upstream impacts in any air quality analysis. For criteria pollutants, the upstream impacts include emissions associated with construction of new biofuel plants, fuel production, bulk transportation, as well as storage and distribution.

## 3.1. GHG EMISSIONS

Table 2 summarizes the methodology developed by CARB for attributing GHG emission reductions associated with actions taken under the latest LCFS amendments. Unlike Oregon (discussed in the next section), CARB does not routinely report on GHG emission benefits of the program and only projects expected reductions into the future as part of their Environmental Analysis as required by the California Environmental Quality Act (CEQA) for major regulatory amendments.

**Table 2: Attribution of GHG Reductions to LCFS**

| Fuel or Project Type | Action | Primary Attribution |
|---|---|---|
| Electricity | Switch to EVs that are charged with electricity at the grid average CI | Light-duty / heavy-duty / off-road ZEV regulations and other vehicle incentive / rebate programs |
| | Use of renewables to reduce the CI for charging below the grid average | LCFS |
| Hydrogen | Switch to FCEVs using hydrogen produced with 33 percent renewable content | Light-duty / heavy-duty / off-road ZEV regulations and other vehicle incentive / rebate programs. SB 1505 requiring 33 percent renewables |
| | Use of greater than 33 percent renewables to reduce the CI of hydrogen used in FCEVs | LCFS |
| Natural Gas | Switch to NG vehicles operating with fossil NG | Vehicle incentive / rebate programs and low NG prices relative to diesel |
| | Switch from fossil NG to landfill RNG | RFS – cellulosic RIN value |
| | Switch from landfill to dairy digester RNG | LCFS |
| **Propane** | Switch from fossil propane to renewable propane | LCFS |
| **Starch Ethanol** | Use of starch ethanol with an average CI of 80 g/MJ | RFS – 20 percent CI reduction to qualify as renewable fuel |
| | Reduction in CI of ethanol below 80 g/MJ | LCFS |
| **Sugar Ethanol** | Use of sugar ethanol with an average CI of 50 g/MJ | RFS – 50 percent CI reduction to qualify as advanced biofuel |
| | Reduction in CI of sugar ethanol below 50 g/MJ | LCFS |
| **Cellulosic Ethanol** | Use of cellulosic ethanol with an average CI of 40 g/MJ | RFS – 60 percent CI reduction to qualify as cellulosic biofuel |
| | Reduction in CI of cellulosic ethanol below 40 g/MJ | LCFS |

| Fuel or Project Type | Action | Primary Attribution |
| --- | --- | --- |
| **Refinery Projects** | Implementation of projects under the RIC and renewable hydrogen for refineries provisions | LCFS |
| **Crude Projects** | Implementation of solar system, solar / wind electricity, and CCS projects under the innovative crude provision | LCFS |
| **Biodiesel** | Use of vegetable oil-based biodiesel with a CI of 50 g/MJ | Blenders tax credit and RFS – 50 percent CI reduction to qualify as biomass-based diesel |
| | Reduction of CI below 50 g/MJ using waste-based feedstocks | LCFS |
| **Renewable Diesel** | Use of vegetable oil based renewable diesel with CI OF 50 g/MJ | Blenders tax credit and RFS – 50 percent CI reduction to qualify as biomass-based diesel |
| | Reduction of CI below 50 g/MJ using waste-based feedstocks | LCFS |

Source: Table F-12, Attachment F, "Updates to The Methodologies for Estimating Potential GHG And Criteria Pollutant Emissions Changes Due to The Proposed LCFS Amendments," at https://ww3.arb.ca.gov/regact/2018/lcfs18/15dayattf2.pdf?_ga=2.14077367.1080511499.1569956163-474233077.1569956057. (Further details on the rulemaking are at https://ww2.arb.ca.gov/rulemaking/2018/low-carbon-fuel-standard-and-alternative-diesel-fuels-regulation-2018.)

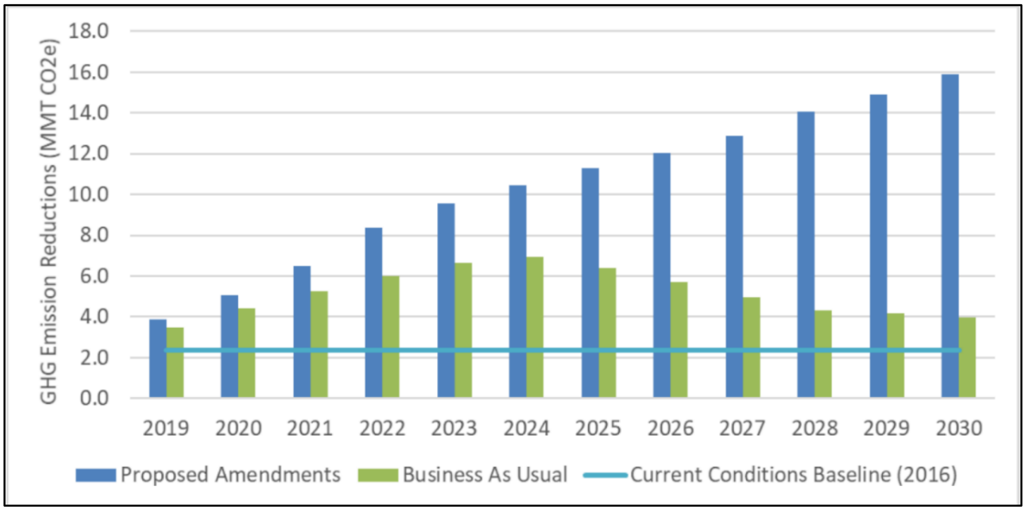
Employing this methodology, CARB has calculated that the LCFS program will reduce statewide transportation GHG emissions by 16 MMT in 2030 (Table 3). Figure 2 visually displays the GHG reductions CARB expects will result from implementation of the 2018 LCFS amendments compared to the "business as usual" (BAU) scenario (i.e., no LCFS in place) and current 2019 baseline conditions. California GHG emissions are projected to decline even if no LCFS program was in place under business-as-usual conditions. The incremental reduction in 2020, for instance, is only 0.6 MMT, and goes up to 11.9 MMT in 2030.

**Table 3: GHG Emission Reductions Attributable to the LCFS (MMTCO2e)**

| Scenario | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | Cumulative |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Proposed Amendments | 3.9 | 5.0 | 6.5 | 8.4 | 9.6 | 10.4 | 11.3 | 12.0 | 12.9 | 14.1 | 14.9 | 15.9 | 124.9 |
| Business As Usual | 3.5 | 4.4 | 5.3 | 6.0 | 6.7 | 7.0 | 6.4 | 5.7 | 4.9 | 4.3 | 4.1 | 4.0 | 62.2 |
| Current Conditions Baseline (2016) | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 28.23 |

Source: Illustrative Scenario Calculator, Low Demand/Low ZEV

**Figure 2: GHG Emission Reductions Attributable to the LCFS (MMTCO2e)**




Source: Figure 4-5, Appendix D, Final Environmental Analysis, https://ww3.arb.ca.gov/regact/2018/lcfs18/finalea.pdf?_ga=2.110428549.1080511499.1569956163-474233077.1569956057

It is important to note that CARB's expected GHG emission reductions have varied significantly over time and are directly related to the volumes and CI values expected for the California fuel pool. For instance, in 2011, while CARB expected low-CI cellulosic ethanol to become the main credit generator on the biofuel side, sufficient volumes did not come into the state, thus CARB adjusted their expectations with the next set of amendments adopted in 2015, and these changes were reflected in their accompanying environmental analysis.

The reductions in GHG emissions achieved by the LCFS should be transparent and easily quantifiable by reviewing cumulative net LCFS credits generated on an annual basis and adjusting for the CI standard percentage reduction. However, problems arise when attributing emission benefits due to the LCFS in concert with other existing programs that promote alternative fuel use, such as the federal Renewable Fuel Standard (RFS) and the California Zero Emission Vehicle (ZEV) mandate. While states might reduce their in-state emissions through such programs, these actions do not necessarily decrease global emissions due to "fuels shuffling," which refers to the case in which fuels are moved, or "shuffled," from one market to another without any significant change in overall fuel supply or characteristics. It is important to note that additional transportation emissions associated with "fuel shuffling" are not accounted for in CARB's environmental analysis. Ultimately, GHG emission benefits must be considered on a global basis, and with a few existing clean fuel programs in North America, GHG reductions will continue to be claimed in areas with the most stringent fuel standards (and highest credit prices), as long as the financial benefits outweigh overall fuel production, distribution, and compliance costs.

Furthermore, in 2019, CARB began issuing LCFS credits for EV/FCV (fuel cell vehicle) infrastructure based on station capacity rather than actual energy throughput; therefore, the LCFS credit pool does not accurately reflect actual GHG reductions attributable to the program. Finally, CARB is working on cost-containment amendments as of October 2019 with the intent to "advance" future year credits from California utilities for residential EV charging to populate the credit pool if needed for compliance. These programmatic changes further cloud the direct relationship between the credit pool and GHG emission benefits.

## 3.2. AIR QUALITY

In addition to conducting downstream or tailpipe emissions analysis to reflect low-CI fuel substitution, CARB included criteria pollutant reductions from refineries due to projects that reduce grid electricity usage. The analysis assumed that criteria pollutant emissions at refineries will decrease proportionally to the rate of GHG emissions due to reduced refinery production volumes. The total criteria pollutant impact was reported in terms of NOx and $PM_{2.5}$ emissions only.

Figures 3 and 4 visually display the net NOx and $PM_{2.5}$ emissions impact of the most recent LCFS amendments. It should be noted that for NOx emissions, CARB assumed that biodiesel used in California would be additized in line with Alternative Diesel Fuel (ADF) regulatory requirements, which mitigate NOx emissions increase due to biodiesel use. However, California is the only state with such requirements in place.

As shown, CARB expects that California LCFS implementation will result in approximately 1,800 tons/year NOx emissions reduced and 250 tons/year PM2.5 emissions reduced, on average. To put these reductions in perspective, Table 4 shows CARB-estimated NOx and PM2.5 emissions for the transportation sector for the 2016 baseline. The 2016 baseline emissions were used by CARB to quantify the emission changes (i.e. the "delta") that would be directly attributable to the LCFS in the future years. It is important to note that average PM2.5 emission reductions estimated by CARB represent only 1% of the total transportation inventory; while NOx emission reductions due to LCFS are only approximately 0.4%.

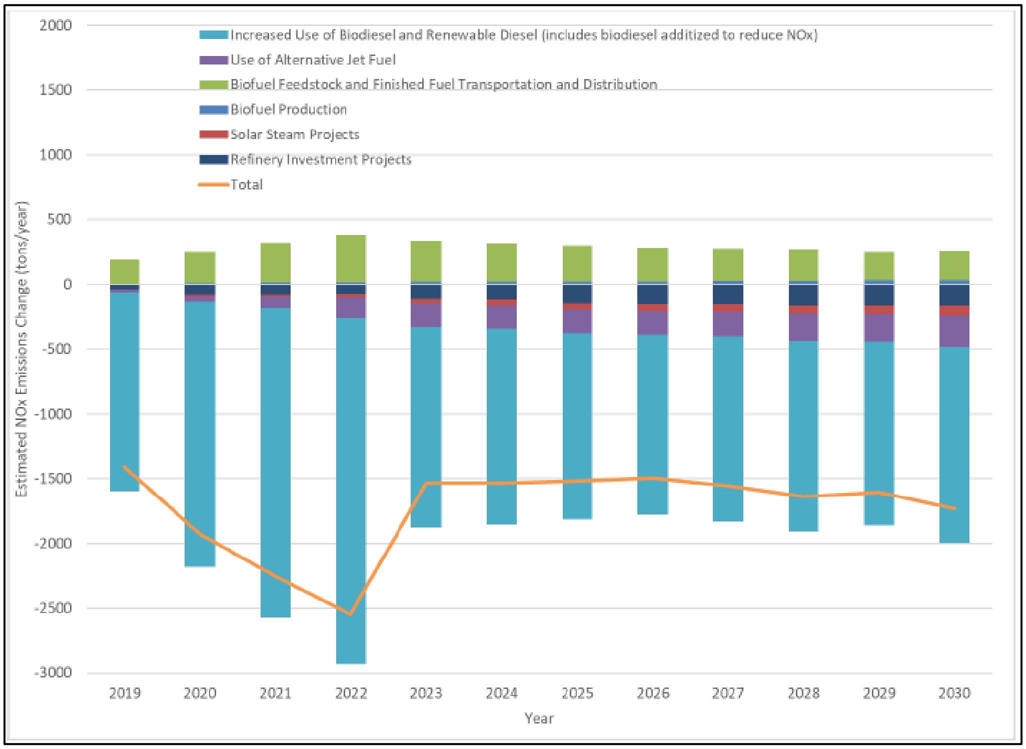
**Table 4: California Transportation Emissions in 2016 (tons/year)**

| **Emission Source** | **$NO_X$** | **$PM_{2.5}$** |
|---|---|---|
| Refining and Crude Production | 10,631 | 2,960 |
| Biofuel Production | 29 | 22 |
| Mobile Sources | 411,659 | 21,347 |
| **Total** | **422,319** | **24,329** |

Source: Table 4-1, Appendix D, Final Environmental Analysis,
https://ww3.arb.ca.gov/regact/2018/lcfs18/finalea.pdf?_ga=2.110428549.1080511499.1569956163-474233077.1569956057

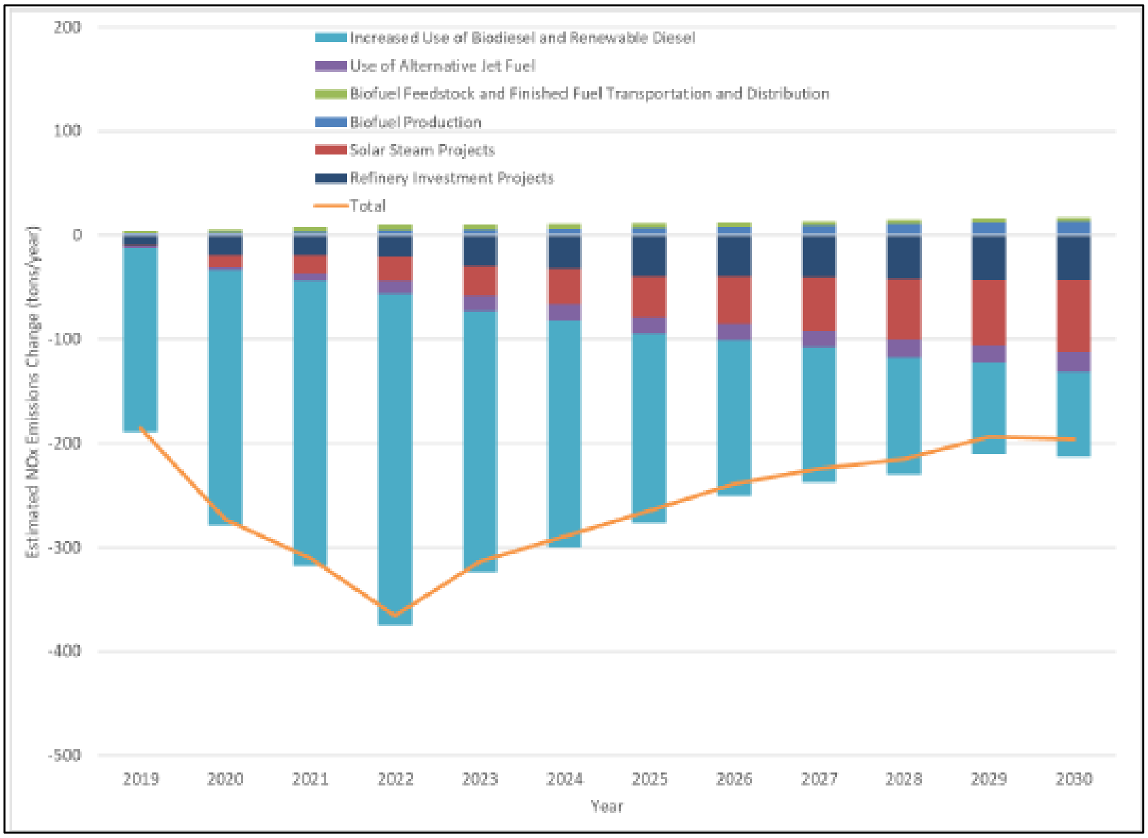
As mentioned earlier for GHG emissions, actual emission reductions will greatly depend on the assumptions for the future California fuel pool. Actual air quality impacts are not recorded or reported on by CARB.

**Figure 3. Estimated Statewide NOx Emissions Impact of the Proposed LCFS Amendments Relative to 2016 Baseline (tons/year)**




Source: Figure 4-1, Appendix D, Final Environmental Analysis, https://ww3.arb.ca.gov/regact/2018/lcfs18/finalea.pdf?_ga=2.110428549.1080511499.1569956163-474233077.1569956057

**Figure 4. Estimated Statewide $PM_{2.5}$ Emissions Impact of the Proposed LCFS Amendments Relative to 2016 Baseline (tons/year)**




Source: Figure 4-2, Appendix D, Final Environmental Analysis, https://ww3.arb.ca.gov/regact/2018/lcfs18/finalea.pdf?_ga=2.110428549.1080511499.1569956163-474233077.1569956057

To calculate GHG emission impacts, it is important to understand how Oregon fuel providers comply with the CFP. Given that Oregon has both E10 and B5 mandates in place, fuel suppliers are limited in the quantities of biofuels they can blend; therefore, compliance is achieved largely through the substitution of lower-CI biofuels in E10 and B5-B20 blends.

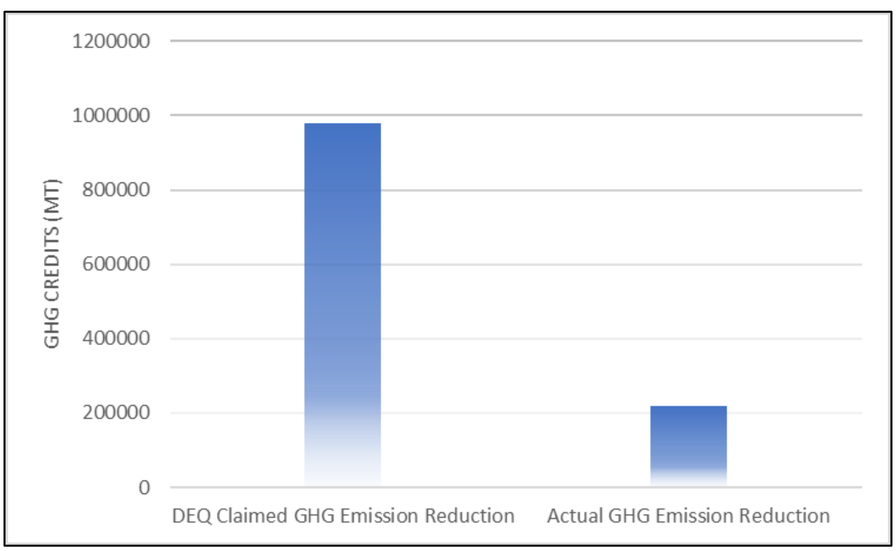
## 4.1. GHG EMISSIONS

Oregon DEQ reports CFP program benefits in terms of metric tons of GHGs reduced on an annual basis. The agency calculates GHG benefits by totaling the number of credits generated for the entire program (without excluding the deficits). However, this approach does not account for interactions with RFS or existing state EV incentives and can be misleading for the reasons noted below.

- Credits awarded to natural gas and electricity should be excluded since their fuel volumes remained generally stagnant over time and have little evidence of increasing as a result of CFP implementation in Oregon. (This aligns with CARB's review of the LCFS in California.)
- Credits generated for volumes of ethanol blended at E10 level and biodiesel blended at B5 level should be excluded since these fuel blends are already mandated in Oregon.
- Credits and deficits generated with E10 and B5 imports and exports should also be excluded since they are part of the traditional fuel supply model in Oregon.

When taking the above critiques into consideration, only a fraction of the claimed benefits is attributable to the implementation of the CFP. For example, DEQ calculated the total GHG benefits that can be attributed to the CFP program to be approximately 978,500 MT in 2018. When accounting for only ethanol and biodiesel volumes blended above mandates, excluding imports and exports of E10 and B5, and excluding electricity and natural gas, only 22% of what the DEQ claimed as GHG benefits are actual reductions (see Figure 5).

**Figure 5. DEQ Claimed Credits Compared to Actual Credits Generated by CFP in 2018**



## 4.2. AIR QUALITY

In addition, this analysis did not consider "fuel shuffling" impacts or the increase in transportation GHG emissions due to low-CI fuels transported over longer distances. Considering all these factors, along with interactions with similar carbon reduction programs, the true GHG benefits are much smaller.

Given the climate change focus of the CFP program in Oregon, Oregon DEQ did not analyze criteria pollutant impacts of the program at the time of its adoption.