Status Review of California’s
Low Carbon Fuel Standard, 2011–2018 Q1

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Highlights

- From 2011–2017, the share of alternative fuels in California’s transportation energy grew from 6.1 percent to 8.5 percent. Of alternative fuel energy, the portion coming from non-liquid fuels increased from 7.6 percent to 13.5 percent over the period.
- Through 2018 Q1, total emissions reduction requirements under the regulation were 28.9 million tons (MMT) CO₂e. Actual reported emissions reductions were 38.3 MMT CO₂e, representing overcompliance of 9.3 MMT CO₂e, creating a system-wide credit “bank” that can be used to meet future targets.
- In 2017 and 2018 Q1, program deficits exceeded credits for the first time, by 0.1 MMT CO₂e and 0.4 MMT CO₂e, respectively, drawing down the credit “bank.”
- Increases in alternative fuel use and declines in carbon intensity (CI) rating came primarily from the diesel pool. Biomass-based diesel—biodiesel and renewable diesel—accounted for 0.4 percent of liquid diesel fuel by volume in 2011 and 15.6 percent in 2018 Q1. Natural gas in transportation grew 111 percent from 2011–2017 to 178.1 gasoline gallon equivalent (gge). Of this natural gas, biogas use was close to nil in 2011 but approximately two-thirds in 2017.
- Among gasoline substitutes, electricity use grew from less than 0.5 percent of alternative energy in 2011 to 4.5 percent in 2018 Q1. Use of ethanol, the largest renewable fuel by volume, remained close to a “blendwall” of 10 percent blended with gasoline.
- Prices of LCFS compliance credits (each representing 1 MMT CO₂e) fluctuated. Average per-credit price increased from $20 to $80 in 2013, ranged between $20 and $30 in 2014 and 2015 under a frozen standard of 1%, rose above $100 in 2016 when the freeze was lifted, and exceeded $160 in summer 2018 as the California Air Resources Board (CARB) was in the process of adopting more stringent targets for 2030.
- LCFS amendments to be voted on at the September 26-27, 2018, CARB board meeting to take effect in 2019, include: a 2030 target of 20 percent CI reduction below 2010 levels; independent verification and monitoring of fuel pathway CI rating inputs; allowing alternative aviation fuel to generate program credits; a protocol for carbon capture and sequestration credits; credits for low- or zero-carbon intensity electricity use; requiring use of a portion of residential electricity credits to fund a statewide point-of-sale incentive program to electric vehicle (EV) buyers if such a program is approved by the California Public Utilities Commission; and introducing capacity credits for EV fast chargers and hydrogen fuel stations. The “capacity credit” provision would permit credit generation untied to current emissions reductions and favor particular fuels (those used in zero emission vehicles, which have no tailpipe emissions) for the first time.
- LCFS-like programs are in development in Canada (a Clean Fuel Standard to cover transportation, industry, and building sectors) and Brazil (the RenovaBio program focused on renewable liquid fuels and biogas). Neither plans to account for indirect land use change emissions in carbon intensity lifecycle analysis at program outset. Implementation of the Oregon and British Columbia LCFS programs is proceeding.

Introduction

California’s Low Carbon Fuel Standard (LCFS) constitutes part of the State’s overall strategy to reduce greenhouse gas (GHG) emissions. An LCFS policy, called a clean fuel standard by some, aims to reduce transportation sector GHG emissions by incentivizing innovation, technological development, and deployment of low-emission alternative fuels and vehicles. It is designed as a performance standard to treat alternative fuels similarly (technology neutrality). The policy sets an average carbon intensity (CI) standard, measured in grams carbon dioxide equivalent per...
megajoule of fuel energy (gCO₂e/MJ), that all regulated parties must achieve across fuels they provide for use in the jurisdiction. To comply, regulated parties may combine strategies like: (i) producing low carbon fuels; (ii) purchasing low carbon fuels from other producers; (iii) purchasing credits generated by producers of low carbon fuels; or (iv) banking credits across compliance years for future use. It does not mandate any particular fuel or technology. Oregon and British Columbia have similar programs;[1] Canada and Brazil are developing fuel carbon intensity standards.[2, 3]

The California LCFS targets a 10 percent CI rating reduction statewide fuel pool in 2020 from 2010 levels. In 2018, the standard requires a reduction of 5 percent in the average CI rating for the gasoline pool and 3.5 percent in the diesel pool, from 3.5 percent for both pools in 2017. The diesel standard is frozen at the 2017 level due to a court ruling regarding the environmental impact analysis of the regulation.

California Air Resources Board (CARB) staff proposed a 2030 LCFS target of 20 percent CI reduction and a smooth compliance trajectory that would lower the 2020 target to 7.5 percent. It is part of a regulatory amendment package that if approved in fall 2018 would take effect in 2019. The package also includes allowing credit generation for new public fuel distribution capacity for hydrogen and electricity fast charging under some restrictions. The capacity crediting program responds to a Governor’s Executive Order, B-48-18, that the LCFS do more to incentivize infrastructure to support the state goal of 5 million zero emission vehicles (ZEVs)—vehicles with no tailpipe emissions—by 2030.[4] The provision favors ZEVs and offers credits for capacity rather than fuel flow, a departure from prior technology neutrality and crediting tied to program GHG emission savings.

This issue reviews LCFS, annual data from 2011 through 2017 and some 2018 Q1 data: transport fuel energy and LCFS credits and deficits (Section 1), carbon intensity of fuels (Section 2), and credit trading and prices (Section 3). The special topic is developments in the LCFS policy context (Section 4), describing proposed LCFS amendments, planned carbon intensity standards planned in Canada and Brazil, and briefly existing programs in Oregon and British Columbia.

1. Transport Energy and LCFS Credits and Deficits

As a share of California’s transportation fuels by energy content, alternative fuel energy increased 68 percent from 2011 through 2017, from 6.2 percent in 2011 and 2012 to 9.5 percent in 2017 and 10.1 percent in 2018 Q1 (Table 1, Figure 1). Liquid biofuels dominated the fuel mix each year. The non-liquid fuel contribution to alternative energy increased from 7.6 percent in 2011 to 13.5 percent in 2017 and 14.3 percent in 2018 Q1. Ethanol, the dominant alternative fuel, remained near a 10 percent blend in gasoline, the “blendwall” level that needs no alternative infrastructure for distribution and use.¹ The average blend rate of biomass-based diesel (biodiesel and renewable diesel) in diesel fuel by volume rose from 0.4 percent in 2011 to 13.5 percent in 2017, or 507 million gallons. In 2018 Q1, 131.5 million gallons of biomass-based diesel were used, 15.6 percent diesel fuel by volume. Natural gas transport energy increased 111 percent from 2011 to 2017 to about 56.8 million standard cubic feet per day (mmscf/d). Biogas was scarcely used in 2011, surpassed fossil natural gas use in 2015, and in 2017 constituted 67.4 percent (38.5 mmscf/d, or about two-thirds) of natural gas reported. Electricity contributed 3.9 percent of transportation alternative energy in 2017 and 4.5 percent in 2018 Q1 (2,436 million kWh). About 59 percent came from off-road sources (electric guideway systems and forklifts) after the LCFS scope expanded to include them in 2016;⁴ electric vehicle (EV) charging provided the rest.
Table 1. Total transportation energy use reported in California’s LCFS program (million gge*).

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<tr>
<td>Gasoline (CARBOB)</td>
<td>13,125</td>
<td>13,211</td>
<td>12,973</td>
<td>13,334</td>
<td>13,445</td>
<td>14,053</td>
<td>14,065</td>
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<td>Diesel (ULSD)</td>
<td>4,033</td>
<td>4,022</td>
<td>3,935</td>
<td>3,923</td>
<td>3,899</td>
<td>3,805</td>
<td>3,760</td>
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<tr>
<td>Ethanol</td>
<td>1,016</td>
<td>1,005</td>
<td>1,008</td>
<td>1,013</td>
<td>1,022</td>
<td>1,089</td>
<td>1,073</td>
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<tr>
<td>Biodiesel</td>
<td>13</td>
<td>21</td>
<td>63</td>
<td>70</td>
<td>133</td>
<td>172</td>
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<tr>
<td>Renewable diesel</td>
<td>2.0</td>
<td>9.6</td>
<td>12.7</td>
<td>12.2</td>
<td>17.9</td>
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<td>109</td>
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<td>62</td>
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<td>15</td>
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<tr>
<td>Biogas</td>
<td>1.8</td>
<td>1.8</td>
<td>11.5</td>
<td>32</td>
<td>78</td>
<td>102</td>
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<td>1.3</td>
<td>8.2</td>
<td>12.6</td>
<td>21.4</td>
<td>30.8</td>
<td>10.0</td>
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<td>Electricity – off road</td>
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<td>--</td>
<td>37</td>
<td>43</td>
<td>11</td>
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<tr>
<td>Hydrogen</td>
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<td>--</td>
<td>--</td>
<td>0.003</td>
<td>0.003</td>
<td>0.260</td>
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<tr>
<td><strong>Total</strong></td>
<td>18,274</td>
<td>18,367</td>
<td>18,222</td>
<td>18,612</td>
<td>18,846</td>
<td>19,619</td>
<td>19,695</td>
<td>4,576</td>
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- Ethanol by volume in gasoline blend: 10.2% 10.0% 10.2% 10.0% 10.0% 10.2% 10.1% 10.1%
- Biomass-based diesel by volume in diesel blend: 0.4% 0.8% 4.8% 4.9% 7.8% 11.0% 13.2% 15.6%
- Total alt fuel (percent of total energy): 6.1% 6.2% 7.2% 7.3% 8.0% 9.0% 9.5% 10.1%
- Non-biofuel portion of alt fuel: 7.6% 8.7% 8.8% 11.0% 11.2% 12.6% 13.5% 14.3%

* gge = blendstock California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB) gasoline gallon equivalents. Source: [5].

Other state and federal policies incentivized California low carbon fuel use. The federal Renewable Fuel Standard (RFS) promotes biomass-based diesel, biogas, and ethanol nationwide. iii California and the U.S. subsidize transport electricity through EV rebates and other policies. Through 2017, California cumulative EV sales totaled...
366,000, about half the U.S. market compared to California’s 12 percent of national light-duty vehicle sales. Year-on-year EV sales growth was 29 percent,[7] reaching about 4.7 percent of new car registrations.[8] EVs generated over $90 million in LCFS credit value, close to amounts distributed for ZEVs through California’s Clean Vehicle Rebate Project.[9]

The LCFS rates all transport energy on its carbon intensity. The rating translates into fuel volumes accruing program credits and deficits, each representing one metric ton of carbon dioxide equivalent (MT CO₂e) of emissions relative to the standard. The standard declines over time. Through 2018 Q1, regulated parties generated 38.3 million credits and 28.9 million deficits under the program. The gap, 9.3 million credits (MT CO₂e), illustrates California fuels have had lower carbon ratings on average than required by the regulation to date. It represents a cumulative net system-wide bank of credits that can be used for future compliance.

The “bank” grew each year from 2011–2016, as program credits exceeded deficits; deficits exceeded credits in 2017 and in 2018 Q1 (Figure 2). The system-wide credit bank increased under a 2013–2015 court-ordered freeze of the standard at 1 percent CI reduction and in 2016 (2 percent CI reduction). Deficits exceeded credits by 0.11 million in 2017 (3.5 percent standard) and 0.42 million credits in 2018 Q1 (standards of 5 percent in the gasoline pool, and 3.5 percent in the diesel pool – see Introduction) (Figure 2).[v]

LCFS credit generation diversified over the period (Figure 3, top). Ethanol generated 78 percent of credits in 2011, 33.5 percent in 2017, and 30 percent in 2018 Q1. Ethanol credits increased in 2016 when revised modeling and lower estimates for land use

![Figure 2. California LCFS carbon credits and deficits. Also shown are cumulative net credit “bank” (black line) and annual standard (data table). Annual data 2011–2017; 2018 Q1 only. Data for 2017 and 2018 do not reflect low complexity/low energy use refinery credits (endnote iv). Data source:[5].](image-url)

![Figure 3. LCFS credit generation diversified over the period.](image-url)
change emissions reduced CI ratings for corn ethanol and other crop-based fuels (see Figure 4, below). Biomass-based diesel surpassed ethanol in credit generation in 2015 up from 13 percent in 2012, and generated 47 percent of credits in 2018 Q1. Natural gas contributed between 8 and 15 percent of credits (2018 Q1 and 2015, respectively) over the period. Reliance on biomass relative to fossil sources grew: in 2017 and 2018 Q1, biogas generated 81 percent and 92 percent of natural gas credits, respectively. LCFS rules allow biogas entering the pipeline in North America to be claimed as used in California with appropriate contracting (“book-and-claim” method). Electricity used as fuel contributed nearly 10 percent of 2016 credits, 13 percent of 2017 credits and 15 percent of credits in 2018 Q1. On-road electric vehicles generated most electricity credits – 6 percent, 8.5 percent and 10.7 percent of total credits in 2016, 2017, and 2018 Q1, respectively. The program expanded to include off-road electricity use from electric forklifts and transit using fixed electric guideways in 2016. The fossil fuel sector may also generate credit for lowering carbon intensity of approved activities in refining operations relative to the baseline (not relative to the standard). This source generated 1.7 percent of credits in 2016, the last year for which complete data are available (see endnote iv).

Gasoline substitutes generated most (78 percent) of program credits at the program’s start (2011). Beginning in 2015, diesel substitutes contributed the majority of credits, reaching 58 percent in 2017 (Figure 3, bottom). Liquid fuels’ share in credit generation was 85 percent in 2011 and 89 percent in 2013, dropping to 79 percent in 2017 and 77 percent in 2018 Q1.

Feedstocks for ethanol’s relatively level volumes and credits over the period remained concentrated in corn (Figure 4, top). In 2017, corn contributed 1.45 billion gallons or 92 percent of ethanol volumes and generated 89 percent of ethanol credits.
Volumes of sorghum-based ethanol including sorghum mixes were 212 million gallons in 2012, falling to 54 million gallons in 2017. Brazilian sugarcane ethanol contributed 5 percent and 10 percent of ethanol volumes in 2012 and 2013, respectively, when U.S. corn ethanol production fell due to severe drought. Molasses ethanol volume primarily from Brazilian sugarcane was 23 million gallons in 2016 and more than doubled in 2017 to 48 million gallons. Corn-based ethanol was behind much of the credit increase for ethanol starting in 2016 from a modeling change (see above). Multiple feedstocks contributed to a rise in biomass-based diesel volumes and credits from 2011 to 2017, especially tallow, used cooking oil and corn oil (Figure 4, bottom). In 2017, tallow contributed 252 million gallons, roughly half of California’s biomass-based diesel volumes and 48 percent of the biomass-based diesel credits. Corn oil biomass-based diesel volumes spiked in 2016 at 123 million gallons before higher 2017 carbon intensity ratings took effect (27–45gCO₂e/MJ, up from 4gCO₂e/MJ in 2016). “Other” biomass-based diesel generated small amounts of net deficits in most years. Over 95 percent of biogas energy was sourced from landfills from 2011–2016. In 2017, wastewater contributed 9 percent of biogas.

![Figure 4](image)

2. Carbon intensity of fuels

Figure 5 (top) depicts carbon intensity rating targets, reductions to date overall and by fuel pool, current compliance targets to 2020, and proposed adjustments from 2019–2030. In 2017, the state’s fuel pool average CI rating was just shy of the 3.5 percent reduction standard from 2010 baseline levels. CI rating reductions in the diesel and gasoline pools were 10.1 percent and 1.4 percent, respectively, below the reference fuel baselines. LCFS credits are fungible across fuel pools, enabling credits generated beyond required levels in the diesel pool to compensate credit shortfalls in the gasoline pool.
From 2011 through 2017, alternative diesel fuels’ reported CI ratings declined 44 percent, from 71gCO₂e/MJ to 39gCO₂e/MJ, and alternative gasoline fuels’ reported CI ratings fell 25 percent, from 87gCO₂e/MJ to 64gCO₂e/MJ; the CI ratings for all alternative fuels declined 36 percent, from 86gCO₂e/MJ to 55gCO₂e/MJ (Figure 5, bottom). A modeling change in 2016 was likely responsible for a considerable portion, perhaps about 10 percentage points, of the CI rating decline.\textsuperscript{xii}

Figure 5. Annual average percent CI rating reduction and compliance targets of gasoline and diesel fuel pools (top). The compliance target for the diesel pool is frozen at 3.5 percent for 2018 at least (see Introduction). Annual CI rating of gasoline, diesel and alternative fuels, by fuel pool (bottom). The alternative fuel CI calculations exclude off-road electricity and project-based credits (e.g., for innovative crude production) due to insufficient information.\textsuperscript{viii} Data source: [5].

Lower CI-rated fuels such as biogas and biomass-based diesel contributed to the diesel pool decline (Figure 6, top). In the gasoline pool, ethanol CI ratings in the program declined from 87.5 gCO₂e/MJ in 2011 to 81.7 gCO₂e/MJ in 2015, or about 7 percent, and an additional 14 percent from 2015 to 2016 under CARB’s CI modeling change (see above).\textsuperscript{ix} The feedstock/fuel combinations for biomass-based diesel exhibited a lower CI rating profile than those for ethanol (Figure 6, bottom).
Figure 6. Carbon Intensity Ratings, 2011–2018 Q1. For reported fuels (top). The ratings for on-road electricity and hydrogen presented here are adjusted for Energy Efficiency Ratio (EER). For on-road electricity, EER is 3.4 (assuming all light-duty vehicles). For hydrogen, EER is 1.9 (assuming all heavy-duty vehicles) until 2017 and 2.5 (assuming all light-duty vehicles) in 2017 and 2018 Q1. For fuel/feedstock combinations (bottom). “Waste” Eth is ethanol from waste beverages plus waste corn and sorghum seed. Data source: [5].

The LCFS had 494 transportation fuel pathways in mid-2018. Of these, 153 pre-dated the 2016 LCFS re-adoption, 280 were certified as mature production processes/technologies (streamlined process) and 11 pathways were newer technologies (“Tier 2 process”-certified). California facilities accounted for 87 pathways. Of 133 pathways from facilities outside the U.S., 96 are in Brazil. A facility may have multiple
fuel pathways certified. Ethanol accounted for 45 percent of pathways (224), biomass-based diesel contributed 24 percent (120 pathways, 99 of them renewable diesel), and 22 percent were biogas (109 pathways). Figure 7 shows CI rating ranges of available LCFS pathways, and non-volume weighted average CI rating, per fuel type.

![Image](image-url)

**Figure 7. CI rating ranges for fuel pathways in California’s LCFS, 2018.** Colored bars represent CI rating ranges for pathways certified in the program and available for use, adjusted for energy efficiency ratio (assumed electricity EER is 3.4 and hydrogen EER is 2.5, both for light-duty vehicles). Black vertical lines are CI ratings for CARBOB and Ultra-Low Sulfur Diesel (ULSD) pathways. The right edge of the orange boxes represents the average adjusted CI rating for the pathways, not weighted by volume. For CI rating by fuel type taking into account reported volumes, see Figure 5, bottom. Source: [10].

### 3. LCFS credit trading and prices

Regulated parties trade credits at a market price shaped by available supply (credits generated by low carbon fuels and offered for sale) and demand (credits needed to cover deficits generated by higher carbon fuels). Credit prices reflect the expected marginal cost of compliance, subject to market and policy uncertainty regarding factors impacting the cost of bringing alternative fuels to California. Policy uncertainty includes the LCFS policy itself and the U.S. RFS, which shapes domestic use of alternative transportation fuels.[11] In 2016, the LCFS instituted a soft credit price cap of $200, indexed to inflation thereafter. The cap is the maximum credit price in a “credit clearance market” – a CARB-led end-of-compliance-year clearinghouse to help match any credit suppliers with parties needing to cover existing deficits. Obligations on remaining deficits after the clearance market clearinghouse can be deferred up to five years with a 5 percent annual interest penalty.

LCFS credit prices and traded volumes trended upward since reporting began in 2013 with some fluctuations (Figure 8, top). Prices were around $20–$25 per credit in early program trading (start of 2013) and...
during a court-ordered freeze of the standard 1 percent in 2014 and 2015. Prices dropped early in 2018 after CARB proposed a downward adjustment of the 2020 target (see Introduction) and increased thereafter as the rulemaking to set 2030 targets at a proposed 20 percent proceeded. Average credit prices in July 2018 were $169 according to CARB data, which may include trades for future delivery, and ranged from $180–$190 according to OPIS reporting on trades.[12, 13] Given those credit price ranges, fuel CI ratings, and current LCFS targets, additional cost for gasoline or diesel would be approximately $0.08–$0.10 per gallon, and used cooking oil biodiesel with a CI rating of 20 would receive a benefit of approximately $1.80 per gallon.[14]

Greater LCFS program stringency in 2018, the policy process for setting more stringent targets to 2030, and/or lower priced RIN credits for the federal RFS program in 2018 may have contributed to higher LCFS credit prices this year (see RIN graphic at [15];[16] on relationship between RIN and LCFS credit prices). There has also been uncertainty about RFS policy direction.[17, 18]

In March 2015, just over 100 entities traded LCFS credits. In June 2018, there were 200 entities—95 buyers, 27 sellers, and 78 entities—both buying and selling. They represented 72 percent of the 277 regulated parties. Buyers’ numbers remained fairly level over the period while selling categories near-term targets, resulting in a 7.5 percent CI reduction in 2020 instead of the 10 percent reduction in the current regulation. Independent third-party verification of program fuel pathways is also proposed.

Program scope to generate credits from fuel use would expand to allow opt-in for alternative aviation fuels, electrified transport refrigeration units, electric power to oceangoing vessels and electric cargo handling equipment. Propane would be

4. Special topic: LCFS policy context

4a. Proposed LCFS amendments

The proposed amendments lay out a compliance schedule of CI reduction targets to 2030 reaching 20 percent below 2010 baseline for reference fuels, as part of the state’s Scoping Plan for its suite of climate policies.[20] As mentioned earlier, the proposal smooths the compliance trajectory from 2019–2030. This cases stringency of
included as an LCFS fuel, and several fuels that can currently opt in to the program—fossil CNG and hydrogen—will come under the regulation as potential deficit generators under the next decade’s stricter program targets.[21]

The amendments would also make changes to how existing fuel pathway credits can be generated. There would be new options to generate credits from electricity as a transport fuel on top of earnings based on the average California grid CI, for either zero-CI electricity charging (from e.g., solar or wind power) or “smart” charging or electrolysis, based on hourly marginal grid emissions information (but not both). Carbon capture and sequestration (CCS) tied to fossil fuel or biofuel production could also generate credits under a new protocol that accounts for leakage risk and monitoring. Credit possibilities from refineries would graduate from pilot to permanent status; credits can be generated for use of lower-CI process energy including electricity (from the grid or from low-CI sources), as well as GHG-reducing process improvements on-site. Energy efficiency ratios (EERs) for drivetrains with higher efficiency than a conventional internal combustion engine would be updated, and more fuel/vehicle combinations explicitly included. Stakeholders could propose new EERs to incentivize innovation of more efficient technologies in more settings.[21]

Several amendments relate to vehicles with no tailpipe emissions, or ZEVs and fueling stations.[xiii] A statewide point-of-sale ZEV rebate using residential electricity credit value is proposed, with program details to be finalized and approved next year.[xiv] The aim is to incentivize ZEV adoption; EV drivers are not directly rewarded for more electric vehicle miles traveled (eVMT).[xv] Another provision would allow credit generation from hydrogen fueling and electricity fast charging stations based on capacity (for up to 15 years and up to 5 years, respectively) at publicly accessible, operational stations.[xvi] The measure aims to overcome investment risks in emerging fueling infrastructure (e.g., uncertain demand, likelihood of underused infrastructure before alternative vehicles are widely adopted); applications would sunset at end of 2025. The provision would depart from LCFS precedent by: a) awarding credits not directly associated with emission reductions; and b) not treating all alternative fuel technology pathways similarly. CARB would tally infrastructure credits and program-rated GHG reductions separately. Both credit types count equally toward meeting LCFS targets. Program scope, target stringency, and cost containment have been identified as key levers in managing an LCFS policy.[25]

Additional administrative changes include creating a buffer account of unallocated credits representing GHG reductions that could be drawn on for program environmental integrity (e.g., if a bankruptcy leaves uncovered deficits). Sources for buffer credits include GHG reductions from ex post pathway assessments not retroactively assigned under the program and a share of CCS credits (level determined by assessed leakage risk). Credit trading via exchanges will be allowed to improve credit market transparency and ability to handle trading in futures.

4b. Oregon and British Columbia Low Carbon Fuel Programs

For context to California’s LCFS, this section briefly describes programs in Oregon and British Columbia. A future issue will delve into more depth on these policies.

Oregon’s Clean Fuels Program (CFP) continued a trend of net credits per quarter in 2018 Q1 under a 1 percent CI reduction standard, up from 0.5 percent in 2017. The CFP system-wide “bank” stood at just under 434,000 credits at the end of 2018 Q1. Credit bank accumulation slowed in 2018 Q1 relative to prior years (just over 10,000 credits, compared to an average of almost 53,000 in prior program quarters).[26] Average CFP credit prices were between
$55 and $61 per MTCO2e in 2018 Q1 and Q2, and $91.53 in August 2018 (9 transfers, about 30,000 credits traded).[27]

British Columbia’s Renewable and Low Carbon Fuel (BC-RLCF) Regulation, also referred to as the BC-LCFS, reported a credit “bank” of 1.66 million credits accumulated between 2013 and 2016. Under a 2016 CI reduction standard of 5 percent, the BC-RLCF added 315,000 net credits, fewer than in prior years. “Part 3” agreement credits for actions taken toward low carbon fuel use were 53 percent of the total net credits.[28] For key components of LCFS-like programs compared, see [29, 30].

Oregon’s CFP is considering amendments for 2019 to remain in step with California’s carbon intensity rating modeling changes and fuel/vehicle efficiency ratios, and to include alternative aviation fuel as a credit generator.[31] The BC-RLCF has undertaken stakeholder consultation on the topic of 2030 targets of 15–20 percent CI reduction, and other matters.[32]

4c. Canadian Clean Fuel Standard and Brazilian RenovaBio

Canada is developing a Clean Fuel Standard (CFS) that rates fuels’ lifecycle carbon intensity and targets annual reductions of 30 MTS of GHG emissions by 2030. The CI rating will not initially include indirect land use change emissions. Liquid, solid, and gaseous fuel categories will have separate targets. The CFS will apply to transportation, industrial, and building sectors, unlike other ‘LCFS’-like programs focused on transportation fuels only. It will operate alongside Canada’s carbon pricing program.[33] The timeline was recently revised from a 2019 start to stagger the onset of regulations for the different fuel categories: liquid fuels by 2022, and gaseous and solid fuels by 2023. A lifecycle analysis model is being developed.[34]

Brazil’s RenovaBio program will be an LCFS-like lifecycle carbon intensity standard to span at least ten years, to help achieve its COP21 commitment to GHG reductions. The program aims for a 10.1 percent CI reduction by 2028, will cover liquid biofuels and biogas used in transportation, and will be enforced alongside mandates for ethanol (currently a 27 percent blend by volume in gasoline) and biodiesel (a 10 percent blend by volume in diesel). Facility-specific CI ratings will be independently certified, and tradable program compliance credits (CBIOs) generated based on fuel volumes and CI ratings. Land use change emissions will be initially excluded from the lifecycle analysis. Feedstock from areas deforested after December 2016 is not eligible; sugarcane producers must be in the Rural Environmental Registry (“CAR,” by its Portuguese acronym) and adherence to domestic agro-ecological zoning regulations for sugarcane and palm oil and encroachment on native vegetation will be monitored. The program comes into force at the end of 2018, with initial obligations at the end of 2019.[3]

References

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5. CARB. Low Carbon Fuel Standard Reporting Tool Quarterly Summaries. 2018; Available from: http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm


12. CARB. Low Carbon Fuel Standard. LCFS Credit Transfer Activity Reports 2018; Available from: http://www.arb.ca.gov/fuels/lcfs/credit/ltrceditreports.htm


20. CARB. Staff Report: Initial Statement of Reasons. Public Hearing to Consider Proposed Amendments to the Low Carbon Fuel Standard Regulation and to the Regulation on Commercialization of


Endnotes

1 The U.S. EPA has approved use of a 15 percent ethanol by volume blend (E15) for passenger vehicles of model year 2001 or newer, but it is not approved in California. E15 use is also restricted seasonally due to volatility properties (Reid Vapor Pressure). E85 can be used in flex-fuel vehicles.

ii The expansion boosted the contribution of non-biofuel to alternative fuel energy by 1 to 2 percentage points that year, and slightly raised the contribution of alternative fuel to total energy (by 0.1-0.2 percentage points).

iii Cellulosic liquid fuels are eligible under the RFS but have not been used in California to date. Cellulosic ethanol reported under the RFS was 2.2 million gallons (1.5 gge) in 2015, 3.8 million gallons (2.5 gge) in 2016, just over 10 million gallons in 2017 (6.7 gge), and 5.6 million gallons (3.8 gge) in the first half of 2018. The first cellulosic diesel for transport under the RFS was reported in late 2017 (6,890 gallons, or 7,849 gge, through June 2018).[6]

iv Data on credits for less complex and lower energy-use refineries are not yet available for 2017 and 2018 Q1, and would alter the credit/deficit balances based on current data listed below for these periods.[5]

vi Figure 4 (bottom right) shows biomass-based diesel net credits, accounting for both deficits and credits. Information on CARB’s LCFS Data Dashboard accounts only for biomass-based diesel credit generation.

vii Based on declines in indirect land use change CI rating for the dominant fuel, corn ethanol, the sunset of a low-CI rating for corn oil-based diesel substitutes, relative to CI rating declines in both fuel pools that year.

viii For more detail see endnote ix below.

ix CI ratings reported reflect the period fuel volumes were used and credits generated in the program. The model updates for 2016 were phased in by 2017. They resulted in lower CI estimates for fuels using land-based feedstocks and somewhat higher ratings for fossil and bio-based natural gas.

x EER is used in the program to account for relative on-road efficiency of fuel/vehicle combinations compared to reference fuels. Off-road electricity was excluded from the CI calculation and assumptions made about electric and hydrogen vehicle type in the absence of information in CARB data on vehicle types and EER applied and timing of vehicle deployment, which impact fossil fuel displacement crediting.

xi Conventional aviation fuel would not generate deficits but would provide a baseline reference CI compared to which aviation fuel credits would be generated. The CI reduction requirement for aviation fuels would be held at baseline levels until 2023 to make alternative aviation and on-road renewable diesel use competitive. The fuels share a production process that can maximize either fuel as a portion of biorefinery output. The nominal benchmark CI for aviation fuel and diesel fuels would decline together from 2023 through 2030.[22]

xii “Book-and-claim” methods for claiming zero-CI charging will be available within a utility service area, paralleling similar methods available for biogas within North America. The smart charging CI values will be from the California Energy Commission’s Avoided Cost Calculator.[22]

xiii ZEV fuel may have associated emissions from fuel production (e.g., electricity from natural gas or coal) (see, e.g., CARB electricity pathways CI ratings) or vehicle lifecycle (production, use, retirement).[23]

xiv The regulation would set a minimum percentage contribution for various utility types. The residual credit value would remain in utility programs for spending in other ways deemed beneficial to EV drivers (e.g., charging infrastructure). The proposal would require approval by the California Public Utilities Commission (CPUC).

xv Staff is directed to consider ways to reward eVMT in ride-hailing applications (e.g., Uber and Lyft).[24]

xvi Unused capacity would generate credits based on fuel flow under full operational use; used capacity would generate credits normally. For fast charging stations, credit value per facility would be capped to not exceed capital expenses; there is no similar cap for hydrogen fueling stations due to expectations of uncovered operational cost in early underused years. To try to limit credit market impact, credits for each fuel type would be capped once potential credits covered 2.5 percent of all deficits generated in the prior quarter.[22]