Analyzing Future Low Carbon Fuel Targets in California

Response to Proposed 15-Day Changes

Proposed Amendments to the LCFS Regulation

August 2024

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Summary of ICF Analysis in Response to 15-Day Changes

The California Air Resources Board (CARB) staff released the Staff Report: Initial Statement of Reasons outlining many proposed amendments to the Low Carbon Fuel Standard (LCFS) program in December 2023. The Staff Report identified three key areas of change with respect to carbon intensity (CI) targets: 1) increased stringency by 2030 (from 20% to 30% carbon intensity reduction), 2) a step down of 5% in the CI reduction required in 2025 (yielding an 18.75% CI reduction requirement compared to the 13.75% reduction scheduled), and 3) the introduction of an Automatic Acceleration Mechanism (AAM). CARB staff provided additional documentation during a Low Carbon Fuel Standard Public Workshop on April 10, 2024.

CARB Staff published additional modifications for the proposed amendments (15-Day Changes) on August 12, 2024. The stringency of the program in 2030 remains unchanged at 30% and CARB did not make any proposed changes to the AAM. However, CARB staff proposed a step down of 9% in the CI reduction required in 2025 (yielding a 22.75% CI reduction requirement compared to the 13.75% reduction scheduled) and introduced several other modifications that have changed the trajectory of ICF's analysis.

Summary of Previous Work

ICF previously reported that in an Accelerated Decarbonization Central Case a carbon intensity reduction target of 41-44% for 2030 is achievable for California's Low Carbon Fuel Standard program.

ICF reached this conclusion based on expected fuel volumes and carbon intensity reductions for a wide array of low carbon fuel pathways—with market-based constraints on feedstocks (e.g., value to the producer; competition between markets, etc.) and a consistent GHG emission accounting framework over the period of the analysis (i.e., no changes to avoided methane emission counting during the time period of the analysis), and without fundamentally changing deliverability requirements of fuels (e.g., by phasing out certain pathways). More specifically, ICF's analysis showed that virgin oils will contribute about 20-33% of the total feedstock used for biodiesel and renewable diesel production over the course of our analysis.

New Analysis in Response to 15-Day Changes

The work presented here was prepared in direct response to the Staff Report, accompanying documentation published in December 2023, and new information made available during the Low Carbon Fuel Standard Public Workshop in April 2024, and the 15-Day Changes and the accompanying information published online. ICF's updated commentary focuses on a) the impact of the proposed cap on credits generated from

biomass-based diesel derived from virgin oils, b) anomalies with respect to forecasted diesel consumption, c) the "model-estimated credit prices" reported by CARB Staff in Attachment C, d) the carbon intensity step down in 2025, and e) the Automatic Acceleration Mechanism.

The proposed cap on credits generated by biomass-based diesel produced from virgin oils will likely put upward pressure on credit prices.

The 15-Day Proposed Changes include a company-wide cap on credit generation for biomass-based diesel produced from virgin oils like soybean oil and canola oil. However, rather than being implemented as a hard cap, Staff have indicated that any biomass-based diesel from virgin oils that exceeds the 20% threshold will be "assessed the carbon intensity of the applicable diesel pool benchmark for that year, or the certified carbon intensity of the applicable fuel pathway; whichever is higher." ICF modeling has indicated that virgin oils will likely be about 20-30% of the feedstock for biomass-based diesel production for product delivered into California. Notably, this is lower than what CARB's own analysis indicates,[1] as shown in the table below, despite claiming that the cap "avoids sending a long-term signal for virgin soy or canola oil to serve California demand." For the sake of reference, virgin oils were about 19% of the biomass-based diesel market (by volume) in 2023.

Table 1. Share of virgin oil and waste oil feedstocks for biomass-based diesel in CARB analysis

Est Share	2025	2026	2027	2028	2029	2030
Virgin oil	38%	51%	56%	56%	56%	55%
Waste oil	62%	49%	44%	44%	44%	45%

ICF does not anticipate that product will be diverted due the proposed cap because producers need a reliable feedstock supply chain, and virgin oils can help stabilize that supply chain through price certainty and feedstock availability. Based on ICF's analysis, the proposed cap on virgin oils and the treatment of incremental volumes is more likely to increase the LCFS credit price in the market in ways that are not reflected in CARB staff analysis.

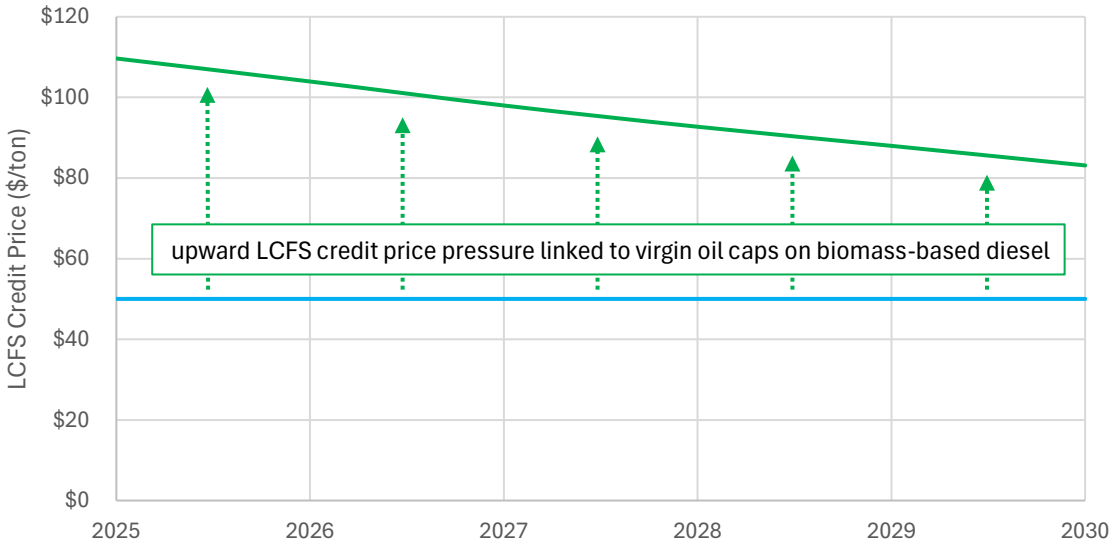
Renewable diesel producers realize value from incentives and environmental commodity markets and their profitability is tied to considerations regarding feedstock costs, operational costs, financing, and logistics to end use markets. For the sake of simplicity, ICF

[1] ICF notes that CARB's background data do not distinguish biodiesel or renewable diesel volumes by feedstock; however, they provide credit generation distinguished between these feedstocks and the CI values assumed in their modeling. ICF calculated the implied volumes based on these data.

has isolated in this analysis the consideration of the LCFS program and the two value streams that renewable diesel producers realize: a) avoided deficits and b) credits generated. Avoided deficits represent the value of displacing diesel with renewable diesel and is a function of the difference between the carbon intensity of diesel and the benchmark. Credits generated are based on the value of the delivered product and is a function of the difference between the benchmark and the fuel-specific CI. Renewable diesel producers capture value from both avoided deficits and credits generated today. Under the proposed virgin oil caps, however, the value stream to incremental renewable diesel gallons would only generate avoided deficits (and not credits).

Rather than divert product to other markets, many companies/producers will likely exceed the proposed cap and keep product in California. However, with the value stream constrained to avoided deficits due to the proposed cap, renewable diesel producers will look to maintain profitability, and that means higher LCFS credit prices. For illustrative purposes, ICF quantified the value stream to renewable diesel producers for a soybean oil based product with a carbon intensity of 53 g/MJ. Holding all other value streams constant, a $50/ton LCFS credit price would yield about 35 cents per gallon (cpg) of value for both avoided deficits and credits. However, if the value stream is constrained to just the avoided deficits, then the producer will face cost pressures. The extent to which the LCFS credit price would increase is dependent on the year of interest and the associated carbon intensity benchmark. In 2025, for instance, the renewable diesel producer would need to see a credit price increase from $50/ton to $110/ton to maintain consistent revenue streams. Though producers may have some ability to accommodate lower returns, they will not simply accept lower net value. The figure below shows how the credit price would have to increase (green line) relative to a flat LCFS credit price (blue line) after accounting for the change in value streams to the renewable diesel producer.

Figure 1. Illustrative LCFS credit price increase due to proposed virgin oil caps



The real-world response will likely be somewhere in between the blue line and the green line—regardless, ICF anticipates that the virgin oil caps as proposed will push credit prices up in ways that Staff has not contemplated, particularly in the near-term future.

The proposed cap on credits generated by biomass-based diesel produced from virgin oils may stall renewable diesel and renewable jet fuel investments.

Staff's proposed cap on virgin oils for biomass-based diesel is applicable to biodiesel and renewable diesel production, however, the cap does not apply to renewable jet fuel. In principle, this could help improve the prospects for renewable jet fuel, sometimes referred to as sustainable aviation fuel (SAF). However, this ignores the value streams available to SAF and renewable diesel (RD). The table below quantifies the value streams on a per gallon basis for SAF and RD, including the commodity price, incentives from the Inflation Reduction Act (IRA), the federal Renewable Fuel Standard, and state-level programs. ICF made several assumptions to develop these values. ICF conducted the analysis for 2025, when the Blender's Tax Credit expires and the market transitions to the Clean Fuel Production Credit (CFPC) from the IRA. ICF assumed a carbon intensity (CI) value of 30 g/MJ for both the CFPC calculation and the LCFS value calculation—we note, however, that it is highly unlikely that a fuel will have the same CI value across these two programs given the differences between the 40B SAF GREET model and the CA-GREET model. The table below includes other assumptions made in ICF's analysis.

Table 2. Value stack for SAF vs RD in 2025

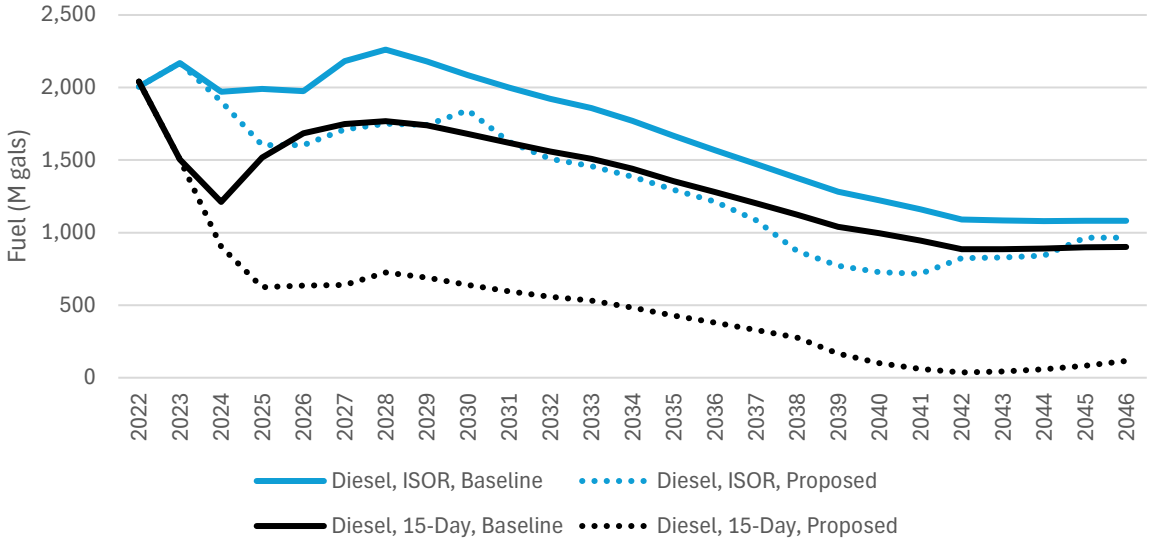
Value Stack Component	Value to SAF $/gal	Value to RD $/gal	Assumptions
Commodity	$2.42	$2.49	June 2024 average[1]
Federal Incentives			
IRA (45Z)	$0.64	$0.37	Assuming 30 g/MJ
RFS	$0.80	$0.85	$0.50 D4 RIN
State			
Low carbon fuel standards	$0.33	$0.34	$50/t, 9% CI stepdown
Carbon compliance costs			
Cap-at-Rack	--	$0.41	$40 CCA
LCFS compliance cost	--	$0.16	$50/t, 9% CI stepdown
TOTAL	$4.19	$4.62	

Spot prices and environmental commodity pricing will vary in California, the CI values will vary by feedstock, and the IRA incentives for SAF will be finalized soon. However, this view of the SAF-RD differential highlights a nearly 43 cpg premium for renewable diesel, which will increase over time as compliance costs on diesel increase over time. Even though it is conceivable that the virgin oil feedstock cap may help incentivize SAF production over RD, that also means that the LCFS credit price would have to increase at a much faster rate than other components of the value stack to levelized these value streams. In other words, even in this case, the virgin oil cap may put upward pressure on LCFS credit prices to narrow the incentive gap to induce SAF production at the levels contemplated by CARB staff.

ICF has reservations about the modeling assumptions related to diesel and the proposed cap on credits generated from biomass-based diesel derived from virgin oils in the Proposed 15-Day Changes.

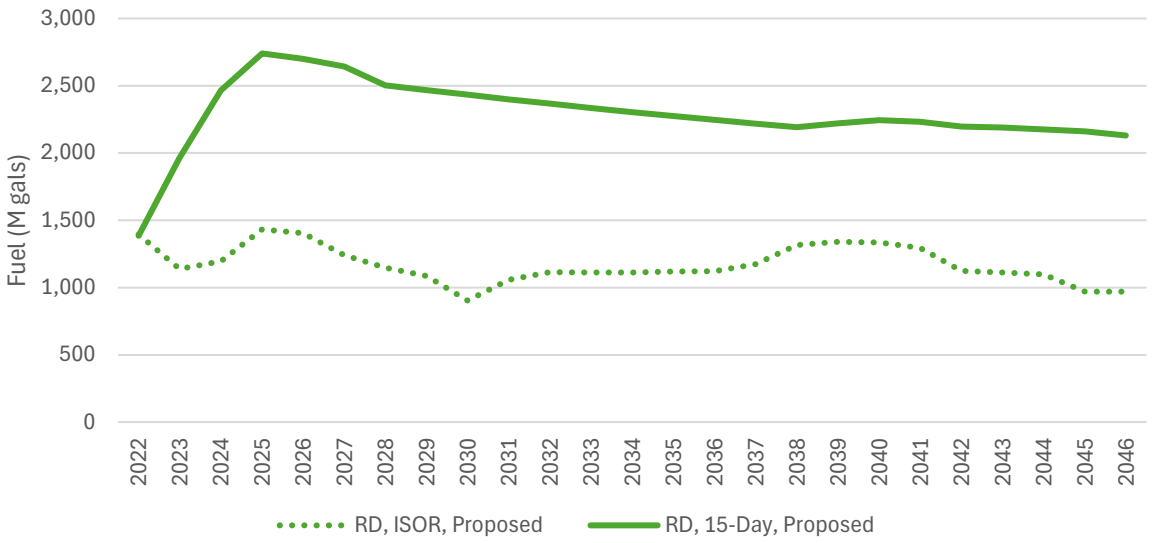
CARB staff have presented a Baseline Scenario and a Proposed Scenario as part of the Staff Report (ISOR) and the 15-Day Changes, as well as some sensitivity cases. ICF analyzed the ultra-low sulfur diesel (ULSD) volumes reported in the Baseline Scenario and Proposed Scenario for data made available and dated 04/09/2024 (linked to the Staff Report) and the same scenarios for the work dates 08/12/2024 (linked to the 15-Day Changes). ICF note that the ULSD volumes have changed considerably (see figure below).

Figure 2. ICF analysis of ULSD volumes in the Staff Report (ISOR) and the 15-Day Changes



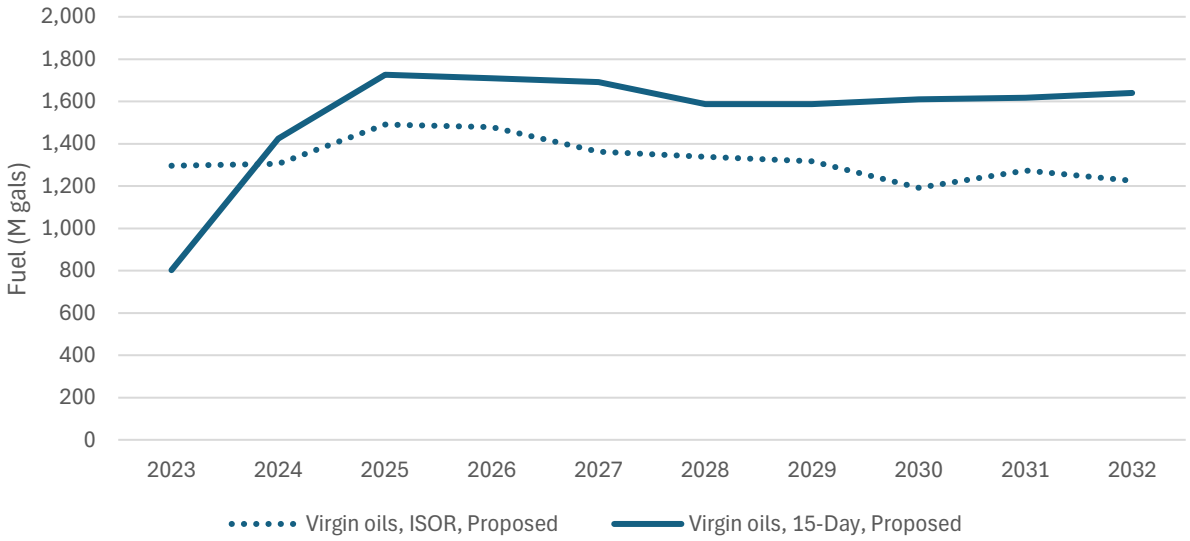
The ULSD fuel volumes in the Baseline Scenario has decreased significantly between the April (blue line, ISOR) and August data (black line, 15-Day Changes). It appears that the 2023 ULSD volumes have been brough more in line with actual data—they were decreased from about 2.2 billion gallons to about 1.5 billion gallons. Furthermore, by 2045, CARB's most recent analysis of the Proposed Scenario via the 15-Day changes yields ULSD volumes of about 120 million gallons compared to the previous estimates of 965 million gallons in the ISOR Proposed Scenario. It appears that CARB has increased renewable diesel consumption in its Proposed Scenario by about 1.2 billion gallons annually (see figure below).

Figure 3. ICF analysis of RD volumes in the Staff Report (ISOR) and the 15-Day Changes



It is unclear to ICF why the expected market response (i.e., via the Proposed Scenarios) has changed so much between iterations. It is also important to note that it appears, despite CARB proposing a cap on virgin oils for biomass-based diesel, that the implied volumes for biodiesel and renewable diesel derived from virgin oils increases by about 300 million gallons annually in the 15-Day Proposed Changes compared to the ISOR (see figure below).

Figure 4. ICF analysis of biomass-based diesel volumes from virgin oils in the ISOR and 15-Day Changes

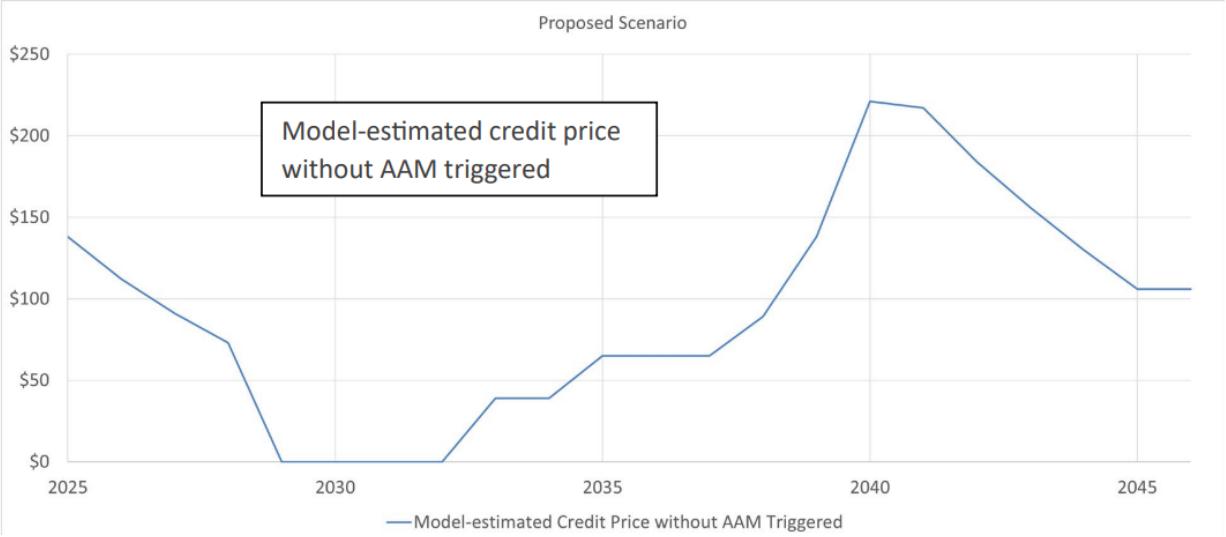


The inconsistencies between the ULSD and RD volumes in the Baseline and Proposed Scenarios for the ISOR and 15-Day Changes lead ICF to believe that one should have reservations about the modeling assumptions, and specifically as it relates to how CARB staff has considered the market response to the proposed cap on credits generated from biomass-based diesel derived from virgin oils.

The "model-estimated credit prices" reported in Attachment C undercut the credibility of the Proposed 15-Day Changes by suggesting that the credit price will go to zero over a 4-5 year period.

The model-estimated credit prices (see figure below) contrast sharply with what was presented previously as part of the ISOR analysis: CARB staff previously had credit prices at the price ceiling of about $220/t in 2025 (with a 5% CI step down, reported on a real basis in 2023 dollars) and in the range of $100/ton in 2030, compared to $140/ton and $0/ton, respectively in the current analysis.

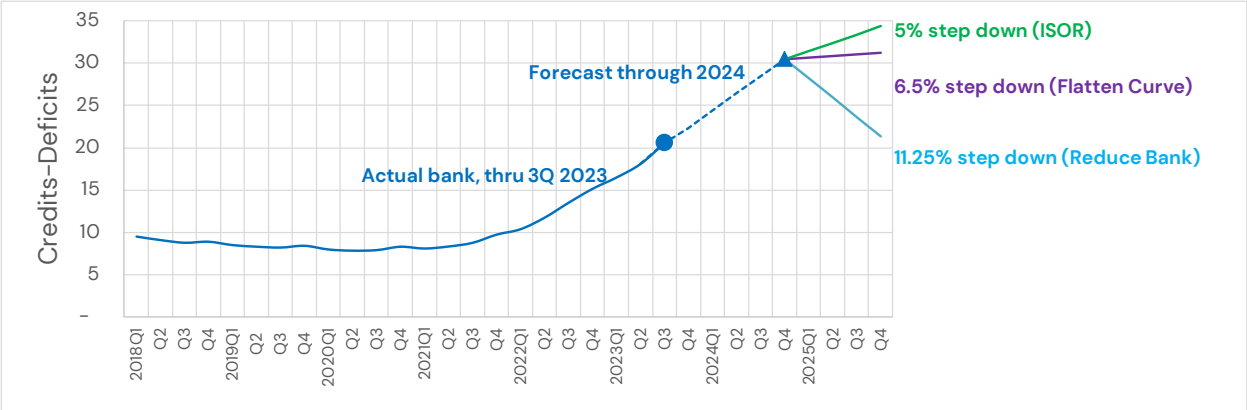
Table 3. CARB model-estimated credit price outlook ($/ton, in real $2023)



These forecasts are difficult to understand in the context of other subsidies available to low carbon fuel producers. To date, CARB staff has not provided sufficient detail regarding the methodology to develop "model-estimated credit prices" in any of the publicly available documentation. Notably, there are two questions related to this outlook that should be answered in the context of broader market influence: 1) How can the market deliver carbon intensity reductions in the range of 28-40% over the 4-5 year period 2028/29-2032/33 at a zero-dollar credit price? 2) What was modified in the approach that changed the structure of the model-estimated credit price so significantly between iterations of the analysis? These are important questions that speak to the credibility of the analysis supporting the Proposed 15-Day Changes.

ICF continues to recommend a step down of 10.5% to 11.5% in 2025 to achieve a target credit bank equivalent of 2-3 quarters' worth of deficits.

This level of stringency is likely what is needed to achieve the stated intent of correcting for the "near-term over-performance" of the program. ICF's analysis indicates that the credit bank will likely continue to build significantly in 2025 if the step down is limited to 5%. ICF analysis suggests that a 6.5% step down is needed to ensure that the credit bank build is flattened in 2025.



ICF analysis indicates that the 9% step down in 2025 will decrease the credit bank. However, ICF modified our modeling to account for the additional year of credit generation via electric forklifts using the CARB-approved estimation methodology and a revised (downward) energy economy ratio (EER). After accounting for this change and others in the analysis, ICF still finds that a 2025 carbon intensity step down in the range of 10.5% to 11.5% is more appropriate than 9%, particularly to align with the clearly stated objective of reducing the credit bank to 2-3 quarters' worth of deficits.

ICF recommends that the Automatic Acceleration Mechanism be considered for implementation as soon as 2026, rather than waiting until 2028.

Delaying the implementation of the Automatic Acceleration Mechanism is unnecessary. The risk of a continuous credit bank building through 2027, thereby depressing credit prices for another 3-4 years, outweighs the risk of triggering the mechanism sooner.

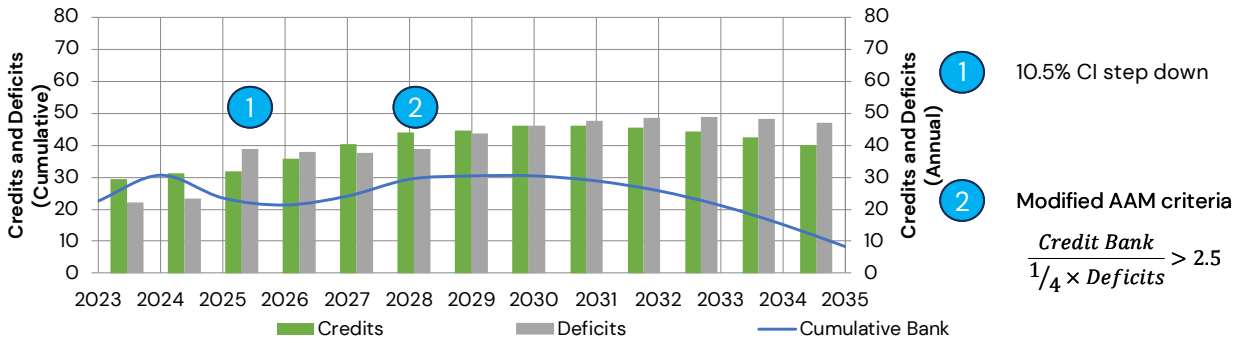
ICF recommends that the Automatic Acceleration Mechanism be implemented on a four-quarter rolling basis.

At the very least, the policy interventions proposed by the California Air Resources Board should be evaluated in the context of the current market to determine if they would have had an impact. As proposed, the Automatic Acceleration Mechanism would not have been triggered based on a review of annual data from 2022, thereby allowing the credit bank to grow during 2023 and again through 2024 with no market correction. If the Automatic Acceleration Mechanism were implemented on a four-quarter rolling basis, then the mechanism would have been triggered sooner and the credit bank build in this hypothetical scenario would have been constrained.

ICF continues to recommend that the first criteria for the Automatic Acceleration Mechanism be modified such that the mechanism is enacted when the credit bank is more than 2.5 times greater than the quarterly deficits generated on a four-quarter rolling basis.

The threshold for the first trigger proposed should be reduced from 3.0 to 2.5 (or lower). ICF disagrees with the underlying presumption that the AAM should be triggered at the proposed threshold i.e., when there are three quarters' worth of deficits in the bank.

The figure below shows the results of ICF's modeling after updating our analysis and focuses on the recommended carbon intensity step down in 2025 (at least 10.5%) and the revised Automatic Acceleration Mechanism recommended based on our analysis.



The figure above has a shape and curve that ICF thinks is more in line with a successful Low Carbon Fuel Standard program i.e., one that maintains a tighter credit-deficit balance and is flexible enough to respond to market conditions in the near-term future (pre-2030), while enabling California to achieve its long-term greenhouse gas emission reduction targets. ICF's view of the market suggests that a focus on an "ideal" credit bank from pre-2021, quantified using a threshold of three quarters worth of deficits, is misguided and may lead to a market that "swings" up and down (as measured by the credit bank) more than necessary, thereby creating market uncertainty for active and would-be participants. Major investments by regulated parties in the last several years have likely improved their respective line of sight on credit generation, thereby reducing the need to carry such a large credit bank.

Appendix

Background on ICF modeling

ICF models the CI reductions that could be achieved using the structure of the LCFS program. The modeling is driven by the demand for transportation fuel in California, which is a function of many variables including but not limited to economic growth, vehicle miles traveled (VMT), vehicle fleet turnover, and the expected compliance with complementary policies that impact transportation fuel demand. ICF's modeling is initiated using documentation associated with the EMissions FACtor model (EMFAC)[2] that is publicly available for download. The EMFAC model is "developed and used by CARB to assess emissions from on-road vehicles including cars, trucks, and buses in California." The EMFAC model enables ICF to characterize top-level transportation fuel demand in California given baseline consideration of the aforementioned key factors, like VMT and fleet turnover. Although EMFAC2021 incorporates expected compliance with several regulations that decrease fossil fuel demand, like the Advanced Clean Truck (ACT) Rule and the Innovative Clean Transit (ICT) Rule, it does not include expected compliance with Advanced Clean Cars II (ACC2) or Advanced Clean Fleet, which were adopted by the Board in 2022 and 2023, respectively. ICF has modified EMFAC2021 to ensure compliance with ACC2 and ACF. ICF then pairs the fleet turnover and fuel demand functions of EMFAC with supply-cost curves for low carbon fuels, including ethanol, biodiesel, renewable diesel, and renewable natural gas (RNG).

ICF previously modeled multiple scenarios for this project and framed each as *Accelerating Decarbonization* in the transportation sector using a diverse array of low carbon fuel strategies that are viable in the timeframe contemplated. Within this framework, ICF presented a Central Case and High Case(s).

- *Accelerating Decarbonization, Central Case*: ICF's primary focus is this case, whereby we limited our consideration of low carbon fuel strategies that require expanded deployment, reasonable technological advancement, and limited, if any, substantive policy changes.
- *Accelerating Decarbonization, High Case(s)*: In these cases, ICF considered additional strategies and/or policy changes that would lead to higher deployment of low carbon fuels and/or greater CI reductions over the course of the analysis. These included but were not limited to reductions in indirect land use change (ILUC) accounting, resumption of FFV manufacturing by OEMs, and relaxation of

[2] ICF is using the most recent version of EMFAC, EMFAC2021 (v1.0.2) as a starting point for our modeling. The EMFAC model is available for download online.

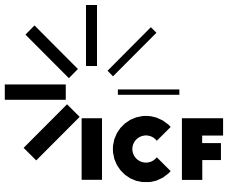
deliverability requirements for electricity used as a transportation fuel and as a processing fuel. Together, these represent a more expansive market and aggressive outlook for decarbonizing the transportation sector.

Stakeholder Outreach

ICF retains exclusive decision-making with respect to the parameters that are included in (or excluded from) the modeling in this project. However, as part of the development of our modeling, we sought (and will continue to seek) input and feedback from stakeholders that are uniquely positioned to characterize trends, constraints, and opportunities across various low carbon fuels. ICF conducted interviews with stakeholders from various low carbon fuel providers. Through these conversations, ICF introduced the broader project objectives and ICF's modeling approach to help stakeholders understand the key drivers for our analysis. ICF then led a discussion guided by the following questions:

- ***Deployment***. What are expected changes in the industry that will increase or decrease the deployment of a particular fuel or fuel/vehicle combination? These generally include supply and demand considerations and should account for opportunities and barriers to the extent feasible. What is the timeframe associated with any changes?
- ***Carbon intensity*.** What is the current and projected carbon intensity of the fuel under consideration? Are there any California-specific policy or regulatory changes that can be accommodated to help achieve these reductions? What is the rate at which these carbon intensity changes are likely to occur?
- ***Demand from Other Markets***. Where are the developments likely to occur? Are there any specific advantages or disadvantages associated with delivering these solutions to California that ICF needs to consider? To what extent will other (existing or potential) low carbon fuel markets be advantaged or disadvantaged as it relates to these solutions as a function of their corresponding geography?

Lastly, it is important to note that ICF developed the modeling framework used in this study based on publicly available tools and data—we have purposefully excluded any proprietary data or considerations as part of this analysis.



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