Analyzing Future Low Carbon Fuel Targets in California

Response to Staff Report

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ICF Resources, L.L.C.
1902 Reston Metro Plaza
Reston, VA 20190
703-934-3000

Contact: Philip Sheehy, PhD
Phone: 415-385-4160
E-Mail: Philip.Sheehy@icf.com

Contact: Fang Yan, PhD, PE
Phone: 916-210-5906
E-Mail: Fang.Yan@icf.com

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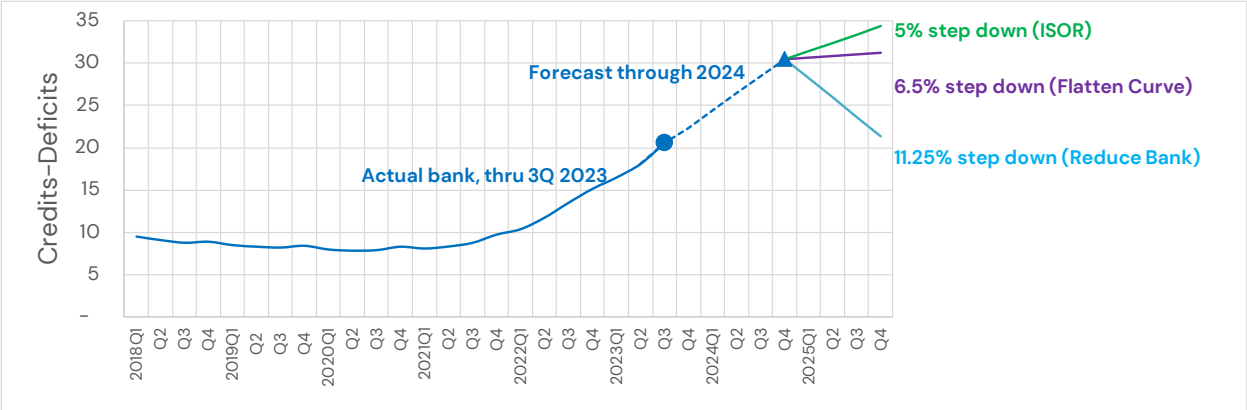
Executive Summary

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

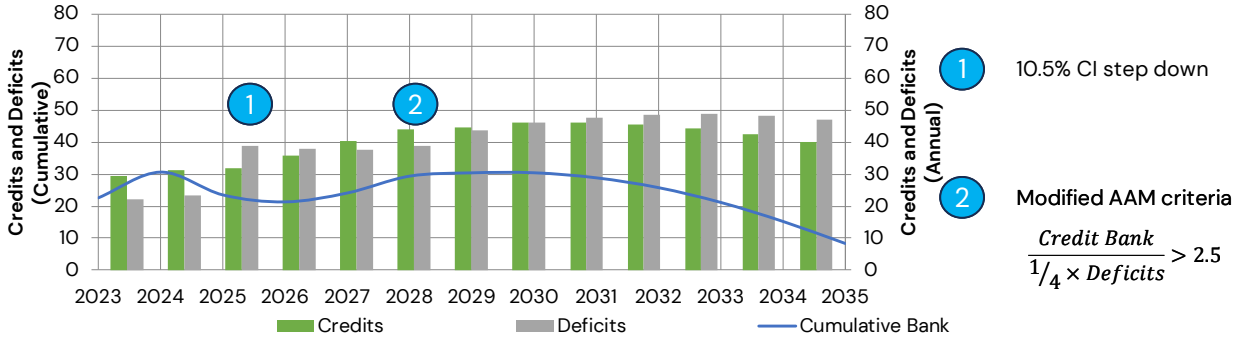
ICF previously reported that in an Accelerated Decarbonization *Central Case* a carbon intensity reduction target of 41-44% for 2030 is achievable for California's Low Carbon Fuel Standard program. ICF reached this conclusion based on expected fuel volumes and carbon intensity reductions for a wide array of low carbon fuel pathways. The work presented here, however, was prepared in direct response to the Staff Report and accompanying documentation published in December 2023. ICF modified and updated our analysis by focusing on a) an *ISOR Case*, b) the step down in 2025, c) the Automatic Acceleration Mechanism, and d) credit pricing.

ICF developed the *ISOR Case* by modifying certain aspects of our modeling with the express intent of aligning more closely with the restrictions or constraints included in modeling done by Staff in support of the proposed amendments. ICF removed both the potential for a 15 percent blend of ethanol with gasoline and any pathways in the analysis that generated credits via the implementation of climate smart agriculture practices at the farm level. ICF also constrained renewable natural gas deployment in line with proposed changes to deliverability requirements and avoided methane emissions accounting. Lastly, ICF updated the carbon intensity value for ultra-low sulfur diesel in our analysis to align with the higher value published by Staff. ICF made other minor modifications to our analysis to reflect market developments that occurred over the course of the project.

ICF recommends 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.



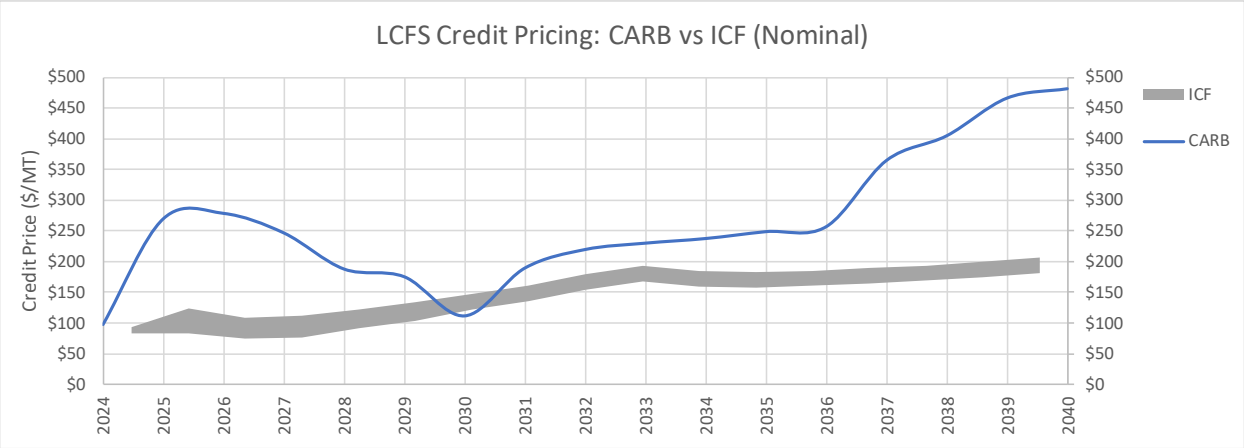
ICF recommends that the Automatic Acceleration Mechanism be considered for implementation as soon as 2026, rather than waiting until 2028. ICF also recommends that the first criteria for the Automatic Acceleration Mechanism be modified such that the mechanism is enacted when the credit bank is more than 2.5 times greater than the quarterly deficits generated in a given year (down from the proposed value of 3 times). The figure below shows the results of ICF's modeling using the *ISOR Case*.



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 GHG 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 3 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.

ICF recommends that Staff make more transparent the credit price modeling so that stakeholders can understand better what is driving the magnitude of credit pricing and the patterns emerging from the data. Staff used an internal estimate of credit pricing as

one of the primary reasons for dismissing a higher carbon intensity reduction target in 2030. Staff claim that a higher target will lead to higher costs faced by consumers associated with pass-through compliance costs. However, Staff's forecasting is flawed and effectively implies that the Low Carbon Fuel Standard program will bear the entire cost of subsidizing low carbon fuel production. This analysis is overly pessimistic because it overlooks the substantial value of the Clean Fuel Production Credit via the Inflation Reduction Act, robust pricing from the federal Renewable Fuel Standard, moderate commodity pricing (e.g., for gasoline and diesel), and increasing California carbon allowance prices. The figure below shows a range of ICF forecasted credit prices in grey compared to the Staff credit price forecast in blue line.[1]



ICF makes three observations associated with the comparison between Staff's forecast and our forecast:

1. In the near-term future (by 2025), Staff is forecasting a four-fold increase in credit pricing. This forecasted credit price spike coincides with the introduction of the Clean Fuel Production Credit and other substantial Inflation Reduction Act incentives that will be flowing to the low carbon fuel market and reducing pressure on the Low Carbon Fuel Standard program.
2. In a post 2030 environment, though the two curves are showing similar patterns of increasing credit prices, Staff's forecast is still $60-65/ton higher than ICF.
3. Post-2035, Staff's forecasts are suggesting that a credit price of $250 to nearly $500/ton is needed to achieve program compliance. There is no reason that the credit price should ever need to be that high to induce the investments necessary to achieve compliance based on ICF modeling.

[1] Staff's credit price forecast has been adjusted to nominal dollars, as ICF has found this is how stakeholders tend to view the market (rather than adjusting pricing to some real-dollar basis).

1 Introduction

The California Air Resources Board (CARB) has proposed more ambitious carbon intensity (CI) targets to increase the stringency of the Low Carbon Fuel Standard (LCFS), with the intent of achieving more significant greenhouse gas (GHG) emission reductions in support of California's pursuit of economy-wide carbon neutrality no later than 2045. With respect to CI targets, CARB has proposed three key areas for change:

1. Increased CI stringency by 2030, increasing the target from 20% to 30% by 2030.
2. Additional 5% CI reduction in 2025 from the current CI target, also referred to as the step down. This step down in 2025 will yield an 18.75% CI target in 2025. The step down in 2025 is "in response to the near-term over-performance."
3. Introduction of an Automatic Acceleration Mechanism (AAM) that is designed to trigger a more stringent CI standard in the event of the market over-performing in the future (with over-performance measured by two criteria).

ICF is supporting a coalition of interested parties representing a diverse mix of low carbon fuel producers seeking to understand the potential carbon intensity reduction that could be achieved assuming the likely aggregate deployment of low carbon fuels and supporting technologies. Previously, in an Accelerated Decarbonization *Central Case*, ICF found that a carbon intensity target of 41-44% for 2030 is achievable based on expected fuel volumes and carbon intensity reductions for a wide array of fuel pathways.[2]

The initial stages of this project were focused on defining an ambitious CI target for 2030. However, the work presented here is in response to the Staff Report: Initial Statement of Reasons[3] and accompanying documentation published by CARB, and ICF has modified the analysis accordingly. The work presented here focuses on a) an *ISOR Case*, b) commentary on the step down in 2025 supported by ICF analysis, c) review of the AAM in light of likely low carbon fuel deployment to California out to 2030 (and beyond), and d) commentary on LCFS credit pricing.

As noted elsewhere, ICF's modeling differs from the modeling conducted by CARB staff using the California Transportation Supply (CATS) model. More specifically, CATS is described as a "transportation fuel supply optimization model" that "minimizes the cost of supplying fuel to meet demand in each year." In other words, given certain modeling constraints, namely a specific CI reduction trajectory and associated policy constraints, the

[2] In a *High Case* reflecting updated science and analysis, additional cost effective GHG reduction opportunities, and alignment with proposed federal policies, ICF reported that a carbon intensity reduction of 43% to about 57% could be achieved by 2030.

[3] Available online at https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2024/lcfs2024/isor.pdf.

CATS model optimizes compliance accordingly. The CATS model is designed to answer the question: *What is the least-cost compliance pathway associated with a CI target of X in year Y?* ICF notes that CARB has used scenario modeling in previous analysis supporting amendments to the LCFS program and has provided no rationale for switching to an optimization model. ICF maintains that an optimization model is not the right approach for target setting because it puts an out-sized impact on the modeling inputs that are used to solve for what is more likely to be a preconceived outcome. Scenario modeling, when done correctly is more useful to understand market outcomes as they might be, rather than how the author(s) wants them to be.

2 ICF Analysis of the Staff Report

Developing an ICF *ISOR Case*

After reviewing the Staff Report and engaging in a peer-exchange with CARB staff, ICF made several changes to our modeling approach with the intent of aligning more closely with the work done by CARB and the resulting proposed regulatory structure. ICF refers to this as an *ISOR Case*. As a reminder, ICF was previously focused on the CI reduction that was achievable by 2030. In this *ISOR Case*, ICF sought to focus on details that were not available prior to the Staff Report, including the 2025 CI step down and the implementation of the Automatic Acceleration Mechanism. While still standing behind the modeling and assumptions previously employed, ICF made the following changes to the supply-demand for low carbon fuels to more closely align with CARB's modeling approach:

- ***E15 Blending Removed.*** ICF removed the opportunities for E15 blending in the modeling. CARB has signaled that they did not include E15 consumption in their modeling because it is not yet approved as a fuel for sale in California. ICF maintains that E15 should be included in the modeling given the high likelihood of approval before 2030 and the interest in E15 to help reduce retail gasoline pricing in line with SB X1-2 ("discussion of methods to ensure an adequate, affordable, and reliable fuel supply"). However, for the purposes of evaluating the 2025 CI Step Down, E15 blending was excluded.
- ***Climate Smart Agriculture Removed***. ICF removed LCFS credit generation attributable to climate smart agriculture from our modeling because CARB has indicated that they did not include this in their modeling, and ICF's intent in the ISOR Case is to align initial assumptions or modeling boundary conditions to the extent feasible with CARB. This had an impact on credit generation associated with liquid biofuels, including ethanol, biodiesel, renewable diesel, and renewable jet fuel. ICF maintains that California will likely find itself as a disadvantage compared to other states considering incentivizing GHG emission reductions at the farm-level. However, although ICF believes climate smart agriculture has the potential to

provide significant additional CI reductions and will be implemented in the LCFS subsequent to 2028, this was removed from our modeling for this analysis.

- ***Constrained RNG Deployment.*** ICF constrained RNG deployment based on changes to deliverability and avoided methane emissions accounting consistent with the Staff Report. The constraints also account for lower credit pricing in the near-term future because of the over-supply of credits occasioned by the current LCFS targets, thereby restricting investment opportunities. [4]
- ***Updated CI value for ULSD.*** ICF updated the CI value for diesel in 2025 based on the revised value published by CARB--the CI of ULSD increased from 100.45 g/MJ to 105.76 g/MJ. ICF modeling suggests that this will have a material impact on the program because biomass-based diesel (i.e., biodiesel and renewable diesel) have displaced more than 50% of ULSD in California. Without a concomitant change in the CI of biodiesel or renewable diesel, ICF analysis suggests that this will yield substantially more credit generation than previously forecast.

ICF made other minor modifications to our analysis based on the market developments that occurred over the course of the project. For instance, ICF revised upward our renewable diesel projections as a result of additional projects coming online, various projects passing significant milestones, and data released by CARB related to deliveries to California through 3Q 2023. ICF also made modifications to the average carbon intensity of fuels based on data available for 2023, including for ethanol, biodiesel, renewable diesel, renewable jet fuel, renewable natural gas, and electricity.

2025 CI Step Down

ICF views the 2025 CI step down as a critical juncture for the program. In our modeling, we first evaluated the following:

1. What is the impact of the proposed 5% CI reduction step down, yielding an 18.75% CI target in 2025?

As of the end of 3Q 2023, the credit bank surpassed 20 million credits, with a bank build of 2.25 million credits in the most recent quarter for which data are available. ICF forecasts that the program will have a bank of about 29-30 million credits by the end of 2024. ICF analysis suggests that the proposed CI step down will slow the bank build by about 50% compared to previous years; however, the credit bank is still likely to grow by nearly 4 million credits by the end of 2025.

[4] Note that ICF's initial assessment indicates that this constraint may restrict California's ability to achieve its methane reduction targets included in SB 1383. It is conceivable that SB 1383 targets are still met; however, this would likely require changes to procurement rules under SB 1440.

ICF then sought to determine two things with our analysis:

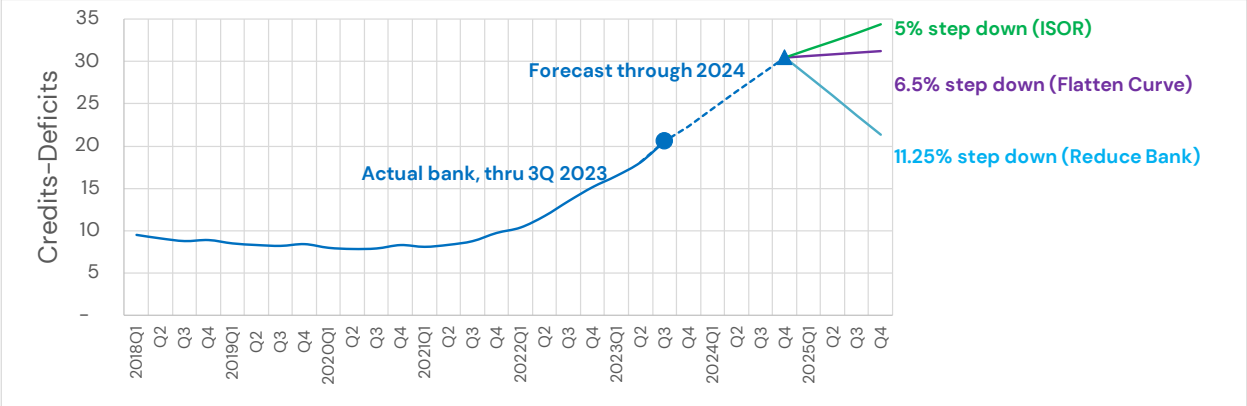
2. What CI step down is necessary to flatten the credit bank in 2025?
3. What CI step down is necessary to decrease the bank of credits to two quarters' worth of deficits?

With respect to the former, ICF modeling sought to identify the level of CI reduction that would be needed for the step down to *at least* flatten the curve of growing credits. ICF analysis shows that a CI of 20.25% in 2025 is likely needed to ensure that the credit bank does not continue to build.

With respect to the latter, ICF sought to identify the level of CI reduction that would be needed for the step down to reduce the bank of credits to about two quarters' worth of deficits in 2025. ICF analysis shows that a CI of 25% in 2025 is likely needed to ensure that the credit bank reverses and that the bank is drawn down to a level that is in line with a credit bank of only two quarters' worth of deficits. This level of stringency, while seemingly high, is likely what is needed to achieve CARB's stated intent of correcting for the "near-term over-performance" of the program.

The figure below illustrates the three aspects of the 2025 CI step down evaluated by ICF: the blue line shows the current credit bank inventory (20 million credits), the dotted blue line shows ICF forecasted credit bank by the end of 2024 (30 million credits), the green line shows the likely growth of the credit bank using CARB's proposed step down in 2025 (5% step down to 18.75% CI reduction), the purple line shows what ICF analysis indicates is needed to flatten the credit bank (6.5% step down to 20.25% CI reduction), and the light blue line shows that a CI step down of 11.25% to a 25% CI step down is needed to restore the program to an appropriate credit bank balance.

Figure 1. ICF analysis of the CI step down in 2025



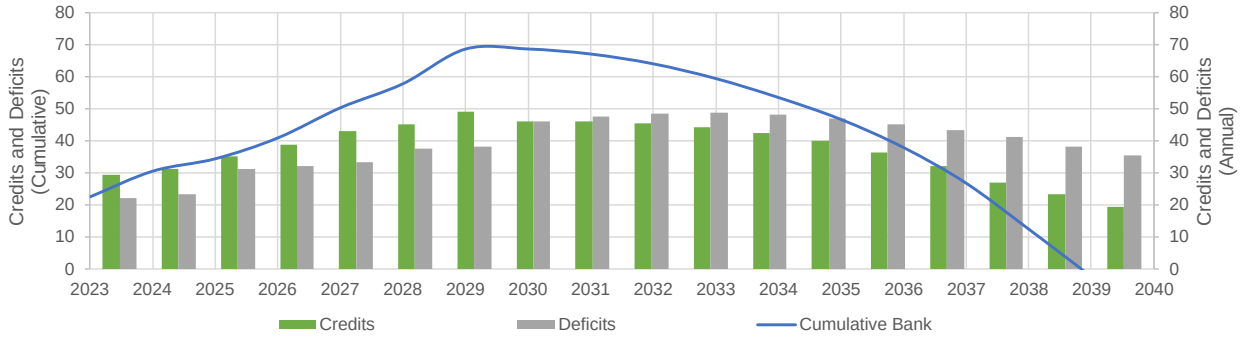
ICF recommends a step down of 10.5%-11.5% to reduce the cumulative bank of credits to the range of 2-3 quarters' worth of deficits by the end of 2025.

Automatic Acceleration Mechanism

The AAM is designed to accelerate the stringency of the LCFS program when certain criteria are met. CARB defined two criteria in the Staff Report: 1) when the credit bank is more than 3 times greater than the quarterly deficits generated in a given year and 2) when credit generation exceeds deficit generation. The Staff Report also indicates that the first year during which the CI reduction schedule can be impacted is in 2028, based on data from 2027.

Building on commentary regarding the CI step down in 2025, ICF's analysis indicates that if CARB keeps the 5% CI step down in 2025, that the credit bank will build in 2025, 2026, and 2027. In fact, by the end of 2027, ICF analysis suggests that the credit bank will reach 45-50 million credits. This will trigger the AAM in 2028 (based on 2027 data). ICF analysis suggests that the bank will be triggered again in 2030 (based on data for 2029)-getting the program to a 39% CI standard by 2030. The figure below shows the credit and deficit generation annually (green and grey bars, respectively) and the associated credit bank (blue line) using CARB's CI trajectory, including the CI step down in 2025, and the AAM as proposed.

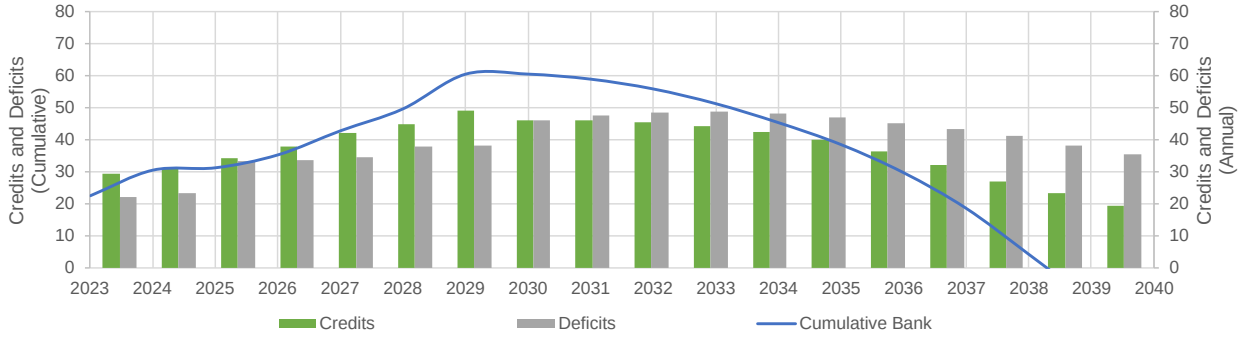
Figure 2. Credit-Deficit Balance in the ICF ISOR Case



In the long-term future, the AAM modifies the trajectory of the program post-2030. However, the short-term impact is muted-the CI step down does not achieve the objective of reversing the credit bank, and delaying the AAM until 2028 slows credit growth, but does not reverse the credit bank build until 2031. The shape of the curve in the figure above is appropriate, but the magnitude of the credit bank is too high to drive higher credit prices.

Implementing a more stringent CI step down in 2025 will reduce credit generation but will still likely lead to credit generation post-2025, and the AAM will be inadequate to reverse the credit bank build until 2030.

Figure 3. Credit-Deficit Balance in the ICF ISOR Case, with 6.5% CI stepdown in 2025

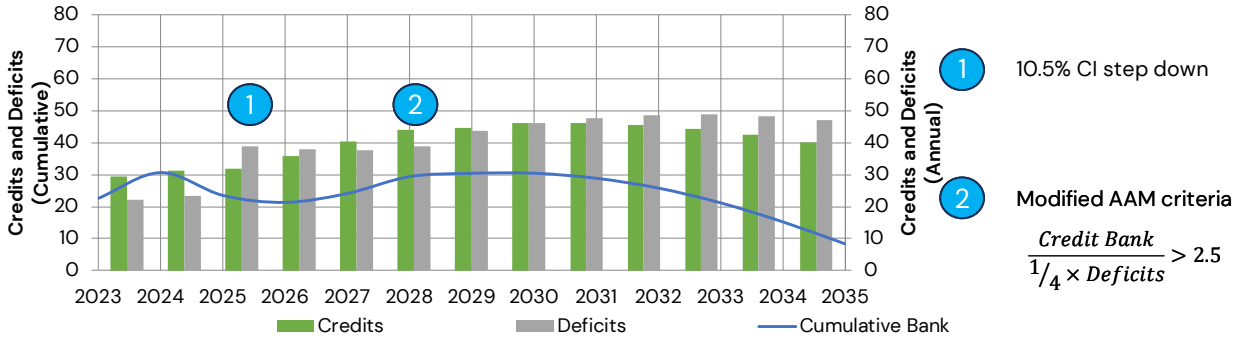


ICF analyzed the ISOR Case using the following assumptions:

- A CI stepdown of 10.5% in 2025 that would require a CI reduction of 24.25%. We adjusted the targets between 2026 and 2030 linearly while maintaining the 30% CI reduction in 2030 and post-2030 CI reduction schedule included in the Staff Report.
- An AAM that is implemented similarly as to what is used in the Staff Report, but adjusting the threshold to being triggered when the credit bank is more than 2.5 times greater than the quarterly deficits generated in a given year.

The figure below shows the results of the ISOR Case using the parameters described above.

Figure 4. ICF ISOR Case with larger CI step down and modified AAM



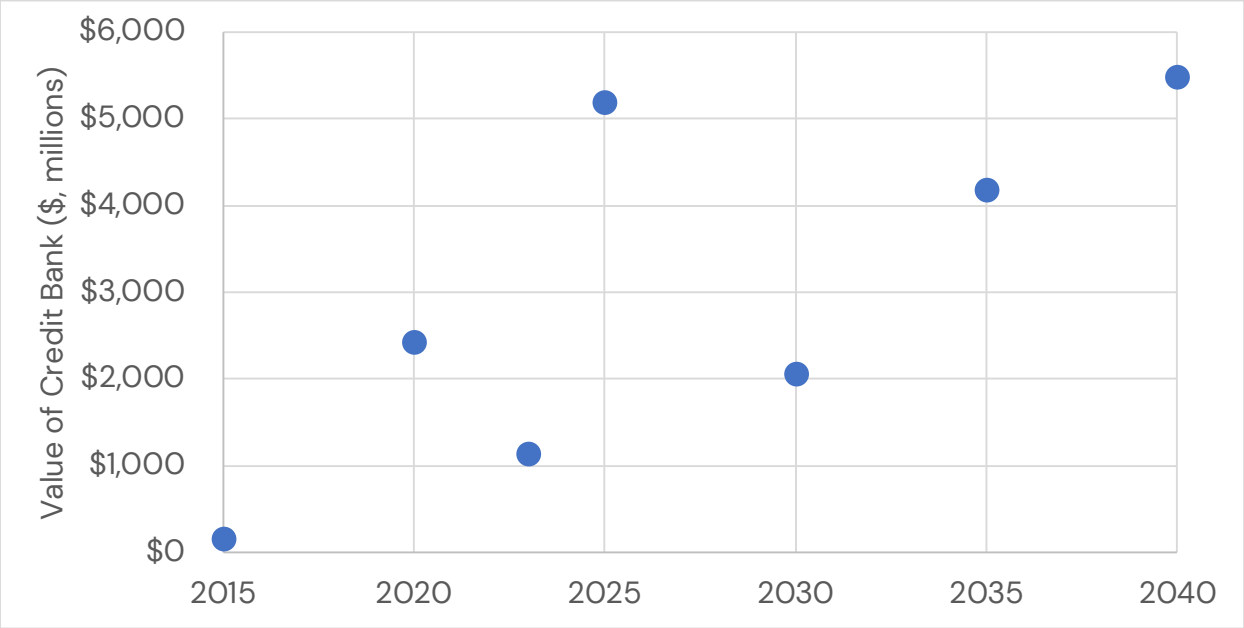
The figure above has a shape and curve that ICF thinks is more in line with a successful LCFS program i.e., one that maintains a tighter credit-deficit balance and is flexible enough to respond to market conditions in the near-term future (pre-2030), while enabling California to achieve its long-term GHG reduction targets. A similar trajectory can be achieved with a shallower step down in 2025, but with an AAM that comes into place in 2026 and an even lower threshold of the first criteria that would trigger the AAM (e.g., lowering the value from 2.5 to 2.0).

ICF recommends that the AAM be considered for implementation as soon as 2026, rather than waiting until 2028, regardless of the 2025 CI step down.

ICF Commentary on AAM Trigger Criteria 1

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. Based on information presented at the May 23, 2023 modeling discussion, the AAM design is looking to program data from prior to 2021 as an indicator of an "ideal" bank of credits. ICF views this as a critical mistake with respect to how the market is likely to unfold in the future. From a market perspective, if we consider the credit bank as a measure of the risk that regulated parties (i.e., refiners) bear in order to do business in California, then the credit bank should be measured in dollars, not credits/deficits. The figure below shows the estimated value of the credit bank in five-year increments from 2015 to 2040. The data for 2015 and 2020 are based on data reported by CARB for both deficits and credits; whereas the data for 2025 to 2040 is based on the deficit generation in ICF's analysis of the proposed CI reduction trajectory and the credit price reported by CARB in the Staff Report. All values are reported in real dollars using 2021 as the basis year ($2021).

Figure 5. Estimated value of LCFS credit bank as a proxy for refiner risk tolerance



A target credit bank of three quarters worth of deficits in 2015 would have been valued at $140 million; by 2020, the value of the bank grew to $2.4 billion. In 2023, ICF estimates that a credit bank with three quarters worth of deficits is valued at $1.1 billion. Based on CARB's forecasted credit price, the value of a credit bank of three quarters worth of deficits in 2025 would rise to $5.2 billion before collapsing back to $2.1 billion in 2030. The higher pricing reported by CARB in 2035 and 2040 yields an "ideal bank" valued at $4.2 billion and $5.5 billion. When viewed from the lens of dollars tied to risk, rather than risk tied to a specific credit bank, the target bank of three quarters worth of deficits does not make

sense. By 2035, for instance, petroleum products will have decreased substantially due to efficiency gains, increased liquid biofuel blending, and transportation electrification. ICF estimates that gasoline consumption may decrease by up to 50% by 2035, while ULSD consumption could decrease by as much as 85% by 2035 (compared to 2022 consumption). Why would an industry that has lost so much market share increase the value of its risk burden by nearly a factor of four over that same time frame?

In line with ICF's hypothesis that the AAM should consider the "ideal credit bank" in terms of managed risk (as measured in dollars' worth of exposure), we also believe that the proposed AAM fails to recognize the evolution of the market post-2020. Consider that in 2018:

- The average CI of ethanol was nearly 70 g/MJ
- Biodiesel volumes were averaging around 5% blend rates in California
- There were 2-3 renewable diesel producers delivering product to California
- The first fuel pathway for RNG from animal manure was submitted and approved by CARB
- EVs represented just 7% of new light-duty vehicle sales
- Off-road electrification applications generated about 500,000 credits

Most of the refiners in the LFCS program had limited visibility with respect to LCFS credit generation and were forced into a position of purchasing LCFS credits from a limited market. As a result, refiners generally opted to build substantial credit banks as part of their compliance strategy. This strategy enabled other market participants to benefit via an increased credit price. However, in the interim years, refiners have made substantial investments that give them a clearer line of sight in their credit generation. The table below highlights the key investments that six refiners have made since 2018; these refiners represent what ICF estimates to be more than 90% of the obligation in the LCFS program. This is not meant to be an exhaustive list, rather it illustrates key investments that will impact LCFS credit generation moving forward.

Obligated Party	Key Investment since 2018
Marathon	• Retrofitted Dickinson facility for RD production • Martinez Renewables joint venture with Neste in California • Acquired RNG platform (LF Bioenergy)
Chevron	• Acquired REG, largest biodiesel producer in US • Converting diesel hydrotreating unit for renewable diesel / renewable jet fuel production at El Segundo • Investments in RNG platforms including California Bioenergy, Brightmark Energy • Acquired natural gas fueling assets via deal with Mercuria
PBF[5]	• St. Bernard Renewables project in Louisiana producing RD
Valero	• Expanded Diamond Green Diesel (a joint venture with Darling Ingredients) at Norco, Louisiana • Commissioned Port Arthur project with expected completion in 2025
Phillips 66	• On the verge of completing Rodeo Renewed project at San Francisco Bay Area refining complex, converting to renewable fuels entirely
BP	• Expanded co-processing capabilities at Cherry Point • Purchased RNG platform via Archaea acquisition

It is clear from this table that there is a much clearer line of sight to LCFS credit generation for regulated parties today in 2024 than there was in 2018. The view of the credit-deficit balance from pre-2021 will not be a good indicator of how the market will evolve moving in 2025 and beyond.

ICF recommends that the first criteria for the AAM be modified such that the mechanism is enacted when the credit bank is more than 2.5 times greater than the quarterly deficits generated in a given year.

LCFS Credit Pricing

ICF views the LCFS credit price as part of a broader set of environmental commodities available to low carbon fuel producers. ICF models environmental commodities using an approach that assumes the marginal cost of compliance is determined by the value of subsidy needed to offset the difference between low carbon fuel production costs and the conventional fuels that they replace i.e., gasoline and diesel. The complicating factor related to determining marginal compliance costs is the multiple subsidies available and the

[5] Shell sold its Martinez Refinery and related logistics assets to PBF in 2021.

associated "loading order" of those subsidies with respect to various fuels. ICF's modeling assumes the value for low carbon fuel producers is generated via multiple streams, including federal tax credits or incentives, federal policies like the Renewable Fuel Standard, and then state level programs like California's LCFS program.

- ***Federal tax incentives***: ICF considers two types of tax incentives, the Blenders Tax Credit and the Clean Fuel Production Credit (CFPC) from the Inflation Reduction Act (IRA).
    - The BTC is available to blenders that blend biodiesel or renewable diesel into the transportation fuel supply and is valued at $1.00 per gallon of eligible fuel blended. The current version of the BTC will expire at the end of 2024. The BTC is not adjusted for inflation.
    - The CFPC is a carbon intensity-based production tax credit that replaces and expands upon the BTC. The CPFC is codified in the Inflation Reduction Act and is often referred to as the Sec 45z credit. It is valued at up to $1.00 per gallon of eligible fuel; however, in order to qualify, an eligible fuel must be produced in the United States and meet a maximum carbon intensity threshold of 50 kgCO2e/mmBtu. The CFPC is calculated as follows:[6]

$$CFPC = \$1.00\ x\ \left(1 - \frac{CI_{fuel}}{50}\right), (\max \$1.00)\ ^{7}$$

- ***Renewable Fuel Standard***: Most transportation fuels generate value via the Renewable Fuel Standard and generate RINs (or Renewable Identification Numbers), the currency and compliance tracking mechanism for the federal program. There are several RIN buckets in the program: D6 RINs, D5 RINs, D4 RINs, and D3 RINs. The RIN designation is tied to two key factors: a) the feedstock used to produce the renewable fuel and b) the GHG emission reductions attributable to the fuel. <u>It is important to note that while there is a GHG emission reduction requirement or threshold within each RIN bucket, fuels are not differentiated by their carbon intensity score the way that they are in the LCFS program.</u>
- ***California Cap at the Rack (CAR)***: Renewable diesel producers to date have received some share of the value of displacing a gallon of ULSD in the Cap-and-

[6] Note that the GREET model referenced in the IRA is the version of the model developed by Argonne National Laboratory (ANL) and not the CA-GREET model used by CARB to regulate the LCFS program. The CI for renewable diesel in the CA-GREET model is *higher* than the CI for renewable diesel in the GREET model for several reasons, but most notably because CARB's model assumes a higher CI adder for land use change (LUC), specifically for soybeans.

[7] ICF assumes that the CI of the marginal gallon of eligible fuel will have a CI score of 35 kg/mmBtu, yielding an incentive of $0.30 per gallon of 30 cpg. The CFPC is adjusted for inflation from 2022 pursuant to the IRA.

Trade program, which is quantified as CAR. Generally speaking, renewable diesel is the only low carbon fuel that has benefitted significantly from California Carbon Allowance (CCA) pricing, which has helped to maintain profitability of renewable diesel production in light of falling LCFS credit prices.

- ***California LCFS Credit Price***: The LCFS credit price serves as a subsidy for low carbon fuel production, with the understanding that many low carbon fuels cost more to produce than their conventional counterparts. The value of the LCFS credit price can be represented by the cost per ton to deliver the last or marginal unit of low carbon fuel to California in any given year, after accounting for revenue from other subsidies.

ICF modeling calculates the LCFS credit price as the difference between the low carbon fuel cost of production (inclusive of any costs to deliver the fuel to California) minus any other revenue streams that the low carbon fuel would otherwise receive. For example, in the case of renewable diesel, the production costs, $C_{production}$, would include the feedstock costs associated with producing the fuel, the fixed and variable production costs, and any logistical costs associated with bringing the fuel to California.

$$C_{production} = C_{feedstock} + C_{fixed} + C_{variable} + C_{logistics}$$

The revenue streams, *R*, for renewable diesel exclusive of the LCFS credit price, including the commodity value of the fuel, the value of the D4 RIN, any tax credits (e.g., the Blenders Tax Credit, BTC), and some share (α) of the value of displacing a gallon of ULSD in the Cap-and-Trade program, which is quantifies as Cap at the Rack (CAR).

$$R = Commodity + Federal\ Tax\ Incentives + \ D4\ RIN + \ \alpha \times CAR$$

In this example, the LCFS credit price needed to bring that gallon of renewable diesel (*LCFS Credit Price*$_{RD}$) to California would be calculated as the difference between the production costs and the revenue streams:

$$LCFS\ Credit\ Price_{RD}\ (\frac{\$}{ton}) \ = \ \frac{C_{production} - R}{Credits}$$

The LCFS credit price in any given year (t) can be approximated as the maximum LCFS credit price amongst low carbon fuels (fuels) delivered to California:

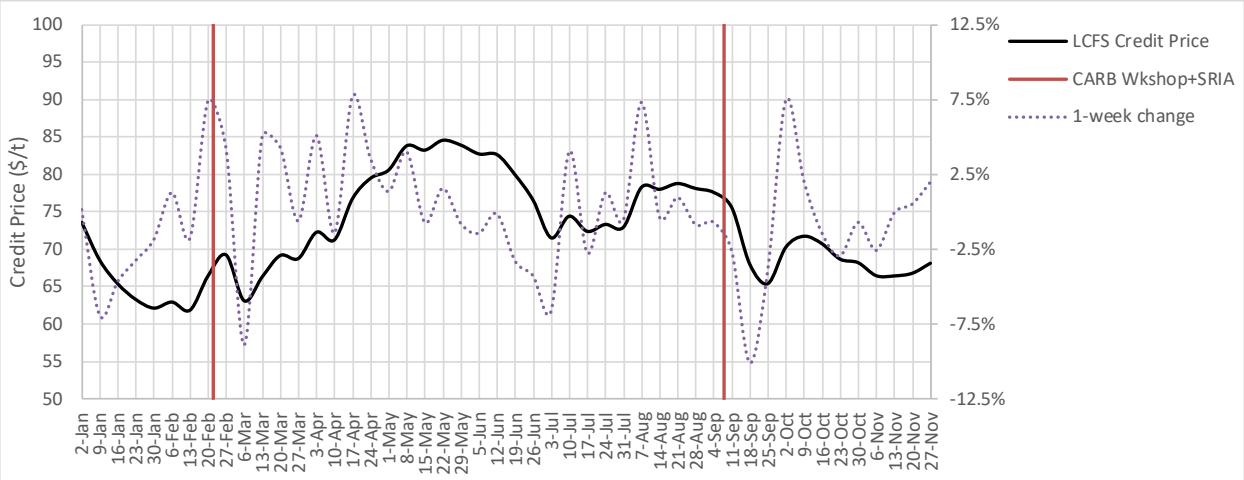
$$LCFS\ Credit\ Price_t\ (\frac{\$}{ton}) \ \approx \ \ Max_t^{fuels}\{LCFS\ Credit\ Price_{fuels}\}$$

LCFS Credit Pricing in response to CARB Proposals

Prior to the Staff Report, CARB staff had two significant opportunities to communicate to the market their intentions with respect to increasing the stringency of the LCFS program. The figure below shows the weekly LCFS credit price for Type 1 transfers reported by CARB from January to late November 2023 (black line), with a range of $60 to $85 per ton over

that time frame. The dotted purple line shows the change from week to week on a percentage basis. The two largest week-over-week decreases in LCFS credit pricing for 2023 occurred after the February 22, 2023 LCFS workshop and when the Staff Regulatory Impact Assessment (SRIA) for the LCFS was made publicly available. In both cases, CARB signaled its intention to advance a proposal with a 30% CI standard in 2030.

Figure 6. ICF analysis of LCFS credit prices in response to CARB announcements



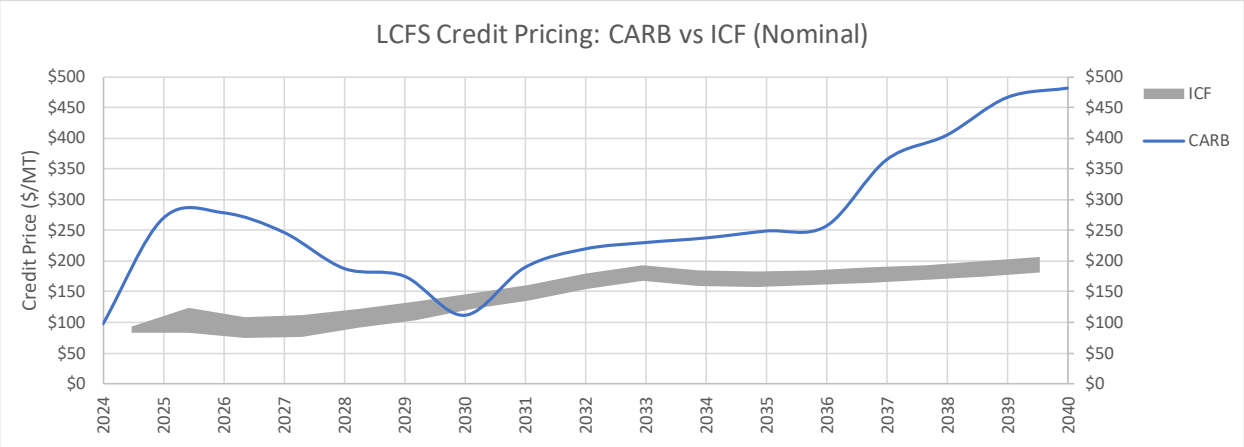
While ICF cautions against overreacting to spot price movements in any market, these movements can be a helpful indicator of market sentiment. In this case, the market was likely hoping for a more stringent standard. This conclusion is bolstered more forcefully in the market reaction after the Staff Report was issued, with credit prices in early 2024 decreasing to below $60/t for the first time in more than five years.

LCFS Credit Pricing: CARB vs ICF

CARB's forecasted LCFS credit pricing has a variety of caveats associated with it; however, CARB staff use the LCFS credit pricing as one of the primary reasons for dismissing a higher CI reduction target in 2030 because of potential consumer impacts associated with pass-through compliance costs. However, the CARB forecasting is flawed and effectively implies that the LCFS will bear the entire cost of subsidizing low carbon fuel production. This is misaligned with market factors given the significant supplemental value of the Clean Fuel Production Credit via the IRA, robust RIN pricing, moderate commodity pricing (e.g., for gasoline and diesel), and increasing CCA prices.

The figure below shows a range of ICF forecasted LCFS credit prices in grey compared to the CARB LCFS credit price forecast in blue line. The CARB LCFS credit price forecast has been adjusted to nominal dollars, as ICF has found this is how stakeholders tend to view the market (rather than adjusting pricing to some real-dollar basis).

Figure 7. Comparison of CARB and ICF LCFS credit pricing forecasts (nominal dollars)



ICF makes three observations associated with the comparison between CARB's forecast and our forecast:

4. In the near-term future (by 2025), CARB is forecasting a four-fold increase in LCFS credit pricing. This credit price spike coincides with the introduction of the CFPC and other IRA incentives flowing to the market. [8]
5. In a post 2030 environment, though the two curves are showing similar patterns of increasing credit prices, CARB's forecast is still $60-65/ton higher than ICF.
6. Post-2035, CARB's forecasts are suggesting that a LCFS credit price of $250 to nearly $500/ton is needed in order to achieve program compliance. There is no reason that the credit price should ever need to be that high in order to induce the investments necessary to achieve compliance based on ICF modeling.

[8] The CFPC will apply to a broader set of fuels than the BTC; however, many fuels that were receiving the $1.00 per gallon benefit of the BTC will be reduced to what ICF estimates is more like $0.30 per gallon. Historically, after the removal of the BTC (via expiration of the incentive based on some timeline defined in statute) the D4 RIN price has increased to accommodate the lost value. ICF analysis suggests that the RIN price has increased and helped to recover as much as 75% of the lost value. ICF assumes a similar dynamic will emerge for RIN pricing as the BTC transitions to the CFPC. The transition from the BTC to the CFPC will also likely reduce imports into the United States. Despite these potential changes, ICF analysis of available supply of low carbon fuels to California will not require such a dramatic increase in LCFS credit pricing, as highlighted in the text.

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)[9] 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

[9] 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.

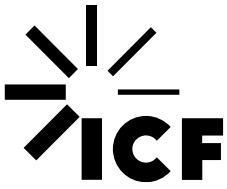
deliverability requirements for electricity used as a transportation fuel and as a processing fuel. Together, these represent a more expansive market and aggressive outlook for decarbonizing the transportation sector.

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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