20 February, 2024

State of California, Air Resources Board
Industrial Strategies Division, Transportation Fuels Branch
California Air Resources Board
1001 I St.
Sacramento CA, 95814

Re: Proposed Low Carbon Fuel Standard Amendments

Dear LCFS Staff:

Thank you for the opportunity to comment on the ideas and materials related to current rulemaking to amend the Low Carbon Fuel Standard (LCFS). The University of California, Davis Institute of Transportation Studies, and the Policy Institute for Energy, Environment, and the Economy have been engaged in research, policy analysis, and technical assistance relating to the LCFS since it was first developed, over 15 years ago. Since then, it has become a critical part of California's robust portfolio of climate policies and a model that has been adopted in many other jurisdictions around the world. Following the strategic vision laid out in the 2022 Scoping Plan, the LCFS would continue to support profound changes in California's transportation and energy systems in order to meet the statutory goals of a 40% reduction in greenhouse gas (GHG) below 1990 levels by 2030, and carbon neutrality by 2045.[1]

2024 marks a critical juncture in the evolution of California's climate policy. Impacts of anthropogenic warming are being felt by Californians today and these will only intensify as time progresses. California's climate policy portfolio has been a global gold standard, and many policies around the world are modeled after concepts developed here, notably the LCFS. To maintain this leadership, California's policy portfolio must recognize that it is transitioning to a new phase in its journey to carbon neutrality. Efforts to date have largely sought to develop scalable, cost-effective alternatives to fossil fuels, and these efforts have had some success. Now, the critical task is to rapidly and efficiently deploy them, balancing the need to reduce GHGs as rapidly as possible with the desire to find the best pathway to achieving carbon neutrality. The approaches that have effectively guided California's climate policy through its first one and a half decades may need to be updated to ensure they're suited for the decade to come. The 2024 LCFS rulemaking is among the first opportunities for reflection and review of existing tools, California is ready to meet coming challenges, and to ensure that our model can continue to be emulated by others.

[1] SB 32 (Pavley, Chapter 249, Statutes of 2016), AB 1279 (Muratsuchi, Chapter 337, Statutes of 2022)

We commend Staff for facilitating a robust series of workshops over the last two years, and for their willingness to engage with stakeholders on this complex issue. These comments are presented in the spirit of UC Davis' and the Policy Institute's mission to bring science into the policy process. Neither UC Davis nor the Policy Institute seek a specific policy outcome; these comments are offered to help California meet its climate, environmental, and equity goals.

The first part of these comments will relay conceptual or high-level thoughts, with an extensive discussion of the scientific and policy considerations that surround each. These issues may span many sections of the LCFS regulation and/or multiple proposed amendments. The second part will discuss specific proposed amendments or elements of existing code and discuss issues directly pertaining to those sections.

Part 1: Comments on General Program Design

Renewable Diesel Capacity Growth and 2030 Targets

Updates Since 2023 Report

Policy Institute researchers conducted several analyses of the LCFS, proposed target levels, program design scenarios, and market conditions over the last two years using our Fuel Portfolio Scenario Model (FPSM). This has led to the publication of two recent reports related to the LCFS and issues affected by this rulemaking, an initial report issued in late 2023, and an update released very recently.[2] These reports evaluated scenarios relating to a variety of program targets and other proposed amendments (in the case of the 2023 report, insufficient detail was available to evaluate some amendments) to help understand the likely impacts on the LCFS credit market, fuel supplies and emissions. Of particular interest was the decline in LCFS credit prices and the related accumulation of banked credits since late 2020. This is due to a combination of factors, including structural over-supply of the market, strong support for some biofuels from the Federal Renewable Fuel Standard, precipitous declines in gasoline consumption due to the COVID-19 pandemic, and the rapid deployment of hydrotreated renewable diesel (RD) into the California fuel market.

Significant data have emerged since the 2023 modeling work was completed that fundamentally altered the landscape in LCFS credit markets and led us to revise the conclusions of the 2023

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[2] **Initial report**: Ro, J., Murphy, C. W, & Wang, Q. (2023). Fuel Portfolio Scenario Modeling (FPSM) of 2030 and 2035 Low CarbonFuel Standard Targets in California. *UC Office of the President: University of California Institute of Transportation Studies*. http://dx.doi.org/10.7922/G2S46Q8C Retrieved from https://escholarship.org/uc/item/6f2284rg
2024 update: Murphy, C., & Ro, J. (2024). Updated Fuel Portfolio Scenario Modeling to Inform 2024 Low Carbon Fuel Standard Rulemaking. *UC Davis: Policy Institute for Energy, Environment, and the Economy*. http://dx.doi.org/10.7922/G25719BV Retrieved from https://escholarship.org/uc/item/5wf035p8

report. These are laid out in depth in the 2024 modeling update paper published on February 16th.[3] In particular, the Department of Energy projections of the U.S. RD capacity deployment from 2021 turned out to be significant underestimates (Figure 1). The 2021 projection of RD capacity that served as the basis for our assumptions and modeling of RD turned out to underestimate actual 2022 capacity deployment by roughly 35%.[4,5] California has historically accounted for the vast majority of the U.S. RD consumption, and this trend continued through 2023, reflected in rapid increases in RD consumption under the LCFS. The most recent 4 quarters for which LCFS data are available (Q4 2022 through Q3 2023) show a 40% increase in RD consumption compared to the four quarters before that, from 1.3 billion to 1.8 billion gallons. It is especially noteworthy that this growth occurred during a period of historically low LCFS credit prices, and before two major California refineries finished conversions to process biofuels instead of petroleum. These projects have a total nameplate capacity of 1.7 billion gallons per year (one is currently operating at approximately 120 million gallons per year) and are expected to bring a large fraction of that capacity on-line in 2024. This, combined with continued growth elsewhere in the U.S. implies that the RD growth trend observed in recent data is likely to continue for at least the next several years.[5]

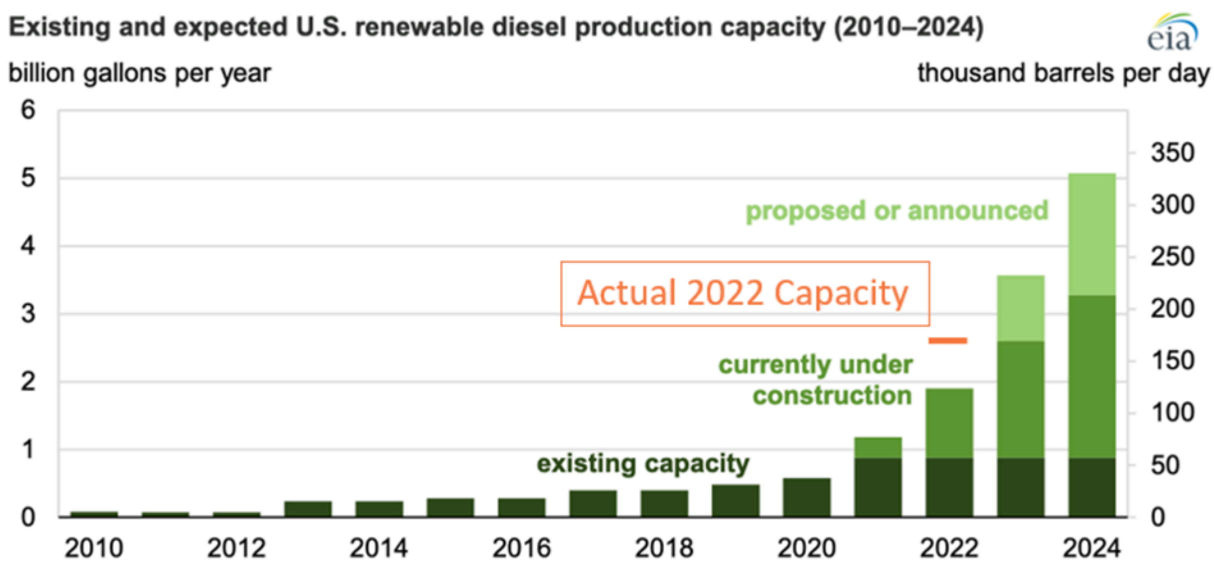

Figure 1. Source: 2021 Projection of renewable diesel deployment in the U.S. from the Energy Information Administration. EIA has since updated the information using 2023 data; actual 2022 capacity marker added by authors based on that source.[4,5] Renewable diesel capacity deployment has dramatically outpaced recent expectations. The majority is consumed in California due to the LCFS incentive.

[3] Murphy & Ro (2024) https://escholarship.org/uc/item/5wf035p8
[4] EIA, U.S. renewable diesel capacity could increase due to announced and developing projects - U.S. Energy Information Administration (EIA) (2021). https://www.eia.gov/todayinenergy/detail.php?id=48916.
[5] EIA, Domestic renewable diesel capacity could more than double through 2025 - U.S. Energy Information Administration (EIA) (2023). https://www.eia.gov/todayinenergy/detail.php?id=55399.

Taken together, these data paint a picture of an extensive pool of RD at the U.S. level, with capacity expected to significantly exceed 5 billion gallons per year by the end of 2025. This capacity can readily enter the California market, even with LCFS credits at relatively low levels. Obligated parties in the LCFS therefore have a readily available source of low-cost compliance credit via RD; absent a significant drop in RFS support or a significant increase in RD production costs. So long as low-cost RD is readily available, it will continue to enjoy a significant competitive advantage until either the supply available at low LCFS credit prices is exhausted or California's market for diesel is fully saturated. RD's strong growth trend indicates that the former condition is unlikely to occur in the near term (especially given incentives at the federal level), and the ability of RD producers to shift part of their output to hydrotreated alternative aviation fuels (commonly referred to as sustainable aviation fuel, or SAF, though not all forms of hydrotreated alternative jet fuels are truly sustainable) means the latter is unlikely to occur as well. So long as these conditions persist, and there is no restriction on the ability of RD and SAF to enter the California market and supply LCFS credit, these fuels will continue to set the prevailing market price for LCFS compliance credit. As long as this is the case, it is unlikely that higher LCFS targets will significantly increase the LCFS credit price.

For this reason, the conclusion we reached in the 2023 report, and articulated in previously submitted comment letters no longer holds.[6] Based on the revised data, the proposed 30% 2030 target, with 4.5% annual target increases, the implementation of the Automatic Acceleration Mechanism (AAM), and other proposed amendments are not likely to bring the credit market back into approximate balance between credit and deficit generation before 2030, or quickly enough to not likely trigger an additional AAM after 2030 . Without achieving a balance, it is unlikely that the LCFS credit price will significantly increase.

Results of Updated FPSM Modeling of Proposed Amendments

Figure 2 (next page) presents results of FPSM modeling of the proposed LCFS amendments, updated to reflect the recent data on RD deployment in the U.S. Given the ready availability of RD, discussed above, we project persistent annual credit surpluses in excess of 5 million credits until 2030. These surpluses would continue to expand the bank, leading to two AAM triggering events, at the earliest possible opportunities (2027 and 2029, resulting in additional target escalation in 2028 and 2030). This results in a 39% LCFS target in 2030. Despite this rapid increase of target levels, the credit bank remains high enough to meet the first AAM trigger criteria, with banked credits more than 3 times greater than average quarterly deficits, though not the second one, since projected deficits exceed credits for 2031-2035. With such a credit bank, if annual credits exceeded annual deficits in any of the years 2031-2035, the AAM would trigger the following year and cause another increase in target level.

[6] Including Policy Institute comments on the July 7, 2022, November 9, 2022, and February 22, 2023 workshop. Comments and material unrelated to target levels or projections of credit market balance remain unaffected.

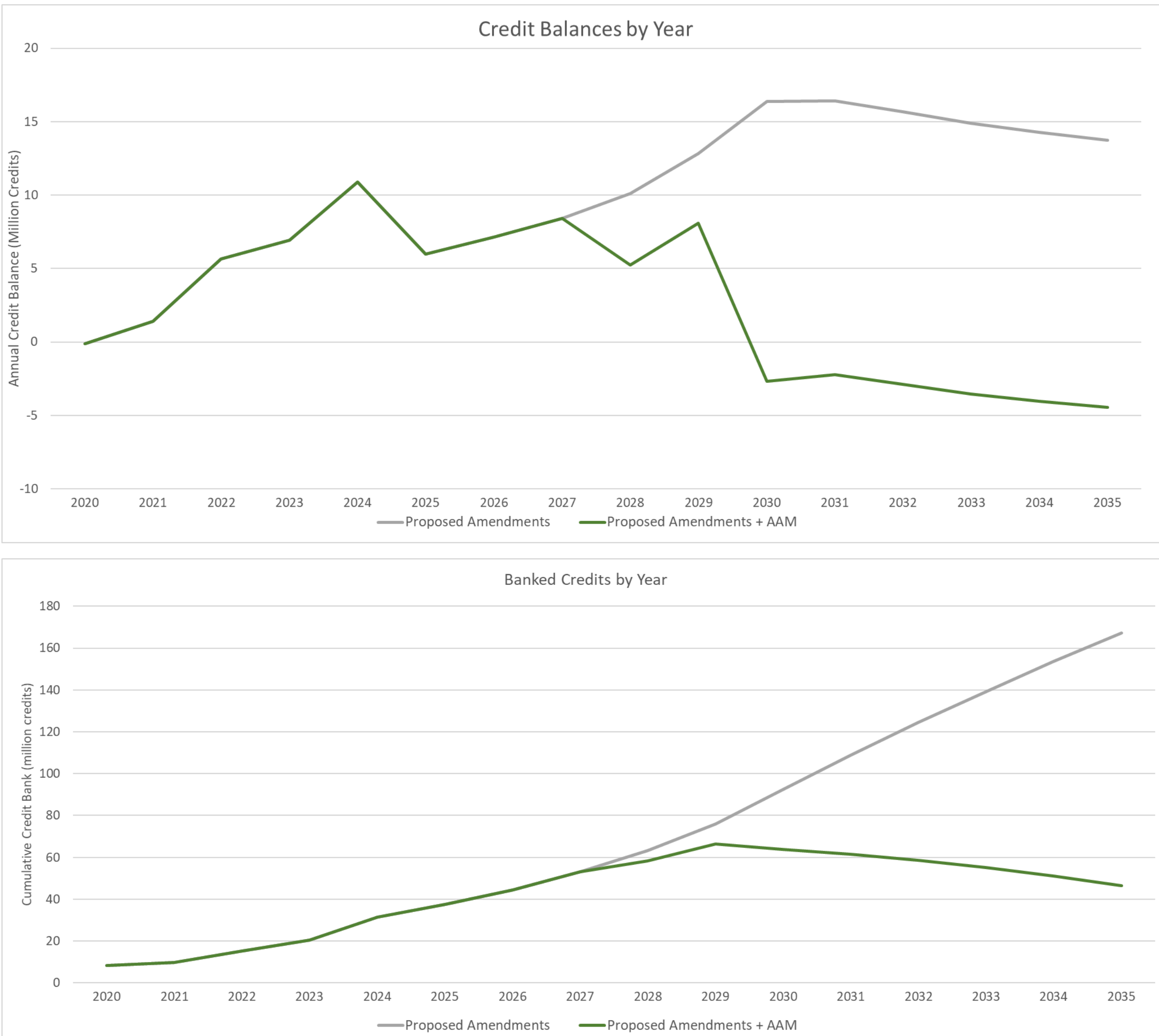

Figure 2: (a, above) Yearly net credit balances and (b, below) net banked credits from updated FPSM modeling of LCFS through 2035. The updated scenario with proposed amendments is projected to trigger the AAM twice, in 2027, and 2029. Source: Murphy & Ro (2024)

These results support the idea that the proposed amendments are unlikely to lead to a significant increase in credit price. In addition to RD effectively establishing a low marginal cost of compliance, as discussed above, the projections suggest aggregate banked credits in excess of yearly deficit generation through 2035; these conditions are not conducive to a significant recovery in credit price. The multiple AAM triggering events, however, could significantly increase the LCFS impact on gas prices to consumers. At a 39% target, the level implied in 2030 by FPSM modeling of the proposed amendments, and a $50 credit price (lower than present prices, which are widely regarded as too low to support needed deployment of innovative low-carbon fuels), the theoretical gas price impacts are around 21 cents per gallon. A $100 credit price would double that impact. In 2030, over three-quarters of California's light duty (LD) vehicles will rely on gasoline internal combustion engines (ICE), meaning that their owners will be exposed to any gas price increases. Given the common expectation that the transition to electric vehicles (EVs) will occur most rapidly among higher income earners, the greater gas price impacts implied by multiple AAM triggering events may magnify potentially regressive impacts on lower-income drivers.

Implications of Updated Modeling for Proposed LCFS Amendments

While a continually increasing LCFS target is necessary to support deep decarbonization of California's transportation fuel pool, an appropriate balance must be struck between arriving at the maximum feasible pace of decarbonization and minimizing the economic impacts of future target increases, especially where they may be regressive. Once consumers are able to switch to EVs or other low-carbon fuels, they are no longer exposed to policy-driven price impacts. Given the very rapid transition of California's LD vehicle fleet expected in the 2030's, due largely to the Advanced Clean Cars 2 rule and programs adopted by California to support EV deployment and clean mobility options in lower-income communities, the risk of regressive impacts from gas price increases would be expected to decline over time. As a result, delaying the onset of higher LCFS targets could mitigate the regressive cost risks. Previous modeling studies have demonstrated that a LCFS target level of 30% is compatible with California's long-run carbon neutrality goals.[7]

Based on the updated FPSM modeling, we now conclude that the proposed amendments are not likely to lead to stabilization of the LCFS credit market, or a recovery by the credit price. Increasing the program's target in 2030 and beyond may reduce annual credit surpluses, or marginally increase credit price, but are unlikely to support significant and sustained credit price recovery. The presence of a large pool of RD (and to a lesser extent, hydrotreated SAF) at the national level likely establishes a low minimum marginal cost of near-term LCFS compliance. So long as these fuels can freely enter the California market, this balance is likely to persist. By the time that the AAM becomes active, the growth of RD could create a credit bank of sufficient size that it will take many years to draw down, even with multiple AAM triggering events. Restricting the ability of RD to maintain its present growth trend in California would likely return the market to conditions more conducive to a stable LCFS credit market under LCFS targets at or around

[7] Brown, A. L; Sperling, D.; Austin, B.; DeShazo, JR; Fulton, L.; Lipman, T.; Murphy, C., et al. (2021). Driving California's Transportation Emissions to Zero. *UC Office of the President: University of California Institute of Transportation Studies*. http://dx.doi.org/10.7922/G2MC8X9X Retrieved from https://escholarship.org/uc/item/3np3p2t0

those suggested by the proposed amendments (see *Capping or Restricting the Continued Growth of Lipid- or Crop-based Fuels*, below).

Sustainability Challenges From Growing Consumption of Lipid-Based Biofuels

Sustainability Considerations Associated With Lipid Feedstocks

The extremely rapid deployment of RD into California's fuel market creates challenges for the stability of the LCFS credit market, as described above. In addition, this rate of growth poses significant sustainability risks as well, especially with regard to indirect land use change (ILUC). The LCFS includes a Land Use Change adjustment value applied to certain biofuels, this increases their CI score, thereby reducing the amount of incentive per gallon. Biofuels using wastes or residues, such as used cooking oil, tallow, or technical corn oil (a byproduct of ethanol production) receive significantly lower CI scores than those made from crop-based feedstocks, thereby increasing their typical per-gallon LCFS incentive. Despite this significant financial incentive to prefer non-crop based fuels, fuels made from soybean and canola oils have grown markedly in recent years. Consumption of biodiesel and renewable diesel from soybean and canola oils grew by over 45% between 2021 and 2022. The first three quarters of 2023 alone have seen total soybean and canola oil fuel consumption grow by over 30% compared to all of 2022; annualizing the 2023 data suggest a year-on-year growth rate in excess of 70%. This is significantly faster than the growth of biodiesel and renewable diesel as a whole.

To support these rates of growth, the availability of feedstock must rapidly grow as well. Biodiesel and current forms of renewable diesel are almost exclusively made from lipids - fats, oils, and greases - that are in some cases wastes or residues of other agricultural or industrial processes and in others, crop-based vegetable oil. These lipids, including most of the nominally waste or residue oils, were historically used in a variety of applications, including human consumption, animal feed, and the production of soap, cosmetics, or other industrial chemicals. Only a small fraction of wastes or residues is typically disposed of without some other value-generating use. Biofuel production can utilize almost any form of lipid, and since fuels using waste or and residue feedstock typically receive higher incentives per gallon in the LCFS and some other programs, they are often the preferred feedstock for biofuel producers. Previous users, who find their supply of wastes or residues now claimed by biofuel producers must turn to local or global markets for alternatives, creating additional demand. It is important to note that the demand caused by expanded biofuel production is often met by producers who also sell or previously sold to non-biofuel consumers, hence the "indirect" element of ILUC. Since the production rate of wastes and residues is effectively capped by the rate of activity in the sectors that generate them, most additional demand for lipids is satisfied by the production of additional vegetable oils; part of this increased production comes from intensification of production on existing cropland, through the adoption of improved farming practices or seed cultivars, double-cropping, etc. Some additional demand, however, for these crops or ones they displace, is satisfied by bringing additional land into cultivation. When land is converted from one use to another, there are often GHG emissions associated, due to the loss of above-ground biomass and the decomposition of soil organic carbon due to soil disturbance. These losses are especially severe when certain types of highly-fertile natural land are converted to cultivation.

ILUC Risk and ILUC Modeling Uncertainty

The rapidly increasing demand for lipids due to current RD growth trends suggest a significant and heightened ILUC risk. Quantifying ILUC risk is challenging, due to the complexity of the modeled systems, data limitations, and the dependence of ILUC models on subjectively determined assumptions regarding system boundaries, allocation methods, counterfactual specification, etc. The EPA recently examined ILUC models that claim to estimate ILUC impacts from biofuels and found that among the five models analyzed, ILUC impacts from soybean oil based biofuels produced in North America ranged from 11 to over 300 gCO_2e/MJ. This compares to the current LCFS ILUC impact factor for soybean oil of 29.1 g/CO_2e/MJ and the total life cycle CI of gasoline of around 100 gCO_2e/MJ.[8]

Biofuel production is only one fraction of global vegetable oil demand, and California, though a major market for biofuels, is only a fraction of U.S. biofuel consumption. However, as the largest market for alternative fuels in North America, California's demand can have significant impacts on aggregate consumption. Additionally, given the state's role as a leader in global climate policy, policy design decisions made here are often replicated in other jurisdictions. This means that near-term decisions made about LCFS design and implementation have significant global impacts beyond the impacts of additional vegetable oil cultivation to satisfy its direct demand.

The current ILUC impact factors used by the LCFS were adopted in 2015 based on modeling done using the Global Trade Analysis Project (GTAP) model to project changes in agricultural commodity consumption and Agro-Ecological Zone (AEZ) model to estimate emissions from those changes in response to new demand for biofuel feedstock. The GTAP model simulated a supply shock based on anticipated impacts of the U.S. Renewable Fuel Standard, as it was structured at the time. They did not account for the rapid growth in lipid-based fuels, nor the more than doubling of Renewable Volume Obligations for biomass-based diesel under the RFS that has occurred since the modeling that informed the LCFS land use change impact values was conducted. Nor do they account for the current and anticipated impacts of climate change, geopolitical conditions, or recent advances in land use change data or modeling. We have highlighted the need to update the current ILUC factors on many occasions during the

[8] US EPA, "Model Comparison Exercise Technical Document" (EPA-420-R-23-017, 2023); https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1017P9B.pdf.

pre-rulemaking process, echoing similar calls from other researchers and technical experts.[9,10] A more appropriately-sized supply shock would be more likely to increase the size of the assessed land use change impact adjustment, than to reduce it; other changes in agriculture or lipid biomass-based diesel production, such as any yield improvements, would be expected to work in the other direction. How the lipid markets under RD have evolved beyond historical patterns is key, but difficult to model.

Additionally, given the reliance of all ILUC models on subjective modeling assumptions regarding critical parameters like definition of counterfactuals, establishment of system boundaries, setting allocation methods, etc., no single ILUC model can provide a highly credible point estimate of future ILUC impacts. Using an ensemble of models with a variety of input parameters to assemble a range of possible impacts, and then selecting a value from that range that considers the risks entailed from different directions and magnitudes of estimation error is a more appropriate approach.[11]

Taken together, these issues reinforce the conclusion that the current ILUC risk mitigation protocols within the LCFS are insufficiently protective against the serious risks of harmful land conversion, competition with food crops, and excess GHG emissions relative to assessed CI scores. Updating this approach to better reflect more recent data and understanding on this issue is critical. Given the technical complexity and entrenched controversy surrounding ILUC, however, such an update would likely entail a multi-year process of research, policy analysis, and stakeholder consultation. Targeted research to develop and/or update models in this space, and work to support a robust technical discussion on the topic, with ample opportunities for stakeholder and public engagement will be required.

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[9] E.g UC Davis Policy Institute comments submitted following the July 7, 2022, November 9, 2022, and February 22, 2023 workshops, as well as discussion in Brown, et al. (2021), Ro, Murphy & Wang (2023), and Murphy & Ro (2024)

[10] E.g. J. O'Malley, N. Pavlenko, S. Searle, J. Martin, "Setting a lipids fuel cap under the California Low Carbon Fuel Standard" (ICCT, 2022); https://theicct.org/publication/lipids-cap-ca-lcfs-aug22/.
J. Glauber, C. Hebebrand, Food versus Fuel v2.0: Biofuel policies and the current food crisis | IFPRI : International Food Policy Research Institute (2023). https://www.ifpri.org/blog/food-versus-fuel-v20-biofuel-policies-and-current-food-crisis.
J. Martin, A Cap on Vegetable Oil-Based Fuels Will Stabilize and Strengthen California's Low Carbon Fuel Standard, The Equation (2024). https://blog.ucsusa.org/jeremy-martin/a-cap-on-vegetable-oil-based-fuels-will-stabilize-and-strengthen-californias-low-carbon-fuel-standard/.

[11] C. W. Murphy, Making Policy in the Absence of Certainty: Biofuels and Land Use Change, ITS (2023). https://its.ucdavis.edu/blog-post/making-policy-in-the-absence-of-certainty-biofuels-and-land-use-change/.

Limitations of Proposed Alternative Approaches to ILUC Risk Mitigation

Proposed amendments to Section 95488.9 (g) of the LCFS would adopt feedstock sustainability guidelines on crop- and forest-based feedstocks, including the requirement for certification by an approved third-party certification body. These guidelines would be expected to help reduce the risk of feedstocks from recently-deforested, ecologically- or culturally- sensitive, or conserved lands entering California's fuel mix. In and of themselves, such sustainability certifications are a valuable tool, however their inherent design makes it impossible for them to mitigate risks from indirect, market-mediated effects like ILUC. This can be clearly observed by looking at a current example. The U.S. is a major global exporter of soybeans, and their primary derivative products, soy meal and soybean oil, 49 million metric tons of soybean and soybean derivatives were exported in 2023, with China the largest consumer.[12] In order to supply growing demand for RD, significant new crushing capacity has come online in the U.S. in recent years, with more anticipated.[13] Where the U.S. was previously exporting whole soybeans (which include the oil), some fraction of that export is now limited to soy meal. Consumers who previously purchased whole soybeans typically crushed them upon receipt and used both the oil and meal. The shift results in a deficit of vegetable oil for those consumers compared to historical patterns. In the case of China, like most countries in the Eastern Hemisphere, palm oil is commonly the cheapest vegetable oil available on the market. Increased consumption of palm oil has been repeatedly linked to increased deforestation of ecologically-sensitive, high-carbon natural land.[14]

At present, the global oilseed markets are seeing a significant decline in U.S. whole soybean exports over the last 3 years, partially compensated by an increase in soy meal.[15] While it is impossible to conclusively assign causality, given the many socioeconomic forces that impact the global agricultural commodity market, these data are aligned with a reality in which biofuel policy is impacting global vegetable oil markets in the manner described above.

Feedstock sustainability certification only applies to the feedstock directly being used for biofuel production. It is blind to market mediated changes resulting from the use of said feedstock. If a U.S. soybean producer who historically exported whole beans elected to crush them and sell

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[12] https://fas.usda.gov/data/commodities/soybeans

[13] https://www.world-grain.com/articles/19463-us-soybean-crush-capacity-on-the-rise

[14] C. Petrenko, J. Paltseva, S. Searle, "ECOLOGICAL IMPACTS OF PALM OIL EXPANSION IN INDONESIA" (ICCT, 2016); https://theicct.org/sites/default/files/publications/Indonesia-palm-oil-expansion_ICCT_july2016.pdf.
S. Searle, "How rapeseed and soy biodiesel drive oil palm expansion" (ICCT, 2017); https://theicct.org/publication/how-rapeseed-and-soy-biodiesel-drive-oil-palm-expansion/.
L. Reijnders, M. A. J. Huijbregts, Palm oil and the emission of carbon-based greenhouse gases. Journal of Cleaner Production 16, 477–482 (2008).

[15] See Table 10 https://apps.fas.usda.gov/psdonline/circulars/oilseeds.pdf

the oil for RD production, the feedstock they produce could be granted certification (assuming they met the relevant criteria) even if it could be conclusively demonstrated that the entity which previously imported those soybeans purchased palm oil from recently-deforested land to replace the lost soybean oil. Certification schemes cannot assess anything other than the specific lots of feedstock they are contracted to certify, and so have no opportunity to assess the feedstock grown by other producers in response to aggregate global demand signals. As such, the proposed feedstock sustainability certification requirements are also inadequate protection against ILUC risks.

Capping or Restricting the Continued Growth of Lipid- or Crop-based Fuels

Consideration of a Vegetable Oil Cap in the ISOR

As discussed in the previous two sections, the current rate of growth in the consumption of renewable diesel, combined with present and future demand for other lipid based fuels such as biodiesel or SAF, create significant market stability challenges for the LCFS in the near future, as well as sustainability risks. Neither the current system of ILUC impact adjustments to CI scores, nor the proposed feedstock sustainability certification protocols are capable of effectively mitigating either risk, and any solution that requires new ILUC modeling would not be ready for implementation soon enough to avert these harms. Successfully addressing these challenges will require an approach that can be adopted during the current rulemaking, provides high certainty of effect, and can be used by other jurisdictions that have adopted the LCFS as part of their climate policy portfolio. One such solution has been proposed, a cap on vegetable oil feedstocks, which was discussed in the SRIA as part of the Environmental Justice Alternative, and in the ISOR as Alternative 1.

Alternative 1 was rejected in favor of the proposed amendments for two primary reasons, less GHG reduction, largely due to lower LCFS target stringency (28% vs. 30%) and less air quality benefit. Our 2023 modeling report clearly demonstrates that a 30% LCFS CI target in 2030 is compatible with lower levels of lipid-based fuel consumption consistent with vegetable oil feedstock caps. Our previous report found that with a 30% 2030 target, and total lipid-based fuel consumption less than 2022 levels, the LCFS program maintained positive credit balances throughout the 2020's; balances grew in 2028 and 2029 to the point where an AAM triggering event (under the proposed trigger criteria) was likely.[16] This indicates that even with binding caps on total lipid-based fuel development, under our assumptions LCFS market is projected to provide ample compliance credit to support a target of 30% or higher by 2030; the conclusion of fewer GHG benefits is therefore at least partly due to the selection of a lower 2030 target, which is not a necessary feature of a crop or lipid feedstock cap. Additionally, as discussed above, given a strong possibility that the current ILUC adjustment approach underestimates actual

[16] Murphy & Ro (2024) https://escholarship.org/uc/item/5wf035p8

ILUC impact, real world GHG emissions from these fuels could be significantly higher than their assessed CI scores, especially as lipid use for biofuels continues to grow.[17]

The estimate of fewer air quality benefits is likely due to assumptions on the impact of RD on emissions from diesel vehicles. While RD does provide significant air quality benefits in older vehicles that lack modern emission control devices, CARB's 2007 Truck and Bus Regulation requires virtually all on-road diesels in California to have PM and NOx control devices, typically diesel particulate filters and selective catalytic reduction systems.[18] A large, and increasing share of non-road diesels are subject to similar emission control regulations. Research supported by CARB found that RD provides no statistically significant emissions benefit when burned in diesels equipped with such devices.[19] UC Davis research on the impact of increased targets in Oregon's Clean Fuels Program found minimal air quality benefit from RD in 2030 due to the prevalence of modern diesels with emission control devices in their fleet, and forthcoming work on the relative air quality impacts of hydrotreated RD and hydrotreated SAF arrives at a similar conclusion.[20] The ISOR does not provide sufficient detail about the methodology used to arrive at its conclusions related to air quality impacts, so we are unable to replicate them, or confirm whether the emissions factors account for the presence of newer diesel engines that meet current regulatory requirements in the California fleet. The air quality work we, and our UC Davis colleagues have produced suggests that appropriately accounting for these effects would dramatically reduce the purported air quality benefit of higher levels of RD in 2030 and beyond.

Alternative Approaches to ILUC Risk Mitigation - Caps on Quantities of Fuels From Specified Feedstocks

Recently-published FPSM modeling explores several options for cap design, with the caveat that FPSM has limited capability to represent differences in feedstock preference, conversion yield, and projected CI scores between different classes of feedstock when used for the production of lipid based fuels - RD, SAF, and biodiesel.[21] As such these results should be

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[17] The ISOR reported only emissions benefits relative to an assumed baseline, and did not quantify aggregate emissions from transportation fuels for any of the analyzed scenarios. This prevents us from making a direct, quantitative comparison of GHG impact.

[18] https://ww2.arb.ca.gov/our-work/programs/truck-and-bus-regulation

[19] T. D. Durbin, G. Karavalakis, K. C. Johnson, C. McCaffery, H. Zhu, H. Li, "Low Emission Diesel (LED) Study: Biodiesel and Renewable Diesel Emissions in Legacy and New Technology Diesel Engines" (18ISD027, CARB, 2021); https://ww2.arb.ca.gov/sites/default/files/2021-11/Low_Emission_Diesel_Study_Final_Report.pdf.

[20] Y. Li, G. Wang, C. Murphy, M. J. Kleeman, Modeling expected air quality impacts of Oregon's proposed expanded clean fuels program. Atmospheric Environment 296, 119582 (2023).
Y. Li, C. Murphy, J.W. Ro, M. J. Kleeman, *Modeling the Differences Between the Air Quality Impacts of Renewable Diesel and Sustainable Aviation Fuel (SAF) in California*. Presentation to the Transportation Research Board's Standing Committee on Alternative Fuels in Aviation. TRB Annual Meeting, Washington DC, 8 January, 2024

[21] Murphy & Ro (2024) https://escholarship.org/uc/item/5wf035p8

considered approximate and additional research and modeling is needed to better understand nuances related to cap design. Still, given that the primary purpose of a cap is to prevent excessive consumption of fuels that present indirect land use change risks, so long as a cap is below the levels that would result in critical environmental harm, it can effectively accomplish its primary purpose.

Figure 3 (following page) presents the findings of several cap scenarios, including ones with restrictions on crop-based lipids (defined as soybean oil and canola oil), and ones with restrictions on total volume of lipid-based fuels.[22] Scenarios with a 1 billion GGE limit on fuels made from crop-based lipid feedstocks, or a 3 billion GGE limit on all lipid-based fuels demonstrate similar behavior to the uncapped scenarios, despite modest reductions in net credit generation. In both cases, the AAM was triggered twice, increasing targets in 2028 and 2030. The reduced credit generation did, however, reduce the aggregate bank to the point where the first AAM trigger criteria was no longer met during the period 2031-2035, meaning that a third AAM triggering event would not occur if credits exceeded deficits in one of these years. Scenarios with a 500 million GGE crop-based lipid fuels cap, or a 2 billion GGE lipid-based fuels cap show a more significant response, with the bank being gradually drawn down during the mid-2020's (more rapidly for the 2 billion GGE lipid-based fuel cap than the 500 million GGE lipid crop-based one), dropping it below the AAM triggering threshold by 2028. In these scenarios the bank is drawn down and an approximate balance between credit supply and demand is reestablished without the need for the 2030 target to increase beyond the 30% proposed in the amendments.

Previous modeling found that 30% targets and caps on aggregate lipid consumption were compatible with California's transition to carbon neutrality by 2045.[23] Additional unpublished analysis suggests that a 2.5 billion GGE lipid based fuels cap may also result in two AAM triggering events, though the second does not occur until 2034 (and it is important to note that model uncertainty increases as projections move farther into the future), while a 750 million GGE crop-based fuels cap is likely to only trigger the AAM once, in 2028. Taken together, these results suggest that adopting a lipid crop-based cap set below 750 million GGE annually reduces the risk of multiple AAM trigger events, a lipid crop-based cap set below 500 million GGE may yield an approximately balanced credit market without the need for AAM triggering events entirely. Similarly, adopting a lipid-based fuel cap below 2.5 billion GGE annually limits

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[22] At present, the greatest risk of significant sustainability or ILUC related harms stem from the consumption of lipid-based biofuels. Corn ethanol is also a crop-based biofuel that plays a significant role in California's fuel portfolio and there are sustainability risks associated with excessive growth in corn consumption for biofuel production. While we focus on vegetable oil crops for the discussion in this section, this should not be taken as an indication that corn should be excluded from a crop-based feedstock cap, to mitigate potential risks if market conditions should change to support rapid expansion of corn-based ethanol.

[23] Ro, Murphy, & Wang (2023) https://escholarship.org/uc/item/6f2284rg, Brown, et al. (2021) https://escholarship.org/uc/item/3np3p2t0

the risk of multiple AAM triggering events, especially before 2030, while a 2 billion GGE cap may yield a balanced market through the 2020's and avoid AAM triggering entirely.

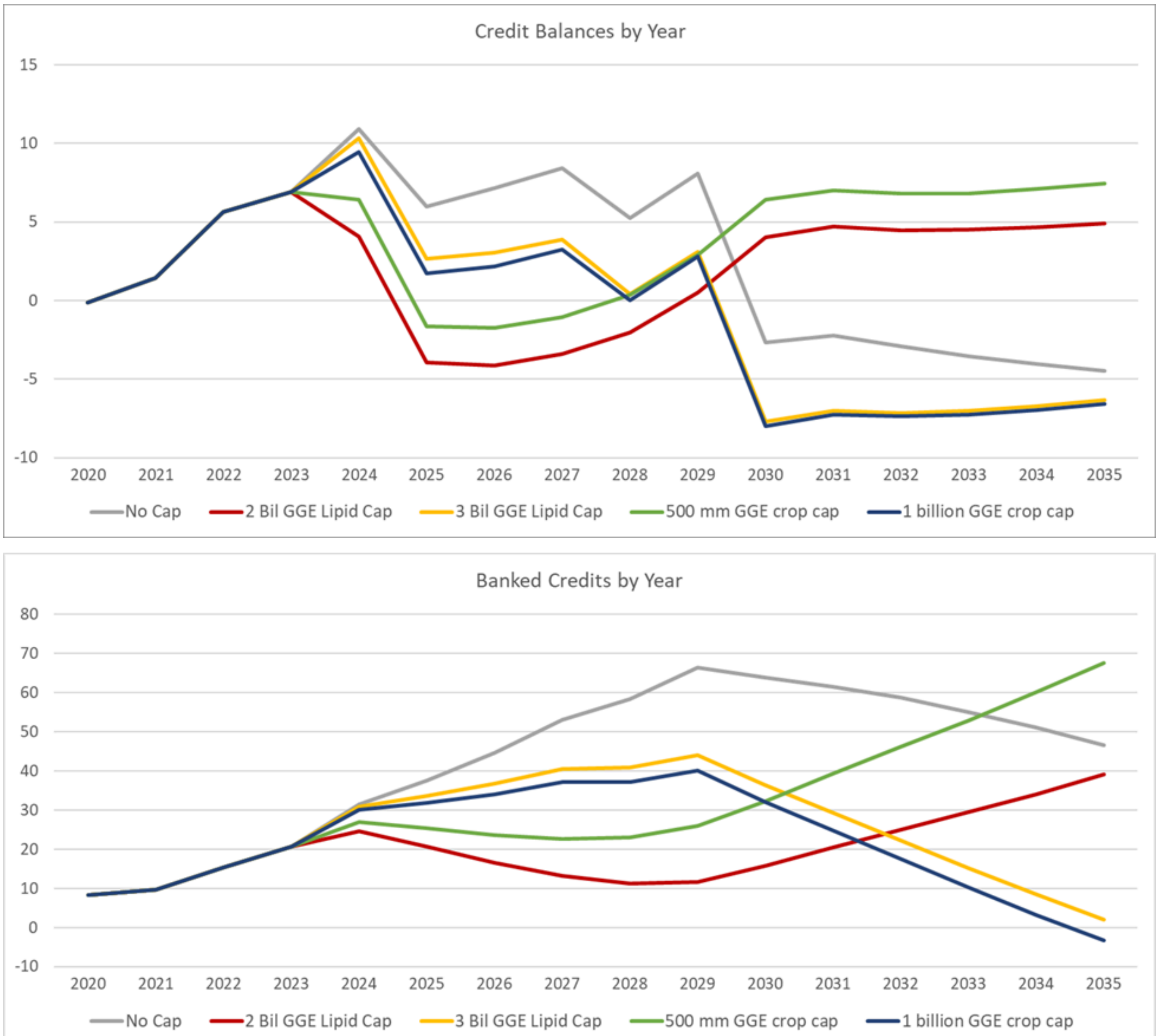

Figure 3: (a, above) Yearly net credit balances and (b, below) net banked credits from FPSM modeling of several lipid fuel scenarios. AAM-triggering events manually added when prior year banked credits exceed ¾ of prior year deficits and yearly deficits>credits. The gray "No Cap" line reflects modeled results for the LCFS amendments at the time of writing (February, 2024). Source: Murphy & Ro (2024)

Given that a cap on vegetable oil feedstock crediting in the LCFS would likely yield nearly equivalent, or possibly better, GHG and air quality impacts as an un-capped scenario, a critical question is: how should any such cap be designed? A number of concepts have emerged during our years of work on the LCFS and similar programs. We present a non-exhaustive list of options below, with the caveat that none of these options has been fully analyzed by ITS-Davis researchers and the presence of any option on this list should not be taken as an endorsement.

1. **Cease issuing LCFS credits for specified fuels once the cap has been reached.** This option risks creating market volatility as producers attempt to schedule deliveries early in the year to ensure they can access the limited supply of credits.
2. **Proportionately reduce credit issuance to all fuel providers once a specified threshold has been reached.** As total volumes approach the cap, begin proportionately reducing the LCFS credit issued per gallon to provide a more gradual transition from full crediting to zero than option 1.
3. **Hold a fraction of credits from capped fuels in a buffer account and retire them if caps are exceeded.** In this concept, a fraction of credits from capped fuel types would be retained by CARB and held in a buffer account. If total volumes of capped fuel types exceeded the specified caps, enough credits would be retired to ensure that only the capped amount was credited. The remainder would be returned to producers.
4. **Limit the ability of deficit-holding entities to submit a greater fraction of credits from capped fuels than their share of total deficits would imply.** For example, if an entity generated 25% of total deficits in the LCFS, they could submit credits from capped fuels to cover only 25% of that obligation. This would functionally create a secondary sub-market for credits from capped fuel types, which would be expected to trade at a lower price than uncapped ones.
5. **Adopt a transferable quota system to assign shares of the cap to specified producers.** Transferable quotas have often been used to allocate scarce capacity in competitive markets, e.g. fisheries. In this approach, the capped volume would be divided into blocks of quota to deliver fuels from the capped categories. These could be auctioned, distributed by lottery, or assigned by formula based on historical presence in the market. Producers could then deliver the volumes specified by their quota, or transfer the quota to other producers.
6. **Adopt a bid-in quota system similar to that used in electricity markets.** Producers would bid into a market to deliver specified volumes of fuel at prices of their choosing to fuel terminals or racks. A portfolio of bids equal to that year's cap would be assembled from the lowest-price bids and those bidders would receive transferable quotas for that delivery. This approach would have the additional benefit of applying downward pressure on diesel prices.
7. **Regulate outside of the LCFS.** The LCFS has not historically regulated or limited fuel volumes, instead focusing on fuel carbon intensity. An alternative to regulation within the LCFS program would be to adopt fuel quality or composition standards that effectively enforced the specified caps on crop- or lipid-based fuels, or establish a new stand-alone volumetric regulation for the purpose.

We are happy to work with CARB and other stakeholders to more fully develop and analyze possible cap design options. Given the rapid growth in RD, any delay in implementing a cap may result in the need to reduce aggregate lipid-based fuel demand in future years to bring it back under the capped level. The greater the delay, the greater the likely need to reduce aggregate consumption of such fuels in the near-term.

Deficit Generation from Intrastate Aviation Fuel Consumption

Estimating Intrastate Aviation Fuel Consumption

The proposed amendments would add fossil jet fuel used in intrastate flights, defined as those that take off and land inside California, to the LCFS as an obligated fuel starting in 2028. This would increase the incentive for aircraft operators to use alternative aviation fuels, such as hydrotreated esters and fatty acids (HEFA) made from lipid feedstocks. These fuels have received ASTM certification for use at blends of up to 50% with conventional jet fuel and many aviation industry stakeholders have demonstrated the feasibility of using such fuels in modern commercial aircraft without blending. Given the operational needs of commercial aircraft, low-carbon liquid fuels are widely viewed as the most feasible option for reducing GHG emissions from aviation. Zero-emission aircraft, powered by batteries or hydrogen have been proposed and some manufacturers are developing these technologies for commercial application, but they do not appear suited for larger aircraft, like those used in interstate and international air travel, the market segment that consumes the majority of jet fuel.

Data on the scope of fuel consumption for intrastate flights is limited. Because aircraft are typically required to carry reserve fuel on flights, and commercial flights often operate on multi-leg cross-border trips, no simple resource to quantify intrastate fuel consumption via direct measurement exists. Recent work by researchers at UC Berkeley and UC Davis models the flight profiles of most intrastate routes and aircraft types to arrive at an estimate of 403 million gallons of jet fuel for both commercial and general aviation in 2019. Projections for 2030 and 2035 are 475 million gallons and 488 million gallons respectively.[24] Staff suggested at a previous workshop an alternative definition of “intrastate” which includes all fuel consumed by flights departing from California while they are within the state’s airspace. Forthcoming work from the same research group suggests this would increase the amount of jet fuel subject to deficit generation to 879, 1137, and 1206 million gallons in 2019, 2030, and 2035 respectively.

[24] Y. Liu, M. Hansen, C. Murphy, *Advancing Sustainable Aviation Fuels in California* (2023). Presentation to Advisory Group for UCB-UCD RIMI Project. (unpublished)

Interactions Between SAF and Other Fuels Regulated by the LCFS

At present, virtually all SAF consumed in California is HEFA made from lipid feedstocks. This process utilizes the same lipid feedstock as renewable diesel, and is produced in a similar production process. Most renewable fuel hydrotreaters produce a blend of SAF, and RD, along with lower-value byproducts such as renewable naphtha and propane, during typical operation. In most cases, producers can alter operational parameters to emphasize the production of RD or SAF, with SAF typically requiring additional energy and hydrogen as compared to RD. This means that the existing capacity to produce RD could shift some of its output to SAF instead. Given the massive amount of hydrotreating capacity in the U.S. (see *Renewable Diesel Capacity Growth and 2030 Targets,* above) we anticipate that the vast majority of SAF entering California's market through 2030 will be HEFA. While some alternative approaches have been proposed, including e-fuels (which synthesize CO_2 and hydrogen into hydrocarbons using renewable electricity to power the process) or advanced forms of cellulosic biofuel, these have yet to demonstrate success at commercial scale. Alcohol-to-jet (AtJ) synthesis has also been proposed, and a pioneer plant (10 million gallons per year SAF plus RD capacity) recently opened in Georgia; however this technology has also not been demonstrated at full scale, nor has it demonstrated operational cost competitiveness.[25] As such, it is premature to make quantitative projections of the availability, characteristics (including CI score) or cost of such fuels, especially given the history of novel alternative fuels struggling to achieve commercial success.

As a result, expansion of SAF consumption in California through 2030 is likely to be driven by increased use of lipid-based HEFA, and as such, all the cautions and concerns related to RD apply here as well. To be clear: this is not meant to imply that all SAF consumption will be harmful or that it should be excluded from the LCFS. Given the lack of alternatives to significantly reduce GHG emissions from aviation, in contrast to on-road transportation where ZEVs can satisfy most applications using zero- or near-zero GHG energy, it could be argued that deployment of SAF might appropriately take priority over on-road RD from a policy perspective. UC Davis researchers have modeled the expected air quality impacts of SAF deployment in CA, compared to equivalent volumes of RD and found slight, though non-significant improvements in regional air quality in scenarios that prioritize SAF over RD.[26] SAF may have a particular benefit in reducing the exposure of airport workers to particulate matter and other air pollutants as well.

[25] https://www.ajc.com/news/lanzajet-celebrates-opening-of-greener-sustainable-aviation-fuel-plant-in-georgia/EVQGJDNUZBEDFGJATQABEJOVIU/

[26] Y. Li, C. Murphy, J.W. Ro, M. J. Kleeman, *Modeling the Differences Between the Air Quality Impacts of Renewable Diesel and Sustainable Aviation Fuel (SAF) in California*. Presentation to the Transportation Research Board's Standing Committee on Alternative Fuels in Aviation. TRB Annual Meeting, Washington DC, 8 January, 2024

These benefits must be taken in context with the fact that HEFA SAF draws from the same pool of feedstock, and therefore is subject to the same sustainability risks and challenges as RD. Unrestricted growth of HEFA SAF would likely result in the same negative environmental impacts as equivalent growth in RD. Policies that seek to limit these harms must apply to both SAF and RD (as well as biodiesel, which also is made from lipid feedstocks, though its aggregate volumes are now smaller than RD), which is why the proposals we discuss above focus on limiting the quantities of feedstock used rather than finished fuels.

Given the lack of alternatives to liquid fuels to decarbonize aviation, and the lack of commercially-deployed alternatives to HEFA within the SAF market at present, prioritizing SAF over RD may be a defensible choice. We adopt that mindset in FPSM via the prioritization of fuels during allocation of preferred waste and residue lipid resources, where SAF demand (assumed to be equivalent to projected intrastate jet fuel demand) is satisfied before RD. We project growth in total volumes of SAF consumption until intrastate demand is satisfied in 2028. This means that when the SAF deficit obligation becomes active in 2028, it has already been integrated into California's total demand for alternative fuels over the preceding years; this explains why no obvious inflection points in the credit balance or bank trend lines are visible in 2028. This approach effectively shifts the deficits that would accrue to SAF into the diesel pool in scenarios where total lipid consumption is capped below total liquid diesel consumption plus intrastate jet fuel consumption. This approach ultimately yields comparatively little difference in FPSM estimates of LCFS crediting trends or estimated emissions between scenarios in which SAF is preferred to RD or ones in which the opposite is true. In reality, there are small but significant distinctions between the production of SAF and RD that would yield different credit and GHG outcomes depending on which feedstocks ultimately went into which fuels. These distinctions are outside the scope of FPSM's ability to effectively characterize or project; additional research into this area is recommended to better understand the trade-offs involved.

Fractional Displacement Crediting Approach for Fuels with EER>1

Assumptions Embedded in Current Method Leads to Increasing Credit Quantification Error

In our previously submitted comment letter on 21 Dec 2022, we argued for the need for a more accurate crediting approach to better align LCFS crediting with real-world emissions as more efficient vehicles come to make up a larger share of California's total vehicle fleet.[27] Research published shortly before the letter was submitted identified and characterized a likely future quantification error in the LCFS credit generation method due to assumptions around the GHG impact of displaced fuel.[28] As higher-efficiency powertrains saturate a market segment, the

[27] Comment #142 for Public Workshop to Discuss Potential Changes to the Low Carbon Fuel Standard (lcfs-wkshp-nov22-ws)

[28] C. Murphy, "Improving Credit Quantification Under the LCFS: The Case for a Fractional Displacement Approach" (2022); https://escholarship.org/uc/item/0px4m8hz

current crediting method will become increasingly less accurate at matching LCFS credits to actual GHG impacts over time, within that segment. This is because the current LCFS credit quantification method assumes that each new high efficiency (EER>1) vehicle will fully replace the travel activity provided by a fossil-fueled ICE vehicle. Over time, this assumption becomes less reflective of actual behavior. While the credit quantification error caused by this inaccurate assumption applies to all vehicles with an EER>1, it will yield its greatest impact on estimates of emissions from EVs. In early years, when the fleet is overwhelmingly composed of ICE vehicles, the assumption of constant and complete displacement of ICE travel is quite defensible, but as EVs come to make up an increasing fraction of the fleet, it is increasingly likely that the travel activity provided by each charging event would otherwise have been done in a different EV, in which case no additional gasoline was displaced. In this case, the credits issued for EV charging would overestimate the actual GHG benefits of such charging, giving LCFS credits for emissions benefits that are not occurring and with costs passed on to gasoline consumers.

Resolving Credit Quantification Error With Fractional Displacement Crediting

Updating the outdated assumptions regarding fuel displacement can be accomplished by algebraically rearranging the existing LCFS quantification equation to separate it into two terms, one reflecting GHG impacts of fuel displacement and another reflecting GHG impacts of lower fuel CI on an equal-energy basis, this allows a displacement fraction term to be added. This term accounts for the fact that as new technologies come to make up larger fractions of a fleet or market segment, each additional vehicle will, on average, displace less travel by an older-technology one. The fraction of the vehicle fleet or market segment still made up of older-technology vehicles can serve as a useful approximation for this displacement fraction term, possibly with a temporal lag to account for the fact that old-technology vehicles are more likely to retire out of the fleet than new ones due to their relative ages.

We recognize that this problem is outside the scope of this rulemaking, as identified by CARB during the pre-rulemaking workshop. Adopting the fractional displacement approach in the next few years, however, would help ensure that medium- to long-term credit quantification matches real-world emission benefits, and helps mitigate potential LCFS credit oversupply in the 2030's that FPSM modeling projects to arise due, in part, to this credit overestimation error, without the need for precipitous action that could cause market disruption.[29]

[29] Brown, et al. (2021) https://escholarship.org/uc/item/3np3p2t0

Reevaluating Previous Assumptions Around Additionality

Rationale for Updating Frameworks for Additionality Determination

As the LCFS moves deeper into its second decade of operation, some assumptions and methods that have served it well in the past may need to be reevaluated. This is especially true in the case of additionality, which is the determination around whether a specified emission impact would have occurred without the product of activity being analyzed. Appropriately determining additionality is a critical element of any consequential life cycle analysis (LCA), and is particularly relevant to GHG accounting in the case of biofuels, and carbon dioxide removal via natural or working lands.[30] The LCFS assesses additionality at the project level, to a limited degree; emissions benefits from a project are assessed in comparison to a counterfactual in which the project did not exist. Specific exemptions are provided for factors that would normally render the LCFS impact on emissions partially or entirely non-additional. These include explicitly allowing the crediting of ethanol produced at facilities built prior to the adoption of the LCFS, which would normally be non-additional due to temporal sequencing. Similar exemptions to policy additionality requirements exist in the case of receiving financial incentives from the RFS, cap and trade program, or the Inflation Reduction Act (the latter being proposed amendments in the current rulemaking), allowing LCFS crediting as if it were responsible for the full emission benefits of a project that receives benefits from those sources as well. The LCFS assumes that in absence of the biofuel production or EV charging event in question, an equivalent amount of transportation activity would occur using conventional vehicles fueled by petroleum. The primary factor upon which the LCFS would find cause to deny the additionality of emissions benefits is legal or regulatory requirements; if a law or policy in a jurisdiction requires a specified action, then any GHG impacts arising from projects supported by the LCFS are considered non-additional. For example, if a jurisdiction required anaerobic digesters for manure management, digesters located there could not claim credit for the avoided methane emissions.

[30] R. J. Plevin, M. A. Delucchi, M. O'Hare, Fuel carbon intensity standards may not mitigate climate change. Energy Policy 105, 93–97 (2017).
https://www.sciencedirect.com/science/article/pii/S030142151730112X
S. T. Sanchez, J. Woods, M. Akhurst, M. Brander, M. O'Hare, T. P. Dawson, R. Edwards, A. J. Liska, R. Malpas, Accounting for indirect land-use change in the life cycle assessment of biofuel supply chains. Journal of the Royal Society, Interface / the Royal Society 9, 1105–19 (2012).
http://rsif.royalsocietypublishing.org/cgi/content/abstract/9/71/1105
A. Zamagni, J. Guinée, R. Heijungs, P. Masoni, A. Raggi, Lights and shadows in consequential LCA. The International Journal of Life Cycle Assessment 17, 904–918 (2012).
http://www.springerlink.com/index/10.1007/s11367-012-0423-x
http://dx.doi.org/10.1007/s11367-012-0423-x
J. Earles, A. Halog, Consequential life cycle assessment: a review. The International Journal of Life Cycle Assessment 16, 445–453 (2011). http://dx.doi.org/10.1007/s11367-011-0275-9

This project-level accounting approach, with consideration of legal and/or regulatory requirements, and specified exemptions creates a set of assumptions around additionality, establishment of baselines, and counterfactuals that shape a wide variety of processes and determinations within the LCFS. For example, fueling EVs or hydrogen fuel cell vehicles generates credits for displaced gasoline based on the assumption that such fueling displaces an amount of petroleum governed by the EER applied to the fueled vehicle. Similarly, avoided methane credits are quantified based on the assumption that in absence of the LCFS incentive, manure would be collected and stored in an open lagoon, with uncontrolled release of methane.

In many cases, the specific assumptions implied by the current approach to additionality were appropriate at the time when the LCFS was first developed and implemented, in the late 2000's and early 2010's. At that time, virtually all vehicles on the road were ICE, so the assumption that any fueling activity by a non-ICE vehicle displaced equivalent ICE vehicle travel was appropriate. Similarly, awareness of the importance of agricultural methane emissions on climate change was only just beginning to be reflected in climate policy making, so in many jurisdictions, lagoon management of manure was ubiquitous.

Rationale for a Comprehensive Review of Additionality and Related LCA Assumptions

Given the changes in technology, policy, and behavior that have occurred, a comprehensive review of LCFS additionality provisions and applied assumptions is warranted. This needs to be comprehensive, across all regulated fuels and technologies in order to maintain technology neutrality and an equitable, competitive market for GHG reducing solutions. Three particular areas stand out as likely to be identified as outdated during such a review (though this should not be considered an exhaustive list).

First, as discussed in the section *Fractional Displacement Crediting Approach for Fuels with EER>1,* above, are assumptions embedded in the current method for assessing emissions benefits arising from the displacement of fossil fuel by use of vehicles with an EER>1. An increasing share of California's vehicle fleet is now composed of vehicles other than ICE; by 2030, UC Davis modeling predicts around 23% of total vehicles will be ZEVs, if projections hold, we predict that the majority of the fleet will be ZEVs sometime in the mid-2030's. Under those conditions, the assumption that any travel by an alternative fueled vehicle displaces an equivalent amount of petroleum-fueled ICE travel will clearly no longer hold.[31]

Second are assumptions around avoided methane credits from livestock digesters. A range of factors including policy, consumer preference, improved technology, voluntary agreements, legal settlements, and others is contributing to broad change across the livestock industry. Assuming

[31] This issue is discussed in depth in C. Murphy, "Improving Credit Quantification Under the LCFS: The Case for a Fractional Displacement Approach" (2022); https://escholarship.org/uc/item/0px4m8hz

that uncontrolled lagoons are, and will always be the alternative to LCFS-supported digesters is similarly problematic.

Finally, as described above, are the exemptions to additionality considerations relating to policy support for alternative fuels from the U.S. Renewable Fuel Standard, California's cap and trade program, and proposed exemptions in the current amendments for support from the Inflation Reduction Act. In the past, when alternative fuel technologies were immature, stacking multiple streams of revenue was necessary to make alternatives to petroleum cost-competitive. Given advancements in technology and the implementation of alternative fuel policy at a variety of jurisdictional levels, stacking multiple streams of policy-driven revenue may not be required to bring these fuels to market.

A comprehensive review does not necessarily mean that the current standards necessarily will, or should, change. In some cases the rationale for adopting assumptions or approaches to additionality assessment in the past may still hold. The LCFS should not, however, assume that all assumptions around additionality will continue to be appropriate more than a decade after they were first adopted. Analytical assumptions that are effective in early phases of a technological and economic transition do not always maintain their effectiveness in later phases. The LCFS is not immune from this effect. At its earliest opportunity, CARB should conduct a comprehensive review of assumptions around additionality and other LCA modeling parameters used by the LCFS to determine whether current ones are likely to meet the program's needs in the decades to come.

Unresolved Issues Point to Need for Additional Rulemaking in the Near Term

From the start of the workshop and engagement process that led up to this rulemaking, Staff were extremely clear that the scope would be strictly limited in order to allow timely and efficient adoption of changes that could stabilize the LCFS credit market and help strengthen the LCFS credit price. The workshops, engagement opportunities, and discussion materials circulated since then have reflected this agenda. Given the recent significant decline in LCFS credit prices, this focus on corrective measures is understandable.

The limited scope, however, meant that many critical and complex structural topics that, when fully explored, might offer avenues to improve the efficiency, resilience, and effectiveness of the LCFS as decarbonization proceeds were excluded from this rulemaking. These include, but are not limited to, consideration of updated EERs, updating how the regulation addresses ILUC impacts, addressing appropriate crediting from fossil fuel displacement in a transitioning fleet, treatment of interactions or potential double-counting with other climate programs, harmonizing LCFS protocols with other jurisdictions that have similar programs in place or coming online, preparing for radical LCFS credit market shifts anticipated in the 2030's as program revenues begin declining due to reduced gasoline consumption, expanding the LCFS to cover air, water, and rail fuels, and integrating vehicle or transportation-system effects into fuel CI assessment, differentiation between so-called “bridge” fuels and those with the capacity to achieve carbon neutrality, etc. As discussed in earlier sections of this comment, several of these -out-of-date EERs, estimation error due to fuel displacement assumptions, ILUC risk mitigation, and additionality considerations - have demonstrated actual or potential capacity to negatively affect the LCFS and/or progress toward California’s climate, environmental, and equity goals within the next 5-10 years. The other issues deserve careful consideration and the opportunity for public discussions in a forum that includes stakeholders from a variety of perspectives and LCFS program staff.

It is especially important in the transportation fuel space to make policy changes as early as possible, in order to avoid a situation that requires precipitous action that may create stranded assets, excessive fuel price volatility, or erode policy certainty about the LCFS market. The LCFS has in the past conducted major rulemakings following the release of the Scoping Plan; if past patterns hold this would imply the next significant LCFS rulemaking in 2028. By that time, failure to address some of the issues listed above could lead to another destabilization of LCFS credit markets. While many of these issues are complex and will take significant time and resources to address, most are amenable to solutions that can be gradually implemented, to minimize disruption. Waiting until a crisis emerges increases the chance that precipitous, disruptive change will be required.

CARB should commit now to a follow-up LCFS rulemaking, without any limitations to its scope, at the earliest possible opportunity.

Part 2: Comments on Specific Elements of the Proposed Amendment Package

Appendix A-1. Proposed Regulation Order

Section 95481 - Definitions.

The following definitions may leave unwanted ambiguity around their interpretation, or create the risk of unwanted outcomes. Except where specifically noted, clarifications of language or intent are likely to be sufficient to address these issues.

“Break ground” - The definition is reasonable, but there is a chance of gaming the system if no additional limitations are added. For example, someone could ‘break ground’ before a specific date to claim benefits under the LCFS (or other regulatory incentive programs), but might not advance the construction of a facility further than having broken ground. This could allow for projects to qualify for eligibility in protocols that have a specified end date for new pathways, e.g. HRI or FCI, even if no other construction activity other than ground breaking occurs until after the cut off date. Clarifying that ‘breaking ground’ implies subsequent construction activity should begin shortly thereafter, or setting a maximum allowable period of time between ground-breaking and subsequent construction activities could resolve this problem. In addition, ‘digestor’ may be a typo of ‘digester’.

“Byproduct” - The expression, ‘marginal economic value’, is insufficiently defined. A quantifiable threshold is required to avoid confusion and gaming the system. Recent Policy Institute research on classification of wastes and residues in LCA set a threshold of 15% of the total economic value for the definition of ‘byproduct’.[32] If a product created more than 15% of the total economic value of the extended system, it was a coproduct, not a byproduct. The quantitative threshold at which to set this cut-off is not adequately discussed in literature, the choice of 15% may not be appropriate for all cases. Adopting a more specific, ideally quantitative definition of ‘byproduct’ offers more certain guidance than the proposed language.

“Carbon capture and sequestration (CCS) project” - The current definition specifies transport and injection of CO_2, it is therefore unclear regarding whether mineralization, such as enhanced weathering (in which CO_2 reacts with certain minerals to form solid carbonates likely to remain solid for centuries or more) would satisfy the definition of “sequestration” in this use. Given the anticipated durability of solid CO_2 we suggest that it should be considered a valid form of CCS for the purpose of eligibility or quantifying LCFS credits.

“Clean Fuel Reward” - Incentives for light duty EV (LDEV) purchases or leases have been removed from the program, with its focus now exclusively on medium- and heavy-duty vehicles. It may be premature to stop supporting the purchase of LDEVs, however. While current EV market trends indicate increasing availability and declining purchase costs for many EV models, the majority of vehicles sold in California remain ICE powered, and significant consumer awareness deficits exist between EVs and conventional ones.[33] Additionally, if the per-vehicle level of incentive plays a critical role in affecting individuals’ vehicle purchase decisions, conventional economic theory would suggest that higher levels of incentive may be required to reach higher sales fractions. While the Advanced Clean Cars 2 rule sets binding targets for LDEV sales and registration, it may be premature to assume that they can be simply or

[32] J. W. Ro, Y. Zhang, A. Kendall, Developing guidelines for waste designation of biofuel feedstocks in carbon footprints and life cycle assessment. Sustainable Production and Consumption 37, 320–330 (2023) https://www.sciencedirect.com/science/article/pii/S2352550923000532

[33] K. Hoogland, K. S. Kurani, S. Hardman, D. Chakraborty, If you build it, will they notice? public charging density, charging infrastructure awareness, and consideration to purchase an electric vehicle. 101007 (2024). https://www.sciencedirect.com/science/article/pii/S2590198223002543

K. S. Kurani, 2021 Zero Emission Vehicle Market Study: Volume 2: Intra-California Regions Defined by Air Districts. (2022). https://escholarship.org/uc/item/8738w7m3 efficiently met without continued, or even increasing levels of incentive.[34] The definition proposed in the draft amendment text forecloses any future use of Clean Fuel Reward incentives to support continued progress in LDEV market penetration.

“Conservative” - This term is used to define “Alternative Method,” and it is appreciated that the intent of these sections is to ensure that estimated GHG impacts, per LCFS methods, do not overstate actual GHG benefits, and that LCFS incentives actually reflect emissions reductions at least as great as their CI score or the quantity of credits they are issued would imply. Conservative estimation, in this sense, is appropriate in a regulatory environment focusing on reducing GHG emissions like this and can help avoid the worst end of asymmetric impacts from inaccurate estimation in some circumstances.[35] However, the definition needs to be clarified. It is not entirely clear what value or parameter the references to 90th percentile or 10th percentile are meant to apply to. As long as the intent of the definition is clear, and in the case of “conservative” we find it to be, the additional clarity may be effectively provided in a subsequent guidance document, that can be updated over time as needed, rather than through exhaustive specification in the rule text itself, in which case clearer conceptual guidance an a requirement for occasional review and/or revision may be advisable. .

“Co-product” - Similar to “Byproduct,” ‘significant market value’ is insufficiently defined. A quantifiable threshold or other more objective test would help ensure efficient implementation and send a clearer signal to market participants.

“Food scraps” - It is defined using the expression, ‘predominantly disposed by landfilling’, but this is a historical practice and may change as a result of state policy, voluntary action, etc. It would be better to specify in the definition that it is a historical reference to past disposal practice. This is particularly important in light of the way historical practice is accounted for in consequential LCA, where emissions from a proposed product, or activity are compared against a counterfactual scenario without the product of activity. If a definition in regulatory text asserts current or past behavior that does not match reality, quantitative values, including LCFS CI scores, can be affected.

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[34] D. Chakraborty, A. W. Davis, G. Tal, The cost of aggressive electrification targets – Who bears the burden without mitigating policies? Transportation Research Interdisciplinary Perspectives 23, 101006 (2024). https://www.sciencedirect.com/science/article/pii/S2590198223002531
G. Tal, A. Davis, D. Garas, California’s Advanced Clean Cars II: Issues and Implications. (2022). https://escholarship.org/uc/item/1g05z2x3
A. Mandev, F. Sprei, T. Gil, Electrification of Vehicle Miles Traveled and Fuel Consumption within the Household Context: A Case Study from California, U.S.A. World Electric Vehicle Journal 13, 213 (2022). https://www.proquest.com/docview/2748382187

[35] C. W. Murphy, Making Policy in the Absence of Certainty: Biofuels and Land Use Change, ITS (2023). https://its.ucdavis.edu/blog-post/making-policy-in-the-absence-of-certainty-biofuels-and-land-use-change/.

"Forest" - The attempt to specify concrete quantitative criteria for the definition of 'forest' is helpful, however different state or federal authorities in the United States may have different definitions for 'forest'. For example, the Natural Resources Conservation Service under USDA characterizes forest land use as land with at least 10 percent cover by trees that will be at least 13 feet (4 meters) tall at maturity, and the land also shows evidence of natural tree regeneration. The LCFS definition should generally align with prevailing definitions in regulatory or scientific literature, unless there is a reason to pick an alternative.

"Fugitive methane" - The definition specifies quantifying using standard values, or a site-specific energy balance of methane within the system boundary. 'Standard values' is vague, and simply because a value is 'standard' does not mean it is accurate, nor even that it reflects the most up-to-date scientific understanding. Moreover, novel approaches for site-scale fugitive methane emissions measurement are being developed; this definition should be expanded to allow such direct measurement, once it has been appropriately validated.[36]

"Hydroprocessed Ester and Fatty Acid (HEFA) Fuel" - A definition of 'lipid feedstock' is required to avoid misinterpretation. We assume that the intent is to limit the definition of lipids to mean non-fossil lipids produced from biomass, such as vegetable oil, tallow, used cooking oil, etc. The proposed definition is not entirely clear whether something like pyrolysis oil made from non-edible cellulosic biomass would be considered a lipid for the purpose of this definition.

"Renewable Diesel" - The definition only includes hydrotreated lipids, biocrudes, or the products of the Fischer-Tropsch process within its definition. Other chemical synthesis approaches other than F-T may become feasible sources of feedstock for hydrotreating in the future, and thus, the present definition may overly limit the scope to exclude them.

"Renewable Naphtha" - Similar to "Renewable Diesel", the definition may overly limit the scope of potential feedstock sources and exclude relevant future chemical synthesis processes.

"Residue" - While the intent of this definition is clear, the lack of any testable significance threshold leaves it open to a variety of competing interpretations. Similar to the definitions of 'byproduct' and 'coproduct' (discussed above) a specific quantitative significance threshold could enhance the clarity of this definition.

Additionally, the proposed definition of 'residue' limits its scope of applicability to biofuel production, excluding other uses in bioenergy or bioproduct systems that could be relevant to future LCFS pathway certification or broader trends in the development of a circular economy. It

[36] Z. Zhu, J. Gonzalez-Rocha, Y. Ding, I. Frausto-Vicencio, S. Heerah, A. Venkatram, M. Dubey, D. Collins, F. Hopkins, Toward on-demand measurements of greenhouse gas emissions using an uncrewed aircraft Aircore system. Copernicus GmbH [Preprint] (2023). https://doi.org/10.5194/egusphere-2023-1527.

would seem that this definition could classify something as a residue when it's used for biofuels, but not if it were combusted to produce electricity, or used as a feedstock for bioplastics.

Finally, the definition relies on establishing that a given material either has no significant value, apart from that which it could gain as biofuel feedstock, or that there would be significant costs for alternative management or disposal costs for fates other than use as a biofuel feedstock. Without a clearly identified significance threshold, this definition may be open to multiple competing interpretations.

This definition also omits a significance threshold for the term 'secondary,' which would allow for a variety of products or activities to be classified as residues inappropriately. If a producer creates a product that is used as a biofuel feedstock from which they obtained 49% of their total revenue stream, it could be classified as a 'residue' under this definition, provided that it had no market value outside of its use as feedstock and that alternative disposal would entail 'significant' cost, despite the fact that producers would certainly optimize their production process to maximize the value of something that provided nearly half of their revenue. For example, if a soybean producer demonstrated that there was no market available for their soybean oil, due to local dietary preferences or lack of appropriate food-grade shipping capacity, they could claim that such oil was a residue for the purpose of LCFS pathway certification under this definition, despite that claim seeming to contradict the intent of this provision. Clarifying a significance threshold around the term 'secondary' and aligning that with definitions for 'byproduct' and 'coproduct' would provide additional clarity.

"Shared MHD-FCI charging site" - Requiring at least two MHD EV fleets under different ownership does not strongly distinguish it from a private station especially given that 'ownership' is undefined and does not recognize the wide variety of ownership, leasing, joint-venture, holding company, franchise or other management structures. A single holding company that creates two independent subsidiary entities for the purpose of vehicle ownership would seemingly qualify as two fleets under this definition. Clarifying the meaning of 'ownership' could help ensure that the intent of this provision is accomplished.

"Shared MHD-HRI station" - The same concern as in 'Shared MHD-FCI charging site' applies here.

Section 95482 Fuels Subject to Regulation

§95482 (f) - Depending on characteristics related to the method of palm oil production and conversion, transportation fuel derived from palm oil or palm derivatives may have a higher carbon intensity than fossil ULSD. Assigning it the CI score of ULSD may therefore underestimate its actual impacts.

§95482 (g) - As discussed in the definition of "Break ground," above, the current proposal could allow projects to perform a minimal amount of earthmoving during a period while a given class of pathway is open to new applications, but delay the majority of construction (along with completion and commissioning) by a significant amount of time. Provisions in the HRI and FCI protocols that allow, but do not require, a pathway application to be canceled if the project is not operational within 24 months of pathway approval offer (e.g. § 95486.3 (a)(4)(F)) offer some assurance that delayed construction can not allow a pathway to be certified after it would otherwise be ineligible, however delays during the pathway approval process plus the 24 month allowed window between pathway approval and the station becoming operational mean projects may not actually go online until significantly more than 2 years after the window of eligibility has nominally closed. Not all potential pathways with limited temporal windows of eligibility have equivalent limitations, as well. Specifying the need for groundbreaking to be shortly followed by continuous construction, or extending requirements for prompt completion of pathways could reduce this risk.

Section 95483 Fuel Reporting Entities

§95483 (c)(1)(A) 5. - The proposed amendments to this section would eliminate the eligibility of "Multilingual marketing, education, and outreach designed to increase awareness and adoption of EVs, clean mobility options, and including information about: the environmental, economic, and health benefits of EV transportation…." as an acceptable use of EDU holdback credits. Developing the EV market in California to the point where it is fully self-sustaining, and no longer needs policy support is a goal of California's decarbonization policies, including the Advanced Clean Cars 2 rule. There are still significant gaps in consumer awareness of EVs, as well as the personal and/or environmental benefits they offer. Recent surveys by the UC Davis Electric Vehicle Research Center find the majority of California consumers still cannot correctly name a single model of EV, indicating a massive need to improve awareness of EVs.[37] Eliminating marketing and outreach activities from eligibility to be supported by EDU holdback credits may delay resolution of this problem. While it is important to ensure that EDU holdback credits are spent efficiently, and the value of marketing and outreach can be difficult to quantify, current evidence indicates such outreach may still have a role in California's policy portfolio.

§95483 (c)(5)(b)(i) - Proposed amendments would create a new category of projects which utilities can support using revenue EDU holdback credits; among them are investments in grid-side distribution infrastructure for EV charging. While there are clearly critical needs to upgrade the grid to support expanded EV charging, EDUs already have mechanisms to fund these upgrades, through utility rate-basing under authority, subject to CPUC regulation and

[37] Hoogland, et al. (2024). https://www.sciencedirect.com/science/article/pii/S2590198223002543
Kurani (2022). https://escholarship.org/uc/item/8738w7m3

approval. Investor-owned utilities (IOUs) are granted the right to claim a rate of return on capital investments made on approved project types. The proposed amendments would make some EV-related projects eligible to be supported by a new revenue stream. It is uncertain, and not explored in the ISOR, how this revenue would interact with CPUC regulation, and whether IOUs will be able to claim an equivalent rate or return on capital projects funded by holdback revenue. If they can, this raises questions about whether LCFS revenue (which predominantly comes from credit acquisition costs passed on to gasoline consumers) is an appropriate source of utility revenue and potential profit for IOUs. Similarly, care should be exercised to ensure that this revenue actually results in additional EV charging infrastructure, rather than having utilities compensated twice (once by normal CPUC approved methods and once by EDU holdback revenue) for the same work.

Section 95484 Annual Carbon Intensity Benchmarks

§95484 (b)(2)(A) defines $\textit{Deficits}_{20xx}$ as “the total number of deficits generated under the program…”. This could be misinterpreted as cumulative program deficits rather than total annual deficits for year *20xx*. This should be clarified.

§95484 (b)(2)(B) - The proposed auto acceleration mechanism relies on two trigger criteria being simultaneously true: the Credit Bank to Average Quarterly Deficit Ratio exceeding three, and credits exceeding deficits for the given year. These conditions could be simultaneously true under market conditions that would not otherwise warrant an AAM triggering event, such as an anomalous net credit surplus year during a multi-year period of credit bank decline. For example, in the analysis of the proposed impacts of current amendments presented in the *Renewable Diesel Capacity Growth and 2030 Targets* section above, we show projections of credit balance and bank for the proposed amendments through 2035. After the second projected AAM triggering event increased the 2030 target to 39%, the credit bank began a period of gradual decline, though the Credit Bank to Average Quarterly Deficit Ratio remained above 3 through 2035. Under these conditions, if a single year in this period happened to yield a net credit surplus, as could happen due to another pandemic-driven temporary drop in gasoline consumption, a third AAM event would be triggered and the gradual decline in banked credits could turn into a precipitous drop into profound credit insufficiency.

This outcome could be prevented through the adoption of a longer look-back period, such as the prior three years. This would reduce the chance that one anomalous year during a multi-year period of declining credits could not trigger an unadvised AAM event.

Additionally, the proposed AAM action mechanism, advancing two years on the compliance schedule rather than one, can risk pushing the market into credit insufficiency in certain conditions, as we described during our presentation at the May, 2023 workshop on Auto

Acceleration mechanisms.[38] This risk magnifies as the yearly increase in CI target goes up, as it does after 2030 in the proposed compliance schedule. These risks could be mitigated by adopting an automatic relaxation mechanism in addition to the AAM; this mechanism would return to the previous compliance schedule when certain criteria were met, such as the Credit Bank to Average Quarterly Deficit Ratio dropping below 1.

§95484 (d) Table 1 - The CI values shown in the table are slightly different from the CI values shown in Table 1 of the Initial Statement of Reasons.

§95484 (f) Table 3 - The CI benchmarks for 2019 to 2022 for SAF have been updated, but it is not clear whether these would be applied retrospectively or whether they imply any changes to past crediting. We assume no retroactive adjustments are implied, however this should be clarified.

Section 95486 Generating Credits and Deficits

§95486 (b)(1) Table 4 - “Renewable Gasoline” has been added to the table, but its definition has not been provided. A definition of “Renewable Gasoline” should be included in section 95481.

§95486 (b)(2) - After 2028, fossil jet fuel will start generating deficits, however the equation for total deficit generation $Deficits^{Gen}(MT)$ does not include a term for deficits from jet fuel.

Section 95486.1 Generating and Calculating Credits and Deficits Using Fuel Pathways

§95486.1 (a) - The equations specified in sub-parts (1)-(3) embed an assumption related to emissions benefits due to the displacement of fossil fuel by vehicles with an EER>1. As discussed in the section *Fractional Displacement Crediting Approach for Fuels with EER>1,* this assumption will become less appropriate over time given the growing presence of ZEVs and other vehicles with EER>1 in the fleet. Algebraically rearranging this set of equations to separate GHG reductions from fuel displacement effect from GHG reductions due to the lower CI of fuels on an equal energy basis provides a more clear and transparent representation of the GHG reductions being evaluated. Separating the terms also allows for a new term to be introduced, *Displacement Fraction*, that allows the replacement of the previous assumption of fuel displacement determined by EER ratio under all conditions, at all times. Equation 1, below, describes the proposed replacement for the equations in §95486.1 (a).

$$Credits_i^{XD}(MT) = \left(CI_{standard}^{XD} - CI_i\right) \times E_i \times C + \left(EER^{XD} - 1\right) \times CI_{standard}^{XD} \times E_i \times F_{displaced}^{XD} \times C$$

[38] https://ww2.arb.ca.gov/sites/default/files/2023-05/UCDavis_052323.pdf

Where $CI^{XD}_{standard}$ CI_i, E_i, EER^{XD}, and C are unchanged from their current definition and $F^{XD}_{displaced}$—"Displacement Fraction"—is the fraction of theoretical displacement to be credited under the given pathway. The fraction of the fleet still using the incumbent, higher-emitting technology (e.g., ICE) is a reasonable approximation here. Note that when $F^{XD}_{displaced}$=1, this equation gives identical results as the equations currently used in §95486.1 (a). These issues are discussed in depth in Murphy (2022)[39]

Section 95486.2 Generating and Calculating Credits for ZEV Fueling Infrastructure Pathways

§95486.2 (a)(7) - The proposed amendments would delay implementation until 2026. This would seem to allow a number of new proposals to be certified under the existing protocols as specified in §95486.2 (a). The new LD-HRI protocols have enhanced requirements relating to disadvantaged community benefit, limitations against crediting in excess of 1.5 times net capital expenditure, and improved financial transparency. No justification for the delay in implementation is given. Presumably, the delay is meant to allow projects that have begun work under the expectation of being governed by the existing HRI protocols to finalize and submit their applications. Given the highly public nature of the LCFS rulemaking and the fact that HRI project developers are typically in contact with LCFS program staff at multiple points in the pre-application process, we are not aware of any significant benefit from this delay. A more rapid implementation would more quickly bring the improvements in the amended protocols into action. Additionally, given the reduced cap on LD HRI and FCI credit generation, delaying implementation allows more projects to apply under the existing protocols and as a result, a greater fraction of credits from this class of pathways would go to projects approved without the additional disadvantaged community benefit, cost containment, and transparency requirements. Maximizing the number of projects subject to the new rules could improve total benefits from the program, especially as they relate to disadvantaged communities.

§95486.2 (a)(7)(F) - These amendments indicate that if estimated LD-HRI credits (i.e. those approved under the rules added by the proposed amendments, after January 1, 2026) exceed 0.5% of prior quarter deficits, then no new LD-HRI pathway applications will be accepted or approved. It is not clear, however, what happens if LD-HRI credits are less than 0.5% of prior quarter deficits but HRI credits (those approved under the existing protocol) are greater than 0.5% of prior quarter deficits, or if the sum of HRI and LD-HRI credits exceed 0.5% after January 1, 2026. Clarifying this behavior, especially regarding the possibility of the sum of HRI and LD-HRI credits exceeding 0.5% of prior quarter deficits would be helpful.

[39] Murphy (2022); https://escholarship.org/uc/item/0px4m8hz

§95486.2 (a)(7)(J) - The proposed amendments would require annual financial reporting by LD-HRI operators to the Executive Officer. Publishing anonymized versions of this data, or averages of all LD-HRI projects would provide additional transparency for the program and help researchers better understand revenue dynamics in this policy domain, while still protecting project operators confidential business information

§95486.2 (b)(1)(C) - The proposed amendments specify protections against non-additionality of infrastructure capacity. These same conditions would also help guarantee the additionality of LD-HRI pathways as well, we suggest staff consider applying them to both LD-HRI and LD-FCI,

§95486.2 (b)(7)(E) - There is a potential typo, which uses the “MHD” subscript in an equation for LD-FCI. If this subscript is intentional, then the descriptions following the equation should be updated.

§95486.2 (b)(7)(J) - Similar to §95486.2 (a)(7)(J) (see above) publication of anonymized data or averages across all approved pathways would help improve program transparency and support research into this topic.

Section 95488.1 Fuel Pathway Classifications

§95488.1 (c) and (d) - Hydrogen pathways have been removed from the list of Tier 2 classification and moved to the Tier 1 list. Although hydrogen produced from steam methane reforming of methane and electrolysis are comparatively well understood and may appropriately belong in the Tier 1 classification, other methods for hydrogen production may emerge over time, and if so, would be most appropriately assessed by a Tier 2 classification.

Section 95488.3 Calculation of Fuel Pathway Carbon Intensities

§95488.3 (d) Table 6 - As discussed earlier in the section *Sustainability Challenges From Excessive Consumption of Lipid-Based Biofuels*, existing Land Use Change Values, as shown in the table, are likely out of date, since they rely on now-dated ILUC modeling methods. The models used to generate them were based on the assumption of a biofuel-demand shock that does not accurately reflect current market conditions. As a result, they are insufficiently protective against significant ILUC impacts, particularly critical for crop-based oils like soy and canola. Updating the Land Use Change Values presented in Table 6 to reflect current scientific understanding of the natural and economic factors surrounding ILUC, or developing a new, more robust approach would protect against these risks, however either of these approaches are likely to require multi-year research, development, and consultation processes. A cap on lipid- or crop-based feedstocks can be more quickly implemented, would provide certainty that ILUC risks could be appropriately mitigated, and could be used as a temporary measure until the development of a more flexible and robust approach.

Section 95488.8 Fuel Pathway Application Requirements Applying to All Classifications

§95488.8 (g)(1)(A)(3) - The proposed amendments intend to protect against the risk that use of forest residue for biofuel production could lead to expanded clear-cutting or other unsustainable forest management methods. This intent reflects an important consideration when leveraging forest resources for this purpose. Referencing existing code or statute related to sustainable forest management, such as the California Forest Practice Rules, or applicable US Forest Service guidance, could improve the clarity and transparency of this section. In particular, the proposed amendments require ascertaining the intent of management interventions in order to ensure only residue biomass subsequent to activities for the “purpose of forest fire fuel reduction or forest stand improvement” can be used. Providing an objective criteria by which to ascertain this intent could be helpful, provided it does not open new loopholes leading to unsustainable practices.

§95488.8 (i)(1)(B)(3) - Proposed amendments seek to ensure claimed GHG benefits satisfy tests of additionality by specifying that environmental attributes or certificates credited or used for compliance under any programs other than the RFS or the cap and trade program would be ineligible. As discussed in the section *Reevaluating Previous Assumptions Around Additionality*, above, existing approaches to additionality determination may deserve reconsideration, including the explicit eligibility of environmental instruments credited under the RFS and cap and trade programs, effectively exempting them from the requirements specified in this provision. As technologies, markets, and consumer behavior evolve, GHG assessment methodologies may need to evolve as well, particularly as it pertains to subjective determinations like system boundary establishment, counterfactual specification, and additionality determination. A comprehensive review of additionality in LCA contexts, including their use to inform policy, would help determine whether changes to this or other LCFS provisions is appropriate.

§95488.8 (i)(1)(C) - The proposed provisions would set limitations on the characteristics of low-CI electricity used for direct air capture (DAC) projects or hydrogen used as a transportation fuel. First, §95488.8 (i)(1)(C) should specify “hydrogen made by electrolysis” since these requirements predominantly only apply to electricity.

More substantively, while they provide some clear guidance that will help ensure that GHG reductions from electrically-powered projects match those predicted by the project’s CI score, they do not align with current best practices in this space. A potentially superior approach was developed in Europe’s Delegated Acts on hydrogen, and proposed in draft regulation regarding the U.S. Section 45V tax credits. Known as the “three pillars” approach to sustainable low-carbon electricity, they require low-CI electricity to be additional to existing regulatory requirements, deliverable to the point of demand, and time-matched at hourly time scales to avoid exacerbating grid peaks or indirectly expanding the use of fossil fueled power generation.

[40,41] The proposed language in §95488.8 (i)(1)(C) 1. captures deliverability, and §95488.8 (i)(1)(C)5. offers a limited approach to additionality requirements, with several specified exceptions. Hourly time matching is, however, excluded. Fully implementing hourly time matching may be beyond the capability of electricity tracking, certification, and accounting systems at present. The EU Delegated Acts offer a delay, until 2030, before the hourly matching provisions are fully enforced. Adopting a similar approach may be advisable in this case. Committing to such an adoption now sends a strong signal to the market to ensure such capabilities are developed, and allows project developers ample time to prepare for the new requirements. Adopting them into the LCFS would align it with best practices from around the globe on this issue and ensure that expanding demand from electrolysis, e-fuel production, or other electrically-powered GHG reduction measures do not cause fossil fueled power plants to be used more than they otherwise would.

§95488.8 (i)(3) - Proposed amendments specify the protocols by which hydrogen can be injected into a pipeline system and subsequently used to fuel vehicles, or as an input to other fuel production. This section omits requirements to regularly assess and report the leakage rate of hydrogen from pipelines and associated equipment. An extensive body of research has documented routine leaks from existing natural gas pipelines. Hydrogen, a much smaller molecule than methane, is likely to pose equal or greater risk of leakage from pipelines or related infrastructure. Given hydrogen's status as a secondary GHG, accurate assessment of the GHG impacts of fuels using pipeline-transported hydrogen requires accurate data about leakage rate.

§95488.8 (i)(3)(B) - The proposed provisions specify minimum GHG thresholds to be met in order for pipeline-transported hydrogen to be eligible for credits. The proposed language specified "well-to-wheel" carbon intensity. This means that different hydrogen vehicles could yield different carbon intensity scores, even when fueled by identical fuel, due to the effect of the EER on well-to-wheels CI. To match the presumed intent of this provision, the proposal should either specify well-to-tank CI, or specify an EER to use when calculating well-to-wheels CI.

Section 95488.9 Special Circumstances for Fuel Pathway Applications

§95488.9 (g) - The proposed provisions would adopt sustainability requirements for feedstocks coming from crops or forest biomass. In general, sustainability requirements like those proposed in this section provide increased assurance that biofuel, bioenergy, or bioproduct feedstocks do not cause excessive environmental harm and that their real GHG benefits match their assessed

[40] http://data.europa.eu/eli/reg_del/2023/1184/oj

[41] See: https://energy.mit.edu/wp-content/uploads/2023/04/MITEI-WP-2023-02.pdf, https://iopscience.iop.org/article/10.1088/1748-9326/acacb5/meta, and https://www.evolved.energy/post/45v-three-pillars-impact-analysis for additional description and analysis on the three pillars approach.

values. That general conclusion applies in this case as well, however several specific considerations and cautions apply to their application in the LCFS as proposed by this section.

First, as discussed in the section *Sustainability Challenges From Excessive Consumption of Lipid-Based Biofuels*, above, sustainability requirements like those proposed here are not capable of effectively mitigating indirect risks, like ILUC, which is a primary vector for GHG and ecosystem risk *vis a vis* current biofuel production systems. Regardless of the specific merits of any sustainability certification system, additional precautions are required to address ILUC.

Second, the scope of sustainability certification excludes used cooking oil and other waste lipid feedstocks. These feedstocks present very high risk of mislabeling or other fraudulent activities due to the higher value of the biofuels produced from them. While such feedstocks do have chain-of-custody requirements per §95488.8 (g) these are limited to chain-of-custody and record retention requirements meant to aid in audits of feedstock flow. Integrating these particularly risky feedstocks into certification requirements provides additional structure and empowers third-party certification bodies to more effectively identify and respond to examples of mislabeling, feedstock adulteration, or other fraud.

Third, §95488.9 (g) specifies the requirements apply to "land that was forested after January 1, 2008," however it is unclear whether "forested" is being used as a verb or adjective in this sentence, which determines whether the scope is any land that had forest cover after the specified date, or land that was *afforested* or transitioned from some other land cover to forest after that time. Given the context, the adjective use appears more likely, but additional clarification could resolve any ambiguity.

Section 95488.10 Maintaining Fuel Pathways

§95488.10 The proposed amendments to this provision may result in reduced credit flows to and/or increased credit flows from the administrative buffer account used to protect against some forms of credit invalidation risk, and to help facilitate certain administrative transactions. No analysis is provided to characterize the anticipated changes to credit flows through the buffer account, the risk of buffer account insufficiency, or the impacts of such insufficiency. It is difficult to evaluate the likely impact of these amendments without such analysis.

Section 95489 Provisions for Petroleum-Based Fuels

§95489 (c) and (e) - Existing provisions to generate LCFS credits from the reduction of GHG emissions during crude production and transport or at petroleum refineries align with the intent of the LCFS, and support continued incremental decarbonization of California's transportation fuel portfolio, provided that the credited reductions actually match real-world GHG impacts. These provisions may be improved however, by stronger requirements to demonstrate the additionality of approved projects, such as a requirement that emission-reducing projects provide emissions benefits in excess of industry standards, or by requiring facility-level mass/energy flow assessment instead of the current requirement that system boundaries for these assessments include only direct and first-order indirect impacts.

§95489 (c)(1)(A)2. - Capturing anthropogenic carbon for sequestration or reuse aligns with the intent of the LCFS, however the proposed language may allow producers to create a new stream of CO_2 in order to subsequently capture it for credit generation. Limiting the eligible sources to those that existed at the time these provisions were adopted would help ensure that captured CO_2 provides additional GHG benefits.

§95489 (c)(1)(D) - On page 189 of Appendix 1 of the rulemaking package is a reference for which it is difficult to interpret which section of the proposed code it falls under. It states “The innovative method must achieve an emission reduction of at least 1,000 metric tons of CO_2e per year”. It appears that this is intended to be part of §95489 (c)(1)(D), but this should be clarified to prevent confusion. Moreover, we could ascertain no reason for reducing the threshold for crediting from the previous 5,000 metric tons to 1,000.

§95489 (c)(1)(G) - As discussed in the section *Reevaluating Previous Assumptions Around Additionality,* above, a comprehensive review of existing considerations around additionality is warranted. The specified exemptions from the usual practice that prevents the use of environmental attributes credited under the cap and trade system from supporting claims of emissions reductions should be reevaluated as part of that review.

§95489 (e)(1)(D)1. - Proposed language specifies capturing anthropogenic sources for the purposes of LCFS crediting. Similar to §95489 (c)(1)(A)2. above, this may allow sources created for the purpose to gain LCFS credits in a way that would render the claimed emissions benefits non-additional..

§95489 (e)(1)(D)3. - Existing language specifies that use of lower-CI process energy, such as biomethane, can be credited for GHG reductions from the displacement of fossil fuels. It is unclear from this provision whether book-and-claim accounting can be used to provide this biomethane or if it must be directly supplied.

§95489 (e)(1)(D)5. - Existing language specifies that curtailment “exclusively for the reduction or cessation” of fuel production is excluded. This definition relies on ascertaining the facility operator’s intent behind any curtailment or capacity reduction, and the use of the word “exclusively” further limits the degree to which this provision is protected against issuing credits for curtailment. Providing objectively determinable criteria for determining whether reduced production should qualify for crediting would improve the clarity and actionability of this provision.

Additionally, as California continues along its path to carbon neutrality, demand for petroleum fuels will necessarily decline, meaning that some refinery capacity may no longer be needed, especially as other jurisdictions that may previously have been markets for refined products exported from California advance along the same trajectory. It may be worth considering whether there is a role for the LCFS in facilitating the shutdown of older, less efficient refineries, or those in or near disadvantaged communities to help California achieve its climate and equity goals. This would entail leveraging the LCFS in a novel way with a wide variety of tradeoffs that would require diligent consideration prior to action, however using the LCFS to help manage the wind-down of California's refining sector may offer significant long-term efficiency advantages. Exploration of this concept is outside the scope of the present rulemaking, however and would require a new rulemaking to fully implement, at which point the provisions in this section could be modified to accommodate the new application of the LCFS.

§95489 (e)(1)(K) - As with §95489 (c)(1)(G) and other sections, the exclusion of environmental attributes credited under the cap and trade or other climate programs may represent an opportunity to improve the treatment of additionality in the LCFS and should be reviewed as part of a comprehensive reevaluation of additionality provisions.

§95489 (f) - As with §95488.8 (i)(1)(C), aligning LCFS requirements on electricity used for hydrogen production with the "three pillars" approach better aligns it with global best practices in this space.

§95489 (f)(1)(E) - As with §95489 (c)(1)(G) and other sections, the exclusion of environmental attributes credited under the cap and trade or other climate programs should be part of a comprehensive review of additionality provisions. .

Section 95490 Provisions for Fuels Produced Using Carbon Capture and Sequestration

§95490 (a)(1) - This section proposed changes to the LCFS provisions on carbon capture and sequestration (CCS), however it retains previous language which limits the definition of CCS to applications in which CO_2 is geologically sequestered. Emerging options for carbon removal may exist that do not sequester CO_2 geologically, such as being converted into non-consumable products including concrete or building materials, or absorbed into carbonaceous minerals via enhanced weathering. The present provision may overly limit the scope of sequestration options; defining sequestration to include conversion to a solid form stable over geologic time scales could resolve this oversight and support innovative approaches to CO2 sequestration.

§95490 (b)(8)(B) - As with §95488.8 (i)(1)(C), above, aligning requirements for low-carbon electricity with the "three pillars" approach reflects global best practices and minimizes the risk on unwanted GHG emissions.

§95490 (c)(2)(A) - Proposed amendments require that if a CCS project uses CO_2 that was previously being captured for industrial use, any replacement for that lost gas comes from new or expanded capture of anthropogenic CO_2 sources. Given that CO_2 is regularly captured for industrial use (e.g. soda carbonation or dry ice production) it is appropriate that CCS projects the deploy new CO_2 capture capacity receive more credit for the additional reduction of net GHG emissions than a project that simply redirects existing captured CO_2 and overlooks measures taken by industrial entities to replace the lost supply. This is especially true given that the intent of the CCS Protocol in the LCFS was to support the deployment of novel technology.

Section 95500 Requirements for Validation of Fuel Pathway Applications; and Verification of Annual Fuel Pathway Reports, Quarterly Fuel Transactions Reports, Crude Oil Quarterly and Annual Volumes Reports, Project Reports, and Low-Complexity / Low-Energy-Use Refinery Reports

§95500 (c)(1)(A)8. - Proposed LCFS amendments would add fossil jet fuel used for intrastate travel to the LCFS as an obligated, deficit-generating fuel starting in 2028. Recordkeeping for aircraft entails several additional considerations compared to ground-based transport. Aircraft operators may fuel aircraft with more fuel than required while in jurisdictions that do not regulate or tax fuel, in order to reduce costs. Carrying the extra fuel over a full leg of a flight entails extra weight on the aircraft, and therefore, higher fuel burn. Preventing this behavior, known as “tankering,” therefore not only helps ensure that the regulatory intent is fully executed, but also reduces emissions. Tankering may be a strategy used by some aircraft operators to minimize costs associated with jet fuel deficit obligations under the LCFS. To mitigate this risk, the ReFuel EU protocol, for example, requires that at least 90% of fuel needed for all intrastate routes be loaded in the EU otherwise additional deficits to achieve 90% equivalence will be assigned. Adopting this approach, or similar ones may require additional fuel transaction records. Recordkeeping requirements as specified in this, or other provisions, should ensure adequate recordkeeping and transparency to allow effective action to prevent tankering.

Appendix A-2. Proposed Regulation Order

Section 95486.3 Generating and Calculating Credits for ZEV Fueling Infrastructure Pathways

§95486.3 (a)(1)(B)2. - The proposed amendments require an MHD-HRI station be “or on or adjacent to a property used for medium or heavy-duty vehicle overnight parking,” this is insufficiently defined or described. It could refer to a parking lot in which only a very small number of vehicles park, or even personal property on which an owner-operator parks their vehicle. Such small-scale parking would conflict with the intent of the HRI and FCI provisions to support the deployment of capacity that can serve all, or at least significant fractions of future

MHD ZEV fleets. As the MHD-HRI application must be approved by the Executive Officer before generating credits, empowering the Executive Officer to reject or demand amendments from applications that attempt to circumvent the intent of these LCFS provisions could mitigate this risk.

§95486.3 (a)(1)(D) - Clause (D) appears to contain redundant sub-clauses (D)2. and (D)3. Editing or clarification could improve this section.

§95486.3 (a)(3)(A) - Proposed language limiting the total credit generation from MHD-HRI provisions aligns with previous HRI provisions by testing to ensure that the sum of issued credits plus potential credits from approved pathways does not exceed the specified level. If the Executive Officer approves multiple installations simultaneously, the aggregate cap could be exceeded. This protocol should clarify that approvals happen one at a time in sequence, rather than simultaneously in batches, for the purpose of assessing whether the credit generation cap has been exceeded.

§95486.3 (a)(3)(A)2. - This provision proposes to limit the credits generated by any one applicant to 1% of prior quarter deficits. Limiting credits to any single entity can help ensure equitable, competitive access to LCFS support. The proposed provisions, however, may not achieve this goal. As discussed in our comments on the definition of “Shared MHD-FCI charging site,” a variety of corporate structures exist that could allow a single entity to control multiple nominally independent entities, thereby becoming eligible to receive credits in excess of 1% of prior quarter deficits.

Additionally, FPSM modeling of the LCFS credit market indicates that the program will generate 40 million or more deficits per year in the early 2030’s. 1% of this implies 400,000 or more credits could be issued to one entity. Assuming a credit price of $100, this would allow up to $40 million or more to go to an individual entity. We question whether this outcome is intended, or if it aligns with LCFS program goals. It also differs from comparable requirements for MHD-FCI shown in §95486.3 (b)(3)(A)2.

§95486.3 (a)(4)(G) - The concept of limiting capacity credit revenue to a specified fraction of total capital minus grant revenue seems appropriate to avoid additionality issues. However, this section appears to be referencing wrong sections. Instead of §95486.3 (a)(6)(B)1, 95486.3 (b)(6)(B)5 and 95486.3 (b)(6)(B)6, it may have intended to reference §95486.3 (a)(6)(C)1, 95486.3 (a)(6)(C)5 and 95486.3 (a)(6)(C)6.

§95486.3 (b)(1)(B)2 - Proposed language adopts the same definition of eligibility for MHD-FCI sites as §95486.3 (a)(1)(B)2, and the same concerns apply.

§95486.3 (b)(2)(F) - The proposed language seeks to set requirements for project developers to disclose total site power, however it makes no distinction between instantaneous power or that which can be sustained for any length of time. In order to prevent stations with limited ability to sustain charging operations under heavy use from receiving LCFS incentive, a minimum sustained time for maximum or near-maximum charging could be specified.

Initial Statement of Reasons

On page 116 during the discussion of the EJ alternative, a statement referring to the proposal to "Cap the use of lipid biofuels (commonly known as crop-based biofuels)," was made. In the context of biofuels and the feedstocks used for them, crop-based biofuels and lipid biofuels share a subset, namely crop-based vegetable oil biofuels, but they are not synonyms. Some crop-based biofuels are not made from lipids and some lipid biofuels are not crop-based. References to various lipid-based fuels in the proposed amendments suggest that this sentence in the ISOR is simply an imprecise choice of words, rather than evidence of any fundamental misunderstanding or conflict with other provisions, but this should be clarified.

Thank you again for the opportunity to provide comments on the proposed amendment package. We appreciate the discussion this process has fostered so far and look forward to continuing our dialog through the coming year. We attach to this submission copies of the three recent reports from our research group related to research and modeling the LCFS, they are also available at the links cited in this letter. If we can offer any additional assistance or clarify any of the material in this comment, please do not hesitate to reach out to Colin Murphy by email at cwmurphy@ucdavis.edu.

Signed,

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