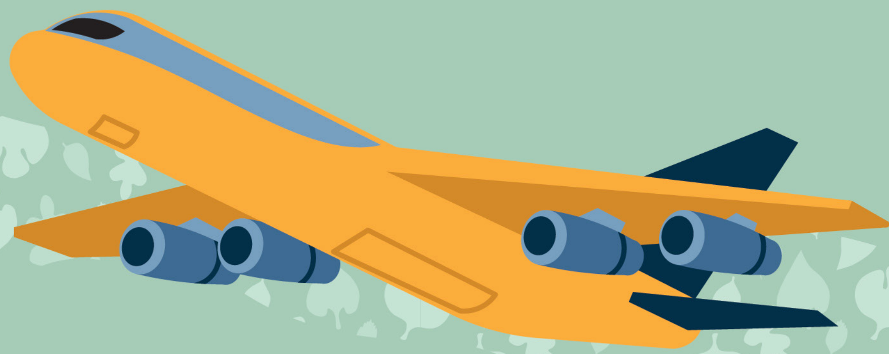

Towards a Federal Low Carbon Fuel Standard for Aviation

THIRD WAY

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THIRD WAY

Towards a Federal Low Carbon Fuel Standard for Aviation

by Fred Ghatala, John Hebert, and Alexander Laska

Executive Summary

Following the passage of the US Inflation Reduction Act of 2022 (IRA) in August 2022 and the release of the Sustainable Aviation Fuel Grand Challenge in September 2021, it is all but indisputable that there has never been more momentum towards establishing Sustainable Aviation Fuel (SAF) production and use in the United States. Specific implementation details aside, addressing aviation emissions is clearly moving up on the US federal government's 'to do' list. New tax credit incentives, grant programs, and increased research and development funding have created a strong foundation for expanding the currently nascent SAF industry. However, the industry still lacks the required policy elements to enable sufficient long-term growth and stability in this emerging market.

The SAF industry has thus far relied on the voluntary actions by end users to achieve environmental, social, and governance (ESG) pledges or related net-zero commitments. These commitments are laudable, but history suggests that they will ultimately be insufficient to create the necessary investment conditions for widespread low carbon fuel production in this sector. So long as SAF use remains voluntary, end users are likely to have economic disincentives to be more aggressive in their acquisitions of SAF and the industry will be slow to scale.

This paper contends that the key missing ingredient in the US's approach to SAF is the creation of firm demand through a federal, carbon intensity (CI) based aviation-specific Low Carbon Fuel Standard (LCFS) that incorporates a minimum volumetric requirement alongside a CI reduction target. This approach utilizes a type of regulatory structure pioneered in British Columbia's Low Carbon Fuel Standard that joins elements of a Renewable Fuel Standard (RFS) alongside a LCFS within the same regulation to create clear signals for low CI fuel production and use. Clear demand-side policy is arguably the essential ingredient to transition SAF from a boutique fuel with relatively limited production volumes to one that is used in levels similar to, if not surpassing, renewable fuels in gasoline and diesel, with the potential to meet the SAF Grand Challenge's vision of complete jet fuel replacement by 2050.[1]

As is discussed later in this paper, a federal aviation-specific LCFS should incorporate the following design considerations:

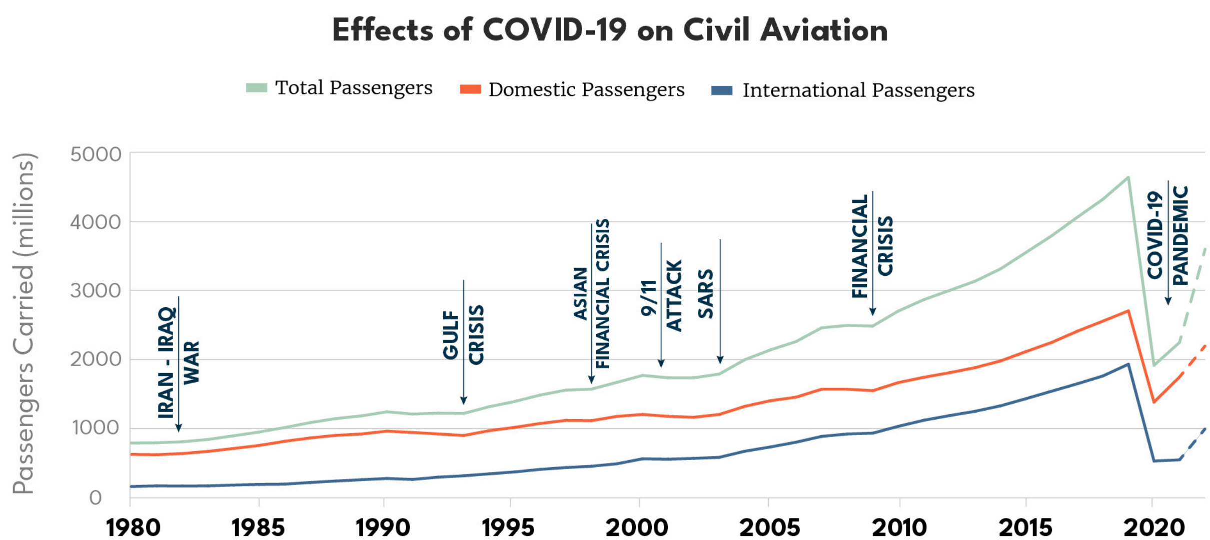
1. The policy must establish clear and aggressive targets, in both the near (annual increments) and longer (decadal, to 2050) terms.
2. The policy must be aviation-specific and not permit GHG reductions (compliance credits) to come from other sectors of the economy (including ground transportation).
3. The aviation-specific LCFS should focus on displacing fossil jet fuel, therefore, opportunities from upstream (fossil fuel) emissions abatement must be limited.
4. An aviation-specific LCFS should not overly emphasize consistency with other systems (e.g., ICAO CORSIA) or jurisdiction that have differing approaches to renewable fuel policies (e.g., outright prohibitions on agricultural or forestry biomass regardless of sustainability or 'land use and biodiversity' type certifications).
5. An aviation-specific LCFS should be technology and feedstock neutral.
6. An aviation-specific LCFS must be based on transparent life cycle analysis (LCA) using equivalent system boundaries.
7. An aviation LCFS should incorporate a progressive minimum SAF blend requirement, established at the outset of the regulation and increases annually until a fixed date, at which point it is maintained constant while the necessity of a SAF blend rate is transparently reviewed.
8. For implementation, policymakers may consider a 'trigger threshold' that defines the conditions required for an aviation-specific LCFS to begin or increase in aspiration.

While some legislative proposals exist for an aviation-specific LCFS, or the inclusion of aviation within a broader federal LCFS, this paper suggests that the statutory authority for implementing such a standard already exists. The Federal Aviation Administration, under 49 U.S. Code § 44714, is required to prescribe standards for aircraft fuel to control or eliminate aircraft emissions that the Environmental Protection Agency has determined to endanger the public health or welfare pursuant to Section 231 of the Clean Air Act. SAF has the benefit of reducing both GHG emissions and particulate matter, creating a strong case for leveraging SAF as a solution to this problem.[2] This paper further argues that issuing an aviation-specific LCFS under this authority would provide an important investment signal for SAF at a critical time in the industry's development.

Introduction

The aviation sector accounts for 1 billion tonnes of GHG emissions, approximately 3% of total global emissions, and strong future emissions growth is expected.[3] Aviation is viewed as a 'hard to decarbonize' sector primarily due to its reliance on energy-dense, liquid fossil fuels, especially for long-haul flights. While aviation has pursued and achieved increases in fuel use efficiency, the expected post-pandemic sector growth levels make efficiency alone insufficient to reduce aviation's emissions impact.

Commercial aviation's recent ride has been turbulent: within the past 36 months, US commercial aviation traversed from historic highs of 2019, the year in which the highest number of flights in a single day was recorded (225,000), to the historic lows of 2020 in which demand dropped by 66% compared with the previous year.[4] This was the sharpest annual reduction in aviation's history before rebounding back to 69% of pre-pandemic levels as of Q2 2022.[5]



Source: ICAO Air Transport Bureau. "Effects of Novel Coronavirus (COVID-19) on Civil Aviation: Economic Impact Analysis." International Civil Aviation Organization, 27 Jan. 2023, www.icao.int/sustainability/Documents/COVID-19/ICAO_Coronavirus_Econ_Impact.pdf.

During this same period, jet fuel prices ranged between $90/barrel in June 2019, down to less than $15/barrel in April 2020, and back up to over $175 per barrel in June 2022. Although air traffic is not yet back to 2019 levels and the sector's workforce remains hindered by the after-effects of the COVID-19 pandemic, aviation has, by and large, re-emerged.

With this re-emergence, aviation's carbon footprint is edging back into the crosshairs of public perception. While the widespread pre-pandemic emergence of 'flygskam', or flight shaming, may be yet to recuperate its momentum, aviation emissions are firmly on the regulatory agenda of policymakers around the globe.[6]

A key factor influencing the continued focus on aviation's emissions is the rising profile of Sustainable Aviation Fuel (SAF). SAF has emerged as the readily accessible solution to improving the environmental impact of the aviation sector and a means to create economic development benefits along the fuel's supply chain.

Sustainable Aviation Fuel: the emergent solution to aviation emissions

SAF is a drop-in renewable hydrocarbon fuel, a category that broadly includes renewable distillates, renewable gasoline, and co-processed renewable feedstocks. Like other renewable hydrocarbon fuels, SAF is produced through a wide variety of biological materials like lipids (oils and fats), sugar and starches, and lignocellulosic materials. SAF can be made with non-biomass materials, including green hydrogen, industrial off- gases, and carbon directly captured from the air.

While SAF is not the only mechanism through which the aviation industry is seeking to lower emissions, it will undoubtedly be the most important tool in getting the industry on a path to net-zero by mid-century. A wide range of technology and operational improvements, ranging from more efficient airframes to reduced engine taxiing, will help airlines improve fuel efficiency at a rate of 1-2% per year through 2050.[7] However, these improvements only constitute a fraction of the emissions reductions needed within the sector.[8] The rest will need to be abated by SAF.

The leading barriers to SAF's commercial deployment relate to its (1) elevated production cost and market price vs. fossil Jet A/A1 fuel, (2) higher production cost and lower compliance value compared with Renewable Diesel, and (3) the inability for producers to have a viable business case that attracts sufficient investment relative to other alternative fuels.[9] Unlike SAF, Renewable Diesel in the US normally sells into a market in which there are requirements for diesel fuel to incorporate renewable content either in response to a blend percentage requirement, or in the cases of California and Oregon, as a means to achieve Carbon Intensity emission reduction targets.

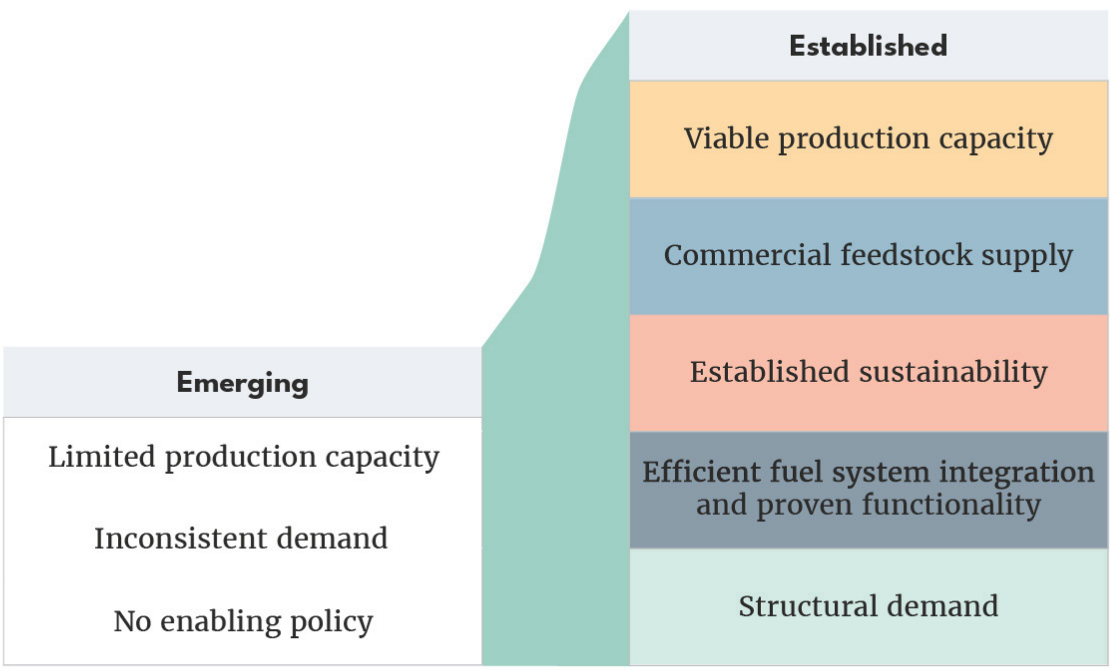
Since the first demonstration flight in 2009, SAF use has expanded to thousands of commercial flights, with at least five airports having continuous supply available.[10] Multiple airlines have used SAF in commercial flights, with select airlines using SAF on an ongoing basis. Current ongoing airline and business aviation use demonstrates that SAF can be seamlessly integrated into existing fueling infrastructure and commercial aircraft fleets. Given that airlines' fuel use represents over 95% of their total emissions, SAF is considered by both policymakers and the informed public as the primary means through which the sector can achieve emission reduction goals. This is understood as the key reason why renewable and low carbon fuel policies (RFS, LCFS) were modified post-implementation to include SAF as a compliance credit-generating pathway with relative ease.[11] While SAF use has benefited from inclusion in existing renewable and low carbon fuel policies, it has always been disadvantaged relative to other fuels (e.g., ethanol, biodiesel, renewable diesel) due to its higher production cost and the current reality that jet fuel is not obligated under US policies as both diesel and gasoline are.[12]

Transitioning SAF from an Emerging to an Established Sector

Despite nearly 15 years of progress, increasing familiarity, successful trials, and constantly growing volumes of fuel purchase offtake commitments, SAF remains a boutique fuel, characterized by limited production capacity and inconsistent demand. In other words, it has only just initiated the sector build out and emission reductions potential that are possible if it followed the trajectory of other established renewable fuel types. Industry observers ask: 'if this fuel is usable up to 50% under ASTM 1655 and ASTM 7566, then why are we at a fraction of a percent in the US?'

The answer to their challenge is that some, but not all, of the required elements are in place for SAF's transition to an established sector:

Transitioning SAF from an emerging to an established sector



Source: Canadian Biojet Supply Chain Initiative. "Executive Summary: Feasibility study of Canadian biojet fuel supply chain." https://cbsci.ca/wp-content/uploads/CTI_Biojet_-Combined_Executive_Summary.pdf

Viable SAF production capacity, albeit limited, is operating continuously and able to fulfill a portion of the current market demand.[13] SAF is made by commercial-scale facilities rather than at bench or demonstration scales. While there are new SAF production technologies and process configurations being developed that must progress through the required 'Technology Readiness Level' steps, there is currently available SAF in the market, predominantly via the HEFA pathway.

Commercially available feedstock for SAF production means the sector's near-term expansion does not hinge on materials yet to be commercially available. Feedstock supply will always be intrinsic to SAF policy discussions (as with all types of renewable fuels), however, there exists quantities of material with consistent quality to permit continuous 'established' fuel production.

Sustainability certification is in place for SAF production to establish its legitimacy using recognized certification schemes and/or renewable biomass provisions (e.g., 40 CFR § 80.1401) that are recognized in legislation and are essential to ensuring that the SAF supply chain is responsible and able to withstand scrutiny.

Efficient fuel system integration and proven functionality is essential when SAF is introduced into an airport's day-to-day operations. Initial SAF delivery methods relied on fuel trucks to place fuel directly into the aircraft. Airports with ongoing SAF supply utilize the same delivery approach as Jet A/A-1 which is via the co-mingled hydrant fuel supply system.

Structural demand is the remaining fundamental element required for an established SAF sector. This element is characterized by a firm regulatory obligation for SAF to be a part of the jet fuel mix. Demand for SAF that is a result of regulations with enforcement provisions is considered 'structural' and able to support project finance, eventually leading to fuel production and sale. Without this, SAF sales – a foundational element that determines project viability – are not driven by demand able to withstand changing financial performance of the commercial airline sector that may impact ESG-driven corporate commitments.[14]

Recent federal SAF policy advances

The past 12-18 months have been replete with major US federal policy measures intended to help transition SAF from a boutique to an established sector.

SAF Grand Challenge

On September 9, 2021, President Biden announced the SAF Grand Challenge (SGC), a whole-of-government approach to help increase SAF production and deployment to 3 billion gallons per year by 2030 and sufficient SAF to cover all liquid aviation fuel demand by 2050, estimated to be 35 billion gallons.[15] The SGC is built upon collaboration between the US Department of Energy (DOE) as represented by the Office of Energy Efficiency and Renewable Energy (EERE), the Department of Transportation (DOT) as represented by the Federal Aviation Administration Office of Environment & Energy (AEE), and the Department of Agriculture (USDA) as represented by the Office of the Secretary.

While the SGC does not in and of itself include policy support for SAF, it does serve as an effective mechanism for guiding the federal government's extensive research, development, demonstration, and deployment (RDD&D) activities across program offices within each agency. In September 2022, the Administration released a roadmap for meeting the goals of the SGC that outlines dozens of specific workstreams and deliverables to further improve coordination between these agencies.

The Inflation Reduction Act of 2022

The August 16, 2022 signing of H.R.5376 - Inflation Reduction Act of 2022 (IRA) - marks a historic milestone for how the US federal government financially encourages SAF production and use in the US.[16]

Section 13203 of the legislation includes a SAF Blenders Tax Credit (SAF BTC) ranging from a minimum value of $1.25 per gallon to $1.75 per gallon based on the percentage of GHG reduction beyond a 50% reduction threshold pegged to an estimated baseline petroleum jet emission factor. Every 1% beyond the 50% reduction is awarded $0.01 per gallon of additional incentive, to a maximum of $1.75.[17] The SAF BTC is in place from January 1, 2023 until December 31, 2024, at which point it transitions to a Clean Fuel Production Credit (CFPC), also known as Section 45Z, that will be in place from January 1, 2025 until December 31, 2027. In other words, the SAF BTC would be in place for 2 years (2023-2024), with the CFPC in place for 3 additional years (2025 – 2027). The CFPC value for eligible SAF would range from $0.35 to $1.75 depending on the amount of GHG reductions achieved beyond the baseline level of 50 kgC02e/MMBTU and projects achieving the prevailing wage and apprenticeship requirements stipulated in the legislation (and are not reviewed in detail here). Projects failing to meet the baseline Emission Rate of 50 kgC02e/MMBTU would not be eligible to receive the CFPC incentive.

Current SAF BTC and CFPC rates are calculated to be the following based on specified Emission Rates:

Clean Fuel Production Credit Rates

Total Emission Rate (kg CO@e/MMBtu)	Jet % Reduction below 94 kg CO2/ MMBtu	SAF BTC, Max $1.75	SAF CFP Credit, 50 Baseline, %/G
60.0	36%	-	-
55.0	41%	-	-
50.0	47%	-	-
45.0	52%	$1.27	$0.18
40.0	57%	$1.32	$0.35
35.0	63%	$1.38	$0.53
30.0	68%	$1.43	$0.70
25.0	73%	$1.48	$0.88
20.0	79%	$1.54	$1.05
15.0	84%	$1.59	$1.23
10.0	89%	$1.64	$1.40
5.0	95%	$1.70	$1.58
0.0	100%	$1.75	$1.75

Note: Although the SAF BTC is explicitly capped at $1.75, the SAF CFP credit is understood to provide higher credits for fuels with negative emissions rates. These rates are not included in this table.

Source: Calculations based on the formulas defined in IRA Sec. 13203, Sustainable Aviation Fuel Credit and Sec. 45Z. Clean Fuel Production Credit. See United States Congress, House. Inflation Reduction Act of 2022. 117th Congress, 2nd session, House Resolution 5376, passed 16 Aug. 2022. https://www.congress.gov/bill/117th-congress/house-bill/5376/text

The IRA also includes several other policies likely to alter the price competitiveness of synthetic fuels (e-fuels), another form of SAF produced by combining captured CO2 with clean hydrogen.[18] E-fuel SAF has been substantially more expensive in the past than biofuel SAF, primarily due to hydrogen production costs. The IRA helps lower this price barrier by introducing the new 10-year clean hydrogen production tax credit (PTC) to allow producers to receive between $0.60 and $3.00 per kg of hydrogen produced, depending on the carbon intensity of the production process. Alternatively, producers can also elect to take a newly expanded investment tax credit (ITC) to cover the cost of production equipment. There are still some production hurdles to overcome, so although we are likely still some years away from e-fuel production ramping up, the IRA is expected to accelerate investment in these fuels.[19]

Remaining Hurdles

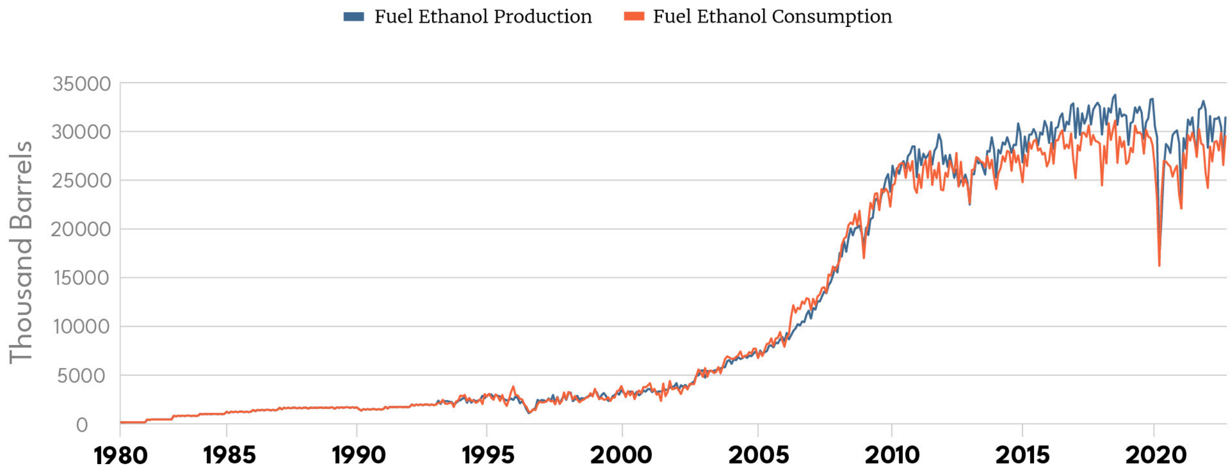
Among the SGC's areas of impact (RDD&D, volumetric production targets, inter-agency cooperation, etc.), its most important component is the clear signal of government intent to create a domestic SAF production sector. Moreover, the SAF-focused measures in the IRA make the SGC's 2030 SAF production goals reasonably feasible.[20] After the SGC's announcement in September 2021 and prior to passage of the IRA in August 2022, there was no line of sight to having the fiscal tools required to progress towards the scale of SAF production envisioned in the SGC (3 BG per year in 2030, 35 BG per year in 2050). Without the financial backing signaled in IRA to assist with SAF blending and production, the SGC would have been a target-setting initiative only. With the SGC's visionary statements for SAF production and the financial incentives included in IRA set to be in place, there remains now a key missing element to create a SAF sector capable of approaching the goals in the SGC.

Following the SGC's announcement and IRA's passage, it remains apparent that both measures stop short of creating a clear obligation for jet fuel suppliers to incorporate SAF into the US commercial aviation fuel mix. The use of SAF therefore relies on the aviation sector's willingness to pay to blend SAF into their fuel supply. This has generally taken form as announced corporate commitments to emission reductions via SAF use, entering into SAF supply agreements, and/or investing in SAF production companies or projects.[21] Aviation's pursuit of SAF is laudable and significant, but is it sufficient to achieve the goals that the SGC sets out? Experience from other transportation sectors suggests that it is not, unless paired with firm regulations.

The Missing Element: The case for firm demand-side SAF policy

The decarbonization journey of gasoline and diesel demonstrate that voluntary action by end users alone is insufficient to create the necessary investment conditions for low carbon fuel production. While there was ethanol production and use in the United States prior to the federal RFS enacted by the Energy Policy Act of 2005, it was not until this statute was in place that ethanol production demonstrably increased.[22] In the same way, while there is currently SAF production and use (that pre-exists any firm demand side policy), commitments made by jet fuel users under ESG and/or net-zero commitments are alone inadequate for bringing about commercially viable SAF production. In practice, SAF's development will be no different from fuel ethanol and renewable diesel fuels (biodiesel, renewable diesel). Firm policy is required that is similar to the demand created by the Energy Policy Act of 2005 which established 'RFS1' and was followed by the Energy Independence and Security Act of 2007 that established 'RFS2'. Without this structural demand, SAF will remain an 'emerging' fuel rather than becoming an established part of the US's jet fuel supply.

Fuel Ethanol Overview



Source: U.S. Energy Information Administration. Monthly Energy Review, Total Energy. Nov. 2022. https://www.eia.gov/totalenergy/data/browser/?tbl=T10.03

Policy Design Frameworks

Policymakers have generally taken one of two approaches to creating structural demand: volumetric blending requirements or carbon intensity-based requirements. These policies are described below:

Renewable Fuel Mandate – a transportation fuel-focused regulation requiring a specific quantity of low carbon fuel to be blended into the fuel supply based on an annual volumetric requirement. Examples of this are the US Federal Renewable Fuel Standard (40 CFR Subpart M - Renewable Fuel Standard) and the Canadian federal Renewable fuel Requirement (SOR/2010-189). Variation exists between implementations of renewable fuel standard-type regulations (e.g., differences in approach to tradable compliance units, flexibilities, penalty amounts, process for establishing % inclusion rates or renewable volume obligations, among others), however, their core principle is to create a firm demand signal for the inclusion of low carbon fuels into the fuel supply during a specified period.

Low Carbon Fuel Standard (LCFS) – this policy works by requiring fossil fuel suppliers to gradually lower the fossil carbon content of the transportation fuels they sell in the market. An LCFS promotes the use of lower carbon fuels by valuing their reduction below an established annual benchmark that decreases over time. The LCFS incorporates lifecycle analysis (LCA) models to establish the Carbon Intensity (CI) scores of each fuel type that can be used for compliance. California's LCFS (CCR sections 95480-95503)), Oregon's Clean Fuels Program (CFP) (OAR 340-253-0040), and the British Columbia LCFS (B.C. Reg. 394/2008) are all examples of this policy type. Of course, variations exist within each specific program.

Leading Examples of Structural Demand Policies in the US

US Federal Renewable Fuel Standard (RFS)

The Renewable Fuel Standard was brought into law via the Energy Policy Act of 2005 and was later expanded through the Energy Independence and Security Act of 2007, both of which amend the US Clean Air Act (CAA), the comprehensive federal law that regulates air emissions from stationary and mobile sources. The RFS is implemented by the US Environmental Protection Agency, in consultation with the US Department of Agriculture and the US Department of Energy.

The RFS works through the annual setting of volume targets for incorporating different categories of renewable fuels into the domestic fuel supply.[23] The categories are: biomass-based diesel (e.g., biodiesel, renewable diesel), cellulosic biofuel (e.g., ethanol derived from lignocellulosic material), advanced biofuel (e.g., biofuels with >50% GHG reduction and are not corn starch ethanol), and renewable (or conventional) fuel (e.g., corn starch ethanol). Each fuel category creates a specific type of Renewable Identification Number (RIN) which represents a gallon of renewable fuel produced using ethanol equivalent gallons. During a compliance year, RINs are used by obligated parties—refiners or importers of gasoline or diesel fuel—to meet their RFS requirements.

In December 2022, EPA proposed a rule update that would allow electric vehicle manufacturers to generate eRINS for electricity produced from renewable biomass.

Depending on the feedstock and production method used, the RFS permits SAF to generate RINs in the biomass-based diesel (D4), advanced biofuel (D5), and cellulosic categories (D3, D7) though aviation fuel does not have any requirements for renewable content inclusion.

California Low Carbon Fuel Standard

California's Low Carbon Fuel Standard (CA-LCFS) regulation was approved by California's Air Resources Board (CARB) in 2009 and implemented in January 2011. The CA-LCFS requires annual reductions in the carbon intensity of California's transportation fuels through a range of low-carbon and renewable alternatives. The CA-LCFS aims to reduce petroleum dependency and achieve air quality benefits in California.[24]

LCFS-type regulations are designed to be technology-neutral by rewarding options that create the lowest cost emission reductions. In 2021, California's LCFS resulted in over 2.5 billion gallons of low-carbon fuels (gasoline equivalent), equating to over 19 million metric tonnes of GHG emission reductions.[25] Aviation fuel is not included in California's LCFS or Cap-and-Trade programs, in part due to deference to the federal government's authority on regulating aviation fuel and aircraft emissions. In other words, fossil jet fuel does not create 'debits' within the California LCFS.

CARB updated the CA-LCFS in January 2019 to enable SAF to generate compliance units, without fossil jet fuel having any obligation to reduce its carbon intensity. This approach is referred to as 'opt-in', with the primary benefit being to reduce the opportunity cost between SAF and RD, even though the cost difference still exists. As of Q2 2019, SAF can create credits in the CA-LCFS. The highest reported annual SAF blend level achieved in California has been 0.25%.

SAF Opt-in Performance in CA-LCFS

	2019*	2020	2021
Jet volume supplied in CA (G)	4,722,114,500	2,884,777,500	3,235,031,500
SAF 2021 volume (G)	1,862,190	4,559,818	8,197,730
SAF 2021 calculated blend level	0.04%	0.16%	0.25%
SAF volume percent of RD	0.30%	0.77%	0.87%

* SAF opt-in as of Q2 2019

Source: California Air Resources Board. LCFS Data Dashboard. ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard. Accessed 31 Jan. 2023.

The relatively low-level blend levels are not surprising as petroleum jet fuel, unlike petroleum gasoline and diesel, does not create debits in the LCFS program and does not fall under California's AB 32 Cap-and-Trade system. The result is that producing SAF is less economically valuable than producing Renewable Diesel from the same feedstock. Despite significant airline interest and publicity within the SAF sector, SAF's opt-in status in California's LCFS and Oregon's CFP has not resulted in strong SAF usage in these markets.

Renewable Fuel and LCFS programs elements work together to drive SAF demand

In general, renewable fuel mandates (RFS regulations) have preceded LCFS regulations in jurisdictions that eventually adopted LCFS regulatory frameworks.[26] The RFS requirements help enable appropriate investments in low carbon fuel production capacity, blending infrastructure, and ensure that fuel delivery systems are in place to scale adoption of higher blends of low carbon fuels over time in response to greater renewable fuel inclusion requirements in the regulation(s). When a LCFS policy is layered with an RFS, LCFS regulations create a direct signal for producers of renewable fuels to pursue lower CI scores to improve their compliance values. This can lead to investment in low CI feedstock supply chains, more efficient production processes, and pursuit of additional opportunities to lower a fuel's CI.

Firm LCFS policies are now driving additional investment; the 5+ billion gallons of anticipated renewable diesel production forecast to come online in the next 3-6 years is testament to the impact that regulations are having on fuel investment decisions.[27] It is asserted here that an LCFS policy—if it would have been brought in without pre-existing RFS policies that already established clear market signals for renewable fuel production in response to regulated demand—would not have had the same impact of causing significant production of renewable fuels (with their corresponding market penetration and emission reductions) to come online. In other words, an LCFS policy dependent on fuels that are not yet in production must be preceded by a volumetric RFS or incorporate a volumetric obligation within its framework.

While neither LCFS-type policies in US states (California, Oregon) incorporate volumetric requirements within their structure, examples from British Columbia demonstrate that these 'quantity and quality' requirements (e.g., volumetric with CI requirements) can proceed through the regulatory development process and establish new clean fuel markets.[28] **Applying progressive SAF blending requirements serves to complement and reinforce the CI reduction signal created through regulation.** This has been demonstrated in the road transportation sector where both RFS and LCFS regulatory signals work together, resulting in lower CI fuels being preferred in markets where this additional signal is present.

As SAF's emergence occurred after the Energy Independence and Security Act of 2007, it is not included in the current federal RFS in a meaningful way. While it is beneficial that SAF generates RINS, these RINS are produced at a disadvantaged rate compared with renewable diesel and are only usable towards compliance in the gasoline or diesel pool obligation (depending on the RIN category produced) rather than within the aviation jet fuel pool itself. SAF's eligibility for LCFS participation has been similarly below expectations.[29] **Based on the results achieved to date from SAF's post-implementation inclusion in existing RFS and LCFS policies, the most useful policy for SAF's expansion is one that creates a volumetric requirement to blend SAF while at the same time requiring CI reductions within the jet fuel supply.**

Policy Principles for a Federal LCFS for Aviation

The design of an aviation-specific LCFS to address GHG emissions from jet fuel combustion benefits from experiences gained through decades of ground-based renewable and low carbon fuel policies. Though aviation is a completely different sector from ground transportation, the key points of policy implementation are highly transferable.

Below are a series of considerations when designing an aviation-specific LCFS:

1. **The policy must establish clear and aggressive targets, in both the near term (annual increments) and longer term.** Since 2007 the global commercial aviation sector is replete with long time horizon goals, termed 'long term aspirational goals' (LTAGs), that are inspirational yet deliberately vague, as they do not include firm SAF use requirements in the 1-to-3-year time horizon. For an aviation-specific LCFS, a feasible longer-term regulatory target should be adopted (e.g., a 30% carbon intensity reduction in jet fuel uplifted in the US by 2035) that is implemented via annual CI reduction requirements. This approach is used in all LCFS policies in the US in Canada. Its usefulness is that it creates near-term certainty for the market while indicating the overall direction of the program. The longer-term targets of the aviation-specific LCFS do not need to match the SGC's goal of a compete jet fuel replacement by 2050. In fact, it will likely be easier to gain airline support for an aviation-specific LCFS if the targets are below the complete jet fuel replacement goal of the SGC.

2. **The policy must be aviation-specific and not permit GHG reductions (compliance credits) to come from other sectors of the economy.** When the CA-LCFS was being designed, it was decided to create a program solely focused on transportation fuels with a compliance market of LCFS credits that was completely separate and distinct from a broader carbon market in which emission reductions could be generated in other sections of the economy (e.g., industrial facility mitigation activities).[30] The LCFS designers at the University of California stated:

   "We do not recommend the use of offsets from outside of the transportation sector, at least initially. Doing so would lessen the incentives for technological innovation within the transportation sector[.]" (Farrell, et al., 2007)[31]

   This proposed approach of limiting participation in an aviation-specific LCFS seeks to address a fundamental shortcoming of the ICAO CORSIA system as it relates to enabling SAF.[32] The ICAO CORSIA system views the emission reductions achieved through offsets created outside of the aviation sector as equivalent to emission reductions achieved through fuel switching within the aviation sector. For this reason, CORSIA is widely viewed as a weak enabling mechanism for encouraging SAF production and use.[33] It is recommended that an aviation-specific LCFS depart from this approach utilized by ICAO's CORSIA system by requiring that the CI of jet fuel be reduced through the inclusion of lower carbon fuels rather than through offsets. Of course, there is a role for using the 'basket of measures' included in CORSIA to reduce emissions in the sector towards Net Zero, however, care should be taken to discourage lower cost offsets from eroding the economic rationale for including SAF in the fuel supply. For this reason, separation for aviation policy instruments is warranted.

3. **The aviation-specific LCFS should maintain a focus on displacing fossil jet fuel, therefore, opportunities from upstream (fossil fuel) emissions abatement must be limited.** California's LCFS allows Carbon Capture and Sequestration (CCS) to generate compliance credits when it is directly linked with refined fuels supplied to the state. It is proposed here that a similar approach be utilized for an aviation-specific LCFS with the modification that the refinery must be supplying jet fuel and that the amount of CCS credits be bound to the percentage of jet output from the refinery. In other words, CCS from the production of gasoline or diesel should not be permitted in an aviation-specific LCFS. Additionally, it is noted that the EU's Fuel Quality Directive limits the participation of CCS (and all upstream emission reductions) to the proportion of the full fuel lifecycle related to upstream activity (~12%).[34]

4. **An aviation-specific LCFS should not overly emphasize consistency with other systems (e.g., ICAO CORSIA) or jurisdictions in the process of implementing SAF-focused policy.** As stated previously, the proposed aviation-specific LCFS differs from the approach used in ICAO's CORSIA system. If it is accepted that the ICAO system will be challenged to create a meaningful signal for SAF production and use (when compared with cheaper offsets), then there is no overriding rationale to seek design consistency with ICAO's program. Clearly, there will be interactions between the ICAO system and any member-state system due to reporting requirements, emission factors (etc.). However, these interactions should not dictate US policy design or be viewed as creating unacceptable administrative burdens, policy complexity, or overlap. Some degree of overlap is useful—SAF's ability to participate in CORSIA as well as a domestic system can reduce policy risk and add certainty that the fuel will be consumed under a system that values its emission reductions.

   Apart from ICAO, Europe is progressing deliberately towards SAF use obligations that are based on the volumetric inclusion requirements most similar to an RFS (rather than a CI reduction requirement similar to an LCFS). The European Union's ReFuelEU Aviation was included in the EU's Fit for 55 in 2030 package that was submitted to the EU Council in July 2021.[35] The updated version of the proposal calls for a 63% overall SAF target by 2050, with a 28% sub target for synthetic fuels emanating from the conversion of carbon dioxide and hydrogen (commonly known as e-fuels). The policy intends to start with a 2% SAF target in 2025, expanding to 5% in 2030. ReFuelEU Aviation has specific requirements on feedstock eligibility (e.g., prohibition on food or feed crops) and contains sub targets (e.g., e-fuel inclusion requirements), that make it dependent on SAF feedstocks and production technologies that are not yet commercially deployed. It is noted that flights within the EU-28 are subject to the EU's Emission Trading Scheme (EU-ETS) which improves the economic rationale for using SAF.

5. **An aviation-specific LCFS should be technology and feedstock neutral.** A central point that differentiates between the US RFS and LCFS policies is that LCFS policies are designed to be technology and feedstock neutral (relying on a CI score alone).

In contrast, the federal RFS contains sub targets for specific fuel types (indicated by types of RINs required for compliance with each years' renewable volume obligation). Under an LCFS, each fuel type applies for and receives a CI score, which determines its compliance value. There are no exclusions based on feedstock type or technology process. For instance, a federal aviation-specific LCFS would not be considered feedstock neutral if it excluded feed and food crop-based fuels a priori (as the ReFuelEU Aviation proposes). When looking at the forthcoming renewable diesel projects in the US that are incorporating flexibility to produce SAF when market demand materializes, the US feedstock mix going into these facilities would likely include agriculture-derived feedstocks that meet the renewable biomass stipulations in the current RFS and potentially come from a jurisdiction with an approved petition for aggregate compliance (in the case of Canadian canola being supplied to RD/SAF facilities).[36]

6. **An aviation-specific LCFS must be based on transparent Life cycle analysis (LCA) using equivalent system boundaries.** The LCA model that is used for determining CI scores under an aviation-specific LCFS must be transparent, utilize current data, and have equivalent system boundaries for the fuel systems being evaluated. For example, emissions from land use changes – both positive and negative – that relate to SAF feedstock production should be included. This can incorporate soil organic carbon sequestration that occurs when regenerative agriculture (e.g., 'no-till') practices are used as well as more efficient application of crop inputs (e.g., nitrogen fertilizer) when there is sufficient evidence (with potential verification and certification) to substantiate the emission values. The LCA approach used under an aviation-specific LCFS should recognize the verifiable opportunities to reduce emissions from SAF feedstock production to SAF delivery to an airport's fueling system.

   It is recognized that Indirect Land Use Change (ILUC) emissions are included in multiple RFS and LCFS policies. In most cases, their inclusion is required by statute. ILUC values (or ILUC 'risk assessments' in the EU and Canadian federal systems) have introduced a level of uncertainty into the eligibility of fuels, most notably renewable fuels from agricultural biomass. At a minimum, the issue of consequential LCA (of which ILUC is a part) should be approached transparently in a way that maintains equivalent system boundaries between SAF and jet fuel and does not create stranded assets (where a SAF pathway is approved though later deemed ineligible because of changing ILUC values or approaches). It is recommended that SAF be treated equivalently to other renewable fuels; it should not have more stringent ILUC or sustainability requirements than what is in place for lower carbon fuels used in ground transportation.

7. **An aviation LCFS should incorporate a progressive minimum SAF blend requirement established at the outset of the regulation and increases annually until a fixed date, at which point it is maintained constant while the necessity of a SAF blend rate is transparently reviewed.** A point of departure of the proposed

aviation-specific LCFS from established LCFS policies in the US states of California and Oregon is that there is a role for minimum SAF blend requirements within the LCFS regulation to provide a clearer signal for SAF production and use. A percentage-based minimum renewable content blend requirement within a CI-based LCFS regulation has been useful in British Columbia's LCFS program because it (1) allowed for both aspects of the regulation to be reviewed and addressed simultaneously (through the same regulatory consultation process) and (2) maintains a 'floor' of quantitative demand for low carbon fuel that is helpful for project investment decision making. Additionally, because CI scores can be extremely negative (some CI scores in California's LCFS are below -500g), a minimum blend rate would ensure the existence of SAF demand under the regulation.[37]

It is proposed that a schedule of minimum SAF blend rates be established at the outset of the regulation rather than being decided annually, like the current RFS's RVO. This would provide stability to fuel producers of the minimum SAF market size.

8. **Policymakers may consider a 'trigger threshold' that defines the conditions required for an aviation-specific LCFS to begin.** This approach would clearly establish when an LCFS would start (or expand) based on enabling factors such as a minimum quantity of installed SAF production. For example, the LCFS could begin when there is sufficient SAF available to supplant a specific percentage of the US's jet fuel supply (e.g., a trigger threshold of domestic SAF production of no more than 0.25% of domestic jet fuel consumption of approximately 27 billion gallons, or 67 million gallons of SAF production).[38] A benefit of this approach is that obligated parties and SAF end users would not be in a situation where a regulation requires fuels that are not yet in commercial production and hence not available. Care should be taken to avoid setting an overly elevated threshold as this could end up forestalling SAF development.

Mechanisms for Implementing a Federal LCFS for Aviation

Positive results from LCFS-type policies implemented in California, Oregon, and British Columbia rightly create interest in advancing a federal-level LCFS, with proposals to create an aviation-specific standard gaining strong momentum in recent years. In 2020, the House Select Committee on the Climate Crisis' Climate Action Plan included a recommendation that Congress develop a national LCFS that builds upon the existing RFS to encourage the use of low-carbon liquid fuels in sectors like aviation.[39] In 2021, Congresswoman Julia Brownley (D-CA-26) introduced the Sustainable Aviation Fuel Act (H.R.741) in the House of Representatives, which among other SAF-related provisions, requires EPA to establish an 'aviation-only Low Carbon Fuel Standard (LCFS) similar to California's successful transportation-wide LCFS'.[40] The aviation-only LCFS in this legislation would target a 20% carbon intensity reduction in aviation fuel used in the US by 2030 and a minimum 50% reduction target by 2050, compared with 2005 average aviation carbon intensity levels.

Statutory Authority for Executive Action

Despite these recommendations and proposals, legislation for addressing aviation emissions has not been passed by Congress in the same deliberate way as for ground transportation fuels. However, the authority for federal action on specifically addressing aviation emissions through requiring lower carbon fuels already exists under current statute.[41]

The relevant statutory authority is:

> **49 U.S. Code § 44714 – Aviation fuel standards**
>
> *The Administrator of the Federal Aviation Administration shall prescribe—*
>
> *(1) standards for the composition or chemical or physical properties of an aircraft fuel or fuel additive to control or eliminate aircraft emissions the Administrator of the Environmental Protection Agency decides under section 231 of the Clean Air Act (42 U.S.C. 7571) endanger the public health or welfare; and*
>
> *(2) regulations providing for carrying out and enforcing those standards.*

The above section reflects the required response to the 2016 US EPA 'endangerment finding' which states that *'greenhouse gas (GHG) emissions from certain classes of engines used in aircraft contribute to the air pollution that causes climate change endangering public health and welfare under section 231(a) of the Clean Air Act'*.[42] In December 2020, under the outgoing Trump administration, EPA published GHG regulations for new airplanes used in commercial aviation which generally matched the emissions standards set in 2017 by the International Civil Aviation Organization (ICAO) and were not viewed as having any impact because the average aircraft being produced in the year of the rule's adoption was already compliant with the 2028 ICAO requirements.[43] In January 2021, the Biden administration listed EPA's rule on aviation emissions (86 FR 2136) as one of the over 100 rules that would be reviewed, with potential options to rescind, suspend, or replace.[44] While the specific approach the administration may take to updating EPA's rule on aviation emissions (86 FR 2136) is yet to be confirmed, it is likely that the statutory authority to proceed with aviation fuel-related policy to reduce GHG emissions and/or particulate matter already exists under 49 U.S. Code § 44714.

A drawback of using this approach is the possibility of policy reversal once a regulation is enacted. However, strong industry support would help guard against this prospect of policy reversal from a subsequent administration. This may be best approached through crafting an aviation-specific LCFS that is feedstock and technology neutral, potentially helping ensure that fuel pathways using feedstocks that include agriculture and forestry materials – which all comply with the US EPA's renewable biomass provisions – can find their place within the regulation.

In terms of airline support, an important consideration in progressing SAF policy via an aviation-specific LCFS is that the GHG reductions targeted by the policy be within the sector's targets towards net zero emissions by 2050 as agreed upon by both the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO).

Conclusion: The Runway Ahead

Following the passage of the US Inflation Reduction Act of 2022 (IRA) in August 2022 and the release of the SAF Grand Challenge in September 2021, there has never been more momentum towards establishing SAF production and use in the US. As this paper notes, the key missing ingredient in the US's approach to SAF is the creation of firm demand through an aviation-specific Low Carbon Fuel Standard that incorporates a minimum volumetric requirement for SAF incorporation into the US jet fuel supply.

As aviation continues to recover from the challenges wrought by the COVID-19 pandemic, SAF provides the opportunity for ensuring that aviation's emissions can decline towards the net-zero targets envisioned for the sector. The significant work ahead pertains to creating clear enabling policy that drives expanded SAF production and use. Thankfully, with the IRA now law and the SAF Grand Challenge targets established, creating an aviation-specific LCFS can use the lessons learned from decades of renewable and low carbon fuel policies in ground transportation.

ENDNOTES

1 US Renewable content inclusion levels calculated via EIA's STEO Data Browser for 2021 accessible at https://www.eia.gov/outlooks/steo/data/browser/

2 Beyersdorf, A. J., et al. "Reductions in Aircraft Particulate Emissions due to the Use of Fischer–Tropsch Fuels." Atmospheric Chemistry and Physics, vol. 14, no. 1, 2 Jan. 2014, pp. 11–23, https://doi.org/10.5194/acp-14-11-2014.

3 Additional aviation emissions related to non C02 climate forcing impacts of aviation contrails and contrail-induced cirrus clouds may become an increasingly established part of quantified jet fuel environmental impacts. This area of analysis, while important, is not explored in detail in this publication; See also World Economic Forum, and McKinsey & Company. Clean Skies for Tomorrow: Sustainable Aviation Fuels as a Pathway to Net-Zero. Nov. 2020. https://www3.weforum.org/docs/WEF_Clean_Skies_Tomorrow_SAF_Analytics_2020.pdf

4 Slotnick, David. "Wednesday Was One of the Busiest Recorded Days in Aviation History — and It's Going to Keep Getting Busier." Business Insider, 25 July 2019, www.businessinsider.com/most-flights-ever-225000-flightradar24-flight-tracking-2019-7.

5 "International Travel Drives May Air Traffic Recovery." International Air Transport Association, 7 July 2022, www.iata.org/en/pressroom/2022-releases/2022-07-07-02/.

6 This is evidenced by SAF demand-side policy efforts in place or underway in countries/blocs such as Norway, Sweden, France, Spain, Netherlands, and at the EU-27 level via ReFuelEUAviation.

7 Air Transport Action Group. "Waypoint 2050." Aviation Benefits beyond Borders, Sept. 2021, aviationbenefits.org/environmental-efficiency/climate-action/waypoint-2050/.

8 It should also be noted that airlines have a financial incentive to reduce fuel usage by optimizing technology or operations, while simply converting from conventional jet fuel to SAF incurs a larger "green premium."

9 The process employed to produce Hydroprocessed Esters and Fatty Acids (HEFA), the predominant HEFA production technology, yields a mix of diesel, jet fuel, naphtha and other light ends.

10 ICAO counts 57 airports distributing SAF, in this paper it is estimated that 5 airports are doing so continuously.

11 SAF was allowed as a compliance pathway in the CA LCFS and Oregon CFP as of Q2 2019. SAF was able to generate RINS as of the same quarter.

12 A detailed review of SAF's incentive gap with renewable diesel is provided by Ghatala (2020), accessible at: Ghatala, Fred. Sustainable Aviation Fuel Policy in the United States: A Pragmatic Way Forward. Atlantic Council, Apr. 2020. https://atlanticcouncil.org/wp-content/uploads/2020/04/AC_SAF_0420_v8.pdf

13 Arguably, the World Energy Paramount SAF production facility has been operational since 2016 and has demonstrated that ongoing SAF is viable even if not as economically attractive as Renewable Diesel production.

14 It is noted that 'structural demand' does not refer to a regulatory obligation to use fuel from a specific SAF producer, rather, it is the obligation that SAF be incorporated into the jet fuel supply.

15 Bioenergy Technologies Office. "Sustainable Aviation Fuel Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel Report." U.S. Department of Energy, 22 Sept. 2022, www.energy.gov/eere/bioenergy/articles/sustainable-aviation-fuel-grand-challenge-roadmap-flight-plan-sustainable.

16 United States Congress, House. Inflation Reduction Act of 2022. 117th Congress, 2nd session, House Resolution 5376, passed 16 Aug. 2022. https://www.congress.gov/bill/117th-congress/house-bill/5376/text

17 The carbon scoring aspect of the credit is calculated using either the International Civil Aviation Organization's (ICAO) lifecycle analysis (LCA) methodology used under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) or a similar methodology to the US RFS program that meets requirements of the US Clean Air Act Section 211(o).

18 The IRA defines "clean hydrogen" as hydrogen produced through a process that results in a lifecycle greenhouse gas emissions rate of not greater than 4 kilograms of CO2e per kilogram of hydrogen.

19 Haley, Ben et al. "Executive Summary: Sustainable Aviation Fuels: Flight Paths to Decarbonization." Third Way. 15 Dec. 2022. https://www.thirdway.org/executive-summary/sustainable-aviation-fuels-flight-paths-to-decarbonization

20 The relative transience of the SAF tax credits means that they are unlikely to influence longer-term investment decisions without a preemptive extension.

21 The Commercial Aviation Alternative Fuels Initiative (CAAFI) maintains a list of SAF offtake agreements and SAF production investments

22 U.S. Energy Information Administration. Current Issues and Trends: Petroleum and Other Liquids. 2022. https://www.eia.gov/dnav/pet/PET_SUM_SND_A_EPOOXE_MBBLPD_A_CUR.htm

23 The RFS mandated statutory minimum volumes until 2022, after which point volumes are set by the Environmental Protection Agency

24 California Air Resources Board. Low Carbon Fuel Standard: About. ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/about. Accessed 31 Jan. 2023.

25 California Air Resources Board. LCFS Data Dashboard. ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard. Accessed 31 Jan. 2023.

26 Specific examples of this are California's LCFS, Oregon's CFP, British Columbia's LCFS all being preceded by federal programs that included specific volumetric requirements. In the case of British Columbia, a federal volumetric requirement was accompanied by a provincial requirement.

27 Kotrba, Ron. "US Renewable Diesel Capacity Projected to Hit 5.1 Billion Gallons per Year by 2024." Biobased Diesel Daily, 22 July 2021, www.biobased-diesel.com/post/us-renewable-diesel-capacity-projected-to-hit-5-1-billion-gallons-per-year-by-2024.

28 British Columbia's LCFS and the Canadian federal Clean Fuel Regulations (CFR) both incorporate both volumetric requirements and CI reductions within a single regulation.

29 As described previously, SAF achieved a 0.25% level of incorporation in California in 2021.

30 Farrell, Alexander, et al. A Low-Carbon Fuel Standard for California Part 2: Policy Analysis | Transportation Sustainability Research Center. University of California Berkeley Institute of Transportation Studies, 1 Aug. 2007, tsrc.berkeley.edu/publications/low-carbon-fuel-standard-california-part-2-policy-analysis.

31 Ibid.

32 Adopted in 2016 by the International Civil Aviation Organization (ICAO), the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is a global market-based measure to manage and reduce aviation's emissions through the use of eligible 'emission units' to offset an airline's emissions. CORSIA recognizes emission reductions achieved through SAF and provides a lifecycle analysis methodology to calculate the emissions performance of the fuel.

33 Lin, Max. "ICAO's Carbon Offset Scheme Fails to Promote Sustainable Aviation Fuel Use." S&P Global Commodity Insights, 11 Aug. 2022, www.spglobal.com/commodityinsights/en/market-insights/latest-news/agriculture/081122-icaos-carbon-offset-scheme-fails-to-promote-sustainable-aviation-fuel-use.

34 The European Fuel Quality Directive is essentially a static LCFS that stipulates a CI reduction of transport fuels by a minimum of 6% by 2020 and thereafter. Ongoing compliance with the FQD are expected to be achieved through a mix of biofuels, electricity, less carbon intense fossil fuels, and renewable fuels of non-biological origin (such as e-fuels). Compliance can be achieved through a reduction of upstream emissions (such as flaring and venting) at the extraction stage of fossil feedstocks; See also "Guidance note on approaches to quantify, verify, validate, monitor, and report upstream aviation emission reductions." European Commission. Accessed 30 Jan. 2023. http://fuelreport652.gr/wp-content/uploads/2019/01/GUIDANCE-NOTE.pdf

35 Think Tank. ReFuelEU Aviation Initiative: Sustainable Aviation Fuels and the Fit for 55 Package. European Parliament, 12 Aug. 2022, www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698900.

36 Renewable Biomass definition: 40 CFR § 80.1401, aggregate compliance petition: 40 CFR § 80.1457

37 California Air Resources Board. LCFS Pathway Certified Carbon Intensities. ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities. Accessed 23 Jan. 2023.

38 Calculation based on 2019 US Jet fuel consumption as reported by EIA; See Petroleum & Other Liquids, U.S. Energy Information Administration, 30 Jan. 2023. https://www.eia.gov/dnav/pet/pet_cons_psup_dc_nus_mbbl_a.htm

39 "Solving the Climate Crisis: The Congressional Action Plan for a Clean Energy Economy and a Healthy, Resilient, and Just America." House Select Committee on the Climate Crisis, Majority Report. p. 101. https://bonamici.house.gov/sites/evo-subsites/bonamici-evo.house.gov/files/documents/Climate_Crisis_Action_Plan.pdf

40 "Brownley Introduces Sustainable Aviation Fuel Act." Office of U.S. Representative Julia Brownley. 18 Nov. 2020. https://juliabrownley.house.gov/brownley-introduces-sustainable-aviation-fuel-act/

41 See 49 U.S. Code § 44714 - Aviation fuel standards

42 Final Rule for Finding That Greenhouse Gas Emissions From Aircraft Cause or Contribute to Air Pollution That May Reasonably Be Anticipated To Endanger Public Health and Welfare. Environmental Protection Agency. Updated May 24, 2022. https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-finding-greenhouse-gas-emissions-aircraft

43 Ahn, Sungjoo. "EPA's New Aviation Emissions Standard: Why It's Already Obsolete." Environmental & Energy Law Program, Harvard University. 25 Feb. 2021. https://eelp.law.harvard.edu/2021/02/epas-aviation-emissions-standard/; Korkut, Ekrem and Lara Fowler. "Regulatory and Policy Analysis of Production, Development and Use of Sustainable Aviation Fuels in the United States." Frontiers in Energy Research, vol 9, 2021. https://www.frontiersin.org/articles/10.3389/fenrg.2021.750514/full

44 The White House. "Fact Sheet: List of Agency Actions for Review." The White House, 20 Jan. 2021, www.whitehouse.gov/briefing-room/statements-releases/2021/01/20/fact-sheet-list-of-agency-actions-for-review/; Ahn, Sungjoo. "EPA's New Aviation Emissions Standard: Why It's Already Obsolete." Environmental & Energy Law Program, Harvard University. 25 Feb. 2021. https://eelp.law.harvard.edu/2021/02/epas-aviation-emissions-standard/