CEAP | CLEAN ENERGY ACCOUNTING PROJECT

CLEAN FUELS IN THE AVIATION SECTOR

Background Report | August 2024

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Key Takeaways

- Aviation directly accounts for as much as 5% of global warming when considering both greenhouse gas (GHG) emissions and the impacts of water vapor contrails.
- Aviation emissions abatement is dependent on a wholesale switch to sustainable aviation fuels (SAFs). However, since 2020, SAFs production accounted for no more than 0.2% of aviation fuel globally.
- Because SAFs do not generally have sufficient octane, they are usually blended to create jet fuel that is typically around 30% (but up to 50%) SAF.[1]
- In most cases, SAF-blended fuel is certified and transported through normal jet fuel distribution channels to all aircraft at a participating airport.
- Using a mass-balance approach, airlines procuring the SAF are credited for the fraction of the fuel blend that is produced from biological materials.
- A registry for tradeable SAF certificates has been developed, with several organizations producing initial verification and accounting standards.

[1] 50% blended SAF is the maximum blend level permitted under the ASTM D7566 standard for synthesized kerosene derived by alkylation of light aromatics from non-petroleum sources, the standard most bio-based SAFs must meet before they can be certified safe for distribution and use as jet fuel. The maximum blend level to be eligible as a low-carbon fuel under the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is also 50%. Depending on the production pathway, some SAF are restricted to blends as low as 10% to meet ASTM certification standards for safe use as an aviation fuel. See International Air Transport Association (IATA), *SAF Handbook*, May 2024, Table 1. www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-handbook.pdf

1. Introduction

Mitigating emissions from the aviation sector relies heavily on replacing conventional aviation fuels with sustainable aviation fuels (SAFs). SAFs are alternative fuels made from non-petroleum sources (usually renewable or waste-derived) that reduce emissions from air transportation (commonly measured as life cycle reductions of greenhouse gas [GHG] emissions, compared to powering the same flight with conventional aviation fuel).

Creating market incentives enough to generate SAFs in the quantities required to displace large volumes of fossil-based aviation fuel is challenging. Because SAFs are roughly two to six times the price of conventional jet fuel, they still constitute no more than 0.2% of global jet fuel supply as of 2022, despite efforts to promote SAFs and expand their availability.[2]

While there are several initiatives underway to grow the emerging SAF market by applying market-based accounting principles to the sale and purchase of Sustainable Aviation Fuel certificates (SAFc), the sector has not yet adopted a universally accepted book and claim accounting system and many details surrounding proposed market-based systems have yet to be worked out.

2. Aviation Sector Overview

Aviation refers to mechanisms of flight and the operations of aircraft. The global aviation sector is divided into three main types of aviation operations.

Commercial Aviation
Commercial aviation involves operating aircraft for hire to transport passengers or multiple loads of cargo. Any cargo freight transported by air for a fee is considered commercial aviation. In 2019 alone, nearly 47 million commercial flights were scheduled, and that number is projected to double by the mid-2030s, according to the International Civil Aviation Organization (ICAO, the UN agency responsible for coordinating international air navigation).[3]

Military Aviation
Military aviation involves military aircraft for freight or personnel transport or combat operations.

[2] See Airbus, "sustainable aviation fuels: a new generation of reduced emissions fuels," *Airbus.com*, Menu > Innovation >Energy Transition h> Sustainable aviation fuels, 2024. https://www.airbus.com/en/innovation/energy-transition/sustainable-aviation-fuels ttps://www.nortonrosefulbright.com/en/knowledge/publications/f81d3390/new-regulatory-initiatives-supporting-sustainable-aviation-fuel
[3] International Civil Aviation Organization (ICAO). "Future of Aviation," ICAO.org, Home > Meetings & Events > Future of. . ., 2023. https://www.icao.int/Meetings/FutureOfAviation/Pages/default.aspx.

General Aviation
General aviation covers the transport of goods or passengers not through an airline, but generally involving privately-owned aircraft. General aviation includes emergency medical evacuations, humanitarian aid, domestic law enforcement, forest fire response, crop spraying, and private flights not on a commercial airline.

All commercial and general aviation not employed for military or government operations are also referred to collectively as 'civil aviation.'

When the climate forcing impacts of water vapor contrails are included, civil aviation is directly responsible for more than 3.5% of global warming.[4,5] Under a business-as-usual scenario, demand for civil aviation is expected to return to pre-pandemic levels by 2025 and then grow 4% annually thereafter, more than doubling by 2050. Absent serious efforts to decarbonize operations, by 2050 the aviation sector will emit annually more than 3 gigatons of greenhouse gases (GHG), roughly equivalent to the GHG that are removed each year by all the planet's forests, wetlands, and soil combined.[6]

In response to the growing concern over the aviation sector's contributions to global climate change, some leading companies have worked with airlines and fuel manufacturers to execute market-based SAF transactions and have even established a registry for SAF certificates (SAFc), which permit the trading of environmental attributes of SAFs separate from the purchase and distribution of the physical fuel.[7]

3. Sustainable Aviation Fuels (SAFs)

SAFs are biofuels or synthetic fuels produced with little or no lifecycle GHG emissions that can be blended with conventional jet fuel to substantially reduce the total GHG emissions of aviation without requiring significant structural changes to aircraft engines.

Production Pathways and Feedstocks
SAFs can be made from many types of feedstocks (e.g. biomass, forestry residues, municipal waste, cooking oil, renewable natural gas, captured CO_2). Historically, most

[4] International Coalition for Sustainable Aviation (ICSA) and Climate Action Network (CAN). "Contribution of the global aviation sector to achieving Paris Agreement climate objectives," *Joint input to the Talanoa Dialogue*, April 5, 2018. https://unfccc.int/sites/default/files/resource/156_CAN%20ICSA%20Aviation%20TD%20submission.pdf. More updated (2022) data is included in Overton, Jeff. *The Growth in Greenhouse Gas Emissions from Commercial Aviation* (2019, updated 2022), Issue Brief, Environment and Energy Study Institute, June 9, 2022. https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation.
[5] Note that this figure includes both direct GHG emissions and the climate forcing impact of water vapor contrails, which some researchers estimate are equal or greater to the climate forcing impacts of aviation's direct emissions alone. See Dr. Edward Gryspeerdt as quoted in Fredenburgh, Jez. "Clouds created by aircraft have a bigger impact than the emissions they emit," *Imperial*, November 30, 2022. https://www.imperial.ac.uk/news/242017/clouds-created-aircraft-have-bigger-impact/.
[6] Codur, Anne-Marie and Jonathan Harris, *After COP26: Why Forests and Soil Will be Crucial to Climate Policy*, Global Development Policy Center, Boston University, April 22, 2022. https://www.bu.edu/eci/2022/04/22/after-cop26-why-forests-and-soils-will-be-crucial-to-climate-policy/.
[7] Climate Action, "Major corporates join forces to purchase sustainable aviation fuel certificates at scale," *Press Release*, April 6, 2023. Available at: https://www.climateaction.org/news/major-corporates-join-forces-to-purchase-sustainable-aviation-fuel-certific

SAFs have been produced using renewable biomass and other organic waste streams (agricultural and forestry residues, municipal solid waste, used cooking oil, etc.). All commercially produced SAFs available today use biogenic feedstocks and are considered biofuels.

Regardless of the feedstocks used to produce them, most SAFs are chemically equivalent to kerosene and are considered "drop-in" fuels, which can substitute for up to 50% of fossil fuels without any modifications to typical commercial aircraft engines in use today. In practice, however, most airlines use a blend that includes only 30% SAF.[8]

Traditionally, SAFs could comprise no more than 50% of a jet fuel blend because the cleaner fuels generally do not contain sufficient aromatic hydrocarbons to maintain the high-octane rating required of aviation fuel.[9] However, new advances in synthesized biofuel aromatics could make 100% SAF blends achievable in practice. In 2023, Virgin Atlantic provided proof-of-concept by fueling a transatlantic flight entirely with SAF.[10]

There are dozens of ways to generate SAF, but the final product must meet ATSM D1655, the standard required of common (JetA) aviation fuel. In many cases, the fuels must also meet ATSM D7566, the standard that defines the minimum characteristics of aviation turbine fuel, including fuels manufactured from non-petroleum sources.

ASTM has approved seven different SAF production pathways, but the majority of SAF being produced today is the product of one of three major processes:[11]

3.1 Hydrodeoxygenation of vegetable oils and fats (HEFA)

The HEFA production process involves running pre-treated and purified waste oils and fats through metal catalysts that replace the oxygen from fat molecules with hydrogen. HEFA is the most mature and most widely used SAF production pathway.[12] One reason is that it can produce fuel from a wide variety of feedstocks, including used cooking oil, all vegetable-based oils (palm, canola, corn, etc.), and animal fat.

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[8] See Airbus, supra note 1. Also, Boeing disclosed that it uses a 30% SAF blend to fuel roughly 20% of Boeing commercial operational flights in the U.S. See Boeing, "Boeing Makes its Largest Purchase of Blended Sustainable Aviation Fuel," Boeing.com, Press Release, Boeing > Investors > News >Press Release Details > Boeing Makes..., April 16, 2024. https://investors.boeing.com/investors/news/press-release-details/2024/Boeing-Makes-its-Largest-Purchase-of-Blended-Sustainable-Aviation-Fuel/default.aspx.

[9] Gilmore. L. and D. Kettner. "Viewpoint: Bio-based Aromatics Point the Way to Burning 100% SAF," *Aviation Week and Space Technology*, February 7, 2024. https://aviationweek.com/business-aviation/aircraft-propulsion/viewpoint-bio-based-aromatics-point-way-burning-100-saf.

[10] Virgin Atlantic Airways Ltd. "Virgin Atlantic flies world's first 100% Sustainable Aviation Fuel flight from London Heathrow to New York JFK," *P.R. Newswire*, November 28, 2023. https://www.prnewswire.com/news-releases/virgin-atlantic-flies-worlds-first-100-sustainable-aviation-fuel-flight-from-london-heathrow-to-new-york-jfk-301998557.html

[11] ASTM International (formerly the American Society for Testing and Materials) is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

[12] Delnegro, L. "The Journey of SAF: The Production Met5hods & Documentation," *Aviation International News*, April 1, 2023. https://www.ainonline.com/aviation-news/business-aviation/2023-04-01/journey-saf-production-methods-documentation.

3.2 The Fischer-Tropsch (FT) Method of Converting Gas to Liquid

Any carbon-containing material (including biological material) can be gasified and converted to a liquid fuel using the Fischer-Tropsch (FT) method.[13] The FT method converts any gas mixture of carbon monoxide and hydrogen (sometimes referred to as 'syngas') to jet fuel using a sequence of chemical reactions involving iron, cobalt, nickel, and ruthenium, each of which adds additional hydrogen atoms to carbon and oxygen.

Typically, the FT method has been used to produce aviation fuel from coal (particularly by China) or from biomass waste. The largest SAF production facility under construction—BP's facility in Louisiana—will use a modified FT method that uses captured CO_2 as a feedstock to produce more than 600,000 tons of SAF annually.[14]

3.3 Power-to-liquid (PtL) or e-fuels

Hydrogen is an essential precursor in several SAF production pathways. The P2L process uses the same FT method but generates the needed hydrogen and carbon through low- or zero-emissions processes. Renewable energy is used to crack highly purified water into green hydrogen. The carbon feedstock is generated from capturing CO_2, converting it into liquid hydrocarbons, and then purifying it to meet ASTM standards.

PtL methods also consume vast quantities of ultrapure water, which goes through electrolysis to 'crack' H_2O into its component parts. The water purification process typically requires reverse osmosis, an energy-intensive method of sifting water through a very fine membrane. Under current reporting protocols, any amount of fossil-based electricity can be used to power the reverse osmosis process without impacting characterization of the produced fuel as 'green'.

The "e-fuels" resulting from the PtL process are differentiated from biofuels because they do not involve decomposition (natural or forced) of biological material. Instead, they achieve low direct emissions because of the renewable energy used to generate the power needed for electrolysis and by using captured CO_2 as an input.[15]

Certification of Production
SAF production pathways are certified by the International Civil Aviation Organization (ICAO), but each batch of SAF developed in the EU also obtains a Certificate of

[13] The method is named for the two scientists who developed the process in the 1930's to permit Nazi Germany to manufacture liquid fuels from the country's abundant coal supply.
[14] Staff. "Fischer-Tropsch method chosen for world's largest SAF production plant," *New Energy World*, April 17, 2024. https://knowledge.energyinst.org/new-energy-world/article?id=138706.
[15] Bennet, Helena and Sophia O'connell. *Preparing for Takeoff: Speeding up the switch to sustainable aviation fuel,* Green Alliance, May, 2022. https://green-alliance.org.uk/wp-content/uploads/2022/05/Preparing-for-take-off.pdf.

Sustainability (COS), which is issued by an accredited organization certifying that the SAF's origin and production pathway meet the criteria of a given sustainability standard.[16] [17]

While the International Energy Agency (IEA) has identified 67 sustainability programs in operation or development around the world, the European Commission formally recognizes the following 15 voluntary and national certification sustainability schemes as being compatible with both the EU Renewable Energy Directive (RED) and the EU Emissions Trading Scheme (EU-ETS):[18] [19]

1. 2BSvs (Biomass Biofuels voluntary scheme)
2. AACS (Austrian Agriculture Certification Scheme)
3. Better Biomass
4. Bonsucro EU
5. ISCC (International Sustainability and Carbon Certification)
6. KZR INiG System
7. RedCert
8. Red Tractor (Farm Assurance Combinable Crops and Sugar Beet Scheme)
9. RSB (Roundtable on Sustainable Biomaterial)
10. RTRS EU RED (Round Table on Responsible Soy EU RED)
11. SBP (Sustainable Biomass Program)
12. Scottish Quality Farm Assured Combinable Crops Scheme
13. SURE (Sustainable Resources Voluntary Scheme)
14. TASCC (Trade Assurance Scheme for Combinable Crops)
15. UFAS (Universal Feed Assurance Scheme)

As with conventional fuel, each batch of SAF produced generates a batch number and undergoes a full conformity test to generate a Refinery Certificate of Quality (RCQ). The RCQ is the definitive original document describing the quality of an aviation fuel product. It contains the results of measurements made by the supplier of all the properties listed in the latest issue of the relevant specification. It also provides information regarding both the type and amount of any additives and includes details identifying where the SAF originated.

Distribution Networks

If a refinery produces SAF, blending usually occurs at the refinery and distributed through the same pipeline system used for fossil jet fuel. If the SAF producer is not located within easy access to fossil jet fuel, blending occurs at a suitable point along the supply chain, such as an intermediate storage facility or a blending tank at the airport.

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[16] International Air Transport Association (IATA). *IATA Guidance Material for Sustainable Aviation Fuel Management, 2nd edition,* 2015. https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/iata20guidance20material20for20saf.pdf.

[18] European Union. Voluntary schemes, *energy.ec.europa.eu*, Home > Topics > Renewable Energy > Bioenergy > Voluntary schemes, 2024. https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en.

Pure (neat) SAF must be blended with conventional jet fuel upstream of an airport's fuel farm, then blended and certified to ASTM D7566 specifications for blended alternative jet fuel before it is released into an airports full farm, where jet fuel is stored until pumped for flight.

When blended SAF is certified to ASTM standards a Certificate of Analysis is issued. A COA documents all the properties mentioned in the standard, including the identity of the original supplier and what fraction of the blended fuel is biogenic, which is essential for assigning the blended fuel a net emissions factor. Once certified, the SAF blend can be handled and used just like conventional fossil jet fuel.

Early SAF supply chains were completely segregated from existing jet fuel supply chains, so that specific aircraft could be fueled with specific SAF. However, today, most SAF is integrated into existing jet fuel supply chains to minimize the additional operations and cost.

For the few supply chains that remain segregated, the SAF arrives via dedicated fuel truck or other transport mode and is transferred into dedicated airport refueler trucks. This way, the 100% SAF product can be physically delivered to a specific aircraft.

SAF that is co-processed with conventional jet fuel at an existing petroleum refinery flows through the supply chain via pipeline to terminals and/or airports and is treated no differently than conventional fuel.

This process means that all aircrafts refueling at the airport physically receive part of the SAF. The entity owning the non-energy attributes of the SAF, however, holds exclusive claim to the benefits derived from the volume fraction of the fuel blend that is SAF, which is usually calculated using a mass-balance approach.

The ICAO publishes on its website a list of the airports that receive and distribute SAF. As of January 2024, the ICAO listed more than 120 airports worldwide (four in the US, all residing in California) receiving SAF from 290 different supply facilities.

Allocation of Non-Energy Attributes
Physical segregation of biological materials is often practically and economically infeasible. Mass-balance is one of several attribute allocation methods that are used to track and verify the allocation of non-energy attributes when ownership of the physical fuel transfers from one entity to another.

Under mass balance, the specified attributes of a batch of biological material entering the SAF refining process are tallied prior to entering the production pathway of the fuel. When the material is processed into SAF and blended with conventional jet fuel, the attributes are allocated to units of the physical fuel blend in proportion to the amount of material input to the pathway. This ensures that the amount of produced

SAF blend that can claim to exhibit specified attributes does not exceed the amount of material with those attributes that that entered the production pathway.[20]

4. Regulations and Initiatives

As SAF manufacturing and distribution has matured, several national governments and multilateral institutions have adopted (or are in the process of adopting) SAF blending mandates, emissions accounting standards, tax incentives, and other regulations intended to speed the uptake of SAFs. Indeed, by the end of 2023, the IATA identified no fewer than seven different organizations working on book-and-claim accounting systems of SAF.[21] Other initiatives include:

4.1 Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Exactly 80 countries have joined the International Civil Aviation Organization's voluntary Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).[22] In 2027, CORSIA requirements will become mandatory for countries with large aviation sectors.[23]

CORSIA was designed to help airlines that could not access SAFs logistically or affordably purchase carbon offsets equivalent to the carbon reductions they could achieve by consuming SAFs. The offsets are generated by projects around the world that claim to produce net negative emissions.

Under CORSIA, airline operators with annual emissions greater than 10,000 tons of CO_2 voluntarily report their emissions from international flights on an annual basis. Operators must keep track of their fuel use for each flight and calculate their CO_2 emissions applying one of five approved fuel use monitoring methods. After a 3-year compliance period, operators must demonstrate that they have retired enough offset credits to cover their excess emissions.

CORSIA allows aircraft operators to reduce offsetting requirements using CORSIA eligible fuels (which include both SAF and low-carbon aviation fuels).[24]

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[20] See International Sustainability and Carbon Certification (ISCC). *ISCC Plus, vol. 3.4*, September 1, 2023. https://www.iscc-system.org/wp-content/uploads/2023/03/ISCC-PLUS-System-Document_V3.4.pdf.
[21] International Civil Aviation Organization (ICAO), *SAF accounting and Book & Claim systems*, ACT-SAF presentation series #6, October 20, 2023. https://www.icao.int/environmental-protection/Documents/ACT-SAF/ACT%20SAF%20Series%206%20-%20SAF%20accounting%20and%20book%20and%20claim%20systems.pdf
[22] ...as of publication of this document.
[23] Lampert, A. "How the aviation industry's carbon offset scheme will work," *Reuters*, September 27, 2019. https://www.reuters.com/article/idUSKBN1W91AO/.
[24] International Civil Aviation Organization (ICAO), *Sustainable Aviation Fuels Guidance*, version 2, December 2018. https://www.icao.int/environmental-protection/Documents/Sustainable%20Aviation%20Fuels%20Guide_100519.pdf.

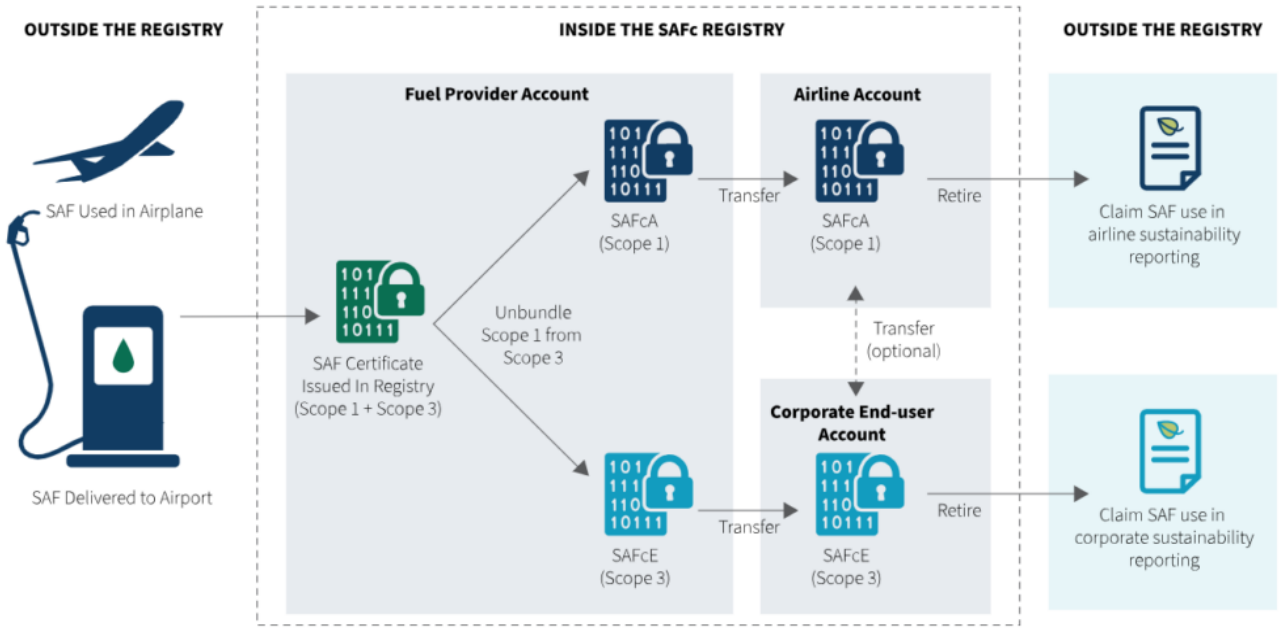
4.2 Sustainable Aviation Buyers Alliance (SABA) SAFc Registry

In April 2021, RMI and the Environmental Defense Fund (EDF) partnered with 14 founding companies to form the Sustainable Aviation Buyers Alliance (SABA), a nonprofit seeking to accelerate decarbonization by supporting the market for SAFs.

SABA initiated SAF certificates (SAFc) as a market mechanism to decouple the emissions attributes of SAFs from consumption of the physical fuel and to facilitate credible emission reduction claims.

SABA also established the SAFc Registry, an electronic book-and-claim data storage system that enables the registration, issuance, holding, transfer and retirement of SAF certificates (SAFc), which represent the non-energy attributes of a physical volume of SAF.[25] Under the Registry, SABA developed different types of certificates reflecting either the direct emissions attributes of SAF combustion by the airline or the indirect emissions attributes by a passenger consuming the service. [26]

Illustration 1: How SAFc Support Two Different Consumption Claims



(Source: EDF Energy Exchange 2023)

Alternative fuels that generate SABA SAFc are required to demonstrate that they meet "key sustainability criteria" established to further the development of high

[25] Roundtable on Sustainable Biomaterials. *RSB Book and Claim Manual, version 3.0*, March 30, 2023. https://rsb.org/wp-content/uploads/2023/04/RSB-PRO-20-001-001-RSB-Book-and-Claim-Manual-3.0.pdf

[26] Sustainable Aviation Buyers Association (SABA). *FAQs: Common questions about the registry*, docs.safcregistry.org, 2023. www.docs.safcregistry.org/faq.

integrity SAFs.[27] SABA recognizes three different tiers of sustainability criteria, ranging from minimum standards that meet any sustainability certification scheme to SABA's additional measures to reduce the risk of indirect land use changes and displacement effects.[28]

4.3: Inflation Reduction Act

The U.S. Inflation Reduction Act (IRA) of 2022 created a new tax credit for fuel producers of $1.25 to $2.25 (depending on carbon intensity) for each gallon of SAF blended with fossil jet fuel and consumed. All SAF that reduce lifecycle GHG emissions by 50% are eligible for a $1.25/gallon credit, which is applied to the tax obligation of the fuel developer. The law permits fuel blenders to claim an additional $0.01 per gallon credit for every percentage reduction in GHG emissions beyond 50%, capping the maximum credit a$1.75/gallon.

4.4: CST Accounting and Reporting Guidelines

In October 2022, the World Economic Forum's Clean Skies for Tomorrow (CST) initiative, in collaboration with RMI and PwC Netherlands, issued emissions accounting and reporting guidelines for SAF emissions reductions, including recommended accounting calculation methods and reporting procedures.[29]

The CST Guidance can be used for emissions calculations by SAFc traders in designing and preparing a GHG emissions inventory and for publicly reporting GHG emissions and reductions associated with the retirements of both SAF certificates issued by SABA.

4.5: ReFuel EU

In September 2023, the European Union Parliament adopted the 'ReFuel EU' initiative, under which, fuel suppliers must include increasing proportions of SAF blended into jet fuel, beginning with 2% as of 2025 and incrementally increasing to 63% by 2060. SAFs must also be produced from feedstock that complies with the sustainability and GHG emissions criteria under the Renewable Energy Directive (EU Directive 2018/2001).

The regulation targets airlines, fuel suppliers and airports and applies to all flights leaving EU airports, regardless of the nationality of the company operating the flight. Due to concerns about the impact of scalable biofuels on land use and the decarbonization of other sectors, crop-based biofuels are not considered SAF under the RefuelEU initiative.

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[27] Sustainable Aviation Buyers Alliance (SABA). "Sustainable Aviation Buyers Alliance Announces Aviation Decarbonization First, with Collective Purchase of Sustainable Aviation Fuel Certificates," www.,flysaba.org, April 4, 2023. https://flysaba.org/2023/04/04/first-collective-purchase-of-sustainable-aviation-fuel-certificates/

[28] Sustainable Aviation Buyers Alliance (SABA). SAFc Registry Guide, December 2022. https://rmi.org/wp-content/uploads/2022/12/safc_registry_guide_saba.pdf.

[29] World Economic Forum, Clean Skies for Tomorrow, Sustainable Aviation Fuel Certificate (SAFc) Emissions Accounting and Reporting Guidelines, White Paper, October, 2022. Available at: https://www3.weforum.org/docs/WEF_SAFc_Accounting_Guidelines_2022.pdf.

4.6: California Low-Carbon Fuels Standard (CA-LCFS)

The CA-LCFS seeks to reduce the carbon intensity of California's transportation sector by putting a value on carbon reduction generated from renewable fuels. SAF has been eligible under the program as an opt-in fuel since 2019. That means while refiners are not required to reduce the carbon intensity of jet fuel, SAF producers can generate and sell LCFS credits to obligated parties to generate revenue. Despite the policy, SAF production and consumption in California remains limited. In 2021, for example, SAF generated only 0.3% of LCFS credits sold in California.[30]

4.7: ISCC Credit Transfer System

In late April of 2024, International Sustainability & Carbon Certification (ISCC), a stakeholder-driven initiative promoting climate-friendly supply chains, launched a SAF Credit Transfer System enabling traceable SAF attributes and credible use claims to be transferred between suppliers, aircraft operators, logistics providers, and end-users in voluntary markets.[31] The system is intended to extend the current chain-of-custody verification schemes for SAF, which track attributes from feedstock to aircraft, further down the value chain to permit trading of attributes between individual end-users wishing to reduce the carbon footprint of their passenger or freight air travel.

5. Conclusion

The aviation industry is a significant contributor to global GHG emissions, with substantial sector-wide growth expected by 2050. SAF has emerged as a credible alternative to conventional aviation fuel in part due to its compatibility with existing infrastructure and the ease of sourcing feedstocks.

Civil aviation is arguably the sector most prepared to adopt widespread market-based accounting methods. To be deemed sustainable, SAF must meet extensive quality criteria that certify the lifecycle reductions of GHG emissions when compared to the lifecycle emissions of conventional aviation fuel. While there has not yet been a universally accepted book and claim system for tracking Sustainable Aviation Fuel certificates (SAFc), efforts are underway to apply market-based accounting principles for trading certificates. The Sustainable Aviation Buyers Alliance SAFc registry is a notable market mechanism used to decouple the emissions attributes of SAFs from physical consumption and may simplify accurate emission reduction claims.

[30] O'Malley, J. "Will California rise to the Biden Administration's grand challenge?" *International Council on Clean Transportation (ICCT) blog*, January 25, 2023. https://theicct.org/ca-sustainable-aviation-fuels-jan23/.
[31] International Sustainability ^ Carbon Certification (ISCC), "ISCC introduces Credit Transfer System for Sustainable Aviation Fuels," *iscc-system.org*, NEWS . ISCC introduces..., April 30, 2024. https://www.iscc-system.org/news/iscc-introduces-credit-transfer-system-for-sustainable-aviation-fuels/

Other regional and international initiatives for SAF accounting have emerged, but there is still need for universally accepted market-based accounting methodologies and some critical questions remain unanswered.