High-integrity sustainable aviation fuels and the imperative of a net-zero climate impact by 2050

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Introduction

The pandemic has brought civil aviation to an inflection point. A precipitous drop in demand, continued reluctance of many leisure travelers to fly, and growing awareness among customers of the need to cut greenhouse gas (GHG) emissions, have all thrown a cloud over the future of passenger aviation. At the same time, new science underscores the larger scale of aviation's role in changing the climate due to non-CO_2 effects, which represent about two thirds of the sector's net climate impact.[1] These developments present an enormous challenge for the industry. But they also open an opportunity to chart a path forward for civil aviation to embrace the imperative of a net-zero climate impact by 2050.

One key step on that path is a dramatic acceleration of sustainable aviation fuel (SAF) use. SAF, which includes both biofuels and e-fuels, provides a distinct opportunity for aviation to decarbonise rapidly and permanently. However, deploying SAF only makes sense if the SAF actually significantly reduces emissions, meets a high standard of environmental integrity, and is transparently and accurately accounted for to avoid double counting emissions reductions.

SAF could potentially help fully decarbonise aviation by 2050, assuming e-fuels with zero life-cycle emissions become available and are deployed at scale (Figure 1). However, these potentials are theoretical and depend on supply constraints and large capital costs, and therefore need strong political support to materialise.

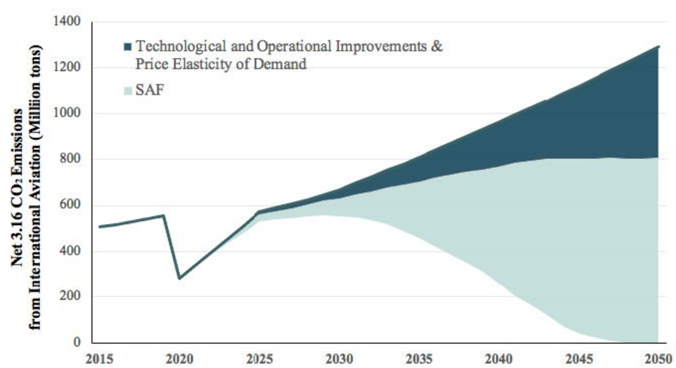

FIGURE 1: Reductions in atmospheric CO_2 from SAF use for international aviation. Based on ICAO 2019 forecasts, enhanced to reflect the notional impact of COVID19 and SAF deployment on price elastic demand and the adoption of technological and operational improvements. Source: The High-Integrity Sustainable Aviation Fuels Handbook.[2]

1 D.S. Lee et al, 2020, "The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018", Atmospheric Environment September 3, 2020.
2 Piris-Cabezas Pedro, 2022, "The High-Integrity Sustainable Aviation Fuels Handbook", Environmental Defense Fund.

SAF could also help reduce significantly the aromatic content[3] in jet fuel and thereby contribute to cut air pollution around airports, benefitting the health of people who live and work nearby, and reduce the non-CO_2 climate effects from contrail cloudiness[4].

In spite of all these co-benefits, SAF alone will not be able to completely eliminate aviation's net warming and public health effects. While SAF could represent a turning point in the aviation sector's journey to decarbonisation, complementary measures would be necessary to address the full spectrum of aviation's environmental impacts, including by balancing non-CO_2 climate effects with emissions reductions — and eventually net negative emissions — from other sectors.

A step in the right direction

The adoption of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) by the International Civil Aviation Organization (ICAO) — operational as of January 1, 2021 — sets out a strong feedstock — and pathway-neutral framework for assessing emissions reductions from SAF use. Furthermore, the November 2021 decision by the ICAO Council to adopt an expanded set of sustainability criteria for SAF further strengthens this framework. This marks a major milestone for ICAO, as it is the first time a United Nations (UN) body has defined a clear standard for what constitutes sustainability for a mitigation action, and operationalised it with a full-fledged system of monitoring, reporting and verification.

However, in its current configuration, the CORSIA approach to SAF can only enable the production of truly beneficial SAF when paired with effective national policies that generate the needed economic incentives.

As countries engage in the design of national SAF policies, they should build on the rigorous, scientifically grounded work done by ICAO, but also ensure that:

1. Feedstocks used to produce SAF have low indirect land-use change (ILUC) emissions risk to avoid unintended consequences;
2. Resources are efficiently allocated to maximise emissions reductions rather than volumes; and,
3. Measures to avoid double counting given that Paris Agreement pledges are in place.

Based on these principles, only then could SAF be deployed with environmental integrity and contribute to the achievement of the UN Sustainable Development Goals.

1. Avoiding unintended consequences from feedstocks with ILUC risk

The state-of-the-art models used in ICAO for estimating default ILUC values incorporate three main market-mediated responses to meet a given additional feedstock demand for SAF production: (i) new agricultural land, (ii) yield increases, and (iii) reduced food and feed demand (including reduced food consumption).

In other words, the default ILUC values represent a theoretical estimation of the GHG emissions from new agricultural land — including from deforestation — that is needed to meet residual feedstock demand after considering: the amount of feedstock demand that would be satisfied by means of yield increases (e.g., from the introduction of cover crops or the restoration of degraded lands); and, the reduction in feedstock demand resulting from higher food and feed prices. While this approach is critical to identify feedstocks with ILUC risk, it does not account for unintended consequences such as biodiversity loss, food insecurity, and hunger/malnutrition that higher feedstocks prices could cause.

Therefore, countries should ensure that only feedstocks that can demonstrate low ILUC risk entitlements are eligible for financial support. This would be equivalent to focusing only on the feedstock produced with integrity by means of yield increases, while avoiding feedstock from new agricultural land or reduced food consumption.

3 Aromatics are hydrocarbons containing a benzene ring and range from benzene, the smallest aromatic compound to others such as toluene, xylene and naphthalene. Particulate matter emissions from aircraft turbine engines are a function of aromatic content.
4 C. Voigt et al., 2021, "Cleaner burning aviation fuels can reduce contrail cloudiness", Communications Earth & Environment.

The CORSIA SAF framework already includes innovative tools for demonstrating compliance with low ILUC risk.

2. Channeling resources efficiently with a focus on emissions reductions rather than volumes

Countries should also ensure that investments are channeled to SAF pathways with the highest emissions reduction potential, as these will deliver the most cost-effective way moving forward. Only SAF pathways that deliver large emissions reductions would make sense economically and environmentally, and represent viable production pathways.

While the SAF production costs are a relevant decision-making parameter, the main focus should be on the emissions reduction costs to establish the merit order in supporting SAF development. Figure 2 provides an overview of SAF production and emissions reduction costs for a number of SAF pathways. It builds on the production costs from ICAO's SAF Rule of Thumb[5] complemented with the relevant default life-cycle values to derive emissions reduction costs. The pathways were then supplemented with e-fuels from renewable electricity, as it represents a potential source of zero life-cycle emissions SAF with no major biophysical constraints, and it is already among pathways certified by ASTM International[6] as safe for use as a drop-in fuel.

While e-fuels are often considered a less mature SAF pathway, its deployment could happen earlier than anticipated if synergies from the decarbonisation of the power sector are fully exploited. The transition to renewables-based power generation systems – on which many countries have already embarked— means that the production of e-fuels could generate valuable ancillary benefits through grid-balancing services.[7] These benefits can significantly reduce the electricity cost for e-fuels production, altering the merit order of SAF pathways in favor of e-fuels, as illustrated in Figure 2. This should not only pave the road for a successful journey to net zero aviation but also beyond, including heavy land/sea transport, given the broad range of e-fuel co-products.

3. Avoiding double counting

ICAO has developed an innovative accounting approach for SAF: Rather than allowing air carriers to claim zero CO_2 combustion emissions from biogenic fuels under CORSIA (as most other GHG emissions reductions programs do), air carriers can only claim SAF emissions reductions for as long as these take place on a life-cycle basis.

Countries might find it challenging to reconcile this innovative approach with their GHG emissions inventories, leading to double counting of SAF emissions reductions, or more precisely double claiming.[8] This is the case because there are potential time lags between SAF use and reporting,[9] and countries have limited information publicly available in the CORSIA Central Registry.[10]

Several approaches exist to avoid double claiming, but the simplest approach involves countries reflecting SAF use as *international bunker* in their emissions inventories, meaning that countries need to rely on the timely information collected by the CORSIA-approved Sustainability Certification Schemes (SCS) to help identify SAF used for international aviation. In principle, SCS are already required to collect and report the necessary information,[11] but SCS

5 https://www.icao.int/environmental-protection/Pages/SAF_RULESOFTHUMB.aspx
6 ASTM International, formerly known as American Society for Testing and Materials, is a standards organization that develops and publishes technical standards for a wide range of products including SAF and jet fuel specification.
7 Once large wind or solar capacity is in place power production becomes intermittent, and the ability to manage the load becomes a critical feature for balancing the grid.
8 Double claiming is a type of double counting that occurs when the same emissions reductions are counted twice towards the climate change mitigation effort of both an air carrier and the host country of the emissions reduction activity.
9 CORSIA allows air carriers some flexibility on when they report the use of SAF, which can create a time lag of up to three years between SAF use and reporting.
10 The CORSIA Central Registry captures aggregate emissions from international aviation and compliance offsetting reports, but only limited information on SAF use claims under CORSIA.
11 See Requirement #12 in Table 1 with Requirements for SCS in ICAO Document Eligibility Framework and Requirements for Sustainability Certification Schemes (2019), available at: https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO document 03 - Eligibility Framework and Requirements for SCS.pdf

FIGURE 2: Present and future SAF production and emissions reduction costs for biofuels (pioneer, and n^{th} plant) and e-fuels (current, future-2035).[12,13] Source: The High-Integrity Sustainable Aviation Fuels Handbook, Appendix B, (op. cit.)

12 Pathways considered: Gasification Fischer Tropsch using (1) municipal solid waste (MSW) with 70% biogenic content, (2) forest residues, and (3) agricultural residues; Alcohol-To-Jet using (1) ethanol from low ILUC risk corn grain as a feedstock, (2) isobutanol from agricultural residues (low and high estimates); Hydro-processed Esters and Fatty Acids - Synthetic Paraffinic Kerosene (HEFA-SPK) using (1) waste fats/oils/greases (FOGs), and (2) Vegetable oil from soybeans with low ILUC risk; e-fuels using (1) Proton-Exchange Membrane Electrolysis Cells (PEMEC) + Reverse Water-Gas Shift (RWGS) + Fischer-Tropsch (FT), and (2) Solid Oxide Electrolysis Cells (SOEC) + FT pathways, with varying feedstocks, technology choices and interactions with the power sector (resulting in varying electricity prices as a feedstock for e-fuels). Note: the “current” estimates for e-fuels consider economies of scale that might not be captured in the “pioneer” estimates for biofuels.

13 Same disclaimer as for the ICAO SAF “Rules of Thumb” apply here.

need guidance. To ensure a harmonised implementation, the ICAO Committee on Aviation Environmental Protection (CAEP) should develop such guidance during the next CAEP cycle.

An advantage is that this approach does not require any accounting adjustments or explicit authorisations by any country. The only adjustments and authorisations would apply to the optional removal and emissions credits embedded in the SAF life-cycle values. For such credits, a *letter of assurance and authorisation* –similar to those applicable to CORSIA offsets— would apply as countries would need to perform corresponding adjustments to prevent double claiming in accordance with the guidance on cooperative approaches of the Paris Agreement.[14]

Conclusion

The ICAO CORSIA framework holds enormous potential to enable the production of truly climate beneficial SAF –provided that national policies generate the needed economic incentives to channel resources towards high-integrity SAF with the highest emissions reduction potentials and implement measures to avoid double counting.

This is a pivotal moment for countries to embrace the imperative of a net-zero climate impact by 2050 and embark the aviation sector on its energy transition. If we successfully leverage all the critical opportunities ahead of us, we can put aviation on a new flightpath to reduce its climate impact and air pollution, while protecting ecosystems and communities.

14 The guidance on cooperative approaches referred to in Article 6, paragraph 2, of the Paris Agreement guidance was adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at the 26th United Nations Climate Change Conference held in Glasgow in 2021. It provides the rationale that needs to inform how and when to perform corresponding adjustments for emissions reductions and removal credits. The guidance applies to mitigation outcomes authorized by a participating Party for use towards the achievement of either another Party's Nationally Determined Contribution or for use for other international mitigation purposes, including ICAO CORSIA. An advance unedited version of the guidance can be found here: https://unfccc.int/sites/default/files/resource/cma3_auv_12a_PA_6.2.pdf