Clean Skies for Tomorrow

In collaboration with RMI and PwC Netherlands

WORLD ECONOMIC FORUM

Sustainable Aviation Fuel Certificate (SAFc) Emissions Accounting and Reporting Guidelines

WHITE PAPER

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Contents

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Foreword

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Sustainable aviation fuel (SAF) is steadily making its way into the public consciousness of climate solutions. Some of the most influential companies and institutions globally have committed to procuring and using SAF at an ever-increasing scale over the past year. This is great news, as SAF is recognized as a critical lever toward making net-zero aviation a reality. From policy advancements, agreement on a long-term aspirational goal for international civil aviation and significant offtake announcements from major airlines, fuel producers and corporate customers, the momentum for scaling up SAF has only grown.

While these achievements are commendable and historic, more work is needed to support the rapid roll-out of SAF that will be required to keep the sector on track to reach net-zero aviation. The current project pipelines for SAF production are insufficient and need to be scaled up by a factor of roughly six to achieve needed SAF production levels of 40-50 megatonnes (Mt) by 2030. This will require the development of hundreds of new fuel production plants, each taking several years for design and construction. Simply put, the clock is ticking, and we must continue to increase our efforts to scale up SAF supply.

The role of aviation customers has never been more important to help establish a thriving SAF market. Corporates and private customers can create a strong, long-term demand signal for the certified emissions reductions from SAF through SAF certificates (SAFc). While major global brands have continued to show true ambition by investing in early SAFc pilot transactions, harnessing the full demand of corporate aviation customers will require the establishment of a standardized, industry-backed book and claim approach for accounting and reporting the carbon benefits of SAFc towards voluntary climate targets.

Clear and standardized accounting and reporting guidance is vital to unlocking significant, long-term investment from corporate aviation consumers for the environmental attributes of SAF – while also ensuring environmental integrity and avoiding the potential negative outcomes, like double counting.

Book and claim – and clear associated accounting and reporting guidance – is critical for airlines and other air transport providers without physical access to SAF supply today. It can also help limit supply chain inefficiencies in shipping fuel around the world, which add to SAF's life cycle emissions.

This publication of the *Sustainable Aviation Fuel Certificate (SAFc) Emissions Accounting and Reporting Guidelines* marks a critical step in developing a standardized accounting and reporting approach, proposing a consistent and transparent book and claim methodology to account for the carbon benefits of SAF and SAFc across the value chain. These guidelines are intended to remove uncertainty in the market and further understanding and alignment. Over the next year the Clean Skies for Tomorrow community will be working together to test these guidelines to support adoption across the entire value chain, including with standard setters such as Greenhouse Gas Protocol (GHGP) and the Science Based Targets initiative (SBTi).

Preface

The scale up of SAF globally can be facilitated by a comprehensive accounting and reporting framework.

About CST and SAF certificates

The Clean Skies for Tomorrow coalition (CST) was initiated at the World Economic Forum annual meeting in Davos in January 2019. The coalition provides a crucial platform for industry leaders and civil society to align on and implement a transition pathway to net-zero aviation by 2050. CST serves as the aviation sector pillar in the Mission Possible Partnership, an international coalition working to decarbonize harder-to-abate heavy industry and transport sectors.

Though sustainable aviation fuel (SAF) is recognized as the most viable in-sector decarbonization approach today, it is approximately two to five times[1] the price of conventional jet fuel and represents less than 0.1% of jet fuel demand.[2] Its adoption suffers from a "chicken-and-egg" challenge, whereby SAF producers and consumers are unable or unwilling to bear the initial cost of scaling global production.

CST's "demand signal" workstream aims to scale the use of SAF through a SAF certificates (SAFc) system that can mobilize corporate demand to contribute to the SAF price premium in exchange for emissions and broader environmental claims.

Individual company efforts to scale SAF use such as SkyNRG's Board Now, United Airlines' Eco-Skies Alliance, KLM's Corporate SAF Programme, and Fly Green Fund, already exist and have set a valuable precedent for this mechanism. However, a universal system that equips the aviation sector with clear guidance to claim environmental benefits is needed. In order to support these claims, the system also requires market infrastructure to track the use of SAFc and lend credibility to this new mechanism. CST's report, *Powering Sustainable Aviation Through Customer Demand*, provides more information on the SAFc concept, its functionality and a preliminary framework for SAFc emissions claims accounting and reporting. These guidelines build from this initial work.

Since the start of the CST initiative, the demand signal group has:

- Convened a broad coalition of over 50 leading entities from across the aviation industry (airlines, airports, fuel providers, manufacturers, corporate flight buyers) committed to the vision of net-zero emissions in aviation.
- Brought evidence that some corporate travellers and airfreight customers are willing to pay a premium for SAF, confirming that demand could drive the initial deployment of SAF at scale.
- Developed a viable framework for SAFc that is compatible with and working towards recognition as a mitigation measure within voluntary carbon reporting programmes through the Greenhouse Gas Protocol (GHGP) and the Science Based Targets initiative (SBTi).
- Influenced transactions that have used the SAFc approach to structure their procurement – including PwC, Microsoft, Deloitte and Deutsche Post DHL in partnership with Alaska Airlines, United Airlines, American Airlines and Delta Air Lines.

SAFc will require robust market infrastructure to scale, the development of which is the focus of CST, the Sustainable Aviation Buyers Alliance (SABA) and the Roundtable on Sustainable Biomaterials (RSB) efforts in 2022. This infrastructure includes:

- The SAFc rulebook, which includes detailed specifications on how SAFc can be issued, transferred and retired in an independently governed registry.
- The SAFc registry, an IT system that will streamline, verify and make transparent the issuance, transfer and retirement of certificates.
- Guidance to support users of SAF and SAFc in their emissions accounting and reporting (this document).

CST, SABA and SkyNRG are also actively working to test this SAFc market infrastructure in pilot transactions, which will generate additional insights to refine the system.

CST's "demand signal" workstream aims to scale the use of SAF through a SAFc system that can mobilize corporate demand to contribute to the SAF price premium in exchange for emissions and broader environmental claims.

How to use these guidelines

❝ These guidelines offer detailed step-by-step instructions including recommended accounting calculation methods and reporting procedures.

The proposed SAF and SAFc accounting and reporting guidelines are designed to guide practitioners including greenhouse gas inventory specialists, auditors, fuel suppliers, air transport providers, and corporate buyers of SAF and SAFc. These guidelines offer detailed step-by-step instructions including recommended accounting calculation methods and reporting procedures, in the absence of formal global standards. Specifically, this document aims to provide five key "personas" including SAF suppliers, airlines, corporate travellers, private aircraft owners and operators and freight operators (carriers, freight forwarders and shippers) with:

- Guidelines for emissions calculations to be used in designing and preparing a greenhouse gas emissions inventory.
- Guidelines for publicly reporting greenhouse gas emissions and reductions associated with SAF and SAFc.

These guidelines are developed to ensure that each user of SAF and SAFc is assigned accurate and proportionate emissions and reductions.

In these guidelines, the term "should" is used to describe recommendations for relevant stakeholders to prepare and report a greenhouse gas inventory. These recommendations are intended to improve the completeness, relevance, transparency, consistency and accuracy of existing accounting and reporting standards for SAF and SAFc.

Standards on GHG emissions accounting already exist and guide accounting and reporting today. These proposed SAF and SAFc accounting and reporting guidelines, as much as possible, use guidance from prevalent standards and frameworks to ensure compatibility with current best practices (see Appendix 1 for further details).

In particular, these guidelines substantially make use of GHGP standards,[3] the SBTi aviation sector target setting guidance, the ICAO CORSIA methodology, the draft *RSB Book and Claim Manual*, the Smart Freight Centre's accounting guidance for a book and claim framework, and the Global Logistics Emissions Council (GLEC) framework[4] (see Appendix 2 for further details). However, as SAFc is a novel accounting and reporting tool, minor modifications to existing accounting approaches are proposed that deviate from current practices in order to accurately and consistently reflect its distinct characteristics. Ultimately, it is hoped that these proposed guidelines can facilitate the incorporation of SAFc into the broader corporate emissions accounting and reporting guidance and standards including the GHGP and the SBTi.

Importantly, these proposed guidelines apply exclusively to voluntary use and reporting of SAF and SAFc. They are not applicable for SAF used towards compliance frameworks such as SAF blending mandates. Compliance use cases will require distinct accounting and reporting principles and protocols, which should be the subject of further analysis. To allow for flexibility, broader use and consistency with other upcoming standards, these guidelines will likely be revisited in the future, in view of the experience and knowledge of SAF and SAFc usage.

These guidelines do not comprehensively detail the performance criteria for SAFc, nor do they fully detail the function of a SAFc registry. To address this, SABA and the RSB, in collaboration with CST, are working in parallel to develop detailed specifications for a book and claim registry for SAFc. The registry is an IT system that will record all issued and retired certificates and prevent double claiming of environmental attributes across the value chain. Thus, the proposed SAF and SAFc accounting and reporting guidelines are intended to be used as practical claims guidance that builds on the comprehensive framework being developed by RSB, SABA and CST.

Executive summary

Building consensus on a unified and standardized approach to accounting and reporting for SAF and SAFc can credibly and consistently help to mitigate aviation sector emissions.

Decarbonizing aviation is difficult but critical. While electric and hydrogen-fuelled aircraft are promising, these technologies, with the potential to decarbonize flights entirely, may not be commercially viable until well into the 2030s and are unlikely to fully serve long-haul flights. Drop-in sustainable aviation fuel (SAF) is already commercially available and therefore plays a critical role in decarbonizing aviation today and in the longer term.

However, SAF comprises less than 0.1% of total jet fuel demand today and is significantly more expensive than conventional jet fuel. With the aim to support its broader adoption, Clean Skies for Tomorrow (CST) is supporting industry-wide efforts to catalyse demand for additional supply of SAF. With its partners, CST has developed a market-based mechanism that can enable more actors to contribute, thus drawing down this price premium, and advancing the SAF market.

SAF certificates

This market mechanism is called a SAF certificate (SAFc), which will function similarly to an energy attribute certificate (EAC), representing the environmental attributes of a metric tonne of neat, i.e. unblended, SAF. There is significant demand from corporate aviation customers – both in their business travel and freight – for tangible solutions to tackle their supply chain or scope 3 emissions. SAFc can harness this demand to facilitate faster scaling of SAF production and enable more actors to start decarbonizing their value chains in tangible ways. This market mechanism can equip consumers with a tool to send a meaningful demand signal to the nascent SAF market.

Thanks to the Roundtable on Sustainable Biomaterials (RSB) and the International Sustainability and Carbon Certification (ISCC), a robust mass balance certification system already exists. In addition to tracing the flow of fuels through the value chain, it verifies facility-level claims about sustainability to compliance and voluntary schemes. Building from this, CST and its partners are collectively developing a book and claim system – a mechanism that enables those environmental attributes to decouple from the physical fuel volume. This involves developing market infrastructure to describe and codify this mechanism: rules for how SAFc can work, an independently governed registry that controls issuance, transfer, and retirement of certificates, and accounting guidance for how SAFc can be claimed.

Bringing SAFc to life is a collective and ongoing endeavour. The collective work of CST, the Sustainable Aviation Buyers Alliance (SABA), the RSB, the Smart Freight Centre (SFC) and many other partners in industry has progressed the broader framework this far. This collaborative effort continues to build a universal market infrastructure that can unlock key barriers to SAF at scale.

Why accounting matters

Standardized SAFc accounting guidance has the potential to de-risk the SAFc market. In order to scale, the market needs consistent clarity on:

1. How SAF and SAFc can be accurately accounted for (i.e. who can claim what).

   First and foremost, it is critical that the environmental attributes of SAF are accounted for correctly. As with EACs, it is important to ensure that each user of SAF and SAFc accurately accounts for and reports emissions and reductions.

2. How SAF and SAFc can be reported towards climate targets.

   A handful of leading companies have already worked with airlines to support SAF purchases in return for the environmental attributes, in effect piloting the SAFc concept. These early pilots have set an important precedent for how SAFc can work. Yet, there is not yet an accepted practice for corporate customers to report these environmental attributes in their climate disclosures or to demonstrate their contribution to meeting corporate goals under frameworks such as the Science Based Targets initiative (SBTi). In order to invest in SAFc at scale, corporate aviation customers will require SAFc to facilitate bona fide claims towards their climate targets.

3. How voluntary and compliance SAF and SAFc claims differ.

   Voluntary action is critical for the sector to scale up SAF supply and for corporates to actively contribute to the energy transition of aviation. At the same time, policy approaches that mandate SAF usage such as “Fit for 55” and “ReFuel EU Aviation” are becoming common.

   The distinction between voluntary and mandatory use, and its implications for SAF and SAFc is important as it ensures accurate accounting and prevention of double claiming of environmental attributes across the value chain. To enable new and additional production, voluntary actors need transparency about which fuels are used towards which compliance schemes, and the incentives that fuels receive.

Purpose of this document and how it should be used

Despite the aviation value chain’s burgeoning interest in SAF and SAFc, there is not yet an agreed-upon or standardized approach that has been adopted by the aviation value chain for the accounting and reporting of SAF and SAFc.

These guidelines intend to bridge this gap and build consensus on how a unified and standardized approach to accounting and reporting for SAF and SAFc can credibly and consistently help to mitigate aviation sector emissions. This document presents detailed and step-by-step instructions including recommended accounting calculation methods and reporting procedures that reflect the needs of fuel suppliers, the aviation sector, and its customers.

Ultimately, it is hoped that standard setters such as the Greenhouse Gas Protocol (GHGP) and SBTi can build from and codify this dialogue into standardized accounting and reporting guidance. A formalized and agreed-upon approach will help stakeholders across the aviation value chain unlock significant investments from corporate aviation consumers for additional SAF and kick-start the SAF market on a pathway consistent with net-zero aviation.

Introduction

Standardized SAF certificate (SAFc) accounting guidance has the potential to de-risk the SAFc market and drive demand.

Sustainable aviation fuel

Sustainable aviation fuel (SAF) is renewable or waste-derived drop-in aviation fuel that meets sustainability criteria, including a life cycle emissions reduction compared to conventional aviation fuel.[5] SAF is produced from sustainable, renewable feedstocks such as used cooking oils, forestry residues, municipal solid waste and captured CO_2.

SAF can be produced through various certified production pathways. All commercially produced SAF available today uses biogenic feedstocks and is considered biofuel. However, fuels produced with municipal solid waste that are not entirely biogenic, as well as electro-fuels or synthetic fuels produced using captured CO_2, are also considered SAF. Production pathways that use these feedstocks are projected to commercialize and scale in the next several years. SAF is chemically equivalent to kerosene and considered to be a “drop-in” fuel, i.e. compatible with today’s typical commercial aircraft engines.

Although the greenhouse gas (GHG) emissions from SAF combustion are comparable to those of conventional jet fuel, SAF usage results in significant emissions reductions over its life cycle relative to conventional jet fuel use. When used to fuel aircraft, SAF can significantly reduce the carbon intensity of flying on a life cycle basis, depending on the feedstock and technological pathway.[6]

SAF supply chain

SAF can be made from many types of feedstocks (e.g. biomass, residues, waste) and through a variety of production pathways (e.g. hydro-processed esters and fatty acids (HEFA), alcohol-to-jet (AtJ), power-to-liquid (PtL)). Each combination has a unique life cycle emissions value.

For SAF made from purpose-grown crop feedstocks (including energy and cover crops), cultivation and harvesting are part of the scope of the life cycle assessment in addition to collection, processing, transport, SAF production and blending. For residue- and waste-based feedstocks (including agricultural and forestry residues, municipal solid waste, used cooking oil and inedible tallow), the product life cycle begins at the point of collection.

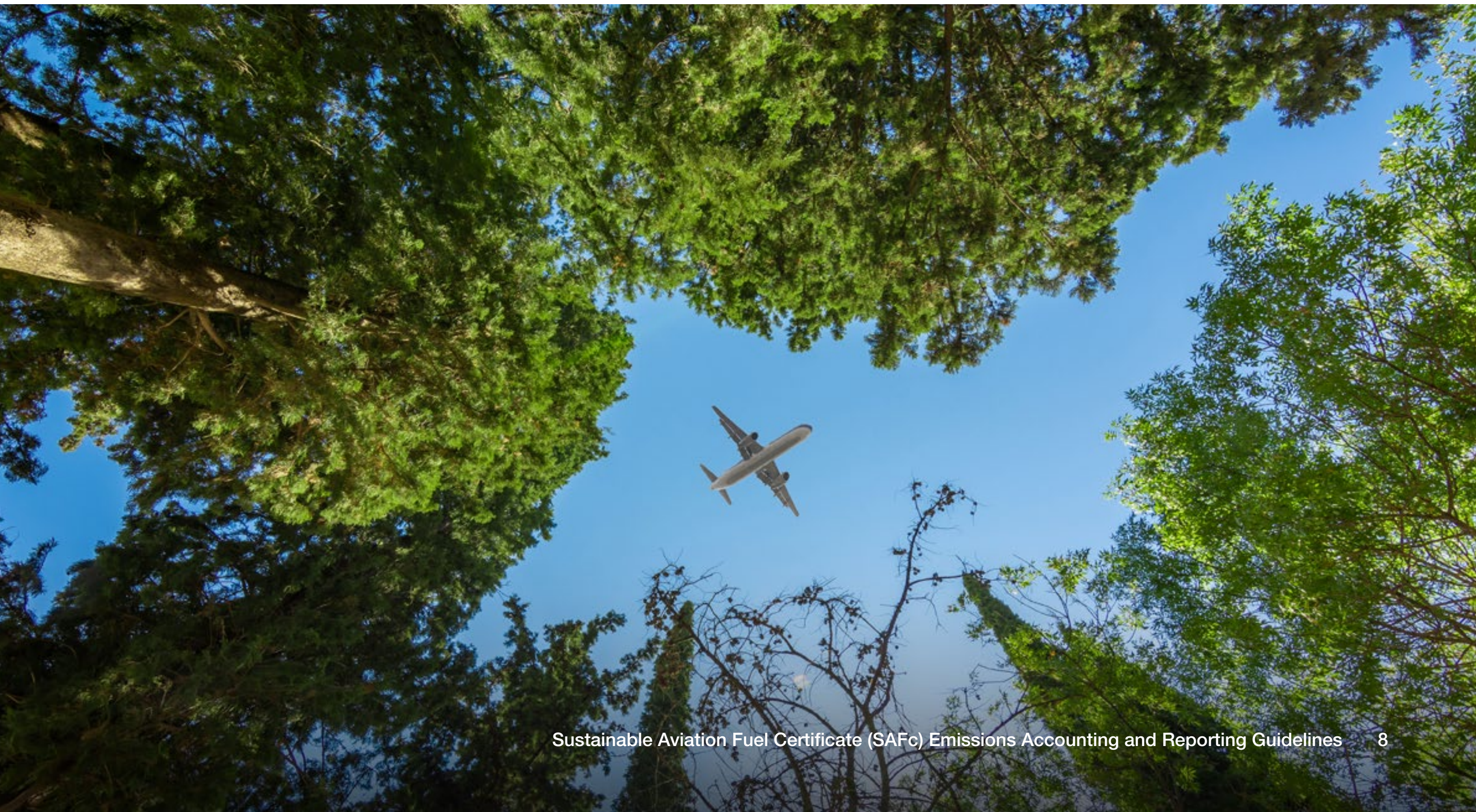
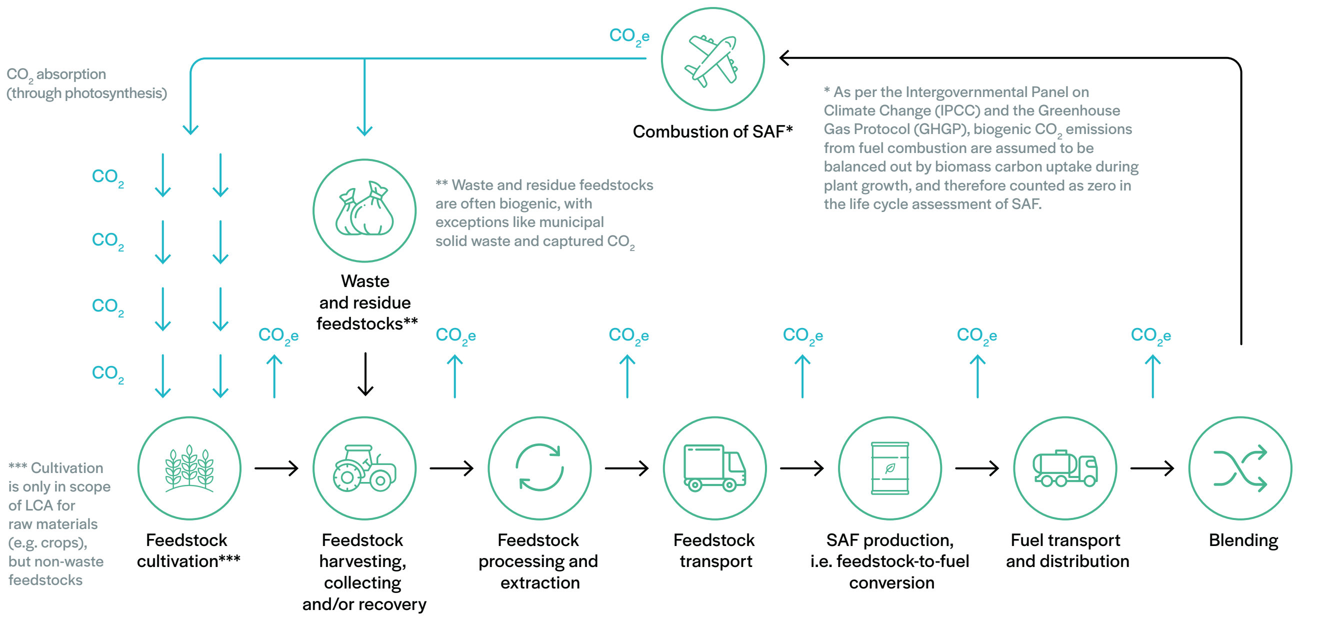


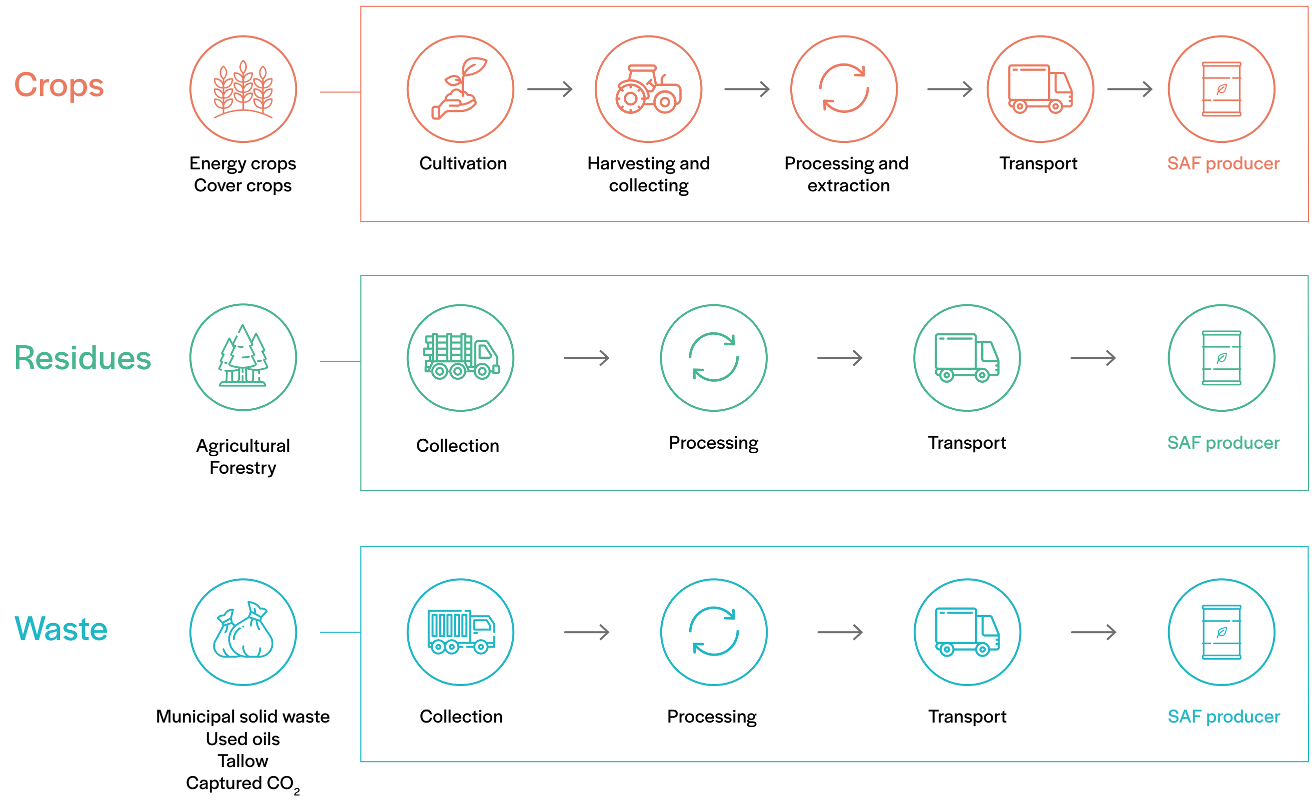
FIGURE 1 The general SAF life cycle from cultivation through combustion

For biogenic fuels, biogenic CO_2 emissions from fuel combustion are assumed to be balanced out by biomass carbon uptake during plant growth, and therefore, counted as zero in the life cycle assessment of SAF



Source: World Economic Forum

FIGURE 2 Life cycle stages for SAF from crop, residue and waste feedstocks



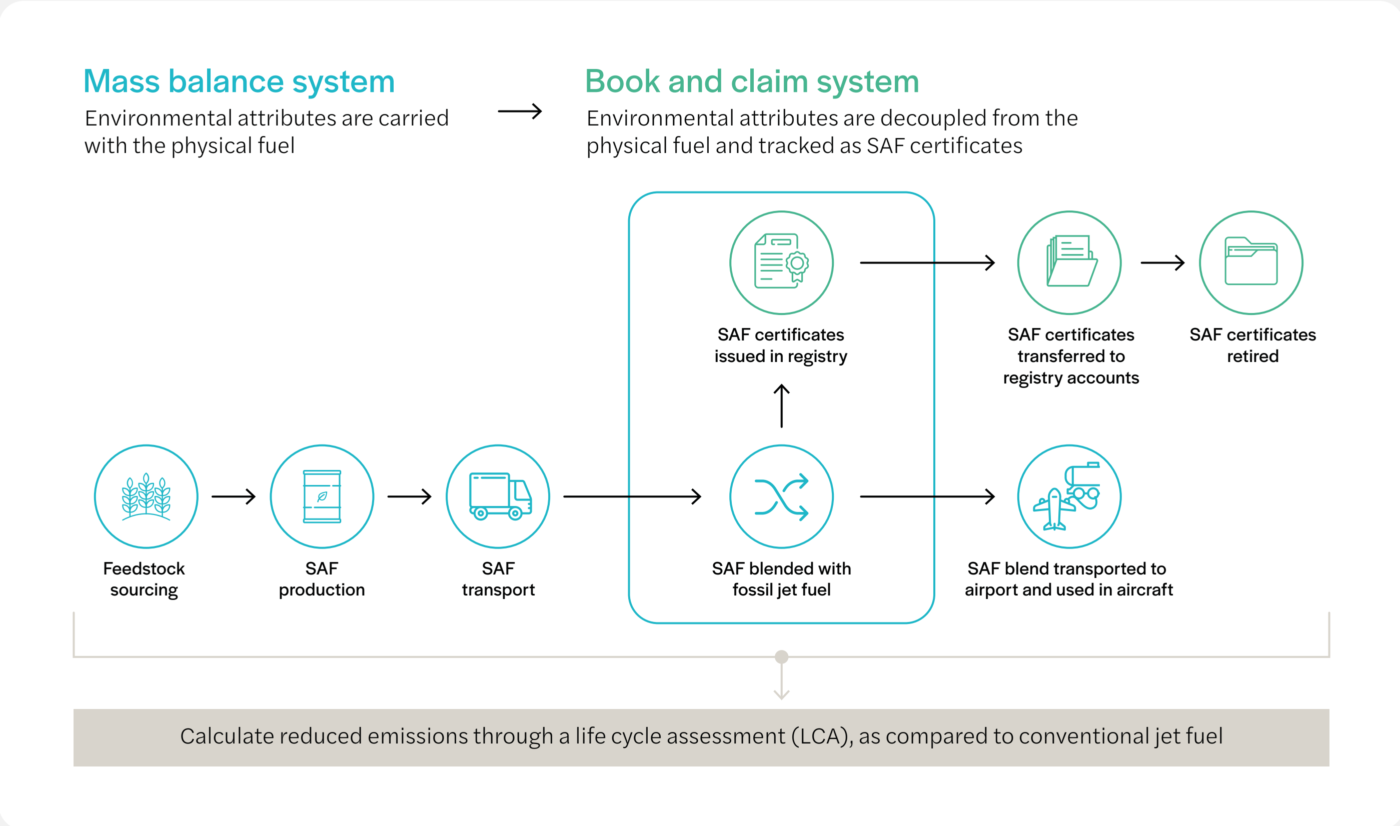
Source: World Economic Forum

SAF certificates

Similar to a renewable electricity certificate or guarantee of origin in the production of green electricity, a SAFc represents the environmental attributes of a metric tonne of neat (i.e. unblended) SAF.[7] SAFc can be either bundled with the physical fuel or unbundled from it. When unbundled from the physical fuel volume, SAFc can be sold and claimed separately.

This enables air transport consumers and providers without physical access to SAF to invest in this nascent industry and make valid emission reductions claims associated with a given amount of SAF, thus more directly addressing their aviation climate impact. Each SAF certificate has at least two intimately connected claims – one that can be made by an air transport provider, and another that can be claimed by a user of aviation services (i.e. a corporate with business travel emissions and/or air freight emissions).

FIGURE 3 **SAF certificates represent the environmental attributes of a batch of SAF**



Source: RMI, 2022

This book and claim mechanism builds from robust existing mass balance certification systems for SAF supply chains, and can enable:

– Air transport providers to share the SAF cost burden with their customers that are willing and able to pay the price premium.

– Stakeholders with air transport footprints who do not purchase jet fuel to contribute to the price premium of SAF. In return they can claim the environmental benefits towards their climate disclosure, and more directly address the climate impacts of their air travel.

– Airlines and carriers without physical access to SAF to purchase and claim the environmental benefits of SAF towards their climate disclosure in the same way they would if purchasing physical fuel and bundled SAFc.

– Supply chains to function more efficiently – for instance, allowing for the physical fuel to be delivered at the nearest airport, minimizing supply chain emissions and the associated environmental attributes to be claimed and reported by an entity elsewhere.

SAFc is designed to be consistent with existing standards and guidance.

In order to serve these use cases, SAFc requires comprehensive sustainability safeguards, a transparent registry to streamline and showcase the creation and use of certificates and clear accounting protocols to avoid the possibility of double counting the environmental benefits. This includes providing assurance that:

- When SAF certificates are unbundled from the underlying physical fuel, the fuel is sold as conventional jet fuel to avoid double claiming, i.e. a fuel supplier cannot sell physical SAF with its attributes and SAFc separately, such that the benefits could be claimed by multiple air transport providers and end users for any given volume.
- SAF certificates are not claimed by end users for voluntary claims if the physical SAF is used towards a compliance obligation.

As much as possible, SAFc is designed to be consistent with existing standards and guidance from the Greenhouse Gas Protocol (GHGP), Science Based Targets initiative (SBTi) and Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

In parallel with the development of these accounting guidelines, the Sustainable Aviation Buyers Alliance (SABA) in collaboration with the Roundtable on Sustainable Biomaterials (RSB) and the Clean Skies for Tomorrow initiative (CST) is developing a rulebook to define SAFc and its registry, which will provide a consistent structure and records for all issued and retired certificates.

SAF and SAFc sustainability criteria

The environmental attributes of SAF are certified at a facility level under mass balance sustainability certification schemes (SCS) throughout SAF supply chains. These SCSs or standards are currently held by the RSB and the International Sustainability and Carbon Certification (ISCC) system. These SCSs define sustainability criteria that are checked by accredited third-party auditors. Auditors certify facilities throughout SAF supply chains against these SCSs, evaluating the environmental attributes of the feedstocks and produced, transported and blended fuels.

ISCC and RSB hold a range of certification standards. Some of these are approved under specific regulations, for instance, the International Civil Aviation Organization's (ICAO) CORSIA and the EU's renewable energy directive (RED) standards. Others, including ISCC PLUS and RSB global standards, are designed to support the broader SAF market. Certification to any of these SCS can substantiate a SAF certificate. These certifications define and verify the environmental attributes of SAFc. For SAF supply chains certified to sustainability certification schemes, SAF certificates can be issued in a registry to a fuel supplier after the neat SAF is blended with conventional jet fuel. Then, any given SAFc can be transferred to and retired by air transport providers and corporate consumers of air transport services. Air transport providers can claim SAFc either when bundled with or when unbundled from the physical fuel volume. SAFc can then be claimed

> SAF should achieve, at minimum, a 60% life cycle CO_2e (carbon dioxide equivalent) emissions reduction relative to conventional jet fuel to substantiate a certificate.

towards climate disclosure once retired. When the attributes are unbundled, the physical fuel must be sold as conventional jet fuel to avoid double claiming.

In addition to SCS certification, the CST community has indicated a preference that SAF should achieve, at minimum, a 60% life cycle CO_2e (carbon dioxide equivalent) emissions reduction relative to conventional jet fuel to substantiate a certificate. This reduction threshold does not consider non-Kyoto Protocol GHGs.[8] Most of today's SAF surpasses this life cycle emissions reduction threshold.[9] Importantly, SAF should not threaten food security, result in direct or indirect land-use changes, or have significant emissions footprints from production.

SAF constitutes a very small percentage of global and individual airline fuel use today. Therefore, using a conventional jet fuel baseline like CORSIA's default value of 89 grams of CO_2e per megajoule (gCO_2e/MJ) or a jurisdiction-specific equivalent to determine the effective emissions reduction from the use of SAF accurately represents the impact of SAF and SAFc usage in emissions accounting and reporting.

However, in the future, when SAF will constitute a higher percentage of global and individual airline usage, this baseline may need to be revised to account for the baseline share of SAF in the fuel mix, likely differentiated by voluntary and mandated SAF. Mixed baselines will ultimately allow users of SAF and SAFc to more accurately account and report emissions reductions and should be the subject of future analysis.

Biogenic and non-biogenic GHG emissions

Biogenic emissions directly result from the combustion, decomposition or processing of bio-based materials other than fossil fuels, peat and mineral sources of carbon. The combustion of SAF made from biogenic feedstocks generates biogenic CO_2 emissions and a very small mass of nitrous oxide (N_2O) and methane (CH_4).[10] While the CORSIA life cycle assessment (LCA) methodology only accounts for CO_2 emissions from fuel combustion, it does account for other non-CO_2 GHG emissions upstream of combustion.[11]

Further, for SAF derived from biomass, biogenic wastes and residues, biogenic CO_2 emissions from fuel combustion are assumed to be balanced out by the CO_2 uptake via photosynthesis during the growth phase of the biogenic feedstock. Hence, the CO_2 emissions from the combustion of biogenic fuel are counted as zero in the assessment of SAF.

This treatment is consistent with the CORSIA and EU RED II life cycle assessment methodologies, GHGP standards, and the Intergovernmental Panel on Climate Change (IPCC) recommendations[12] for national GHG inventories. The combustion emissions of petroleum jet fuel consist of 83% (74 gCO_2e/MJ) of its total life cycle GHG emissions, thus avoiding this through the use of SAF provides significant GHG emissions benefits.[13]

For non-biogenic SAF and SAF with non-biogenic components, such as SAF produced from some municipal solid waste, non-biogenic CO_2 emissions from fuel combustion should be fully accounted for. In the case of e-fuels or power-to-liquid fuels, captured CO_2 can in certain cases be accounted as an emissions removal within the life cycle of the fuel. Non-biogenic CO_2 emissions from fuel combustion should not simply be assumed zero in any case.

There are several potential sources of captured CO_2 for e-fuels production – direct air capture (DAC) and industrial point source capture from bioenergy or fossil energies – some of which can be accounted for in other industrial actors' supply chains. If the removal of emissions is accounted for at the time of emissions capturing, then an air transport provider should fully account and report combustion emissions at the time of fuel combustion. Alternatively, if an upstream actor does not account for their removal of emissions at the time of emissions capturing, an air transport provider should account for the removal and report their combustion emissions as zero.

As all commercially available SAF today is produced from entirely biogenic feedstock, these guidelines recommend that in accounting for and reporting SAF and SAFc, stakeholders should report CO_2 combustion emissions as zero. In the future, however, when SAF produced from non-biogenic feedback feedstock is available, these guidelines will likely be changed to reflect the above.

Induced or indirect land use change

Induced or indirect land use change (ILUC) describes the potential unintended consequences of biofuels production on land use, quantified in terms of GHG emissions. For instance, if forested land is cleared to produce crop-based fuel, this fuel may cause a net increase as opposed to a decrease in GHG emissions. Including ILUC values (as determined through techno-economic models) in LCA calculations enables users of SAF to understand a broader range of supply chain implications associated with biofuels production and consumption.

In the CORSIA methodology, the LCA for any given SAF is calculated as the sum of the core LCA and ILUC, i.e. direct and indirect emissions values, and then compared with the LCA of conventional (petroleum-based) jet fuel to determine its life cycle emissions benefits.

According to the CORSIA methodology, SAF produced with waste and residue feedstocks by default does not result in ILUC impacts; however, additional certifications can help verify this.

SAF and global effective radiative forcing

Air transport impacts global climate in other ways than through its direct CO_2 contribution. While CO_2, N_2O and CH_4 are known to be the main contributors to aviation emissions, their contribution to the global effective radiative forcing (ERF) is estimated to be only a fraction – approximately half[14] – of the industry's total impact.

Emerging research indicates that other emissions from jet engine combustion at cruising altitude can cause further global warming beyond the impact of GHGs. For example, particulate matter has been linked with contrail-induced cirrus clouds that form in ice supersaturated regions (ISSR). Particulate matter can trap heat from the earth's surface in certain atmospheric conditions.

“ GHG emissions, in particular CO_2 emissions during air operations, are the only ones that are directly proportional to the fuel burned during flight operations.

However, GHG emissions, in particular CO_2 emissions during air operations, are the only ones that are directly proportional to the fuel burned during flight operations. The total climate impact of non-GHG emissions from aviation is significant and very uncertain.

A recent scientific publication[15] estimates that while the impact of non-CO_2 emissions from aviation was about 66% of the aviation net ERF in 2018, the range of uncertainty of this impact is eight times higher than that of CO_2 alone. A European Council report[16] also indicates, “the nature of ERF, in any form, is ‘backward looking’ and informs on the current perturbation of the radiation budget from historical and current-day emissions”. It goes on further to suggest that ERF does not inform on potential future changes, and neither does it provide any direct emission equivalence on the climate impact of GHG and non-GHG emissions. For this reason, the European Council report concluded that while ERF is relevant for understanding science it is not suitable for direct use in regulation that considers emissions equivalency.

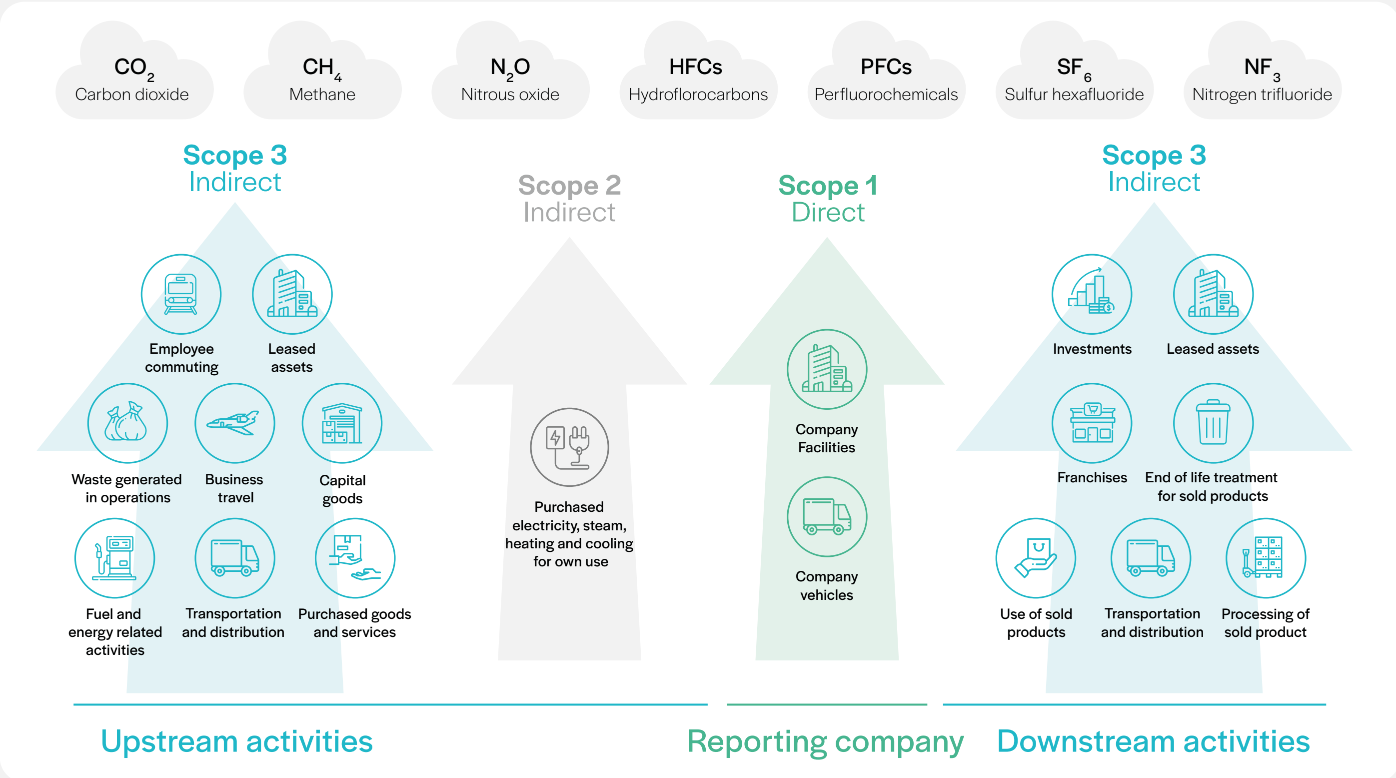
In view of the above and in line with the SBTi aviation sector guidance,[17] these guidelines focus exclusively on the impact of Kyoto GHG emissions for SAF accounting as there is even less scientific certainty about SAF's impact on radiative forcing than there is for conventional jet fuel. When scientific uncertainties associated with non-GHG emissions are resolved, these guidelines should be revisited to reflect these impacts on SAF accounting and reporting.

Some companies are starting to factor radiative forcing effects into their air transport inventories today to as accurately as possible capture their climate impacts. This is a commendable practice.

1 Key SAF accounting and reporting concepts

For SAF accounting and reporting to be robust, direct and indirect emissions must be considered.

FIGURE 4 Scope 1, scope 2 and scope 3 emissions as covered by the GHGP



Source: GHGP, 2013

1.1 Accounting SAF GHG emissions

Scope 1, 2 and 3 of carbon emissions

Scope 1 emissions are from activities performed directly by the reporting company. Scope 2 emissions are indirect emissions related to purchased energy (primarily electricity) of the reporting company. Scope 3 emissions are all indirect emissions related to activities performed throughout a reporting entity's value chain.[18]

Scope 3 emissions categories

Scope 3 corporate value chain emissions are categorized into 15 distinct categories as listed below. These are intended to provide companies with a systematic framework to organize, understand and report on the diversity of scope 3 activities within a corporate value chain. Each scope 3 category is composed of multiple activities that individually result in emissions.

TABLE 1 Upstream and downstream scope 3 categories

Upstream or downstream	Scope 3 categories
Upstream emissions	1. Purchased goods and services 2. Capital goods 3. Fuel- and energy-related activities (not included in scope 1 or scope 2) 4. Upstream transportation and distribution 5. Waste generated in operations 6. Business travel 7. Employee commuting 8. Upstream leased assets
Downstream emissions	9. Downstream transportation and distribution 10. Processing of sold products 11. Use of sold products 12. End-of-life treatment of sold products 13. Downstream leased assets 14. Franchises 15. Investments

Source: GHGP, 2013

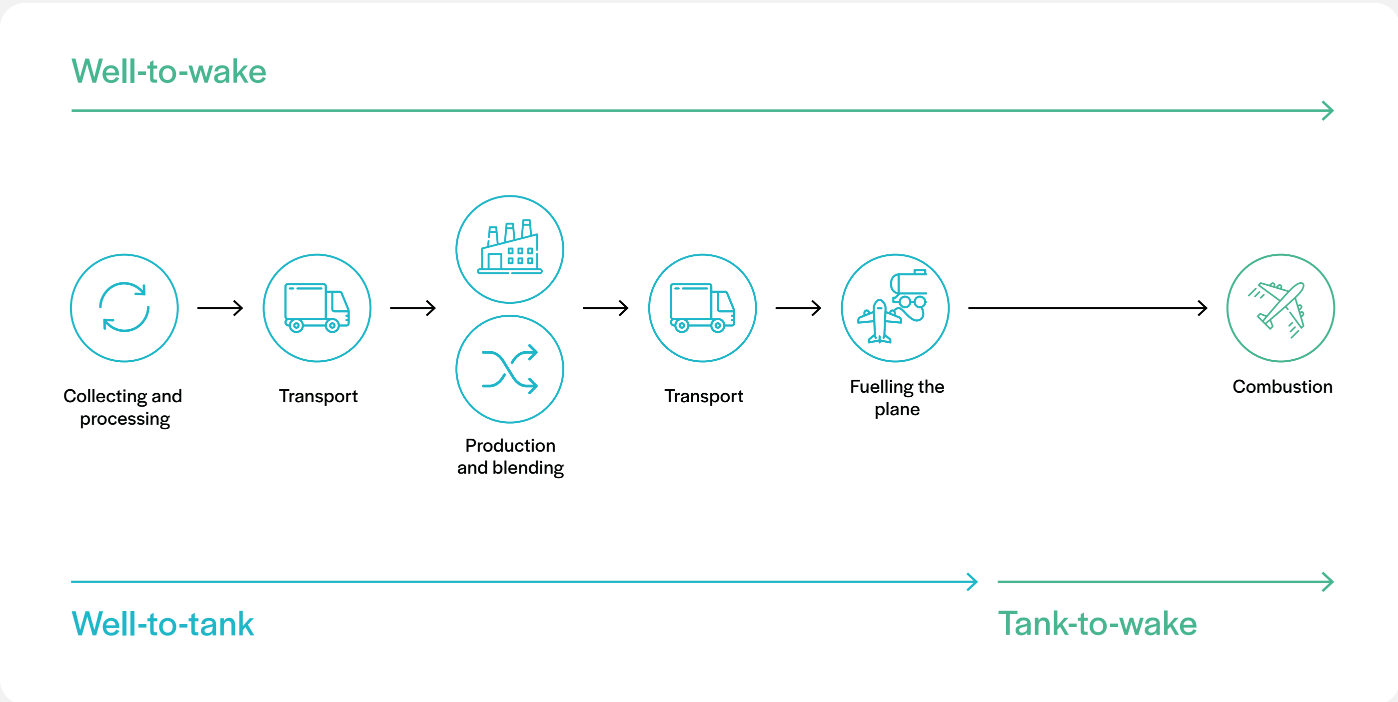
Well-to-tank, tank-to-wake and well-to-wake emissions

Well-to-wake (WTW) emissions represent emissions of the activities across the value chain of jet fuel in the aviation sector. These emissions can be split into two components:

– Well-to-tank (WTT) encompasses emissions from feedstock sourcing, processing and transport to fuel production, and distribution.

– Tank-to-wake (TTW) consists of emissions exclusively from the combustion of fuel.

FIGURE 5 **Example of an indicative well-to-wake process**



Source: World Economic Forum

Preventing double counting of emissions

To prevent double counting of emissions, the GHGP corporate standard defines scope 1 and scope 2 emissions to ensure that two or more companies do not account for the same emissions within the same scope.[19]

However, the standard acknowledges that double counting within scope 3 emissions can occur when multiple entities in the same value chain account for the scope 3 emissions from a single emissions source. Scope 3 accounting[20] facilitates the simultaneous action of multiple entities to reduce emissions throughout society. It is important to note that while a single emission may be accounted for by multiple entities as scope 3, the emissions should be reported in different scope 3 categories.

Emissions calculation using the GHGP five-step approach

The GHGP prescribes the following five-step sequential approach for companies to identify and calculate their GHG emissions:[21]

1. Identify GHG emissions sources
2. Select a GHG emissions calculation approach
3. Collect activity data and choose emission factors
4. Apply calculation tools
5. Roll up GHG emissions data to corporate level

The five-step approach is applied and explained in detail in the proposed accounting guidelines for each "persona" in the following sections. Specific data requirements and calculation methodologies are also included within each "persona".

Furthermore, these guidelines also include examples in Appendix 1 to demonstrate the practical application of the five-step approach.

Approaches for rolling up GHG emissions data to corporate level

The GHGP offers two basic approaches for gathering data on GHG emissions from a corporate's facilities:

TABLE 2 **Description of the decentralized vs centralized approach according to the GHGP**

Decentralized	Centralized
Individual facilities collect activity/fuel use data, directly calculate their GHG emissions using approved methods, and report this data to the corporate level.	Individual facilities report activity/fuel use data (such as quantity of fuel used) to the corporate level, where GHG emissions are calculated.

Source: GHGP, A Corporate Accounting and Reporting Standard (Revised edition), 2004

The decision of the preferred approach by the corporate should be based on the following:[22]

- Nature of the business including operational and geographical dispersion
- Approach to procurement and availability of raw material.
- Consistency in the characteristics of sourced raw material
- Availability of activity data and reporting tools
- Availability of a quality management system to ensure consistency and integrity of data
- Reporting knowledge of the involved staff members

These guidelines include recommendations for appropriate approaches to gather data at the corporate level in the following sections.

1.2 SAF life cycle assessment

These guidelines refer to the CORSIA LCA methodology for the calculation of the life cycle GHG emissions of SAF. The system boundary of the CORSIA LCA methodology covers the full value chain of SAF. SAF life cycle emissions are calculated as the sum of emissions from all attributed processes along the supply chain (the core LCA) and the modelled induced or indirect land use change (ILUC) value.

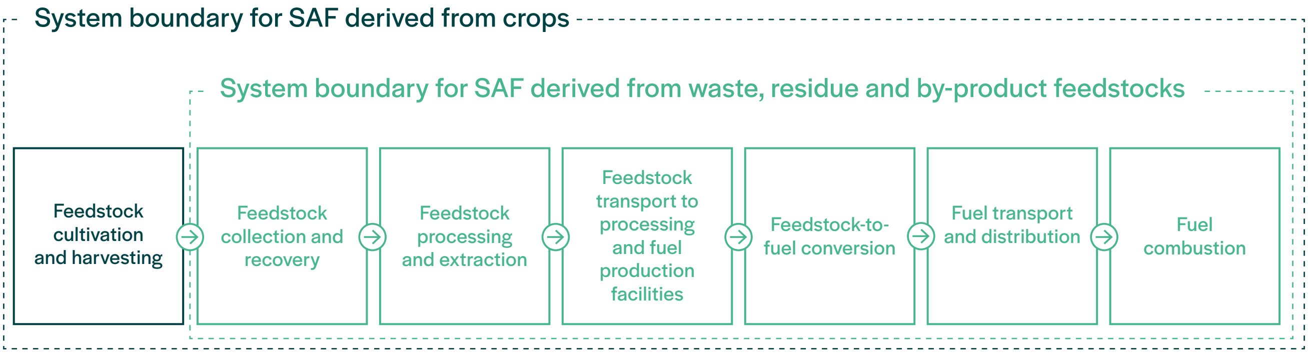
The core life cycle GHG emissions of SAF are calculated using a process-based attributional LCA approach. This method accounts for the product's mass and energy flows along the whole value chain of SAF. When using attributional analysis for the core LCA GHG emissions calculations, emissions are allocated as the sum of emissions from each stage of the value chain and allocated between co-products on the basis of the products' embodied energy content.

As detailed within the CORSIA standard and the SBTi aviation sector guidance, participating operators can either use default life cycle emissions factors, or may alternatively use an actual core life cycle value certified through an ICAO-approved SCS.[23]

SAF core LCA [gCO_2e/MJ] = Feedstock cultivation **+** feedstock harvesting and collection **+** feedstock processing **+** feedstock transportation **+** feedstock to fuelconversion **+** fuel transport and distribution **+** fuel combustion

As the life cycle of each batch of SAF varies by feedstock type and conversion pathway, so will the component elements of the core LCA calculation. For instance, SAF derived from agricultural crops will include the following core LCA components:

FIGURE 6 **Core LCA calculation system boundaries differ by feedstock type**



Source: ICAO, 2019

For ILUC emissions, a consequential approach is taken that estimates how global environmental burdens are affected by the production and use of the SAF.

Total life cycle GHG emission values for a given SAF are a sum of the "core LCA" emissions calculated and the ILUC emission value. Of note, the CST community has indicated a preference that for fuel to be considered SAF, it should not threaten food security or result in direct or ILUC.

CO_2, CH_4 and N_2O are the only relevant GHG emissions in the life cycle assessment of SAF.

SAF life cycle emission factor = Core LCA values (gCO_2e /MJ) **+** ILUC emission values (gCO_2e/MJ)

1.3 Reporting SAF GHG emissions

GHG emissions are reported by businesses as part of their publicly available sustainability or annual reports. Businesses also provide emissions data to other global environmental disclosures, such as the Carbon Disclosure Project (CDP) and the Task Force on Climate-Related Financial Disclosures.

Where possible, the reporting suggestions in these guidelines are built on existing GHGP standards. Revisions and supplements are proposed to promote transparency and consistency. In accordance with the GHGP, a corporate public emissions report published by the SAF and/or SAFc user will include the following:

- An outline of the organizational and operational boundaries chosen by the reporting company.
- For scope 3, a list specifying the types of categories/activities covered.
- The reporting period covered.
- Methodologies/calculation tools used to calculate scope 1, 2 and 3 emissions.
- The year chosen as the base year[24] to which current emissions can be compared.
- In case any significant changes within the reporting boundaries occur, a recalculation of the base year emissions.
- Any specific exclusion of sources, facilities or operations within the reporting period.
- An emissions profile that is consistent with and clarifies the chosen reporting company's policy for making base year emissions recalculations.

Limitations of existing reporting guidelines

The GHGP currently considers only direct emissions from jet fuel burn without incorporating more accurate life cycle emissions, which, in the case of SAF, includes upstream impacts from biogenic feedstocks[25] and ILUC. Furthermore, it requires that biogenic CO_2 from the combustion of biomass be reported separately from scope 1.

In order to ensure that corporate buyers of SAF and SAFc are credited for mitigating aviation-related emissions, revisions and supplements are proposed under each "persona" in these guidelines.

Once a reliable methodology is available, these guidelines propose that users of SAF and SAFc include the following reporting components currently not included in the GHGP:

- Emissions data for all GHG emissions, including CO_2, CH_4, N_2O in tonnes and in tonnes of CO_2e (within the relevant scopes).
- GHGs not covered by the Kyoto Protocol, as well as radiative forcing reported separately from scopes, as per the SBTi Aviation Sector Guidance.

Overview of SAF and SAFc emissions and reporting

TABLE 3 **Overview SAF and SAFc emissions and reporting per "persona"**

		Fuel suppliers	Airlines	Corporate travelers	Private aircraft	Freight		
						Carriers	Shippers	Freight forwarders
Emissions	WTT (well-to-tank)	Scope 1, 2, and/or 3 depending on op boundary	Scope 3 category 3	Scope 3 category 6	Scope 3 category 3	Scope 3 category 3, 4	Scope 3 category 3, 4	Scope 3 category 3, 4
	TTW (tank-to-wake)*	Scope 3 category 11	Scope 1	Scope 3 category 6	Scope 1	Scope 1	Scope 3 category 3, 4	Scope 3 category 3, 4
Reporting	SAF*	Scope 1, 2, and/or 3 depending on op boundary	Scope 1	N/A	Scope 1	Scope 1	N/A	N/A
	Unbundled SAFc	N/A	Scope 1	Scope 3 category 6	Scope 1	Scope 1	Scope 3 category 3, 4	Scope 3 category 3, 4

* Biogenic CO_2 emissions are accounted as zero for every actor

2 Persona: SAF supplier

2.1 Introduction

SAF suppliers encompass all actors downstream of feedstock supply and upstream of airlines in the value chain of SAF. These actors collectively source feedstock and produce and supply SAF to commercial airlines and other air transport providers. Yet, many suppliers only play a subset of these roles in SAF supply chains.

SAF is sourced from sustainable resources including waste oils of biological origin, biomass raw materials, direct air capture (DAC) CO_2, forestry and agricultural residues, or municipal solid waste. Suppliers seek sustainability certification of the supply chain of SAF they provide to enable consumers to understand and claim the environmental attributes of their products.[26] Eligibility for sustainability certification is determined and confirmed via third-party audits to a sustainability certification scheme (SCS) such as the RSB and ISCC's CORSIA standards.

Proposed inventory boundary

The corporate emissions inventory boundary and the accounting treatment of a SAF supplier are dependent on its organizational and operational boundary, as well as business context, which can vary widely.

The choice of the inventory boundary is dependent on the business characteristics of the persona. All relevant emissions sources within the chosen inventory boundary should be accounted for so that a comprehensive and meaningful inventory is compiled.

These guidelines recommend that SAF suppliers should include complete life cycle or WTW emissions including direct scope 1 and scope 2 emissions, and indirect scope 3 emissions as part of GHG emissions inventories.

Suggested emissions accounting and reporting treatment

- A SAF supplier is directly responsible for feedstock-to-SAF conversion-related emissions from their facilities, accounted for and reported as scope 1. Emissions from the generation of purchased electricity consumed during the production are accounted for and reported as scope 2.
- Upstream emissions attributed to feedstock cultivation, collection, processing and production, are accounted for and reported as indirect scope 3 category 1 emissions.
- Downstream emissions associated with the transport and processing of neat SAF[27] should be attributed to the entity responsible for transport and processing. If the aforementioned activities are not within the organizational boundary of the SAF supplier, emissions will be classified as its indirect scope 3 category 9 and 10 emissions.
- Downstream emissions attributed to fuel combustion are classified as indirect scope 3 category 11 emissions of the SAF supplier.
- For biogenic fuels, CO_2 emissions from fuel combustion are assumed to be offset and therefore counted as zero in the LCA of SAF.
- Many SAF suppliers produce a number of products in addition to SAF. Suppliers should allocate emissions between any co-products on an energy content basis in order to accurately convey the life cycle emissions of SAF.[28]

2.2 Emissions accounting

This section explains emissions accounting for a typical SAF supplier using the GHGP stipulated five-step approach in identifying and calculating GHG emissions.

To illustrate the application of the five-step approach, the SAF supplier's assumed organizational boundary only includes fuel production/conversion from various types of sustainable feedstocks, including biomass or waste resources.

These guidelines include a sample calculation included in Appendix 1 to demonstrate the application of the five-step approach for the SAF supplier.

Step 1. Identify and map emissions sources to corporate inventory

Scope 1	Emissions associated with the production of SAF from the feedstock
Scope 2	Emissions associated with the generation of purchased electricity consumed during the production
Scope 3 category 1	Upstream emissions associated with the feedstock cultivation, harvesting, collection, processing and extraction
Scope 3 category 4	Upstream transport and distribution of the feedstock and/or fuel
Scope 3 category 9	Downstream emissions associated with the outbound transport and distribution of SAF to airports/ storage facilities
Scope 3 category 11	Downstream emissions associated with fuel combustion (end use of goods and services)

Step 2. Select a GHG emission calculation approach

As per the GHGP standards, the selection of an emission calculation approach should consider the availability and source of activity data as well as the applicable emission factor.

- Data should be activity- and supplier-specific, based on the raw material acquired and jet fuel produced and distributed.
- Emission factors should be based on total life cycle emissions of SAF using either the CORSIA default factor for a given feedstock type and conversion pathway, or an actual calculated LCA value as certified through an CORSIA eligible SCS.

Step 3. Collect activity data and choose emission factors

Emissions data should be identified and collected on a life cycle/WTW basis.

Upstream emissions data	**Primary data sourced from the supplier,** based on the mass (kg) of feedstock acquired from the feedstock supplier
Process emissions data	**Primary activity data**, based on production data
Downstream emissions data	**Primary supplier-specific data,** based on transport and distribution data **Secondary data sourced from atmospheric emission databases,** for example UK Department for Business, Energy and Industrial Strategy (BEIS) and US Environmental Protection Agency (EPA) emissions databases

The applicable LCA emission factor will vary depending on the underlying SAF feedstock and the conversion pathway.

Step 4. Apply calculation approach

The system boundary of the LCA methodology consists of the full value chain of SAF. SAF life cycle emissions should be calculated as the sum of the LCA values of all attributed processes – adding up direct emissions along the supply chain and the estimated ILUC values.[29]

For SAF derived from biomass and biogenic waste and residues, biogenic CO_2 emissions from fuel combustion in the aircraft engine are assumed to be balanced out by carbon uptake during growth (please refer to chapter one of this paper), and therefore, counted as zero in the core LCA of SAF.

Core LCA [gCO_2e/MJ] = Feedstock cultivation **+** feedstock harvesting, collection and recovery **+** feedstock processing and extraction **+** feedstock transport to processing and fuel production **+** feedstock to fuel conversion **+** fuel transport and distribution to the blend point **+** fuel blending **+** fuel combustion in an aircraft engine

SAF life cycle emissions are calculated as the sum of the "core LCA" and the estimated ILUC emission values.

Total SAF life cycle emissions = Core LCA values (gCO_2e/MJ) **+** ILUC emissions values (gCO_2e/MJ)

Step 5. Aggregate of emissions data to the corporate level

To report total corporate-wide emissions, a SAF supplier should gather and total the life cycle emissions for all batches of SAF produced.

This includes SAF batches produced in different locations during the reporting period.

As proof of sustainability documentation of certified batches can vary, a SAF supplier should use a decentralized approach to aggregate and report the GHG life cycle emissions data to the corporate level.

2.3 Proposed emissions reporting

A public GHG emissions report for a SAF supplier should include the following information:

- Emissions data reported for scope 1, scope 2 and scope 3, based on organizational and operational boundaries and the used raw materials, including:
- **Scope 1:** All relevant GHG emissions related to the supplier's activities in their operational boundary, reported **within the scope.**
- **Scope 2:** All relevant GHG emissions attributed to the production of electricity used during the production of SAF, reported **within the scope.**
- **Scope 3:** All relevant GHG emissions associated with downstream activities, including fuel transport and processing, and the combustion of supplier's SAF during flight operations, reported **within the scope**.
- All relevant GHG emissions associated with the upstream sourcing of feedstock by the SAF supplier, reported **within the scope.**
- Other SAF sustainability criteria verified through SCS certification and conveyed through proof of sustainability documentation.
- Name of the certification scheme(s), certification body or bodies and certification identification numbers.

3 Persona: Airlines

3.1 Introduction

Airlines are commercial aircraft operators that provide air transport services for travelling passengers and freight. Airlines use aircraft either owned by or leased to them, often on a long-term basis.

To reduce their life cycle emissions, airlines procure and use SAF as an alternative to conventional jet fuel, which is their largest GHG emissions source. Alternatively, airlines can purchase and retire unbundled SAFc via the registry to claim related environmental benefits and reduce total flight emissions. This in particular can enable aircraft operators in regions with limited physical access to SAF to invest in the nascent industry and make valid emissions reduction claims.

Proposed inventory boundary

The corporate emissions inventory boundary and the accounting treatment of an airline are dependent on its organizational and operational boundary as well as business context, which can vary widely.

Currently, most airlines only account for and report on combustion/TTW emissions. However, the SBTi aviation sector guidance recommends sectoral stakeholders develop inventories on a life cycle/WTW basis to account for all indirect and direct emissions.

For SAF, the inclusion of emissions attributed to production, transport and distribution is important as emissions reductions occur upstream of fuel combustion. Therefore, in order to claim an accurate emissions reduction and for a direct comparison with emissions from their SAF usage, airlines also need to account for and report fossil fuel upstream emissions on a WTW basis.

In view of the above, these guidelines recommend that commercial airlines include complete life cycle/WTW emissions including direct scope 1 and indirect scope 3 category 3 emissions as part of GHG emissions inventories.

Scope 1 emissions include emissions from the combustion of fuel during flight operations. Scope 3 category 3 includes upstream fuel and energy-related activities including all upstream emissions of purchased and consumed fuel.

Suggested emissions accounting and reporting treatment

– Airlines using physical SAF bundled with SAFc as well as those only purchasing unbundled SAFc should claim scope 1 emissions reductions.

– All direct and indirect (combustion-related and upstream) emissions associated with the procurement and use of SAF, except for biogenic CO_2 emitted during SAF combustion, should be accounted for and reported within the emissions inventory and public GHG reports.

“ To reduce their life cycle emissions, airlines procure and use SAF as an alternative to conventional jet fuel, which is their largest GHG emissions source.

3.2 Emissions accounting

In line with the GHGP standards, the emissions calculation should be based on consumption (mass or volume) and life cycle emissions or WTW for the used SAF, which varies for different production pathways and types of feedstock.

The data used in the emissions calculation should be activity-based primary data as well as supplier-specific secondary data.

These guidelines include a sample calculation in Appendix 1 to demonstrate the application of the five-step approach for airlines.

Step 1. Identify and map emission sources to corporate inventory

Scope 1	Emissions attributed to aircraft internal combustion engine
Scope 3 category 3	Upstream emissions from fuel- and energy-related activities, including emissions of purchased and consumed SAF including feedstock cultivation, harvesting, collection, processing and extraction, feedstock transport, blending, feedstock to fuel conversion, jet fuel transport and distribution

Step 2. Select a GHG emissions calculation approach

As per the existing GHGP standards, the selection of an emissions calculation approach should consider the availability and source of activity data, as well as the applicable emission factor.

- Primary activity data based on the mass or volume of SAF procured by the airline for flight operations, sourced from fuel purchase receipts and internal purchase records.
- Actual supplier and SAF-specific emission factors, based on life cycle assessment, obtained from the fuel supplier.

Step 3. Collect activity data and choose emission factor

Emissions data should be collected on a well-to-wake basis – the sum of both scope 1 emissions from SAF combustion and scope 3 category 3 fuel- and energy-related activities emissions from upstream production and distribution of SAF.

SAF suppliers will provide an LCA emission factor – the sum per unit of fuel for all the GHG emissions released into the atmosphere during the cultivation, harvesting, collection, processing and extraction, feedstock transport, feedstock to jet fuel conversion, jet fuel transport and distribution, and fuel combustion – as well as the ILUC value applicable to the type of feedstock via proof of sustainability documentation verified through SCS certification.

The applicable LCA emission factor will vary depending on the underlying feedstock type and the production pathway.

Step 4. Apply calculation approach

As suggested by the SBTi aviation sector guidance, to recognize that the choice of fuel can influence both the upstream and combustion emissions, airlines should account for their emissions on a WTW basis. Note that the GHGP does not recommend the same WTW accounting scope.

The outcome of the above calculation will be the per-flight well-to-wake emissions of the airlines, based on the life cycle emissions of neat SAF. By accounting for SAF life cycle emissions using LCA-based emission factors or alternate approved LCA values, an airline can account for reduced value chain emissions.

As SAF is blended with conventional jet fuel, airlines should keep a record of the effective amount of neat SAF purchased and consumed for flight operations during the reporting period. This data can be obtained from the purchase invoices of SAF or product transfer documentation from SAF suppliers to determine the exact amount of neat fuel consumed during the flights throughout the year.

Once a registry is live, airlines can also use the system to maintain a record of their retired SAFc – both bundled and unbundled – and the emissions reductions they represent.

SAF WTW emissions = **Scope 1 combustion emissions** based on TTW emission factor or approved LCA values ($kgCO_2e/kg$) **x** SAF consumption (kg) **+ Scope 3 category 3 emissions** based on based on WTT emission factor or approved LCA values ($kgCO_2e/kg$) **x** SAF consumption (kg)

Step 5. Aggregate emissions data to the corporate level and roll up

As described in the GHGP standards, to report total corporate-wide emissions, an airline should gather and sum up the data for all its flight operations during the reporting period.

An airline's GHG emissions inventory should include life cycle emissions from neat SAF as well as the conventional jet fuel use. The sum of the life cycle emissions of the two categories of fuel will be the total life cycle emissions of flight operations during the reporting period.

To fulfil their SAF demand, airlines may rely on multiple suppliers operating across varying jurisdictions, and therefore, SAF produced from a variety of feedstocks and production pathways.

In view of the limited production capacity and the impact of local regulations on SAF production and reporting, airlines should use a decentralized approach to total GHG life cycle emissions data. Under a decentralized approach, fleet and fuel management should collect fuel purchase and fuel consumption data for all flight operations to calculate emissions. When possible, airlines should use life cycle emission factors provided by suppliers and report the emissions data to the corporate level.

3.3 SAFc accounting treatment

Airlines without the ability to purchase physical fuel can also purchase and retire unbundled SAFc (via the registry once live) to claim SAF's environmental attributes. This should allow aircraft operators in regions with limited physical access to SAF to invest in the nascent industry and make valid emissions reduction claims.

Airlines should report their SAFc usage by subtracting the mass of CO_2e represented on the retired SAFc from their scope 1 emissions. The CO_2e represented by SAFc is based on the life cycle emissions of the SAF, relative to conventional jet fuel.

Each SAFc represents a CO_2e mass value explained in the equation below:

Total CO_2e emissions (mass) represented by SAFc = Volume of fuel **x** applicable conventional jet fuel LCA EF*– Volume of fuel **x** SAF LCA EF

*Emission factor

3.4 Proposed emissions reporting

A public GHG emissions report for airlines using SAF and/or SAFc to manage their aviation emissions should include the following information:

- Total flight operations life cycle emissions based on different data sets for all the batches of SAF and conventional jet fuel reported separately for both:
  - **Scope 1 (TTW)** – direct emissions attributed to fuel consumption during flight operations.
  - **Scope 3 category 3 (WTT)** – upstream emissions attributed to activities in the life cycle of SAF and conventional jet fuel production.
- Combustion and upstream emissions data for biogenic CO_2 and other Kyoto Protocol emissions reported within the scopes in metric tonnes and in metric tonnes of CO_2 equivalent.
- Total emissions reductions in CO_2e claimed through SAFc purchase.
- Proof and name of the sustainability certification scheme (RSB or ISCC) to which purchased SAF and/or SAFc supply chains are certified (see RSB Book and Claim Manual[30] and SAFc registry rulebook for more details).
- Airlines retiring and reporting unbundled SAFc should continue to report their actual as well as reduced emissions, calculated by subtracting emissions represented by retired SAFc from actual emissions. Termed as "dual reporting" in GHGP, this helps to demonstrate effective emission reductions as a result of retiring SAFc.

In the absence of a SAFc registry in which airlines can retire SAFc, airlines should make emissions reduction claims only after they receive corresponding proof of sustainability and product transfer documentation from their fuel suppliers in bilateral transactions.

4 Persona: Corporate traveller

4.1 Introduction

Corporate travellers are businesses with employees that are actively involved in business travel by air, in aircraft operated by commercial airlines. These guidelines only apply to corporate travellers that make use of commercial airlines. In the case of companies with private aircraft, the accounting and reporting method differs and is described in the "Private aircraft persona" section of this paper.

Proposed inventory boundary

Corporate travellers should account for and report total business air travel emissions under scope 3 category 6, which should comprise LCA emissions of the associated airlines. This differs from the existing boundary of air travel related scope 3 category 6 emissions, which only includes an associated airline's scope 1 combustion emissions.

Suggested emissions accounting and reporting treatment

- The corporate traveller emissions inventory should be based on a life cycle or WTW basis.
- When accounting for business travel emissions, corporate travellers should first calculate emissions for all flights based on conventional jet fuel use.
- Emission reductions, as a result of a corporate traveller purchasing and retiring SAFc, should be accounted for by subtracting emissions represented by retired SAFc from the corporate traveller's business travel emissions.
- Corporate travellers should claim reductions in emissions from purchased and retired SAFc through the registry, once functional.
- Corporate travellers not retiring SAFc in the registry should only use the applicable LCA emission factor of conventional jet fuel to report their air travel emissions. This reporting requirement should not be affected by the associated airlines' choice of fuel.

4.2 Emissions accounting

The emissions calculation should be based on the consumption and life cycle emissions of conventional jet fuel. The data used in the calculation will be both activity-based primary data as well as third-party-provided secondary data.

These guidelines include sample calculations, which can be found in Appendix 1 to demonstrate the application of the five-step approach for the corporate traveller.

Step 1. Identify GHG emission sources to corporate inventory

Scope 3 category 6	Upstream emissions associated with business air travel, using applicable life cycle emissions factor/intensity of conventional jet fuel.

Step 2. Select a GHG emissions calculation approach

" The fuel-based method for calculating travel emissions is the most accurate as it involves determining the exact amount of fuel consumed and applying the related emission factor.

GHGP recommends using one of three calculation methods to calculate air transport GHG emissions:

- **Distance-based method,** which involves determining the distance and mode of business trips, and then applying the appropriate emission factor for the mode used.
- **Fuel-based method,** which involves determining the amount of fuel consumed during business travel and applying the appropriate emission factor for that fuel.
- **Spend-based method,** which involves determining the amount of money spent on each mode of business travel and applying secondary (environmentally extended input-output) emission factors.

According to GHGP,[31] the fuel-based method for calculating travel emissions is the most accurate as it involves determining the exact amount of fuel consumed and applying the related emission factor. However, the distance-based method is often the most practical approach for aviation corporate travellers today to calculate their business travel emissions because:

- The data required to accurately estimate emissions with the fuel-based method is not always readily available.
- The distance-based method is most consistent with the prevalent accounting and reporting practices.
- Distance is the most available data within corporate customers' internal data set, unless they work directly with airlines to receive more accurate, fuel-based data.
- The fuel-based method may become more suitable when the requisite datasets become readily available. Therefore, these guidelines provide the reader with a sample fuel-based calculation approach.[32]

Although the spend-based method is effective for screening purposes, it can be highly inaccurate. Hence, the spend-based method is the least preferred while calculating and reporting emissions from business travel, and therefore, is not detailed here.

Step 3. Collect activity data and choose emission factors

The emissions calculation should be based on activity data, jet fuel consumption for the fuel-based method or distance travelled for the distance-based method. The activity data and emission factors used to calculate business travel emissions will depend on the choice of the calculation methods explained above.

Distance-based:
Activity data includes the number of kilometres travelled per person (passenger-kilometres, abbreviated as p-km) for a particular aircraft type.

Total distance (p-km) travelled by mode of air transport (type of aircraft, travel class etc.) for employees in the reporting period can be calculated or collected from the following:

1. Automatic tracking of distance travelled by aircraft through a travel agency or other sources
2. Travel reports provided by airlines
3. Annual surveys/questionnaires/reporting manual of employees

Irrespective of the fuel type used by their associated airlines, corporate travellers should use secondary emission factors of conventional jet fuel. These are based on the default databases of regional or national emission factors of various travel types (short, medium or long haul and economy, business or first), represented as kilograms of CO_2e emitted per kilometre or passenger-kilometre. Examples of entities with published emission factor databases include BEIS (Department for Environment, Food and Rural Affairs (DEFRA)), the US EPA and the Dutch Emissions Authority.

Fuel-based:
Activity data includes mass (kg or tonnes) of fuel consumed by an associated airline allocated to the reporting company's corporate travels. As explained above, this data is not commonly shared with corporate travellers today. Hence, this version of the guidelines does not include a suggestion on the sourcing of the data for the fuel-based method.

Step 4. Apply calculation approach

Distance-based:
The distance-based method uses the applicable conventional jet fuel LCA emission factor ($kgCO_2e$/p-km) and flight distance (p-km) to calculate category 6: business travel emissions

∑ (Distance per air travel (km)) × conventional jet fuel WTW emission factor ($kgCO_2e$/p-km)

In calculating the total emissions for the reporting period, the activity data should be summed to obtain the total annual kilometres travelled with airlines.

In Appendix 1 examples, secondary emission factors published by BEIS (DEFRA) have been used to calculate distance-based emissions.

Fuel-based:
The fuel-based method uses fuel consumption data (kg) and the applicable conventional jet fuel LCA emission factor (kg CO_2e/p-km).

∑ (Mass of fuel consumption (kg)) × conventional jet fuel WTW emission factor ($kgCO_2e$/kg fuel))

Step 5. Aggregate emissions data to the corporate level and roll up

To report total corporate business travel emissions, the reporting company will gather and sum up the emissions data for all business air travel emissions for the reporting period, on a life cycle or WTW basis.

Most corporate travellers report their business travel emissions using a centralized approach. However, the reporting company should select the approach best suited to them.

4.3 SAFc accounting and reporting treatment

Corporate travellers should report their SAFc usage (via the registry once live) by subtracting emissions represented by retired SAFc from scope 3 category 6 business travel emissions inventory. The CO_2e represented on each SAFc is based on the applicable life cycle emissions of the conventional jet fuel.

Each unit of SAFc represents a CO_2e reduction (kg or tonnes) explained in the equation below:

Total CO_2e emissions (mass) represented by SAFc = Volume of fuel **x** applicable conventional jet fuel LCA emission factor (EF) **–** Volume of fuel **x** SAF LCA EF

4.4 Proposed emissions reporting

A public GHG emissions report for a corporate traveller purchasing SAFc to reduce its aviation travel emissions should include the following information:

1. The corporate traveller emissions reported on a complete life cycle or WTW basis.
2. Total scope 3 emissions reductions in CO_2e claimed by SAFc via the book and claim system.
3. Corporate travellers retiring SAFc should continue to report their original as well as reduced emissions. Termed as dual reporting in GHGP, this helps to demonstrate effective emissions reductions as a result of retiring SAFc.
4. Corporate travellers using SAFc to reduce scope 3 emissions should disclose proof and the name of the sustainability certification scheme (RSB or ISCC) to which the fuel supply chain is certified (see RSB Book and Claim Manual[33] and SAFc registry rulebook for more details).

In the absence of a SAFc registry, corporate travellers should make emissions reduction claims only after they receive corresponding proof of sustainability and product transfer documentation from their associated airlines or fuel supplier in bilateral transactions.

Once the SAFc registry is live, corporate travellers should use this IT system with their associated fuel supplier and airlines to streamline the SAFc issuance, transfer and retirement process. This system will require that fuel suppliers upload proof of sustainability documentation linked to an active mass balance certification to substantiate certificate issuance. SAFc buyers should only make claims on SAFc after a unit has been retired in their name within the registry.

5 Persona: Private aircraft

5.1 Introduction

Private aircraft are owned, or leased aircraft used by businesses to transport their own passengers and/or freight.

To reduce their travel-related life cycle emissions, businesses using private aircraft may procure SAF and use it instead of conventional fuel. Alternatively, they can claim related environmental benefits to reduce business travel-related emissions by purchasing and retiring SAFc via a registry.

Proposed inventory boundary

Businesses using private aircraft should account for all the direct and indirect emissions attributed to the use of private aircraft in a reporting period on a life cycle or WTW basis. These businesses should include in their GHG emissions inventory all the applicable life cycle emissions including:

- Scope 1 emissions from the combustion of fuel during flight operations.
- Scope 3 category 3 emissions from upstream fuel and energy-related activities, including all upstream emissions of purchased and consumed fuel.

Suggested emissions accounting and reporting treatment

- Businesses with private aircraft using SAF or purchasing SAFc should claim emissions reductions, resulting from significantly lowered emissions during upstream fuel and energy-related activities, similar to that of an airline.
- Combustion and upstream emissions data for biogenic CO_2 and other Kyoto Protocol emissions reported within the scopes.
- Emissions calculations should be based on consumption (mass or volume) or distance travelled and life cycle emissions of the used SAF.

5.2 Emissions accounting

Please see below for GHGP stipulated five steps to account for SAF-related emissions.

Step 1. Identify and map emissions sources to corporate inventory

Scope 1	Direct emissions attributed to internal combustion engine
Scope 3 category 2	Upstream emissions from fuel and energy-related activities

Step 2. Select GHG emissions calculator approach

The selection of an emissions calculation approach should consider the availability, source and accuracy of activity data and applicable emission factors. Businesses using private aircraft should use the following emissions calculation methods, prioritizing the fuel-based method if data is available as it is more accurate:

- **Fuel-based method**, which involves determining the amount of SAF consumed during air transport and applying the appropriate emission factor for that fuel.

- **Distance-based method**, which involves determining the distance and, if applicable, the mode of air transport, then applying the appropriate secondary emission factor for the mode used. (The mode of air transport refers to long-, medium- and short-haul, as well as business versus economy class).

Step 3. Collect activity data and choose emission factor

Emissions data should be collected on a WTW basis – the sum of both scope 1 emissions from SAF combustion and scope 3 category 3 fuel- and energy-related activities emissions from upstream production and distribution of SAF.

SAF suppliers will provide an LCA emission factor – the sum per unit of fuel for all the GHG emissions released into the atmosphere during the cultivation, harvesting, collection, processing and extraction, feedstock transport, feedstock to jet fuel conversion, jet fuel transport and distribution, and fuel combustion – as well as the ILUC value applicable to the type of feedstock via proof of sustainability documentation verified through SCS certification.

The applicable LCA emission factor will vary depending on the underlying feedstock type and the production pathway.

Activity data and sources:

- For fuel-based calculations: fuel receipts, purchase or procurement records

- For distance-based calculations: distance travelled, based on actual travel reports

Emission factors and sources:

- SAF supplier provided certified carbon intensity value

- CORSIA default conventional jet fuel LCA baseline of 89 gCO_2e/MJ.

Step 4. Apply calculation approach

Fuel-based business travel emissions inventory of business using private aircraft	=	**Scope 1 combustion emissions** (LCA based TTW emission factor or approved LCA values: $kgCO_2e/kg$) **x** SAF consumption (kg) **+ scope 3 category 3 emissions** (LCA based WTT emission factor or approved LCA values: $kgCO_2e/kg$) **x** SAF consumption (kg)
Distance-based business travel emissions inventory of businesses using private aircraft	=	Distance per private aircraft air travel (km) **×** SAF WTW emission factor ($kgCO_2e$ /km)

Step 5. Aggregation of emissions data to the corporate level and roll up

As SAF are blended with conventional jet fuel, the reporting company should keep a record of the amount of neat SAF as well as conventional jet fuel purchased and consumed for flight operations during the reporting period.

The business travel-related emissions inventory of the reporting company should comprise life cycle emissions from the neat SAF as well as the conventional jet fuel use. The sum of the life cycle emissions of the two fuel categories will be the total life cycle emissions of private aircraft flight operations during the reporting period.

Alternatively, if the reporting company is purchasing and retiring SAFc via the book and claim system, it should maintain a record of the amount of emissions reductions represented by its retired SAFc.

5.3 SAFc accounting treatment

Businesses using private aircraft can also purchase and retire unbundled SAFc (via the registry once live) to claim SAF's environmental attributes, much like an airline without the ability to purchase physical SAF. This should allow businesses in regions with limited physical access to SAF to invest in the nascent industry and make valid emissions reduction claims.

Similar to that of an airline, businesses using private aircraft should report their unbundled SAFc usage by subtracting the mass of CO_2e represented on the retired SAFc from their scope 1 emissions. The CO_2e represented by SAFc is based on the life cycle emissions of the SAF, relative to the same volume of conventional jet fuel.

Each SAFc represents a CO_2e mass value explained in the equation below:

Total CO_2e emissions (mass) represented by SAFc = Volume of fuel **x** applicable conventional jet fuel LCA EF **–** Volume of fuel **x** SAF LCA EF

5.4 Proposed emissions reporting

- Total flight operations related life cycle or WTW emissions for SAF as well as conventional jet fuel reported separately for:
  - **Scope 1** – direct emissions attributed to fuel consumption during flight operations.
  - **Scope 3 category 3 (WTT)** – upstream emissions attributed to activities in the life cycle of SAF and conventional jet fuel production.
- Combustion and upstream emissions for the biogenic CO_2 and all the other Kyoto Protocol emissions reported within the scopes in metric tonnes and in metric tonnes of CO_2 equivalent.
- Total scope 1 emissions reductions in CO_2e claimed by SAFc via the book and claim system.
- Proof and name of the sustainability certification scheme (RSB or ISCC) to which purchased SAF and/or SAFc supply chains are certified (see RSB Book and Claim Manual[34] and SAFc registry rulebook for more details).
- Businesses using private aircraft retiring SAFc should continue to report their original as well as reduced emissions. Termed as dual reporting in GHGP, this helps to demonstrate effective emission reductions because of retiring SAFc.

In the absence of a SAFc registry in which businesses using private aircraft can retire SAFc, these businesses should make emissions reduction claims only after they receive corresponding proof of sustainability and product transfer documentation from their fuel suppliers in bilateral transactions.

6 Persona: Freight

6.1 Introduction to freight emissions accounting

Key concepts and suggested emissions accounting and reporting treatment

These freight guidelines cover the following three key stakeholder types:

1. **Carriers or freighters** that operate aircraft with the sole purpose of transporting freight.[35]
2. **Freight forwarders or logistics service providers (LSPs)** that act as delegates between the company that makes the shipment (the shipper) and the carrier and/or an associated airline. Unlike a carrier, freight forwarders do not carry out the shipments themselves.
3. In the case of larger, worldwide LSPs, freight forwarders can also act as a carrier if it operates their own aircraft. However, in these guidelines, the freight forwarder doesn't assume the additional role of carriers.
4. **Shippers** that are purchasers of freight transport services with freight that requires transport by air. Shippers may hire freight forwarders to secure air transport services on their behalf or may hire air carriers directly.

Any given company may include business units across more than one of these stakeholder types, i.e. a company can assume and report emissions in multiple roles. In that case, it should follow the recommendations detailed below for each stakeholder type (presented as mutually exclusive here for clarity) and then total their emissions across each category.

Freight or cargo are goods that are transported by air, sea or land. For this accounting and reporting guideline, only air transport of cargo will be considered.

Air freight, including mail, is **transported by two types of aircraft**: dedicated cargo aircraft, which carry freight only, and aircraft operated by commercial airlines, which carry both passengers and freight in the holds of aircraft, called **belly cargo**.

When unbundled from the physical SAF, SAFc can be sold and claimed separately, which enables:

The above-listed stakeholders to contribute to the cost of and claim the environmental attributes of the underlying neat SAF and more directly address the climate impacts of their aviation freight operations.

1. Shippers to contribute to and report – by purchasing and retiring SAFc – environmental attributes associated with the consumption of SAF. With the help of a functioning SAFc book and claim registry, the shippers can do so even if the associated carriers aren't directly using SAF for their freight aviation operations.

2. Carriers using SAF for their freight aviation operation to allocate the emissions reductions to shippers that contribute to their abatement efforts by purchasing freight services and SAFc.

Where possible, these guidelines directly make use of and build from the GHGP Global Logistics Emissions Council framework and the draft Smart Freight Centre Abatement Cost Sharing Framework.

As SAFc is currently not explicitly addressed or recognized in the above standards, the specific recommendations on the use of SAFc may not conform with the above.

Proposed inventory boundary and scope allocation

The corporate emissions inventory boundary and the accounting treatment of carriers, freight forwarders and shippers are dependent on their organizational and operational boundary, as well as business context, which can vary widely.

The scope and categories listed above include the following activities and related emissions:

- Scope 1 emissions include direct emissions from the combustion of fuel during flights.
- Scope 3 category 3 comprises upstream fuel and energy-related activities, including all upstream emissions of purchased and consumed fuel.
- Scope 3 category 4 comprises upstream transport and distribution, including emissions from outsourced fuel consumption.

TABLE 4 **Overview of scope reporting and accounting for freight "personas"**

Carrier	Freight forwarder	Shipper
– Scope 1 emissions from combustion during flights – Scope 3 category 3 – Scope 3 category 4	– Scope 3 category 3 – Scope 3 category 4	– Scope 3 category 3 – Scope 3 category 4

6.2 Emissions accounting

This section proposes emissions accounting for the aforementioned three key stakeholders using the GHGP stipulated five-step approach in identifying and calculating GHG emissions. The emission factor used in the calculation of SAF-related emissions should be based on consumption (mass and/or volume) and life cycle emissions of the used SAF. The applicable LCA emission factor will vary depending on the underlying SAF feedstock and the conversion pathway.

Step 1. Identify and map emissions sources to corporate inventory:

Carrier	
Scope 1	Direct emissions attributed to internal combustion engine
Scope 3 category 3	Upstream emissions from fuel and energy-related activities, including emissions of purchased and consumed SAF including feedstock cultivation, harvesting, collection, processing and extraction, feedstock transport, blending, feedstock to fuel conversion, jet fuel transport and distribution.
Scope 3 category 4	Upstream transport and distribution-related activities (outsourced fuel consumption) for freight forwarders and shippers, including fuel consumption of associated carriers.

Freight forwarder	
Scope 3 category 3	Upstream emissions from fuel and energy-related activities, including emissions of purchased and consumed SAF including feedstock cultivation, harvesting, collection, processing and extraction, feedstock transport, blending, feedstock to fuel conversion, jet fuel transport and distribution.
Scope 3 category 4	Upstream transport and distribution-related activities (outsourced fuel consumption) such as associated carriers' fuel consumption.

Shipper	
Scope 3 category 3	Upstream emissions from fuel and energy-related activities, including emissions of purchased and consumed SAF including feedstock cultivation, harvesting, collection, processing and extraction, feedstock transport, blending, feedstock to fuel conversion, jet fuel transport and distribution.
Scope 3 category 4	Upstream transport and distribution-related activities (outsourced fuel consumption) such as associated carriers' fuel consumption.

In identifying the inventory boundary of the freight-related SAF and SAFc corporate buyers, these guidelines conform with the following standards:[36]

- Assumes scope 1 or TTW combustion-related emissions of biogenic SAF to be zero.
- Includes SAF-related WTT emissions attributed to production, transport and distribution.

SAF suppliers will provide an LCA emission factor – the sum per unit of fuel for all the GHG emissions released into the atmosphere during the cultivation, harvesting, collection, processing and extraction, feedstock transport, feedstock to jet fuel conversion, jet fuel transport and distribution, fuel combustion – as well as the ILUC value applicable to the type of feedstock via proof of sustainability documentation verified through SCS certification.

Steps 2 and 3. Select a GHG emission calculation approach, collect activity data and choose emission factor

Carrier

A carrier is responsible for accounting and reporting the complete life cycle emissions of the SAF as well as the conventional jet fuel that it consumes.

Since activity data such as fuel use for the duration of the flight can be directly and readily sourced, the fuel-based method should be used to calculate GHG emissions.

Emissions data should be collected on a WTW basis as the sum of combustion and energy-related emissions from the upstream production and distribution of SAF and conventional jet fuel.

> A carrier is responsible for accounting and reporting the complete life cycle emissions of the SAF as well as the conventional jet fuel that it consumes.

Activity data:

- SAF and conventional jet fuel consumption in mass, from receipts and fuel management systems. Fuel use data should be based on full round trip flights, defined by the Smart Freight Centre[37] as a group of sequential journeys that start and end in the same place.

Emission factor:

- Supplier-specific emission factor based on LCA emissions for each batch of SAF purchased and used.
- For conventional jet fuel, the default CORSIA LCA emission factor of conventional jet fuel or jurisdiction-specific equivalent.

Freight forwarder

Based on its inventory boundary, the freight forwarder is responsible for all upstream emissions of the fuel consumed during the transport of the cargo, as well as any emissions from upstream transport and distribution of the cargo.

Although the freight forwarder can use any of the three methods (fuel-based, distance-based or spend-based) to calculate its scope 3 emissions, **distance-based** is the most commonly used.

Activity data:

– Distance travelled, based on onboard systems or Great Circle Mapper

– Mass of shipment (gross mass)

Emission factor:

– Default CORSIA LCA emission factor of conventional jet fuel baseline or jurisdiction-specific equivalent based on LCA

Default factors:

– Fuel efficiency (International Air Transport Association (IATA) RP1678 or EN 16258) and fuel intensity (IATA RP1678 or EN 16258)

Shipper

Based on its inventory boundary, the shipper is responsible for all emissions from upstream transport and distribution of the cargo, carried out by the carrier or the freight forwarder – in cargo-designated aircraft or in the belly hold of a passenger aircraft.

Based on the availability of data and common industry practice, shippers should use the **distance-based method** to calculate their scope 3 emissions.

Activity data:

– Distance travelled, based on onboard systems or Great Circle Mapper

– Mass of shipment (gross mass)

Emission factor:

– Default CORSIA LCA emission factor of conventional jet fuel baseline or jurisdiction-specific equivalent based on LCA

Default factors:

– Fuel efficiency and fuel intensity (IATA RP1678 [to be superseded soon by RP1726] or EN 16258)

Explanatory note for freight forwarders and shippers

For shippers and freight forwarders, the distance-based method uses mass to quantify the amount of cargo transported or processed. Mass is selected due to its consistent application across the supply chain, and also because it is widely accepted in published methodologies.

The distance a shipment is transported is measured from the point at which the shipper hands it over to the carrier and ends with the hand-over of the shipment to another carrier or the end receiver, for example, a household or another business.

In order to ensure that emissions inventories are based on life cycle emissions, freight forwarders and shippers should use WTW emission factors for both SAF and conventional jet fuel.

Freight forwarders and shippers should use the CORSIA baseline of 89 gCO_2e/MJ or an alternative jurisdiction-specific LCA value in their emissions calculations.

For freight forwarders, note that while distance-based is the GLEC prescribed and most commonly used method, depending on the availability of activity data (fuel use or invoices for fuel purchase) and operational or/and jurisdictional guidelines, a freight forwarder can also use the fuel- or spend-based method.

For all three methodologies, calculation approaches should be in line with the GHGP and GLEC frameworks.

Step 4. Apply calculation approach

Carrier: Fuel-based method

SAF WTW emissions = **Scope 1 combustion emissions** based on TTW emission factor or approved LCA values (kgCO_2e/kg) **x** SAF consumption (kg) **+ scope 3 category 3 emissions** based on based on WTT emission factor or approved LCA values (kgCO_2e/kg) **x** SAF consumption (kg)

The above methodology should also be used to calculate emissions from the consumption of conventional jet fuel.

SAF is mixed with conventional jet fuel to varying degrees. Hence, it is important for carriers to keep a record of the amount of neat SAF, as well as conventional jet fuel, consumed during the reporting period. This data can be obtained from the purchase invoices of SAF or product transfer documentation from SAF suppliers to determine the exact amount of neat SAF consumed during the flights throughout the year.

By adding the life cycle emissions of the two fuel types, the carrier should calculate the total life cycle emissions of their flight operations during the reporting period.

When calculating their respective emissions inventories, freight forwarders and shippers should use the applicable life cycle emissions of conventional jet fuel or the CORSIA default conventional jet fuel LCA baseline of 89 gCO_2e/MJ. Both "personas" should ensure that the underlying data accounts for all relevant GHGs and full life cycle emissions of the conventional jet fuel.

Freight forwarder and shipper: Distance-based

Step 1:

Tonne-km (tkm)	=	Total freight in mass (tonne) **x** average shipment distance (km)

Step 2:

Total GHG emissions ($kgCO_2e$) *With a fuel efficiency factor*	=	∑ (total tkm **×** jet fuel WTW efficiency factor (kg/tkm)) **x** fuel emission factor ($kgCO_2e/kg$)

Step 5. Aggregate emissions data to the corporate level and roll up

In the case of the carrier, to aggregate total corporate business travel emissions, the reporting company should gather and add-up data for air business travel-related WTW emissions for the reporting period based on SAF and conventional jet fuel consumption.

In the case of freight forwarders and shippers, the total emissions based on the applicable activity data should be summed for the reporting period to calculate distance-based emissions.

6.3 SAFc accounting treatment

Carriers, much like airlines, can purchase and retire unbundled SAFc (via the registry once live) to claim environmental attributes. This should allow carriers in regions with limited physical access to SAF to invest in the nascent industry and make valid emissions reduction claims.

Carriers should report their unbundled SAFc usage by subtracting the mass of CO_2e represented on by the retired SAFc from their scope 1 emissions inventory.

Freight forwarders and shippers, to claim SAFc-related emissions reductions in their scope 3 emissions inventory, should similarly subtract their emissions by the CO_2e represented by the retired SAFc.

Each SAFc represents a CO_2e mass value explained in the equation below:

Total CO_2e emissions (mass) represented by SAFc	=	Volume of fuel **x** applicable conventional jet fuel LCA EF **–** volume of fuel **x** SAF LCA EF

Key recommendations and next steps

Bringing SAFc to life is a collective and ongoing endeavour. The collaborative work of CST, the SABA, the RSB, the Smart Freight Centre (SFC) and many other partners in industry has progressed the broader framework this far. This collaborative effort continues to build a universal market infrastructure that can unlock key barriers to SAF at scale.

The key recommendations made in these guidelines are:

- All users of SAF and SAFc should account for and report their use – as well as their use of conventional jet fuel – on a well-to-wake basis. Accounting for the life cycle emissions of both conventional jet fuel and SAF with the same full life cycle scope will enable every actor to compare the lifecycle emissions of these fuels more holistically and accurately.
- The emissions reductions associated with SAF certificates, when claimed by air transport providers and aviation customers, should be reported within scopes as direct reductions to their air travel emissions (Scope 1 for air transport providers, Scope 3 Category 6 for corporate travellers, Scope 3 Category 3 and 4 for freight forwarders and shippers).
- For air transport providers (airlines, private aircraft owners and operators, and freight carriers), this recommendation holds true for both bundled (i.e., carried with the physical fuel volume they purchase) and unbundled (i.e. not carried with the physical fuel volume they purchase) certificates, which critically enables air transport providers operating in regions without SAF supply to invest in SAF to start decarbonizing their value chains, if not their direct supply chains.
- While spend-based calculations are common and simple ways to calculate emissions associated with air travel, they are not as accurate as distance and fuel-based calculations. These guidelines recommend that aviation customers use distance-based calculations to understand their aviation footprint more accurately, and the role that SAFc purchases can play in reducing this footprint. Fuel-based calculations are not yet practical for many aviation customers, but if this changes, the fuel-based method is also recommended as an accurate alternative to spend-based calculations.

Next steps

These guidelines will be piloted in the coming months with an eye to practicality, consistency and clarity. In this spirit, interested companies in the aviation value chain are invited to test the recommendations included herein. Participating as an early adopter will help to establish consensus towards a unified set of guidance for how SAF and SAFc accounting and reporting can work to facilitate the decarbonization of the aviation sector.

Ultimately these guidelines aim to remove uncertainty in the market and foster a common understanding and alignment across the aviation value chain, as well as with practitioners and standard setters outside of it.

Appendix 1: Sample calculations

A Sustainable aviation fuel (SAF) supplier sample calculation using corn oil and hydro-processed esters and fatty acids (HEFA) pathway

SAF life cycle emissions are calculated as the sum of the "core life cycle assessment (LCA)" and the estimated induced land use change (ILUC) emission values.

Total SAF life cycle emissions = Core LCA values (gCO_2e/MJ) **+** ILUC emissions values (gCO_2e/MJ)

SAF core LCA values = EF (cultivation) **x** kg of feedstock **+** EF (harvesting and collecting) **x** kg of feedstock acquired **+** EF (processing and extraction) **x** kg of feedstock **+** EF (feedstock transportation) **x** (kg of feedstock **x** distance) **+** EF (fuel production) **x** kg of SAF **+** EF (SAF transport and distribution) **x** (kg of SAF **x** distance)

Data used:	
Mass of corn oil purchased by the SAF supplier	1,000 tonnes or 1,000,000 kg
LCA values for corn oil based on MIT-GREET model[38]	
Feedstock cultivation and collection	0.0025 $kgCO_2e/MJ$
Feedstock transport	0.0005 $kgCO_2e/MJ$
Feedstock to fuel conversion	0.014 $kgCO_2e/MJ$
Fuel transport	0.0005 $kgCO_2e/MJ$
Midpoint carbon intensity value	0.0172 $kgCO_2e/MJ$[39]
Corn oil ILUC LCA value[40]	0
Combustion emission factor (For biomass-derived fuels, CO_2 emissions from fuel combustion are assumed to be offset, therefore counted as zero in the LCA of SAF)	0
Energy density/content by mass of hydro-processed oil of biomass origin, to be used for replacement of jet fuel[41]	44 MJ/kg

Calculating GHG emissions for SAF suppliers

Corn oil purchased kg	Feedstock cultivation and collection $kgCO_2e/MJ$	Feedstock cultivation and collection $kgCO_2e/kg$	Emissions $kgCO_2e$
1,000,000	0.0025	0.11	110,000
Corn oil purchased kg	**Feedstock transport gCO_2e/MJ**	**Feedstock transport $kgCO_2e/kg$**	**Emissions kg CO_2e**
1,000,000	0.0005	0.022	22,000
Corn oil purchased kg	**Feedstock to fuel conversion gCO_2e/MJ**	**Feedstock to fuel conversion $kgCO_2e/kg$**	**Emissions $kgCO_2e$**
1,000,000	0.014	0.616	616,000
Corn oil purchased kg	**Fuel transport gCO_2e/MJ**	**Fuel transport $kgCO_2e/kg$**	**Emissions $kgCO_2e$**
1,000,000	0.0005	0.022	22,000
Fuel transported kg		**Fuel combustion $kgCO_2e/kg$**	**Emissions $kgCO_2e$**
1,000,000		0	0
		Total LCA emissions	770,000

Note: LCA values are converted from $kgCO_2e/MJ$ to $kgCO_2e/kg$ by multiplying the former with the energy density/content of SAF in MJ/kg.
For example: 0.0025 $kgCO_2e/MJ$ X 44 MJ/kg = 0.11 $kgCO_2e/kg$

B Airline sample calculation using total SAF WTW emissions using the Fischer-Tropsch pathway

Total SAF WTW emission = Scope 1 combustion emission (LCA based TTW emission factor or approved LCA values: $kgCO_2e/kg$) **x** SAF consumption (kg) **+** scope 3 category 3 emission (LCA based WTT emission factor or approved LCA values: $kgCO_2e/kg$) **x** SAF consumption (kg)

Data used:	
Type of SAF consumed	Agriculture residue
Total SAF consumed during reporting period	1,000,000 tonnes or 1,000,000,000 kg
Agriculture residue GHG intensity[42]	0.0077 $kgCO_2/MJ$[43]
Energy density (energy content) by mass	44 MJ/kg
Agriculture residue emission factor (WTT) (Agriculture residue emission factor (WTT) **=** agriculture residue GHG intensity **x** energy density (energy content) by mass)	0.34 $kgCO_2e/kg$
Combustion emission factor (TTW)	0

Calculating GHG emissions for airline using SAF

SAF consumption (kg)	Emission factor (TTW) $kgCO_2e/kg$ (a)	SAF TTW emissions ($kgCO_2e$)
1,000,000,000	0	0
SAF consumption (kg)	**Emission factor (WTT) $kgCO_2e/kg$ (b)**	**SAF WTT emissions ($kgCO_2e$)**
1,000,000,000	0.34	340,000,000

SAF WTT emissions (tCO_2e)*	SAF TTW emissions (tCO_2e)	SAF WTW emissions (tCO_2e)
340,000	0	340,000

* Unit conversion from tonne to kg (1 t = 1000 kg).

C Corporate traveller sample calculation using the distance-based method

Example of distance-based emissions calculation approach based on the applicable well-to-wake emission factor.

The method uses the applicable secondary emission factor of conventional jet fuel denominated in passenger kilometres ($kgCO_2e$/p-km).

∑ (Distance per air travel (short, medium and long haul + travel class) × applicable WTW jet fuel emission factor ($kgCO_2e$/p-km)

Data used to calculate emissions from corporate traveller flying from London Heathrow (LHR) to Rome Fiumicino Airport (FCO) using BEIS emission factor

Distance as per Great Circle Mapper	1,446 kilometers
BEIS sourced WTT emission factor from short-haul flights to and from the UK	
WTT	0.01681 $kgCO_2e$/p-km
TTW	0.01681 $kgCO_2e$/p-km
WTW	0.17034 $kgCO_2e$/p-km

Travel activity (km)	WTW emission factor ($kgCO_2e$/p-km)	Total WTW emissions ($kgCO_2e$)
1,446	0.17034	246

D Example calculation of SAFc accounting and reporting treatment

To calculate the total scope 3.6 emissions of the corporate traveller for the reporting period, the total WTW emissions of each air business travel are calculated and summed up.

In the below example, it is assumed that employees of the reporting company travelled twice for business during the reporting period.

Flight	Associated jet A energy (MJ)	CORSIA based energy intensity ($kgCO_2e/MJ$)	Total emissions including WTW ($kgCo_2e$)
LHR-FCO	2.876	0.089	0.256
LHR-JFK	13.504	0.089	1.202
			1.458

In order to account for and report its air-travel-related scope 3.6 emissions inventory, the corporate traveller in this example subtracts their business travel emissions by 0.75 t CO_2e represented by the retired SAFc.

Total emissions including WTW (tCO2e) during the reporting period	tCO2e representation in the retired SAFc	Scope 3.6 emissions (tCO2e) during the reporting period
1.4578*	0.75	0.708

* Unit conversion from tonne to kg (1 t = 1000 kg).

The same calculation applies to any other "persona", for example, airlines or businesses using private jets, purchasing and retiring SAFc via the book and claim system, although the scope will vary.

E Corporate traveller sample calculation using the fuel-based method

Data used to calculate fuel-based emissions for corporate traveller flying from LHR to JFK	
Fuel consumed during flight from London Heathrow (LCR) to John F. Kennedy International Airport (JFK)	70,000 litres (approximation)
CORSIA default conventional jet fuel LCA baseline	0.089 $kgCO_2e/MJ$
Jet A fuel density by volume	0.820 kg/litres
Jet A fuel energy content by volume	35.4 MJ/litre
Jet A LCA emission factor (volume)[44]	**WTW 3.20 $kgCO_2e$/litre jet fuel**

Corporate travel emissions calculated using CORSIA default conventional jet fuel LCA baseline:	=	∑ (quantity of fuel consumed (litres)) **×** jet fuel energy content (MJ/litres) **×** CORSIA baseline emission factor of the fuel (e.g. $kgCO_2e/MJ$)

Fuel (litres)	Jet A fuel energy density (MJ/litre)	CORSIA baseline ($kgCO_2e/MJ$)	Total WTW emissions ($kgCO_2e$)
70,000	35.4	0.089	220,542

Corporate travel emissions calculated using jet A LCA emission factor:	=	∑ (quantity of fuel consumed (litres)) **×** jet fuel density (kg/litres) **×** emission factor of the fuel (e.g. $kgCO_2e$/litre)

Fuel (litres)	LCA emission factor jet A ($kgCO_2e$/litre)	Total fuel-based emissions ($kgCO_2e$)
70,000	3.20	224,000

The data required to accurately estimate emissions with the fuel-based method is not always readily available. Hence the fuel-based method, despite being most accurate, is currently not practicable.

The fuel-based method may become more suitable when the requisite datasets become accessible. Therefore, these guidelines provide the reader with a sample fuel-based calculation approach.

Step-by-step calculation guide for corporate traveller emissions accounting

Distance-based method	km **x** DEFRA EF $kgCO_2e$/km = $kgCO_2e$
Fuel-based method	L (fuel) **x** density kg/L = kg
	kg **x** energy content MJ/kg = MJ
	MJ **x** $kgCO_2e$/MJ = $kgCO_2e$

Appendix 2: Normative references

The proposed SAF certificate (SAFc) accounting and reporting guidelines attempt to align as much as possible with other standards on carbon accounting for the aviation sector, business travel and freight. These guidelines build on the below-listed publications, which contextualize and inform this document.

Owing to the relative nascency of the SAF and SAFc industry and system, the listed resources offer diverse perspectives on key issues. The proposed guidelines, therefore, compare these resources and make appropriate suggestions to maximize compatibility while also streamlining data collection, accounting and reporting efforts.

The Greenhouse Gas Protocol – *A Corporate Accounting and Reporting Standard*

- This corporate standard establishes the requirements and guidance for organizations and companies who wish to prepare a corporate-level greenhouse gas emissions inventory.

The Greenhouse Gas Protocol – *Scope 2 Guidance*

- The *Scope 2 Guidance* standardizes how corporations estimate emissions from purchasing or acquiring various types of energy. Importantly it includes requirements for accounting of emissions from energy contracts and instruments such as EACs in GHG inventories.

The Greenhouse Gas Protocol – *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*

- The *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* establishes guidance for companies to assess emissions impact across their entire value chain and thus determine an effective strategy for focusing their emissions reduction activities.

The Greenhouse Gas Protocol – *Technical Guidance for Calculating Scope 3 Emissions*

- The *Technical Guidance for Calculating Scope 3 Emissions* guides businesses in completing their scope 3 inventories. It provides methods for calculating GHG emissions for each of the fifteen scope 3 categories, data sources and worked examples.

The Greenhouse Gas Protocol – *Product Life Cycle Accounting and Reporting Standard*

- The product standard articulates a methodology that can be used to understand the full life cycle emissions of a product and thus provides companies and organizations with insight as to where best to focus their emissions reduction activities.

Science-Based Targets initiative – *Science-based Target Setting For the Aviation Sector*

- This SBTi guidance outlines a target-setting method for airlines to meet the sector's Paris-aligned GHG intensity by 2050. It provides guidance for using SAF towards a science-based target but acknowledges that there is no clear guidance as of yet for SAFc accounting under the GHGP.

ICAO – *CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels*

- ICAO's CORSIA gives default life cycle emissions values that may be used by an aircraft operator to claim emissions reductions from the use of CORSIA-eligible fuels each year. CORSIA also provides an actual life cycle emissions methodology for SAF suppliers whose supply chains may not be accurately represented by the default values.

RSB Book and Claim Manual

- This draft manual proposes the framework for a robust book and claim system by describing the necessary prerequisites for registration, transfer and retirement of units or certificates in a registry. The SAF certificate rulebook and registry that SABA is developing are designed to be compatible with the draft *RSB Book and Claim Manual*.

Powering Sustainable Aviation Through Consumer Demand: The Clean Skies for Tomorrow Sustainable Fuel Certificate (SAFc) Framework

- The previous report developed by the World Economic Forum's Clean Skies for Tomorrow initiative introduces the SAFc framework. The report explains the need for, purpose of, initial steps towards and general functionality of SAFc.

Smart Freight Centre – *SAF Greenhouse Gas Emissions Accounting and Insetting Guidelines*

– Smart Freight Centre's guidelines guide stakeholders in SAF emissions accounting and lay out principles for a book and claim chain of custody system for SAF insets.

Smart Freight Centre – Framework to Incentivize Freight Transportation Greenhouse Gas Emission Reduction Activities

– Smart Freight Centre's draft framework lays out how companies can incentivize GHG emission reduction activities across freight transport supply chains through book and claim mechanisms. It addresses barriers to broader partnerships around freight transport decarbonization and outlines a way for shippers, forwarders, carriers and providers of low-emission transport solutions to share the costs of decarbonizing freight transport.

Global Emissions Logistics Council (GLEC) Framework

– GLEC has put together a globally recognized methodology for harmonized calculation and reporting of logistics GHG footprints across multi-modal supply chains. It can be implemented by shippers, carriers and logistics service providers. The calculations in the GLEC framework are complemented by the following tools:

International Air Transport Association (IATA) – Recommended Practice 1678

– IATA provides a standard methodology by which an airline or any third party can calculate CO_2 emissions generated by air cargo at the shipment level. It aims to serve as an industry-wide solution to address the challenges of air cargo carbon footprint measurement and reporting.

US Environmental Protection Agency (EPA) – *2018 SmartWay Air Carrier Partner Tool: User Guide*

– SmartWay Air Carriers represents a set of member organizations that measure, benchmark and report emissions, and improve their sustainability performance on an annual basis. Users must timely submit a completed and accurate SmartWay Air Tool to the US EPA to make sure data is in the EPA partner database.

European Standards – *CSN EN 16258,23*

– This standard specifies general principles, definitions, system boundaries, calculation methods, apportionment rules and data recommendations, with the objective to promote standardized and verifiable declarations regarding GHG emissions related to transport services. It also includes example applications of the principles. The standard will be succeeded by ISO 14083 in November 2022.

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