Sustainable Aviation Fuel Greenhouse Gas Emission Accounting and Insetting Guidelines

Smart Freight Centre and MIT Center for Transportation & Logistics

Smart Freight Centre

MIT Center for Transportation & Logistics

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About Smart Freight Centre

Smart Freight Centre was established in 2013 as a global non-profit organization dedicated to sustainable freight. We cover all freight and only freight. Our vision is "Smart Freight," an efficient and zero emissions global logistics sector that contributes to Paris Climate Agreement targets and UN Sustainable Development Goals. Our mission is to bring together the global logistics community through our Global Logistics Emissions Council to work towards this vision. We believe that increased transparency and collaboration will mobilize companies to reduce the climate and pollution impacts from global freight.

About MIT Center for Transportation & Logistics

The MIT Center for Transportation & Logistics (MIT CTL) has become a world leader in supply chain management research and education since its inception nearly 50 years ago. MIT CTL has made significant contributions to supply chain and logistics management theory and practice. Fueled by the demands and requirements of consumers, governments, and investors – and by the Center's previous work in resilience and risk – supply chain sustainability emerged as a key research area for the Center in the early 2000s. In 2018, MIT CTL founded MIT Sustainable Supply Chains to better support ongoing research and collaboration that aim to improve the social and environmental sustainability of supply chain business processes.

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Executive Summary

The air transportation industry is responsible for a significant amount of greenhouse gas (GHG) emissions each year. In 2018, global aviation operations generated approximately 903 million tonnes of CO_2 emissions [1]. If global aviation were a country, it would have been the sixth largest emitter of CO_2 that year, emitting less CO_2 than Japan and more than Iran [2]. Although the COVID-19 crisis has profoundly impacted the air transportation industry, air freight transportation volumes are already back to 2019 levels and air passenger transportation activity is also expected to rebound [3] [4].

Commercial aviation's operational requirements and need for high energy density fuels make it particularly difficult to decarbonize the sector using solutions – like batteries charged with renewable electricity – that are available in other transportation applications. Use of sustainable aviation fuels (SAF), which have lower life cycle GHG emission intensities than conventional aviation fuels, is one of the principal means currently available for reducing air transportation emissions.

While nearly 200,000 commercial flights have been conducted using SAF [5], SAF uptake is still extremely limited. For comparison, in 2019 alone, there were over 38 million global commercial flights [6].

One reason for the limited uptake of SAF is its cost, which can be several times that of conventional aviation fuels. It is difficult for air carriers to commit to buying large volumes of SAF without firm financial commitments from their customers to bear some of the significant cost premium of SAF. Similarly, it can be difficult for fuel producers to demonstrate enough demand for SAF to warrant investment in SAF production infrastructure without commitments to purchase SAF from users of air transportation services as well as from air carriers.

Until now, there has been no clear guidance on how a user of air transportation services making a financial commitment to reduce GHG emissions within its supply chain can receive a benefit from that commitment by reporting a reduced GHG emission footprint. This process of investing in emission reductions within an organization's supply chain, called insetting, is particularly relevant as a tool for reducing GHG emissions from the transportation sector [7].

This document outlines a system for GHG insets that allows air carriers, logistics service providers, freight shippers, aviation fuel suppliers, business travelers, and travel management companies to collaborate with each other to bear the cost premium of SAF, increase the uptake of SAF, and reduce air transportation emissions. The document also shows how these organizations can benefit from the ability to report lower emissions as a result of their investment. The guidelines include:

- Principles for a book and claim chain of custody system to track aviation fuel environmental attributes. These principles serve as the structural framework for insetting with SAF.
- Directions on accounting for the GHG emission reduction benefits of SAF. These accounting directions are based on and consistent with broadly accepted emissions accounting practices.
- Default life cycle GHG emission factors for several different types of SAF.

The book and claim system described in these guidelines is designed to provide entities along the SAF value chain confidence that SAF environmental attributes are of legitimate origin, of a reasonable vintage, and not erroneously double counted. The system is also intended not to be so strictly defined that it will hinder the use of SAF. Specifically, these guidelines establish two principles for insetting SAF environmental attributes in air transportation value chains:

1. SAF environmental attributes can only be used to inset GHG emissions associated with the insetting organization's actual transport activity.
2. A declaration of SAF environmental attributes is only valid for up to two consecutive annual reporting periods from the date of SAF production.

The GHG emission accounting procedures in these guidelines explain how to document and account for SAF emissions and how entities in air transportation value chains can work together to report SAF emission reductions consistently and transparently. Specifically, the accounting procedures:

- Clarify the distinctions between conventional aviation fuels and biogenic SAF as they relate to GHG emission reporting.
- Outline the fundamentals of reporting life cycle emissions for SAF.
- Provide detailed instructions on reporting SAF emissions to stakeholders in air transportation value chains.
- Provide detailed instructions on allocating the emission benefits of SAF, as bound by transport activity, between parties in the air transportation value chain.
- Describe how to avoid erroneous double counting of the emission reduction benefits of SAF.

To summarize, this document provides purchasers of the GHG emission reduction benefits of SAF the tools to make reputable claims about the emissions reductions realized from the use of SAF. The document also outlines a framework for insetting with SAF to facilitate the increased utilization and production of SAF. In so doing, these guidelines serve as a resource for realizing GHG emission reductions for both air carriers and their customers.

Part 1:
Background and Global Context

The Air Transportation Industry and Sustainable Aviation Fuel

The air transportation industry is a significant emitter of GHG and has an important role to play in achieving global climate goals. Before the COVID-19 crisis, the industry was responsible for approximately 3% of annual global GHG emissions. And aviation emissions were projected by International Energy Agency (IEA) to grow 2% per year between 2015 and 2025 [8] [3]. Air transportation is also a lever that organizations can pull to reduce their GHG emission footprints, for example, by replacing business trips with digital conferencing or by switching to lower-GHG alternatives for their transportation needs.

The COVID-19 crisis changed the dynamics of the industry profoundly. IEA predicts passenger volumes may not fully rebound until 2030 [3]. As for freight transportation, the International Air Transport Association (IATA) estimates that air cargo volumes rebounded to 2019 levels in 2021 [4]. While the near-term future of passenger aviation is less certain than that of freight, if the industry is to meet global climate goals, the long-term imperative for aviation GHG emissions performance improvement remains.

An essential part of the International Civil Aviation Organization's (ICAO) strategy for meeting aviation climate goals between now and 2035 involves offsetting of incremental GHG emissions through the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) [9]. Offsets involve a GHG emission reduction or removal outside of an organization's supply chain.

In contrast to offsets, GHG insets involve interventions to reduce or remove emissions in an organization's supply chain. As such, insets address the source of emissions attributable to the organization and its products or services more directly than offsets. Insetting is particularly relevant as a tool for reducing GHG emissions from the transportation sector [7].

One option for GHG insetting is the use of SAF [10]. Despite barriers to widespread adoption, SAF is often acknowledged to be a feasible solution for effective GHG emission reductions in air transportation [11] [12] [13].

However, significant upfront investment is needed to scale up SAF availability. The construction of new biorefineries alone will involve annual costs estimated to be hundreds of billions of dollars [14].

These infrastructure costs, and the costs of producing SAF even once infrastructure is in place, contribute to a significant price premium for SAF as compared to conventional aviation fuels. Lacking certainty that there will be demand for SAF at this premium, potential investors are reluctant to finance the development of SAF infrastructure.

Insetting with SAF provides users of air transportation services a way to cover the cost premium of SAF for their air transportation activity. In demonstrating a willingness to pay the premium for SAF, these users of air transportation services help provide investors the certainty needed to underwrite development of SAF infrastructure.

Additionally, guidelines that describe how to account for and disclose SAF emissions are required to incentivize demand for SAF [10]. A lack of a defined transportation fuel insetting framework has limited the adoption of insetting as a way to abate GHG emissions within organizations' supply chains [15]. These guidelines provide an approach for SAF emissions accounting and disclosure while outlining a system for GHG insets that allows organizations in the air transportation value chain to collaborate and reduce emissions within the sector.

Global Context for SAF Emission Accounting Methods

The GHG emission accounting principles described in these guidelines are aligned with recognized emissions accounting frameworks, including those published by the Greenhouse Gas Protocol (GHG Protocol) and Science Based Targets initiative (SBTi), and with the UN-led Global Green Freight Action Plan. The guidelines are based on and supplement the Global Logistics Emissions Council (GLEC) Framework.

The GLEC Framework includes the only globally recognized method for harmonized calculation and reporting of logistics GHG footprints across multi-modal supply chains. It can be implemented by carriers, logistics service providers, and shippers to inform business decisions and steer efforts to reduce emissions. The GLEC Framework carries the "Built on GHG Protocol" mark and is a core input to a forthcoming International Standards Organization (ISO) standard, ISO 14083 [16].

While the GLEC Framework describes GHG accounting for the freight sector, passenger transportation is not specifically covered in the GLEC Framework. The GLEC Framework was, however, developed considering International Air Transport Association (IATA) Recommended Practice (RP) 1678 and European Standard EN16258. Both RP 1678 and EN16258 address passenger as well as freight transportation.

These guidelines were developed considering CORSIA [9]. CORSIA defines how and where GHG offsets can be used to reach international aviation climate goals. CORSIA also provides standards for the sustainability characteristics of SAF. These sustainability characteristics include minimum life cycle GHG emission reductions compared to conventional aviation fuel.

Revisions to the guidelines may be necessary as new methods and instruments emerge.

For example, the production of biogenic SAF has implications for agriculture and land use change emissions. In 2020, World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) launched a new project that will provide additional guidance under the GHG Protocol for carbon removal in the land sector. This work could prove important with respect to reporting biogenic emissions and carbon sequestration [17].

Similarly, the World Economic Forum's Clean Skies for Tomorrow (CST) initiative is developing a "SAF certificate (SAFc) Framework" for scaling the uptake of SAF through a SAFc mechanism. CST describes the SAFc as a market instrument for sharing the cost premium of SAF across air transportation value chain partners. A market instrument like the SAFc mechanism, once mature and if implemented with appropriate controls, could serve as means for transacting the emissions reduction benefits of insets.

The Value Change consortium, including Gold Standard, CDP, WWF, SBTi, and Navigant, developed a Value Chain Interventions Guidance document that is also relevant to these insetting guidelines [18]. The Value Change document describes a pathway for collaboration between value chain partners to incentivize emission reductions in agricultural supply chains in a way that can be reported in conformance with GHG Protocol scope 3 standards. The Value Change document also establishes the concept of the "supply shed," or "a group of suppliers providing similar goods and services that can be demonstrated to be within the company's supply chain" [19]. The Value Change concepts have closely informed the SAF insetting approach described in these guidelines.

Finally, this document was developed considering materials published by SBTi. SBTi has already established guidance for transportation decarbonization target setting [20]. Focused SBTi guidance for the aviation sector is expected to be released soon.

Though this list of methods and concepts is not comprehensive – and the field is dynamic – these methods help establish the current global context for SAF emission accounting.

Part 2: Purpose and Scope of the Guidelines, Overview of the Air Transportation Value Chain

Purpose of the Guidelines

These guidelines describe the details of an accounting and reporting system for insets applied to SAF. In so doing, the guidelines provide two elements to facilitate financing for the production and distribution of SAF. First, they provide directions to account for the GHG emission reduction benefits of SAF based on the GLEC Framework and GHG Protocol [21] [22]. Second, they provide principles for insetting with SAF in the air transportation value chain without erroneously counting SAF emission reductions benefits twice or more (i.e., double counting).

By meeting these objectives, the guidelines provide purchasers of the GHG emission reduction benefits of SAF the ability to make reputable voluntary claims about the emissions reductions realized from the use of SAF. The ability to make reputable voluntary claims about emission reductions provides purchasers of SAF emission reduction benefits the grounds on which they can charge a premium for those emission reductions. The ability to charge a premium for emission reductions provides purchasers of SAF emission reduction benefits means to recoup the cost premium for SAF as compared to conventional aviation fuels.

Credible and transparent GHG accounting allows value chain partners to share GHG information along the supply chain and to track progress towards climate goals. These guidelines include practical recommendations for reporting SAF emissions based on widely accepted accounting principles.

This guidance also addresses the disclosure gap for the full life cycle emissions of fuels. Although the principle of reporting the emissions resulting from the production and distribution of fuel is well established, 2020 research by Smart Freight Centre and CDP found that these emissions are still often overlooked, under-reported, and-or misunderstood [23]. Accordingly, these guidelines describe practices for full life cycle emission reporting.

Scope of the Guidelines

This document only addresses the GHG emissions from the production and use of SAF.

Air transportation has a unique impact on climate because the majority of aviation emissions occur at cruising altitudes of 8-12,000 meters [24]. The Intergovernmental Panel on Climate Change (IPCC) notes that high altitude deposition of NO_X, methane, water vapor, and ozone – in addition to CO_2 – generates a climate warming impact. Aircraft emissions can also seed clouds that trap heat from the earth's surface [25]. While radiative forcing impacts of air transportation are important and have been estimated to increase the impact on global average temperatures by a factor of around three compared to the impact of GHGs alone [26], radiative forcing impacts of air transportation are outside the scope of these guidelines.

There are also sustainability aspects of SAF not related to aircraft emissions. For example, CORSIA requires SAF to meet sustainability principles related to land use change like deforestation and wetlands degradation [27]. These additional non-GHG sustainability aspects of SAF are outside the scope of these guidelines.

Finally, although SAF is not available at scale now, future SAF supply chains will likely have diverse inputs. These supply chains may rely on a variety of feedstocks and conversion processes that lead to a broad range of associated GHG emissions [13] [28]. While this document is drafted to be flexible enough to be adapted to these kinds of changes, the guidelines may need to be updated as the air transportation industry evolves and as SAF becomes more prevalent and more heterogeneous.

The Air Transportation Value Chain

There are many entities that contribute to the safe and efficient transportation of people and freight by air. For example, air transportation value chain members include entities like caterers, mechanics, air traffic controllers, and parts manufacturers. However, these guidelines focus exclusively on six value chain entities that are expected to have direct involvement in the purchase of and accounting for emissions from SAF. Figures 1 and 2 depict the relationships between these six air transportation value chain entities:

1. Air carriers
2. Logistics service providers (LSP)
3. Shippers
4. Fuel suppliers
5. Business travelers
6. Travel management companies (TMC)

These terms, and the logos below, are used regularly throughout the remainder of this document.

Air Carrier

Air Carriers
Air carriers are companies that operate aircraft, consume aviation fuel, and directly conduct air transportation activity. Carriers have contractual and purchasing relationships with LSPs, shippers, business travelers, and TMCs to provide air transportation services.

LSP

Logistics Service Providers
LSPs are companies that secure and facilitate transportation activity for multiple shippers. Shippers retain LSPs to purchase air transportation activity on their behalf. LSPs have contractual relationships with shippers to transport cargo by air and contractual relationships with air carriers to provide air transportation services.

Shipper

Shippers
Shippers are organizations with freight that they need transported by air. Shippers may hire LSPs to secure air transportation services on their behalf, and they may also hire air carriers directly.

Business Traveler

Business Travelers
Business travelers are people who travel by air for work-related matters. As used throughout this document, the term "business traveler" refers to both the travelers themselves, and to the organizations that they represent. Business travelers may establish contractual relationships with TMCs to provide air transportation activity, and they may also contract with air carriers for air transportation activity or purchase air transportation activity directly from air carriers.

Fuel Supplier

Fuel Suppliers
Fuel suppliers are companies that provide fuel to air carriers to operate their aircraft. In some cases, fuel suppliers may produce their own fuel. In others, the supplier may purchase fuel from a variety of producers. Fuel suppliers have supply contracts with air carriers for fuel. Suppliers of SAF may also have contracts with carriers, shippers, LSPs, business travelers, or in some cases, with TMCs, for the purchase of environmental attributes associated with SAF.

TMC

Travel Management Companies
TMCs are companies that arrange air transportation services on behalf of business travelers. TMCs may have contracts with business travelers, as well as arrangements with air carriers regarding booking volumes and related incentives.

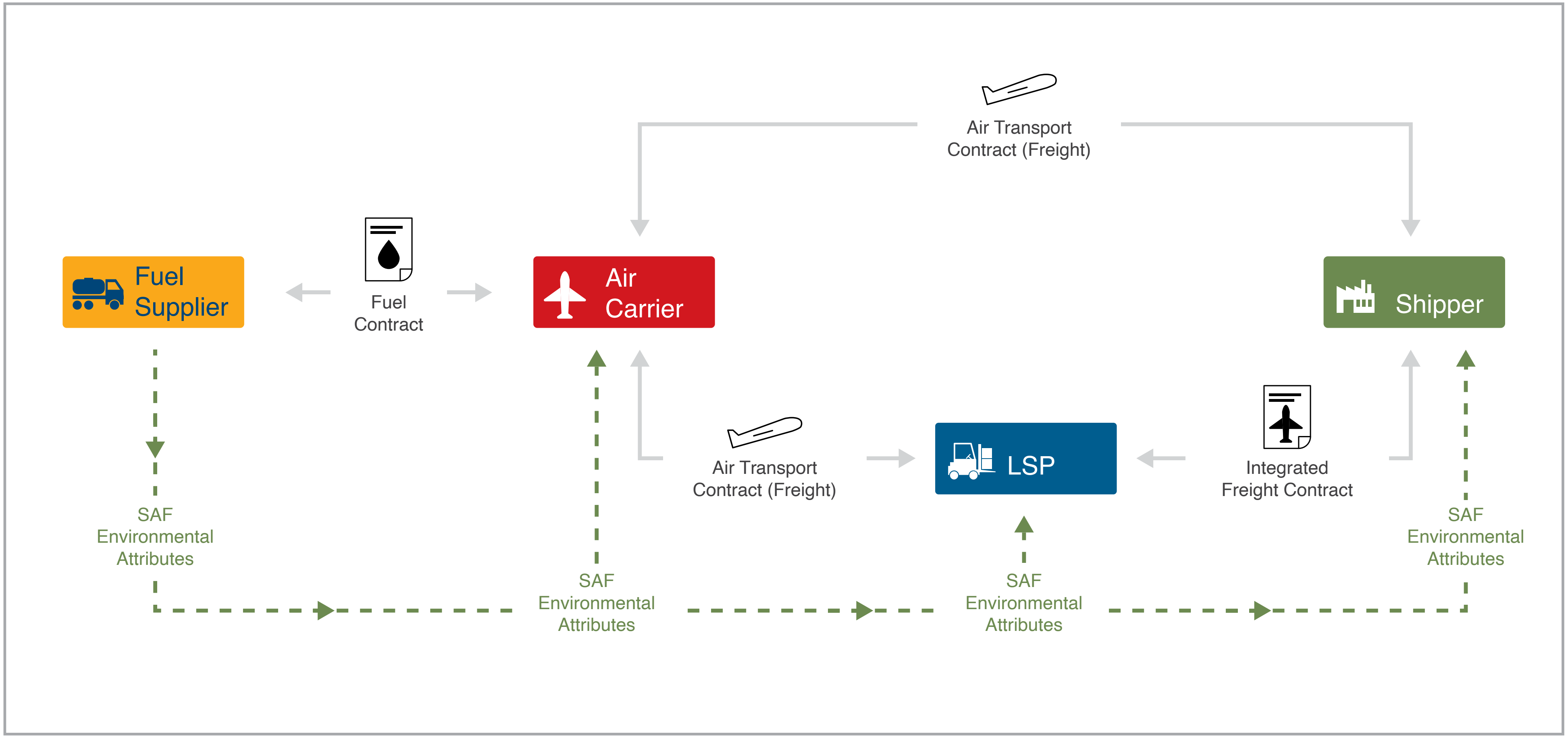


Figure 1: The air freight value chain.

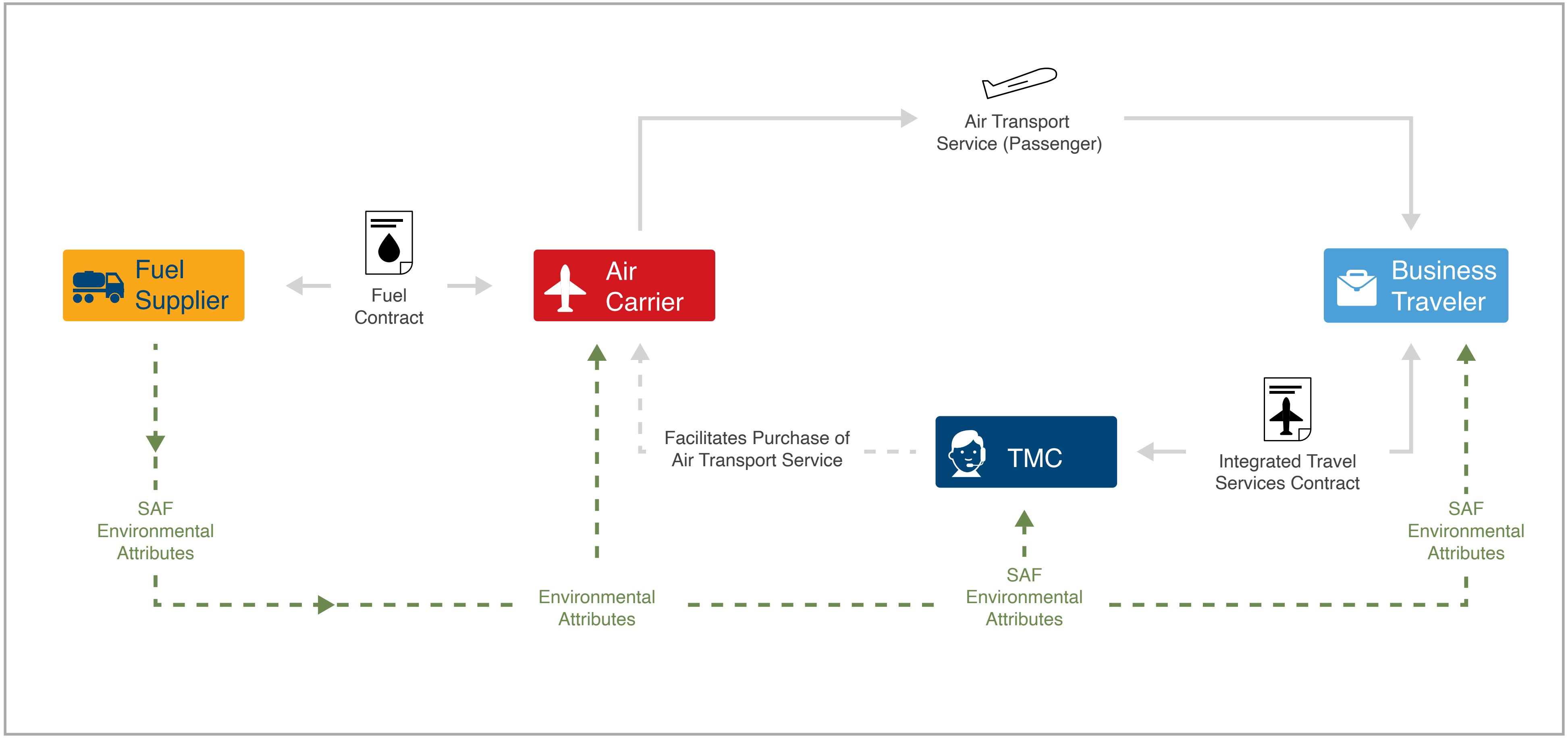


Figure 2: The air passenger value chain.

Part 3: A Chain of Custody System for SAF Environmental Attributes

Establishing the Environmental Attributes of SAF

SAF Environmental Attributes for GHG Emission Accounting

Environmental attributes of SAF are properties of the fuel related to the environmental impact of its production and use. As described in the scope section above, this document focuses on GHG emissions. For the purpose of GHG emission reporting and accounting, important SAF environmental attributes include the:

- Life cycle GHG emission factor of the fuel, or the amount of emissions generated in association with the use of a particular amount of fuel.
- Percentage of non-biogenic material included in the fuel feedstock (if any).
- Feedstocks and production processes for the fuel.

There are several different SAF feedstocks and production pathways, each yielding SAF with its own profile of environmental attributes. The differences between two batches of SAF generated from similar feedstocks through the same production process are generally considered minimal. However, the environmental attributes of SAF generated from different feedstocks and through different production pathways can vary significantly.

Therefore, a SAF producer needs to establish the environmental attributes for the specific types of fuel that it produces. The environmental attributes must be validated by a qualified certifying body so that buyers of the SAF can have confidence in the producer's claims about those environmental attributes. Only two bodies, the Roundtable on Sustainable Biofuels and the International Sustainability and Carbon Certification Scheme, are currently recognized by ICAO for the sustainability validation of SAF under CORSIA. However, the European Framework Renewable Energy Directive (RED) II accepts over a dozen sustainability validation systems, and other certifying bodies may be recognized by ICAO in the future.

Of the environmental attributes listed above, a fuel's emission factor is the most important environmental attribute to be established by a fuel producer with respect to GHG emission reporting. The emission factor must be provided in terms of all the life cycle steps leading up to delivery of the fuel to the aircraft, and in terms of the combustion phase of the fuel's life cycle, so that air transportation value chain entities can appropriately report emissions against GHG Protocol scope 1 and scope 3 (see Part 4 below for more information on life cycle emissions and on emission scopes).

There are other environmental attributes that may be of interest to SAF buyers. As described in the scope of the guidelines section above, these other attributes, such as whether the fuel was produced in a manner to protect soil and water, or if the fuel was produced in way that protects land with high biodiversity value or high carbon stock, are not addressed in these guidelines.

Declaring and Registering SAF Environmental Attributes

These guidelines are not intended to describe the structure and operation of, or specific requirements for, registries of SAF environmental attributes.

A fuel producer or supplier will need to declare the environmental attributes associated with a discrete volume of SAF to the purchaser of the environmental attributes. This declaration of environmental attributes (DEA) could take any number of forms. The detailed form of a DEA and the means by which it is transferred from seller to buyer – be it through a global centralized registry or through a number of distributed registries – is beyond the scope of these guidelines.

A global central registry for SAF DEAs does not currently exist. Instead, fuel suppliers generate and issue their own DEAs directly to buyers through a variety of means. A global centralized registry may need to develop as SAF production increases.

Whether or not a global centralized registry for SAF DEAs develops, air transportation value chain members must implement appropriate due diligence practices before purchasing SAF DEAs. Similarly, fuel suppliers that sell SAF environmental attributes must implement robust controls to ensure that SAF DEAs are accurate and not double sold, as well as transparency mechanisms that provide DEA buyers confidence in the sellers' practices.

Chain of Custody Systems for Tracking SAF Environmental Attributes

Introduction to Chain of Custody Systems

Once the environmental attributes of SAF have been established and verified by the SAF producer, those environmental attributes must be tracked. If an organization paying for SAF environmental attributes does not know those attributes, the organization cannot report SAF-related emission reductions and cannot directly benefit from the environmental attributes it purchased. Tracking of environmental attributes, then, is necessary from the production of the fuel up to the organization that is reporting on the fuel's use.

As described above, organizations reporting emission benefits of SAF need to know at least the emission factor of the fuel (by fuel life cycle phase), the feedstock from which the fuel was produced, the fuel production process used to generate the fuel, and the volume of fuel associated with these specific attributes.

Chain of custody systems can be used to track the environmental attributes of SAF. A chain of custody system is comprised of chronological, physical, or electronic documentation (i.e., a paper trail) showing the purchase, acceptance, custody, control, transfer, and disposition of a product and-or its environmental attributes [(29)]. Physical separation, mass balance, and book and claim are chain of custody systems that may be used for SAF.

PHYSICAL SEPARATION

Chain of custody by physical separation involves the separation of conventional aviation fuel and SAF from the point of production all the way up to the point of loading into an aircraft (i.e., use of a separate fuel supply network).

MASS BALANCE

Chain of custody by mass balance requires the documentation of the amount of SAF at each stage of the aviation fuel distribution network[1]. While physical co-mingling of SAF with conventional aviation fuel is permissible under a mass balance system, from an accounting perspective, the virtual share of SAF in the distribution network must be quantified at all points from the SAF's introduction to the network until the point of loading into an aircraft.

BOOK AND CLAIM

Chain of custody by book and claim allows the complete physical and virtual separation of a batch of SAF from its environmental attributes. Under a book and claim system, a batch of SAF does not need to be traced, tracked, or handled separately from conventional aviation fuel in an aviation fuel distribution network. The environmental attributes of the SAF are separated from the physical SAF and can be purchased independent of the physical SAF. See figure 3.

[1] *Some air transportation value chain entities may informally refer to the "mass balancing" of emission reduction benefits from SAF. These references to mass balancing of emission reduction benefits are not to be confused with a mass balance chain of custody system. Mass balance, as used here, refers to mass balance chain of custody tracking systems. Allocation of emission reduction benefits is addressed in Part 5 below.*

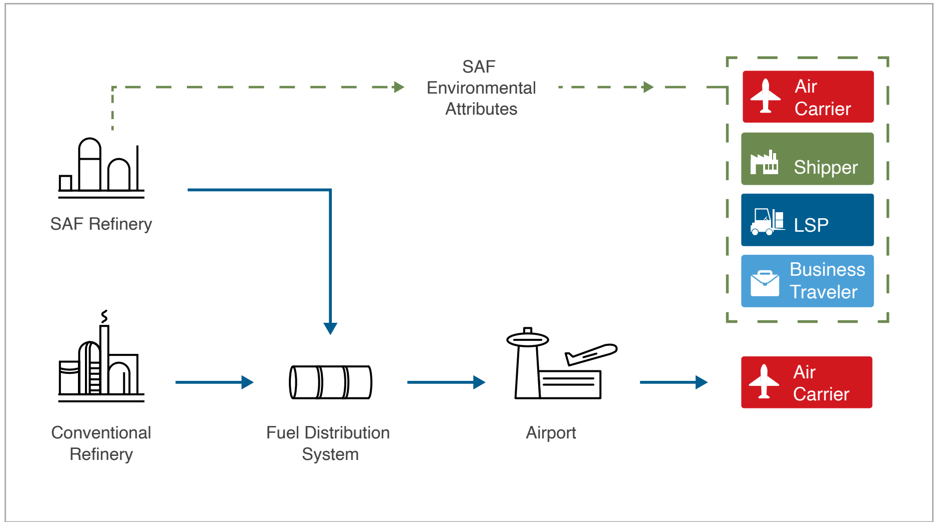


Figure 3: A book and claim chain of custody system for SAF[2].

Selecting a Chain of Custody System for SAF

Each of these chain of custody systems comes with its own benefits and challenges, particularly in the context of SAF. It is important to select the appropriate chain of custody system in order to facilitate the actual usage of SAF.

A physical separation system that requires development of a segregated fuel distribution network is impractical in the context of the established fuel distribution system. A physical separation system is also likely to be costly. As such, a physical separation system will increase the cost of SAF, leading to an even higher cost premium for SAF compared to conventional aviation fuels. Similarly, a complex mass balance system that drives up administrative costs for distributers and purchasers and increases the difficulty of tracking SAF during distribution also could disincentivize the widespread adoption of SAF.

With respect to tracking and accounting SAF environmental attributes, the book and claim system is the most flexible [30], and is the least disruptive, least complex, and most auditable of the three chain of custody systems [29]. For these reasons, a book and claim chain of custody system is recommended for tracking SAF environmental attributes.

[2] *While SAF and conventional aviation fuel can be comingled in a book and claim system, as shown here, the comingling of SAF and conventional aviation fuel is not required under a book and claim system. Therefore, existing or future segregated SAF distribution networks would not need to be altered under a book and claim system.*

Establishing the Principles for a Book and Claim System

Principles to Make a Book and Claim System an Effective Insetting Tool

For a SAF book and claim system to provide a structure for companies to inset emission reductions within their transportation supply chain, the book and claim system must be:

- Defined strictly enough to provide all participants in the SAF value chain confidence that the SAF environmental attributes are of legitimate origin, a reasonable vintage, and not erroneously double counted. Without this confidence in a SAF insetting book and claim system, purchasers of SAF environmental attributes will not be able to make reputable claims about emissions reductions from SAF.
- Flexible enough to incentivize the uptake of SAF. As described in the previous section about chain of custody systems, a framework that is so costly or inflexible that it is not practicable for air transportation providers or users will not be adopted and will do little to scale the use of SAF.

Therefore, a SAF book and claim system must be bound by a clear set of principles that establish which companies in a transportation value chain can report the environmental attributes of SAF as insets, the amount of SAF environmental attributes that these companies can report as insets, and the acceptable vintage of those environmental attributes.

The following two principles address these objectives for a SAF insetting book and claim system.

Principle One: Environmental Attributes of SAF Can Only be Used to Inset Air Transportation Activity

An air carrier can only report environmental attributes for SAF associated with air transportation activity that it conducts. A shipper, LSP, or business traveler can only report environmental attributes for SAF associated with the air transportation activity conducted on its behalf.

This principle ensures that companies only report SAF for their actual air transportation activity and do not use the purchase of SAF to offset emissions associated with other activities.

For example, if an organization has contracted with three air carriers to transport its products, that organization can report environmental attributes of SAF to cover the transportation activity conducted by these carriers in moving its products (see the section below on calculating transportation activity). Another organization that does not transport any products or people by air and is not otherwise responsible for any air transportation activity cannot purchase SAF environmental attributes as insets[3].

[3] *A company that is not responsible for any air transportation activity may still choose to purchase SAF environmental attributes, but any such purchase of SAF environmental attributes would be considered offsets rather than insets.*

Principle Two: SAF DEAs are Valid for up to Two Consecutive Reporting Periods from the Date of SAF Production

The emission reduction benefits associated with a SAF DEA must be reported by the purchaser of the DEA either during the emission reporting period[4] in which the fuel was produced, or during the emission reporting period immediately following the emission reporting period in which the fuel was produced.

This principle ensures that:

- SAF suppliers cannot produce SAF, introduce that SAF into a comingled conventional aviation fuel distribution system, "stockpile" the sellable environmental attributes associated with the SAF for an unlimited period of time, and sell those environmental attributes at a premium years later.
- Buyers of SAF DEAs cannot purchase SAF environmental attributes and hold those attributes to be reported against their GHG emission footprint several years later.

As such, the principle generates a temporal correlation between SAF production, SAF usage, and the reporting and accounting for the environmental attributes of the SAF used. The principle also permits some flexibility to air transportation value chain members if actual transportation activity varies from predicted transportation activity in a reporting period.

For example:

- On 1 August 2022, Supplier 1 produces 100,000 liters of SAF. Shipper A purchases the environmental attributes of that SAF.
- Shipper A reports its greenhouse gas emissions to external stakeholders and through emissions disclosure platforms on a calendar year basis.
- Shipper A realizes in December 2022 that it overestimated its 2022 transportation activity and only conducted 90,000 liters of transportation activity in 2022.
- Shipper A can report 90,000 liters of environmental attributes for the 2022 calendar year reporting period and may choose to report up to 10,000 liters of environmental attributes from this SAF purchase against the 2023 calendar year reporting period.

Please note that this principle does not restrict any commitments to purchase SAF environmental attributes before they are generated. Continuing the example above, Shipper A could commit to buy 10 million liters worth of SAF environmental attributes from Supplier 1, every year, for the next seven years. These kinds of commitments are critical to scaling the uptake of SAF and are not the focus of principle two.

[4] *The term "reporting period," rather than calendar year, is used here as not all organizations report and disclose GHG emissions on a cycle aligned with the calendar year. Some organizations, for example, may disclose emissions for a fiscal year. And the time within a calendar year that an organization's fiscal year begins varies between organizations.*

Purchasing SAF Environmental Attributes from One Supplier and Fuel from Another

An important aspect of the book and claim system for insetting described in these guidelines is that it allows a carrier, and the LSPs, shippers, TMCs, and business travelers that the carrier serves, to purchase and report SAF environmental attributes from a fuel supplier whether or not that fuel supplier provides aviation fuel to the carrier.

This flexibility removes barriers to the uptake of SAF associated with the structure of fuel purchase contracts. Specifically, it allows:

- A carrier to purchase and report SAF environmental attributes without that carrier having to cancel or change existing fuel supply contracts.
- Shippers, LSPs, business travelers, and TMCs to purchase and report SAF environmental attributes without having to convince air carriers to change fuel suppliers.

The examples below demonstrate the benefits of allowing the purchase of SAF environmental attributes from one fuel supplier and the purchase of fuel from another supplier.

In the first example:

- Shipper A has a contract with Carrier Y to conduct air transportation activity.
- Carrier Y has a fuel supply contract with Fuel Supplier 1. Fuel Supplier 1 does not supply SAF.
- Carrier Y cannot break its contract with Fuel Supplier 1.
- Shipper A wants to purchase SAF environmental attributes to cover its transportation activity with Carrier Y.

If Shipper A can only report SAF environmental attributes purchased from the fuel supplier that provides fuel to Carrier Y, Shipper A cannot inset SAF environmental attributes for its transportation activity with Carrier Y. Carrier Y's supplier does not provide SAF and therefore cannot provide SAF environmental attributes. No SAF environmental attribute transaction can take place and Shipper A cannot incentivize the production of SAF and reduce its supply chain emissions with SAF. See figure 4.

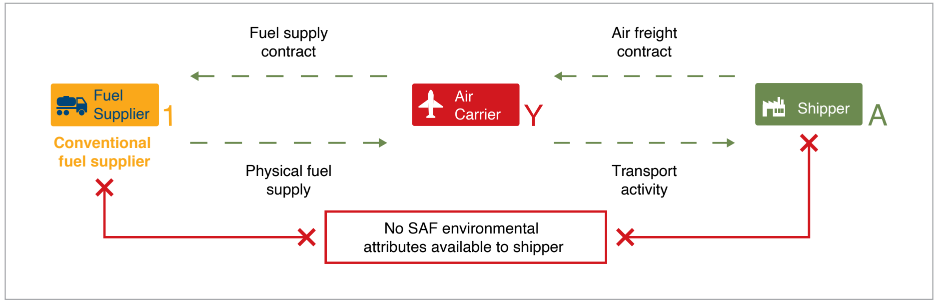


Figure 4: Shipper A has no access to SAF environmental attributes.

In the second example:

- Shipper A has a contract with Carrier Y to conduct air transportation activity.
- Carrier Y has a fuel supply contract with Fuel Supplier 1. Fuel Supplier 1 does not supply SAF.
- Carrier Y cannot break its contract with Fuel Supplier 1.
- Shipper A wants to purchase SAF environmental attributes to cover its transportation activity with Carrier Y.
- Shipper B has a contract with Carrier Z to conduct air transportation activity.
- Carrier Z has a fuel supply contract with Fuel Supplier 2. Fuel Supplier 2 can supply SAF.
- Neither Shipper B nor Carrier Z are willing to pay the premium for SAF.

If Shipper A is allowed to report the emission reduction benefits of SAF environmental attributes that it purchases from Fuel Supplier 2, Shipper A can incentivize the production of SAF by Fuel Supplier 2 by paying the SAF premium, at the same time that Shipper A reduces its supply chain emissions footprint[5]. See figure 5.

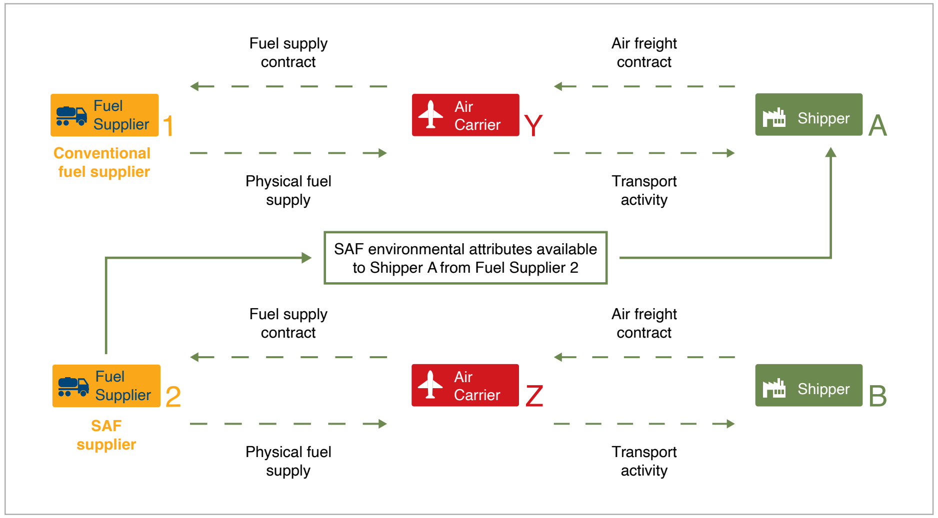


Figure 5: Shipper A can access SAF environmental attributes.

[5] Note that Shipper B cannot report any emission reduction benefits associated with the Supplier 2 SAF. Shipper B may not even be aware of the environmental attribute transaction between Supplier 2 and Shipper A, or the fact that Supplier 2 is meeting its fuel supply requirements to Air Carrier Z with SAF instead of conventional aviation fuel.

Part 4: Introduction to SAF GHG Emission Accounting

Establishing the Environmental Attributes of SAF

Emission Scopes

Emissions are divided into three scopes under the GHG Protocol.

Scope 1 emissions are the direct emissions from assets that are owned or controlled by the reporting company.

Scope 2 emissions are indirect emissions from the production and distribution of electricity, heat and steam purchased by the reporting company. Scope 2 emissions are not currently of direct relevance to these guidelines.

Scope 3 emissions are indirect emissions. These emissions are a consequence of the activities of a reporting company but occur from sources not owned or controlled by the company. Examples of scope 3 emissions include:

- Transportation emissions generated in the movement of goods to the reporting company from suppliers as well as from the reporting company to the end customer.
- Emissions from the production and distribution of fuels combusted under scope 1.

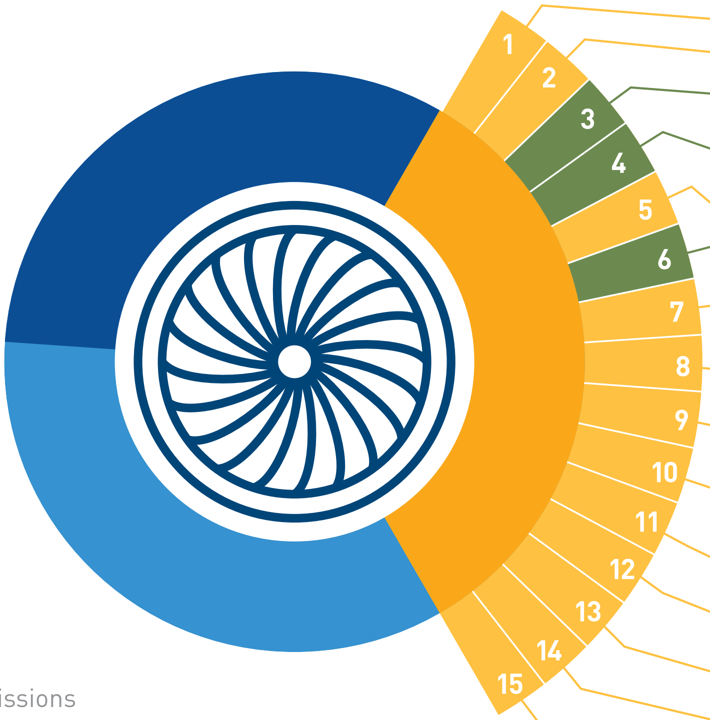
The GHG Protocol describes 15 categories of scope 3 emissions (see figure 6). The most relevant categories of scope 3 emissions for this guidance are:

- Category 3 - Fuel and energy related emissions
- Category 4 - Upstream transportation and distribution
- Category 6 - Business travel

Scope 1

Direct Emissions

Combustion emissions from assets that are owned or controlled by the reporting company.



Scope 3

Indirect Emissions

All indirect emissions not reported under scope 2. Emissions that are a consequence of the activities of a reporting company but that occur from sources not owned or controlled by the company.

There are 15 categories of scope 3 emissions. Three of those categories, 3, 4, and 6, are the focus of these guidelines.

1. Purchased goods and services

2. Capital goods

3. Fuel-and energy-related emissions

Extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company, not already accounted for in scope 1 or scope 2.

4. Upstream transportation and distribution

Transportation and distribution of products purchased by the reporting company between a company's tier 1 suppliers and its own operations, transportation and distribution services purchased by the reporting company, and transportation and distribution between the reporting company's own facilities.

5. Waste generated in operation

6. Business Travel

Transportation of employees for business-related activities (in vehicles not owned or operated by the reporting company).

7. Employee commuting

8. Upstream leased assets

9. Downstream transportation and distribution

10. Processing of sold products

11. Use of sold products

12. End of life treatment for sold products

13. Downstream leased assets

14. Franchises

15. Investments

Scope 2

Indirect Emissions

Emissions from the production and distribution of electricity, heat, and steam purchased by the reporting company.

Figure 6: Emission scopes and categories.

Emission Life Cycles

The GHG Protocol requires the full climate impact of fuel use to be captured in GHG emission reporting. There are two types of emissions that, when taken together, comprise the full life cycle emissions for fuels:

1. Well-to-tank (WTT) emissions, which are emissions from all processes between the source of the energy (the well) and its use. Emissions associated with raw material extraction, processing, storage and delivery are WTT emissions.
2. Tank-to-wake (TTW) emissions, which are emissions generated during the actual use (i.e., combustion) of the fuel.

Well-to-wake (WTW) emissions, the sum of the WTT and TTW emissions, are the life cycle GHG emissions of a fuel. See figure 7.

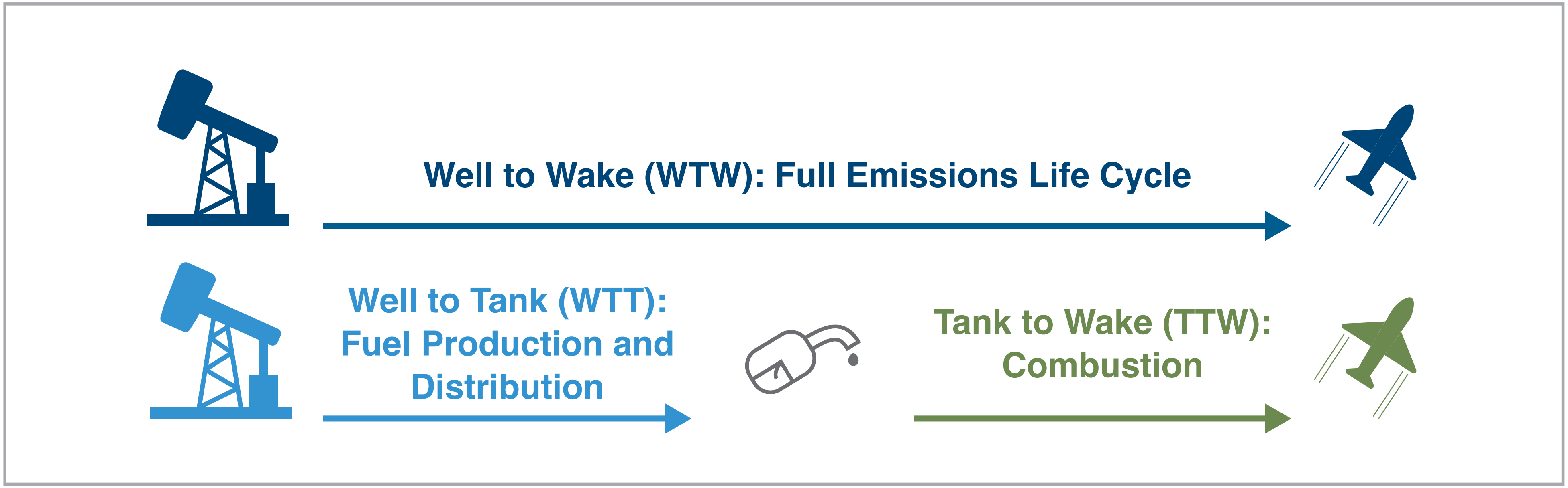


Figure 7: The emissions life cycle.

Biofuel Life Cycle Emissions

Biofuel GHG emissions are reported differently than conventional fuel GHG emissions because of the different origins of the carbon in biofuel feedstocks and conventional fuel feedstocks.

Conventional aviation fuel is made predominantly from fossil oil reservoirs. The CO_2 released to the atmosphere during the combustion of conventional aviation fuel therefore contains carbon that has been sequestered from the atmosphere for millions of years. See figure 8.

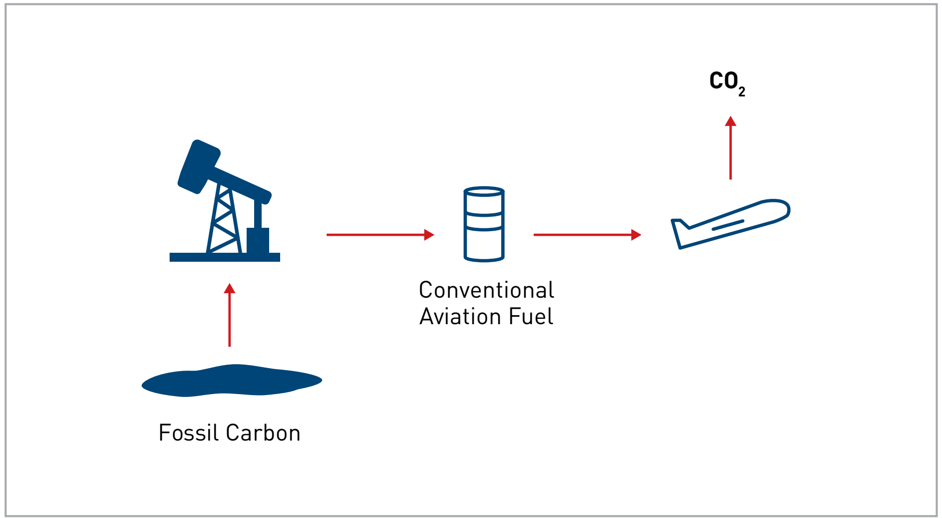


Figure 8: Carbon from conventional fuels results in an introduction of "new" CO_2 into the atmosphere.

Biofuels are of biogenic origin, meaning they are made from biomass. This biomass is partially comprised of carbon that has been removed, in the form of CO_2, from the atmosphere on a comparatively short timescale. See figure 9.

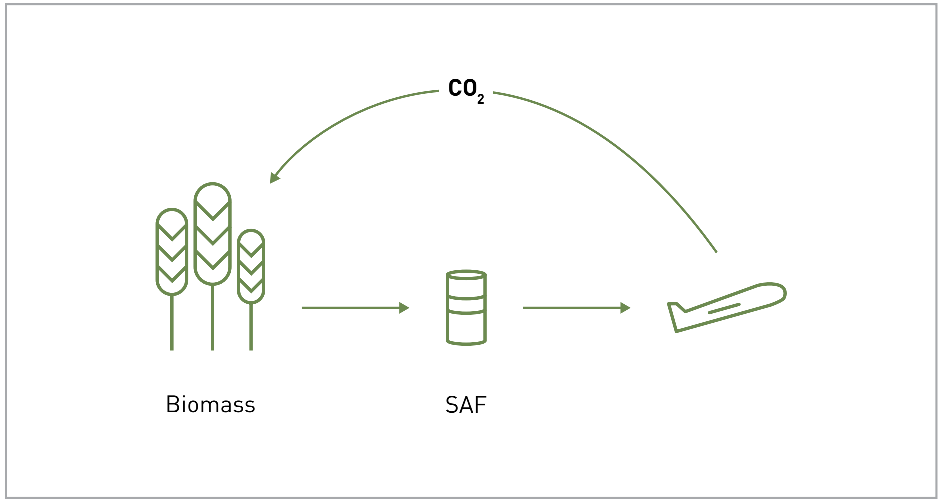


Figure 9: Carbon in biogenic fuels "cycles" through the atmosphere as CO_2.

Figures 8 and 9 demonstrate how CO_2 generated during the combustion of bio-fuels is "recycled," while CO_2 generated during the combustion of conventional fuels represents an introduction of "new" CO_2 to the atmosphere. Please note that figures 8 and 9 only show CO_2 emissions generated during the combustion of fuels. There are other CO_2 and non-CO_2 GHG emissions generated during the production and distribution, and non-CO_2 GHG emissions generated during the combustion, of both conventional fuels and biofuels.

It also bears noting that the amount of CO_2 generated during the combustion of many types of SAF does not differ significantly from the amount of CO_2 generated during the combustion of conventional aviation fuels. SAF and conventional aviation fuel have similar chemical compositions and carbon content. It is this similarity of chemical compositions that makes SAF blends viable as drop-in alternatives to conventional aviation fuel.

Life Cycle Reporting of Biogenic Emissions

Biogenic CO_2: TTW Emissions

Because the CO_2 emitted during the combustion of biogenic SAF comes from carbon in biomass that was removed (as CO_2) from the atmosphere relatively recently, the CO_2 emissions from the combustion of biogenic SAF are considered – from an accounting perspective – to be zero. This approach is consistent with the approach taken in the IPCC Guidelines for National GHG Inventories [31].

Similarly, SAF TTW CO_2 emissions are not reported under scope 1 by air carriers or under scope 3 by shippers, LSPs, or business travelers.

For transparency and completeness, however, the GHG Protocol requires biogenic CO_2 emissions to be reported in a separate disclosure outside of the scopes.

TTW biogenic CO_2 emissions can be estimated based on the emission factor for conventional aviation fuel considering the similar chemical compositions between SAF and conventional aviation fuel.

Biogenic CO_2: WTT Emissions

Biogenic CO_2 emissions that result from the production and distribution of SAF, if any, would also be reported outside the scopes. WTT biogenic CO_2 emissions are not commonly reported and are not discussed further in these guidelines.

Biogenic Non-CO_2 GHG: TTW Emissions

There are some non-CO_2 GHG emissions generated during the combustion of SAF, even SAF made from biomass. These non-CO_2 TTW emissions, which are not part of the cycle shown in figure 9 above, are to be reported under the GHG Protocol scopes.

Biogenic Non-CO_2 GHG: WTT Emissions

Also as described in the previous section, non-CO_2 GHGs are emitted during the production and distribution of SAF. These WTT non-CO_2 emissions are accounted for in SAF emission factors at Part 6 and reported under the GHG Protocol scopes.

Emission Reporting Across Life Cycles and Scopes

Conventional Aviation Fuel

Figure 10 shows where different entities in the air transportation value chain will report emissions for conventional aviation fuel.

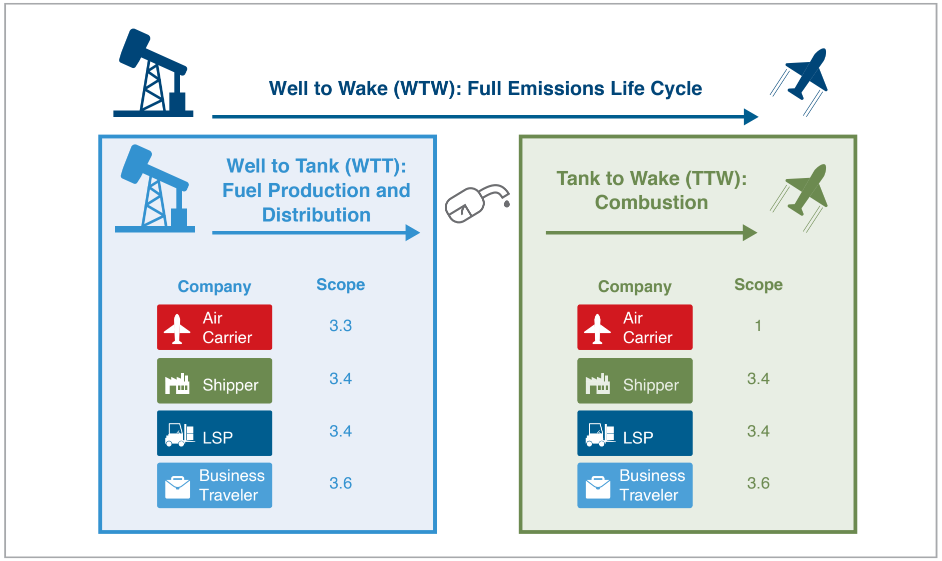


Figure 10: Reporting life cycle emissions for conventional aviation fuel.

This figure highlights an important aspect of reporting across emission scopes. While two air carriers cannot report the same scope 1 TTW emissions for a discrete volume of fuel (the fuel cannot be burned by both carriers), multiple companies can report an air carrier's scope 1 emissions in their scope 3 inventories.

SAF

Figure 11 shows where different entities in the air transportation value chain will report emissions for SAF.

Figure 11: Reporting life cycle emissions for SAF.

Part 5: Calculating and Reporting SAF Emissions

Reporting GHG Emission Data to External Stakeholders

The GLEC Framework describes the contents of emission declarations that organizations make to two categories of stakeholder:

1. Companies, where the information reported focuses on the service the organization provides to a specific customer. This information is provided in a business-to-business declaration.
2. Stakeholders in general, where the information reported addresses the reporting organization's performance broadly. This information, provided in an external declaration, may be presented in a sustainability or financial report, or disclosed to customers or investors through platforms like CDP, Ecovadis, or the S&P Global Corporate Sustainability Assessment.

Transportation Operation Categories

Transportation operation categorization is a way of classifying transportation activity that provides companies the ability to declare transportation emissions data at a level of resolution not possible if all transportation activity is aggregated.

A transportation operation category (TOC) is defined here as a group of transportation operations with similar characteristics (e.g., aircraft type and size, load factor, or nature of itinerary) that correspond to how transportation services are provided and procured.

For air transportation, TOC variables may include:

- Length of haul (e.g., short, medium, long).
- Aircraft type (e.g., freight only, passenger with belly cargo, passenger without belly cargo).

Carriers, LSPs, TMCs, shippers, and business travelers will need selected SAF-specific information to be able to prepare GLEC Framework business-to-business or external declarations. It is important for air transportation value chain members to disclose this data to their value chain partners, as follows:

	Volume of SAF supplied and its environmental attributes	Fuel intensity by transportation operation category	Emission intensity of SAF transportation activity
Air Carrier	As necessary, to LSPs, Shippers, TMCs, and Business Travelers	To LSPs, Shippers, TMCs, and Business Travelers	As necessary, to LSPs, Shippers, TMCs, and Business Travelers
LSP	As necessary, to Shippers	As necessary, to Shippers	As necessary, to Shippers
TMC	As necessary, to Business Travelers	As necessary, to Business Travelers	As necessary, to Business Travelers
Fuel Supplier	To purchaser of SAF Environmental Attributes	-	-

Table 1: Emissions information needs for air transportation value chain entities.

The volume of SAF supplied and its environmental attributes are described in the section above about SAF DEAs. The importance and application of fuel intensity and emission intensity information is described later in the guidelines.

Entries in this table qualified with "as necessary" refer to information that may not be required, depending on the nature of the relationship between value chain entities. For example, if an LSP is allocating emission reduction benefits associated with the use of SAF directly to a specific shipper, that LSP will need to provide that shipper the emission intensity of the shipper-specific transportation activity. All LSPs do not necessarily need to provide all information listed in the table above to all of their shipper customers. In some cases, if an LSP provided all of the information listed in the table above to all of their customers, the LSP may be erroneously double counting emission reduction benefits of SAF.

Also note that shippers and business travelers, as the final end users of the air transportation services, are not listed as information providers in this table. Shippers and business travelers are not included as information providers here as they are not necessarily expected to disclose information related to SAF emissions to their suppliers in the air transportation value chain. Shippers and business travelers may, however, disclose information on SAF to other stakeholders in an external declaration as described in detail in the GLEC Framework.

Air Transportation Activity

Air transportation activity is a fundamental metric that underpins three key concepts described in these guidelines.

First, transportation activity serves as the constraint on the amount of SAF environmental attributes that can be inset by a carrier, LSP, shipper, or business traveler (as described in principle one above). Second, transportation activity serves as a tool to ensure that SAF emission reduction benefits are not erroneously double counted (see the section on double counting below). Third, transportation activity is a metric that shippers, LSPs, and business travelers can use to determine their aviation emissions footprint for emissions reporting and disclosure (see Part 4 above and the last part of this section).

Transportation activity is defined as the product of the amount of cargo transported and the distance that cargo was transported.

For freight:

$$\text{Transport Activity} = \text{Mass Transported} \times \text{Distance that Mass was Transported}$$

For passengers:

$$\text{Transport Activity} = \text{Passengers Transported} \times \text{Distance those Passengers were Transported}$$

Transportation activity is described in terms of tonne kilometers in freight supply chains. For passenger transportation supply chains, transportation activity is often described in terms of revenue passenger kilometers (RPK).

Transportation Activity as a Volume of Fuel

Because environmental attributes of SAF are associated with a volume of SAF, carriers, shippers, LSPs, and business travelers must be able to convert transportation activity into an equivalent volume of fuel. Stated differently, a carrier, shipper, LSP, or business traveler needs to know not only the air transportation activity they conducted (carriers) or that was conducted for them (shipper, LSP, or business traveler), they need to know how much fuel was consumed to conduct that transportation activity (see figure 12).

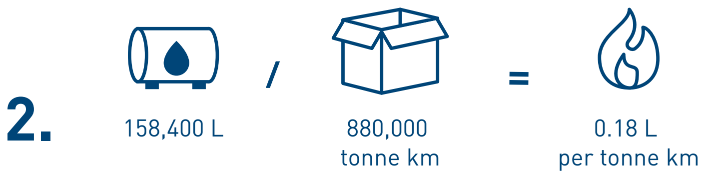
Transportation activity can be converted to an equivalent volume of fuel by calculating the product of the fuel intensity of air transportation activity and the amount of transportation activity conducted.

$$\text{Fuel Consumed Conducting Transport Activity} = \text{Fuel Intensity} \times \text{Transport Activity}$$

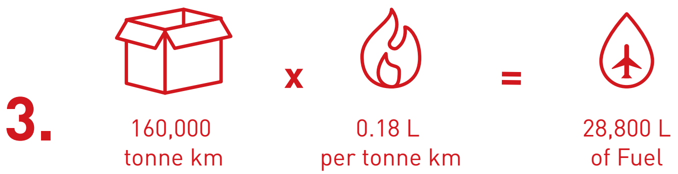
Fuel intensity is a measure of the efficiency of the transportation activity in terms of fuel consumption.

$$\text{Fuel Intensity} = \frac{\text{Volume of Fuel Consumed}}{\text{Transport Activity}}$$

Shipper A hired Air Carrier B to transport 20 tonnes of freight on the 8,000 kilometer flight from airport X to airport Y. Air Carrier B conducted 160,000 tonne km of transport activity for Shipper A on this flight.



Air Carrier B also transported cargo for other shippers on the flight from X to Y. Specifically, Carrier B's aircraft was loaded with 110 tonnes of cargo for the flight, making its total transport activity for the flight 880,000 tonnes. The aircraft burned 158,400 L of fuel traveling from X to Y. Carrier B's fuel intensity was therefore 0.18 L per tonne km.That is, Air Carrier B burned 0.18 L of fuel for each tonne km of transport activity on the flight from X to Y.



Shipper A was responsible for 160,000 tonne km of transport activity on flights from X to Y. Carrier B burned 0.18 L per tonne kilometer on the flight from X to Y. Shipper A was therefore responsible for 28,800 L of fuel on the flight from X to Y.

Figure 12: Calculating transportation activity and converting to an equivalent volume of fuel[6].

[6] *While this example shows calculations for a single flight, in practice, the calculations would involve aggregated data for an entire transportation operation category.*

Collecting Fuel Intensity Data

Shippers, LSPs, and business travelers often will not have access to actual air carrier fuel consumption data or air carrier total air transportation activity. As such, shippers, LSPs, and business travelers (or TMCs on behalf of business travelers) must request fuel intensity data directly from their air carriers.

If primary fuel intensity data is not available, shippers, LSPs, business travelers, and TMCs may use program or modeled fuel intensity values. As described in the GLEC Framework, default fuel intensity values may be used only if primary, program, or modeled data is not available.

For freight, default global air transportation fuel intensities can be calculated from data included in the GLEC Framework. Air Transport Action Group also periodically publishes fuel efficiency data that can be converted to fuel intensity data (if a fuel emission factor is also available).

For business passengers, indicative default global air transportation fuel intensities, by aircraft and passenger class, are as follows:

Aircraft Type	Consumption (L Fuel/RPK) by Passenger Class				
	Economy	Premium	Business	First	Average
Regional	0.057	0.085	-	-	0.063
Narrow Body	0.030	0.045	-	-	0.033
Wide Body	0.024	0.036	0.073	0.11	0.034

Table 2: Indicative default global fuel intensities[7].

[7] *These values are based on 2019 passenger CO_2 emissions and intensity data (by aircraft class) from International Council on Clean Transportation's 2020 report, CO_2 Emissions from Commercial Aviation (1).*

[8] *Air carriers will in most cases have direct fuel consumption data and, as such, can use actual fuel consumption data to calculate overall emission footprints without first having to work through the fuel intensity calculations. Carriers will, however, need to calculate fuel intensity for transportation operation categories so that they can provide this data to their customers (shippers, LSPs, business travelers, and TMCs).*

Converting Fuel Use to GHG Emissions

Shippers, LSPs, carriers, and business travelers can multiply the fuel used for conducting their transportation activity[8] by fuel-specific emission factors to determine their air transportation GHG emissions footprints.

$$\text{GHG Emissions} = \text{Fuel Consumed} \times \text{Fuel Specific Emission Factor}$$

In this calculation, the fuel emission factor represents the amount of GHG emissions per unit volume of fuel.

$$\text{Emission Factor} = \frac{\text{Mass GHG Emitted}}{\text{Volume Fuel}}$$

Part 6 of these guidelines provides SAF emission factors, by feedstock and production process.

Allocating SAF Environmental Attributes without Erroneous Double Counting

Introduction to the Allocation of SAF Environmental Attributes

A shipper, LSP, TMC, or carrier may want to market and sell a lower emission air transportation service or allocate SAF emission reduction benefits to its customers. The allocation of the emission benefits of SAF between parties in the air transportation value chain entities can be carried out with two metrics:

1. The emission intensity of the transportation activity.
2. The amount of transportation activity conducted at that emission intensity.

To allocate emission reduction benefits of SAF, an LSP, TMC, or carrier must calculate the emission intensity of transportation activity conducted with SAF. The emission intensity benefits of SAF can then be allocated, as bound by transportation activity, across the LSP, TMC, or carrier's customers.

See, for example, figure 13. Carrier A has 10,000,000 tonne kilometers of transportation activity at a lower emission intensity to allocate across the air transportation value chain. Carrier A allocates some of these emissions benefits to LSPs B, C, and D, and some of the emissions benefits to shippers 1, 2, and 3. LSPs B, C, and D can then allocate their portion of the 10,000,000 tonne kilometers of transportation activity allocated to them by Carrier A to each of their own customers as they see fit. Note that in this example, total transportation activity at a lower emission intensity, 10,000,000 tonne kilometers, serves as a limit on the amount of low emission transportation that can be allocated or reported by the carrier, LSPs, and shippers.

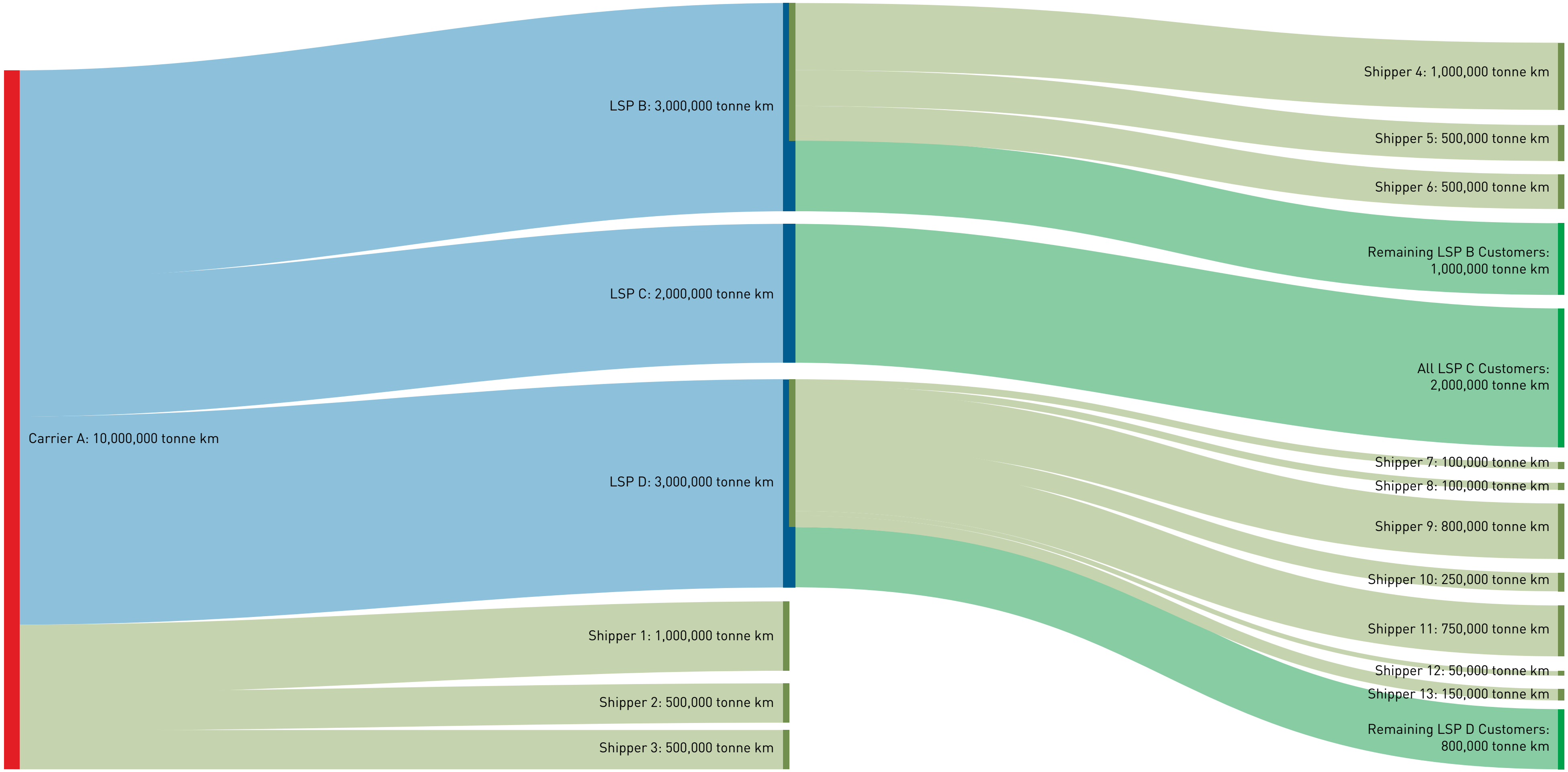


Figure 13: Allocation of emission intensity, bound by transportation activity, across an air freight transportation value chain.

Defining Emission Intensity

The emission intensity of transportation activity is the amount of GHG emitted per unit of transportation activity.

$$\text{Emission Intensity} = \frac{\text{Mass GHG Emitted}}{\text{Transport Activity}}$$

The emission intensity of transportation activity is directly related to the life cycle emission factor of the fuel used to conduct the transportation activity. As described above, the emission factor of a fuel is defined as the mass of GHG emitted per unit of volume of fuel consumed.

Based on these definitions of emission intensity and emission factor, the relationship between emission factor and emissions intensity is as follows:

$$\text{Emission Intensity} = \frac{\text{Emission Factor} \times \text{Fuel Volume}}{\text{Transport Activity}}$$

Allocating Emission Intensity by Transportation Activity: Freight Transportation

As described at the outset of this section, emission reduction benefits associated with SAF can be allocated by a carrier or LSP to that carrier or LSP's customers based on the emission intensity of transportation activity as bound by the amount of transportation activity.

Consider an example in which Carrier A consumed 158,400 L aviation fuel on flight 12. Carrier A purchased environmental attributes for 79,200 L of Fischer-Tropsch processed agricultural residue SAF for this flight, based on the assumption that the flight could have been fueled by a 50% conventional jet fuel and 50% SAF blend. Flight 12 was an 8,000 kilometer flight of 110 tonnes of cargo.

Carrier A conducted 880,000 tonne kilometers of transportation activity on flight 12:

$$\text{Transport Activity}_{\text{Flight 12}} = 8{,}000 \text{ kilometers} \times 110 \text{ tonnes} = 880{,}000 \text{ tonne kilometers}$$

The emission intensity of this transportation activity is 302 gCO_2e per tonne kilometer:

$$\text{Emission Intensity}_{\text{Flight 12}} = \frac{(EF_{\text{SAF Neat}} \times \text{SAF Volume}) + (EF_{\text{Conventional}} \times \text{Conventional Volume})}{\text{Transport Activity}}$$

$$\text{Emission Intensity}_{\text{Flight 12}} = \frac{\left(\left(\frac{254\ gCO_2e}{L}\right) \times 79{,}200\ L\right) + \left(\left(\frac{3{,}100\ gCO_2e}{L}\right) \times 79{,}200\ L\right)}{880{,}000 \text{ tonne km}}$$

$$\text{Emission Intensity}_{\text{Flight 12}} = \frac{302\ gCO_2e}{\text{tonne km}}$$

Provided with the emission intensity and transportation activity for flight 12, Carrier A can allocate the benefits of using SAF on flight 12 to its customers.

Perhaps Carrier A partnered with Shipper Z in the purchase of 79,200 L of SAF environmental attributes. Shipper Z conducted 900,000 tonne kilometers of transportation activity with Carrier A in the same transportation operation category as flight 12. Carrier A can declare an air transportation emission intensity of 302 gCO_2e per tonne kilometer to Shipper Z for 880,000 tonne kilometers of the transportation activity it conducted for Shipper Z in that transportation operation category.

Alternatively, perhaps Carrier A partnered with LSP Y in the purchase of 79,200 L of SAF environmental attributes. LSP Y conducted 10,000,000 tonne kilometers of transportation activity with Carrier A in the same transportation operation category as flight 12. Carrier A can declare an air transportation emission intensity of 302 gCO_2e per tonne kilometer for 880,000 of those tonne kilometers of transportation activity.

Note that LSP Y could then declare an air transportation emission intensity of 302 gCO_2e per tonne kilometer to its customers for up to 880,000 tonne kilometers of air transportation activity. LSP Y could spread those emission intensity benefits as it desired across its customer base. LSP Y could allocate all of the benefits to one flight, to one customer, to several flights, to several customers – so long as LSP Y does not allocate the 302 gCO_2e per tonne kilometer emission intensity to more than 880,000 tonne kilometers of transportation activity.

Allocating Emission Intensity by Transportation Activity: Passenger Transportation

Emission reduction benefits associated with SAF can also be allocated by a carrier or TMC to that carrier or TMC's customers based on the emission intensity of transportation activity as bound by the amount of transportation activity.

The calculations for allocating emission reduction benefits for passenger transportation are slightly different than the calculations for freight transportation.

Consider an example in which TMC A is marketing a reduced emission business travel offering to its customers. To do so, TMC A purchased a SAF DEA for 100,000 L (neat) of hydro-processed esters and fatty acids (HEFA) used cooking oil. The DEA states that the emission factor of the fuel is 500 gCO_2e per L.

TMC A received fuel intensity information from Carriers X and Y as follows:

Aircraft Type	Carrier X Consumption (L Fuel/RPK) by Passenger Class		Carrier Y Consumption (L Fuel/RPK) by Passenger Class	
	Economy	Premium	Economy	Premium
Regional	0.060	0.084	0.061	0.088
Narrow Body	0.031	0.044	0.029	0.041
Wide Body	0.021	0.036	0.019	0.033

If TMC A decided to allocate all emission reduction benefits to customers flying economy class on Carrier X regional aircraft, the DEA that TMC A purchased would cover 1,666,667 RPK of transportation activity at 30 gCO_2e per RPK:

$$\text{Consumption}_{\text{X Regional Economy}} = \frac{0.060\text{ L}}{\text{RPK}}$$

$$\text{HEFA Volume} = 100{,}000\text{ L}$$

$$\text{HEFA Volume Represened as Transport Activity} = \frac{100{,}000\text{ L}}{0.060\text{ L / RPK}} = 1{,}666{,}667\text{ RPK}$$

$$\text{HEFA Emission Intensity}_{\text{X Regional Economy}} = \frac{500\text{ gCO}_2\text{e}}{\text{L}} \times \frac{0.060\text{ L}}{\text{RPK}} = \frac{30\text{ gCO}_2\text{e}}{\text{RPK}}$$

Alternatively, if TMC A decided to allocate all emissions reduction benefits to customers flying premium on Carrier Y wide body aircraft, the DEA TMC A purchased would cover just over 3,000,000 RPK of transportation activity at 16.5 gCO_2e per RPK:

$$\text{Consumption}_{\text{Y Wide Body Premium}} = \frac{0.033\text{ L}}{\text{RPK}}$$

$$\text{HEFA Volume} = 100{,}000\text{ L}$$

$$\text{HEFA Volume Represened as Transport Activity} = \frac{100{,}000\text{ L}}{0.033\text{ L / RPK}} = 3{,}030{,}303\text{ RPK}$$

$$\text{HEFA Emission Intensity}_{\text{Y Wide Body Premium}} = \frac{500\text{ gCO}_2\text{e}}{\text{L}} \times \frac{0.033\text{ L}}{\text{RPK}} = \frac{16.5\text{ gCO}_2\text{e}}{\text{RPK}}$$

Avoiding Erroneous Emission Intensity Double Counting

Because the emission intensity of a specific amount of transportation activity is directly related to the emission factor of the fuel used to conduct that transportation activity, shippers, LSPs, TMCs, business travelers, and carriers must exercise caution to ensure that they do not erroneously double count the emission benefits of SAF within GHG Protocol emission reporting scopes.

Stated differently, the emission benefits of a discrete volume of SAF are bound by the amount of transportation activity conducted in association with that SAF. Once allocated to a specific transportation activity, the emission benefits of SAF cannot be transferred to an alternative activity. Carriers, LSPs, business travelers, TMCs, and shippers may not report or substitute the emission intensity of a discrete volume of SAF that is associated with specific transportation activity to transportation activity conducted in association with conventional aviation fuels.

Constraints to Avoid Erroneous Double Counting: General

The emission factor associated with a discrete volume of SAF must only be accounted for within the value chain associated with the purchaser of that SAF's environmental attributes. The emission reduction benefits associated with a discrete volume of SAF will be erroneously counted more than once if:

1. The purchaser of a SAF DEA reports or allocates the emission reduction benefit of this purchase (as they are entitled to do); and
2. The emission factor of the aviation fuel in the distribution network to which SAF was added is reduced to account for the addition of SAF; and
3. Any user of the aviation fuel from that network reports their emissions based on the lower emission factor resulting from the addition of SAF.

Constraints to Avoid Erroneous Double Counting: Freight Transportation

In the freight example described above, Carrier A had an emission intensity of 302 gCO_2e per tonne kilometer for flight 12. Flight 12 was treated as though it was fueled by a 50% Fischer-Tropsch processed agricultural residue SAF, 50% conventional jet fuel blend.

In addition to flight 12, Carrier A also conducted flight 34. On flight 34, Carrier A consumed 158,400 L of conventional jet fuel. Flight 34 was an 8,000 kilometer flight of 110 tonnes of cargo.

$$\text{TransportActivity}_{\text{Flight 34}} = 8{,}000 \text{ kilometers} \times 110 \text{ tonnes} = 880{,}000 \text{ tonne kilometers}$$

$$\text{Emission Intensity}_{\text{Flight 34}} = \frac{EF_{\text{Conventional Jet}} \times \text{Convetional Jet Volume}}{\text{Transport Activity}}$$

$$\text{Emission Intensity}_{\text{Flight 34}} = \frac{\left(\frac{3{,}100 \text{ gCO}_2\text{e}}{\text{L}}\right) \times 154{,}800 \text{ L}}{800{,}000 \text{ tonne km}}$$

$$\text{Emission Intensity}_{\text{Flight 34}} = \frac{545 \text{ gCO}_2\text{e}}{\text{tonne km}}$$

Note that flight 12 and flight 34 have different emission intensities, even though both flights involved the exact same amount of fuel consumption and transportation activity. The flight 12 emission intensity (302 gCO_2e per tonne kilometer) is lower than the flight 34 emission intensity (545 gCO_2e per tonne kilometer) as a result of the SAF environmental attributes associated with flight 12.

Carrier A can only allocate the flight 12 emission intensity to 880,000 tonne kilometers of transportation activity. If Carrier A assigned the flight 12 emission intensity to any more than 880,000 tonne kilometers of transportation activity, Carrier A would be erroneously double counting the benefits of the SAF environmental attributes associated with flight 12.

Constraints to Avoid Erroneous Double Counting: Passenger Transportation

As with freight transportation, transportation activity serves as a constraint to avoid erroneous double counting for passenger transportation. And for the same reasons – the emission intensity for a specific amount of transportation activity will vary based on the emission factor of the fuel used to conduct that transportation activity.

Continuing the passenger transportation example from above, TMC A has 100,000 L HEFA used cooking oil (emission factor of 500 gCO_2e per L) environmental attributes available to it for allocation to customers. While these environmental attributes can be split any number of ways across air carriers, aircraft classes, and passenger classes, the total allocation cannot exceed the equivalent of 100,000 L of transportation activity for that fuel type.

Based on the fuel intensity table provided above, the maximum amount of reduced emission transportation activity that TMC A can allocate to business travelers, by carrier, aircraft class, and passenger class is as follows:

Aircraft Type	Maximum SAF Allocation by Class (RPK) for Carrier X Flights		Maximum SAF Allocation by Class (RPK) for Carrier Y Flights	
	Economy	Premium	Economy	Premium
Regional	1,666,667	1,190,476	1,639,344	1,136,364
Narrow Body	3,225,806	2,272,727	3,448,276	2,439,024
Wide Body	4,761,905	2,777,778	5,263,158	3,030,303

These maximums were calculated exactly as shown in the worked example above.

The emission intensities that TMC A can allocate *at these maximums* are as follows:

Aircraft Type	Emission Intensity at Maximum SAF Allocation to Carrier X Flights (gCO_2e per RPK)		Emission Intensity at Maximum SAF Allocation to Carrier Y Flights (gCO_2e per RPK)	
	Economy	Premium	Economy	Premium
Regional	30	42	31	44
Narrow Body	16	22	15	21
Wide Body	11	18	10	17

Again, these intensities were calculated exactly as shown in the worked example above.

Based on these tables, TMC A could allocate just under 1,200,000 RPK of Carrier X regional premium transportation at 42 gCO_2e per RPK to its customers. TMC A could not allocate 1,300,000 RPK of Carrier X regional premium transportation at 42 gCO_2e per RPK without erroneously double counting some of the SAF environmental attributes. If TMC A is allocating the emissions benefits from the HEFA DEA that it purchased all to Carrier X, regional premium transportation, TMC A only has 1,200,000 RPK of transportation activity (not 1,300,00 RPK of transport activity) at its disposal.

Alternatively, TMC A could allocate up to 5,263,158 RPK of Carrier Y wide body economy transportation at 9.5 gCO_2e per RPK. TMC A could not allocate 5,263,158 RPK of Carrier Y wide body economy transportation at 9.5 gCO_2e per RPK at the same time that it was allocating 100,000 RPK of Carrier Y regional economy transportation at 30.5 gCO_2e per RPK. Here again, TMC A would have maxed out the environmental attributes at its disposal with the 5,263,158 RPK allocation to Carrier Y wide body economy seats and would not have any emission reduction benefits left to allocate to Carrier Y regional economy seats.

To summarize, TMC A can allocate the emission reduction benefits associated with its purchase of a DEA for 100,000 L of HEFA in any combination of ways. TMC A must ensure, however, that the total allocation of benefits does not exceed those benefits actually achieved by the environmental attributes that TMC A purchased.

Emission Intensity for a Transportation Operation Category

A carrier, LSP, or TMC does not necessarily need to allocate the environmental attributes of SAF to a specific flight, customer, aircraft, or seating class. Carriers, LSPs, and TMCs may decide to spread the benefit of the SAF environmental attributes across an entire Transportation Operation Category (TOC).

Emission Intensity for Freight Transportation Operation Categories

Continuing the freight example:

- Carrier A decides not to allocate the environmental attributes from the SAF used in association with the flight 12 transportation activity to any specific customer.
- Flight 12 and flight 34 are both on TOCσ.
- Flights 12 and 34 are the only flights on TOCσ during the reporting period.

Carrier A can disclose an emission intensity including the impact of the SAF equally to all users of this TOCσ.

$$\text{Emission Intensity}_{TOC\sigma} = \frac{(EF_{\text{SAF Neat}} \times \text{SAF Volume}) + (EF_{\text{Conventional}} \times \text{Conventional Volume})}{\text{Transport Activity}}$$

$$\text{Emission Intensity}_{TOC\sigma} = \frac{\left(\left(\frac{254\ gCO_2e}{L}\right) \times 79{,}200\ L\right) + \left(\left(\frac{3{,}100\ gCO_2e}{L}\right) \times 237{,}600\ L\right)}{1{,}760{,}000\ \text{tonne km}}$$

$$\text{Emission Intensity}_{TOC\sigma} = \frac{430\ gCO_2e}{\text{tonne km}}$$

Emission Intensity for Passenger Transportation Operation Categories

Continuing the passenger example:

- TMC A is marketing its lower-emission air travel offerings, focused on customers who conduct most of their transportation activity on narrow body aircraft.
- TMC A has defined a TOC for narrow body aircraft, across all narrow body aircraft carriers and seating classes.
- TMC A has calculated an average narrow body fuel intensity (based on fuel intensity data from the carriers) of 0.033 L fuel per RPK.
- In the previous year, TMC A arranged 50,000,000 RPK of air transportation activity on narrow body aircraft and allocated all of the emission benefits from its 100,000 L HEFA SAF DEA purchase to the narrow body TOC.

$$\text{Transport Activity}_{\text{Narrow Body}} = 50{,}000{,}000 \text{ RPK}$$

$$\text{Transport Activity}_{\text{NB}} \text{ as Consumption} = \left(\frac{0.033 \text{ L}}{\text{RPK}}\right) \times 50{,}000{,}000 \text{ RPK} = 1{,}650{,}000 \text{ L}$$

$$\text{Emission Intensity}_{\text{NB}} = \frac{(EF_{\text{SAF Neat}} \times \text{SAF Volume}) + (EF_{\text{Conventional}} \times \text{Conventional Volume})}{\text{Transport Activity}}$$

$$\text{Emission Intensity}_{\text{NB}} = \frac{\left(\left(\frac{500 \text{ gCO}_2\text{e}}{\text{L}}\right) \times 100{,}000 \text{ L}\right) + \left(\left(\frac{3{,}100 \text{ gCO}_2\text{e}}{\text{L}}\right) \times 1{,}550{,}000 \text{ L}\right)}{50{,}000{,}000 \text{ RPK}}$$

$$\text{Emission Intensity}_{\text{NB}} = \frac{97 \text{ gCO}_2\text{e}}{\text{RPK}}$$

This emission intensity (considering the HEFA SAF purchase) compares to an emission intensity without the HEFA SAF of 102 gCO_2e per RPK:

$$\text{Emission Intensity}_{\text{NB Conventional}} = \frac{\frac{3{,}100 \text{ gCO}_2\text{e}}{\text{L}} \times 1{,}650{,}000 \text{ L}}{50{,}000{,}000 \text{ RPK}} = \frac{102 \text{ gCO}_2\text{e}}{\text{RPK}}$$

TMC A can claim that their purchase of SAF resulted in a reduction of 5 gCO_2e per RPK on all narrow body flights they arranged during the previous year.

Emission Intensity for Transportation Operation Categories: General

Generalizing these examples, a carrier, shipper, LSP, business traveler, or TMC can calculate the emission intensity across a TOC as follows.

$$\text{Emission Intensity}_{\text{TOC}} = \frac{\sum_i^n (EF_{\text{SAF } i} \times \text{Volume}_{\text{SAF } i}) + (EF_{\text{Conventional}} \times \text{Volume}_{\text{Conventional}})}{\text{Transport Activity}}$$

Where:

- *i* represents a specific batch of SAF associated with the TOC
- The company is accounting for environmental attributes from *n* different batches of SAF on the TOC
- $EF_{\text{SAF } i}$ = Emission Factor for SAF batch *i*
- $\text{Volume}_{\text{SAF } i}$ = Volume of SAF Consumed on TOC with Emission Factor $EF_{\text{SAF } i}$
- $EF_{\text{Conventional}}$ = Emission Factor for Conventional Aviation Fuel
- $\text{Volume}_{\text{Conventional}}$ = Volume of Conventional Fuel Consumed on TOC
- Transport Activity = Total Transport Activity on TOC

Emission Intensity Across Several Transportation Operation Categories

A carrier, shipper, LSP, TMC, or business traveler may also need to make an external declaration (e.g., in a corporate sustainability report) of emission intensity across all of its air transportation activity. In this situation, the declared emission intensity is meant only to represent the emission intensity of the carrier, shipper, TMC, business traveler, or LSP's activities as a whole. This intensity cannot be used for customer specific emission calculations (unless the carrier, LSP, or TMC has not allocated any emission benefits to a specific customer's transportation activity).

The emission intensity calculations are similar to those for TOCs, though they represent data from across TOCs:

$$\text{Emission Intensity} = \frac{\sum_i^n (EF_{SAF\ i} \times Volume_{SAF\ i}) + (EF_{Conventional} \times Volume_{Conventional})}{\text{Transport Activity}}$$

Where:

- i represents a specific batch of SAF for which environmental attributes were purchased
- The company is accounting for environmental attributes from n different batches of SAF
- $EF_{SAF\ i}$ = Emission Factor for SAF batch i
- $Volume_{SAF\ i}$ = Volume of SAF Consumed with Emission Factor $EF_{SAF\ i}$
- $EF_{Conventional}$ = Emission Factor for Conventional Aviation Fuel
- $Volume_{Conventional}$ = Volume of Conventional Aviation Fuel Consumed
- Transport Activity = Total Air Transport Activity

Part 6: Emission Factors

Overview of Emission Factors

While the TTW CO_2 emissions of different types of SAF are similar to each other and to those from conventional aviation fuel, the WTT emissions associated with SAF vary significantly by feedstock and production process. As such, SAF emission factors – the GHG emissions associated with the use of a particular amount of fuel – also vary by feedstock and production process.

Table 3 below includes a selection of emission factors for CORSIA eligible SAF, by feedstock and production process[9].

[9] *A SAF producer may assign a different emission factor to a batch or batches of fuel than the emission factor described in Table 3. Such an emission factor, captured on a declaration of environmental attributes for the fuel, may vary from the Table 3 factor based on the producer's primary data for the feedstocks and production processes used in the production of that fuel, or based on calculation of an emission factor using methods for conducting life cycle analyses under a non-ICAO framework (e.g., under the California Low Carbon Fuel Standard framework).*

ICAO SAF Emission Factors and their Relationship to the Table 3 Emission Factors

In November of 2019, ICAO published life cycle emission factors for 28 different CORSIA eligible fuels [32]. These emission factors were calculated based on the methods and assumptions described in detail in an ICAO CORSIA eligible fuel life cycle assessment supporting document [33].

The numbers underlying the ICAO emission factors are the basis for the emission factors presented in Table 3. The values presented in Table 3 are not the same values presented in the ICAO emission factor table, though, for several reasons.

Units of Measure

First, the ICAO units of measure for the SAF emission factors were changed for presentation in Table 3.

ICAO represent SAF emissions in units of gCO_2e per mega joule (MJ) of fuel energy content. The SAF accounting guidelines provided throughout this document and the GLEC Framework address fuel as a unit of volume rather than by fuel energy content. As such, the emission factors in Table 3 are shown as emissions per L instead of emissions per MJ. The energy to volume conversion was made based on the energy content data presented in Annex III of EU Directive 2018/2001 on the promotion of the use of energy from renewable resources (RED II) [34]. Energy content of synthetic isoparaffins (chemically specified as farnesane) is not included in EU Directive 2018/2001. The energy content of farnesane was therefore calculated based on the higher heating value from Fu and Turn (2019) and density data from the European Chemicals Agency dossier for farnesane [35] [36].

Induced Land Use Change Assumptions

Second, not all ICAO emission factors for CORSIA eligible SAF are included in Table 3.
ICAO determined Induced Land Use Change (ILUC) values for CORSIA eligible SAF based on outputs from two models, the GLOBIOM and GTAP-BIO models. In some cases, the ILUC value generated by these two models differed considerably. These considerable differences in model outputs for fuels with herbaceous energy crop and short rotation woody crop feedstocks imply that there is a degree of uncertainty in the resulting consolidated life cycle emission factors. As such, the emission factor for these fuels are not included in Table 3.

CO_2 Equivalents

Third, ICAO's method for addressing non-CO_2 GHG emissions was not adopted in the calculation of the Table 3 emission factors.

ICAO does not assign TTW non-CO_2 direct GHG emissions to SAF in its list of CORSIA eligible SAF emission factors. In contrast, aviation fuel is assigned 2 gCO_2e/L in non-CO_2 GHG emissions in the GREET database. The emissions factors in Table 3 assume that all SAF is associated with 2 gCO_2e/L of TTW non-CO_2 direct GHG emissions (e.g., N_2O and methane). The TTW emission factors in Table 3, then, are consistent with the assumptions captured in the GREET database.

Palm Fatty Acid Distillate

Fourth, an emission factor for Palm Fatty Acid Distillate (PFAD) is not included in Table 3.

ICAO treats PFAD as a by-product of crude palm oil production when calculating life cycle emissions of PFAD. In considering PFAD a by-product of crude palm oil production, the ICAO PFAD emission factor does not include upstream emissions from palm oil cultivation.

There is some debate as to whether PFAD is a by-product or a coproduct of crude palm oil production. If PFAD were considered a coproduct of crude palm oil production, then upstream emissions from palm oil cultivation would need to be included in the life cycle emissions of PFAD.

Because of the uncertainty around the classification of PFAD (as a by-product or as a coproduct of crude palm oil production), Table 3 does not include an emission factor for PFAD.

Fuel Conversion Process	Region	Fuel Feedstock	ICAO Core LCA Emissions (g CO_2e/L)	ILUC Emissions (g CO_2e/L)	WTT Emissions (g CO_2e/L)	TTW Emissions (g CO_2e/L)	WTW Emissions (g CO_2e/L)
N/A	Global	Conventional Jet Fuel[10]	N/A	0	549	2,525	3,074
Fischer-Tropsch	Global	Agricultural Residues	257	0	257	2	259
	Global	Forestry Residues	277	0	277	2	279
	Global	Municipal Solid Waste (MSW) - 0% Non-Biogenic Carbon (NBC)	174	0	174	2	176
	Global	MSW - 50% NBC[11]	2,985	0	1,842	1,179	3,021
Hydro-Processed Esters and Fatty Acids	Global	Tallow	751	0	751	2	753
	Global	Used Cooking Oil	464	0	464	2	466
	Global	Corn Oil from Dry Mill Ethanol Plant	574	0	574	2	576
	USA	Soybean Oil	1,348	818	2,167	2	2,169
	Brazil	Soybean Oil	1,348	901	2,250	2	2,252
	EU	Rapeseed Oil	1,582	805	2,387	2	2,389
	Malaysia and Indonesia	Palm Oil - Closed Pond	1,249	1,305	2,554	2	2,556
	Malaysia and Indonesia	Palm Oil - Closed Pond	2,003	1,305	3,308	2	3,310
Alcohol (Isobutanol) to Jet	Global	Agricultural Residues	978	0	978	2	980
	Global	Forestry Residues	795	0	795	2	797
	Brazil	Sugarcane	801	244	1,045	2	1,047
	USA	Corn Grain	1,863	738	2,601	2	2,603
Alcohol (Ethanol) to Jet	Brazil	Sugarcane	506	183	1,095	2	1,097
	USA	Corn Grain	1,380	527	3,031	2	3,033
Synthetic Isoparaffins	Brazil	Sugarcane	1,120	386	1,472	2	1,474
	EU	Sugar Beet	1,110	690	1,756	2	1,758

Table 3: SAF emission factors

[10] *Emission factors taken from the GLEC Framework.*
[11] *These calculations assume that 50% of the carbon in MSW is NBC.*

Part 7: Conclusion

This guidance provides a framework for advancing the uptake of SAF in air transportation value chains using an emerging financing mechanism, GHG insets. GHG insets provide a pathway for collaboration within the air transportation value chain. Through this mechanism, air transportation value chain organizations can work together to make the financial investments needed to meet global climate goals.

For insets to work with SAF, entities in the air transportation value chain must agree on and adopt a framework to quantify and track SAF emissions – for shippers, carriers, LSPs, TMCs, and business travelers. This document supplements existing methods in the GLEC Framework and outlines guidance for quantifying and tracking SAF emissions.

The guidelines establish principles for a SAF book and claim system, the basis for the transportation fuel inset. They provide a process through which SAF users can verify that SAF environmental attributes are legitimate, and that emissions reductions claims are credible and transparent. They also provide a structure to avoid erroneously double counting those emissions reductions. Finally, they provide SAF emission factors that allow accounting for a range of SAF feedstocks and production pathways.

The guidelines describe how insetting through a book and claim system can be used to realize emission reductions in air transportation value chains. Starting with SAF, this guidance provides a first step toward an inset system that may be applied for other low emission transportation fuels.

While this guidance provides a starting point, more work is needed to advance these concepts. Industry leaders are needed to adopt GHG insets for SAF, test these systems, and offer feedback on how they can be improved.

Decarbonizing the logistics sector will require more than SAF. New energy sources need to be scaled, distribution infrastructure constructed, and new propulsion technologies designed and deployed across all modes. These are often costly endeavors that will require significant investments.

As many transportation assets are ultimately shared across many users, GHG insets offer a new pathway for joint investment in emissions reduction strategies. However, GHG insets as a tool for emissions reduction need recognition from GHG accounting and target-setting programs in order to facilitate insets' widespread adoption by organizations.

While much work remains ahead, through collaboration, value chain partners can spark new pathways to reach global decarbonization goals.

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