



D3.2

Best practice handbook and tools for fuel logistics, quality monitoring, and accounting

Version number:	1.0
Dissemination level	PU (public)
Work package:	WP 3 – Implementation and usage of Sustainable Aviation Fuels
Date:	31.03.2025
Lead beneficiary:	IATA (International Air Transport Association)
Author(s):	IATA
Co-author(s):	NISA, Airbus, AirBP, TUHH, CPH, ADR
Contact person	Damiana Serafini – serafinid@iata.org
	Alejandro Rivera Gil – riveragil@iata.org mailto:



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957824

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957824.

The statements made herein do not necessarily have the consent or agreement of the ALIGHT consortium. These represent the opinion and findings of the contributing author(s). The European Union (EU) is not responsible for any use that may be made of the information they contain.

Similarly, this document has been developed making extensive use of IATA publications, mainly:

- [IATA SAF Handbook, May 2024 - Understanding SAF Sustainability Certification, June 2024](#)
- [IATA ReFuelEU Aviation Handbook, September 2024](#)
- [IATA SAF procurement: Pricing options for different strategies, December 2024](#)
- [IATA Sustainable Aviation Fuel \(SAF\) Accounting & Reporting Methodology, January 2025.](#)

Note that no intellectual property rights to IATA publications are granted by the delivery of this document or the disclosure of its content.

Copyright © 2022, ALIGHT Consortium. All rights reserved.

This document and its content are the property of the ALIGHT Consortium. It may contain information subject to intellectual property rights. No intellectual property rights are granted by the delivery of this document or the disclosure of its content. Reproduction or circulation of this document to any third party is prohibited without the prior written consent of the Author(s), in compliance with the general and specific provisions stipulated in ALIGHT Grant Agreement.

THIS DOCUMENT IS PROVIDED BY COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS DOCUMENT, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Content

Acknowledgements.....	10
A. Introduction to Project ALIGHT	11
B. Target audience, aim, and scope	15
C. How to use this handbook.....	18
1. Sustainable Aviation Fuels Fundamentals.....	19
1.1 Why SAF?.....	20
1.2 Technical overview.....	23
1.2.1 SAF Feedstocks and production pathways	24
1.2.2 Fuel specification and sustainability certification	28
1.2.3 Supply chain quality control & blending	37
1.2.4 SAF Readiness - Aircraft compatibility.....	42
2 Market based measures, mandates, and incentives.....	44
2.1 Market-Based Measures	45
2.1.1 CORSIA	45
2.1.2 European Union Emissions Trading System.....	46
2.2 Mandates.....	47
2.2.1 ReFuelEU Aviation.....	48
2.1.1 National mandates	56
2.3 Incentives.....	58
2.3.1 USA – incentives for the SAF industry	59
2.4 Recipe for a functional SAF policy.....	60
3 SAF Accounting and Reporting	61
3.1 Fundamentals of SAF accounting and reporting.....	61
3.2 Chain of Custody approach to traceability	64
3.2.1 Physical segregation	65
3.2.2 Mass balance.....	66
3.2.3 Book-and-claim	67
3.3 Global harmonization on sustainability certification and accounting & reporting processes.....	69
3.3.1 Sustainability Framework.....	70
i. European Union	70
ii. United Staes of America	71
iii. CORSIA	71

iv.	Lack of Harmonization in Sustainability Frameworks.....	72
3.3.2	Accounting and Reporting Methods.....	78
i.	Lack of Harmonization on Accounting and Reporting Procedures	78
4	Handling, Safety & Quality Assurance	80
4.1	Compatibility of SAF handling with existing infrastructure	80
4.1.1	SAF Usage Scenarios.....	82
4.2	Quality assurance	85
4.3	Future considerations related to non-CO2 climate effects	86
4.4	Fuel Handling Matrix – Co-mingled vs. Segregated – Pros and Cons.	87
4.5	SAF Usage Case Studies – The Experience of CPH and ADR	88
4.5.1	SAF usage case study – CPH.....	90
4.5.2	SAF usage cases study – ADR.....	105
5	Procurement of SAF	123
5.1	Types of procurement	123
5.1.1	SAF Procurement by Airlines.....	123
5.1.2	Commercialization of SAF	123
5.1.3	SAF Procurement by General Aviation customers	124
5.2	Procurement Documentation Requirements.....	124
5.2.1	PoS – Proof of Sustainability	124
5.2.2	PoC – Proof of Compliance.....	125
5.2.3	PTD- Product Transfer Document	125
5.3	SAF Production Costs.....	125
5.4	SAF Pricing Structure	126
5.5	Types of SAF Purchasing Agreements.....	129
5.5.1	Spot Agreements	129
5.5.2	Term Agreements	129
5.5.3	Agreements for future offtakes / Investment into SAF producers	129
5.5.4	Equity Stake Investment.....	130
5.5.5	Joint Purchasing (procurement) Agreement.....	130
5.6	CoC models and SAF procurement	130
6	SAF Readiness Self-Evaluation.....	132
6.1	How to use this checklist.....	132
6.1.1	Airports - Step-by-Step Instructions	133
6.1.2	Fuel Supplier - Step-by-Step Instructions.....	135
6.1.3	Aircraft Operators - Step-by-Step Instructions.....	137
D.	Conclusion	140
	References.....	141
	Appendix I: Data Elements in a PoS	144

Appendix II: Key common principles of a robust SAF accounting approach	151
--	-----

List of Figures

Figure 1 - Levers of action for aviation CO2 emissions reductions by 2050	20
Figure 2 - Breaking Down IATA's 5 Net Zero Roadmaps	22
Figure 3 - SAF blends in compliance with aromatic content	23
Figure 4 - SAF production pathways and associated feedstocks	25
Figure 5 - ERF from different combinations of SAF feedstocks and technology pathways	26
Figure 6 - Classifying feedstock generations	26
Figure 7- SAF ASTM certification process.....	29
Figure 8 - Fuel life-cycle emissions for fossil and biofuel	33
Figure 9 - Depiction of a hypothetical SAF supply chain.....	34
Figure 10 - PoS to ensure a robust chain of custody	35
Figure 11- Supply chain quality control documents relevant by stakeholder	38
Figure 12 - SAF blending possibilities	40
Figure 13 - Regulation along the SAF supply chain	44
Figure 14 - RFEUA scope and obligations.....	49
Figure 15- Binding shares of SAF and synthetic aviation fuels - RFEUA	51
Figure 16 - Mandates vs. Incentives	59
Figure 17 - Building blocks for effective SAF policy frameworks.....	60
Figure 18- Generic CAF accounting workflow	62
Figure 19 - Generic SAF accounting workflow	63
Figure 20 - Fuel accounting based on Chain of Custody (CoC) approaches.....	65
Figure 21 - Physical segregation CoC model.....	65
Figure 22- Mass Balance CoC model	67
Figure 23 - Book and Claim COC model	68
Figure 24 - Exemplary SAF supply chain	69
Figure 25 - Supply and distribution chain	83
Figure 26 - Scenario 1 – Co-Mingled BAU.....	83
Figure 27 - Scenario 2 – Dedicated flights	84
Figure 28 - Scenario 3 – Dedicated airports.....	84
Figure 29 - Scenario 4 – Supply of non-drop in 100% SAF fuel or Jet-X	85
Figure 30 - Requirements for CAF, SK, and SAF before and after blending	86
Figure 31 - Pros & Cons Matrix for Co-mingled SAF usage.....	88
Figure 32- Pros & Cons Matrix for Segregated SAF usage	88
Figure 33 - The HEFA process.....	93
Figure 34 - Aviation fuel supply handling and logistics at CPH	94
Figure 35 - SAF blend delivery process Scenario 1	95
Figure 36 - SAF blend delivery process Scenario 2.....	95
Figure 37 - Aeroporti di Roma Sustainability Strategy	106
Figure 38 - SAF blend supply chain for Test 1	111

Figure 39 - SAF blend delivered to FCO by truck	113
Figure 40 - SAF blend supply chain for Test 2.....	113
Figure 41- SAF related schemes and regulations along the supply chain.....	125
Figure 42- Product yields for key SAF conversion pathways.....	127
Figure 43 - SAF Off-Take Agreements - Action Today and Tomorrow	130
Figure 44 - SAF Readiness Level Self-Assessment Checklist.....	133

List of tables

Table 1 - SAF Sustainability Certification.....	31
Table 2 - CORSIA eligible fuels sustainability criteria include the following themes.....	32
Table 3 - Approved SAF Pathways, blending ratios, and coprocessing limits	41
Table 4 - Conversion processes under evaluation	42
Table 5 - Impact to Primary Stakeholders – RFEUA.....	53
Table 6 - Comparison between COC approaches	68
Table 7 - Comparison table – Sustainability Frameworks	75
Table 8 - Comparison table – Accounting and Reporting Procedures.....	79
Table 9 - Actual Partners – Pact for Decarbonization of Air Transport	107
Table 10 - Breakdown of cost structure and challenges per SAF pathway.....	126
Table 11 - Breakdown of cost structure and challenges per SAF pathway.....	128

Acronyms

1G	First Generation
2G	Second Generation
3G	Third Generation
A4A	Airlines for America
ADR	Aeroporti di Roma
Air BP	Air BP Limited
AMS	Amsterdam Airport
APU	Auxiliary Power Unit
ASTM	American Society for Testing and Materials
AtJ	Alcohol-to-Jet
BAU	Business as usual
BKL	Braendstoflageret Kobenhavns Lufthvn Is
BLQ	Bologna Airport
BTC	Blenders Tax Credit
BtL	Biomass to Liquid
CAF	Conventional Aviation Fuels
CEF	CORSIA eligible fuel
CFPC	Clean Fuel Production Credit
CIA	Ciampino Airport
CO ₂	Carbon Dioxide
COA	Certificate of Analysis
CoC	Chain-of-Custody
CoQ	Certificate of Quality
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPH	Copenhagen Airport Kastrup Airport Guide
DCC	DCC & Shell Aviation Denmark A/S
DLR	Deutsches Zentrum Fur Luftund Raumfahrt EV
DTI	Teknologisk Institut
EASA	European Union Aviation Safety Agency
EEA	European Economic Area
EI	The Energy Institute
ENI	Eni S.p.A
ERF	Emission Reduction Factor
EU	European Union
EU ETS	EU Emissions Trading System
EU RED	EU Renewable Energy Directive
FAME	FattyAcid Methyl Ester
FCO	Fiumicino Airport
FOGs	Fats, Oils, and Greases
FID	Final Investment Decision
FT	Fischer-Tropsch
GdF	Guardia di Finanza
GHG	Greenhouse Gases
GHGP	Greenhouse Gas Protocol
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies

GSE	Ground Support Equipment
HEFA	Hydro-Processed Esters and Fatty Acids
HTL	hydrothermal liquefaction
HVO	Hydrogenated Vegetable Oil
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ACT-SAF	Assistance, Capacity-building, and Training for Sustainable Aviation Fuels
IFQP	IATA Fuel Quality Pool
IRA	Inflation Reduction Act
ISCC	International Sustainability and Carbon Certification
JIG	Joint Inspection Group
LCA	life-cycle analysis
LCAF	Low Carbon Aviation Fuel
Levorato	Levorato Marcevaggi
LIN	Milan Linate Airport
LTAG	Long-Term Global Aspirational Goal
MBM	Market-Based Measures
MRV	Monitoring, Reporting, and Verification
MRVA	Monitoring, Reporting, Verification, and Accounting
NISA	Nordic Initiative for Sustainable Aviation
NOx	Nitrous Oxide
PoC	Proof of Compliance
PoS	Proof of Sustainability
PTD	Product Transfer Document
PtL	Power-to-Liquid
RCQ	Refinery Certificate of Quality
RED	Renewable Energy Directive
REFUA	ReFuelEU Aviation
RFNBO	Renewable Fuels of Non-Biological Origins
RFS	Renewable Fuel Standard
RINs	Renewable Identification Numbers
RSB	Roundtable on Sustainable Biomaterials
RTC	Recertification Test Certificate
RTFO	Renewable Transport Fuel Obligation
OEMs	Original Equipment Manufacturers
SAF	Sustainable Aviation Fuels – sustainably certified synthetic blending component
SAF blend	Sustainable Aviation Fuels blend – sustainably certified semi-synthetic jet fuel
SAF BTC	SAF blenders' tax credit
SAFE	Sustainable Aviation Fuels: Passenger, Public, and Stakeholder Perceptions
SAK	Synthetic Aromatic Kerosene
SARPs	Standards and Recommended Practices
SAS	Scandinavian Airlines System Consortium
SBC	Synthetic Blending Component
SBTi	Science Based Targets initiative
SCS	Sustainability Certification Schemes
SFJ	Søndre Strømfjord/ Kangerlussuaq Airport
SGF	Sector's Growth Factor

SPK	Synthetic Paraffinic Kerosene
SSJF	Semi-synthetic Jet Fuel
StL	Solar to Liquid
TUHH	Technische Universitat Hamburg
UK	United Kingdom
UK Def. Stan 91-091	United Kingdom's Defence Standard 91-091
UNFCC	United Nations Framework Convention on Climate Change
UNIPR	Universita Degli Studi Di Parma
USA	United States of America
USD	United States Dollars
VCE	Venice Airport
WP3	Work Package 3

Acknowledgements

IATA thanks all Project ALIGHT consortium members who collaborated in the authoring and editing of this handbook, external guideline development group, and internal review group for their invaluable contributions in the development of this publication.

ALIGHT's consortium partners who co-authored and edited the handbook include the following colleagues and institutions:

1. ADR - Maria Sole Salomoni and Angela Di Lullo
2. Air BP - Sven Rieve
3. Airbus - Didier Gendre, Hamzah Ahmed, Emile Mulder, and Amelia Jones
4. BKL - Peter Laybourn
5. CPH - Peter Wiboe Holm, Sabrina Jensen, and Louise Krohn
6. DLR - Benedict Enderle
7. NISA - Alexander Bjørn Hansen and Martin Porsgaard
8. RSB - Blanca de Ulibarri and George Deslandes
9. SAS - Ann-Sofie Hörlin
10. TUHH - Nils Bullerdiek and Gunnar Quante

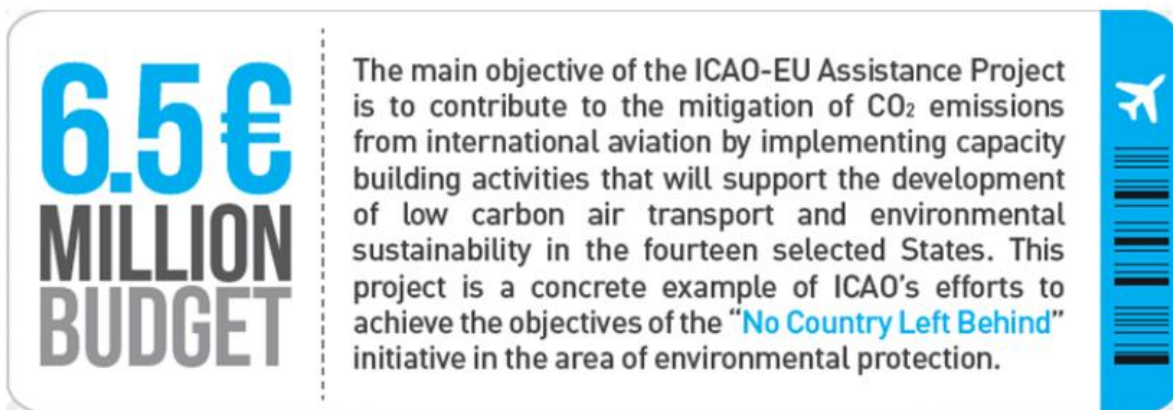
The external guideline development group includes a team of recent graduates in aerospace engineering under the supervision of the Director of the research center Grupo Transporte Aéreo, College of Aerospace Engineering, University of La Plata - UNLP. Their guidance testing the self-assessment tool has helped to greatly improve its quality and functionality, our appreciation goes out to Alejandro Di Bernardi, Belen Urdangarin, Jose I. Escoz, Matias Testa, and Thiago Aude.

The systematic internal review and administrative work included the ever patient and expert team at IATA composed of the following individuals: Abijith Amberi Premanand, Alejandro Block, Alejandro Rivera Gil, Andrew Matters, Anick Léger, Azim Bin Norazmi, Bojun Wang, Daniel Chereau, Eliezer Arellano Garcia, Hemant Ministry, Laurent Delarue, Manuel Lanuza Fabregat, Marie Owens, Mark Vaughan, Nellie Elguindi, Nicolas James, Preeti Jain, and Yue Huang.

IATA gratefully acknowledges funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957824.

A. Introduction to Project ALIGHT

As early as 2008, Virgin Atlantic and Boeing conducted the first ever commercial flight on a 747 using a blend of conventional aviation fuel (CAF) and sustainable aviation fuel (SAF). Once it was approved for use in aircraft operations in 2011, additional SAF pathways were qualified by the American Society for Testing and Materials (ASTM) and more airlines began adopting SAF for their flights. In 2013, the International Civil Aviation Organization (ICAO) and European Union (EU) launched the assistance project 'Capacity building for CO₂ mitigation from international aviation.'¹



As the commitment of the aviation sector to reduce its environmental impact grew, so did the need for guidance and harmonization of SAF usage practices. In 2018, ICAO adopted standards and recommended practices (SARPs) for Member States and aviation operators to reduce emissions from international aviation. These SARPs provided the core elements for the implementation of ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), the overarching scheme to realize ICAO's aspirational objectives of increasing fuel efficiency by 2% per year and achieving carbon neutral growth in international aviation after 2020. As researched progressed and implementation advanced, concerns remained at the fuel handling level, mainly at the point of introduction of SAF and SAF blends into airport grounds.

In this context, Project ALIGHT was launched in 2020, a Horizon 2020 EU funded project whereby key aviation partners meet to collaborate with the mission to:

- Enhance sustainable aviation, and
- Bring forward the necessary solutions, knowledge, guidelines, and best practice handbooks supporting an efficient airport paradigm shift towards zero emission aviation and airport operation.

¹ ICAO - European Union Assistance Project: https://www.icao.int/environmental-protection/pages/ICAO_EU.aspx

Project ALIGHT calls for the extensive collaboration among 17 partners

Airline: SAS

Airports: Copenhagen, Rome, Vilnius, and Warsaw.

Fuel supplier/handler: Air BP, BKL

Sustainability Certification Scheme: Roundtable on Sustainable Biomaterials

Industry Association: IATA

Knowledge Institutions: DLR, DTI, NISA, Hamburg Univ. of Technology, University of Parma.

Technology providers: Airbus, Hybrid Greentech, BMGI Consulting



Copenhagen Airport (CPH) was selected as the airport where to develop and demonstrate two sustainable solutions for implementation, namely:

1. The supply, implementation, integration, and smart use of SAF and SAF blends.
2. The development, integration, and implementation of smart energy system (including renewable energy sources, energy storage and energy management).

ALIGHT Objectives

- To facilitate Copenhagen Airport as a Lighthouse Airport, showing the sustainable way towards zero emission airport operation.
- To facilitate the deployment of sustainable aviation fuels (SAF), e-mobility, energy storage and waste heat recovery at Copenhagen Airport (Lighthouse airport), Rome Airport, Vilnius Airport (fellow airport) and the new Warsaw Airport.
- To secure knowledge transfer and tools supporting a smooth and efficient replication on a pan-European scale.
- To facilitate the integration of smart & sustainable airport deployment into urban planning and cities strategic development for a bold vision by 2050.

ALIGHT will thereby contribute to achieving the environmental targets set by national governments, of the Paris Agreement, the Renewable Energy Directive (RED II) and others through the reduction of GHG and other air emissions by the aviation industry, ALIGHT will also contribute to developing a bold vision for the sustainable airports of the future.



ALIGHT Approach



Copenhagen Airport is the lighthouse for the H2020 Smart Airports project ALIGHT. CPH will showcase the way to the sustainable airport of the future. The mission is to give best practice recommendations that can be replicated by other airports.

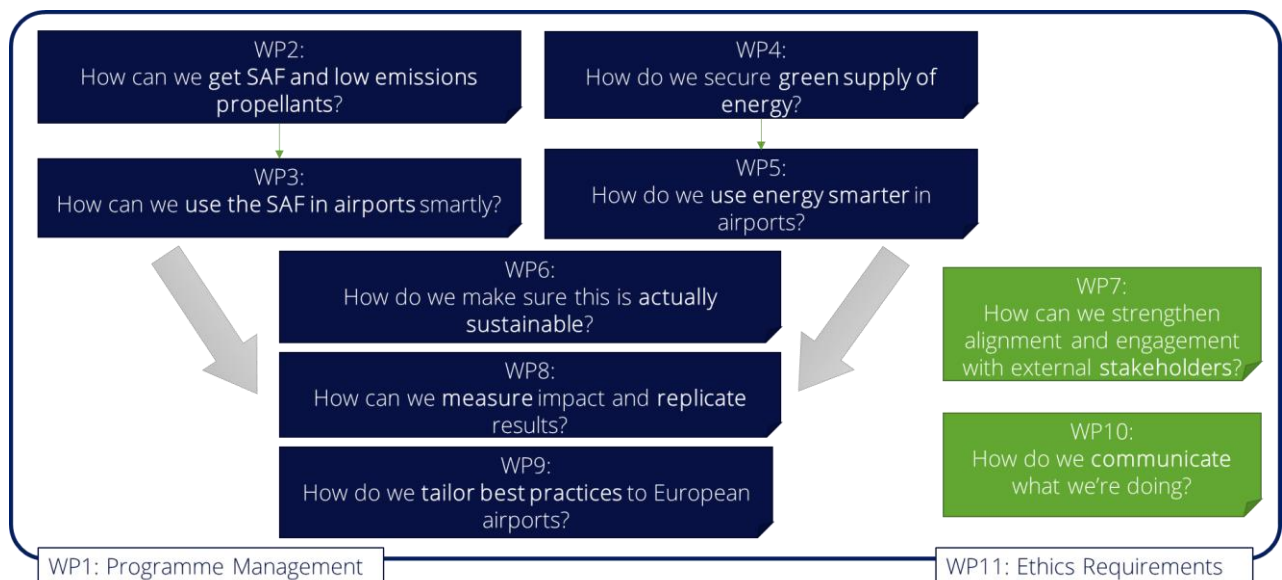


A best practice guide for Sustainable Energy Fuel handling and logistics will be developed. An innovative concept for a cost-effective fuel supply chain will be demonstrated at CPH.



Solutions for renewable energy for ground activities and vehicles within the airport will also be found. This includes own production of sustainable energy, energy storage and electrification.

ALIGHT Work Packages



Led by IATA, the objective of work package 3 (WP3) is to streamline the use of SAF by means of improving the logistics supply chain and SAF uptake process at airports in an efficient and cost-effective manner. Within the broad range of activities outlined in WP3, task 3.1 "Integration of sustainable aviation fuels in the airport fuel supply and operations," intends to provide a state-of-the-art handbook on best practices for the integration of SAF and SAF blends into the airport system with aim to improve the logistics chain and make the use of SAF more efficient and cost-effective. Stakeholder's concerns, e.g. regarding safety, fuel quality regulations, use of logistics infrastructure and sustainability will be addressed as well as the recognition of a global and robust accounting and reporting mechanism. In alignment with European and internationally recognized regulations such as ICAO's CORSIA, this accounting and reporting mechanism is intended to allow airlines to transparently track and credibly claim the environmental benefit of their SAF purchases.

Similarly, this handbook provides guidance on the potential for optimizing the physical use of sustainable fuels for specific flights, e.g. for flights through areas with high contrail formation potential (reduced non-CO₂ climate impact using SAF), specific airports, and fuels with the greatest potential to maximize CO₂ and non-CO₂ emission reductions from aviation.

This document is a practical handbook that provides guidance to address remaining challenges faced by fuel suppliers, airports, and aircraft operators. The handbook shares a comprehensive overview of SAF and SAF blends, detailing its dual components: the physical fuel and its associated environmental benefits. It examines key regulatory frameworks that incentivize SAF adoption and delves into the specifics of SAF procurement and accounting, covering pricing, agreements, contracts, and required certifications for environmental claims.

This is a living document that has undergone several updates during its production. Even so, because SAF is a quickly evolving topic, some of the information herein may not be any more reflective of circumstances at the time of submission to the European Commission.

B. Target audience, aim, and scope

This handbook is primarily targeted to airports, airlines, and fuel suppliers, yet it has been developed with a broader audience in mind, including fuel producers, practitioners, and all those interested in improving their understanding on SAF and its handling and procurement process. Mainly, this handbook has been designed as a guide to allow readers to achieve the following objectives:

- Enhance technical capacity and core skills concerning deployment and handling SAF from all stakeholders,
- Apply and improve reliable and effective accounting methods for fuel quantities and sustainability; guidance on how global harmonisation could be achieved, and
- Address concerns on safety, fuel quality regulations, use of logistics infrastructure, and sustainability based on clear and accurate guidance material from logistics partners.
- Understand the different options on SAF usage at the airport level to optimize CO₂ and non-CO₂ emission reductions

To achieve the above objectives, this handbook provides guidance on the following main themes:

Section 1 - Fundamentals of SAF

Section 2 - Market based measures, mandates, and incentives

Section 3 - Accounting and Reporting SAF Usage

Section 4 - SAF Handling, Safety, and Quality Assurance

Section 5 - SAF Procurement

Section 6 - SAF Readiness Level

For the **Fundamentals of SAF**, this handbook includes a detailed description of the core principles of SAF related to its environmental and operational benefits, production processes, sustainability and safety certification, and compatibility with current aircraft design. These concepts provide users and suppliers the right tools to know the difference between CAF and SAF and to identify the SAF pathway that provides them with the greatest benefit in compliance with internal sustainability goals and legal obligations on aviation emission reductions.

Similarly, section 1 contains basic knowledge on safety, fuel quality control, documentation and certification requirements that will be expanded in further detail in the following sections, both being crucial subjects to ensure the benefits of SAF are enjoyed and safety is ensured.

For **Market based measures, mandates, and incentives**, the reader will be given full access to pertinent regulation and standards under development and implementation to support the use of SAF in the EU and across the world. This section describes the role and responsibilities of each actor along the SAF value chain explaining procedures for compliance and the impacts of nonconformity.

Crucial to this section is the comparison between the different support measures taken in different markets, all aiming to accelerate SAF uptake. Gaps are identified and solutions proposed in those cases where improved harmonization among measures can provide a functional environment for the SAF industry to prosper, and consequently for the aviation industry to reach its net zero ambitions for 2050.

For the **Accounting and Reporting of SAF Usage**, this handbook analyses the Chain-of-Custody (CoC) models currently available to the industry, as well as the guidelines and systems under development to ensure that the sustainability attributes of SAF are appropriately accounted for, traced, transmitted, and communicated.

A sound SAF accounting approach with global applicability must fulfil various requirements, especially the safeguarding against double counting and the prevention of errors, duplication, and fraud. This handbook examines essential core principles needed to ensure a high-integrity SAF accounting mechanism and alignment with existing regulation.

Based on the data describing the fundamentals of SAF and applicable market-based measures, mandates, and incentives aimed at accelerating the use of SAF, section 2 sets out to guide aviation stakeholders on the strategic drivers to accurately account and report environmental attributes from SAF usage to:

- Warrant the efficient deployment of SAF while reducing cost on logistics and avoiding unnecessary transportation emissions.
- Ensure alignment with existing global accounting and reporting guidelines.
- Avoid unintended consequences from implementing multiple accounting and reporting mechanisms (double counting and double claiming of emission reductions).
- Claim the use of SAF under mandatory Greenhouse Gases (GHG) emission reductions schemes (e.g., EU ETS, CORSIA), and voluntary reporting standards (e.g., GHG protocol or GHGP²) in a transparent manner.

For **SAF Handling, Safety, and Quality Assurance**, this handbook aims to provide guidance and support to stakeholders involved in the supply and handling of aviation fuels, including SAF, to ensure that fuels delivered to the airport and aircraft are fit-for-purpose.

Thereupon, this document does not intend to replace industry standards for the management of aviation fuels throughout the supply chain. Instead, it utilizes such standards to illustrate their application to the management of SAF, identifies gaps, and evaluates requirements to ensure compliance with mandatory provisions for quality assurance of conventional and sustainable aviation fuel from point of entry to airport grounds through fuel distribution systems.

Furthermore, this handbook provides two case studies where the incorporation of SAF blends into airports is illustrated from an active and reactive perspective. Aeroporti di

² GHGp: <https://ghgprotocol.org/>

Roma (ADR) and CPH offer an internal view on their experience welcoming a SAF blend deliveries into airport grounds. The aim of the cases studies is to allow other airports to situate themselves under the circumstances experienced by ADR or CPH and learn to avoid missteps and implement achievements for the successful set up of a functional SAF supply chain.

Section 4 also provides airports and fuel suppliers with strategic knowledge on the options available to ensure they can satisfy demand even in regions where SAF production is low or non-existent via implementation of approved measures.

For **SAF procurement**, this handbook provides readers with a description of the differences and similarities of SAF procurement with existing practices used to acquire CAF. One important aspect to understand about SAF procurement is all that concerned with its environmental attributes, which help reduce the environmental impact of the aviation industry. The procurement process therefore includes a new step in the required documentation, where the environmental attributes of the SAF purchased need to be accurately reported and their ownership transferred along the supply chain to allow for end users to credibly account for and report emission reductions achieved. Additionally, this handbook provides readers with different options on SAF purchase agreements and a description on SAF pricing for a deeper understanding on the costs involved with SAF use.

Lastly, Section 6 utilizes all previous sections 1 through 5 to develop a set of checklists readers can use to determine their **SAF Readiness Level**. Simply, airports, fuel suppliers, and aircraft operators will be able to understand how ready they are to welcome the supply/use of SAF into their day-to-day operations, and comply with local, regional, and global SAF use mandates. This section also provides guidance to airports on the implementation of best practices for the safe, efficient (optimizing emission reductions), and cost-effective incorporation of SAF into the aviation value chain.

C. How to use this handbook

The handbook is a practical tool to be used as guidance to determine the readiness level of fuel suppliers, airports, aircraft operators, and all stakeholders along the value chain for SAF adoption. It is designed to enhance readers' technical capacity and core skills on SAF, address concerns with clear and accurate guidance on safety, supporting regulations, the use of logistics infrastructure, and quality and sustainability certification. Ultimately, this handbook is designed to accelerate SAF adoption through a practical self-evaluation readers can use to define their role within the value chain and take action, become a valued player in the supply and use of SAF and help lead the transition to sustainable aviation.

The handbook is divided into 6 sections. It begins by defining SAF and explaining the two distinct goods it encompasses: the physical fuel component, and the environmental attributes associated with it, clarifying how the climate benefits are obtained, key quality checks upstream in the process of making SAF up to uplift, and the relevant certification needed on fuel specification and for claiming SAF's environmental attributes. Section 2 provides an overview of the main existing regulatory frameworks designed to incentivize SAF uptake. Operational specifics of SAF accounting and reporting are presented in Section 3 followed by section 4 which delves into aspects of SAF handling, safety, and quality assurance. This section includes two practical cases studies on experiences lived during the first time a SAF blend was used at Fiumicino and Copenhagen airports allowing readers to situate themselves in each scenario and determine actions to avoid and achievements to replicate when incorporating SAF into their fuel supply. Section 5 presents readers with important aspect of SAF procurement, including pricing considerations, types of agreements, and elements to be captured in a SAF supply contract.

Along the first 5 sections, roles, responsibilities, and impact is pointed out for each relevant stakeholder. The reader can clearly understand where they stand among all stakeholders along the SAF value chain and consequences their actions will have in the successful development and deployment of SAF.

After describing the stakeholder landscape of SAF, the handbook concludes with a set of functional checklists readers can use to pour all their knowledge on the theory and applicable examples learned in section 1-5 of this handbook and determine in general terms their SAF readiness level.

1. Sustainable Aviation Fuels Fundamentals

Sustainable Aviation Fuels are defined as jet fuel derived from biomass or non-biomass waste that has been certifiably produced in conformity with fuel quality specifications and sustainability criteria, considering both carbon and environmental factors. Specifically, SAF refers to the synthetic blending component (SBC) produced from sustainable feedstock that needs to be blended with CAF to meet specifications for use in an aircraft.

SAF or SBC?

Synthetic Blending Components - SBCs:

- SBCs can be derived from both renewable and non-renewable feedstocks. These include natural gas, coal, biomass, or even waste materials. The key is that SBCs serve as "building blocks" for jet fuel, but the sustainability of their production isn't inherent—it's dependent on the source of the feedstock and the production process.

Sustainable Aviation Fuels - SAF:

- SAF is essentially a subset of SBCs that meet strict sustainability criteria. This means SAF is specifically derived from renewable feedstocks like used cooking oil, plant materials, or agricultural waste. More importantly, SAF must be certified as sustainable, ensuring that it reduces life-cycle greenhouse gas emissions compared to conventional jet fuel.

In short, all SAF are derived from SBCs, and not all SBCs are sustainable. The certification process and adherence to sustainability criteria make all the difference. This distinction also plays a vital role in regulatory frameworks and environmental impact goals for aviation.

For the purpose of this document, the following terms will be used when speaking about SAF:

- **SAF – when referring to sustainably certified synthetic blending component**
- **SAF blend – when referring to sustainably certified semi-synthetic jet fuel**

SAF's chemical and physical characteristics are closely related to those of CAF. This is why SAF can be mixed with CAF and once blended, certified to the same standard as conventional jet fuel. This allows the use of the same supply infrastructure and does not require any adaptation of aircraft or engines. Fuels with these properties are called "drop-in fuels" (i.e., fuels that can be directly incorporated into existing airport fueling systems and onboard aircraft).

The following paragraphs aim to strengthen the technical capabilities and essential skills of all stakeholders in deploying and managing SAF. Readers will find here essential information on the important role SAF plays within the aviation industry's efforts to reduce emissions followed by detailed technical aspects, production pathways, environmental

benefits, fuel quality specifications, sustainability certification, and an overview of blending ratios and aircraft compatibility. Users, producers, suppliers, and all beneficiaries from the use of SAF will find the information in this section crucial to conduct fair and intelligent commercial transactions as well as all the information needed to ensure fuel quality and safety as well as legal compliance on emission reductions.

1.1 Why SAF?

In 2021, IATA with the support of member airlines, pledged to achieve net zero emissions by 2050, representing the first ever industry to voluntarily commit itself to a decarbonization strategy of this nature.

Reaching this target requires a comprehensive approach to emissions from aviation whereby the use of SAF is anticipated to result in the greatest contribution to efforts to lower CO₂ emissions together with complementary measures, including the following:

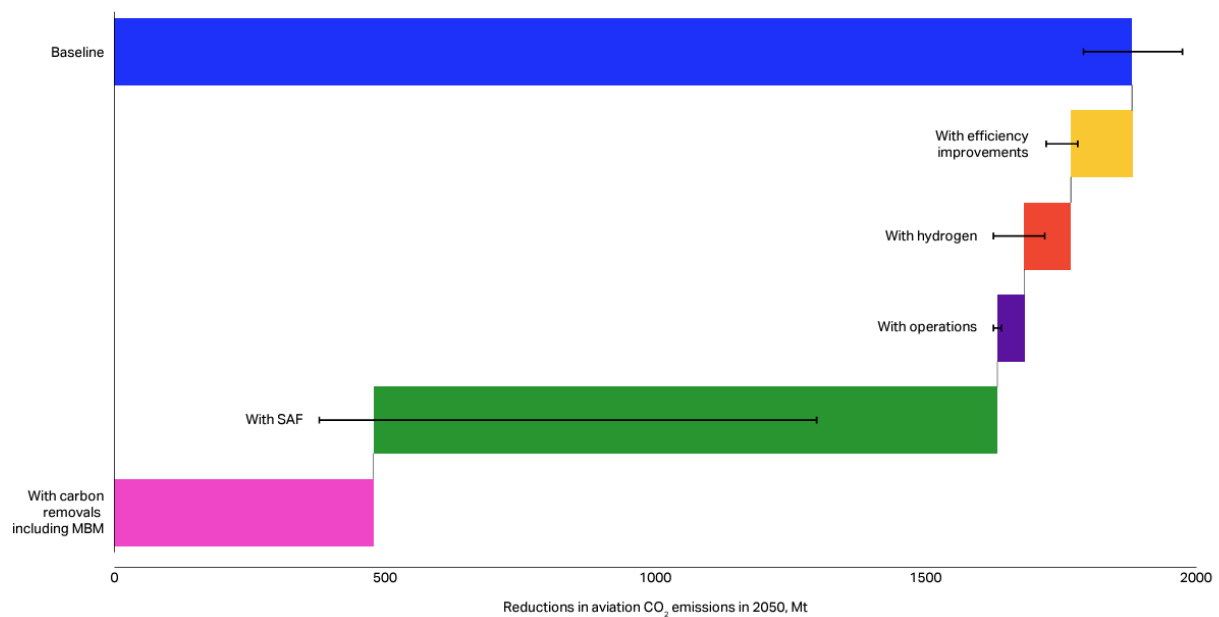
1. The deployment of fuel-efficient aircraft, which will eventually include new airframe and propulsion systems.
2. Sector-wide efficiency improvements, especially in operations, including the likes of air traffic management, ground handling and taxiing, as well as the decarbonization of key infrastructure such as airport assets.
3. Investments in high-quality and independently verified offsets, as well as carbon removal opportunities to address residual CO₂ emissions.
4. The production, scaling, and deployment of SAF.

From the above measures, it is estimated that approximately 62% of the industry's sector-wide emission abatement would be achieved by using SAF, thereby underpinning its status as the central driver of the sector's pledge³. The following figure illustrates these different levers and their potential contribution to lower CO₂ emissions from aviation⁴:

Figure 1 - Levers of action for aviation CO₂ emissions reductions by 2050

³ IATA, 6 June 2023: "SAF Production Set for Growth but Needs Policy Support to Diversify Sources," <https://www.iata.org/en/pressroom/2023-releases/2023-06-06-01/>

⁴ The solid bar indicates the central case, and the black lines indicate maximum and minimum reductions based on the scenarios modelled.



Source: IATA Sustainability and Economics, ICAO LTAG SAF availability scenarios.

An estimated 450 million tonnes of SAF will be needed by 2050 to attain this target, contingent on investments between USD 1-1.4 billion per year to build the required capacity. In 2023, SAF production tripled to 600 million litres from 300 million litres in 2022, representing 0.2% of global jet fuel use⁵

In 2022, the 41st Assembly of the ICAO adopted a Long-Term Global Aspirational Goal (LTAG) for international aviation of net-zero carbon emissions by 2050 in support of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement's temperature goal. Each ICAO Member State committed to contribute to achieving the goal in a socially, economically, and environmentally sustainable manner and in accordance with its national circumstances. In support to the Assembly Resolution provisions, ICAO launched the ICAO Assistance, Capacity-building, and Training for Sustainable Aviation Fuels (ACT-SAF), which aims to provide tailored support for States in various stages of SAF development and deployment and facilitate partnerships and cooperation on SAF initiatives under CORSIA. ACT-SAF is also intended to serve as a platform to facilitate participation and knowledge sharing and recognition of all SAF initiatives around the globe, a continuation yet much more comprehensive programme to ICAO-EU's Capacity building for CO₂ mitigation from international aviation programme phase I&II.

In April 2023, the Council and the European Parliament reached an agreement on the ReFuelEU proposal within the 'Fit for 55 package' launched on 14 July 2021⁶. The proposal aims to create a level-playing field within the European transport market to increase both

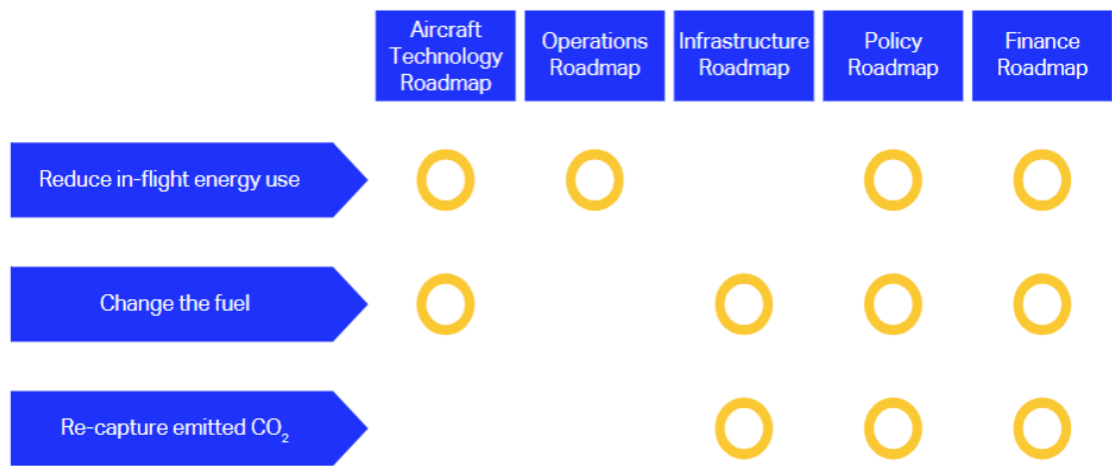
⁵ IATA SAF Fact Sheet: <https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet--alternative-fuels/>

⁶ European Parliament (EP-ph45, 2023). "Sustainable aviation fuels (ReFuelEU Aviation Initiative):" https://www.europarl.europa.eu/doceo/document/TA-9-2023-0319_EN.html

the demand and supply of SAF and place the aviation sector on the trajectory of the European Union’s climate targets for 2030 and 2050⁷.

In 2024, IATA released [five industry roadmaps](#) articulating developments that are necessary to incorporate SAF in the 2050 horizon, identifying important milestones on the way. The chart below depicts how the five Roadmaps cover the three levers to reduce, neutralize or eliminate emissions:

Figure 2 - Breaking Down IATA’s 5 Net Zero Roadmaps



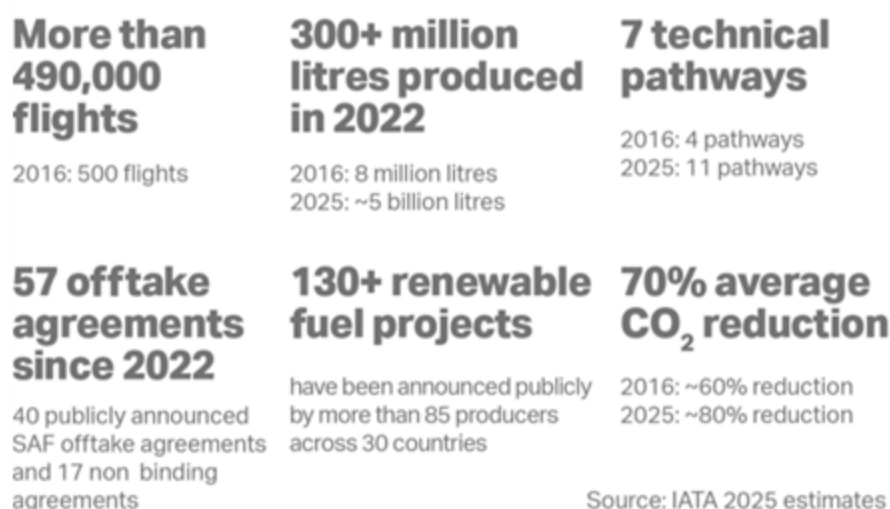
Source: IATA 2023⁸

The roadmaps chart a possible course towards net zero for the aviation industry by leveraging all the possible technological, infrastructural, operational, financial, and policy levers in an integrated way.

⁷ Transport, Telecommunications and Energy Council (Transport), 2 June 2022: <https://www.consilium.europa.eu/en/meetings/tte/2022/06/02/>

⁸ IATA Net Zero Roadmaps, 2023: <https://www.iata.org/en/programs/sustainability/roadmaps/>

The state of sustainable aviation fuel (SAF) in 2023

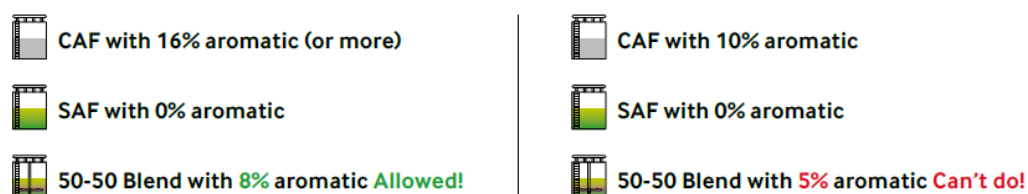


1.2 Technical overview

SAF are produced from non-fossil fuel sources, resulting in lower GHG emissions than CAF on a lifecycle basis. When blended with CAF, SAF is the most expedient lever for decarbonizing aviation. As a drop-in fuel, SAF blends can be used to decarbonize aviation immediately, without the need for aircraft and infrastructure changes or the constraints on flight range typically associated with alternative forms of propulsion.

SAF have a similar chemical composition to CAF except for the aromatic content. Standards for synthetic fuels, including ASTM⁹ and the United Kingdom's Defense Standard 91-091 (UK Def Stan 91-091), set the content of aromatics in aviation fuels to 8-25%. SAF produced today do not contain aromatics and therefore are required to be used as a blend with CAF to comply for safety and quality. Following is a clear example on how SAF may or may not be used:

Figure 3 - SAF blends in compliance with aromatic content



Source: Airport Carbon Accreditation 2022

SAF can reduce CO₂ emissions by up to 80% depending on the type of feedstock and production technology (also known as pathway) used. It may be produced from several

⁹ ASTM is one of the world's largest international standards developing organizations, encompassing about 150 major global industries.

feedstocks including waste fats and oils, municipal solid waste, agricultural and forestry residues, as well as non-food crops cultivated on marginal land. They can also be produced synthetically via a process that captures carbon directly from the air.

1.2.1 SAF Feedstocks and production pathways

The following segment provides valuable information on the different opportunities and challenges posed by the various pathways for SAF production, each posing a particular challenge to actors along the SAF supply chain.

Stakeholders:

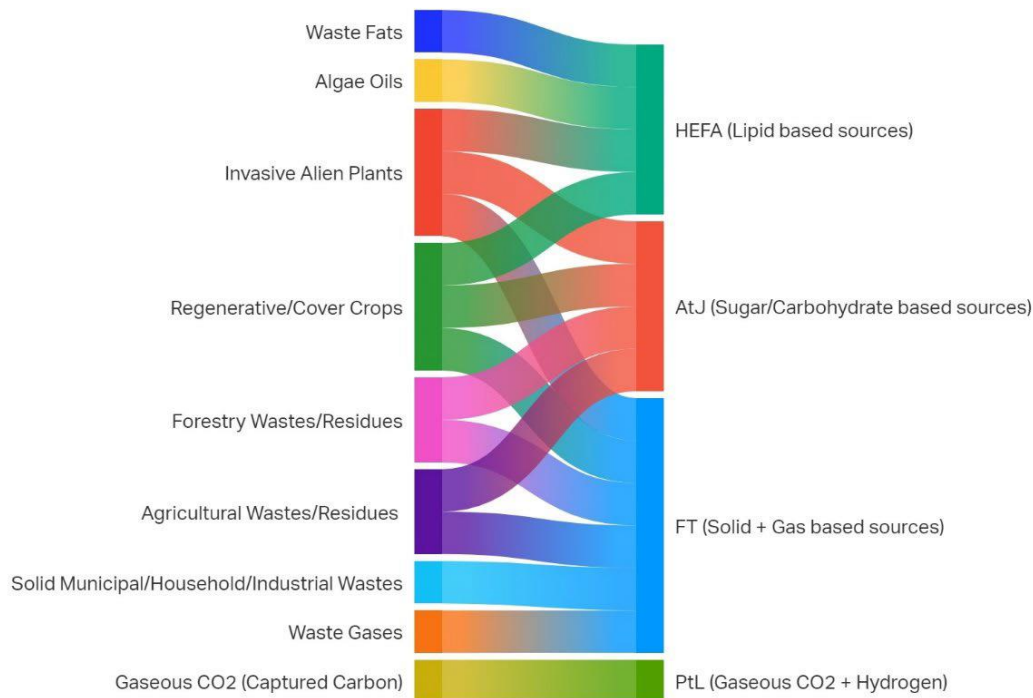
- **Fuel suppliers:** SAF users may look for a SAF produced with a specific feedstock, either because they need to comply with mandates that rule out certain raw materials or because they are interested in a particular set of environmental attributes exclusive to peculiar feedstocks. Understanding the data herein allows for a comprehensive overview of options fuel supplier need to consider to satisfy potential demand.
- **Airports and Aircraft operators:** SAF users and their clients such as airports can use this information to understand the options available to reduce their environmental impact by using SAF produced through a specific pathway. At the time to account and report SAF usage (more on this under section 2), it is crucial that SAF users know how the SAF they have purchased was produced to ensure their investment is well directed to comply with environmental obligations and objectives.

SAF are hydrocarbon fuels; the carbon contained in their feedstocks derives from various sources and can be made from different technological pathways and feedstock combinations, which means that there are several kinds of SAF. Each SAF variety works with different technologies, cost profiles, carbon abatement profiles, environmental impact, and of course, feedstock.

1. Any source of fat, oil, or grease can be converted into a bio-oil, which can in turn be converted using the Hydro-Processed Esters and Fatty Acids, or HEFA, technology, into a SAF.
2. Any source of sugar can be converted into either bioethanol or iso-butanol, which in turn can be converted into SAF via a technology referred to as Alcohol-to-Jet (AtJ).
3. Solid biomass such as biogenic municipal waste (including bioplastic), or forestry residues, can be converted into a synthetic-gas intermediary product, which can in turn be converted into SAF using a technology referred to as Fischer-Tropsch (FT).
4. Renewable energy can be used to obtain hydrogen from water and to enable carbon dioxide capture from the atmosphere or from a point emission source. Using synthetic gases as intermediaries, Power-to-Liquid (PtL) SAF can be obtained via the FT or AtJ processes.

A production pathway is defined as "a type of technology used to convert a feedstock into aviation fuel"¹⁰. Like CAF, SAF technical pathways are evaluated and approved by organizations such as ASTM and Def Stan 91-091. A general overview of feedstocks and associated pathways is illustrated in the following figure:

Figure 4 - SAF production pathways and associated feedstocks



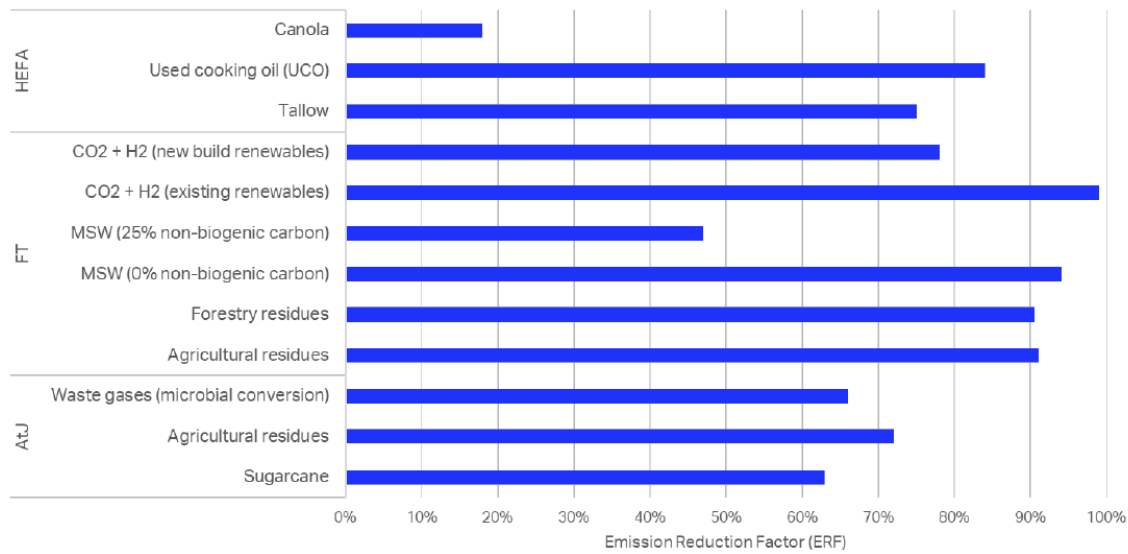
Source: IATA Sustainability & Economics

The emission reduction factors of the SAF output will vary in function of the feedstock and technology pathways. Therefore, the scaling up of SAF production is less a question of maximizing volume than targeting the SAF with the greatest carbon abatement. If a fuel delivers twice the amount of carbon savings relative to another, half the volume would be needed to achieve the same ultimate carbon abatement goal. The levers that allow SAF to reduce emissions are explained in detail in the upcoming section on sustainability certification (see Figure 8).

The following figure shows typical emission reduction factor (ERF) values across HEFA, AtJ, and FT pathways, per type of feedstock:

¹⁰ ICAO Environment - SARPs - Annex 16 Volume IV: <https://www.icao.int/environmental-protection/CORSIA/Pages/SARPs-Annex-16-Volume-IV.aspx>

Figure 5 - ERF from different combinations of SAF feedstocks and technology pathways

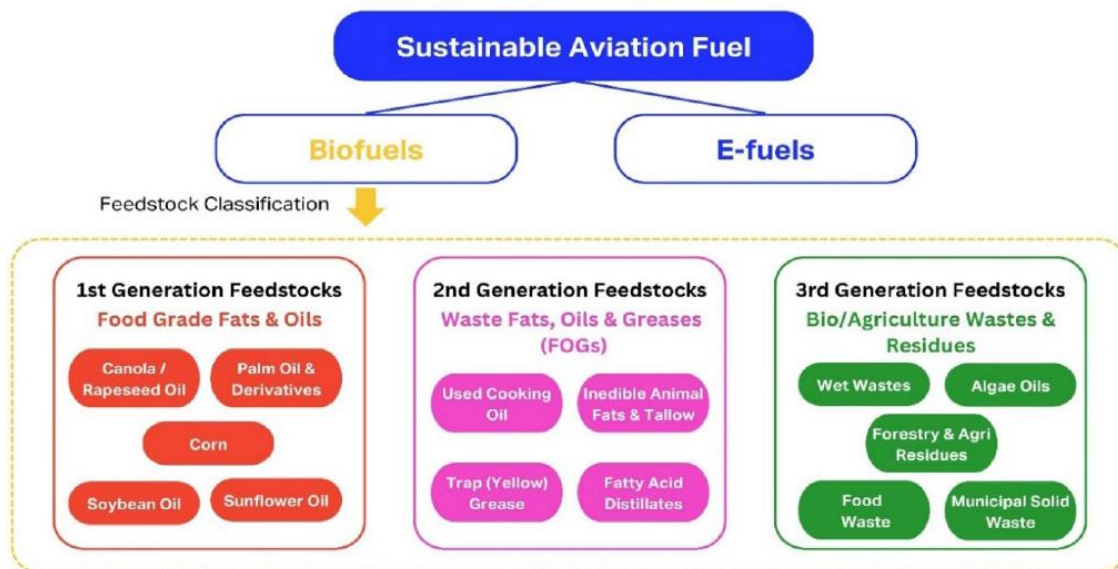


Source: Adapted from EASA – Charts and tables

1.2.1.1 Feedstock Generations

Depending on the following factors, three broad generations of feedstocks have been defined, as illustrated in the following figure:

Figure 6 - Classifying feedstock generations



Source: IATA Sustainability & Economics

The break-down of different considerations for each generation is as follows:

1. The chronology in which they have been used by the industry
2. Emission reduction potential
3. Ability to meet broader sustainability criteria
4. Ability to achieve restorative or regenerative outcomes in their associated environment

5. Global availability and abundance

Stakeholders:

- **Fuel suppliers:** knowledge of the different feedstock generations for SAF production is crucial for a fuel supplier. Several markets place restrictions on specific generations leaving supplier outside of the SAF market. To avoid having to change SAF production processed of getting stuck with a technological pathway, SAF producers and fuel supplier need to plan ahead and ensure their fuel is approved for use in their target market.
- **Aircraft operators:** similar to fuel suppliers, aircraft operators need to be aware of the type of generation of SAF they are purchasing to ensure it aligns with restrictions specific to the regulation which they need to comply with, so their emission reductions claims are accepted.

First Generation (1G) – Food Grade Fats and Oils: these include canola, rapeseed, palm and palm derivatives, corn, soybean, etc. As the process of converting such oils into fuels is technologically mature, 1G feedstock has already “scaled” commercially and can be produced at a relatively lower cost in comparison to other sources. The major challenge associated with many 1G feedstock lies with their trade-off with global food supply, and broader sustainability issues, such as high levels of required arable land usage, and in some extreme cases, deforestation. For the most part, the airline industry is moving away from 1G feedstock, aside from some specific exceptions where sustainable farming practices have been verified and showcased, to prove the integrity of sustainability claims.

Second Generation (2G) – Waste Fats, Oils, and Greases: this group includes non-edible waste fats, oils, and greases (FOGs), such as used cooking oil, inedible animal fats and tallow, as well as industrial waste greases, and biomass. The use of 2G feedstock is typically more sustainable than 1G, as they achieve a higher reduction in greenhouse gas emission abatement, without requiring additional land usage. However, 2G feedstocks are commonly the most expensive among the three categories, as they are wastes tied to industrial processes, implying constrained supply. Today, these waste fats, oils, and greases are the most common feedstock, aligning with the most technologically mature production pathway, HEFA. As 2G feedstock supplies become increasingly scarce, other feedstocks will likely come to market. HEFA production plants will still be relevant, as various bio-crude (conversion technology) solutions mature.

Third Generation (3G) – Biological/Agricultural Wastes and Energy Crops from Degraded Land: this category includes feedstocks like municipal solid waste, forestry residues, woody biomass, agricultural waste from harvest cycles, algae oils, wet waste, as well as specifically grown energy crops on degraded, marginal, or fallow land. This also includes cover crops, which are grown outside of typical harvest seasons, when that farmland would otherwise not be utilized. 3G feedstocks are abundant in nature and therefore benefit from lower associated costs relative to the constrained supply set of 2G feedstock, although the needed supply chains are not robust. 3G feedstocks also have the most

positive environmental impact potential, relative to 1G and 2G, as they constitute by-products and wastes that otherwise would have to be disposed of, which would generate additional emissions. Processing 3G feedstocks requires advanced technologies such as Gasification-FT and hydrothermal liquefaction (HTL).

1.2.1.2 Advanced biofuels

Fuels produced from 2G and 3G feedstocks are collectively referred to as Advanced Biofuels. These are expected to make up most of aviation's SAF supply for at least the next 10 to 15 years.

In general, feedstocks to produce Advanced Biofuels will include carbon rich waste material, low-value by-products, or purpose-grown energy crop that has been cultivated on degraded or marginal land. The use of food crops for SAF is not allowed under most relevant regulatory schemes. Rather, the essence of waste feedstock is to repurpose surplus materials, which are derived from pre-existing processes or cycles. These waste feedstocks do not require the use of any additional resources such as agricultural land (or land clearing), water, fertilizer, etc.

Some energy crops are purpose-grown on marginal or degraded land, otherwise unfit for agricultural use. This brings the benefits of expanding land use and improving the overall quality of these lands.

Advanced biofuels can help as follows:

- Achieve land restoration and/or regeneration
- Promote and foster biodiversity
- Develop sustainable supply chains at the regional level
- Create local income and employment
- Improve energy independence and security

1.2.2 Fuel specification and sustainability certification

Given that safety is fundamental in aviation, SAF must meet the requirements described in the relevant fuel specifications to be used on commercial aircraft. Specifications control the chemical and physical properties of aviation turbine fuel (both CAF and SAF) and allow fuel to be checked periodically for compliance as it travels along the distribution infrastructure through to its airport storage destination.

The sustainability certification of SAF serves as a comprehensive tool for demonstrating environmental, social, and economic sustainability across various aspects of operations, products, and supply chains. It enhances credibility and trust and is an important process to assure that products or services offered by an organization meet recognized sustainability standards or comply with environmental regulations and standards set by governments and regulatory bodies.

Producers, suppliers, and users can use the information contained in the following paragraphs to ensure the SAF they sell, or purchase adheres to mandatory fuel specifications

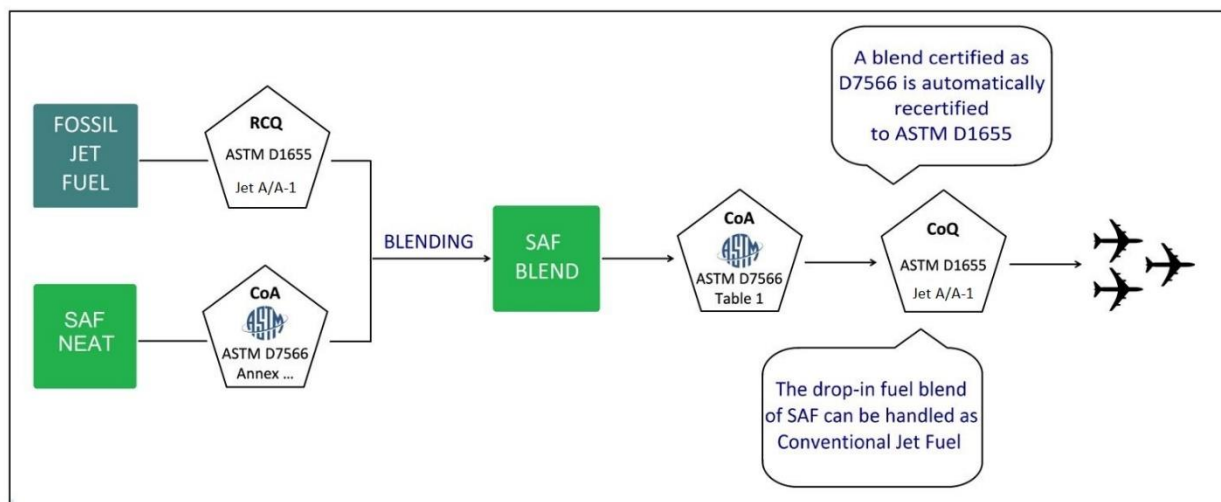
and sustainability certification requirements. Since there exist multiple principles and criteria defining the sustainability of SAF pathways, it is crucial also to focus attention on all facts explaining each approach to certification.

1.2.2.1 Fuel quality

Rigorous international fuel specifications have been adopted to ensure quality compliance for aviation fuels. SAF, just as CAF, must conform to strict quality conditions to be eligible for use in the aviation industry. ASTM D1655 'Standard Specification for Aviation Turbine Fuels' lays the foundation for jet fuel quality specifications and plays a crucial role in ensuring operational safety and reliability (Def Stan 91-091 in the UK). ASTM D7566 is the 'Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons' and describes the fuel quality specifications for each qualified SAF production pathway¹¹.

All SAF production pathways undergo stringent testing for compliance with safety and quality specification requirements to receive its D7566 certification. The process is shown in detail in the following figure:

Figure 7- SAF ASTM certification process



Source: IATA¹²

ASTM D7566 defines the requirements for neat SAF. In its pure form, SAF is a different product from Jet A-1 fuel and must be treated separately and independently as its own type of fuel. Once adequately blended with CAF, the SAF component becomes a drop-in fuel certified to ASTM D1655, regarded as CAF; it needs no differentiated treatment within the CAF's fueling handling system thereon.

¹¹ SkyNRG 2021

¹² RCQ - Refinery Certificate of Quality. CoA 0 Certificate of Analysis. CoQ - Certificate of Quality.

The 'drop-in' condition on the SAF-CAF blend is a major requirement for the aviation industry. Any aviation alternative fuel that does not meet this condition requires a parallel infrastructure for handling and may present safety issues associated with risks of mishandling during transport, blending, storage, and the aircraft refueling process, along with significant additional costs.

1.2.2.2 Sustainability certification

In addition to ensuring that SAF complies with relevant fuel specifications, it also must adhere to strict sustainability principles and criteria.

Sustainability certification is the process whereby a product, service, or organization is assessed against a set of criteria or standards to determine its environmental, social, and economic sustainability performance. These certifications are generally conducted by independent third-party organizations and serve as a way for consumers, businesses, and other stakeholders to identify and support sustainable practices. They are also used by government authorities to ensure compliance with specific regulations.

A sustainability certification standard is a structured framework or set of criteria used to assess and verify the sustainability performance of products, services, or organizations. For SAF, sustainability certification involves evaluating the environmental, social, and economic aspects of the fuel production process to ensure that it meets specific sustainability criteria.

Generally, sustainability certification aims to ensure the following:

- Sustainability in feedstock production

- SAF can be produced from a wide range of feedstocks – including crops, wastes, agricultural or forestry residues, processing residues, and by-products.
- For primary biomass (e.g., crops), certification aims to ensure that feedstock is not cultivated on certain valuable lands (such as those classified as high carbon stock or highly biodiverse). In addition, feedstock cultivation must avoid negative environmental effects (on water quality and availability, soil health, air quality, conservation, etc.) as well as detrimental socioeconomic effects (e.g., on human and labor rights as well as food security, among others).
- For wastes and residues (e.g., used cooking oil), the focus is on verifying that those feedstocks are genuine wastes and residues – i.e., that they have not been intentionally modified or contaminated to count as waste or residue.

- Traceability and chain of custody of sustainable materials through the supply chain

- The term “traceability” describes the ability to identify and trace the origin, processing history, distribution, and location of products (e.g., sustainably certified SAF) as they move through supply chains.
- The term “chain-of-custody” describes the process of transferring, monitoring, and controlling inputs and outputs and related information as they move through the supply chain. In essence, this provides assurance that a given batch of product

(e.g., a batch of SAF) is associated with a set of specific characteristics (e.g., related to its sustainable production or savings in greenhouse gas emissions) and that the information on these characteristics is also transferred, monitored, and controlled throughout the supply chain.

- Demonstrating traceability and chain of custody throughout the supply chain is essential, as it forms the basis for any claims made about the certified product, i.e., SAF. This is particularly important because SAF supply chains can often be complex, globally spanning, and involve co-mingling of sustainable with non-sustainable products at different supply chain stages.

- Verified reduction in life cycle emissions compared with conventional aviation fuel alternatives

- Providing assurance that SAF truly achieves GHG emissions reductions over its full life cycle compared to its conventional, fossil-based counterpart is crucial. Many regulatory frameworks prescribe certain GHG emissions saving thresholds that SAF must meet to be able to be considered eligible under those frameworks.
- GHG emissions arise along the full life cycle of SAF, including at the level of feedstock production, processing and refining, storage, transport and distribution, and combustion. Taking a comprehensive life cycle approach to GHG emissions from SAF is essential to ensure the full GHG emissions impact of SAF is considered.
- Certification schemes provide a standardized framework for how GHG emissions are to be consistently calculated and verified along the SAF life cycle – in line with GHG emissions methodologies as defined under relevant regulatory frameworks.

Several organizations offer sustainability certification standards under their sustainability certification schemes¹³. Basically, sustainability certification schemes operationalize and implement sustainability certification standards through accreditation, auditing, and certification processes, ensuring credibility and consistency in certification.

As of today, two organizations are particularly prominent in SAF sustainability certification: the International Sustainability and Carbon Certification (ISCC), and the Roundtable on Sustainable Biomaterials (RSB). Both offer SAF sustainability certification schemes (SCS) for regulatory compliance, and for the voluntary market, as follows:

Table 1 - SAF Sustainability Certification

Provider	Sustainability Certification Scheme		
	For compliance with ICAO CORSIA	For compliance with EU RED	For voluntary market
ISCC	ISCC CORSIA	ISCC EU	ISCC CORSIA, ISCC EU, ISCC PLUS

¹³ SCS operationalize and implement sustainability certification standards through accreditation, auditing, and certification processes, ensuring credibility and consistency in certification.

RSB	RSB ICAO CORSIA	RSB EU RED	RSB ICAO CORSIA, RSB EU RED, RSB Global
------------	-----------------	------------	---

Source: ISCC & RSB

More details on sustainability certification and mandatory and voluntary compliance is offered in the next section. For now, it is important to understand that sustainability certification for SAF has gained significant momentum in recent years as it is the primary tool the aviation industry can rely on to transparently and credibly decarbonize and achieve its commitment to net-zero emissions by 2050.

Sustainability criteria specific to SAF is defined under CORSIA: ICAO's global offsetting market mechanism whereby aircraft operators will be required to reduce their CO₂ emissions by either purchasing CO₂ emissions offsets or by use of CORSIA eligible fuels (including SAF and/or lower aviation carbon fuel) that reduce at least 10% of lifecycle emissions compared to CAF and meet the specific set of sustainability criteria depicted in the following table:

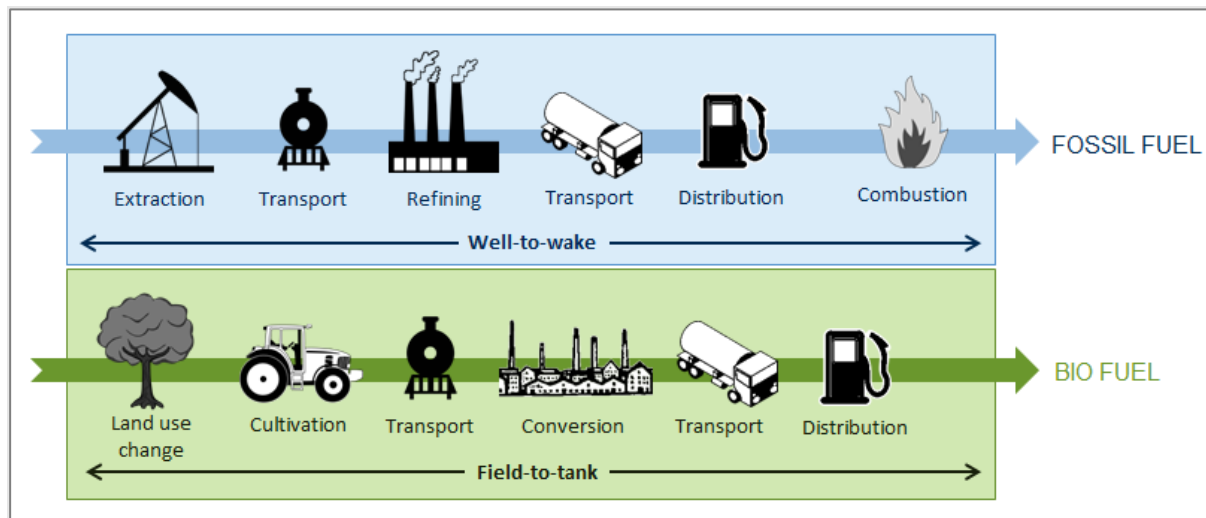
Table 2 - CORSIA eligible fuels sustainability criteria include the following themes

Sustainability Themes		Principle for Eligible Fuels
Carbon Reduction	1. GHG	Should generate lower carbon emissions on a life cycle basis.
	2. Carbon stock	Should not be made from biomass obtained from land with high carbon stock.
	3. GHG reduction permanence	Should ensure carbon reductions are not reversed.
	4. Water	Production should not pollute waterways or impede on availability.
Environment	5. Soil	Production should maintain or enhance soil health.
	6. Air	Production should minimize negative effects on air quality.
	7. Conservation	Production should maintain biodiversity, conservation value and ecosystems.
	8. Waste and chemicals	Production should promote responsible waste management and chemical use.
Socio-Economic	9. Human and labor rights	Production should respect human and labor rights.
	10. Land use rights and land use	Production should respect land rights including indigenous and customary.
	11. Water use rights	Production should respect prior formal or customary water use rights.
	12. Local and social development	Production should contribute to localized socio-economic development.
	13. Food security	Production should not impede food-crop harvest and promote food security.

Source: adapted from ICAO Environment – CORSIA Sustainability Criteria

These criteria are defined by the comprehensive accounting of emissions across all steps of the fuel's life cycle, called a life-cycle analysis (LCA). If the total emissions from an alternative fuel are less than the total emissions from fossil fuel, there is an environmental benefit attributable to that fuel¹⁴, illustrated in the following figure:

Figure 8 - Fuel life-cycle emissions for fossil and biofuel



Source: adapted from ICAO Environment - Fuel Life Cycle and GHG emissions

Unlike in the CAF life cycle, CO₂ in the SAF life cycle is taken up from the atmosphere by the biological matter, temporarily sequestered in the liquid fuel, and then is re-released back to the atmosphere when the fuel is combusted. Therefore, no additional carbon would be released into the atmosphere, as would be the case with CAF.

While there are no common globally mandated sustainability criteria for SAF, the standards defined under CORSIA eligible fuels offer a comprehensive and robust global definition. Avoiding a patchwork of regulations and thus streamlining and harmonizing criteria reduces complexity and increases the trust of the investors and end users, but also mitigates the risk of carbon leakage. Further details on these matters, including risks and potential solutions, are provided under section 2, subsection 2.3 - Global harmonization on sustainability certification, and accounting & reporting processes.

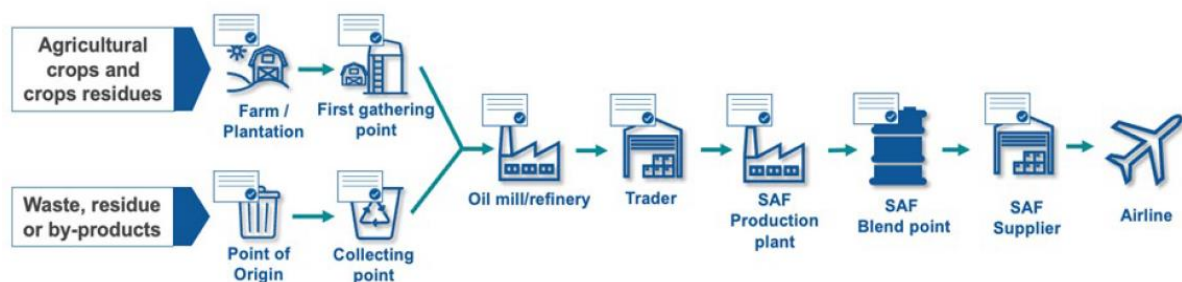
- Sustainability certification along the entire SAF supply chain

SAF supply chains feature feedstock production, different processing and refining steps, and transportation and distribution of raw materials, intermediates, and final SAF. These supply chains can be complex, global in scope, and involve the commingling of sustainable and non-sustainable products at different stages of the supply chain.

¹⁴ ICAO Environment: GFAAF - Aviation Alternative Fuels

As ensuring traceability and chain of custody is key to maintaining the integrity of SAF, it is essential that every “participant” – often also referred to as economic operator – is individually certified. Individual certification implies regular auditing of that economic operator – regarding compliance with sustainability requirements, traceability, and chain of custody, as well as accurate calculation of GHG emissions.

Figure 9 - Depiction of a hypothetical SAF supply chain



Source: ISCC

Stakeholder:

- **Fuel suppliers:** each economic operator, from feedstock production (e.g., farm or “point of origin” for waste and residue materials) up to the SAF supplier, is required to be certified¹⁵. In other words, any economic operator along the supply chain who makes changes to the SAF (chemical change or change to the GHG emission factor¹⁶) or takes legal ownership of the SAF feedstock or SAF, must be certified.
- **Airports:** any purchase of certificates to allow for scope 3 emission reductions needs to come with the adequate and full sustainability certification for those claims to be valid and approved if reported for obligatory compliance.
- **Aircraft operators:** sustainability certification for SAF provides assurance to airlines, regulators, and consumers that the fuel meets rigorous sustainability criteria and contributes to reducing the aviation industry's environmental footprint. It helps to promote transparency and credibility in the market while driving the adoption of more sustainable practices in SAF supply chains. Understanding the sustainability certification process is then crucial for airlines to be able to identify the right SAF to purchase to transparently claim environmental benefits achieved.

¹⁵ An exception applies for CORSIA certification, where ICAO mandates individual certification only up to and including the SAF blender.

¹⁶ A GHG emission factor is a numerical value that represents the amount of greenhouse gas emissions produced per unit of activity, product, or energy consumed.

Specific scenarios

- A provider of storage for the SAF (or SAF-blend) who does not take ownership of the SAF or make changes to it would be exempt from certification. For example, an intermediate storage provider who does not have ownership of the SAF but merely provides a service to an economic operator, is itself not required to hold its own certification, but the economic operator would need to include the storage facilities as part of its certification scope and be responsible for maintaining the book-keeping and mass balance system.
- A blender who provides a SAF blending service but does not take ownership of the SAF does not need to be certified. The economic operator using the blending service must include the blending facilities as part of its certification scope and be responsible for maintaining the book-keeping and mass balances. However, if the blender owns the SAF, it must be certified.
- A fuel reseller who purchases SAF from producers, distributors, or other fuel suppliers and then sells or resells it to airlines, takes ownership of the SAF in the process and hence will need to be certified.

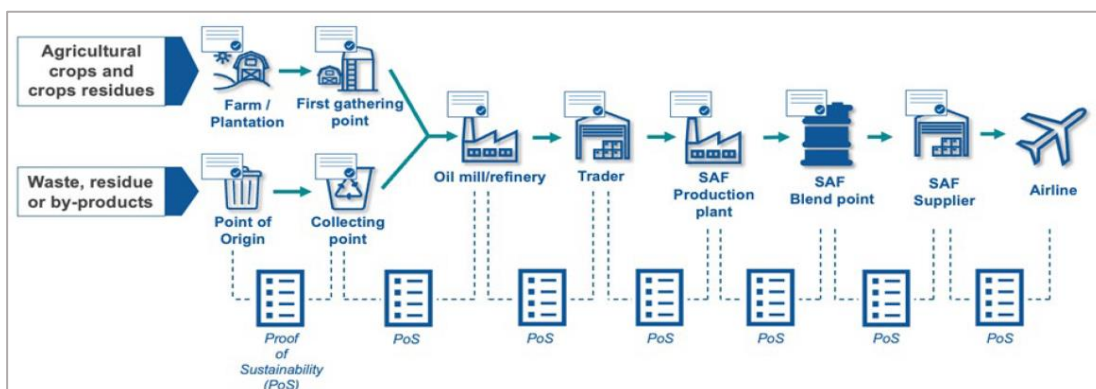
Following a successful audit, certified entities will be issued a certificate containing a certificate number. Under ISCC, certificates are site-specific. A certificate can only be issued per geographical site and legal entity. RSB allow for flexibility of a certificate to cover a single geographical site or multiple geographical sites within the same supply chain.

- The importance of certification

Certification recognizes that an entity (i.e., an economic operator such as a feedstock producer, fuel producer or trader) has demonstrated compliance with specific sustainability criteria and standards established for SAF production and supply chains under a certain certification scheme. With this recognition, the certified entity is in the position to handle (i.e., receive, store, process, and further sell) certified sustainable material and issue valid documentation proving the sustainability of that sustainable material, namely a Proof of Sustainability (PoS) certificate.

The following flow diagram below based on a hypothetical SAF supply chain depicts the role of the PoS to ensure a robust chain of custody:

Figure 10 - PoS to ensure a robust chain of custody



Source: ISCC

Stakeholder:

- **Fuel supplier:** a certified economic operator must provide proof of sustainability documentation for any batch of outgoing sustainable material, no matter if that is the raw material, intermediate product or SAF. The PoS contributes to establishing a robust chain of custody in the SAF supply chain.
- **Aircraft operator:** the PoS is needed mainly as supporting documentation to enable airlines to claim the environmental attributes of the SAF under various regulatory frameworks and voluntary commitments. Without it, accounting and reporting will lose credibility and may pose a reputational risk to the organization.

ISCC and RSB provide PoS templates for each SAF certification scheme they offer. The use of these templates is optional – currently, the respective templates are accessible only upon successful registration as an RSB Operator or ISCC System User. It is important to note that if a certified entity chooses to develop its own PoS template, it is mandatory for that template to include all required sustainability information, as shown in Appendix I. Included also examples of a completed PoS template for ISCC CORSIA, RSB ICAO CORSIA, RSB EU RED, and ISCC EU.

For SAF to be compliant with CORSIA requirements, supplementary information must be provided, this supplementary information accompanies the PoS issued from the SAF production point onwards. The additional data elements are listed in Table A 5.2, Appendix 5¹⁷ of the CORSIA Standards and Recommended Practices.

FAQ

Is there a distinction between a Certificate and a PoS?

A PoS:

- *Is issued by a certified economic operator (e.g., a SAF producer or supplier).*
- *Verifies that a specific batch of SAF meets the sustainability and GHG emissions savings criteria under a particular scheme or regulation (e.g., ISCC EU or RSB CORSIA).*
- *Serves as the primary documented evidence for regulatory compliance used by SAF suppliers or aircraft operators (e.g., under EU RED, EU ETS, ICAO CORSIA).*

A Certificate:

- *Is issued by a Certification Body to affirm that an economic operator (e.g., a SAF producer or supplier) meets the standards of a specific certification scheme.*
- *Enables the economic operator to produce or trade SAF as compliant with the certification scheme.*

¹⁷ ICAO document, 2019: 'CORSIA Eligibility Framework And Requirements For Sustainability Certification Schemes': <https://www.iata.org/en/programs/sustainability/reports/saf-sustainability-certification-guidance-june-2024/section-4/>

- *Does not imply that every outgoing batch of fuel is automatically certified as sustainable.*

1.2.3 Supply chain quality control & blending

Of particular interest to producers and suppliers of SAF, this segment provides more in-depth details on crucial steps and processes to follow and keep track off to ensure the safe handling of SAF and SAF blends. Users of SAF will find this section very instructive to understand the documentation they are required to acquire, maintain, and use as evidence when reporting the purchase and use of SAF.

1.2.3.1 *Quality Control*

Technical documents demonstrating fuel quality must accompany the product to its destination. The most common of these documents are listed here:

- Refinery Certificate of Quality
- Certificate of Analysis
- Recertification Test Certificate

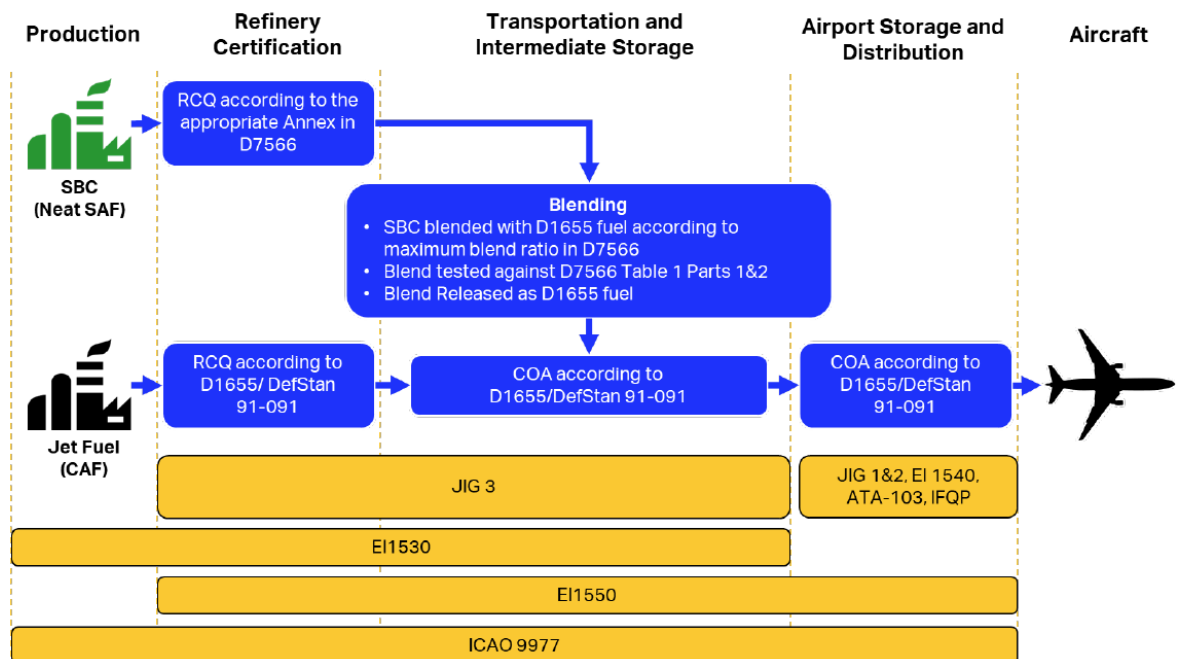
- Refinery Certificate of Quality (RCQ): the RCQ is the definitive original document describing the quality of an aviation fuel product. It contains the results of measurements made by the product originator's laboratory of all the properties listed in the latest issue of the relevant specification. It also provides information regarding the use of additives, including both the type and amount of such additives. Moreover, it includes details relating to the identity of the originating refinery and the traceability of the product described. RCQs shall always be dated and signed by an authorized signatory.

- Certificate of Analysis (COA): a COA may be issued by independent inspectors or laboratories that are certified and accredited, and it contains the results of measurements made of all the properties included in the latest issue of the relevant specification. It does not, however, include details of the additives added previously. It shall consist of more information relating to the originating refiner's identity and the traceability of the product described. It shall be dated and signed by an authorized signatory. Note that a COA shall not be treated as an RCQ.

- Recertification Test Certificate (RTC): the RTC demonstrates that recertification testing has been carried out to verify that the aviation fuel quality has not changed and remains within the specification limits, for example, after transportation in ocean tankers or multiproduct pipelines. In these cases, where aviation product is transferred to an installation under circumstances that could result in contamination, recertification is necessary before further use or transfer. The RTC shall be dated and signed by an authorized laboratory representative carrying out the testing. The results of all recertification tests shall be checked to confirm that the specification limits are met and that no significant changes have occurred in any of the properties.

A diagram of the main steps in the supply chain, including references to the main specification and other quality documents, is shown in the following figure:

Figure 11- Supply chain quality control documents relevant by stakeholder



Source: IATA SAF Handbook 2024¹⁸

For CAF, the quality process starts with the creation of an RCQ according to the relevant specification. Once the fuel leaves the refinery, it will travel by pipeline, truck, rail, or barge directly into the airport tank farm or an intermediate terminal before reaching the airport. Typically, the fuel will be re-inspected at each transition point, and a COA according to the relevant specification will be issued.

The process is similar for neat SAF but has some additional steps, particularly blending. As with CAF, an RCQ will be issued at the refinery, but in this case, it will be according to the appropriate annex in the ASTM D7566 specification and not to ASTM D1655 or Def Stan 91-091. As such, the neat SAF cannot yet enter the supply chain for CAF. First, the neat SAF must be blended with CAF up to the limits specified in ASTM D7566. Once the fuel is blended, it will be tested against ASTM D7566. Once confirmed that the blended fuel meets this specification, it will be released as meeting the ASTM D1655 specification. From then on, the fuel is considered fungible with CAF and could be handled as regular ASTM D1655 fuel.

¹⁸ IATA SAF Handbook, 2024:

<https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-handbook.pdf>

1.2.3.2 Blending

As stated previously, according to ASTM D7566, SAF must be blended with CAF to meet D1655 requirements. The current maximum blending rate allowed is up to 50% (depending on pathway; see Table 4) to ensure compatibility with aircraft engines of all ages. However, in its pure form, SAF already meets most of the requirements of aviation fuel specifications, except for its aromatic contents, and in some cases parameters such as viscosity and density, which makes the blending necessary.

Before SAF can enter the common supply infrastructure, blending and re-certification according to ASTM D1655 must occur. In theory, blending can take place at any point along the supply chain; however, there are several factors to consider when choosing the best location, including:

Source of conventional fuel: where and how the CAF for blending is procured is essential. If the refinery where SAF is produced has ready access to CAF, either because it also produces CAF or is located within easy reach of a CAF source, blending at the refinery may be the best solution.

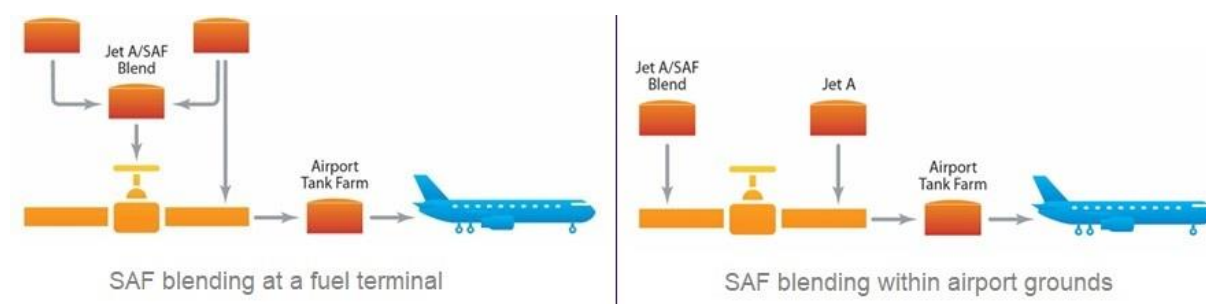
1. If the SAF refinery is not located within easy access to CAF, blending could occur at a suitable point along the supply chain, such as an intermediate storage facility. In this case, SAF must be kept segregated until the blending point. This may increase transportation and handling costs but can be the most practical solution in some cases.
2. Availability of blending and storage infrastructure: access to existing infrastructure for blending reduces cost as new facilities would not be needed. It is essential to consider that three to four tanks may be required for blending: one for the CAF, one for SAF, one for blending, and one for the blended fuel, according to the process illustrated in
- 3.
4. Figure 11. Depending on the volumes of the respective fuels, additional or larger receiving tanks may be required.
5. Quality of conventional fuel: it is important to note that not all CAF is created equal. The specifications allow for a range of values for the different properties, such as density and aromatic content, which are vital for blending. Thus, before blending, it is essential to understand the quality of the CAF to ensure that the blend meets the ASTM D7566 specification.

While it is widely accepted that SAF should not enter the airport fuel farm because it has not yet been certified to meet the ASTM D1655 or Def Stan 91-091 specification, there can be a situation in which the blending location is separate from, but in the proximity of the airport fuel farm to take advantage of the availability of CAF nearby. Once SAF is blended with the CAF upstream of the airport fuel farm storage and certified to the relevant specification, it can be released into the airport fuel storage.

Depending on local conditions at given airports, this blending location could be located within the airport property but separated from the airport fuel farm (intermediate storage facility). In this case, blending would happen on airport property but upstream from the airport fuel storage. Whether this will be permitted is still an open question expected to be resolved as more experience with blending and handling SAF is gained.

The following figures illustrate SAF blending outside and within airport grounds:

Figure 12 - SAF blending possibilities



Source: NREL - Sustainable Aviation Fuel Blending and Logistics

The following table offers a closer look at the benefits and risks associated with blending SAF at the airport:

Table 3 - Pros & Cons – SAF blending within airport grounds

PROS	CONS
On-Site Blending Control: allows for better control over the blending process, ensuring the correct proportions and quality.	Quality Assurance: maintaining consistent fuel quality can be challenging, and any deviations could impact aircraft performance and safety.
Reduced Transportation Costs: it can reduce transportation costs and emissions associated with moving fuel from blending facilities to the airport.	Regulatory Compliance: airports must ensure that the blending process complies with all relevant regulations and standards, which can be complex and time-consuming.
Increased Flexibility: airports can adjust the blending ratios based on demand and availability, providing more flexibility in fuel management.	Operational Risks: there is a risk of fuel contamination during the blending process, which could lead to safety issues such as engine malfunctions.
Streamlined Operations: On-site blending can simplify logistics and fuel management, potentially reducing operational costs and improving efficiency.	Infrastructure Requirements: setting up blending facilities within an airport requires significant investment in infrastructure and equipment.

Maintaining safe, secure, and resilient operations is a top priority for aviation which makes the balance to tip towards the cons when it comes to determining the blending location

for SAF. Furthermore, the Energy Institute (EI) states that blending should only occur upstream of airports¹⁹. Similarly, Def Stan 91-091 prohibits blending at airport depots²⁰.

As of July 2024, eleven production pathways for SAF have been approved, depicted under the following Table:

Table 4 - Approved SAF Pathways, blending ratios, and coprocessing limits

ASTM reference	Conversion Process	Abbreviation	Possible feedstocks	Maximum blend ratio	
ASTM D7566 Annex A1	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene	FT	Coal, natural gas, biomass	50%	
ASTM D7566 Annex A2	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids	HEFA	Vegetable oils, animal fats, used cooking oils (UCO)	50%	
ASTM D7566 Annex A3	Synthesized iso-paraffins from hydroprocessed fermented sugars	SIP	Biomass used for sugar production	10%	
ASTM D7566 Annex A4	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	FT-SKA	Coal, natural gas, biomass	50%	
ASTM D7566 Annex A5	Alcohol to jet synthetic paraffinic kerosene	AtJ-SPK	Ethanol, isobutanol and isobutene from biomass	50%	
ASTM D7566 Annex A6	Catalytic hydrothermolysis jet fuel	CHJ	Vegetable oils, animal fats, used cooking oils	50%	
ASTM D7566 Annex A7	Synthesized paraffinic kerosene from hydrocarbon - hydroprocessed esters and fatty acids	HC-HEFA-SPK	Algae	10%	
ASTM D7566 Annex A8	Synthetic paraffinic kerosene with aromatics	AtJ-SKA	C2-C5 alcohols from biomass		
Co-processing		Possible feedstocks		Input limit	Output limit
ASTM D1655 Annex A1	Co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery	Vegetable oils, animal fats, used cooking oils from biomass processed with petroleum		5%	10%
ASTM D1655 Annex A1	Co-hydroprocessing Fischer-Tropsch hydrocarbons in a conventional petroleum refinery	Fischer-Tropsch hydrocarbons processed with petroleum		5%	
ASTM D1655 Annex A1	Co-processing of HEFA	Hydroprocessed esters/fatty acids from biomass		24%	

Source: IATA adapted from ICAO – Approved conversion processes²¹

¹⁹ EI 1533

²⁰ EASA - Risks Related to Out of Specification Aviation Turbine Fuels

²¹ IATA SAF Handbook, 2024: <https://www.iata.org/content-tassets/d13875e9ed784f75bac90f000760e998/saf-handbook.pdf>

Various technical pathways are currently under evaluation for approval by ASTM as illustrated under the next table:

Table 5 - Conversion processes under evaluation

Conversion process	Abbreviation	Lead developers
Synthesized aromatic kerosene	SAK	Virent
Integrated hydropyrolysis and hydroconversion	IH2	Shell
ATJ derivative starting with the mixed alcohols	<i>pending</i>	Swedish Biofuels
Single Reactor HEFA (drop-in Liquid Sustainable Aviation and Automotive Fuel)	DILSAAF	Indian CSIR-IIP
Pyrolysis of non-recyclable plastics	ReOIL	OMV
Co-processing of pyrolysis oil from used tires	<i>pending</i>	<i>pending</i>
Co-processing of hydroprocessed biomass	<i>pending</i>	<i>pending</i>

Source: ICAO Environment - Conversion processes

1.2.4 SAF Readiness - Aircraft compatibility

Very strict standards are required for fuel in the aviation industry where Jet A-1 fuel must meet DEF STAN 91-91 (Jet A-1), ASTM specification D1655 (Jet A-1), IATA Guidance Material (Kerosene Type), and NATO Code F-3.

In the same way, SAF need to be approved as safe and appropriate for commercial use and presently must meet the same fuel specifications to be recognized as jet fuel.

Stakeholders:

- **Fuel supplier:** understanding the compatibility of 100% drop-in and paraffinic SAF means that the current market ceiling of 50% SAF blend may double. In regions where the proper incentives and tools are available to minimize the price disparity between SAF and CAF, demand for SAF could have the potential to mirror demand volumes for CAF more closely.
- **Airports:** it is important to observe the specific needs in fuel handling systems when incorporating 100% drop-in and paraffinic SAF into airport grounds. The differences in their chemical composition to CAF will require adjustments or the incorporation of dedicated fueling handling systems.
- **Aircraft operators:** the purchase and use of 100% drop-in and paraffinic SAF means a greater contribution towards achieving the industry's goal of net zero by 2050. The environmental benefits will be maximized and allow companies to raise their ambition to sustainable growth.

The technical denomination for SAF as a synthetic blending component is synthetic paraffinic kerosene (SPK), and in its pure form, unlike CAF, it contains near zero levels of aromatics. Today as per ASTM, SAF can be blended up to 50% by volume with conventional jet fuel ([Table 3](#)). Reasons for the current blend limits are to ensure that the resulting mix follows the ASTM specification D1655 (Jet A-1), hence ensuring the appropriate level of safety and compatibility with the aircraft fueling systems (mainly due to the content of aromatics requested from the different systems).

Efforts are ongoing to expand **SAF usage up to 100%**, the following two avenues are being explored:

- Introducing **100% drop-in** SAF containing between 8-25% aromatics and qualified by ASTM, known as synthetic aromatic kerosene (SAK) – 100% drop-in SAK SAF
- Defining a new fuel specification “**100% paraffinic**” for 100% SPK SAF qualified by ASTM, regardless of production pathways, to be used directly, without blending nor additives.

The difference in aromatic content between 100% SPK SAF and Jet A-1 can have a significant impact on aircraft design and will require a dedicated certification, regarding:

- Materials compatibility
- Aircraft overall performance
- Engine and APU operability
- Fuel system operability and safety

The following technical matters will need to be addressed by change of design / mitigation means when using 100% paraffinic SAF:

- Absence of aromatics make the existing elastomeric seals lose their swelling (and then increase the risk of leakage). More generally, engine, auxiliary power unit (APU), and fuel system materials compatibility will need to be evaluated as part of the safety assessment (certification).
- A higher specific energy (MJ/kg) results in better performance (lower specific fuel consumption ~5%) when not operating at max. fuel volume.
- The lower volumetric energy (MJ/m³) resulting in a slightly lower performance (lower range ~2%) when operating at max. fuel capacity (a remote case for operating the aircraft)
- The differences in fuel permittivity versus density & temperature requires a redesign of the fuel system to ensure gauging accuracy.
- The higher viscosity and lower density make engine & APU start (on ground) or APU relight (in flight) more critical after a cold soak.
- Different flammability properties (such as a lower auto ignition temperature) will need a safety assessment at aircraft level and potential redesign to meet applicable certification requirements.

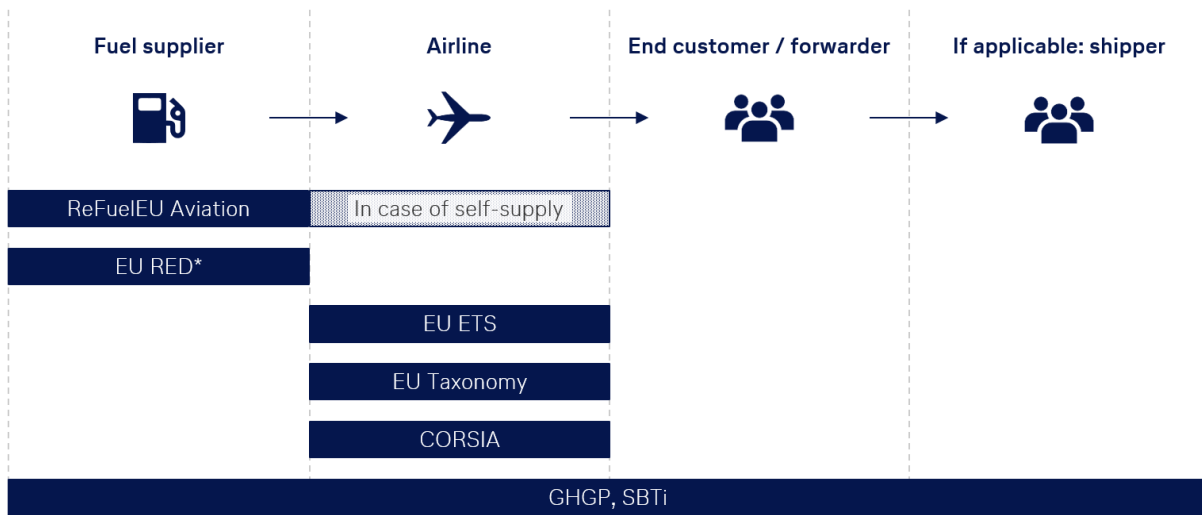
Either approach to expand SAF usage up to 100% result in the same net CO₂ emissions benefit than using a SAF blend (up to -80%) but it also provides additional environmental

benefits by reducing particulate matter emissions, hence better local air quality and lower non-CO₂ climate impact. Both approaches raise different challenges in terms of availability and fuel distribution logistics at airports. Airbus and other original equipment manufacturers (OEMs) are actively supporting both approaches at industry level and leading the way to enabling the use of 100% paraffinic SAF, which maximizes environmental benefits.

2 Market based measures, mandates, and incentives

There is a growing interest to regulate the use of aviation fuels and determine their environmental performance. Such policies can be roughly divided into market-based measures and mandates, on the one hand, and incentives and voluntary frameworks on the other. While market-based measures and mandates follow the polluter pays -principle, which charges (penalizes) the sector for emitting CO₂, incentives focus on optimizing the aviation fuel production by rewarding production and purchase of less polluting alternatives. The next figure attempts to illustrate measures aimed at supporting SAF usage:

Figure 13 - Regulation along the SAF supply chain



*not in terms of sustainability criteria for fuels, just quantitative targets

Source: Adapted from SBTi - Book-and-Claim for Sustainable Aviation Fuel

This section of the handbook serves as an introduction to the most relevant policies and incentives that affect SAF suppliers, aircraft operators, and airports in their management of SAF, both in Europe and worldwide, as well as voluntary schemes widely used by industry to support their environmental commitments.

Fuel providers will gain valuable information to help them plan SAF production both in terms of pathway and applicable certification for adequate and qualifying supply to different markets. Airports find detailed guidance on their obligations along the SAF supply chain and ensure mandated compliance to avoid penalties, and to adapt their operations to satisfy demand on SAF supply by their clients. Aircraft operators get a deep dive on all those obligations they need to follow to adhere to regulatory requirements. They will also

gain crucial understanding on the responsibilities and requirements SAF suppliers and users are to follow to enable conformity in the use of SAF across the various markets where they operate.

2.1 Market-Based Measures

Market-Based Measures (MBM) are out-of-sector measures that support the reduction of aviation CO₂ emissions through financial means (i.e. trading, levies, offsetting etc.), in a more flexible manner than traditional ‘command and control’ regulatory measures generic to mandates.

2.1.1 CORSIA

The global MBM for aircraft operators is CORSIA²² which was adopted in 2016 and commenced its first phase in 2024. Within CORSIA, aircraft operators must purchase offsets for the emissions that exceed the established baseline. Aircraft operators can reduce their regulatory obligations by claiming the usage of SAF or low carbon aviation fuel (LCAF) which are fossil-based fuels with a better environmental performance than traditional jet fuel²³. To be eligible, CORSIA eligible fuel (CEF) must achieve net greenhouse gas emissions reductions of at least 10% compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis.

Stakeholders: as of its second phase (2027-2035), CORSIA will enter its mandatory period, whereby offsetting requirements will apply to all international flights, applicable to aircraft operators that meet CORSIA criteria (e.g. this includes annual CO₂ emissions from international flights less than or equal to 10,000 tonnes²⁴); no impact on airports nor SAF suppliers.

Procedure: aircraft operators submit a verified emissions report to their CAA which submits the aggregated information of all aircraft operators’ emissions operating in their state to ICAO. ICAO calculates the Sector’s Growth Factor (SGF). States calculate the individual offsetting requirements for each aircraft operator, utilizing SGF.

Impact: aircraft operators purchase offsets or uplift CEF to meet the offsetting requirements. For 2022 the aircraft operators did not have offsetting requirements as the annual SGF was 0.0.

²² <https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx>

²³ <https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx>

²⁴ <https://www.icao.int/environmental-protection/CORSIA/Pages/SARPs-Annex-16-Volume-IV.aspx>

CORSIA Carbon Offsetting and Emission Reduction at ICAO level



Source: adapted from Lufthansa Group

2.1.2 European Union Emissions Trading System

There are also regional market-based measures such as the Emissions Trading System in the European Union (EU ETS) or national ETS for example in China, Korea, Switzerland, or the UK. In these emissions trading schemes carbon credits are obtained, traded, and sold within defined standards for the prevention or reduction of GHGs²⁵.

EU ETS, that has been in place for aviation since 2012, is a so called 'cap and trade' – mechanism which caps the CO₂ emissions of aviation for intra- European Economic Area (EEA)²⁶ routes²⁷. It requires the airplane operators that exceed the established limit (cap), to purchase allowances to cover for those emissions. In this scheme, SAF is zero-rated, meaning that by evidencing their utilization, an operator can reduce their requirement to surrender CO₂ allowances. Furthermore, following a recent revision, 20 million allowances will be made available to cover a part of the remaining price differential between fossil kerosene and the eligible SAF for individual aircraft operators between 2024 and 2030.

Stakeholders: mandatory for aircraft operators that comply with EU ETS criteria for aviation activity (e.g. commercial operators with more than 243

²⁵ Greenhouse Gas Emissions include carbon dioxide (CO₂) which is the primary greenhouse gas emitted through human activities but also e.g., methane, nitrous oxide and fluorinated gases.

²⁶ European Economic Area (EEA)

²⁷ https://climate.ec.europa.eu/eu-action/transport/reducing-emissions-aviation_en

flights per 4-month period, and more than 10,000 t CO₂); no impact on airports nor SAF suppliers.

Procedure: aircraft operators submit the emissions report to the competent authority of their administering country who then forwards the aggregated information of all aircraft operators operating in their state to the European Commission

Impact: aircraft operators purchase CO₂ allowances or evidence the use of SAF for the amount of emissions exceeding the established cap.

SNAPSHOT



Source: adapted from Lufthansa Group

2.2 Mandates

To enable the scale-up of SAF, some regulators worldwide have established mandates that oblige the supply and use of SAF. Well-known examples are found in Europe, namely in the context of the RefuelEU Aviation (REFUA) regulation of the European Union and national mandates like the upcoming SAF mandate in the UK. SAF mandates are implemented differently in each jurisdiction and the Interpretation and implementation of each of these mandates can become complex.

2.2.1 ReFuelEU Aviation - REFUA

RFEUA is part of the Fit for 55 package of the Green Deal strategy of the European Union whose objective is to reach climate neutrality in the block by 2050. The Fit for 55 is a package of measures that aim to support the interim target of 55% reduction of emissions by 2030, compared to the emissions generated in 1990. The objective of RFEUA is to foster the ramp-up of SAF supply in Europe, by setting obligations to aviation fuel suppliers, aircraft operators, and airports²⁸.

REFUA applies only to commercial air transport flights²⁹ and concerns aircraft operators, Union airports and their managing bodies, and aviation fuel suppliers.

Definitions – REFUA

Union Airport

‘Union airport’ being an airport where passenger traffic was higher than 800,000 passengers or where the freight traffic was higher than 100,000 tonnes in the previous reporting period that runs from 1 January until 31 December³⁰.

A Member State, after consulting with or at the request of an airport management body³¹, may designate an airport located on its territory that falls outside the aforementioned threshold as a Union airport. This is contingent on such airport facilitating access to aviation fuels with minimum SAF shares, as required by the regulation³². The decision must be communicated to the European Commission and European Authority for Aviation Safety (EASA) at least six months before the relevant reporting period begins.

Aircraft operator

Aircraft operator means a person or owner of the aircraft that operated at least 500 commercial passenger air transport flights, or 52 commercial all-cargo air transport flights departing from Union airports in the previous reporting. commercial air transport flight” implies flights operated for transporting passengers, cargo, or mail for remuneration or hire, including business aviation³³.

A person or aircraft owner who falls outside the specified threshold or operating non-commercial flights, fully or partially, may choose to be treated as an aircraft operator under the regulation. This decision must be communicated to the relevant Member State's competent authority, which will then inform the Commission and EASA at least six months before the applicable reporting period³⁴.

²⁸ ReFuelEU Initiative: <https://www.consilium.europa.eu/en/press/press-releases/2023/10/09/re-fueleu-aviation-initiative-council-adopts-new-law-to-decarbonise-the-aviation-sector/>

²⁹ Article 2(1)

³⁰ Article 3(1)

³¹ As defined in Article 2(2) of Directive 2009/12/EC or, the body for which the Member State concerned has reserved the management of the centralized infrastructures for fuel distribution systems for another body pursuant to Article 8(1) of Council Directive 96/67/EC

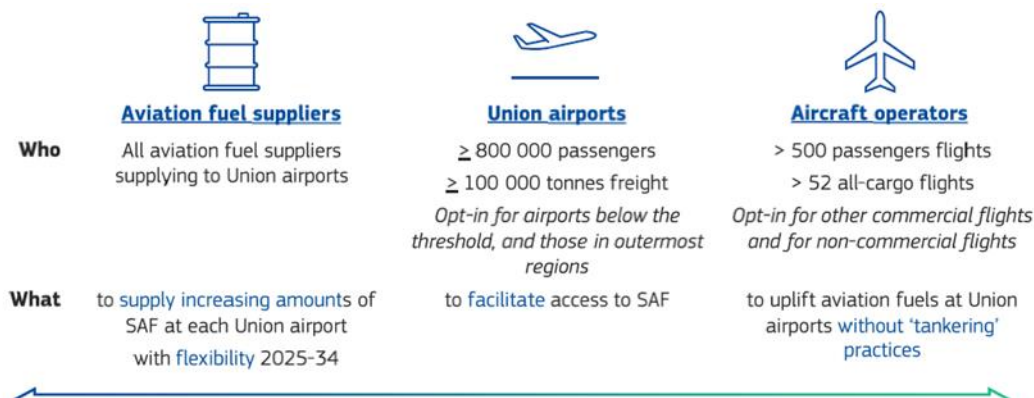
³² Article 6(1)

³³ Article 3(4)

³⁴ Article 11(5)

The following figure describes scope and obligations of RFEUA:

Figure 14 - RFEUA scope and obligations



Source: European Commission/DG Move, 2023

Are territories associated with all the EEA member countries included within this scope? **FAQ**

No, the regulation applies only to EU Member States. Therefore, EEA countries not in the EU (Iceland, Liechtenstein, Norway) and Switzerland are excluded from the scope of RFEUA. This distinction is reflected in the list of [Union airports within the scope for the reporting period 2024](#).

Do flights performed on wet leases fall within the scope of this regulation?

Yes, if the flight is a commercial air transport flight and the aircraft operator falls within the regulation's scope. The ICAO designator determines which flights fall under which aircraft operator's responsibility, regardless of whether the aircraft is leased, owned, or wet-leased.

What exactly are the "flights covered by this Regulation"? Are they all flights departing from Union airports?

The regulation covers commercial air transport flights performed by aircraft operators within its scope. The phrase "flights covered by this Regulation" usually refers to those "departing from given Union airports," mainly in the context of an aircraft operator's reporting obligations. The list of aircraft operators for the reporting period 2024 can be found [here](#).

Would the competent authority under RFEUA be the same as that for EU ETS?

The competent authorities for RFEUA are assigned by the Commission and listed for each operator in scope. The list of contacts for the authorities is available on the EC page [here](#). Generally, aircraft operators are attributed to the same Member State as per the EU ETS Directive. Member States must clarify if their designated authorities for EU ETS and RFEUA are the same or different, determining whether operators have a common point of contact.

Do the provisions apply only to fuel uplifted onto intra-EU flights?

No, they apply to all fuel uplifted by aircraft operators at Union airports, for both intra-EU and extra-EU flights, whether conducted by EU or non-EU aircraft operators.

2.2.1.1 Flexibility mechanism

The regulation established flexibility mechanisms for fuel suppliers to meet their obligations, which are currently envisioned to apply from 1 January 2025 until 31 December

2034. The flexibility mechanism is meant to support the scale-up of SAF production as the industry matures. A fuel supplier may provide the minimum shares of SAF as a weighted average across all aviation fuel supplied during the reporting period instead of providing SAF bidding shares to each Union airport.

The regulation also allows for improvements to flexibility mechanisms pending a Commission assessment. These improvements may include a tradability system for SAF, enabling fuel supply within the European Union without a direct physical connection to a supply site. It might also incorporate a "book and claim" scheme, allowing aircraft operators or fuel suppliers to purchase SAF through contracts and claim its use at Union airports³⁵.

Under the flexibility mechanism, if an aircraft operator is contracted to Supplier Y at CPH and FCO, can they meet the minimum SAF requirement by supplying it solely at FCO for both CPH and FCO obligations?

FAQ

Yes, under the flexibility mechanism, fuel suppliers are not required to guarantee that each aircraft operator receives the minimum SAF share at each Union airport. Instead, it addresses the overall supply of SAF by a fuel supplier to all its aircraft operator customers at a Union airport. This approach allows for flexibility in meeting the minimum SAF requirements while considering the aggregated supply across multiple airports. It is meant to be a practical way to balance the supply and demand of sustainable aviation fuel.

Is the flexibility mechanism designed for use by both fuel suppliers and aircraft operators?

No, the flexibility mechanism is solely intended to ease obligation compliance for fuel suppliers and does not include provisions for aircraft operators. However, it suggests establishing "a system of tradability of SAF to enable fuel supply in the Union without it being physically connected to a supply site" which facilitates the purchase SAF for fuel suppliers and claim process for both aircraft operators when SAF is not readily available.

2.2.1.2 Obligations and penalties for non-compliance

The implementation of RFEUA imposes obligations on fuel suppliers, Union airports, and aircraft operators, which are outlined as follows:

Stakeholders:

- **Fuel supplier:** the obligation for aviation fuel suppliers is to ensure that all fuel made available to aircraft operators at EU airports contains a minimum share of SAF from 2025 and, from 2030, a minimum share of synthetic fuels, with both shares increasing progressively until 2050. Fuel suppliers will have to incorporate

³⁵ IATA – ReFuelEU Aviation Handbook

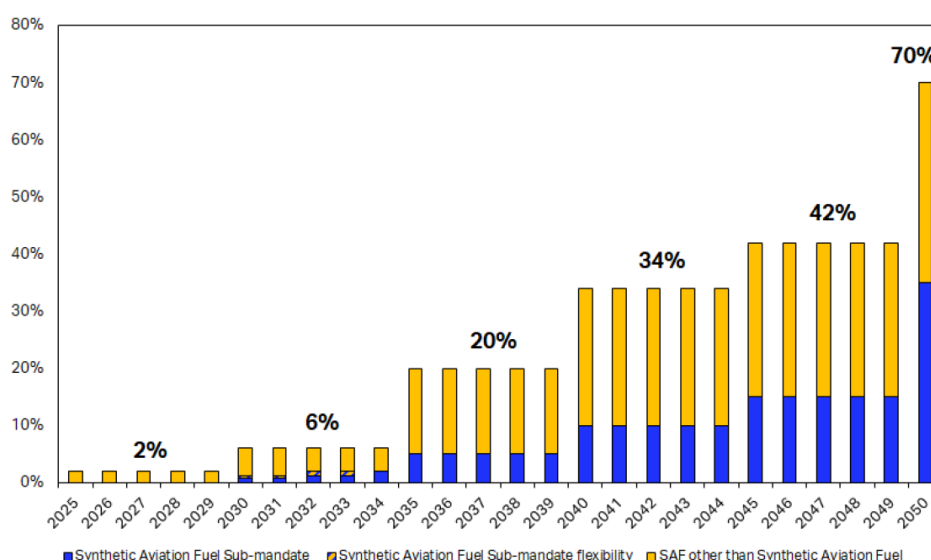
2% SAF in 2025, 6% in 2030 and 70% in 2050. From 2030, 1,2% of fuels must also be synthetic fuels, rising to 35% in 2050.

SAF must be compliant with the RED III 's³⁶ sustainability and emissions-saving criteria to count to the targets, and SAF is composed of:

- Aviation biofuels, notably advanced biofuels, and other biofuels, produced from waste and residues,
- Synthetic aviation fuels, produced from renewable hydrogen, and
- Recycled carbon aviation fuels.

Additionally, aviation fuel suppliers may choose to meet both minimum shares with hydrogen for direct use in aircraft (renewable and non-fossil low-carbon hydrogen), along with synthetic low-carbon aviation fuels (produced from non-fossil low-carbon hydrogen)³⁷.

Figure 15- Binding shares of SAF and synthetic aviation fuels - RFEUA



Source: IATA ReFuelEU Aviation Handbook

- **Airports:** European Union airports to take all necessary measures to facilitate the access to aviation fuels for aircraft operators containing minimum shares of SAF in accordance with this regulation. Union airport managing bodies to undertake efforts to facilitate the access of aircraft operators to hydrogen or electricity used primarily for the propulsion of an aircraft and to provide the infrastructure and services necessary for the delivery, storage, and uplifting of such hydrogen or electricity to refuel or recharge aircraft.

³⁶ European Commission - RED Key Facts: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

³⁷ EUR-Lex: <https://eur-lex.europa.eu/EN/legal-content/summary/refueleu-aviation-sustainable-air-transport.html>

- **Aircraft operators:** airlines are to uplift aviation fuels without tankering³⁸ practices, meaning that the yearly quantity of aviation fuel uplifted by a given aircraft operator at a given Union airport shall be at least 90 % of the yearly aviation fuel required.
- **EU Member States:** designate the competent authorities to enforce this regulation, and enforce this regulation, and on penalty systems in case of non-compliance.

Penalties: in case of non-compliance, the competent authority of the Member State may introduce *effective, proportionate, and dissuasive* penalties, taking into account the evolution of the price of aviation fuel and SAF.

- **Fuel supplier:** Member States must ensure that any aviation fuel supplier failing to meet the obligations specified in Article 4 regarding the minimum shares of SAF will incur a fine. This fine should be proportionate and dissuasive, and at least double the amount calculated by multiplying the difference between the annual average price of CAF and SAF per tonne by the quantity of aviation fuels not meeting the minimum shares³⁹.
- **Airports:** in case of possible non-compliance, the competent authority may request the Union airport managing body to:
 - Provide the information necessary to prove compliance, and for proven non-compliance,
 - Identify and take the necessary measures to address the lack of adequate access to aviation fuels containing minimum shares of SAF.
- **Aircraft operator:** for airlines, 'the fine must be at least twice as high as the amount resulting from multiplying the yearly average price of aviation fuel per tonne by the total yearly non-tanked quantity⁴⁰.'

The penalty for RFEUA non-compliance to fuel suppliers, aircraft operators, and airports can be summarized as follows:

³⁸ Tankering in aviation refers to the practice of an aircraft carrying extra fuel on a flight leg to avoid refueling at a destination where fuel prices are higher. The ReFuel policy aims to prevent the additional emissions caused by the increased weight of the aircraft for carrying extra fuel from cheaper locations.

³⁹ ReFuelEU Aviation Article 12, "Enforcement:" <https://eur-lex.europa.eu/eli/reg/2023/2405>

⁴⁰ ReFuelEU Aviation Article 3(26) – the total yearly non-tanked quantity is the sum of the yearly non-tanked quantities by an aircraft across all Union airports in a reporting period

Table 6 - Impact to Primary Stakeholders – RFEUA

Stakeholder Type	Penalty
Fuel supplier	- Subject to proportionate and dissuasive fines if they fail to supply minimum binding shares of SAF to Union airports.
Airport managing bodies	- Competitiveness of Union airports may be impacted by availability to supply SAF.
Aircraft operators	- Current interpretation of EU ETS requires physical SAF uptake (or mass balance) challenges for some operating at Union airports with no supply. - Impact on fuel costs is uncertain – supplier competition, pricing power at each airport, loss of price bargaining power due to tinkering restrictions.

2.2.1.3 Reporting

The regulation mandates reporting requirements for both fuel suppliers and aircraft operators, as follows:

Stakeholders:

- **Fuel suppliers:** fuel suppliers must report in the Union database⁴¹ by 14 February of a reporting year⁴², and for the first time in 2025.
- **Aircraft operators:** Aircraft operators must submit their report by 31 March each year, covering the previous calendar year. The first report, due in 2025, must include information from 2024.

Procedure:

- **Fuel suppliers:** all fuel suppliers covered by the regulation must report the following information in the Union database:
 - The amount of aviation fuel supplied at each Union airport, expressed in tonnes.
 - The amount of SAF shares supplied at each Union airport, and for each type of SAF, as detailed in point iii., expressed in tonnes.
 - The conversion process, the characteristics and origin of the feedstock used for production, and the lifecycle emissions of each type of SAF supplied at Union airports.
 - The content of aromatics and naphthalenes by percentage volume and of sulphur by percentage mass in aviation fuel supplied per batch, per Union airport, and at Union level, indicating the total volume and mass of each batch and test method applied to measure the content of each substance at batch level.
 - The energy content for aviation fuel and SAF supplied at each Union airport for each fuel type.

⁴¹ As established in Article 31a of Directive (EU) 2018/2001 – legislative text of EU RED

⁴² Article 3(22) - Period from 1 January to 31 December, during which the reports by aircraft operators and fuel suppliers are to be submitted.

- **Aircraft operator:** aircraft operators shall report the following information to the competent authorities via EASA Digital Reporting Tool⁴³:
 - Total amount of aviation fuel uplifted at each Union airport, expressed in tonnes,
 - The total amount of aviation fuel uplifted at each Union airport, expressed in tonnes.
 - The yearly aviation fuel required, per Union airport, expressed in tonnes.
 - The yearly non-tanked quantity, per Union airport, which is to be reported as zero if the yearly non-tanked quantity is negative or if it is lower than or equal to 10% of the yearly aviation fuel required.
 - The yearly tanked quantity, per Union airport for reasons of compliance with applicable fuel safety rules, expressed in tonnes.
 - The total amount of SAF purchased from aviation fuel suppliers, for the purpose of operating their flights covered by this regulation, departing from Union airports, expressed in tonnes.
 - For each purchase of SAF, the name of the aviation fuel supplier, the amount purchased expressed in tonnes, the conversion process, the characteristics, and origin of the feedstock used for production, and the lifecycle emissions of the SAF, and where one purchase includes different types of SAF with differing characteristics, providing that information for each type of SAF.
 - The total flights operated covered by this regulation departing from Union airports, expressed in number of flights and in-flight hours.

A third-party verifier must verify this report, which must be submitted to the respective authorities by March 31, 2025. Aircraft operators will have to submit their report with the following reporting templates⁴⁴:

1. Template to report fuel tankering, REFUA

Union Airport Name	ICAO Code of Union Airport	Total flights operated departing from the Union Airport (No flights)	Yearly aviation fuel required (tonnes)	Yearly actual aviation fuel uplifted (tonnes)	Yearly non-tanked quantity (tonnes)	Yearly tanked quantity for fuel safety rules (tonnes)

2. Template to report SAF purchases, REFUA

Fuel Supplier	Batch Number	Amount Purchased (tonnes)	Category of eligible fuel for use in aircraft	Feedstock	Lifecycle emissions of the Eligible Fuel (cCO ₂ eq/MJ)	Eligible Fuel (tonnes) claimed under EU ETS	Eligible Fuel (tonnes) claimed under CH ETS	Eligible Fuel (tonnes) claimed under CORSIA	Eligible Fuel (tonnes) claimed under other MBMs	Eligible Fuel (tonnes) not claimed

⁴³ <https://www.easa.europa.eu/en/newsroom-and-events/press-releases/new-responsibilities-place-easa-centre-drive-decarbonise>

⁴⁴ <https://sustainabilityportal.easa.europa.eu/>

2.2.1.4 Exemptions

Aircraft operators can request an exemption from their obligations for specific routes shorter than 850 km or connecting island airports without rail or road links, departing from a Union airport and less than 1,200 km long. The request must be made at least three months before the exemption is needed, with a decision required one month before the exemption applies.

Exemptions are allowed in cases of:

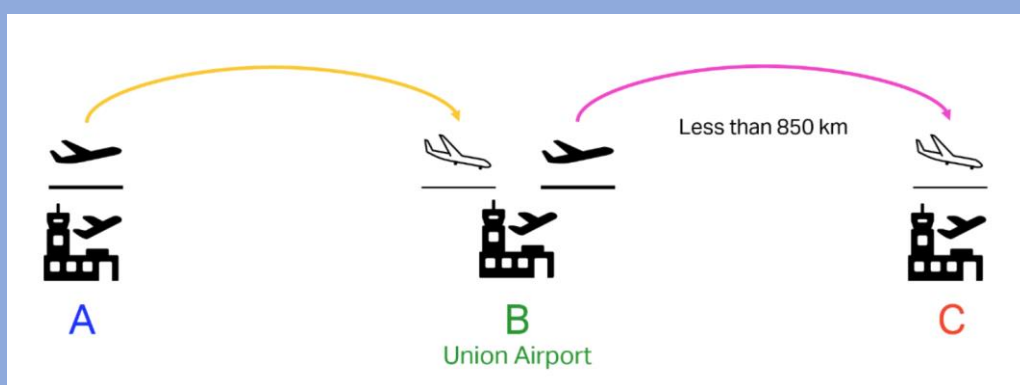
1. Serious, recurring refueling difficulties at a Union airport causing turnaround delays.
2. Structural fuel supply issues at a Union airport leading to significantly higher fuel prices due to transport constraints or limited availability, creating a competitive disadvantage.

The competent authority must notify the Commission of approved and rejected exemptions with justifications. The Commission will publish and update the list of authorized exemptions at least once a year.

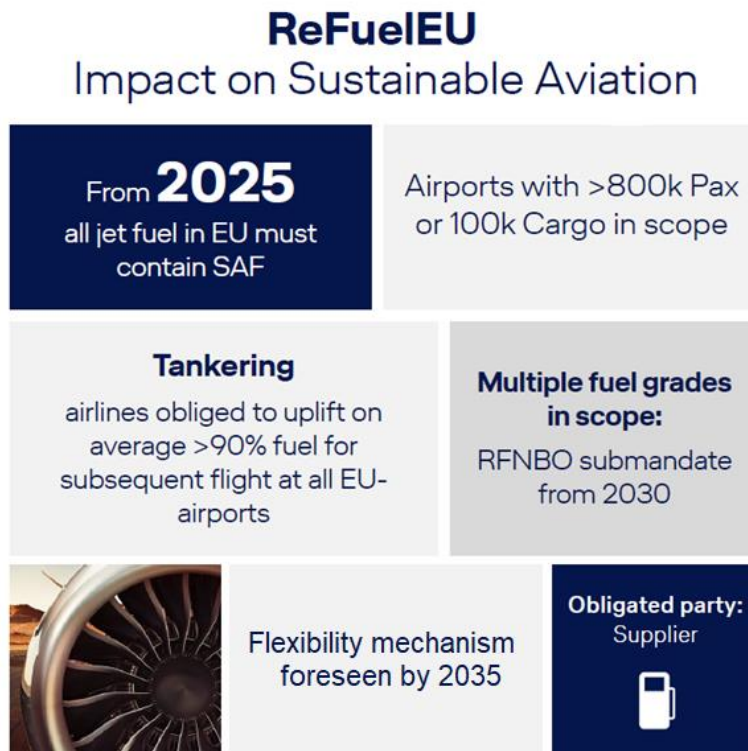
Exemptions are valid for up to one year. The Commission will publish and update the list of authorized exemptions annually. Detailed guidelines will be adopted by the Commission, specifying the information needed to justify exemptions.

RFEUA Exemptions - An example

An aircraft operator flying from Airport A to Union Airport B, and onward to Airport C (less than 850 km from Airport B) may request an exemption from uplifting 90% of their yearly aviation fuel at Union Airport B. Airports A and C don't need to be Union Airports.



Source: IATA ReFuelEU Aviation Handbook



Source: adapted from Lufthansa Group

2.1.1 National mandates

In addition to RFEUA, there are other nationally established SAF mandates, some of which have existed before RFEUA's provisions were agreed on.

The UK has established a national mandate for SAF supply, as per their Jet Zero Strategy. The mandate that will enter into force in 2025 will require at least 10% of aviation fuel to be SAF by 2030. The existing national mandates of France, Norway⁴⁵ and Sweden are deemed to discontinue with the implementation of the RFEUA regulation. Some newer national SAF targets are e.g. those of Brazil, India, Malaysia, Japan, or Singapore that all require operators flying from the national airports to ensure part of the aviation fuel uplifted is sustainable.

While mandates have become attractive across different jurisdictions, regulators should understand their limitations and potential adverse impact if not carefully implemented. At the current stage of development of this nascent industry, the introduction of

⁴⁵ Even if Norway is not part of the European Union, they have signaled interest into matching their national mandate to comply with the EU targets.

mandates may be effective only if complemented by incentives and programs that facilitate innovation, scale-up, and unit cost reduction for SAF.

There are several standards that either mandate the sustainability performance of aviation fuels or steer it by rewarding credits to producers or end users who opt for less emitting solutions. While RED affects a variety of companies involved in SAF across the EU including airlines, RFTO and RFS are examples of standards that benefit fuel producers opting for SAF production in the UK and the US, respectively. The following standards are prominent examples worldwide.

2.2.3.1 Renewable Energy Directive in the EU

The Renewable Energy Directive (RED) is a legal framework for the development and production of renewable energy and fuels across the European Union (EU) that was adopted in 2009⁴⁶. RED was first revised in 2018 (REDII) and again in the context of the Fit for 55 – package, namely in October 2023 (REDIII)⁴⁷. The EU REDIII introduces a revised target of at least 42.5% renewable energy in the overall energy consumption in the EU across all sectors by 2030, up from 32% in EU REDII. By extension, this also includes notable changes to renewable fuel obligations in the transport sector, including aviation. The directive includes sustainability criteria for SAF which is divided into three categories of biofuels, advanced biofuels, and renewable fuels of non-biological origins (RFNBO).

Stakeholders: Member States and in extension, companies in different industries, including aviation.

Procedure: Member States to provide a report to the European Commission regarding the energy consumption in their respective state

Impact: Member States must transpose the regulation into national law. For aircraft operators, this changes the definition of feedstocks that are eligible within REFUA and EU ETS, affecting eligibility for the airlines to claim SAF use under EU ETS. For airports, no impact unless they are involved as SAF suppliers.

2.2.3.2 Renewable Transport Fuel Obligation in the UK

The Renewable Transport Fuel Obligation (RTFO) is the UK's main policy framework to promote the introduction and use of alternative fuels and will be complemented with a SAF mandate⁴⁸. Since 2018, SAF supply has been rewarded through the RTFO, which provides tradeable certificates for every liter of verified sustainable renewable fuels supplied

⁴⁶ <https://www.europarl.europa.eu/legislative-train/package-fit-for-55/file-revision-of-the-renewable-energy-directive>

⁴⁷ <https://eur-lex.europa.eu/eli/dir/2023/2413/oj>

⁴⁸ <https://www.gov.uk/guidance/renewable-transport-fuels-obligation>

for aviation in the UK. The RTFO explicitly includes opt-in provisions for jet fuel and aviation gasoline whenever the SAF are obtained from selected feedstocks and meet specific sustainability criteria.

2.2.3.3 Renewable Fuel Standard in the US

The Renewable Fuel Standard (RFS) is a federal fuel standard in the United States that was created by the Energy Policy Act of 2005 and was later updated through the Energy Independence and Security Act of 2007⁴⁹. This regulation focused on renewable fuel for ground transportation, requiring a minimum amount of renewable fuel annually, ramping up over time. The RFS offers SAF an “opt-in” approach, allowing SAF to generate compliance units (Renewable Identification Numbers “RINs”) without aviation fuel-generating compliance obligations. Currently, SAF has been determined to generate 1.6 RINs per gallon. This approach intends to advance SAF’s competitiveness with renewable diesel while refraining from imposing a mandated SAF use obligation.

2.3 Incentives

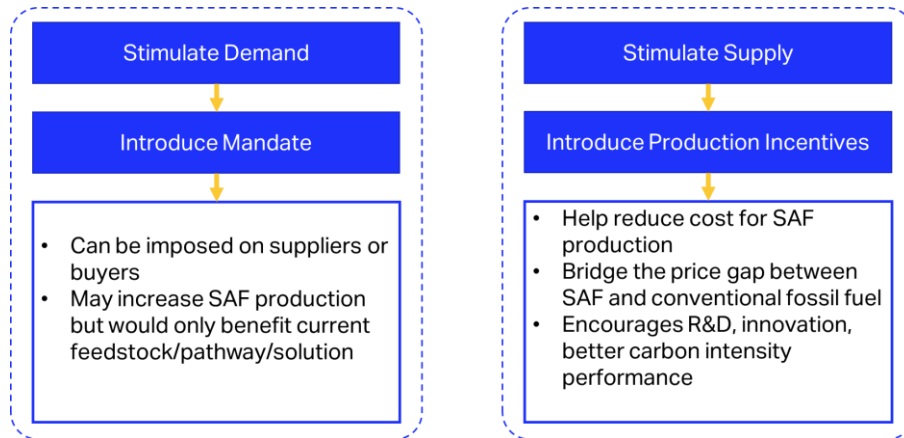
Mandates and targets can be considered ‘punitive’ measures that aim to reach the policy objective of aviation decarbonization by obliging the stakeholders to comply with the established SAF usage, supply, or production criteria against regulatory sanctions. They follow the ‘polluter pay’ approach. Other type of measures includes those encouraging the use of SAF through economic incentives. Such ‘positive’ policies can act as a trigger to stimulate supply (incentives targeted at production) or demand (incentives targeted at end users). Incentives take different forms, such as:

- Tax relief and tax exemptions on production, sale, or procurement
- Direct funding for the use of SAF, airport incentives
- Capital support and loan guarantees for production facilities
- Feedstock subsidies or similar support mechanisms
- Research grant and development programs and support
- SAF (clean energy) credits
- Financial market policies including green bond mechanisms and debt guarantees.

The main differences between mandates and incentives and their interactions can be summarized as follows:

⁴⁹ <https://afdc.energy.gov/laws/RFS>

Figure 16 - Mandates vs. Incentives



Source: IATA sustainability & economics

2.3.1 USA – incentives for the SAF industry

The USA has developed a basket of stackable incentives that have improved the attractiveness of SAF against other products in a fuel refinery. SAF projects in the US are now more than triple than in other countries worldwide, and it is estimated that the latest policy package has attracted over 70% of announced SAF capacity to the US⁵⁰.

In 2021, the US announced the Sustainable Skies Act which was complemented by a number of policies aimed at increasing the production of SAF in the country. This was followed by the SAF Grand Challenge in 2022, a Memorandum of Understanding and roadmap that established a set of targets for SAF use and production, such as the production target of SAF 3 billion gallons per year by 2030 and up to 35 billion gallons per year by 2050 or the supply of sufficient SAF to meet 100% of aviation fuel demand by 2050.

Through the Inflation Reduction Act (IRA)⁵¹ which aimed at supporting the US industry and households through the energy transition, the SAF Grand Challenge⁵² found a practical translation in the form of grants, research and development incentives but most importantly, tax and production credits. The IRA included the Sustainable Aviation Fuel Credit, a so-called Blender's Tax Credit, for sale/use of SAF with lifecycle GHG emissions reduction of at least 50% which was deemed to be in place until end of 2024 and the Clean Fuel Production Credit which will take over in 2025.

⁵⁰ <https://www.sustainableaviation.co.uk/wp-content/uploads/2023/04/Sustainable-Aviation-SAF-Roadmap-Final.pdf>

⁵¹ <https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/>

⁵² <https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge>

2.4 Recipe for a functional SAF policy

The price tag of aviation decarbonization by 2050 amounts to USD 5 trillion. Of this amount, SAF takes up the biggest portion. Considering this major challenge, and the nascent SAF landscape, the public sector intervention is deemed fundamental. To enable a quick ramp-up in SAF production, supply and usage, governmental incentives to steer the transition play a critical role. The following figure illustrates the main elements needed to build a sustainable, effective, and fair SAF policy:

Figure 17 - Building blocks for effective SAF policy frameworks



Source: IATA sustainability & economics

To ensure the global approach and support the states that may move slower than others, in the spirit of ‘not leaving anyone behind’, ICAO has established ACT-SAF⁵³ which assists such stakeholders to get a global view and learning from the experiences of early movers.

⁵³ <https://www.icao.int/environmental-protection/Pages/act-saf.aspx>

3 SAF Accounting and Reporting

Once SAF enters the jet fuel supply chain and becomes fungible with conventional jet fuel, it is imperative to have a robust accounting mechanism in place for airlines to be able to track and claim the environmental benefit of their SAF purchases against their various decarbonization commitments and obligations. Moreover, such an accounting system enables the separation of the environmental claims from the physical journey of the fuel, a critical element for the scaling up of SAF.

This section of the handbook explains the critical role played by a suitable tracking mechanism to ensure that the sustainability attributes of SAF are appropriately accounted for, traced, transmitted, and communicated. This is necessary because SAF is only approved for use blended with CAF, and once they are co-mingled and used in existing distribution and fueling infrastructure along the supply chain, the emissions reductions associated with SAF need to be accounted for separately from the physical product, while remaining allocated to their rightful owner (i.e., airlines and their customers).

By the end of section 3, readers will have extensive knowledge to identify what makes for a refined, dependable, and effective method for accounting and reporting, including guidance on the need to achieve global harmonization among existing methods.

3.1 Fundamentals of SAF accounting and reporting

This section of the handbook serves as an introduction to the SAF accounting and reporting principles, procedures, and role of stakeholders along the value chain, as well as best practices on how to record, report and claim for SAF benefits in a transparent and credible manner.

Stakeholders:

- **SAF producer / supplier:** The following section offers SAF producers with details on the documentation they need to create and provide to their clients, and in cases, for regulatory compliance. Suppliers will need to provide all documentation related to the environmental benefits attributed to the SAF purchased to their clients, the airlines, which will use this documentation to account, report, and claim for their achievements on emission reductions and improvement in local air quality from the use of SAF.
- **Airports:** Credible and transparent accounting and reporting of SAF environmental attributes may contribute towards achieving an airport's voluntary commitments, and possible regulatory obligations, to reduce emissions from third parties, aircraft, or passengers who make use of their installations, also referred to as downstream scope 3 emissions. In fact, most airport emissions are within the Scope 3 category and are therefore not under the direct control of airport's management. This section provides airports with important knowhow to understand how their clients account for

and report their emission reductions and opportunities this may create for them to tackle scope 3 emissions.

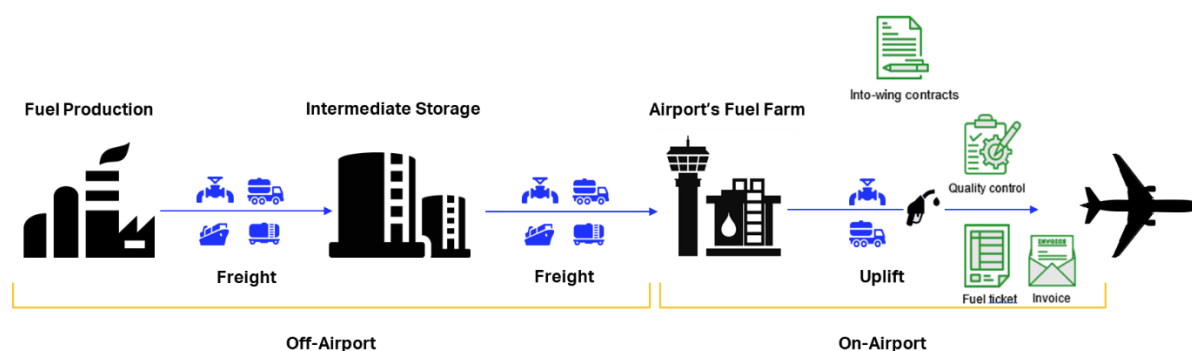
- **Aircraft operator:** Airlines find here the right tools and knowledge to account for and report their SAF usage towards end customers and official authorities in a reliable manner. After reading section 2 of this handbook, airlines will know how to obtain the PoS⁵⁴ of purchased volumes of SAF and claim its use under mandatory GHG reduction schemes (e.g. EU ETS, CORSIA) as well as voluntary reporting standards (e.g. Greenhouse Gas protocol) in a transparent manner.

A robust SAF accounting framework, based on trusted chain-of-custody approaches, is necessary to support the global aviation industry's goal to reach net-zero carbon emissions by 2050. It is fundamental for ensuring a cost-effective and environmentally efficient way to incentivize the scaling-up of all technologies, feedstocks, methods, and approaches required for reducing lifecycle GHG emissions across the SAF supply chain.

What is SAF accounting?

SAF accounting refers to an accounting framework that enables airlines and their customers, to claim the environmental attributes from SAF purchases to meet or reduce their regulatory obligations and fulfil voluntary commitments. For CAF, accounting and reporting along the fueling purchasing process is primarily about clearly separating (accounting for) and properly passing on the ownership of the fuel purchased and used along the supply chain (from seller to user). The following figure depicts a CAF fuel transaction:

Figure 18- Generic CAF accounting workflow



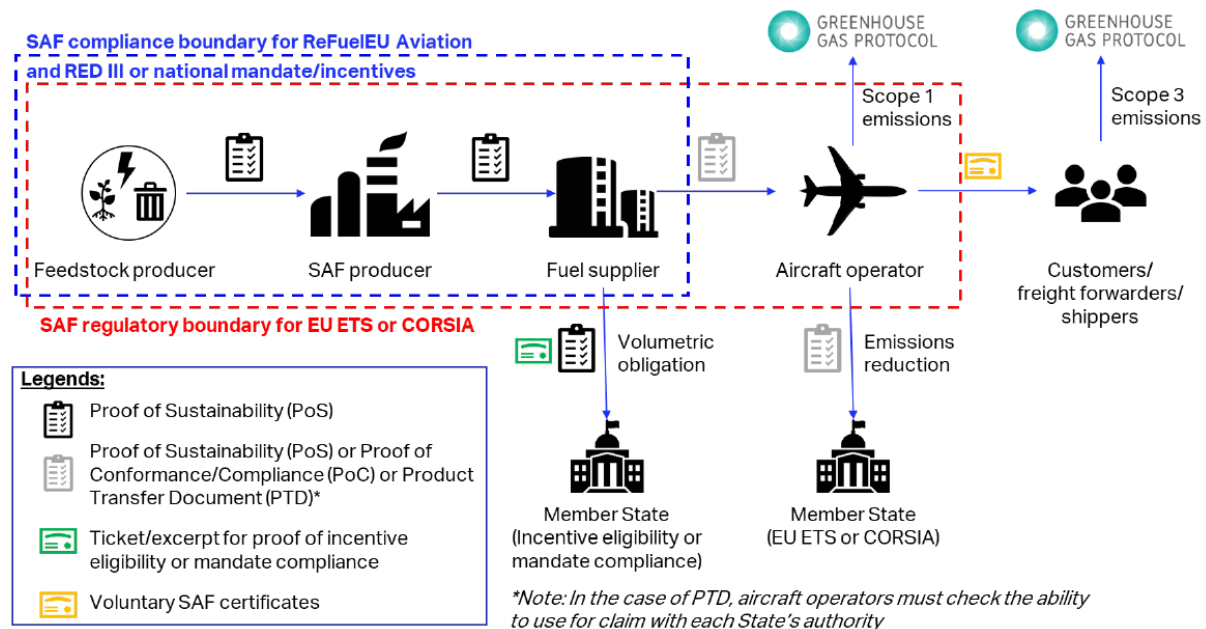
Source: adapted from IATA Sustainability & Economics

Differently from CAF, SAF accounting and reporting on fuel purchases also involves tracking of the environmental attributes. Specifically, a SAF fuel transaction involve two elements: 1) fuel purchase transaction process common to CAF, and 2) accounting and

⁵⁴ PoS refers to a delivery document issued by a SAF supplier certified under a relevant SCS, such as through a CORSIA Approved Sustainability Certification Scheme or European Union RED II Sustainability Certification Scheme, including but not limited to ISCC and RSB for each delivery of SAF.

reporting of the environmental benefits (e.g. CO₂ emission reductions) associated to the volume of SAF purchased, illustrated under the following figure:

Figure 19 - Generic SAF accounting workflow



Source: IATA Sustainability & Economics

What are environmental attributes?

SAF's potential to reduce emissions is calculated against its entire lifecycle, from feedstock production to its use when combusted by an aircraft. The overall lifecycle CO₂ equivalent emissions of SAF occur from the feedstock growth, collection, transportation, and production, subtracting them from the CO₂ equivalent emissions from combustion of SAF in the aircraft. This results in significant life cycle emission savings for SAF compared to traditional fossil-based jet fuel, for which lifecycle carbon emissions are a sum of those generated from crude oil extraction until the fuel is combusted. SAF's environmental attributes include CO₂ emission reductions, GHG intensity, and reductions in particulate matter emissions as they relate to local air quality.

What are required accounting principles?

To ensure that the sustainability attributes of SAF are appropriately accounted for, traced, transmitted, and communicated, a tracking mechanism is required. This is necessary because SAF is only approved for use blended with CAF, and once they are co-mingled and used in existing distribution and fueling infrastructure along the supply chain, SAF molecules can no longer be traced independently. In the absence of an adequate accounting mechanism, the sustainability attributes can only be ascertained if the SAF remains physically segregated from the CAF, from the point of origin to the wing of the aircraft. Hence, the emissions reductions associated with SAF need to be accounted for separately from the physical product, while remaining allocated to their rightful owner (i.e., airlines and

their customers). This can be ensured and safeguarded with a robust SAF accounting mechanism⁵⁵ based on trusted CoC approaches.

Several initiatives are currently under development to ensure that the environmental attributes of SAF are appropriately traced, transmitted, and communicated. Operationally, the steps in the supply chain together with their corresponding accounting elements to maintain transparency shall encompass the following:

- **SAF production:** SAF environmental attributes are certified under a recognized SCCs, such as RSB or ISCC. A PoS is then issued.
- **Fuel tracking:** The PoS must be updated at every step in the supply chain (regardless of the chain-of-custody model used for accounting) to reflect the final life-cycle emissions of the SAF. Once SAF has been uplifted to one or multiple aircraft, it is considered “used”, and the sustainability information from the PoS enters a master registry. At this point, the claiming and reporting process may start.
- **Registry:** A master registry, or a group of interoperating registries, will ensure that no double counting occurs for claims under the same emissions scope⁵⁶.
- **Claiming and reporting:** After SAF use is proven, stakeholders along the value chain can start their claiming and reporting processes in accordance with the rules set by each regulatory or voluntary framework.

3.2 Chain of Custody approach to traceability

The chain-of-custody accounting approach is one of several efforts being explored to support the rapid growth of the SAF industry without compromising the integrity of the accounting and reporting process. The CoC approach follows materials and the associated information transfer through every step of the supply chain as they go through various stages of sourcing, production, processing, shipping, and retail. As a user, producer, and supplier of SAF it is crucial to bear close knowledge on each transfer stage that SAF molecules follow to ensure accuracy in accounting and reporting of environmental attributes, the source of value to prove legal compliance or achievement of corporate environmental objectives.

The SAF molecules itself can be accounted for using any of the chain of custody approaches or a mix of them. This is a process by which inputs and outputs and associated information are transferred, monitored, and controlled as they move through each step in the relevant supply chain⁵⁷. There are typically 3 types of chain of custody models:

⁵⁵ IATA – SAF Accounting Principles: https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-accounting-policy-paper_20230905_final.pdf

⁵⁶ Direct emissions from combustion which airlines can claim against their decarbonization obligations are called Scope 1 emissions. Indirect emissions, notably in the downstream supply chain (passenger and cargo), are called Scope 3 emissions. A quantity of SAF could be claimed by an airline under Scope 1 and by a customer, such as a corporation, under Scope 3 and is not considered as double counting by the Greenhouse Gas Protocol (GHGP).

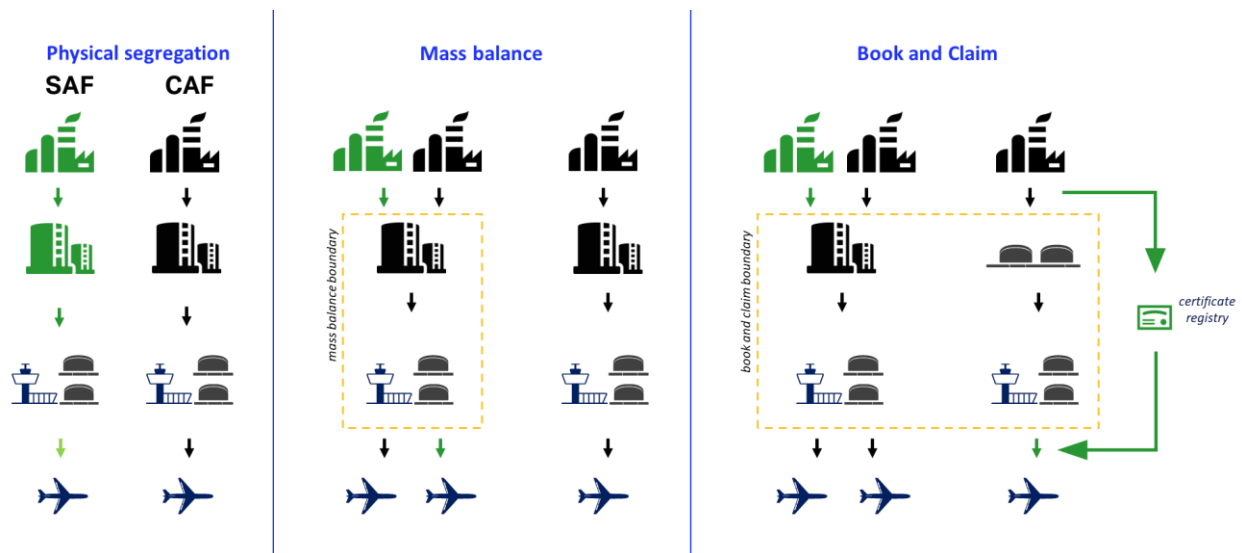
⁵⁷ ISO 22905:2020: <https://www.iso.org/standard/72532.html>

⁵⁷ ISO 22905:2020: <https://www.iso.org/standard/72532.html>

- Physical segregation
- Mass balance
- Book and claim

The following illustration provides a general overlook of the differences in fuel handling among the three CoC approaches:

Figure 20 - Fuel accounting based on Chain of Custody approaches



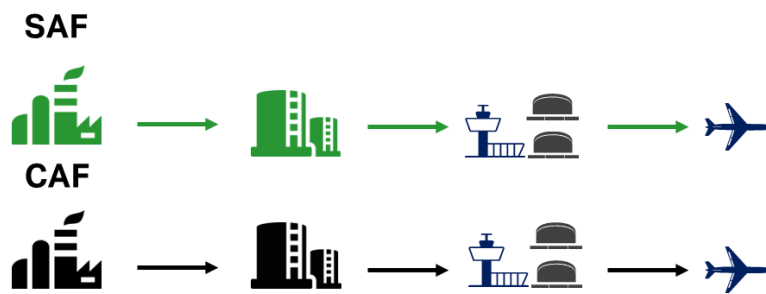
Source: Source: Adapted from SBTi - Book-and-Claim for Sustainable Aviation Fuel

3.2.1 Physical segregation

Specified characteristics of a material or product are maintained from the initial input to the final output.

Description: within a physical segregation approach suppliers need to maintain neat SAF molecules physically separated from all other fuel within the supply chain. Also referred to as the 'identity preservation' approach, neat SAF always remains physically separated from conventional jet fuel and other SAF batches along all stages of the fuel supply chain until it needs to be blended to uplift. In both cases the administrative handling (i.e. handling of the SAF attributes (e.g. GHG emission reductions) along the SAF supply chain goes hand in hand with the physical neat SAF product facilitating the full tracing of molecules back to its individual origin. The documentation is forwarded between each stage of the fuel supply chain. The below figure illustrates the example of a physical segregation CoC mechanism for neat SAF:

Figure 21 - Physical segregation CoC model



Source: Source: Adapted from SBTi - Book-and-Claim for Sustainable Aviation Fuel

Function: In this model, SAF is handled using dedicated storage, transportation, and handling facilities to maintain its purity. The physical segregation ensures that there is no cross-contamination between SAF and conventional fuels, providing end users with fuel that meets the highest sustainability standards.

Example: An airport receives a shipment of 1,000 liters of SAF, which is stored in a dedicated tank and transported using separate pipelines. Aircraft refueled from this tank receive 100% SAF, ensuring that there is no mixing with conventional fuel. This model provides the highest level of assurance regarding the purity of the SAF supplied to the end user.

3.2.2 Mass balance

Materials or products with a set of specified characteristics are mixed according to defined criteria with materials or products without that set of characteristics. - ISO/DIS 22095

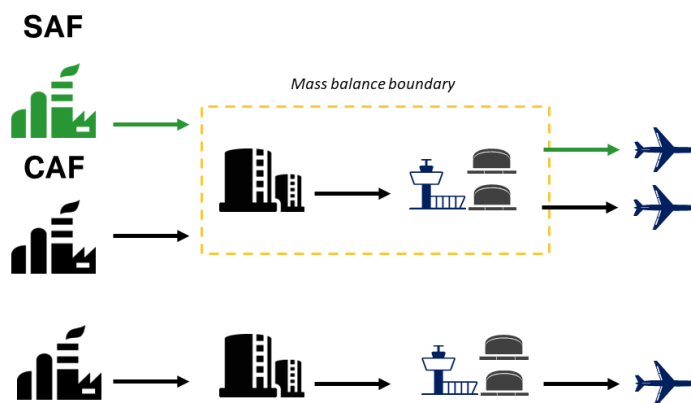
Description: The mass-balance model allows for the mixing of the SAF blend and CAF within the supply chain. This model ensures that the total quantity of SAF introduced into the supply chain is accounted for and that the claims made by end users do not exceed the actual amount of SAF supplied. It provides a practical approach to tracking SAF while allowing for flexibility by using existing fuel handling infrastructure and processes.

Function: In the mass-balance model, the SAF blend and CAF are mixed, but records are meticulously kept to track the volume of SAF entering and leaving the supply chain. The model operates on the principle that the amount of SAF claimed by end users must match the amount initially supplied, ensuring transparency and accuracy. This requires a robust accounting and reporting mechanism.

Example: An airport receives a total of 10,000 liters of fuel, consisting of 1,000 liters of a SAF blend with a total of 400 liters of SAF component, and 9,000 liters of CAF. Under the mass-balance model, the fuel supplier can blend these fuels and use existing airport fuel storage and handling infrastructure. Because the fuels are mixed records of the fuel's components must be kept to maintain credibility in the claims process and transparency that emission reductions from only correspond to 400 liters of SAF. This allows for flexibility in fuel management while ensuring that the SAF claims are accurate.

The next figure illustrates an example of a mass balance model:

Figure 22- Mass Balance CoC model



Source: Adapted from SBTi - Book-and-Claim for Sustainable Aviation Fuel

3.2.3 Book-and-claim

Administrative record flow is not necessarily connected to the physical flow of material or product throughout the supply chain - ISO/DIS 22095

Description: Book-and-claim is a CoC approach used to facilitate the traceability of the environmental benefits of SAF along the supply chain, based on purchase records. It complements mass balancing and gives access to SAF to all aircraft operators, while allowing cost efficient SAF deployment in all locations, maximizing the environmental benefits of SAF and accelerating aviation's decarbonization.

By providing a global market for SAF, the use of book and claim can:

- Enable SAF production where it is most efficient
- Minimize logistics costs
- Help avoid additional emissions from transport
- Promote competition

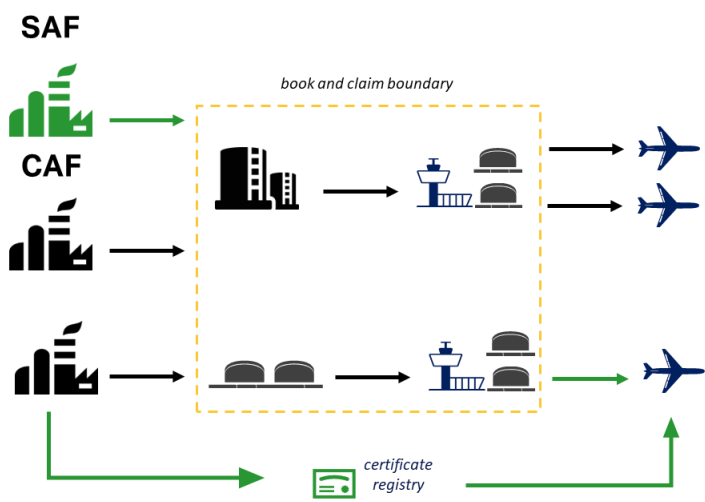
Function: within a book-and-claim approach to accounting and reporting, the SAF blend can be seamlessly fed into the existing fuel supply system and be commingled with further jet fuel batches. While only those aircraft that operate at airports that are fueled with SAF get physical SAF shares, under book-and-claim the environmental attributes of SAF

are completely decoupled from the physical SAF batches at this point. Ownership is attributed to the entity that purchased the SAF who may decide to keep them or issue corresponding certificates that can be managed through a central registry. From thereon, the certificates can be purchased and consequently allocated to those actors that have been granted access to the book-and-claim central registry and chose to purchase the rights to claim the SAF’s environmental attributes.

Example: A fuel supplier produces 1,000 liters of SAF and issues certificates representing the environmental benefits of this production. An airline operating in a different location purchases these certificates and claims the environmental benefits of using 1,000 liters of SAF, even though the physical fuel used by the airline may be 100% CAF. This model allows for greater flexibility and encourages the production and use of SAF across different locations.

The following figure illustrates the book-and-claim CoC model:

Figure 23 - Book and Claim CoC model



Source: Source: Adapted from SBTi - Book-and-Claim for Sustainable Aviation Fuel

The book-and-claim concept must fulfil various requirements, especially safeguards to prevent double counting, duplication, or fraud. Key principles laid out in Appendix I can serve as guidance to achieve the necessary functionality of a global, interoperable SAF accounting framework. For SAF producers, suppliers, and users, modern digital technology and recognized tracking and verification systems that facilitate the auditing of SAF environmental attributes can provide the necessary assurance.

The following illustrates a summary of all three CoC approaches:

Table 7 - Comparison between CoC approaches

Chain of Custody Model	Physical Segregation	Mass Balance	Book and Claim
------------------------	----------------------	--------------	----------------

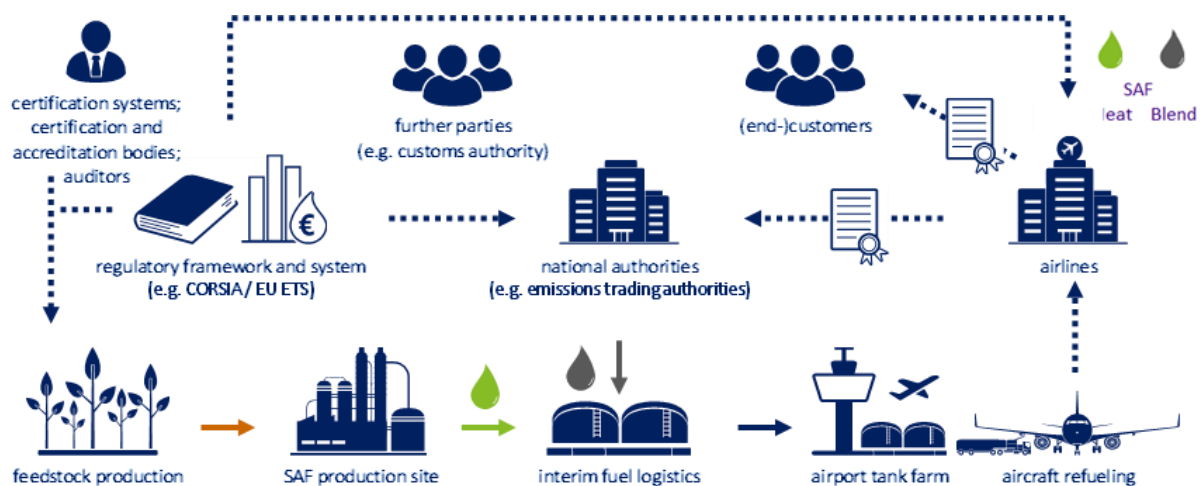
Ensures output of certified materials claim does not exceed the input	Yes	Yes	Yes
Physical traceability is possible	Yes	Yes (through allocation)	Restricted (decoupled)
Origins of a final product can be identified	Yes	Yes (through allocation)	Restricted (decoupled)
Mixing of certified and non-certified materials	No	Yes	Yes
Administrative and logistical cost and efforts	Highest	Medium	Lowest

The acceptance of robust SAF accounting and reporting mechanisms is essential for SAF deployment and uptake worldwide. The development and adoption of accounting and reporting mechanisms for SAF will require active collaboration among stakeholders across the supply chain, corporate users, and regulators.

3.3 Global harmonization on sustainability certification and accounting & reporting processes

To deploy SAF at an industrial scale, it is crucial to have a coordinated effort addressing both the supply and demand aspects. Additionally, when it comes to using SAF in everyday aircraft operations, specific measures are necessary to ensure a smooth integration. A key element of this endeavor is establishing frameworks and standards that govern the sustainability requirements of SAF and provide clear and practical standards for its reporting and accounting. Sustainability frameworks and reporting and accounting concepts are closely connected elements in this context, as illustrated in the following figure:

Figure 24 - Exemplary SAF supply chain



Source: TUHH

Sustainability frameworks set forth crucial prerequisites on feedstock and fuel production. Examples of such systems and frameworks include the EU ETS, CORSIA, and REFUA. Multiple stakeholders, including certification schemes like RSB and ISCC, as well as various auditing organizations, actively participate in this process, working together to confirm

and validate the practical application of the established sustainability standards within the aviation fuel industry.

In accordance with these requirements and in adherence to sustainability criteria, SAF can be produced and integrated into the aviation fuel ecosystem. Airlines subsequently use these SAF products in their aircraft operations. A key aspect of this process is the ability for stakeholders involved, especially airlines, to accurately monitor, report, and account for the quantities of SAF they use and its environmental attributes. For example, airlines may need to pass on these attributes to their end customers, account for them in programs like the EU ETS, or report SAF usage to national authorities.

This intricate process includes various stakeholders and entities within the aviation industry. However, due to the global nature of the aviation sector, characterized by its interconnectedness across international borders, attaining global alignment and harmonization for these frameworks and systems is not always a straightforward task. For instance, SAF processing plants are located across the world, where SAF is produced based on various feedstock options and conversion technologies. It can then be transported and used by numerous global airlines, each with its unique route networks, home markets, and compliance with various global, regional, and national regulations. The presence of diverse regulatory frameworks for SAF poses challenges as they impose varying requirements for the purchase, supply, utilization, and reporting of SAF by airlines. The determination of whether the produced SAF and its environmental attributes are considered "suitable" can depend on the specific target market where it is intended for use. This situation has led to an overall ongoing need for comprehensive global alignment and harmonization of sustainability frameworks, reporting, and accounting concepts in the aviation industry.

3.3.1 Sustainability Framework

Notable challenges arise from the differences in SAF frameworks and sustainability criteria, which vary internationally. These discrepancies can lead to divergent perspectives and approaches in different regions which can create uncertainty among stakeholders in the aviation industry regarding the scaling-up of SAF. These differences will be examined in more detail, with a focus on the regulatory frameworks for SAF in the European Union the United States of America and CORSIA.

i. European Union

In the EU, the EU Renewable Energy Directive serves as the fundamental regulatory framework for increasing renewable energy adoption across all sectors of the EU economy, including aviation.

Sustainability criteria specified in the EU RED has a global applicability. This means that if a renewable fuel aims to support the EU's renewable energy objectives and enters the EU market, all entities engaged in the fuel's value chain, regardless of their geographical location or country of production, must comply with the sustainability standards outlined in the RED.

EU RED and its related Delegated Acts remain pivotal as regulations, not only due to their regular updates but also because many other EU policies and instruments rely on the sustainability requirements and framework outlined in the RED. For example, under EU ETS provisions, emissions from SAFs are exempted, attributing them zero emissions if they meet the EU RED sustainability criteria (Table 8). In other words, SAFs need to be certified as compliant with the sustainability criteria of EU RED to qualify. Additionally, RFEUA heavily references the sustainability requirements outlined in the RED when determining the eligibility of renewable fuels under this framework.

ii. United States of America

Unlike in the EU, the several standards and incentives in the US that help support the deployment and uptake of SAF do not refer to sustainability criteria but instead they allocate incentives based on the fuel's emission reductions potential. For example, via an "opt-in" approach, SAF producers have the choice to participate in the RFS where they can generate RINs; SAF is credited with generating 1.6 RINs per gallon when compared 1 RIN per gallon for renewable diesel, without mandating the use of SAF in aviation fuel.

In the IRA, to qualify for the SAF-blenders tax credit (BTC) of 1.25 US\$ per gallon, the SAF must demonstrate a GHG emissions reduction over their lifecycle of at least 50% compared to CAF. Producers seeking to benefit from the SAF BTC must possess a valid certificate from an ICAO-approved sustainability certification scheme to ensure that emissions calculations align with ICAO's CORSIA methodology or a comparable methodology. The regulation offers an extra incentive for SAF achieving GHG reductions exceeding 50% by providing an additional tax credit of 0.01 US\$ per gallon for each percentage point above the 50% reduction threshold, up to a maximum credit cap of 1.75 US\$ per gallon. This encourages the adoption of fuels with the lowest lifecycle emissions.

Starting from 2025 and continuing through 2027, the Clean Fuel Production Credit (CFPC) will replace the SAF BTC. This credit will be available to SAFs with CO₂ equivalent emissions of less than 50 kilograms per million British thermal units (CO₂eq/MMBTU). The calculation of lifecycle emissions will also follow the methodology outlined by the ICAO CORSIA framework or a comparable methodology. The standard or base credit for aviation fuel is established at 0.35 US\$ per gallon and is multiplied by the "emissions factor" of the fuel and compared to a fossil comparator of 94 kg CO₂eq/MMBTU. This structure ensures that SAFs with lower lifecycle emissions will receive larger credits proportionally, thus promoting the development and use of more climate friendly SAF. Like the SAF BTC, SAF producers seeking compliance must hold a valid certificate from an ICAO-approved sustainability certification scheme (such as RSB or ISCC). This certification process verifies that emissions calculations align with ICAO's CORSIA methodology and confirms the fuel's adherence to ICAO's CORSIA sustainability criteria.

iii. CORSIA

CORSIA mandates that SAF must achieve a minimum lifecycle emission reduction of 10% when compared to a fossil fuel baseline of 89 grams of CO₂ equivalent per megajoule of fuel (g CO₂eq/MJ). These fuels must also meet various other sustainability criteria,

including aspects regarding carbon stock, water, soil, air, biodiversity, waste management, human rights, land and water rights, and food security.

LCAF is considered an eligible fuel if it achieves a minimum 10% reduction in lifecycle emissions compared to a fossil fuel baseline of 89 grams of CO₂ equivalent per megajoule of fuel (g CO₂eq/MJ). Like SAF, LCAFs must meet various other sustainability criteria, including aspects regarding carbon stock, water, soil, air, biodiversity, waste management, human rights, land and water rights, and food security.

To ensure compliance with the sustainability criteria, all eligible fuel must be verified and certified by CORSIA approved SCSs.

iv. Lack of Harmonization in Sustainability Frameworks

Given the disparities in regulatory frameworks, sustainability criteria, and associated nuances, there's a discernible lack of alignment between EU and US policies (Table 8). The EU prioritizes policies such as EU RED II, EU ETS, and REFUA, which incorporate specific restrictions on feedstocks like soybean and palm oil. However, the criteria outlined in the EU RED form the bedrock of these frameworks. Nevertheless, disparities exist in eligible fuel options within the EU RED and other programs like REFUA. Additionally, there's a strong emphasis on phasing out first-generation sources and adopting more stringent measures for fuels with CO₂ emissions from fossil sources. In contrast, the US places a greater emphasis on financial incentives, primarily through programs like blender tax credits (SAF BTC and CFPC).

The distinct set of sustainability criteria set by CORSIA means that producers aiming to offer SAF to airlines looking to comply with CORSIA or with EU mandates must navigate these differences; they must also secure certification from an approved SCS for fuel production, depending on the specific system.

Dual Conformance – a solution to widen SAF markets in the EU?

The absence of harmonization on sustainability criteria requirements between EU mandates and CORSIA limits market access for SAF:

- Airlines operating from outside Europe often don't have obligations under EU ETS (European Union Emissions Trading System).
- Since SAF certified under EU RED isn't recognized for CORSIA compliance, there's no incentive for non-European airlines to buy SAF and claim environmental benefits.

The recognition of **dual conformance** as a valid measure for compliance on sustainability criteria allows SAF to meet both EU RED and CORSIA requirements simultaneously.

Ultimately, dual conformance opens more opportunities for suppliers to sell SAF, enhancing market dynamics and competitiveness. This, in turn, increases its adoption, and supports global efforts to reduce aviation's climate impacts.

In contrast, the US approach which uses incentives to accelerate the uptake of SAF is more aligned with CORSIA's sustainability criteria and the methodologies to demonstrate compliance with these criteria as global standards.

Crucially, this diversity in regulatory frameworks extends beyond the US and the EU, if regions and countries worldwide, for example Asia and South America, develop their own SAF regulations in the future without considering alignment with existing systems. This global diversity of regulations poses a significant challenge for the aviation industry in terms of understanding and complying with various frameworks. Therefore, prioritizing harmonization, whenever possible, becomes a crucial consideration.

Additional aspects can be noted in this context as well.

- There is a lack of alignment between EU and USA SAF sustainability policies, particularly concerning feedstock and the inclusion of stringent social and ecosystem aspects. In the EU, policies and instruments like EU RED II, the EU ETS, and RFEUA include feedstock restrictions like soybean and palm oil and a phase-out of first-generation sources. In contrast, the USA primarily relies on blender tax credits systems based on emission reductions (where the "Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies" model, GREET model, can for example be used), with less comprehensive consideration of social and environmental factors such as water and soil, which may even be entirely omitted.
- The Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model and the methodology developed by the ICAO for CORSIA are used to assess the lifecycle emissions of SAF. However, these methodologies utilize different models and

assumptions, leading to partly significantly different estimations of lifecycle GHG emissions from SAF.

- GREET and ICAO CORSIA differ in how they handle land conversion emissions. GREET assumes carbon sequestration when cropland pasture turns into corn cropping, resulting in lower emissions estimates. ICAO CORSIA models assume carbon loss, leading to higher emissions estimates. Using ICAO CORSIA's approach in GREET would provide less optimistic estimates for corn ethanol's lifecycle emissions.
- Another difference between GREET and ICAO CORSIA is how they account for carbon sequestration in soil due to agricultural practices (such as cover crops, better fertilizer practices) during SAF production. GREET allows producers to choose these practices, potentially reducing emissions estimates, even if real-world benefits are uncertain. In contrast, the ICAO CORSIA methodology uses default values and MRV protocols to prevent potential misuse of reduced emission estimates.

The following table illustrates the disparities and similarities on SAF frameworks and corresponding sustainability criteria:

Table 8 - Comparison table – Sustainability Frameworks

Europe			US				ICAO
	EU RED	EU ETS	REFUA	US RFS	SAF BTC	CFPC	CORSIA
Fossil comparator	94 gCO₂eq/MJ	Aligned to EU RED	Aligned to EU RED	94 gCO₂eq/MJ	Aligned to CORSIA	94 kg CO₂eq/MMBTU	89 gCO₂eq/MJ
Minimum GHG reduction	- Biofuels: 50% / 60% / 65% - RFNBOs: 70% - RCFs: 70%	Aligned to EU RED	Aligned to EU RED for advanced biofuels, RFNBOs, RCFs	50% for advanced bio-fuel	50% (life cycle GHG emissions calculation follows ICAO CORSIA or comparable methodology)	<50 kg CO₂eq/MMBTU (life cycle GHG emissions calculation follows ICAO CORSIA or comparable methodology)	10%
Additional criteria	- Biomass feedstock exclusion from high biodiversity land, high carbon stock land, peatland - Fossil CO₂ emissions from power stations in RFNBO / RCF production count as zero until 2036 and until 2041 for other industrial sources. Post 2041, CO₂ must be sourced from DAC or biomass combustion (but biomass combustion must not be used solely as a carbon source) - Specific definition of Hydrogen sourcing requirements and	Aligned to EU RED	- Introduction of synthetic low-carbon aviation fuels, i.e. fuels from non-fossil, non-renewable sources (e.g. nuclear power) - Consideration of direct use of hydrogen in aircraft engines	- Production of SAF is credited by Renewable Identification Numbers (RINs) “opt-in” mechanism for SAF - Currently, SAF is credited with 1.6 RINs per gallon	- Base credit of 1.25 US-\$ per gallon, for each %-p. above 50 % GHG-reduction, additionally 0.01 US\$ - Maximum credit 1.75 US\$	Successor of SAF BTC, new minimum GHG reduction (s. above) and now multiplication of base credit (0.35 US\$) by “emissions factor” of fuel	SAF being a renewable or waste-derived aviation fuels, while LCAF is a fossil-based aviation

	GHG methodology for RFNBOs and RCFs defined by two additional, legislative acts						
Further restrictions	- cap on food / fodder crop biofuels (<1 %-point 2020 share; max. 7% share of road and rail final energy consumption) - high iLUC crops phase out (0% 2030) - cap on Annex 9B feedstock biofuels (limited to 1,7 % of transport fuel energy content)	Aligned to EU RED	- Biofuels sourced from raw materials not listed in Annex IX of RED II are limited to 3% - Food crops, cash crops, PFAD), soap stock, palm and soybean oil derivatives, etc. are excluded	Differentiation of the minimum GHG reduction depending on feedstock, e.g., 20 % for conventional biofuels and 50 % for advanced biofuels	- Complies with ASTM D7566 or FT provisions of ASTM D1655, Annex A1. - Derived from biomass materials. - Must be blended and sold in the U.S. (foreign production allowed if sold in the U.S.). - Excludes fuel from co-processing with non-biomass feedstocks, palm fatty acid distillates, or petroleum.	- Complies with ASTM D7566 or FT provisions of ASTM D1655, Annex A1. - Derived from biomass materials. - Must be blended and sold in the U.S. (foreign production allowed if sold in the U.S.). - Excludes fuel from co-processing with non-biomass feedstocks, palm fatty acid distillates, or petroleum.	Various regarding carbon stock, water, soil, air, biodiversity, waste, human rights, land and water rights, food security and more
Further mechanism	- advanced biofuel (Annex 9A feedstocks) sub-mandate - Multiplier of 2 for (all) Annex 9 feedstock biofuels - Multiplier of 1.2 for aviation / maritime supplied fuels (except	Aligned to EU RED	- Use of low-carbon fuels (they are not considered SAF but can be used to meet the synthetic fuel sub-mandate) - Blending mandates is considered as a	Update of volume requirements in 2023			

	from food / fodder crops)		weighted average across the EU during transition period until the end of 2034 ▪ during that time, fuel suppliers may trade SAF certificates from overachievers to underachievers.				
Eligible SCS	▪ 15 (RSB, ISCC, Bonsucro EU, RTRS EU RED, 2BSvs, RBSA, Greenenergy Brazilian Bioethanol verification programme, etc.)	▪ Aligned to EU RED	▪ Aligned to EU RED	▪ Defined list of production pathways ▪ Each pathway needs to be qualified by US Environmental Protection Agency (EPA)	▪ Aligned to CORSIA	▪ Aligned to CORSIA	▪ RSB & ISCC
Allowed MRVA mechanism	▪ Physical segregation ▪ Mass balance	▪ Physical segregation ▪ Mass balance	▪ Under flexibility mechanism (until 2035): ▪ Mass balance ▪ Potentially in the future: Book-and-claim ▪ Physical segregation ▪ Mass balance	▪ Book-and-claim via RVO.	▪ Credit for fuel blending, not use	▪ Credit for fuel blending, not use	▪ Mass balance ▪ Book-and-claim

3.3.2 Accounting and Reporting Methods

In addition to regulatory frameworks governing SAF sustainability criteria the development and integration of CoC models for SAF is a crucial aspect on a broader system scale. Much content on accounting and reporting has already been described section 2 of this handbook, but essentially, an effective CoC model serves as a connecting element to demonstrate SAF compliance with specific sustainability requirements (e.g., from regulatory frameworks) and to track, monitor, report, and verify its environmental attributes along the fuel supply chain.

In particular, accounting concepts based on the book-and-claim CoC model are gaining popularity. Additionally, there is a growing interest among airline end customers in tracing the SAF used in their upstream value chain, underscoring the critical importance and need for effective reporting and accounting procedures. However, presently, harmonized CoC models for SAF have not been fully integrated into existing SAF policies, GHG schemes that include SAF, or voluntary SAF reporting frameworks. Thus, currently, airlines and fuel suppliers often find themselves implementing individual "best practice" strategies, resulting in SAF accounting and reporting being a complex and time-intensive process.

In existing GHG schemes that incorporate SAF, such as the EU ETS and CORSIA, there are already basic accounting and reporting procedures in place. However, these procedures often rely on simplistic and complex accounting and reporting processes, which necessitate gathering various types of documentation from different stakeholders throughout the supply chain.

Furthermore, fuel suppliers and airlines typically operate on a global scale, and SAF producers are likely to be situated in various locations worldwide in the future. It is then essential to consider the requirements and necessary concepts related to CORSIA and the European Union's 2050 carbon neutrality goal and the RFEUA initiative within the broader global context. This implies that the efforts and implementations concerning Monitoring, Reporting, Verification, and Accounting (MRVA) for SAF must be designed to be as compatible as possible across mechanisms and regulations globally right from the outset.

Ensuring accurate accounting and reporting based on current requirements is already a significant challenge for some airlines, whether within national blending mandates or for voluntary environmental reporting. As the SAF market grows, complexities in accounting and reporting for SAF usage are likely to become more challenging and lead to increased administrative costs. Overall, there should be a harmonized approach for all international industry stakeholders involved as far as possible.

i. Lack of Harmonization on Accounting and Reporting Procedures

The aviation industry lacks a universally accepted framework for MRVA of SAF. Instead of a cohesive standard, various stakeholders often follow "best practices". This fragmented approach results in inconsistencies, scalability issues, and compatibility challenges across regions and facets of the aviation sector. Pilot projects are underway to refine MRVA concepts, providing foundational knowledge for broader standardization efforts. The industry increasingly recognizes the need for systems like book-and-claim to harmonize SAF

MRVA practices. A comprehensive, globally recognized MRVA standard, can address these disparities and fully leverage SAF's potential, ensuring uniformity and alignment across the aviation landscape. The following table illustrates the disparities and similarities on SAF Accounting and Reporting Procedures:

Table 9 - Comparison table – Accounting and Reporting Procedures

	Europe			US			ICAO
	EU RED	EU ETS	REFUA	US RFS	SAF BTC	CFPC	CORSIA
Allowed MRVA mechanism	-Physical segregation -Mass balance	-Physical segregation -Mass balance	-Under flexibility mechanism (until 2035): -Mass balance -Potentially in the future: book-and-claim, physical segregation, mass balance	-Book-and-claim via RVO	-Credit for fuel blending, not use	-Credit for fuel blending, not use	-Mass balance -Book-and-claim

4 Handling, Safety & Quality Assurance

As the aviation industry transitions into sustainable practices through various scaling and new technologies, airports play a key role in planning and facilitating the path towards net-zero targets. SAF aims to be the largest contributor to minimize the environmental impact of aviation.

As of now, the supply of CAF is well established and encompasses a highly interconnected network of pipelines, ships, rail, or road transports carrying large fuel volumes across the globe, to match the places of production with the places of demand. CAF is traded as commodity, with a defined set of properties and components. Those properties and components are defined in the fuel specifications. In contrast, SAF is currently produced, traded, and supplied at far smaller volumes than conventional jet fuel. Considering its drop-in quality, once blended with CAF, SAF is fully compatible for handling in the same infrastructure as conventional jet fuel, which in terms reduces logistical cost as well as associated emissions.

4.1 Compatibility of SAF handling with existing infrastructure

When a SAF blend reaches an airport and is found to be fully compliant with fuel specifications, it is ready to be uplifted by aircraft operators and for a fuel supplier point of view, it is handled using the same procedures and infrastructure as CAF.

Jet fuels are transported in bulk quantities to airports. They often use shared systems between fuel suppliers and other fuel grades. Although there are requirements to separate jet fuel from other fuels, the same storage sites (different tanks) can be used, and vessels and pipelines can transport multiple kinds of fuels, with appropriate quality control measures. As described above, SAF is typically supplied as blend compliant with ASTM D1655 and can thus be treated in the same way as CAF. Detailed fuel handling standards are laid out as follows:

■ The Energy Institute

The EI is a professional membership body based in the UK that provides knowledge and information to the energy sector through conferences and technical publications. EI has published several significant technical documents for the aviation industry, including:

- Joint Inspection Group or JIG/EI 1530 Quality assurance requirements for manufacturing, storing, and distributing aviation fuels to airports. This document presents best practices for safely handling jet fuel from the refinery to storage at the airport and has a short section on synthetic fuels. EI 1530 is a joint publication with JIG.
- EI 1533 Quality assurance requirements for SSJT and SBCs. This document provides quality assurance requirements and recommendations for the manufacture of synthetic (jet fuel) blending components (in accordance with ASTM D7566), their export and import, blending with conventional jet fuel/jet fuel components to produce semi-synthetic jet fuel (also referred to as Sustainable Aviation Fuel), and the export/import of semi-synthetic jet fuel from its point of origin through to delivery to airports. EI 1533 is a supplement to, and intended to be read in conjunction with, EI/JIG Standard 1530.

- EI 1550 Handbook on equipment to maintain and deliver clean aviation fuel. This document complements JIG/EI 1530 with more in-depth information regarding equipment and best practices to keep aviation fuel clean as it travels along the supply chain.

■ **Joint Inspection Group (JIG)**

The JIG was initially established by major oil companies serving large airports worldwide to develop standards for the operation and handling of jet fuel at shared facilities at those airports. JIG continuously updates these standards to reflect the latest understanding of jet fuel quality control practices. The Standards which JIG maintains are:

- JIG 1 – Aviation Fuel Quality Control and Operating Standards for Into-Plane Fueling Services
- JIG 2 – Aviation Fuel Quality Control and Operating Standards for Airport Depots
- JIG 4 – Aviation Fuel Quality Control and Operating Standards for Smaller Airports

JIG also maintains the Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS), a checklist with the most stringent requirements from both ASTM D1655 and Def Stan 91-091. As with Def Stan 91-091, synthetic components are permitted but “shall be reported as a percentage by volume of the total fuel in the batch”. This checklist is used extensively, especially at airports outside the United States. The IATA Fuel Quality Pool (IFQP) audits fuel companies and infrastructure to ensure compliance with this standard and checklist.

■ **Airlines for America (A4A)**

A4A, formerly known as the Air Transport Association or ATA, is the largest trade association for commercial airlines in the United States. With the collaboration of representatives from airlines, oil companies, and fuel handling companies, A4A developed the ATA Spec 103 “Standard for Jet Fuel Quality Control at Airports”, which is widely used at airports in the United States.

■ **International Civil Aviation Organization**

In 2012, ICAO published the Manual on Civil Aviation Jet Fuel Supply (Doc 9977, AN/489), which summarizes the main recommended practices for safely handling jet fuel along the entire supply chain from the refinery to the aircraft's wing. The manual references guidelines published by other entities such as EI and JIG.

To improve utilization and reliability, airport infrastructure (e.g., kerosene storage) is mainly shared between two or more fuel suppliers, but this depends on geography and size of the airport. In the EU, the Ground Handling Directive mandates that airports with more than two million passengers must give nondiscriminatory access to multiple fuel suppliers, to ensure competition. This leads to multiple fuel suppliers using the same systems at the airport. For the current system design, the shared use of tanks and supply lines prevents a segregated supply

of particular fuel batches to individual aircraft. Additionally, fuel suppliers need to account their supplies and deliveries via a mass-balance approach.

From airport storage tanks, there are two common ways to supply an aircraft: fuel bowzers and underground hydrant systems. While there is no clear boundary what system is used when, fuel hydrants are mostly found at larger hubs, due to the increased cost of installation. Fuel bowzers offer a more flexible solution but will be more costly to run at high frequency locations. In addition, for larger long-haul aircraft, more than one fuel bowser might be needed, adding complexity and costs.

Unless there is a specific purpose for segregation, a SAF blend is fully compatible to be handled using existing airport infrastructure and following existing handling standards.

The following section further explores those scenarios where airports may want to choose to segregate SAF while supply remains limited, intended to optimize environmental benefits.

4.1.1 SAF Usage Scenarios

Based on the climate modelling and benefits derived from SAF usage investigated by ALIGHT consortium partner DLR, two categories of scenarios were selected aimed at optimizing SAF usage to gain the most benefits to the environment:

- Category I: segregated supply **at the gate**
 - SAF drop-in blends - segregated to maximize environmental benefits.
 - Jet X - segregated for safety reasons (mandatory given its non-drop-in characteristics) and to further maximize environmental benefits.
- Category II: optimization **at mission scale**
 - Taxi-out & take-off
 - In flight switching when high risk of contrails

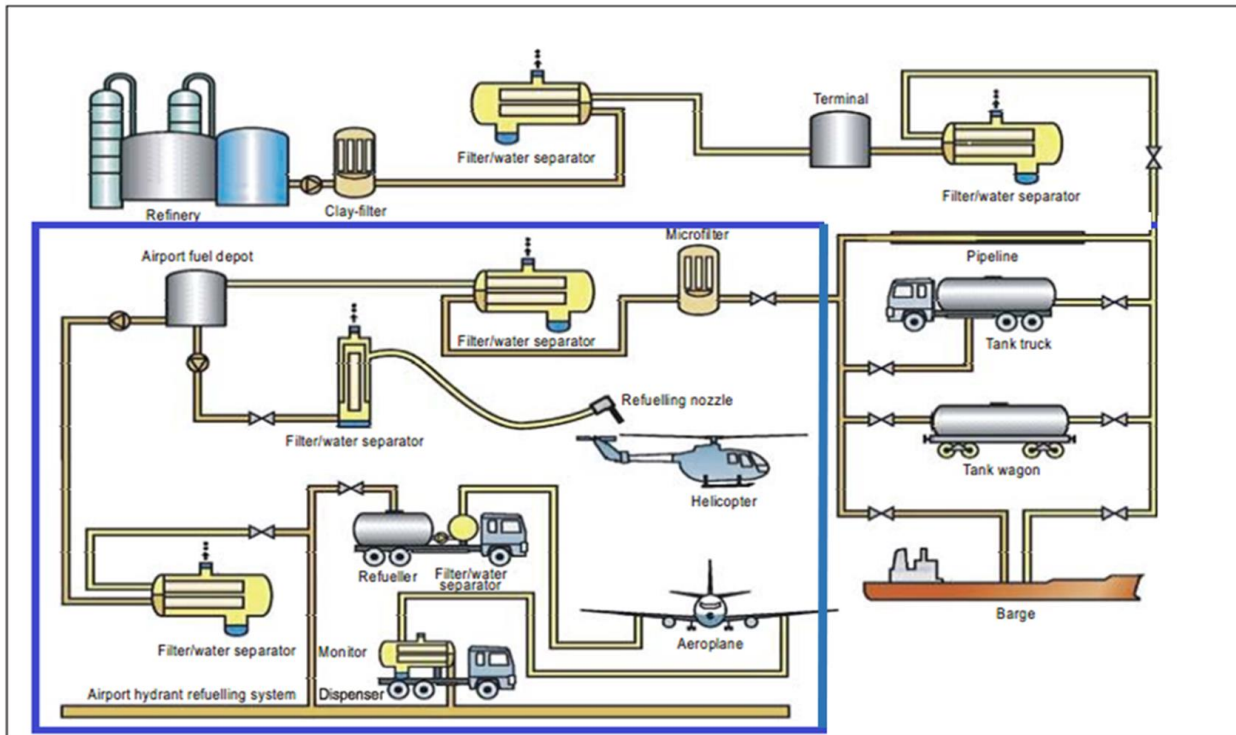
The identification of the above categories led to the selection of the following four primary scenarios to explore and four options for future consideration to optimize SAF usage:

Primary Scenarios

- i. Scenario 1 – Co-Mingled / business as usual
- ii. Scenario 2 - Dedicated flights
- iii. Scenario 3 - Dedicated airports
- iv. Scenario 4 - Non-drop-in Jet X

The four primary SAF usage scenarios are described in detail below, all situated along the following boundary:

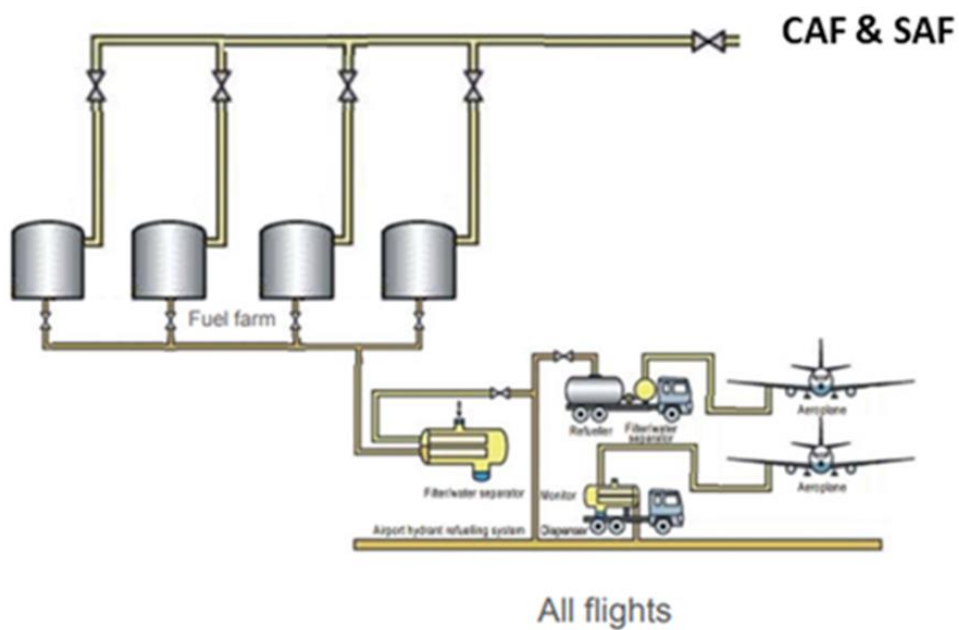
Figure 25 - Supply and distribution chain



Source: ICAO Doc 9977

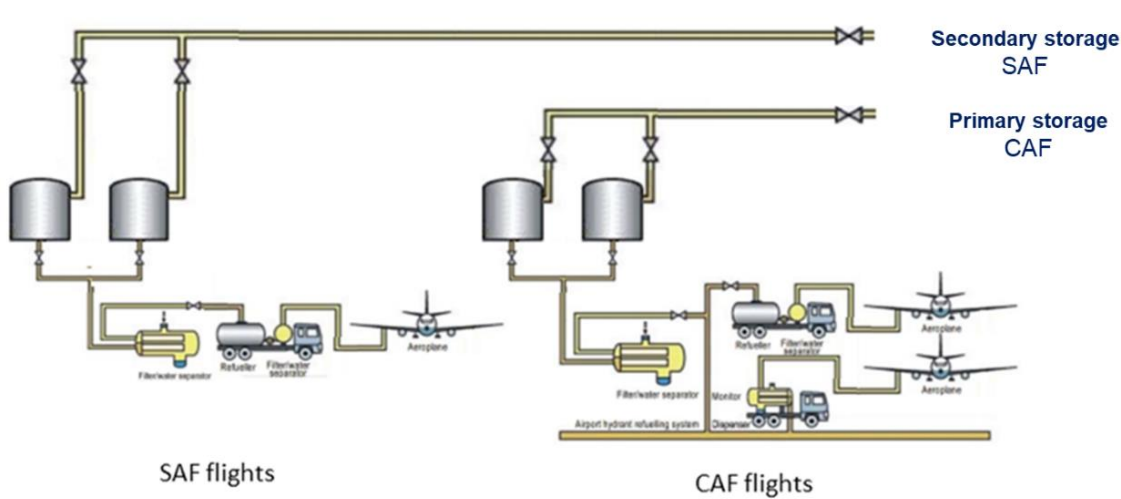
- i. **Scenario 1- Co- Mingled Business as Usual (BaU):** CAF is blended and stored with up to 50% SAF limit authorized as per ASTM at the fuel farm of the airport utilizing the existing storage infrastructure. Distribution of fuel to the aircraft is completed following existing procedures (fuel trucks or hydrants).

Figure 26 - Scenario 1 – Co-Mingled BAU



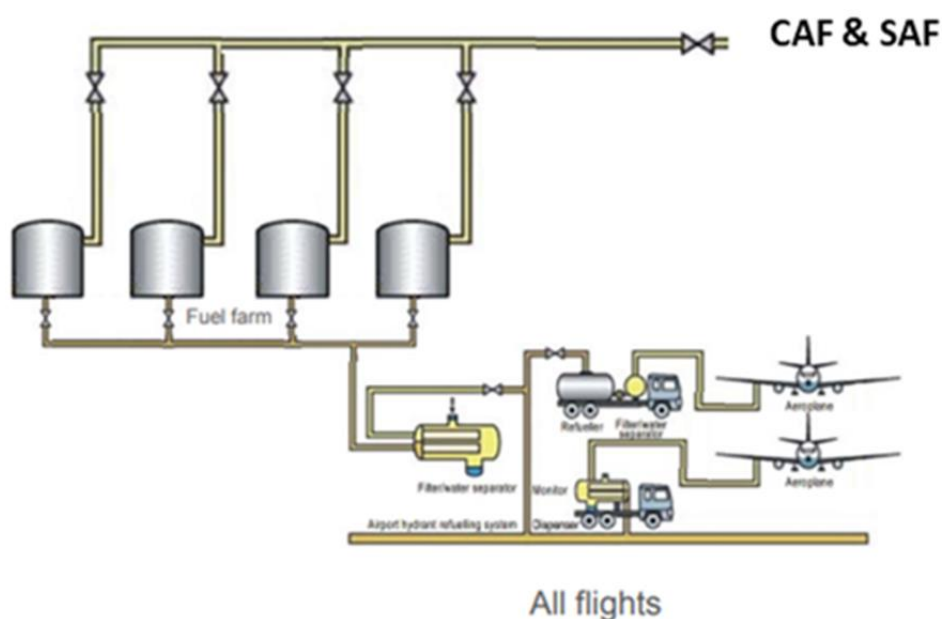
- ii. **Scenario 2 – Dedicates flights:** existing fuel storage tanks at the fuel farm are dedicated to the SAF blend up to the 50% SAF limit authorized as per ASTM. Alternatively, new storage tanks are added to the fuel farm to store the SAF blend. The remainder storage tanks at the airport’s fuel farm are used for CAF storage. This segregation enables the filling of a fuel truck to meet the specified fuel grade and deliver only to those flights selected to use the SAF blend. Alternatively, for long term distribution, the use of a parallel hydrant system may apply. Distribution of CAF follows existing procedures.

Figure 27 - Scenario 2 – Dedicates flights



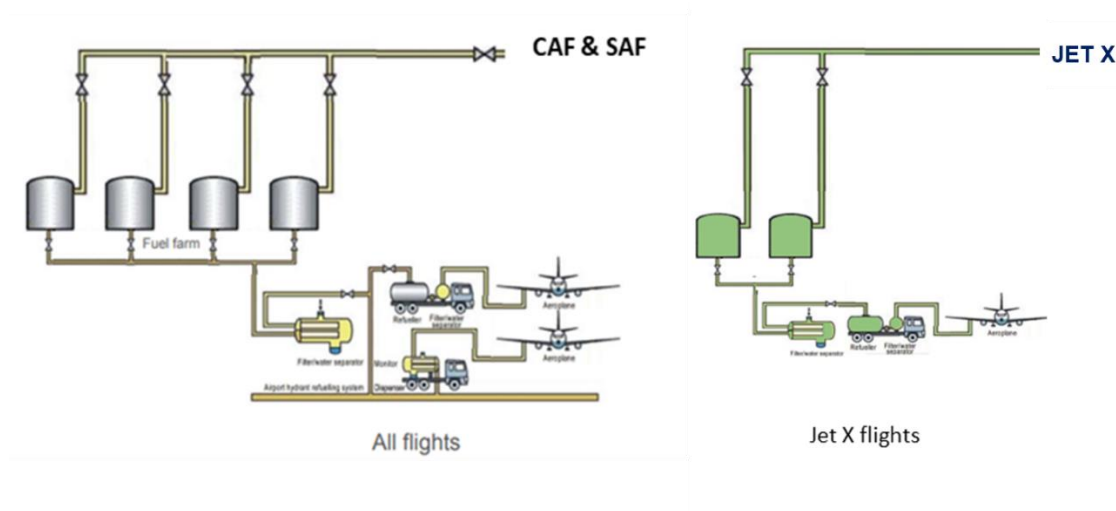
- iii. **Scenario 3 – Dedicated airports:** CAF is blended and stored with up to 50% SAF limit authorized as per ASTM at the fuel farm of the airport utilizing the existing storage infrastructure. The supply of the SAF blend is prioritized to selected airports qualified to optimize non- CO2 benefits. Distribution of fuel to aircraft is completed as of today (fuel trucks or hydrants), with control of the % of SAF that enters the aircraft.

Figure 28 - Scenario 3 – Dedicated airports



- iv. **Scenario 4 – Supply of non-drop in 100% SAF fuel or Jet-X:** a section of the fuel farm at the airport is dedicated to store jet X (100% non-drop-in SAF), the remainder is dedicated to store CAF neat or blended with up to 50% SAF limit authorized as per ASTM at the fuel farm. If needed, new storage tanks are added to the fuel farm to store 100% jet X fuel. The segregation of jet-X at the airport's fuel farm enables the filling of a dedicate jet-X fuel truck to meet the specified fuel grade for aircraft compatible to use jet X fuel only during uplift (feasibility of the distribution of jet-X by hydrant to be assessed for long term supply). Distribution of CAF neat and CAF/SAF blend fuel to aircraft is completed following existing procedures.

Figure 29 - Scenario 4 – Supply of non-drop in 100% SAF fuel or Jet-X



Additionally, section 4.5 provides two case studies on the experience lived by CPH and ADR during the first time SAF was used at their airports as a blend.

Besides the physical flow of aviation fuel within existing airport fuel infrastructure, whether SAF or CAF, the safety aspect of quality assurance and corresponding documentation is another pivotal point to track and comply with safety standards. This will be described in detail in the following section on quality assurance.

4.2 Quality assurance

SAF is jet fuel which uses a proportion of sustainable feedstock in place of conventional crude-oil (fossil) feedstocks for manufacture (see Section 1). From a fuel quality and specifications point of view, composition of molecules in the fuel blend resembles the composition in CAF as the approved synthesis routes have been carefully reviewed by the aviation industry, aircraft and engine manufacturers, regulators, and military. Thus, there are no new components in SAF which have not existed in CAF for decades, the fuel being within known parameters.

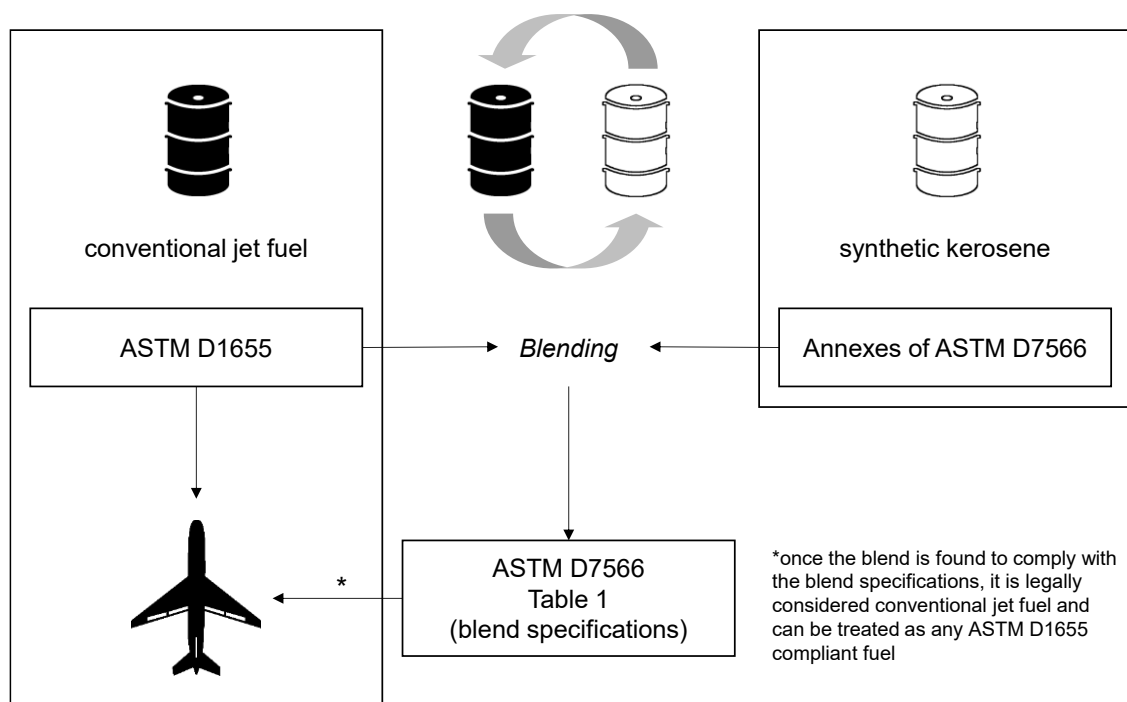
Commonly used specifications for CAF include the following:

- ASTM D1655: "Standard Specification for Aviation Turbine Fuel" (US and international). ASTM specifies two grades: Jet A and Jet A-1, which differ in accepted freezing points.

- UK Defense Standard 91-091: “Turbine Fuel, Aviation Kerosene Type, Jet A-1” (UK and international).
- Joint Inspection Group (JIG): Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS, or “joint checklist” – international).
- GOST 10227 TS-1: Russia grade fuel.
- Number 3 Jet Fuel: China-grade fuel.
- Others, produced by organizations (engine manufacturers, pipeline operators, etc.) wishing to define fuel to their requirements.

While ASTM D1655 and Def-Stan 91-091 describe standards, which the fuel at the airport needs to adhere to, ASTM D7566 is the specification for the synthetic kerosene part of the blend, SAF for the purpose of this handbook. Once found to be compliant with ASTM D7566, SAF needs to be blended with conventional kerosene to further comply with specification ASTM D1655. Once compliance with ASTM D1655 has been demonstrated, the blend can be treated in the same way as CAF and thus the same, well-established quality assurance measures apply. For this reason, there are hardly any additional fuel quality assurance measures required for SAF blends, as illustrated in the following figure:

Figure 30 - Requirements for CAF and synthetic kerosene – SAF - before and after blending



Source: air bp

4.3 Future considerations related to non-CO₂ climate effects

Non-CO₂ climate effects are estimated to make up for up to 2/3 of aviation climate impact in terms of radiative forcing⁵⁸. Hence, these effects have gained increasing attention in recent years. A large part of non-CO₂ effects, is caused by cirrus clouds formed based on soot particles

⁵⁸ Lee, Sep. 3, 2020.

emitted by aircraft. Such clouds can develop a warming climate impact, depending on various meteorological and environmental conditions. Further non-CO₂ effects are attributed to the emission of nitrous oxide (NO_x) and direct and indirect effects of soot and sulfate aerosol emissions⁵⁹.

Certain components in aviation kerosene, mainly aromatics, are considered to enhance the formation of soot for present-day aircraft engines. Since SAF contain fewer aromatics and neat synthetic kerosene is virtually aromatics free, the use of SAF to reduce contrail climate impacts is discussed as a potential mitigation measure⁶⁰. Another option to mitigate contrail climate impacts could be the avoidance of contrail-sensitive flight regions⁶¹.

Given current limitations on SAF availability, it is still a long way until fueling with 100% SAF is possible. Yet if that scenario is reached, it should lead to considerations on how to utilize SAF in the most efficient way and promote mitigating non-CO₂ effects, e.g., by targeting SAF towards particularly climate relevant flights or supplied to dedicated airports at risk of compromising LAQ levels, for example. This could require the development of a segregated SAF supply and the creation of mechanisms supporting non-CO₂ mitigation measures in general.

Under section 4.2 below, readers can find two matrices analyzing the infrastructure needs, among other, according to the four SAF usage scenarios, focused on BaU vs segregated supply to maximize non-CO₂ and LAQ benefits from SAF.

4.4 Fuel Handling Matrix – Co-mingled vs. Segregated – Pros and Cons.

As science provides more accurate data on aviation's non-CO₂ climate impacts, the use of SAF may contribute to reduce the risks of contrail formation during flight and improve levels of LAQ at airports. These benefits may be attained by implementing SAF usage scenarios 1 or 2 through 4 referenced under section 4.1 above, mainly:

- Scenario 1: Co-mingled - BaU
- Scenario 2 - 4: Segregated use of SAF

The following matrices present the pros & cons. of these two scenarios on SAF usage that consider probable technical, commercial, and regulatory implications of co-mingled vs. segregate fuel handling practices:

⁵⁹ Lee, Sep. 3, 2020.

⁶⁰ Gunnar Quante et. Al, August 2024: <https://www.sciencedirect.com/science/article/pii/S2590162124000467?via%3Dihub>

⁶¹ Teoh, Roger; Schumann, Ulrich; Stettler, Marc E. J. (2020): Beyond Contrail Avoidance: Efficacy of Flight Altitude Changes to Minimise Contrail Climate Forcing.

Figure 31 - Pros & Cons Matrix for Co-mingled SAF usage

Scenario	Stage	Implications		
		Technical	Commercial	Regulatory
		Product Quality, space or actual ability to change refueling infrastructure (e.g.: hydrants underneath the tarmac)	Cost of setting up a parallel infrastructure, customer preferences, refueling operator preferences.	Non-CO2 impacts, credibility of emission reductions claims, LAQ, etc.
1. Co-mingled	JV Hubs	Use of existing fuel storage and fueling infrastructure, no modifications needed.	No parallel infrastructure needed – no additional costs.	Unable to adjust to customer preferences on SAF physical usage aimed at reducing climate impact of contrails. At total overall SAF blend >30%, enhanced impact in improved LAQ.
	Documentation	BAU on fuel quality and safety checks along the supply chain.	Decreased admin burden given no need to trace physical blend at each step. Robust IT systems to improve traceability of environmental benefits and credibility of emission reductions claims.	In cases where certain aircraft operators purchase higher emission reductions rights to claim than the SAF uplifted would provide, higher potential risks for double counting. This would generate a regulatory risk.
	Operator (Commercial, FBO)	Single operator can handle SAF-CAF blend	No need for additional personnel/service providers for storage and into-plane fuel handling.	

Figure 32- Pros & Cons Matrix for Segregated SAF usage

Scenario	Stage	Implications		
		Technical	Commercial	Regulatory
		Product Quality, space or actual ability to change refueling infrastructure (e.g.: hydrants underneath the tarmac)	Cost of setting up a parallel infrastructure, customer preferences, refueling operator preferences.	Non CO2 impacts, credibility of emission reductions claims, LAQ, etc.
2. Segregated	JV Hubs	Requires parallel infrastructure for fuel storage and fueling and a dedicated fuel farm and hydrant system or browser trucks for segregated into-plane delivery.	Short and medium term, very costly option due to interruptions to existing airport operations for construction of parallel infrastructure Increased turn around time due to refueling by multiple operators.	Provides option for aircraft operators to lower climate impact of contrails. If SAF is uplifted mostly in least efficient engines, better potential for improvements in LAQ. If SAF blend >30%, better potential for LAQ improvement.
	Documentation	Increased costs for parallel check on quality and safety of fuel along the supply chain.	Increased admin costs to prove traceability at physical bend per stage. Robust traceability of segregation provides added credibility to accounting and reporting on emission reductions claims.	Risk of fueling cross-contamination may lead to errors in accounting, reporting, and claims.
	Operator (Commercial, FBO)	Increased costs as multiple operators are needed to handle both CAF and SAF segregated and simultaneously.	Increased cost of personnel/service providers for storage and into-plane fuel handling.	Potential regulatory risk if use of available space within airport grounds may is not fit for use (permitting) to accommodate additional fuel storage, parallel refueling systems, and additional browser trucks.

4.5 SAF Usage Case Studies – The Experience of CPH and ADR

This section includes two cases studies describing the experiences of CHP and ADR using SAF blends for the first time. There is a clear contrast on the approach each took to either react or act when looking to incorporate SAF blends into airport grounds.

Each case study serves as an example of those actions to replicate and those to avoid for any airport that is looking to ensure a safe and efficient supply of SAF to aircraft operators. Depend-ent on the type of airport, some may choose to replicate the case of CPH or ADR, or a blend between both approaches to better suit the current situation and future ambitions on SAF usage.

These case studies are structured as follows:

- **Executive Summary:** Provides an overview of efforts and achievements in integrating SAF and other sustainability initiatives.
- **Introduction:** Contextualizes the operations and historical fuel supply infrastructure at the airport, establishes the significance of incorporating SAF, and outlines the scope and key aspects of the case study.
- **A bold step forward - incorporating SAF into airport grounds:** Discusses the commitment to decarbonization and the strategic actions taken.
- **Stakeholder engagement:** Details the involvement of key stakeholders in the SAF integration process.
- **SAF procurement: how, what, and where:** Explains the procurement process for SAF, including supplier selection and pathway considerations.
- **SAF handling and logistics:** Describes the logistics and handling processes for SAF, including the two tests conducted.
- **Documentation:** Covers the documentation requirements for SAF procurement and handling.
- **Leadership and communications:** Highlights leadership in sustainability and efforts to raise public awareness.
- **Conclusions:** Summarizes the key findings and lessons learned from the experience of integrating SAF into airport operations.
- **Timeline:** Provides a visual representation of the stakeholders involved, actions taken, and the evolution of the case study over time.

Ultimately, these case studies aim to provide a comprehensive overview of the opportunities and challenges that have emerged from the implementation of SAF at CPH and ADR's airports, taking a reactive and active approach correspondingly, while also offering an assessment of the practices adopted that may serve for replication in other airports.

4.5.1 SAF usage case study – CPH

Executive Summary

This case study details the introduction and implementation of SAF blends at CPH. The airport relies heavily on a continuous supply of jet fuel to maintain safe and efficient operations. In 1961, the joint venture Braendstoflageret Københavns Lufthavn I/S (BKL) was established to manage the growing fuel demand. The fuel supply operations remained unchanged until 2023 when SAF was blended with CAF and introduced into CPH's infrastructure for the first time.

The document outlines the entire supply chain process, from planning to delivery, involving key stakeholders such as Air Greenland and DCC & Shell Aviation Denmark A/S (DCC). It emphasizes the importance of SAF in reducing CPH's scope 3 emissions and improving local air quality. Although traditionally, jet fuel procurement has not handled by the airport, the potential benefits of SAF have garnered CPH's active interest and support.

In 2023, CPH received its first SAF blend delivery, with Air Greenland being the primary initiator. Air Greenland's commitment to sustainability led to the decision to use SAF, aligning with their business plan and local community needs. DCC, with prior experience in SAF handling, facilitated the trade and ensured proper logistics and quality assurance. The SAF procurement involved various logistical considerations, including segregated delivery and co-mingling with CAF. CPH did not play a direct role in the procurement but supported the initiative due to its environmental benefits. Future plans include continuous SAF blend supply using existing infrastructure and involvement in various projects to support sustainable aviation.

This case study provides insights into the efforts and collaborations required to introduce SAF blends at CPH, highlighting the challenges, successes, and future directions for sustainable aviation at the airport.

1. Introduction

Operations at CPH require a constant supply of jet fuel of the right quantity and quality to ensure continuous and safe operations, a responsibility assumed by fuel suppliers and CPH's fuel farm operator BKL. As air traffic movements increased through the years, so did the need for a more robust fuel supply infrastructure and in 1961, CPH fuel suppliers created the joint venture BKL, deciding to build a supply pipeline and hydrant infrastructure to manage the increased demand. Fuel supply operations remained unchanged until 2023, when SAF, blended with CAF, was introduced into CPH's fuel infrastructure for the first time.

This case study describes the set-up, key actors, and considerations and decisions taken by stakeholders along the entire supply chain to plan for and realize the use of a CAF/SAF blend at CPH. Actions regarding handling, logistics, sustainability certification, and quality assurance are also described in detail.

Though the purchasing of jet fuel has never been a matter handled by the airport, the potential for SAF to contribute toward CPH reducing scope 3 emissions and improve local air quality makes it an interesting initiative for the airport to follow and support closely. This case study also offers a deep dive on expected activities related to SAF usage at and by CPH, a look at

regulation that will affect the uptake of SAF at the airport, and CPH's plans to work on raising awareness about SAF among clients, passengers, and the public.

2. A bold step forward – incorporating SAF into airport grounds

This section outlines the activities, decisions made, and stakeholders involved in delivery of the first SAF batch to CPH.

In 2019, it was anticipated that SAF would be gradually introduced at CPH for voluntary purchases, as aviation transitioned towards a more sustainable future. However, the COVID-19 pandemic drastically altered these plans, temporarily closing most airport operations. As a result, the global use and production of SAF took a step back. As the world and the aviation industry returned to business-as-usual post-pandemic, the momentum that had built up around SAF still struggles to regain its former strength.

Nonetheless, in 2023, the first delivery of a SAF blend to CPH took place. This voluntary SAF purchase required all involved parties to collaboratively address potential obstacles and new sustainability documentation requirements, which will be detailed in the following sections.

2.1 Decision making process and stakeholder engagement

Not until 2023 were the first volumes of SAF introduced to CPH, driven by demand from Air Greenland. Air Greenland, which operates from Greenland, serves as a vital connection point for European air travel across the Atlantic. The company has a strong commitment to contributing to the country's sustainable development goals. Their sustainability agenda is embedded in their business plan and aligned with the needs of the local community, as well as the ambitious environmental protection demands of their customer base.

Though Air Greenland is a small-to-medium-sized airline, the company has worked to become a sustainable aviation operator by first tackling operational efficiencies and capacity building, making the use of SAF the obvious next step. Understanding the sustainable trend taking hold of the industry, the company realized that investing in SAF was a vital part of their transition. This realization led to an internal discussion between management and the board concerning future investments in alternative propellants. After six months of deliberations in 2021, a decision was made to position Air Greenland as a leader in voluntary SAF usage, with the aim of inspiring the rest of the aviation industry to join them in this journey.

In late 2021, Air Greenland began discussions with DCC to determine the process that would facilitate the voluntary purchase of SAF for use on their route to and from CPH.

2.2 Stakeholder engagement

Air Greenland's preliminary search for SAF was facilitated by consulting the two largest fuel suppliers in CPH: AirBP and DCC. Since DCC had prior experience handling SAF at various locations in the Nordic region, including Denmark, they became the preferred choice for Air Greenland over other suppliers.

Additionally, Air Greenland holds an established purchase agreement for conventional aviation fuel with DCC, so for the purchase of SAF, they engaged directly with their existing account contact within the company to plan for the voluntary purchase of SAF.

DCC facilitated the trade through an international network of traders, selecting Neste as the SAF provider, with volumes purchased and planned for shipping according to the agreement between DCC and Air Greenland.

The engagement process with the supplier was conducted following the same procedures as for CAF.

3. SAF procurement: what, where, and how

The procurement and purchase of SAF was negotiated between Air Greenland and DCC throughout the entire process, with no other stakeholders involved.

Initially, Air Greenland showed interest in using e-fuels due to their higher GHG-reduction potential and sustainable feedstock sourcing. Through conversations with DCC, it became apparent that the purchase of e-fuels was not economically feasible, and the available volumes were limited compared to the needed quantities at the time. Consequently, the decision was made to purchase available second generation SAF.

DCC chose to use dedicated fuel tanks at Prøvestenen to store and deliver SAF blends to CPH and other customers. This enabled DCC to satisfy Air Greenland's SAF needs in accordance with the agreement and to deliver SAF to other airports as well.

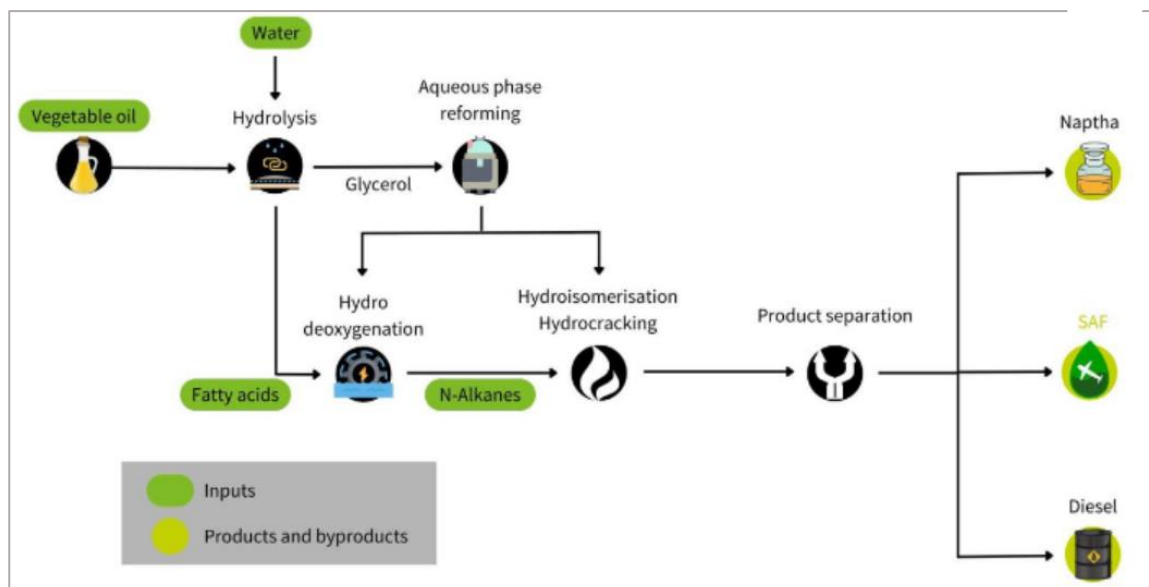
The decision to deliver the SAF exclusively to CPH was made considering that DCC was already developing a new storage and supply line dedicated to SAF blends in Copenhagen. This was deemed a more feasible option, both logistically and economically, than delivering to Sønder Strømfjord/ Kangerlussuaq Airport (SFJ) in Greenland, where neither SAF storage nor production was available.

The first delivery of a SAF blend was transported by DCC from the blending facility to CPH, using segregated fuel trucks. The segregation allowed for better control and traceability of the SAF blend to ensure timely delivery of this milestone in Air Greenland's path towards sustainable travel. Subsequent deliveries of SAF blends to the airport were transported co-mingled with CAF, utilizing existing fuel handling infrastructure.

3.1 SAF pathway and supplier

At the time of procurement negotiations, DCC had engaged with a fuel trading house to search the market for SAF, standard practice between fuel supplier and the market. Given the limited size of the SAF market in early 2021, the search concluded that the best option was for Air Greenland to purchase SAF volumes processed via the HEFA pathway, using primarily used cooking oil as feedstock, illustrated in the following figure:

Figure 33 - The HEFA process



Source: adapted from CZ⁶²

3.2 Procurement process

Negotiations between Air Greenland and DCC run from late 2021 into 2022, a process that took little more than six months to settle on a final agreement. The possibility of delivering the fuel segregated was presented to Air Greenland, along with an undisclosed price, yet known to be higher than the price for CAF.

It was settled that the first delivery of the SAF blend would travel segregated in a DCC fuel truck from Belgium to Denmark and consequently delivered to BKL's fuel farm at CPH. All subsequent deliveries would reach Prøvestenen port by ship and unloaded into DCC dedicated tanks. The SAF blend would reach BKL's fuel farm at CPH from the port using the jetfuel pipeline. In both cases, the SAF blend would be delivered into plane via the hydrant system co-mingled with existing CAF volumes.

After securing the needed volumes, the greater part of procurement negotiations became the price of the SAF including DCC service fee. The final purchase agreement was for 5% SAF content on the total fuel volume needed to supply the flight route between SFJ and CPH for one year, amounting to 700,000 liters of neat SAF.

The entire process of engagement, negotiation, contracting, and procurement was conducted in the same manner as with CAF, except for the search on the type of SAF to purchase. The specific type of SAF purchase agreement has not been disclosed, but it is almost certain that it followed one of the types described under section 5 of this handbook - Procurement of SAF.

⁶² Czarnikow (CZ), 2024

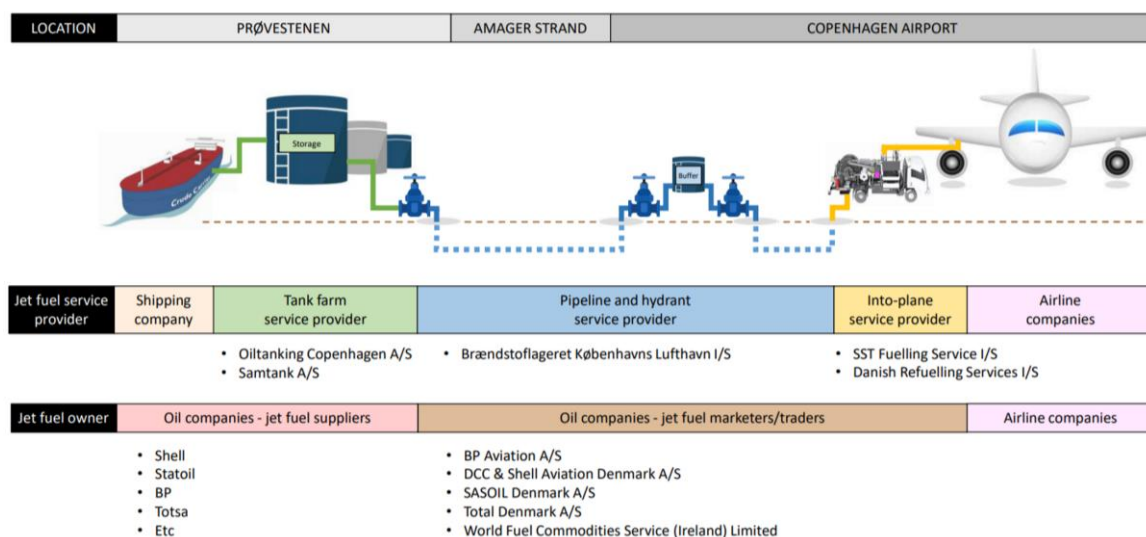
4. SAF handling and logistics

This section describes peculiarities related to the handling and logistics of the SAF blend to CPH airport, along with considerations on alternative delivery options.

The fuel supply at CPH airport is facilitated by BKL, which is an independent company owned by five fuel suppliers, who owns all infrastructure associated with fuel handling at the airport. BKL and two into-plane service providers are therefore responsible for all fuel operations at CPH.

Aviation fuel handling at CPH begins 7 kilometers away from the airport, at the import terminal at Prøvestenen port. The fuel arrives on barges, where it is tested to ensure compliance with established standards set by ASTM and JIG, before being offloaded into one of several fuel storage tanks. The fuel is then transported from the storage tanks through a single pipeline to the airport, where an intermediate fuel farm with smaller storage tanks for daily operations is located. At the intermediate fuel farm, several tests are conducted to ensure compliance with safety and JIG standards before distributing the fuel to the aircraft stands via the underground hydrant system. At the aircraft stands, a bowser truck connects to the hydrant system and delivers the required fuel to the aircraft. The following figure illustrates the aviation fuel handling practices at CPH:

Figure 34 - Aviation fuel supply handling and logistics at CPH



Source: CPH

The supply of the SAF blend to CPH was conducted in two theoretical scenarios:

- Scenario 1 - First SAF delivery,
- Scenario 2 – Continuous SAF deliveries

Scenario 1 marked a milestone both for CPH and Air Greenland as it was the first ever SAF supply at CPH. As stated earlier, the agreement specified that the first delivery would transport and supply the SAF blend segregated from all other aviation fuel to BKL's fuel farm at CPH, primarily to ensure timely delivery of the right volumes only to Air Greenland aircraft.

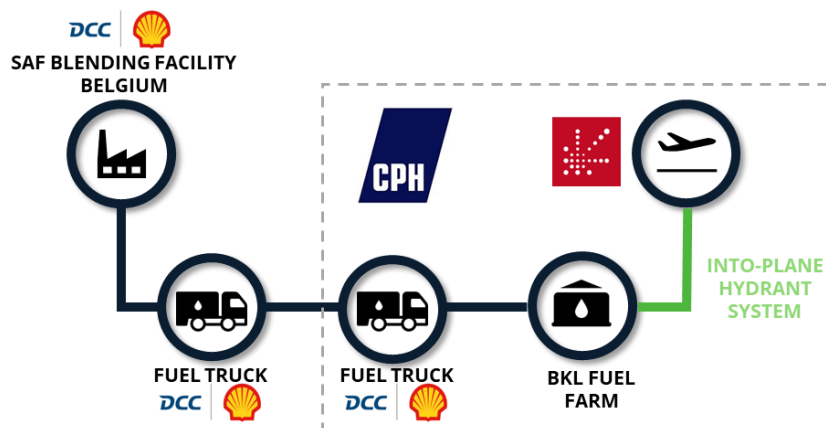
All subsequent deliveries for daily use up to date use using existing fuel handling and storage infrastructure co-mingled with CAF from the port to CPH, aligned with scenario 2.

Scenario 1 – Semi-segregated supply

SAF was first introduced into CPH in March 2023, a historic moment for most everyone involved. Unlike all other fuel deliveries, the SAF blend was delivered by truck as it allowed to better accommodate any unforeseen circumstances or delays and deliver the fuel on time.

The SAF blend traveled from Belgium to Denmark segregated in a DCC fuel truck and after arrival at the CPH airport area, the SAF blend was checked for quality assurance in accordance with JIG standards. The truck unloaded the SAF blend into the airport fueling system at the intermediate fuel farm and fed into the hydrant system for uplift com-mingled with existing CAF volumes. The following figure illustrates the delivery process followed:

Figure 35 - SAF blend delivery process Scenario 1

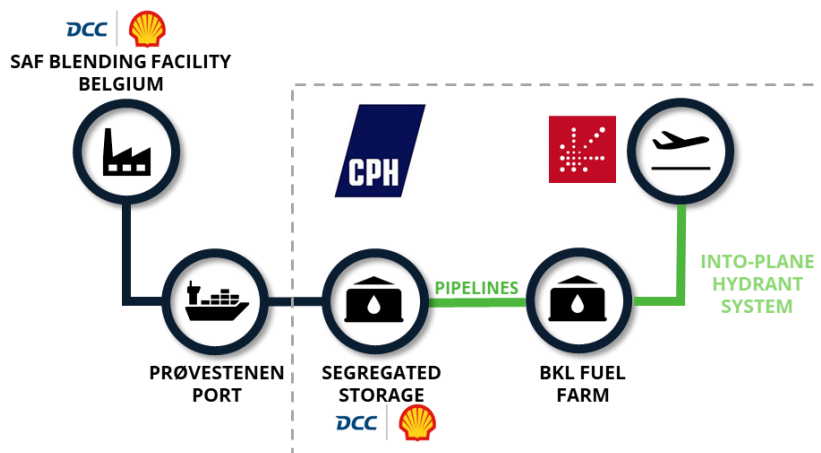


Source: CPH

Scenario 2 – Continuous long-term supply of SAF blends

After SAF blends arrive by ship to Prøvestenen. Since not all aircraft operators require the supply of SAF, DCC uses dedicated fuel tanks at Prøvestenen for storing SAF blends to facilitate its delivery only to clients who request it. SAF blends are transported from the port's storage tanks to CPH using the existing jetfuel pipeline. As it reaches CPH's fuel farm, from a logistics and handling point of view, the SAF blend is treated as CAF thereon. Delivery into-plane is conducted using the hydrant system. The following figure illustrates the delivery process followed:

Figure 36 - SAF blend delivery process Scenario 2



Source: CPH

4.1 Considerations taken before introduction into airport grounds

Several aspects were explored during procurement negotiations to understand the different options available to introduce SAF into CPH grounds for the first time. These were considered in preparation for Scenario 1 and included the following:

- I. Logistics
- II. Transport and storage
- III. Security and safety

Scenario 1

- I. Logistics

Scenario 1- The option to deliver the first SAF blend segregated using trucks meant careful planning was needed on time management, supply logistics, stakeholder engagement, and traceability of the SAF molecules for accounting and reporting purposes.

DCC managed all logistical aspects of the delivery to ensure the fuel was delivered on time, fit for purpose, and to the right customer.

- II. Transport and storage

Two transport options were considered, both built around the idea of keeping the SAF blend segregated while managing increased costs on transport and logistics.

Option I - Segregated supply of the SAF blend reaching the port via ship and offloaded into DCC's dedicated storage tanks. Consequently, delivering the SAF blend segregated from the port dedicated fuel tanks to CPH using supply methods common to CAF supply: this would entail building a dedicated pipeline to run from the port to the airport's fuel farm and install there a dedicated storage tank, a roughly estimated at 250 million DKK (€33,5 million).

Option II - Segregated supply of the SAF blend from Belgium to CPH using trucks: this involves the loading of dedicated trucks with the SAF blend from the blending facility in Belgium and transporting it to the intermediate fuel storage facility at CPH.

Option II initially seemed more manageable due to its much lower immediate costs. However, it was well understood that while this approach is feasible for handling smaller quantities of SAF blends, scaling up and keeping costs down to segregate larger volumes could prove difficult. This approach would yield questionable results compared to the efficiency of keeping the SAF blend co-mingled with CAF and fueling via the existing fuel pipeline. Fuel delivery by truck takes significantly longer than current fueling practices at CPH. If option II were adopted as the common practice for all SAF blend deliveries, it would most certainly result in increased turnaround times, affecting air traffic management. If future segregation of the SAF blend proves to optimize environmental benefits, building a parallel dedicated pipeline from the port to the airport's fuel farm, as well as dedicated storage tanks, would be an option worth a more in-depth analysis.

Exceptionally, and only for the one-time delivery of the first-ever SAF blend into CPH grounds, the supply method chosen was option II, using trucks.

Since the SAF would arrive to CPH already blended and qualified as ASTM 1655, no special measures were planned for its storage at BKL's fuel farm. the fuel.

III. Security and safety

Although the use of trucks to deliver fuel is not common practice at CPH, it has been done before and there are specific JIG processes within the rulebook that describe actions needed to ensure security and safety. These JIG procedures were therefore considered for implementation when evaluating the delivery of the SAF blend using trucks. From a fuel safety point of view, no additional fuel safety measures were taken given that, from a fuel handler's perspective, ASTM D1655 qualified SAF blends that arrive at the airport are handled identically to CAF volumes.

Scenario 2

In contrast, no significant changes in logistics, storage and transport, and security and safety were explored to plan for the delivery of SAF blends under scenario 2. The only deviation for common practices took place at the fuel storage facility at Prøvestenen, where DCC again chose to dedicate a storage tank specifically to the SAF blend; a process that had been established during the first delivery of the SAF blend to CPH.

4.2 Supply method

This section explains more in detail every step along the fuel supply chain followed for delivery of the SAF blend to CPH for scenarios 1 & 2.

Scenario 1

DCC took the following considerations specific to steps along the supply chain to complete the first delivery of the SAF blend to CPH:

- Transport of the SAF blend from Belgium: since the SAF was already blended with CAF, fuel safety and quality checks followed the same procedures as those applied to CAF. The SAF blend was uploaded into dedicated fuel trucks that traveled from Belgium to Denmark, arriving at CPH.
- Upon the truck's arrival to CPH, all quality and safety assurances were conducted treating the SAF identically to CAF, as described in ASTM 1655 and JIG standards. After entering airport premises, the truck off-loaded the SAF at the intermediate fuel farm storage tanks. The aircraft was fueled through the hydrant system, physically co-mingled with all other existing fuel in the farm, applicable to the mass balance chain of custody method. The SAF blend was delivered on time and in the agreed quantity.

Scenario 2

All subsequent deliveries up to today are performed following BAU fuel supply practices. SAF blends arrive by ship at Prøvestenen and once offloaded, they are tested to comply with safety

standards before being stored into DCC's dedicated tank, the latter being the only practice that deviates from BAU. The SAF blend reaches CPH fuel farm through the fuel pipeline co-mingled with CAF, and the uplift is conducted using the hydrant system; the chain of custody method used is mass balance.

5. Documentation

This section describes the documentation processes associated with the purchase of SAF for delivery at CPH. Since CPH did not play a role in the procurement and use of SAF at the airport, the following mainly describes the interaction among DCC and Air Greenland in the documentation process.

Fuel delivery documentation is a collection of all the documents aviation fuel suppliers receive per fuel batch. The time required to deliver it to the client is in line with the standard practice of aggregating information from several batches and delivering it all at once, rather than processing documentation for each batch individually. Air Greenland requested documentation from DCC that is common to most fuel deliveries: a fuel ticket describing volume, quality, energy content, and price, among other details. Additionally, they requested the PoS, owned by DCC, a unique piece of documentation for SAF that allows the airline to report confidently on the carbon emission reductions achieved by using SAF for its flights. For more details on the PoS, revisit section 5.2.1 of this handbook.

Air Greenland received the fuel ticket and, instead of the PoS, DCC provided two distinct documents describing the environmental attributes of the purchased SAF: a "SAF sustainability statement" and a "SAF letter" from DCC. This is because, in preparation to the upcoming RFEUA regulation, DCC was aware that they would need to surrender the unique PoS to competent authorities as proof of compliance; providing Air Greenland with a "SAF sustainability statement" and a "SAF letter" was a feasible alternative.

In the "SAF sustainability statement," the SAF component is described in two sections. Section one provides a general description of the purchased product, including the following data points:

SAF Sustainability Statement – section one

- Type of SAF product - pathway
- Quantity of SAF in m³ and tonnes
- Average life cycle GHG intensity
- Energy content presented in MJ
- GHG savings in relation to baseline of 94g. CO₂/MJ
- Sustainability Certification mentioning the scheme used (RSB, ISCC, etc.)
- Status of compliance with EU RED criteria
- Chain of custody break point with responsible stakeholder.

Section two described each batch of delivery including the following data points:

SAF Sustainability Statement – section two

- Supplier sustainability certificate number
- Batch number
- Blending ratio
- Quantity in m3 and tonnes
- Energy content
- Actual density at 15° C
- Amount in tonnes
- Conversion process
- Feedstock
- Country of origin of feedstock
- Lifecycle emission

The SAF letter confirmed the SAF purchase from Air Greenland in 2023.

The overall documentation process took longer than usual given the new documents and steps not commonly delivered when purchasing CAF. The expectation is that as SAF use increases and becomes ordinary, the entire process will be optimized for efficiency, in particular the delivery and format of the PoS (or similar document) to the SAF user to facilitate a more expedient claims process on emission reductions achieved.

5.1 Sustainability certification

The SAF product fueled at CPH was certified by under the ISCC SCS and was disclosed in both the SAF sustainability statement and the SAF letter.

The certification was compliant with REDIII criteria, ensuring the product complied with the criteria set for the EU's definition of sustainable aviation fuels. This allowed Air Greenland to report their purchase as contributing to the national targets set in REDII and compliance with their obligations under EU ETS.

5.2 Quality assurance

The quality of the fuel was fully compliant with ASTM D1655 when it entered the airport, a must for all fuel that enters the airport either segregated via trucks or transported through the hydrant system at CPH.

The specific attributes of the fuel were documented in accordance with the applicable JIG standard as it is done with all CAF entering European airports. The documentation process for quality assurance of the SAF blend therefore followed usual disclosure practices common to any CAF delivery at CPH.

6. Leadership and communications at CPH

CPH has committed to becoming a Net-Zero airport by 2050, and as various roadmaps were investigated, it became clear that such a commitment required the leadership of every stakeholder in and around the airport. Several initiatives were started, including the sustainable design of new and existing buildings, increased recycling of waste generated at the airport, and the electrification of vehicles, among others. SAF is one solution among a range of measures in

this transition; IATA has estimated that approximately 62% of the industry's sector-wide emission abatement could be achieved by using SAF. Yet, given its limited availability and price disparity with CAF, SAF remains a challenging solution for the entire industry to manage. Even though CPH does not participate in the procurement and handling of fuel, projects like ALIGHT show the need for the airport to play an active role in other areas of fuel handling processes to support the industry's transition.

6.1 Lasting commitment to SAF usage at CPH

CPH initially took a reactive role during the introduction of the first-ever SAF blend into airport grounds. However, its significant volume of air traffic within Denmark and the Nordic region has driven CPH's management team to now lead efforts in reducing aviation emissions. While CPH plans to remain uninvolved in CAF transactions, it aims to contribute to SAF and alternative fuel development to support its clients and climate ambitions.

Furthermore, CPH participates in the Climate Partnership for Aviation, contributing to two working groups focused on reducing emissions: the low-aromatic jet fuel and SAF groups. The low-aromatic jet fuel group explores using passenger tax revenue to process jet fuel with reduced aromatic and sulfur content, improving air quality and potentially reducing climate impacts from contrails. The SAF group investigates using passenger tax revenue to support SAF production, with financial distributions planned from 2025 onward. Recommendations and a roadmap for climate-neutral aviation in Denmark are expected by October 2024.

CPH is also involved in the Mission Green Fuels Methanol-to-jet project, which aims to develop methanol as a feedstock for future SAF production. Additionally, CPH is a member of Project Skypower, an alliance supporting e-SAF projects to Final Investment Decision (FID) by the end of 2025. CPH's participation in these projects ensures alignment across the aviation ecosystem and supports the development of the e-SAF industry, projected to reach 250 billion euros by 2050 and create almost 90,000 direct jobs.

6.2 Global, regional, and national regulation supporting the use of SAF

At the time of this case study, the EU had implemented the EU ETS and CORSIA. Linked to the 'Fit for 55 Package,' RFEUA legislative proposal was made in 2021 and published as regulation in October 2023.

EU ETS is a cornerstone of the EU's policy to combat climate change and reduce GHG emissions in a cost-effective and economically efficient manner. Operating on a cap-and-trade principle since its establishment in 2005, the EU ETS sets a cap on the total amount of certain GHG that can be emitted by installations covered by the system. Companies receive or buy emission allowances, which they can trade with one another as needed. The cap is reduced over time, ensuring that total emissions fall. As it relates to aviation, the EU ETS covers flights within the EU and the EEA, as well as departing flights to Switzerland and the United Kingdom.

CORSIA is a global MBM developed by ICAO. CORSIA aims to stabilize CO₂ emissions from international aviation at 2020 levels by requiring airlines to offset any growth in emissions above those levels. Airlines can achieve this by purchasing carbon credits from approved projects that

reduce or remove emissions from the atmosphere. CORSIA complements other aviation in-sector emissions reduction efforts, such as technological innovations, operational improvements, and the use of SAF.

RFEUA aims to ensure that EU air transport meets the EU's climate targets for 2030 and 2050. This regulation creates a strong and stable legal framework to promote the gradual supply and uptake of SAF in the EU. Enforcement of RFEUA started in 2025, whereby aviation fuel suppliers are required to supply a minimum of 2% SAF, which will gradually increase to at least 70% by 2050. The regulation also sets out rules for enforcement, reporting, and a new flight label to help consumers make informed choices regarding their transport options.

Denmark also took significant steps during this time period to support the use and supply of SAF. The Danish government has committed to becoming a Net-Zero airport by 2050 and has implemented several initiatives to achieve this goal. Additionally, Denmark has introduced a CO₂ tax on aviation as part of its efforts to reduce GHG emissions and promote sustainable aviation. Starting in 2025, the CO₂ tax will be gradually implemented, with the full tax payable by all from 2030 onwards. The tax applies to commercial aviation, including domestic flights, and is calculated based on the amount of fuel consumed. The revenue generated from this tax will be used to support the development and adoption of SAF and other renewable energy solutions. The Danish government aims to make all domestic flights green by 2030, aligning with its ambitious climate goals. This tax is part of a broader strategy to decarbonize the aviation sector and achieve Denmark's commitment to becoming a Net-Zero country by 2050.

CPH's declaration in 2019 to becoming a Net-Zero airport by 2050 continues to show its unwavering support to the SAF industry considering that it is estimated that approximately 62% of the industry's sector-wide emission abatement would be achieved by using SAF.

6.3 Public awareness and client uptake

The SAF initiative, primarily involving Air Greenland and DCC, was envisioned as a significant step forward towards net zero aviation by 2050. Air Greenland aimed to demonstrate its commitment to sustainability in a country known for its natural beauty and its aspiration to attract more tourists through sustainable transport. The decision to contribute to green transformation through the purchase of SAF was linked to the replacement of the company's Atlantic aircraft with an A330neo, which delivers 25% lower fuel burn compared to previous generation aircraft.

Recognizing the crucial role airports play in supporting the aviation industry's efforts to achieve net-zero by 2050, Air Greenland's experience sparked action at CPH. In 2024, the airport joined the project "Sustainable Aviation Fuels: Passenger, Public, and Stakeholder Perceptions" (SAFE), which aims to provide the value chain with information on SAF demand among end-users, including airline companies, CPH at large, and passengers. The first study, due for publication when the project ends in late 2025, is expected to reveal SAF perceptions, knowledge, and demand among the Danish public through a multidisciplinary approach and field experiments. The project will use dedicated gate screens at CPH to communicate the sustainability of SAF as part of an experimental study investigating passengers' willingness to pay for SAF.

SAFE will provide valuable insights into future SAF markets in the short and long term, enabling SAFE's commercial partners to act efficiently and strategically, support decision-making, and enhance sustainability communication to passengers and the value chain.

7. Conclusion

The introduction of SAF at Copenhagen Airport marks a pivotal step towards a more sustainable future in aviation. Air Greenland's commitment to sustainability and its collaboration with DCC has demonstrated the feasibility and benefits of incorporating SAF into existing fuel infrastructure, setting a precedent for future initiatives.

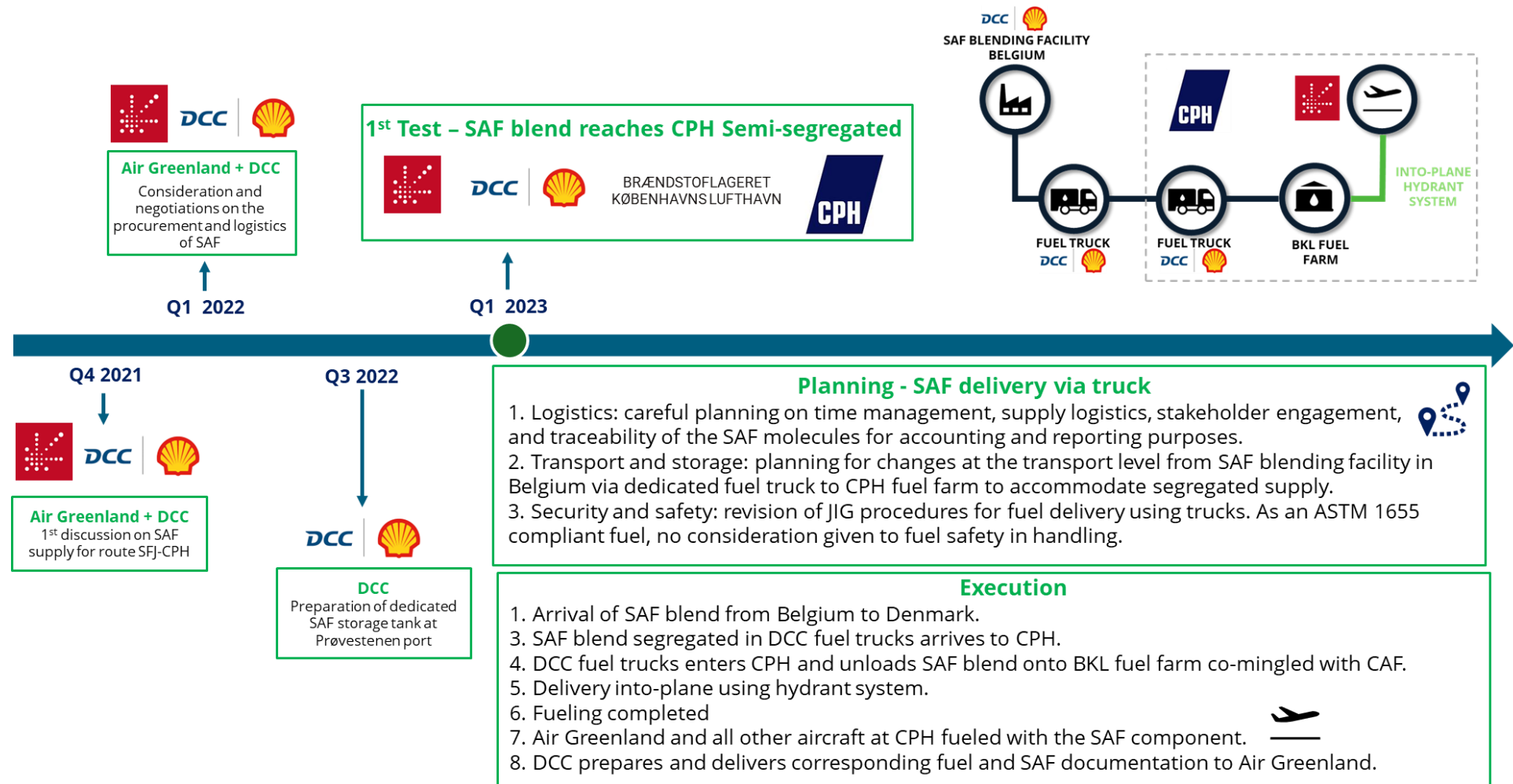
The case study highlights the comprehensive planning, stakeholder engagement, and meticulous execution required to successfully integrate SAF into CPH's operations. Despite the challenges posed by the COVID-19 pandemic and the logistical complexities of SAF procurement and delivery, the project has shown that with dedication and collaboration, significant strides can be made towards reducing the aviation industry's environmental impact.

Furthermore, the historic signing of a SAF agreement between Air Greenland, DCC & Shell Aviation Denmark in 2023 has meant a continuous supply of up to 5% of SAF to power flights between SFJ and CPH. The agreement signified the largest SAF supply commitment in terms of fuel proportion within Denmark and underlines the collaborative efforts of Air Greenland, DCC, and Shell to make Greenland a more sustainable travel destination while supporting the global push towards decarbonizing aviation by 2050.

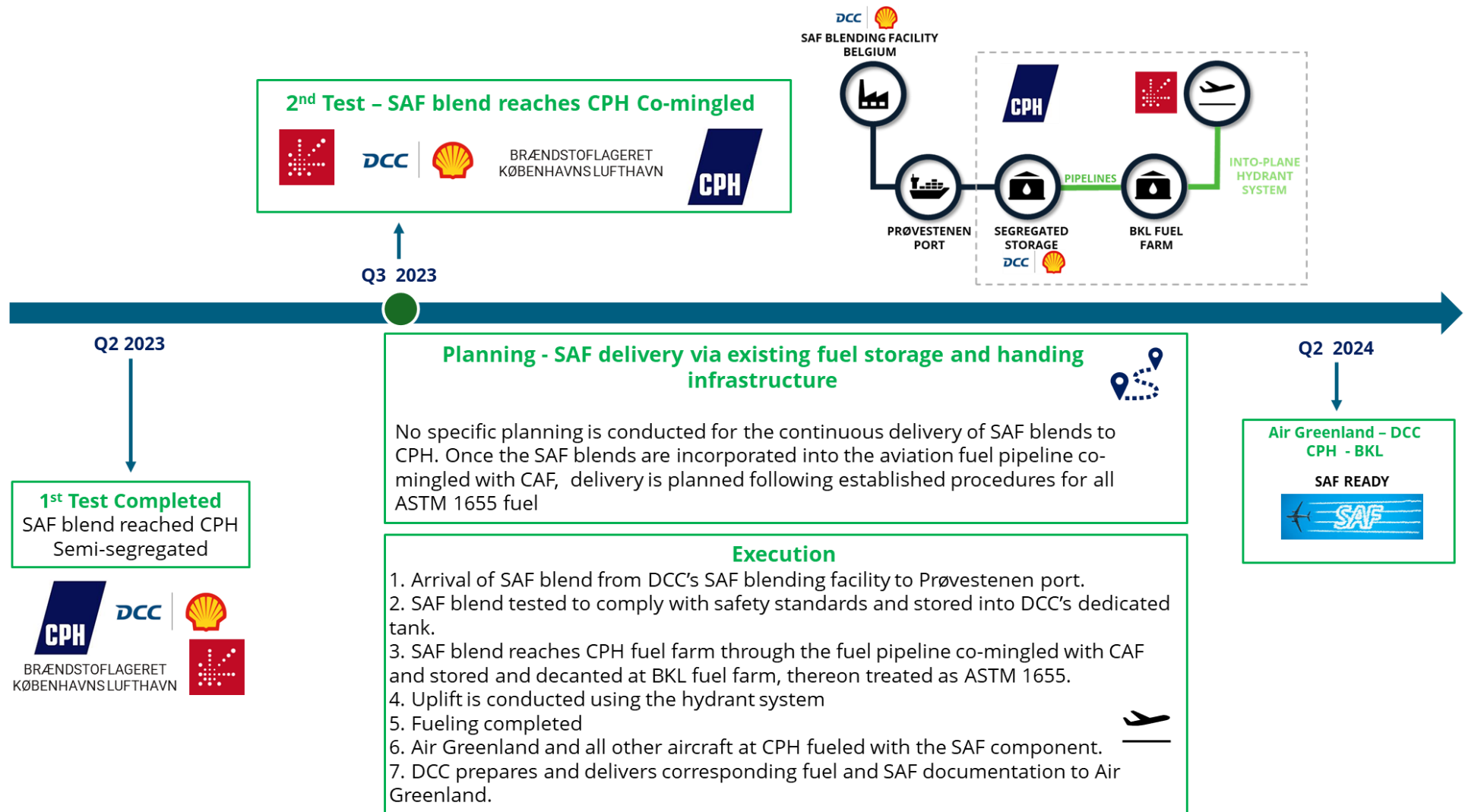
While CPH did not play a direct role in the procurement and handling of SAF, the airport's support and interest in the initiative underscore the importance of collective efforts in achieving sustainability goals. The experience gained from this project has undoubtedly steered future SAF initiatives, not only at CPH but also at other airports globally.

As the aviation industry continues to seek solutions to its environmental challenges, the successful implementation of SAF at CPH serves as an encouraging example of how innovation, collaboration, and commitment can drive positive change. Moving forward, the continued support of key stakeholders, coupled with advancements in SAF technology and infrastructure, will be essential in realizing the vision of a more sustainable aviation industry.

Timeline – SCENARIO 1 – SAF blend reaches CPH SEMI-SEGREGATED



Timeline – SCENARIO 2 – Continuous Long-Term Supply of SAF Blends to CPH



4.5.2 SAF usage cases study – Aeroporti di Roma

Executive Summary

ADR, the operator of Fiumicino (FCO) and Ciampino (CIA) airports, has taken a pioneering step in the decarbonization of aviation also by integrating SAF into its operations. This initiative is a cornerstone of ADR's ambitious sustainability strategy, which aims to achieve carbon neutrality by 2030 and aligns with the broader objectives of reducing Scope 3 emissions—one of the most challenging aspects of airport environmental management. This effort complements other transformative initiatives, including the deployment of photovoltaic systems, the adoption of electric vehicles, and innovative energy storage solutions utilizing second-life automotive batteries.

In partnership with Eni, ADR introduced SAF through a strategic agreement launched in 2021, with the goal of promoting decarbonization across the aviation value chain. Two pilot tests conducted at FCO in 2021 and 2022 explored different SAF handling methods: segregated transport via truck and integration through existing fuel pipeline and hydrant systems. The first method, while operationally viable, revealed significant logistical challenges, requiring bespoke procedures, extensive coordination, and increased resource allocation. Conversely, the second method demonstrated the feasibility of seamlessly integrating SAF into existing infrastructure, proving to be more efficient, cost-effective, and less disruptive to daily airport operations.

Fiumicino Airport's strategic location and advanced infrastructure make it an ideal testing ground for SAF supply chain implementation. Its proximity to the port of Civitavecchia and direct pipeline connections enables streamlined fuel transport, and greenhouse gas emissions. A market analysis conducted in collaboration with Eni and Roland Berger within the work done for the Decarbonization Pact further reinforced FCO's suitability as a model for SAF adoption, highlighting the HEFA pathway as the most mature production technology in Italy.

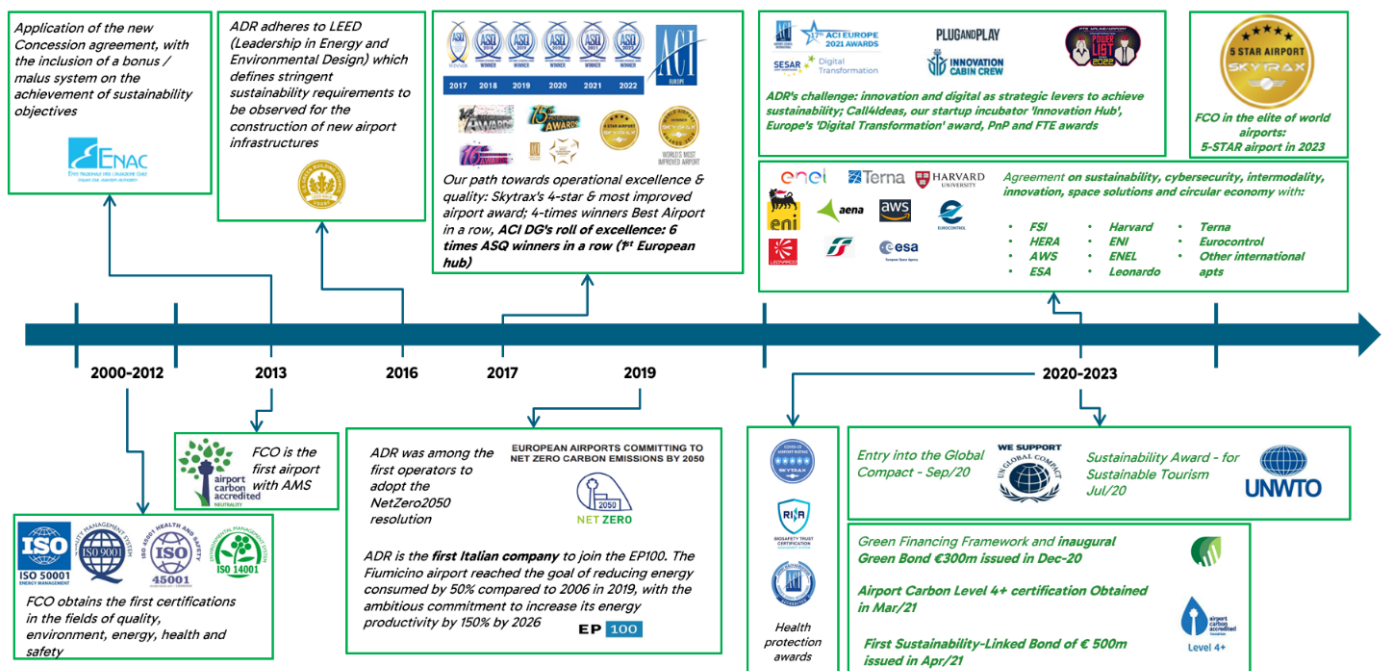
These pilot tests confirmed that SAF can be safely and effectively managed using existing procedures and infrastructure, establishing a scalable and replicable model for decarbonizing aviation. This milestone positions ADR as a leader in sustainable airport operations, setting a benchmark for the integration of alternative fuels within the aviation sector. ADR's experience underscores the critical importance of cross-sector collaboration, innovative supply chain strategies, and infrastructure readiness in achieving the ambitious goal of Net Zero emissions by 2050, in line with European and global decarbonization targets.

1. Introduction

The purpose of this document is to describe the experience of ADR, the society that manages FCO and CIA, with the first introduction of SAF into airport grounds. The report delves into the decision-making process for incorporating SAF into the fuel supply chain, highlighting the key factors and considerations that have guided this decision. Additionally, it examines the involvement of various stakeholders in the management of the new fuel and their contribution to the design and implementation of a SAF strategy and a functional supply chain.

ADR has set ambitious decarbonization goals, aiming to achieve carbon neutrality by 2030. This goal will be reached through a series of initiatives, including the installation of photovoltaic systems, the adoption of energy storage systems using second-life batteries from the automotive sector, the implementation of electric vehicles for the airport fleet, and the integration of low carbon propellants. These measures are a fundamental part of ADR's plan to promote sustainability and energy efficiency in the aviation sector, in which SAF plays a key role for the reduction of scope 3 emissions from airport operations. The following figure best exemplifies ADR's achievements on sustainability commitments from 2000 through 2023:

Figure 37 - Aeroporti di Roma Sustainability Strategy



Source: ADR

This case study aims to provide a comprehensive overview of the challenges that have emerged from the implementation of SAF at the airport, while also offering an assessment of the practices adopted to facilitate its penetration in the market.

2. A bold step forward – incorporating SAF into airport grounds

ADR is strongly committed to take bold action against climate change. Both FCO and CIA airports are accredited at level 4+ "Transition" under the Airport Carbon Accreditation Europe scheme for direct and indirect CO2 emission reductions.

The company's commitment does not stop there. Through the years ADR has implemented solutions and formed alliances with stakeholders along the value chain to find an efficient and meaningful path forward to reduce the environmental impact of its operations.

2.1 Decision making process and stakeholder engagement

In 2021, the Italian multinational energy company Eni S.p.A. (Eni) and ADR signed a strategic agreement to promote decarbonization initiatives in the aviation sector and accelerate the

transition to Net Zero by 2050 of airports. The agreement provided for the development of decarbonization projects to encourage airports to transition to the “smart hubs” concept managed by ADR. Efforts focused on reducing scope 3 emissions, the airport’s greatest and most difficult environmental impact to tackle. In particular, the agreement saw the introduction of SAF for aircraft and lower carbon hydrogenated vegetable oil (HVO) for ground support equipment (GSE) as key actions to achieve its climate goals.

In 2022, ADR created the Pact for Decarbonization of Air Transport together with partners representing industry, institutions, associations, and academia. The Pact for Decarbonization of Air Transport was born with the aim to identify available solutions to reduce GHG emissions from aviation. Similarly, the Pact’s intention was to define the stages of the path toward implementing actions flanked by realistic policy proposals to help achieve the challenging environmental objectives. The Pact’s partners so far are listed in the following table:

Table 10 - Actual Partners – Pact for Decarbonization of Air Transport

Pact for Decarbonization of Air Transport Actual Partners			
Industry		Institutions	Associations
Enel	Gruppo SAVE S.p.a	Italian Civil Aviation Authority - ENAC	Asvis
Eni	ITA Airways		Global Compact
Boeing	Aeroporto di Bologna		Symbola
Airbus	Intesa Sanpaolo		AICALF
Mundys	Aviapartner		IBAR
Neste	Aviation Services		IATA
Swissport	Italo		
SNAM	Aeroporti 2030		

Ultimately, the intention was to jointly promote action and accelerate the implementation of solutions to achieve the sustainability objectives of air transport in the context of the SDGs and the 2030 Agenda, taking as reference the goal of Net Zero Emissions by 2050, and to prepare its airports for compliance with RFEUA requirements.

2.2 Stakeholder engagement

ADR took an active approach to the incorporation of a SAF blend into airport grounds, owning the process from the beginning in alliance with key stakeholders supporting actions at every stage of development.

The first experience where a SAF blend was incorporated into ADR administered airports was unique, both being the first time ever to have an alternative fuel to Jet-A used for jet engines at an Italian airport and having a supply chain which involved a much greater number of stakeholders when compared to the supply of conventional aviation fuel caused by the uncommon modality chosen to deliver the SAF blend in FCO that was different from the business as usual. ENI and ADR agreed to run two different tests to incorporate a SAF blend into FCO, primarily to better understand handling and fueling infrastructure needs at FCO; the tests took place in 2021 and 2022.

In October 2021, a SAF blend was introduced to FCO for the first time. Delivery was conducted using trucks which kept the SAF blend segregated from all other fuel within the airport. Key stakeholders were involved since the very early stages of planning to make the tests possible; these include the following:

- ENI, the fuel supplier [...]
- ITA Airways, the airline company committed to fueling their flight with a SAF blend.
- SERAM, the company that manages fuel farms at FCO
- Guardia di Finanza, Italy's financial police force, responsible for operations related to fuel clearance and seals removal.
- Levorato Marcevaghi (Levorato), the company in charge of the into-plane delivery of fuel.

The internal departments at ADR engaged for this test, involved in operations, those include the following:

- Post Holder Movement Area
- Energy Manager
- Security Manager
- Environment and sustainability department
- Innovation department
- Legal department

In March 2022, the second test took place. This time the delivery of the SAF blend to FCO was conducted following business as usual practices using the existing pipeline, fuel farm, and hydrant system for uplift to the aircraft. This time around, no more stakeholder compared to the one involved in the CAF delivery were involved, so:

- ENI, the fuel supplier
- ITA Airways, the airline company committed to fueling their flight with a SAF blend.
- SERAM, the company that manages fuel farms at FCO
- Guardia di Finanza, responsible for operations related to fuel clearance and seals removal.
- Levorato, in charge of the into-plane delivery of fuel
- ADR Post Holder Movement Area

3. SAF procurement: what, where, and how

In most instances, the procurement of a SAF blend does not follow the same path as that for CAF, primarily on the how and what. Differences lie on the type of purchase agreement to establish with the supplier, the variety of suppliers to procure from, and the documentation process, mainly the existence of the PoS certificate that users require to adequately account for and report environmental benefits achieved. There are several SAF pathways under production today, each with its own environmental profile, but production volumes remain low enough that the 'what' choice is limited to whatever the authorized fuel supplier for a given airport is willing to supply.

The process was no different for ADR at the time to choose how to procure, what type, and where to purchase SAF. With an increase in SAF production volumes worldwide, this may change where users may be given the option to choose the specific pathway or combination of pathways to procure in alignment with a desired environmental profile, but that was not the case when ADR began planning the use of a SAF blend at FCO.

3.1 SAF pathway and supplier

Local, that was the variable ADR used to choose a SAF supplier and with it came the pathway. At the time the tests were conducted, ENI was the sole supplier of SAF in Italy, the only pathway available was co-processing of HEFA, and the choice of feedstock was UCO.

3.2 Procurement process

The procurement process for both tests using a SAF blend was atypical in every way when compared to the process that is normally followed for purchasing fuels at FCO, even beyond the differences illustrated above.

Usually, fuel purchases are handled by the airlines through purchase agreements directly with the oil companies, ADR does not enter the merits and is not required to become involved in any sense. Since the decision to test the use of a SAF blend at FCO was taken by ADR and supported by allied stakeholders, in this instance the procurement agreement for SAF to FCO was signed between Eni and ADR; also, the SAF blend purchased was intended for use only in a particular ITA aircraft departing from FCO vs. any and all flights as volumes would be used if the procurement had been for CAF. This procurement processed mirrored a lab test, were BAU changes dramatically to allow for the testing of an uncommon situation, limited in scope and under a controlled environment.

Another particular aspect in this procurement process was the absence of a plurality of suppliers from whom to purchase the SAF blend from; the agreement aimed at promoting the development and use of SAF was between ENI and ADR directly, so ENI became the default supplier.

4. SAF handling and logistics

As stated in the body of this handbook, SAF is defined as jet fuel derived from biomass or non-biomass waste that once blended with CAF, meets the relevant specification for use on an aircraft, such as ASTM D1655 or Def Stan 91-091. From a handlers' point of view, no special attention nor additional processes are added when handling a SAF blend, it is carried out using existing JIG protocols.

Any deviation from existing handling and logistics protocols are usually taken when there is a specific interest to segregate SAF blend. The aim of segregating the SAF blend during the first test was mainly to demonstrate the feasibility of using SAF in small and medium airports like CIA.

In contrast, the SAF blend for test 2 was handled following the mass balance chain of custody approach. The objective was to demonstrate the feasibility of transporting and delivering a SAF blend using existing infrastructure and fuel handling procedures.

The following section explains more in detail handling and logistics processes specific to test 1 and test 2.

4.1 Considerations taken before introduction into airport grounds

Airports play a crucial role in the value chain to ensure sufficient volumes of SAF are available. This aids users and producers in complying with EU ETS and RFEUA regulations, facilitating a smooth transition despite current limitations in SAF volumes and higher prices compared to CAF. Similarly, within this transitional period, the European Commission is evaluating the establishment of a system of negotiable certificates for the supply and purchase of SAF. This would utilize a book & claim chain of custody model to address the limited supply of SAF in specific regions until the industry scales up.

In this context, both FCO and CIA were under consideration when ADR and Eni first begun evaluating where to run the two tests on SAF usage. Through a detailed decision process, FCO was selected as the airport of choice. The role that FCO plays in Italy to host the SAF value chain seemed more favorable considering the following:

1. FCO serves as the principal hub for ITA Airways, the Italian flag carrier, and the largest airline in the country,
2. The airport is located with strategic proximity to the sea and the port of Civitavecchia, directly connected via pipeline to the port's fuel depots, which contributes toward reducing risks in safety and security as well as costs and GHG emissions on fuel transport and delivery.
3. Unlike CIA, the SAF blend uplift at FCO can be conducted through the existing hydrant system as well as trucks, allowing for both delivery methods to be tested.

FCO seemed well suited to serve as the example to follow for all those other airports in Italy and abroad as the most efficient and cost-effective model to accommodate the supply of a SAF blend to immediately and efficiently help lower GHG emissions from the aviation sector.

In fact, to test the above assumptions, in 2023 ADR took the time and effort to evaluate the suitability of FCO to continue to play the role as study grounds for SAF usage among all other airports it administers. With the support of the consultancy firm Roland Berger, ADR and project partner Eni conducted a comprehensive market analysis of the entire SAF supply chain in Italy to set its own strategy towards establishing the optimal SAF supply chain compliant with RFEUA.

As expected, the study concluded that FCO was in fact a well-suited airport in Italy to begin building a strong and reliant SAF supply chain, considering distance to mayor fuel depots, ATM volumes, and average fuel consumption by type of aircraft.

Another important result of the study was the state of art of the different SAF production pathways in Italy, concluding that HEFA was the most mature technology at the time with production volumes at commercial scale, while other technologies such as AtJ, G-FT, and PtL seem to be less mature and production volumes very low or null. Furthermore, their growth was highly dependent on a significant increase in low-cost renewable energy production for feedstock

processing and further development and optimization of processing technologies, which meant their availability at scale were not foreseen for the near future.

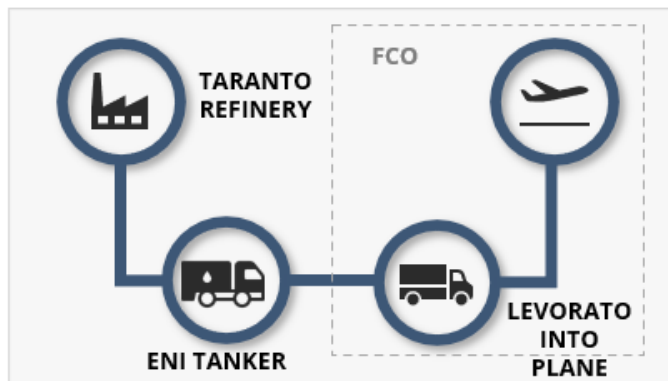
4.2 Supply method

For the first phase of planning, a working group was set up to verify important logistics, safety, and compliance aspects of the different scenarios. To arrange for the most efficient supply chain for SAF to reach FCO, the working group evaluated two supply scenarios: via truck and via pipeline.

Test 1: SAF delivery via truck

As per recommendations from the working group, the first introduction of a SAF blend into FCO was delivered via segregated supply using Eni's tank trucks. ADR organized the first delivery to FCO that took place on 15 October 2021, the process is illustrated in the following figure:

Figure 38 - SAF blend supply chain for Test 1



Source: ADR

The preparation phase for this first delivery was led by ADR's Post Holder Movement Office, who collected necessary documentation related to access permits to the airside area for the driver of the Eni tanker. They also organized the preliminary meetings and briefings with the representatives of Eni, SERAM, and Levorato to jointly define the logistics, authorization, regulatory, and customs requirements of the SAF blend delivery from Civitavecchia port's fuel depot to the aircraft. The outcome of these meetings was the establishment of a special procedure for the unloading and transfer of the SAF blend from the tanker to the aircraft.

Managers from the Safety Management System department at ADR met with SERAM's counterparts to clarify the characteristics of the SAF blend and eventually its impacts on common fueling procedures. The aim was to confirm the following safety aspects of SAF and SAF handling:

- A SAF blend is to be considered equivalent and compatible with other A1 jet fuels.
- A SAF blend is already approved and regulated internationally according to ASTM D1655 and Def Stan 91-091.

Similarly, in the days preceding the first supply of the SAF blend to FCO, ADR's Security Manager took the important role to lead the security process and share with the Air Border Police the special procedures:

- Arrival of the Eni tanker at customs gate.
- Safety checks for the driver and the Eni tanker.
- A safety escort for the tanker formed by ADR Security and Guardia di Finanza (GdF) from the customs gate to SERAM's site.
- The supervision by the GdF of the whole process involving the fuel transfer from the Eni tanker to Levorato's into-plane vehicle after removing the seals.
- The return of Eni's tanker to the customs gate and exit from the airport.

The day of the first test on 15 October 2021, ADR monitored operations to ensure compliance with the program agreed by all the stakeholders, taking care to communicate any changes on arrival time of the tanker and coordinating the operations under the profile of the agreements made with customs and GdF. The following paragraphs are dedicated to illustrating details on the special procedures followed as per the above bullet points to provide a more in-depth description of the actions taken and stakeholders involved:

The safety checks before the SAF blend were introduced into FCO grounds, specifically SERAM's fuel depot, involved four steps:

- Safety briefing communicated to the driver.
- Verification of the integrity of the seals.
- Verification of customs documents.
- Verification of quality documents.

After completing the checks for each step with positive results, the tanker was taken to the weightbridge and weighted. The tanker was then escorted by ADR and SERAM's personnel to the entrance, the customs gate and throughout its entire trajectory as required by the established security process. The tanker was then driven to SERAM's airside fueling island parked in a concrete paved area following safety instructions given by SERAM's staff, taking into consideration:

- Fire-fighting equipment.
- Entry inhibition.
- Spill containment.

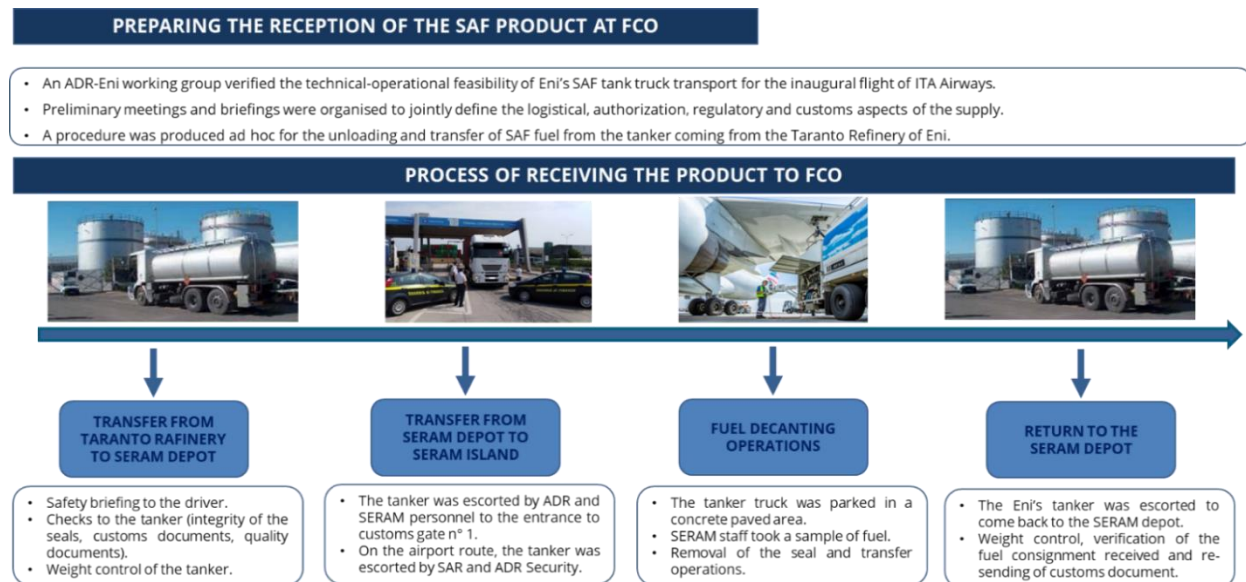
SERAM's staff took a sample of fuel from the Eni tanker to be subjected to common quality checks, bleeding of the tanker to verify the absence of water and measure the density of the fuel. After quality checks gave positive results, the tanker was prepared for decanting.

Decanting took place similarly to a "defueling" process and was coordinated jointly by the into-plane company Levorato and Eni. The removal of the seal of the defueling system, was carried out in the presence of an official from the GdF. At this point, the into-plane tanker was authorized to refuel the selected seven ITA Airways aircraft with SAF blend. The transfer was considered completed only after Eni's SAF tanker was completely emptied and double checks confirmed that there were no residual volumes of fuel left inside. Eni's SAF tanker was then escorted out via the customs gate and exited the airport.

The first ever introduction of SAF into FCO grounds was conducted successfully, the fuel segregated using trucks as the choice of supply method. The seven ITA Airways aircraft took off on the 15th of October during the morning from FCO, four of them were destined to Milan Linate Airport (LIN), one to Venice (VCE), one to Bologna (BLQ), and one to Amsterdam (AMS).

The following figure documents the planning process and delivery of a SAF blend segregated by truck to FCO:

Figure 39 - SAF blend delivered to FCO by truck

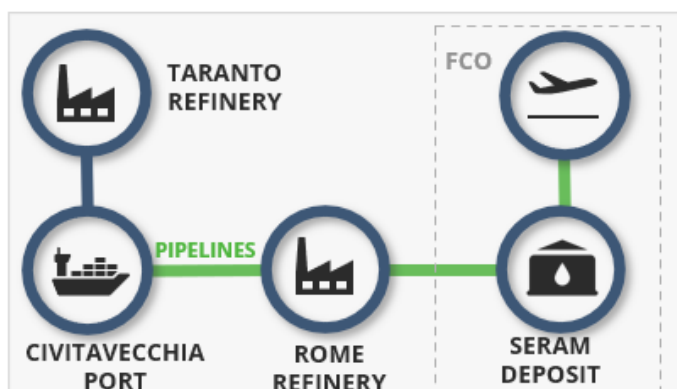


Source: ADR

Test 2: SAF delivery via pipeline

The second test on SAF use at FCO led ADR involved the delivery of a SAF blend via pipeline. The delivery took place in March 2022; the objective was to demonstrate how the SAF blend could be integrated in existing infrastructure following the same fuel handling and delivery procedures common to Jet A-1, as illustrated in the following figure:

Figure 40 - SAF blend supply chain for Test 2



Source: ADR

FCO has access to two different pipelines for fueling: one connects the airport to Civitavecchia's port, the other one to Fiumicino's Port. The first one has been used for this test.

The ship coming from Eni's refinery in Livorno loaded with about 3000 tons of SAF blended arrived at Civitavecchia Port; the fuel was unloaded at a coastal depot connected to FCO through a long network of pipelines. The SAF blend arrived to FCO following BAU procedures using existing fuel handling infrastructure, stored at FCO's fuel farm managed by SERAM, and ultimately uplifted to selected ITA Airways aircrafts via a mass balance chain of custody approach through the hydrant distribution system.

Results for the second test allowed ADR, Eni, and ITA Airways to demonstrate the feasibility of transporting a SAF blend using existing pipelines and its successful delivery following a mass balance approach without having to increase costs associated with fuel transport, handling, storage, and delivery.

5. Documentation

Both tests at FCO were conducted for more than one purpose, yet the common objective was to understand fuel handling procedures for SAF at the airport, ultimately looking to reduce the environmental impact of aviation. The handling of documentation remained an important factor in both tests, aimed at determining differences among the CoC approaches selected, mainly the ease of traceability, accounting, and reporting on emission reduction claims gained via SAF usage handled via segregation and mass balance.

In addition to the issuance of the proper documentation to certify for the fuel's quality assurance, the SAF procurement process must ensure that SAF suppliers provide specific documentation to enable airlines and their customers to claim the environmental attributes and prove they meet the eligibility criteria of specific regulatory schemes, financial incentive programs, and other carbon reduction programs in accordance with guidance set by GHGP. Without this documentation, the buyer lacks proof to credibly claim the environmental attributes associated with the SAF purchased.

5.1 Sustainability certification

As described at length under section 1.2.2 of this handbook, the sustainability certification of SAF involves evaluating the environmental, social, and economic aspects of the fuel production process to ensure that it meets specific sustainability criteria. Generally, it aims to ensure the following:

- Sustainability in feedstock production,
- Traceability and chain of custody of sustainable materials through the supply chain
- Verified reduction in life cycle emissions compared with conventional aviation fuel alternatives

For the tests at FCO, the sustainability certificate was issued by certification body 2BSvs + PRO04, utilizing the ISCC-EU certification scheme of raw material's supplier. The PoS was issued by the fuel provider Eni, the following sustainability parameters reported:

- Type of product/input material: HVO (co-processed hydrotreated vegetable oil kerosene fraction)
 - Country of Production: Italy

- Raw material/s: Regenerated Used Cooking Oil
 - Country of origin: Italy
 - Harvest: N/A
- Total amount Jet A1+Eni SAF equal to 30,210 tons of which sustainable amount is 0,1396 tons; 42,8 MJ/Kg; energy content 5.974 MJ
- The biofuel has been produced from waste, residues or by-products, with by-products not arising from agriculture, forestry, fisheries or aquaculture.
- GHG Saving % of the bio component part of the SAF blend: 90,52 %
- Carbon intensity Total 8,9 g CO₂eq/MJ
- Delivery based on the mass balance system pursuant to §30 European Directive 2018/2001/EU ("REDII" e ss.mm.ii.).

To ensure that a proper claim could be issued and avoid double claiming, the PoS also reported what would become the "identity" for this specific batch of SAF delivered, primarily as follows:

- Certification system/scheme	- Batch Number
- Certificate n°	- Supplier/Shipping Site
- Contact details of certificate issuer	- Buyer/Delivery site
- Issued by Rina Services S.p.A.	- Contract reference number
- Expiry date	- Delivery date
- Date of last verification	- Transportation mean
- Number of Sustainability Claim	

This PoS therefore confirmed that the batch of SAF meet the requirements for sustainability and GHG emissions savings compliant with EU ETS and CORSIA; accounting, reporting and claim on achieved emission reductions for the SAF tests at FCO were made accordingly. Since for this scheme SAF is zero-rated, by evidencing its utilization, ITA was able to reduce requirement to surrender CO₂ allowances.

5.2 Quality assurance

As previously explained on section 3 of the handbook, technical documents demonstrating fuel quality must accompany the product to its destination. The most common of these documents are listed here:

- Refinery Certificate of Quality - RCQ
- Certificate of Analysis - COA
- Recertification Test Certificate - RTC

Since for both test 1 and test 2 the SAF was manufactured via co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery, the quality assurance process of the aviation fuel followed the same procedures as it would have for documenting CAF. An RCQ was issued for the SAF blend by Eni following existing procedures, no extra steps and documents were issued for quality assurance purposes. The RCQ reported required data to ensure the safe use of the fuel, mainly the following parameters:

- | | |
|---|------------------------------------|
| - Appearance | - Corrosion |
| - Particulate Contamination at Point of Manufacture | - Stability |
| - Composition | - Contaminants |
| - Refining Components at Point of Manufacture | - Water Separation Characteristics |
| - Incidental Materials | - Conductivity |
| - Volatility | - Lubricity |
| - Fluidity | - Additives |
| - Combustion | |

Unlike the certificate for a fossil fuel in pure form, the RCQ for a fuel that contains a bio-component must specify under the 'Refining Components at Point of Manufacture' and 'Incidental Materials' categories, the type, units (in %), limits, test method, and results specific to the bio-component.

The following was reported under the RCQ for the SAF test at FCO:

- Refining Components at Point of Manufacture: Hydroprocessed components including Co-hydroprocessed synthesized kerosene.
- Incidental Materials: Fatty Acid Methyl Ester (FAME) - ASTM 07797

5.3 Quantifying SAF volumes reaching the airport

Usually, the purchase of SAF is a transaction conducted between the user, an airline, and the provider, a SAF supplier; it is not common practice for airports to get involved in the fuel procurement process.

This case study was exceptional in that sense since the initiative to introduce SAF into FCO came for a joint effort between ADR and Eni. This meant that the volumes of SAF that reached FCO for both tests were recorded and delivered to the buyer instead of the user, via the PoS where total tons of fuel delivered, and the proportion of the bio-component were clearly identified. Of course, no claim would have been possible unless ITA burned the SAF blend, yet ADR was involved in the process and was able to ascertain the potential for scope 3 emission reductions from SAF usage, crucial to help them achieve their commitment to reach its Net Zero commitment by 2030.

This scenario helps identify a not-too-distant obstacle Union airports may face under existing RFEUA provisions. As it stands today, and soon to come into force as of January 2025, aircraft operators shall report total amount of aviation fuel uplifted at each Union airport to the competent authorities and via the EASA Digital Reporting Tool. For fuel suppliers, RFEUA stipulates that they must implement a data collection and reporting mechanism enabling to monitor the effects of this regulation (see section 2.2.1). Union airports are to take all necessary measures to facilitate the access to aviation fuels for aircraft operators containing required minimum shares of SAF, seemingly no other involvement.

6. Leadership and communications at CPH

The Rome airport system is an engine for the development of the country and the territory surrounding the airports from an economic, environmental, and social point of view. ADR's

transition to sustainable development has and will continue to reach groundbreaking achievements, to name a few:

- Rome airports are the first European airports to obtain ACA 4+ certification
- By 2030 all new infrastructures such as terminals or piers that will be built or renovated will have to be designed according to the highest international sustainability standards (LEED and BREEAM)
- Ongoing key projects include the construction of different large multi-MW photovoltaic plants at FCO, securing SAF supply volumes, extending the supply of HVO to power ground support vehicles, and the development of a capillary network of recharging points for electric vehicles.

Already in 2020, actions taken to reduce its environmental footprint allowed ADR to generate Green Bonds worth € 300 million; leadership in environmental action and sustainable development is embedded within ADR's business plan.

6.1 Lasting commitment to SAF usage by ADR

Since an airline's scope 1 emissions embody an airport's scope 3 emissions, actions on SAF usage represent an opportunity to further reduce the environmental impact of ADR's administered airport's operations. Both SAF tests conducted by ADR in 2021 and 2022 have served to understand the operational and infrastructural needs that entail SAF usage at an airport. The experience and results obtained have shown that ADR is ready to provide SAF to its custom airlines.

ADR remains strongly committed to its environmental goals and is continuously analyzing the market and finding ways to support usage and raise awareness on the benefits of SAF usage.

6.2 Global, regional, and national regulation supporting the use of SAF

At the time of this case study, the EU had implemented the EU ETS and CORSIA. Linked to the 'Fit for 55 Package,' RFEUA legislative proposal was made in 2021 and published as regulation in October 2023.

EU ETS is a cornerstone of the EU's policy to combat climate change and reduce GHG emissions in a cost-effective and economically efficient manner. Operating on a cap-and-trade principle since its establishment in 2005, the EU ETS sets a cap on the total amount of certain GHG that can be emitted by installations covered by the system. Companies receive or buy emission allowances, which they can trade with one another as needed. The cap is reduced over time, ensuring that total emissions fall. As it relates to aviation, the EU ETS covers flights within the EU and the EEA, as well as departing flights to Switzerland and the United Kingdom.

CORSIA is a global MBM developed by ICAO. CORSIA aims to stabilize CO₂ emissions from international aviation at 2020 levels by requiring airlines to offset any growth in emissions above those levels. Airlines can achieve this by purchasing carbon credits from approved projects that reduce or remove emissions from the atmosphere. CORSIA complements other aviation in-sector emissions reduction efforts, such as technological innovations, operational improvements, and the use of SAF.

RFEUA aims to ensure that EU air transport meets the EU's climate targets for 2030 and 2050. This regulation creates a strong and stable legal framework to promote the gradual supply and uptake of SAF in the EU. Enforcement of RFEUA started in 2025, whereby aviation fuel suppliers are required to supply a minimum of 2% SAF, which will gradually increase to at least 70% by 2050. The regulation also sets out rules for enforcement, reporting, and a new flight label to help consumers make informed choices regarding their transport options.

Between 2021 and 2023, Italy also made significant efforts to support SAF. ENAC played a key role by implementing policies and creating a roadmap for SAF usage. Italy transposed the EU Directive 2018/2001 (RED II) into national legislation through Legislative Decree 8/11/2021, which came into effect in December 2021. Furthermore, the Italian government participated in RFEUA and provided supported to research projects to improve SAF production processes and provided financial incentives for SAF adoption.

Individually, ADR has demonstrated a strong commitment to climate action through various initiatives and strategies aimed at reducing aviation's environmental impact. In addition to the actions described in this cases study in support of SAF usage, ADR's sustainability efforts also include the implementation of measures to improve energy efficiency, reduce FCO's and CIA's overall GHG emissions, and promote the use of renewable energy sources. ADR has achieved commendable milestones in reducing its carbon footprint by adopting the Airport Carbon Accreditation program and investing in sustainable infrastructure projects, such as solar panels and energy-efficient buildings. ADR also engages with stakeholders to promote environmental awareness and sustainable practices. Their commitment to sustainability includes reducing emissions, improving energy efficiency, and promoting renewable energy sources.

Overall, the Italian Government and ADR's actions during this period demonstrated a strong commitment to promoting SAF usage in aviation, aligning with EU goals of reducing GHG emissions and achieving climate neutrality by 2050.

6.3 Public awareness and client uptake

To inform the public and raise awareness, the very first delivery of a SAF blend to FCO in 2021 was greatly disseminated through articles on the national press and the local press as well as on some institutional websites like that for the Agenzia delle Dogane and on different LinkedIn posts. Furthermore, ADR created a footage of the delivery that showed in a few seconds the supply chain of the handling and delivery of the SAF blend from the beginning to the end.

To follow up on the success of the dissemination of the decarbonization projects, in the summer of 2022, ADR launched a survey with the scope of understanding passengers' awareness about aviation's commitment to decarbonization, and their role within the value chain. In total, 400 passengers responded to the survey revealing that 80% of them was not aware of the environmental efforts of the aviation sector.

The survey also tested passengers' sensitivity to the topic, asking them if they would have liked to know more about the decarbonization strategy of the aviation industry. Half of respondents said they would, in fact, have liked to know more, choose announcements on the airplane or at the airport as their preferred communication channel

Results from the survey helped demonstrate that there was still more work to do in terms of communication and public awareness. Furthermore, according to passengers' feedback, airports and airlines should play the main role in this challenge and cooperation among all the various stakeholders within the aviation industry is key to increase public awareness and gain their support and participation to reduce the environmental impact of the aviation industry.

7. Conclusion

This case study analyzed two different modes of transporting and handling SAF blends at an airport: segregated and via mass balance. The results of the tests clearly highlight the operational differences and logistical implications between the two chain of custody approaches.

In the first test, the SAF blend was transported segregated by truck from the port of Civitavecchia directly to FCO's airport stand for uplift. This fuel handling process presented several operational complexities. It required the implementation of an ad hoc procedure, outside of regular airport operations. Managing the out-of-line fuel flows compared to established fuel handling procedures using the pipeline and hydrant system involved significant effort in terms of planning, coordination, and monitoring, making it less efficient and with a higher impact in terms of resources and operational costs. There were no safety nor infrastructural constraints for ADR to use the pipeline and the hydrant system for distribution. As a drop in fuel, the SAF blend posed no restrictions on using the same fuel handling infrastructure and JIG procedures as CAF. Yet, the objective of using SAF at ADR's airports was to understand the needs in instance where the SAF blend needed full segregation, unlike in the second test where BAU practices were followed.

The second test helped to demonstrate that transporting the SAF blend from the port of Civitavecchia to FCO fuel farm via pipeline does not present any, significant differences compared to managing CAF. This approach allows for the SAF blend to be integrated within existing infrastructures and procedures, minimizing the need for extraordinary interventions or adjustments to daily operations. The test demonstrated that a SAF blend can be effectively managed through existing pipelines, thus facilitating a smoother delivery of SAF blends while reducing costs and operational complexities.

The experience of integrating SAF at ADR revealed several valuable lessons. First and foremost, the importance of leveraging existing infrastructure cannot be overstated. The second test, which utilized existing pipelines for SAF delivery, demonstrated the efficiency and cost-effectiveness of this approach compared to the segregated transport via truck. This highlighted that incorporating SAF into pre-existing systems minimizes operational disruptions and resource allocation, proving to be a more scalable and replicable model for broader implementation. Additionally, close collaboration with key stakeholders, including fuel suppliers, airlines, and regulatory authorities, was crucial in navigating the logistical and regulatory challenges associated with SAF handling and integration.

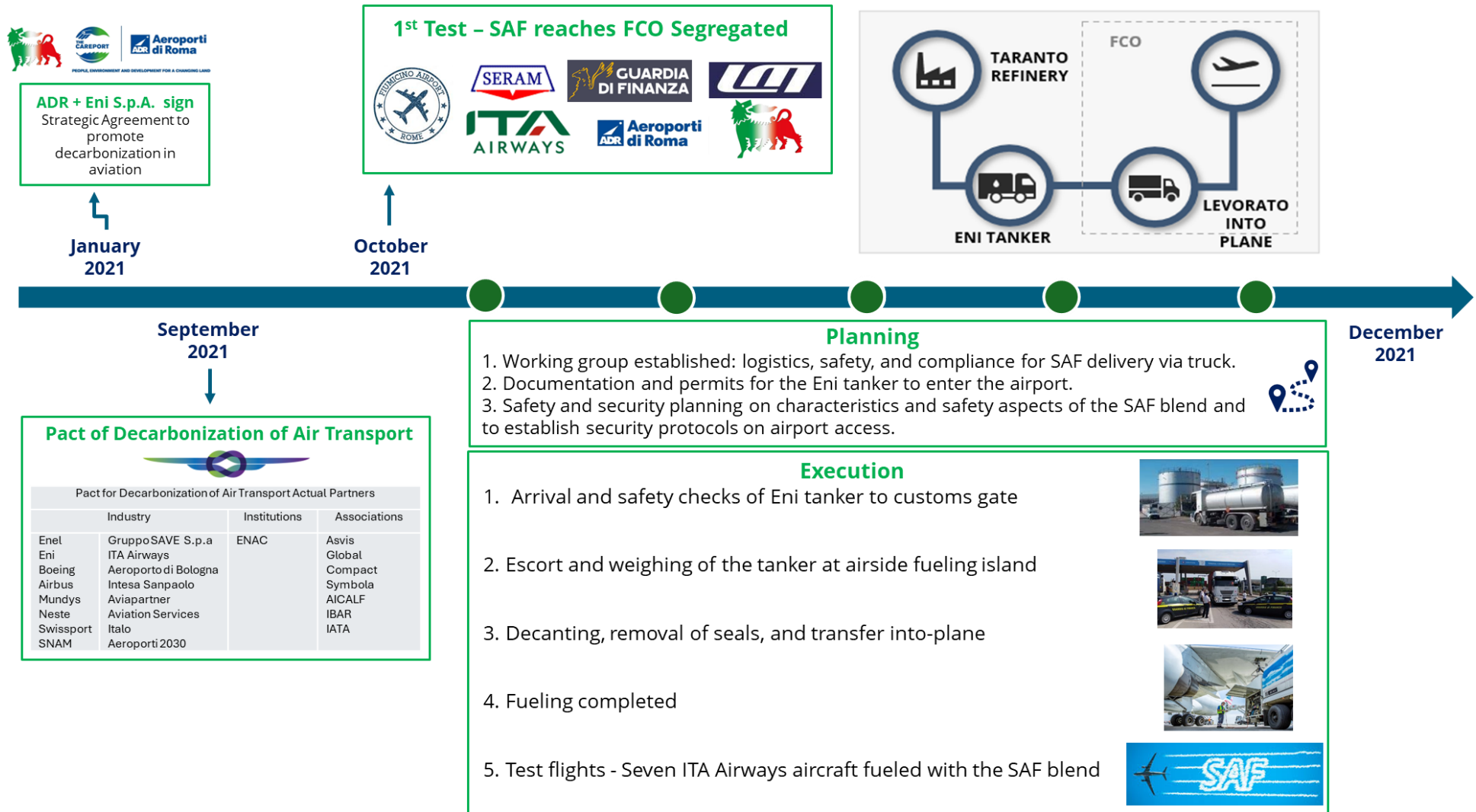
Another significant lesson was the necessity of comprehensive planning and coordination. The initial test using truck transport uncovered various logistical challenges that required bespoke procedures and extensive coordination. This experience underscored the need for meticulous

planning and proactive stakeholder engagement to address unforeseen issues and ensure smooth operations.

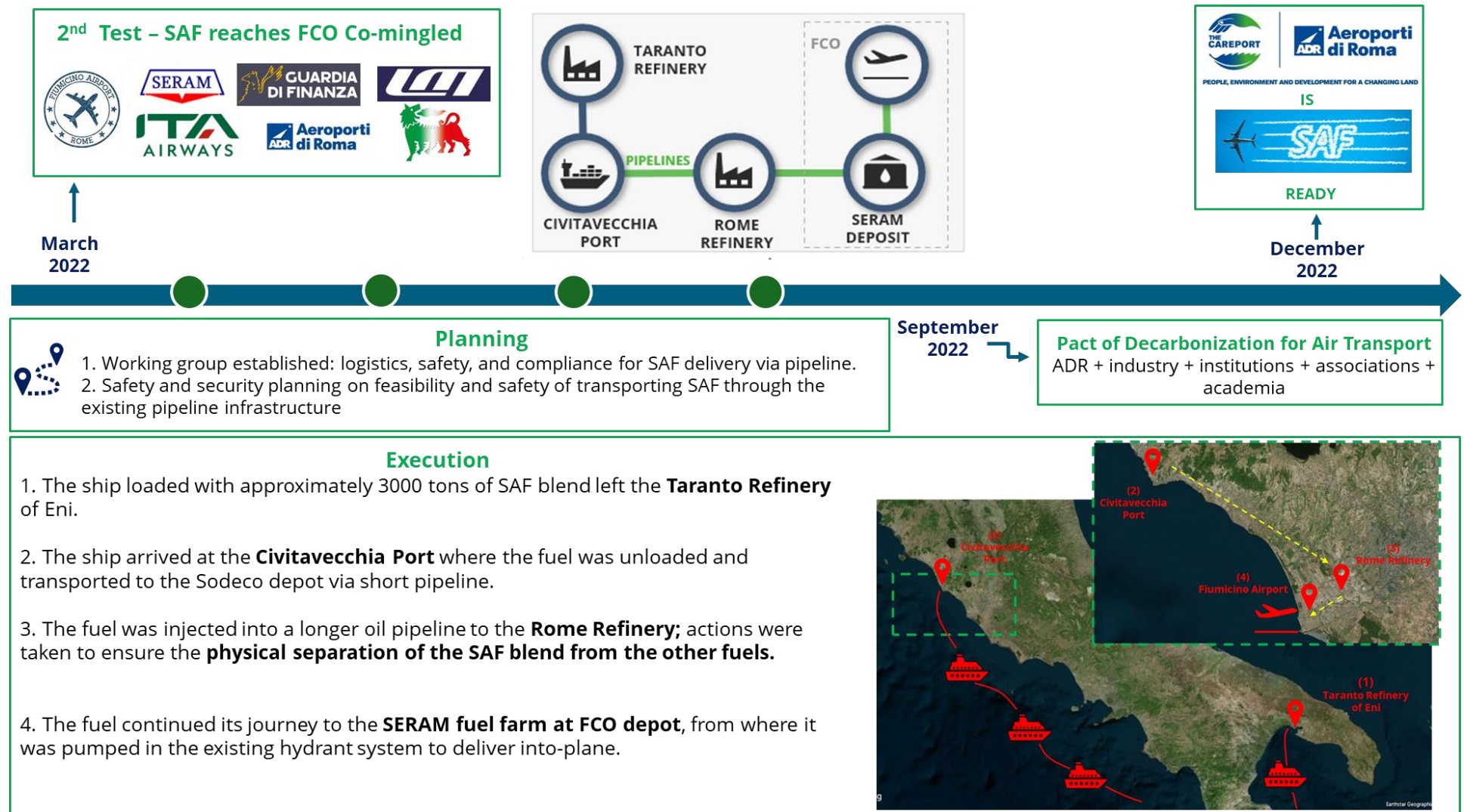
In conclusion, for an airport like FCO, both tests helped demonstrate that it is safe, feasible, and cost and time effective to handle and deliver a SAF blend using the same procedures and infrastructure used for CAF. The lessons learned emphasize the critical role of infrastructure readiness, stakeholder collaboration, and regulatory frameworks in advancing SAF's initiatives.

The following timeline provides an illustration of stakeholders involved, actions taken, and the evolution of this case study through time to serve as an example for other airports to follow:

TIMELINE – 1st TEST – SAF REACHES FCO SEGREGATED



TIMELINE – 2nd TEST – SAF REACHES FCO CO-MINGLED



5 Procurement of SAF

The SAF industry is complex and fast-changing, which presents challenges for airlines looking to start procuring SAF. Third-party entities can assist airlines in obtaining intelligence on the SAF market and where to source supply. IATA and ICAO provide details of global SAF supply and projected volumes, which can be easily accessed online to assist in the process of identifying potential suppliers.

This section discusses issues related to the purchase of SAF by airlines (general aviation customers and commercial airlines) and identifies the changes required in the procurement cycle. For these purposes, the fuel seller is assumed to be one of the following four parties: SAF producer, petroleum refinery, blender, and oil and fuel trader. In all cases, purchase agreements should list (but not be limited to) the agreed conditions for fuel specification, sustainability certification, pricing, and the assignment of any renewable energy and minimum GHG emissions reduction requirements via a robust SAF accounting mechanism.

5.1 Types of procurement

The market for SAF increased more than twofold from 2021 to 2022.¹ However the current fuel use is predominantly conventional fossil fuel based with lower than 1% of fuels containing SAF. To scale the market of SAF, it is important for all participants to understand the process of how SAF can be bought and what are the key considerations of market players.

5.1.1 SAF Procurement by Airlines

For International Airlines, SAF procurement is driven by considerations on price, feedstock preferences and geographical availability. Due to their larger footprint and low amount of SAF relative to fuel use currently available, airlines can concentrate SAF purchases in advantaged locations, which either reduce the economic impact, have better availability, or match their feedstock or other priorities.

Due to the high economic impact of SAF, it is important to understand the economic drivers and make sure that the best option is chosen to not fall back on cost structure against competitors. In this sense, supporting policy like incentives becomes crucial to accelerate SAF uptake.

5.1.2 Commercialization of SAF

Some Airlines can create 'sustainable air products' (sustainable cargo transport or sustainable seats) on their aircraft, by achieving lifecycle carbon savings and finding ways to attribute them to specific customers. Airlines may allow customers to purchase SAF via corporate programs, such as SAS's program for Sustainable Aviation⁶³.

Specifically, a corporate SAF program is an initiative that airlines can include in their SAF procurement strategy, which establishes a transparent mechanism allowing corporate customers to participate in the transition and claim scope 3 emission reductions. Participating corporates receive a scope 3 emissions reduction certificate, which can be reported according to guidelines

⁶³ SAS, 2023: <https://www.flysas.com/en/corporate-program/corporate-sustainability-program/>

set by GHGP and other initiatives. These claims must be verified by an independent third-party carbon auditor (i.e., a “verifier”). How these programs are developed and executed will always be airline-specific and part of a broader commercial strategy including decarbonization. However, the main objectives of this type of initiative include the following:

- Accelerate the global and regional transition to SAF through increased demand from users of air transport services.
- Provide corporate customers with the option to reduce their scope 3 emissions.
- Corporate customers can communicate a willingness to contribute to a sustainable future (brand enhancement) and share in shouldering its costs.

Corporate programs require significant documentation to verify emissions reductions and proof of sustainability, which should be enabled by a robust SAF accounting mechanism.

5.1.3 SAF Procurement by General Aviation customers

General aviation customers generally have a different operating mode than commercial airlines. Most fly a smaller number of aircraft or operate on ad-hoc schedules. This makes it more difficult, as demand from commercial airlines has not reached the expected volumes. For general aviation customers it is therefore difficult to pool demand to certain locations, which are more predictable in terms of demand structure. Pooling demand many times allows for more favorable pricing negotiations for users, it allows for the flexibility fuel suppliers need in order to supply SAF to the operator.

5.2 Procurement Documentation Requirements

Consistent with the sustainability certification process presented in section 1.2.2, the SAF procurement process must also ensure that SAF suppliers provide specific documentation to enable airlines and their customers to claim the environmental attributes and prove they meet the eligibility criteria of specific regulatory schemes, financial incentive programs, and other carbon reduction programs in accordance with guidance set by the GHGP⁶⁴. Without this documentation, the buyer may be unable to claim the environmental attributes associated with the batch of SAF purchased.

In sum, the following documents, at a minimum, should always be specified in a SAF procurement contract:

5.2.1 PoS – Proof of Sustainability

A delivery document issued by a supplier and certified under a relevant certification scheme, such as CORSIA Approved Sustainability Certification Scheme or EU RED Sustainability Certification Scheme, by SCSs as described in Section 3.3, for each delivery of sustainable material. The delivery document includes relevant information about the sustainable material that will be delivered, which is SAF.

⁶⁴ GHGP: <https://ghgprotocol.org/>

5.2.2 PoC – Proof of Compliance

A delivery document issued by a supplier and certified under the EU RED Sustainability Certification Scheme, by a certifying organization such as ISCC and RSB, for delivery of sustainable material, in a situation where the associated Proof of Sustainability document is required to be surrendered to the relevant regulatory authority. (Note: At the time of writing of this handbook, eligibility of the PoC has yet to be implemented.)

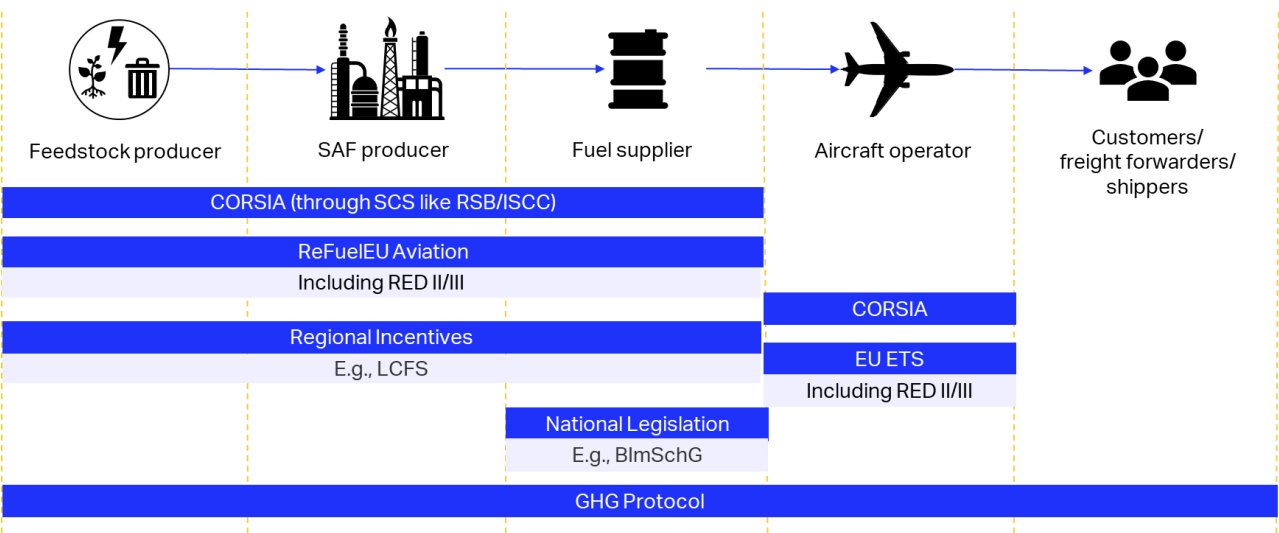
5.2.3 PTD- Product Transfer Document

A delivery document that authenticates the transfer of ownership of the SAF from the Seller to the Buyer.

Airlines need to pay close attention to what documentation suppliers are willing to include in the contract; in some circumstances, a PoS will not flow through to the buyer. A PTD or PoC (mandated volumes) could be offered as a substitute, but airlines need to verify that these are acceptable for claiming the environmental attributes under specific regulatory schemes in a particular jurisdiction.

Specific sustainability documentation will be needed for compliance under different regulatory and voluntary schemes, some of which are illustrated in Figure 10 for quick reference.

Figure 41- SAF related schemes and regulations along the supply chain



Note: Each framework would specify their GHG reductions requirements and can be different to one another.

Source: Adapted from Lufthansa Group

5.3 SAF Production Costs

One of the main deterrents to broader SAF deployment today is their high price, largely explained by high feedstock and production costs. SAF prices can range between 2 to 5 times that of CAF, depending on the technology pathway and chosen feedstock. Some innovative business models have been reported to produce and sell SAF at prices competitive with CAF. With effective policy and commercial innovation from both the demand and supply sides, it is possible to increase supply options and achieve more competitive SAF prices as the SAF industry develops. However, in the medium term, stronger policy support will be critical to ensure the development and scale-up of SAF production by addressing the following main cost drivers:

- feedstock cost and composition
- the capital cost of a proposed process
- overall yield (conversion)
- quality and composition of the produced SAF
- operating expenses
- financial requirements
- logistics
- initial resources

The following table outlines the different elements that may drive the cost of future SAF per different pathways and feedstocks:

Table 11 - Breakdown of cost structure and challenges per SAF pathway

Pathway/Feedstock	Operational Cost	Capital Cost	Comments
HEFA: Waste Fats/Oils/Greases	High Constrained feedstock	Low Existing renewable fuel production capacity	Requires incentives, policies to reduce operational costs, linked to high feedstock costs.
Alcohol-to-Jet + FT: Agriculture & Forestry Wastes	Low/Medium Abundant waste-based feedstock; low value	High New renewable fuel production capacity required	Risk capital required to enable new biorefining ventures. Once capital cost is absorbed, cost of production benefit from lower Feedstock costs.
Fischer-Tropsch: Agriculture & Municipal Solid Waste (MSW)	Low/Medium Abundant waste-based feedstock; low value	High New renewable fuel production capacity required	In addition to above, higher tipping fee for waste collection can be a further incentive to leverage these feedstocks.
Power-to-Liquid: Industrial Waste CO ₂	Low/Medium Abundant synthetic carbon source from existing processes	High New renewable fuel production capacity required	Requires a concentrated CO ₂ source of synthetic carbon, but questions remain over their fossil origin sources and thus use in SAF production.
Power-to-Liquid: Direct Air Capture CO ₂	High Abundant synthetic carbon source, but requires further technological maturing	Very High New renewable fuel production capacity required	The most abundant source of synthetic carbon, but limited today by current technology immaturity; significantly high capital intensity and renewable energy requirements.

Source: IATA Sustainability & Economics

5.4 SAF Pricing Structure

SAF is usually not priced in correlation to conventional jet fuel. For conventional jet fuel certain considerations are made:

- Crude oil pricing
- Refining cost and availability (and margins for other refined products)
- Jet differential to Gasoil

Based on the above pricing regional quotes are published by pricing agencies, which can provide insights into pricing at key regional hubs. Furthermore, locations not directly located at those regional hubs are subject to logistics premia based on the market levels of logistics costs. For smaller or not as well-connected locations or for separate customer requirements, other pricing structures can be chosen.

For SAF pricing and procurement, the key considerations are:

- Feedstock costs
- Conversion technology
- Logistics costs (differential to conventional Jet fuel logistics)
- Policy support (i.e. RTFO/HBE, RFS, others)

For a SAF blend, a combination of the above is needed to reflect the final price at the wingtip. For aircraft operators that are part of carbon pricing schemes or other schemes where SAF can generate an incentive or benefit, the net price will be lower than the price purchased from SAF suppliers.

Several considerations other than pricing alone play a factor in structuring the price for SAF, for example its co-dependency to other renewable sources of energy.

Under the current SAF production ecosystem, which is almost entirely associated with fuels from biological origin, facilities producing SAF are simultaneously producing several other co-products from the same feedstock, such as renewable diesel, biogas, and naphtha. As such, it is not a given that any SAF will be derived from these facilities, as producers optimize their product mix in function of supply and demand, and potential profits.

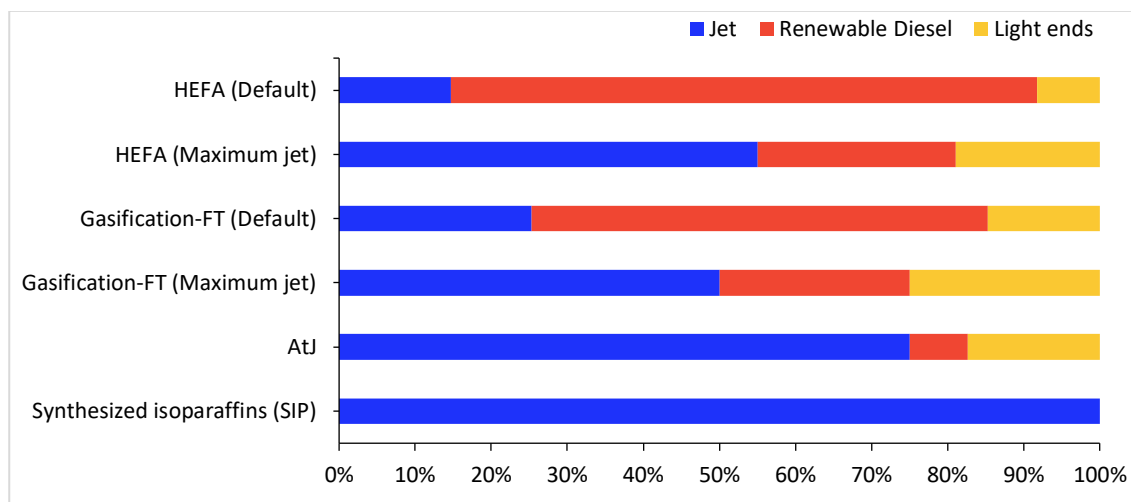
In the interest of airlines' ability to meet decarbonization obligations and achieve their net zero commitment, two key factors must be considered:

- The global availability of sustainable fuels refineries capable of producing SAF.
- The optimum SAF percentage fraction derived from renewable fuel production facilities.

The maximum theoretical threshold for the SAF percentage fraction in the refinery depends on the production pathway. HEFA, for example, can deliver a SAF fraction between 15-50%, while FT can yield 25-40% SAF of the refinery's total output. The SAF yield at AtJ plants can range between 70-90% SAF.

The following figure shows typical product yields for the key SAF conversion pathways, and the yields while maximizing the SAF output for the HEFA and FT pathways, for comparison:

Figure 42- Product yields for key SAF conversion pathways



Source: IATA SAF Handbook 2024, adapted from [ICCT – The cost of supporting alternative jet fuels in the European Union](#)

While technologies can enable the adjustment of product slates, this often comes at the expense of overall yields. The choice and diversification of SAF pathways and the economic feasibility of SAF production require careful study. At this early stage of the market's creation, policy is the key enabler. Balanced incentives to support optimum outputs from the refining process and fairly supporting all renewable fuels are key to facilitating the energy transition as specified under Section 2 of this handbook.

PtL fuels, also referred to as E-Fuels, are a bit different than the above as they are produced with electricity which if generated by renewable energy such as wind or solar, makes them less carbon intensive. The renewable energy is used to power the capture of carbon dioxide, either directly from the atmosphere or from an emission source. It is also used to power the production of green hydrogen which can be used as a liquid fuel itself or synthesized with the captured carbon dioxide. This synthetic gas can be converted into a liquid SAF via PtL using the Fischer-Tropsch process. PtL SAF will likely play a pivotal role in aviation's decarbonization strategy. However, it will have to contend with multiple challenges, competing markets, technologies, and over longer timelines than advanced biofuels. PtL fuels might only begin to scale and complement advanced biofuels from the mid-2030s. Moreover, achieving such scale in e-fuels will require greatly increased global production of renewable electricity to power the carbon dioxide capture process, and to produce the hydrogen for PtL fuels. There is also a need to scale the number and capacity of carbon capture facilities.

The following table outlines the different elements that may drive the cost of future SAF per different pathways and feedstocks:

Table 12 - Breakdown of cost structure and challenges per SAF pathway

Pathway/Feedstock	Operational Cost	Capital Cost	Comments
HEFA: Waste Fats/Oils/Greases	High Constrained feedstock	Low Existing renewable fuel production capacity	Requires incentives, policies to reduce operational costs, linked to high feedstock costs.
Alcohol-to-Jet + FT: Agriculture & Forestry Wastes	Low/Medium Abundant waste-based feedstock; low value	High New renewable fuel production capacity required	Risk capital required to enable new biorefining ventures. Once capital cost is absorbed, cost of production benefit from lower Feedstock costs.
Fischer-Tropsch: Agriculture & Municipal Solid Waste (MSW)	Low/Medium Abundant waste-based feedstock; low value	High New renewable fuel production capacity required	In addition to above, higher tipping fee for waste collection can be a further incentive to leverage these feedstocks.
Power-to-Liquid: Industrial Waste CO ₂	Low/Medium Abundant synthetic carbon source from existing processes	High New renewable fuel production capacity required	Requires a concentrated CO ₂ source of synthetic carbon, but questions remain over their fossil origin sources and thus use in SAF production.
Power-to-Liquid: Direct Air Capture CO ₂	High Abundant synthetic carbon source, but requires further technological maturing	Very High New renewable fuel production capacity required	The most abundant source of synthetic carbon, but limited today by current technology immaturity; significantly high capital intensity and renewable energy requirements.

Source: IATA Sustainability & Economics

5.5 Types of SAF Purchasing Agreements

Many SAF offtake agreements have been published, of different types and sizes. ICAO tracks the major SAF offtake agreements and can give insight into the scale. To date, 117 SAF offtake agreements have been published, which consist of more than 40 million tons of SAF⁶⁵. Agreements can vary drastically in length of contract duration and can also vary by the type of agreement.

5.5.1 Spot Agreements

Spot contracts are usually defined as shorter term than term contracts. In Aviation, although there is no definitive time cutoff date for spot contracts, one may reasonably assume spot contracts to not only be fulfilled at one point in time, as in other industries, as the product traded in this context is a physical resource that needs to be transported and used by aircrafts. Therefore, spot contracts define a shorter period of time, below one year and mostly between one and three months. For SAF, this has several benefits for the airlines and fuel suppliers, as there is higher volatility in SAF contracts, which with a spot contract is easier to manage for both airlines and fuel suppliers. A spot contract is therefore usually combined with term agreements, to smooth out unforeseen demand impacts or changes in short-term volume.

For most spot contracts, public announcement may not be made, so the total SAF in offtakes is likely to be higher than what data is publicly available.

5.5.2 Term Agreements

Term agreements are usually agreed for a prescribed time period, with the expectation that a new contract can be agreed with the same or different supplier at the end of the contract. Term contracts are generally anywhere between 1 and 20 years long, reflecting different needs for different types of SAF contracts. In conventional Jet procurement, term contracts are usually 12-24 months contracts, with one airline, or airline group, which generally include one fuel supplier, and multiple locations based on a competitive tender process. However, this process may vary depending on procurement policies of the airlines involved. Term contracts offer security of supply and stability of pricing for airlines and allow airlines to make longer term commitments to their customers or underpin longer term voluntary targets for SAF use.

5.5.3 Agreements for future offtakes / Investment into SAF producers

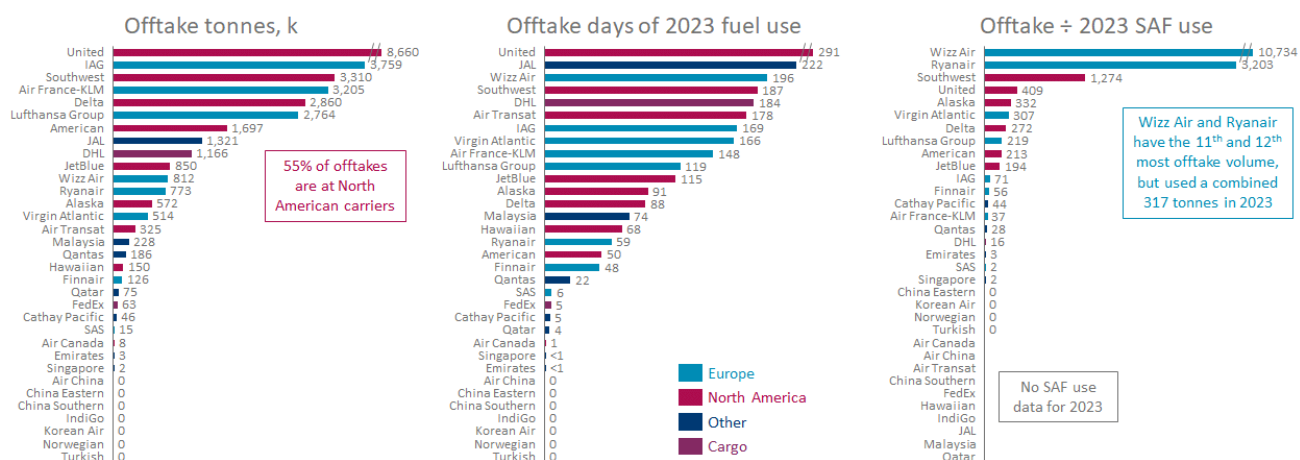
Aside from buying fuel for the airline, offtake agreements can also serve to make upcoming SAF projects bankable, by removing the risk of the product not being able to be sold. Airlines are stepping in as risk mitigator, allowing SAF project developers to integrate debt capital at lower rates than equity to finance upcoming projects. This can have multiple benefits for the parties involved, such as lower overall cash costs for SAF, and enabling both the airline and the SAF producer to make long term commitments to their respective suppliers and customers. For the airline there are additional risks, mainly that a project could not deliver in time due to building delays, regulatory changes, a project that fails to gain access to financing, etc. On the other

⁶⁵ ICAO, 2023: <https://www.icao.int/environmental-protection/GFAAF/Pages/Offtake-Agreements.aspx>

hand, engaging early in projects, provides unique insights into new technologies and knowledge of market developments.

Following a series of graphs illustrating the latest information on SAF off-take agreements:

Figure 43 - SAF Off-Take Agreements - Action Today and Tomorrow



Sources: ICAO Tracker; airline voluntary reporting of top airlines representing 78% of 2023 global jet fuel consumption, as analysed by IAG. Cathay Pacific and United figures adjusted for Fulcrum (JAL volume never disclosed), FedEx and Southwest adjusted for Red Rock, IAG adjusted for Project Speedbird (82k tonnes/year x assumed 30-year lifespan). Airlines shown are at least one of the top 20 largest by 2023 fuel use, 2023 SAF use, or SAF on order.

Source: Aaron Robinson - U.S. at International Airlines Group

5.5.4 Equity Stake Investment

An equity stake is a strategic investment for airlines, involving the purchase of ownership in a SAF refinery. This ownership ensures future supply access and preferential pricing, enhancing control over the supply chain. However, it presents a new risk, as the investment can be lost if the project fails. Thus, it's an option for airlines with strong financial resources. Some airlines have taken equity stakes to secure SAF supply and access to feedstock in the short to medium term. These agreements may use different pricing methodologies, such as CAF parity.

5.5.5 Joint Purchasing (procurement) Agreement

Given the current price of SAF, some airlines are starting to enter joint procurement discussions with other airlines as part of broader alliance activities. The benefit of joint procurement is that it allows multiple customers to pool their volume and provide greater demand certainty to potential suppliers. It is a concern that smaller airlines find themselves priced out of access to a market that is still structurally under-supplied, and that supply remains constrained if purchase volumes are insufficiently large.

5.6 CoC models and SAF procurement

Similarly to the case for accounting and reporting, the three CoC models discussed in section 2 also have a role to play in the supply and procurement of SAF, that is:

- Physical segregation
- Mass Balance
- Book and claim

The choice of CoC will have impacts on the applicability of certain rules under the myriads of mandatory and voluntary regulations, including ReFuel EU aviation, EU ETS, SBTi, GHGP and others. Physical segregation for jet fuel supply chains is very difficult to achieve due to the burden of additional logistics and the impossibility to share the use of infrastructure at airports (fuel is mostly part of the central infrastructure, not every fuel supplier has their own tank at the airport). Mass Balancing is currently widely used in the aviation industry because it allows for SAF to be handled using the shared infrastructure at airports and be incorporated into the fuel supply chain BAU.

Through book and claim, the physical fuel and the environmental attributes of the fuel are separated. The physical fuel is sold as fossil at an airport, while the environmental attributes are sold to a customer, who can then claim the benefits of the usage of SAF, without having used the physical fuel. Book and claim is currently not (fully) recognized by most regulatory schemes, including EU ETS, national SAF blending mandates and some voluntary GHG accounting schemes. Examples of book and claim schemes include mostly pilot demonstrations such as the RSB book and claim scheme⁶⁶ and the ISCC Credit transfer scheme⁶⁷ for SAF procurement.

Therefore, for most aviation operators, at this current timeframe, mass balancing is the most favorable procurement option. While some benefits exist beyond mass balancing in the segregation and book & claim options, they are currently not sufficient to outperform mass balancing.

⁶⁶ RSB, 2021: [RSB launches first SAF book & claim pilot with Air bp to enable certified SAF claims from Microsoft and United Airlines – RSB](#)

⁶⁷ ISCC, 2023: [11 ISCC TCSAF Thomas-Bock The-ISCC-Credit-Transfer-System--Overview-of-System-and-Registry.pdf \(iscc-system.org\)](#)

6 SAF Readiness Self-Evaluation

This section is dedicated to understanding the level of SAF readiness for airports, fuel suppliers, and aircraft operators. Using this self-assessment checklist, readers will be able to understand if they have all that is necessary to facilitate, supply, and use SAF at an airport aimed at optimizing the climate benefits through target use.

For airports, the following self-assessment checklist provides guidance on incorporating SAF into ground operations. Depending on the current infrastructure, an airport may be equipped to segregate different fuel grades and types, or it may need to handle SAF co-mingled with CAF. Airports that are equipped to segregate fuel will be ready to offer clients more options to minimize their climate impacts. Where segregation isn't possible, there are significant opportunities to improve LAQ.

For fuel suppliers, this self-assessment checklist provides guidance on incorporating SAF into airport fueling storage and handling operations. Depending on the current infrastructure of an airport, a fuel supplier may be equipped to segregate different fuel grades and types, or it may need to handle SAF co-mingled with CAF. Fuel suppliers that can accommodate the segregation of fuel will be ready to offer clients more options to minimize their non-CO₂ climate impacts. Where segregation isn't possible, there are significant opportunities to offer clients improvement on LAQ levels.

For aircraft operators, this self-assessment checklist provides guidance on incorporating SAF usage to daily flight operations. Depending on the current infrastructure of an airport, a fuel supplier may be equipped to segregate different fuel grades and types, or it may need to handle SAF co-mingled with CAF. Where fuel segregation is feasible, aircraft operators will find the opportunity to optimize environmental benefits from SAF usage minimizing the non-CO₂ climate impacts from contrails. Where segregation isn't possible, there are significant opportunities for aircraft operators to improve LAQ levels through the targeted use of SAF.

After completing the self-assessment, airports, fuel suppliers, and aircraft operators will have determined their positioning within the four SAF usage scenarios outlined in Section 4.1.1 of the handbook:

- Scenario 1 – Co-mingled.
- Scenario 2 – Dedicated Flights
- Scenario 3 – Dedicated Airports
- Scenario 4 – Non-Drop-In fuel

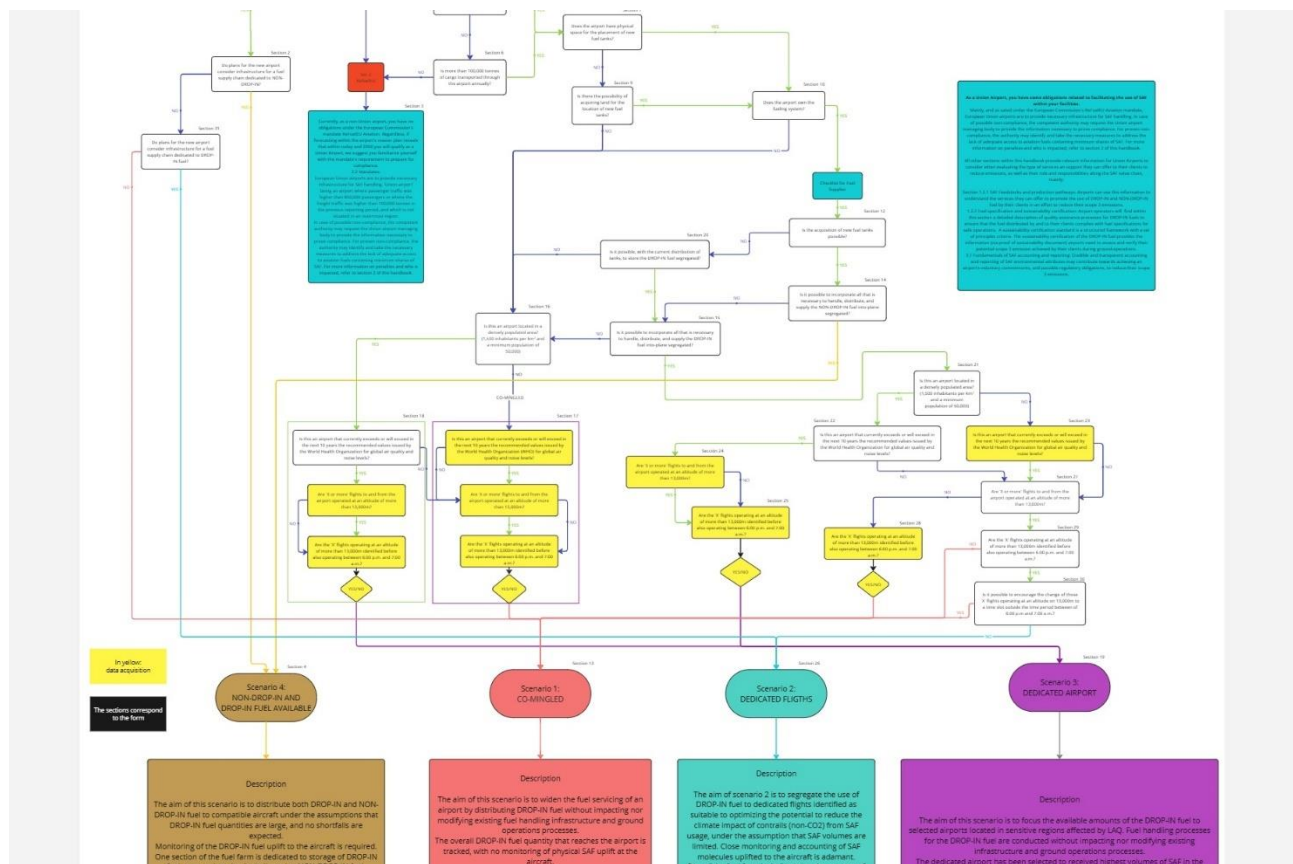
Ultimately, this self-assessment provides guidance to ensure compliance with applicable regulations while helping maximize non-CO₂ and LAQ benefits of SAF both in-flight and on the ground.

6.1 How to use this checklist

This checklist has been developed based on a skeleton of mazes that consider all possible options for SAF usage under the 4 established scenarios aimed at optimizing climate benefits and

compliance with applicable regulations. The following illustration provides a glimpse of the extensive work performed:

Figure 44 - SAF Readiness Level Self-Assessment Checklist



Following is a step-by-step guidance on how to use the self-assessment checklist:

6.1.1 Airports - Step-by-Step Instructions

Before you begin the self-assessment, there are several sets of valuable data we recommend you have handy:

To determine an airport's suitability to optimize the use of SAF aimed at minimizing the impact of contrail formation, it is essential to first assess if the airport handles sufficient traffic of 'dedicated flights.' A dedicated flight is one that has been classified as having a greater potential to generate a contrail. While several parameters must be considered, and uncertainties remain regarding the accuracy of identifying these flights, two parameters are primarily associated with 'dedicated flights:' they operate at an altitude of over 13,000 meters and during nighttime hours, specifically between 6:00 p.m. and 7:00 a.m. for the purpose of this exercise.

Airports that can confirm that at least a certain number of flights arriving and departing operate at an altitude of over 13,000 meters and within the time range of 6:00 p.m. to 7:00 a.m. will be better positioned to understand if they can accommodate SAF usage scenario 2 – Dedicated flights.

Similarly, to understand if an airport is well suited to receive highest volumes of SAF aimed at improving LAQ, it is important to know the if it is located in a densely populate area (15,000

inhabitants per km² and a minimum population of 50,000) and if the airport is currently exceeding or will exceed in the next 10 years the 2021 World Health Organization's global air quality guidelines. For this assessment, those are the two parameters used that qualifies a 'dedicated airport.'

If such data is not available, the self-assessment will still take you through the series of questions needed to determine your airport's suitability among the remaining three scenarios.

You are now ready; follow the next steps to begin the checklist:

a) Access:

- Use the following link to access the self-assessment checklist: <https://forms.office.com/e/WuSd1fLtQv>
- Enter your email address as user ID, chose and password, sign in, and follow the flow of the questions. You can navigate forward by answering the questions and clicking on the 'next' button. You can easily return to the previous screen if you want to edit your answer by clicking on the 'back' button. There is also an option to "save and exit" allowing you to come back to the self-assessment at your convenience from where you left off.

b) Initial Identification:

Begin by determining whether your airport is new or already existing. This distinction will guide you through the subsequent questions tailored to your specific circumstances.

c) Fuel Segregation Capability:

- Assess whether your airport's infrastructure supports the segregation of fuel grades and types. If feasible, segregating sustainable drop-in and non-drop in fuel from CAF can provide more options for reducing the climate impact of contrail formation.
- If segregation is not possible, focus on the opportunities to improve LAQ.

d) Compliance with Regulations:

- Review the checklist to ensure your airport meets the necessary infrastructure requirements for fuel handling as well as obligations on SAF availability as stipulated by the European Commission's RFEUA mandate.
- Familiarize yourself with the definition of a "Union airport" and the relevant passenger and freight traffic thresholds that may apply.

e) Infrastructure and Space Evaluation:

- Determine if your airport has the physical space required for new fuel tanks and related infrastructure.
- Assess whether the airport owns the fueling system and has the capability to acquire new fuel tanks if necessary.

f) Scenario Identification:

Based on your responses, the checklist will guide you to identify your airport's positioning within the four SAF usage scenarios outlined in Section 4.1.1 of the handbook:

- **Co-Mingled:** For airports distributing drop-in fuel within existing infrastructure without modifications.
- **Dedicated Flights:** For specific flights identified to optimize the non-CO₂ benefits of SAF usage.
- **Dedicated Airport:** For airports selected to receive high volumes of drop-in fuel to improve LAQ in sensitive regions.
- **Non-Drop-In SAF Available:** For airports with dedicated infrastructure for both drop-in and non-drop-in fuels.

g) Conclusion:

By thoroughly completing this self-assessment checklist, you would by the end have situated your airport within the recommended SAF usage scenario. This will help ensure compliance with regulations and allow the airport to offer its clients a variety of services and opportunities to enhance local air quality and maximize the environmental benefits of SAF both in-flight and on the ground.

6.1.2 Fuel Supplier - Step-by-Step Instructions

Before you begin the self-assessment, there are several sets of valuable data we recommend you have handy:

To determine a fuel supplier's suitability to provide fueling services that can optimize the use of SAF to minimize the impact of contrail formation, it is essential to first assess if the airport handles sufficient traffic of 'dedicated flights.' A dedicated flight is one that has been classified as having a greater potential to generate a contrail. While several parameters must be considered, and uncertainties remain regarding the accuracy of identifying these flights, two parameters are primarily associated with 'dedicated flights:' they operate at an altitude of over 13,000 meters and during nighttime hours, specifically between 6:00 p.m. and 7:00 a.m. for the purpose of this exercise.

Fuel suppliers who can confirm that the airport under consideration has at least X number of flights arriving and departing operating at an altitude of over 13,000 meters and within the time range of 6:00 p.m. to 7:00 a.m. will be better positioned to understand if they can accommodate SAF usage scenario 2 – Dedicated flights.

Similarly, to understand the opportunities a fuel supplier may have to offer fueling services to their clients looking to improve LAQ, it is important to know the airport under consideration is located in a densely populated area (15,000 inhabitants per km² and a minimum population of 50,000) and if the airport is currently exceeding or will exceed in the next 10 years the 2021 World Health Organization's global air quality guidelines. For this assessment, those are the two parameters used that qualifies a 'dedicated airport.'

Fuel suppliers with access to the density of the population surrounding the airport and its LAQ data will have the opportunity to determine if they can accommodate SAF usage scenario 3 – Dedicated Airports.

If such data is not available, the self-assessment will still take you through the series of questions needed to determine your airport's suitability among the remaining three scenarios.

You are now ready; follow the next steps to begin the checklist:

a) Access:

- Use the provided link to access the self-assessment checklist: <https://forms.office.com/e/qPPmJ6KXs0>
- Enter your email address as user ID, choose a password, sign in, and follow the flow of the questions. Navigate forward by answering the questions and clicking on the 'next' button. Easily return to the previous screen if you want to edit your answer by clicking on the 'back' button. There is also an option to "save and exit" allowing you to come back to the self-assessment at your convenience from where you left off.

b) Initial Identification:

Begin by selecting the airport where you would like to assess your SAF supply options and confirm that it is a Union Airport. This distinction will guide you through the subsequent questions tailored to your specific circumstances.

c) Fuel Segregation Capability:

- Assess whether the fueling infrastructure at the selected airport supports the segregation of fuel grades and types. If feasible, segregating sustainable drop-in and non-drop in fuel from CAF can provide more options for reducing the climate impact of contrail formation.
- If segregation is not possible, focus on the opportunities to improve LAQ.

d) Compliance with Regulations:

- Review the checklist to ensure you meet the necessary infrastructure requirements for fuel handling as well as obligations on SAF availability as stipulated by the European Commission's RFEUA mandate.
- Familiarize yourself with the definition of a "Union airport" and the relevant passenger and freight traffic thresholds that may apply.

e) Infrastructure and Space Evaluation:

- Determine if you own the fuel handling and storage infrastructure at the airport.
- Assess whether the airport's infrastructure can support segregation and storage of DROP-IN and NON-DROP-IN fuels.
- Determine if you can acquire new fuel tanks if necessary to enhance segregation capabilities.

f) Scenario Identification:

Based on your responses, the checklist will guide you to identify your readiness level within the four SAF usage scenarios outlined in Section 4.1.1 of the handbook:

- **Co-Mingled:** For airports distributing drop-in fuel within existing infrastructure without modifications.
- **Dedicated Flights:** For specific flights optimized to benefit from SAF usage.
- **Dedicated Airport:** For airports designated to receive high volumes of drop-in fuel helping improve LAQ.
- **Non-Drop-In SAF Available:** For infrastructure supporting both drop-in and non-drop-in fuels.

g) Conclusion:

By completing this self-assessment checklist, you will determine your readiness level for supplying SAF. This will help ensure compliance with regulations and enable you to offer a variety of services and opportunities to your clients aimed at improving LAQ and maximizing the environmental benefits of SAF both in-flight and on the ground.

6.1.3 Aircraft Operators - Step-by-Step Instructions

Before you begin the self-assessment, there are several sets of valuable data we recommend you have handy:

To determine an aircraft operator can optimize the use of SAF aimed at minimizing the impact of contrail formation, it is essential to first assess if they have sufficient traffic of 'dedicated flights' at the airport under consideration. A dedicated flight is one that has been classified as having a greater potential to generate a contrail. While several parameters must be considered, and uncertainties remain regarding the accuracy of identifying these flights, two parameters are primarily associated with 'dedicated flights:' they operate at an altitude of over 13,000 meters and during nighttime hours, specifically between 6:00 p.m. and 7:00 a.m. for the purpose of this exercise.

Airports that can confirm that at least a certain number of flights arriving and departing operate at an altitude of over 13,000 meters and within the time range of 6:00 p.m. to 7:00 a.m. will be better positioned to understand if they can accommodate SAF usage scenario 2 – Dedicated flights.

Similarly, to understand if an airport is well suited to receive highest volumes of SAF aimed at improving LAQ, it is important to know the if it is located in a densely populated area (15,000 inhabitants per km² and a minimum population of 50,000) and if the airport is currently exceeding or will exceed in the next 10 years the 2021 World Health Organization's global air quality guidelines. For this assessment, those are the two parameters used that qualifies a 'dedicated airport.'

If such data is not available, the self-assessment will still take you through the series of questions needed to determine your airport's suitability among the remaining three scenarios.

You are now ready; follow the next steps to begin the checklist:

a) Access:

- Use the provided link to access the self-assessment checklist: <https://forms.office.com/e/Jzr7HNxAz8>
- Enter your email address as user ID, choose a password, sign in, and follow the flow of the questions. Navigate forward by answering the questions and clicking on the 'next' button. Easily return to the previous screen if you want to edit your answer by clicking on the 'back' button.

b) Initial Identification:

Begin by selecting the airport where you would like to assess your SAF supply options and confirm that it is a Union Airport. Determine whether your company operates at least 500 commercial passenger air transport flights or at least 52 commercial all-cargo air transport flights departing from the selected Union airport in the previous reporting period. This distinction will guide you through the subsequent questions tailored to your specific circumstances.

c) Fuel Segregation Capability:

- Assess whether your fuel supplier can provide you with fuel supply services that accommodate the segregation of fuel grades and types. If feasible, segregating sustainable drop-in and non-drop in fuel from CAF can provide more options for reducing the climate impact of contrail formation.
- If segregation is not possible, focus on the opportunities your fuel supplier can provide you with to improve LAQ.

d) Compliance with Regulations:

Familiarize yourself with the definition of a "Union airport" and the relevant passenger and freight traffic thresholds that may apply.

e) Infrastructure and Space Evaluation:

- Confirm if your fuel supplier can accommodate segregated supply of sustainable drop-in fuel to facilitate the uplift onto dedicated flights.
- Confirm if your fuel supplier can accommodate segregated and separated supply of sustainable non-drop-in fuel to allow the uplift onto compatible aircraft.
- Confirm if your fuel supplier is not able to provide you with services that accommodate fuel segregation.

f) Scenario Identification:

Based on your responses, the checklist will guide you to identify your readiness level within the four SAF usage scenarios outlined in Section 4.1.1 of the handbook:

- **Co-Mingled:** For airports distributing drop-in fuel within existing infrastructure without modifications.

- **Dedicated Flights:** For specific flights optimized to benefit from SAF usage.
- **Dedicated Airport:** For airports designated to receive high volumes of drop-in fuel to improve LAQ.
- **Non-Drop-In SAF Available:** For infrastructure supporting both drop-in and non-drop-in fuels.

g) Conclusion:

By completing this self-assessment checklist, you will determine your readiness level for incorporating SAF. This will help ensure compliance with regulations and enable you to optimize the environmental benefits of SAF both in-flight and on the ground.

D. Conclusion

The integration of SAF into the aviation sector is pivotal in driving the industry's shift towards decarbonization. This handbook outlines best practices, operational guidelines, and strategic insights, designed to facilitate the adoption of SAF across airports, airlines, and fuel suppliers. Through a combination of robust fuel logistics, quality assurance protocols, and transparent accounting methods, industry stakeholders can enhance the environmental performance of aviation without compromising safety or operational efficiency.

The case studies of CPH and ADR illustrate how airports can incorporate SAF into their operations using existing infrastructure and innovative approaches to logistics and fuel handling. By adopting a blend of SAF and CAF, both airports demonstrated a practical pathway for reducing aviation emissions, highlighting the importance of collaboration among fuel suppliers, airlines, and airport operators. These examples provide valuable lessons on overcoming technical, logistical, and regulatory challenges.

As the SAF market evolves, industry players will need to maintain rigorous accounting methods to ensure that the environmental attributes of SAF are properly tracked and reported. The establishment of clear standards is essential for aligning with global and regional regulations, including CORSIA and the European Union's Emissions Trading System. Accurate reporting will also safeguard against double-counting and enhance the credibility of emissions reductions, allowing aviation stakeholders to capitalize on the environmental benefits of SAF.

The future of sustainable aviation rests on the collective effort of the entire value chain. This handbook serves as a practical tool to support that effort, offering guidance on SAF procurement, supply chain optimization, and regulatory compliance. By following these best practices, airports and airlines can position themselves as leaders in the transition to net-zero aviation, contributing meaningfully to the global climate goals for 2050.

The adoption of SAF is not only an environmental imperative but also a practical, scalable solution for the aviation industry. The lessons learned from early adopters, as shared in this handbook, provide a clear roadmap for others to follow. With continued investment and collaboration, SAF can become a key driver of the industry's net-zero ambitions, ensuring a sustainable future for global aviation.

Ultimately, this handbook serves as a strategic framework for industry leaders to drive innovation and continuous improvement in SAF logistics, quality monitoring, and accounting, paving the way for a greener and more sustainable future in aviation.

References

1. Air bp, 2022, "Sustainable aviation fuel (SAF) – specifications and composition:" https://www.bp.com/en/global/air-bp/news-and-views/views/saf_specs_and_comparison.html
2. Airports Council International & Aerospace Technology Institute, 2022, "Integration of Sustainable Aviation Fuels into the air transport system ": <https://www.ati.org.uk/wp-content/uploads/2022/06/saf-integration.pdf>
3. Czarnikow (CZ), 2024, "The Pros and Cons of the HEFA Pathway for SAF": <https://www.czapp.com/analyst-insights/the-pros-and-cons-of-the-hefa-pathway-for-saf/>
4. European Union Aviation Safety Authority, 18 February 2025 [Correction: 26 February 2025], "Risks Related to Out of Specification Aviation Turbine Fuels," Safety Information Bulletin Airworthiness – Operations – Aerodromes: https://ad.easa.europa.eu/blob/EASA_SIB_2025_01_C1.pdf/SIB_2025-01_1
5. Energy Institute (EI) 1533, February 2025, "Quality assurance requirements for semi-synthetic jet fuel and synthetic blending components (SBC)," REF/ISBN 9781787254626, 2nd Edition: <https://www.energyinst.org/technical/publications/sectors/aviation/ei-1533-quality-assurance-requirements-for-semi-synthetic-jet-fuel-and-synthetic-blending-components-sbc>
6. European Parliament, 2023 (EP-ph45), "Sustainable aviation fuels (ReFuelEU Aviation Initiative)": https://www.europarl.europa.eu/doceo/document/TA-9-2023-0319_EN.html
7. European Parliamentary Research Service, 2023, " ReFuelEU Aviation": [https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/751437/EPRS_ATA\(2023\)751437_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/751437/EPRS_ATA(2023)751437_EN.pdf)
8. Greenhouse Gas Protocol (GHGP): <https://ghgprotocol.org/>
9. Gunnar Quante, Christiane Voigt, Martin Kaltschmitt, Volume 23, August 2024: "Targeted use of paraffinic kerosene: Potentials and implications," <https://doi.org/10.1016/j.aeaoa.2024.100279>
10. IATA Executive Summary Net Zero Roadmaps, 2023: <https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/executive-summary---net-zero-roadmaps.pdf>
11. IATA Net Zero Roadmaps, 2023: <https://www.iata.org/en/programs/sustainability/roadmaps/>
12. IATA Net zero 2050: Sustainable Aviation Fuels - Fact sheet: <https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternative-fuels/>
13. IATA ReFuelEU Aviation Handbook, September 2024, version 1: <https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/refuel-eu-aviation-handbook.pdf>
14. IATA SAF Accounting and Reporting Methodology, 31 January 2025: <https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/iata-sustainable-aviation-fuel-saf-accounting--reporting-methodology.pdf>
15. IATA SAF Handbook, 2024: <https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-handbook.pdf>
16. IATA, 6 June 2023, "SAF Production Set for Growth but Needs Policy Support to Diversify Sources," <https://www.iata.org/en/pressroom/2023-releases/2023-06-06-01/>

17. IATA "Understanding SAF Sustainability Certification - Guidance document on requirements and criteria for sustainability certification," June 2024: https://www.iata.org/contentassets/0bf212bfc0548f2b6ad4c1e229f7e94/guidance-document-on-saf-sustainability-certification-v0.41_rm-indepth.pdf
18. ICAO document, 2019, 'CORSIA Eligibility Framework And Requirements For Sustainability Certification Schemes': <https://www.iata.org/en/programs/sustainability/reports/saf-sustainability-certification-guidance-june-2024/section-4/>
19. ICAO Environment – CORSIA Sustainability Criteria: https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_Eligible_Fuels/ICAO%20document%2005%20-%20Sustainability%20Criteria%20-%20November%202022.pdf
20. ICAO Environment - Fuel Life Cycle and GHG emissions: https://www.icao.int/environmental-protection/Pages/AltFuels_LifeCycle-Box.aspx
21. ICAO Environment – Global Framework for Aviation Alternative Fuels (GFAAF) Aviation Fuel Maps: <https://www.icao.int/environmental-protection/GFAAF/Pages/Maps.aspx>
22. ICAO Environment - SARPs - Annex 16 Volume IV: <https://www.icao.int/environmental-protection/CORSIA/Pages/SARPs-Annex-16-Volume-IV.aspx>
23. ICAO Environment, 2022, "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values:" https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_Eligible_Fuels/ICAO%20document%2007%20-%20Methodology%20for%20Actual%20Life%20Cycle%20Emissions%20-%20June%202022.pdf
24. ICAO - European Union Assistance Project, "Capacity Building for CO₂ Mitigation from International Aviation:" https://www.icao.int/environmental-protection/pages/ICAO_EU.aspx
25. ICAO, 2023, "SAF Offtake Agreements:" <https://www.icao.int/environmental-protection/GFAAF/Pages/Offtake-Agreements.aspx>
26. ICCT, 2019, "The cost of supporting alternative jet fuels in the European Union:" https://theicct.org/sites/default/files/publications/Alternative_jet_fuels_cost_EU_20190320.pdf
27. Lee, D. S.; Fahey, D. W.; Skowron, A.; Allen, M. R.; Burkhardt, U.; Chen, Q.; Doherty, S. J.; Freeman, S.; Forster, P. M.; Fuglestvedt, J.; Gettelman, A.; León, R. R. de; Lim, L. L.; Lund, M. T.; Millar, R. J.; Owen, B.; Penner, J. E.; Pitari, G.; Prather, M. J.; Sausen, R.; Wilcox, L. J. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmospheric environment* (Oxford, England : 1994) 2021, 244, 117834. DOI: 10.1016/j.atmosenv.2020.117834. Published Online: Sep. 3, 2020.
28. Kristi Moriarty and Robert McCormick, "Sustainable Aviation Fuel Blending and Logistics," National Renewable Energy Laboratory (NREL): <https://www.nrel.gov/docs/fy24osti/90979.pdf>
29. ReFuelEU Aviation, "Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport:" <https://data.consilium.europa.eu/doc/document/PE-29-2023-INIT/en/pdf>
30. ReFuelEU Initiative, "Council adopts new law to decarbonise the aviation sector:" <https://www.consilium.europa.eu/en/press/press-releases/2023/10/09/refueleu-aviation-initiative-council-adopts-new-law-to-decarbonise-the-aviation-sector/>
31. Regulation (EU) 2023/2405 of the European Parliament and of the Council, on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation), 18 October 2023, Article 12, "Enforcement:" <https://eur-lex.europa.eu/eli/reg/2023/2405>

32. SAS, 2023, "SAS Corporate Sustainability Program:" <https://www.flysas.com/en/corporate-program/corporate-sustainability-program/>
33. Science Based Targets Initiative (SBTi), November 2023, "Book-and-Claim for Sustainable Aviation Fuel,": https://sciencebasedtargets.org/resources/files/Call-for-Evidence/251_Lufthansa-Group_2023_Book-and-Claim-for-Sustainable-Aviation-Fuel.pdf
34. SkyNRG, 2021, "Sustainable Aviation Fuel Certification and ASTM International: What Is It & Why Does It Matter?" <https://skynrg.com/sustainable-aviation-fuel-certification-and-astm-international-what-is-it-why-does-it-matter/>
35. Teoh, Roger; Schumann, Ulrich; Stettler, Marc E. J. (2020): Beyond Contrail Avoidance: Efficacy of Flight Altitude Changes to Minimise Contrail Climate Forcing. In Aerospace 7 (9), p. 121. DOI: 10.3390/aerospace7090121.
36. Transport, Telecommunications and Energy Council (Transport), 2 June 2022: <https://www.consilium.europa.eu/en/meetings/tte/2022/06/02/>
37. U.S. at International Airlines Group (IAG), LinkedIn posting by Aaron Robinson - Vice President of Sustainable Aviation Fuel, 2024, 'https://www.linkedin.com/posts/aaron-robinson-iag_my-most-recent-posts-have-looked-at-2023-ugcPost-7236723676287553536-dxqz/

Appendix I: Data Elements in a PoS

A certified entity using its own PoS template must ensure that the PoS contains at least the following information:

Transaction Information

- Unique PoS ID
- Delivery Note number
- Date of issuance
- Date of shipment
- Date and place of physical loading entry
- Date and place of physical loading exit

Supplier/Customer Information

- Name / Address of supplier
- Name / Address of customer of outgoing material
- Name / Address of last production/processing site
- If applicable: Name/Address of the third party managing the previous production/processing site

Certification Information

- Name of the certification scheme (i.e. ISCC CORSIA, RSB ICAO CORSIA, ISCC EU, RSB EU RED, ISCC PLUS, RSB Global)
- Name and Valid Certificate Number of Certification Body
- Chain of Custody model used (e.g. physical segregation, identity preserved, or mass balance)
- Short claim (a concise statement regarding the environmental, social, or economic benefits of SAF)

Production information

- Product description (production process)
- Country of fuel production
- Date production plant entered into operation
- Quantity of certified product
- Energy quantity of certified product

Raw Material information

- Description of the material used to produce the product (i.e. specification of the crop, production residue, or end-of-life product that was used)
- Country of raw material origin
- Statement if the raw material is eligible as production residue or end-of-life product under the certification system
- If applicable, additional claim as allowed under the certification system (e.g. Low ILUC Risk Biomass)

Greenhouse Gas Information

- Show calculations for GHG intensity of the product

Example Case 1 – Completed PoS Template for ISCC CORSIA

Proof of Sustainability (PoS) for CORSIA Eligible Fuels		V2.0																
For one batch of CORSIA eligible fuel according to the ICAO Standards and Recommended Practices, Annex 16, Volume IV, Part II, Appendix 5, Table A5-2																		
Unique Number of Sustainability Declaration / Batch ID number:	ABC-123	 www.iscc-system.org																
Place and date of dispatch:	CEF producer site, Example Street 123, 789 Ontario; 15 March 2024																	
Date of Issuance:	17. Mar 24																	
Original CEF Batch Information This information is determined by the CORSIA eligible fuel (CEF) producer and must be forwarded/reproduced by downstream entities along the supply chain with future PoS																		
Date of CEF production:	27 February 2024																	
Original CEF batch number (as determined by CEF producer):	ABC-123																	
Mass of original CEF batch (in mt):	10																	
Supplier Name: Example CEF producer Address: CEF producer site, Example Street 123, 789 Ontario Certification System: ISCC CORSIA Certificate Number: ISCC-CORSIA-Cert-US133-11804512		Recipient Name: Example CEF blender Address: CEF blender site, Another Example Street 456, 678 Toronto Contract Number: DEF456																
1. General Information Type of Product: AtJ-SPK (ethanol) Type of Raw Material: Corn grain Additional Information (voluntary): Country of Origin (of the raw material): Canada Quantity: 10,000 mt ☐ m³ ☒ metric tons Energy content (MJ): 440.000 MJ																		
2. Scope Of Certification Of Raw Material The raw material complies with the approved CORSIA sustainability criteria (i.e., was certified under ISCC CORSIA or another CORSIA approved scheme)¹ ☒ Yes ☐ No The raw material complies with the approved CORSIA sustainability criteria as well as additional social sustainability criteria (i.e., was certified under ISCC CORSIA PLUS)² ☐ Yes ☒ No The raw material was additionally certified according to the low land use change (LUC) risk approach³ ☐ Yes ☒ No The raw material meets the definition of waste, residue or by-product according to CORSIA⁴ ☐ Yes ☒ No																		
3. Life Cycle Emissions Information Use of default core life cycle emissions value ☐ Yes ☒ No Default induced land use change (ILUC) value (or DLUC value where applicable)⁵ 29,7 gCO₂eq/MJ Actual core life cycle emissions values: <table border="0"> <tr> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td></td> </tr> <tr> <td>10,0</td><td>2,0</td><td>4,0</td><td>2,0</td><td>8,0</td><td>3,0</td><td>0,0</td><td>= 29 gCO₂eq/MJ</td> </tr> </table> Total life cycle emissions of the CORSIA eligible fuel (CEF): 58,7 gCO₂eq/MJ Life cycle emissions reduction of the CORSIA eligible fuel:⁶ 34,0% for jet fuel (baseline: 89 gCO₂eq/MJ) 38,2% for aviation gasoline (AvGas) (baseline: 95 gCO₂eq/MJ) This form is valid without signature. By issuing this PoS, the issuing party guarantees that all information made on this Proof of Sustainability are correct, in compliance with the requirements of ISCC and CORSIA			1	2	3	4	5	6	7		10,0	2,0	4,0	2,0	8,0	3,0	0,0	= 29 gCO ₂ eq/MJ
1	2	3	4	5	6	7												
10,0	2,0	4,0	2,0	8,0	3,0	0,0	= 29 gCO ₂ eq/MJ											

Example Case 2 – Completed PoS Template for ISCC EU

Proof of Sustainability (PoS) for Biofuels, Bioliquids and Biomass Fuels		V3.0
Applies under the Renewable Energy Directive (EU) 2018/2001 (RED II)		
Unique Number of the PoS:	ABC-123	
Date of Issuance of the PoS:	17. Mar 24	
 International Sustainability & Carbon Certification www.iscc-system.org		
Supplier		Recipient
Name: Example SAF producer Address: SAF producer site Example Street 123 789 Ontario Certification System: ISCC EU Certificate Number: EU-ISCC-Cert-XY123-12345678		Name: Example SAF blender Address: SAF blender site Another Example Street 456 678 Toronto Contract Number: DEF456
Address of dispatch/shipping point of the sustainable material: ☒ Same as address of supplier		
Address of receipt/receiving point of the sustainable material: ☒ Same as address of recipient		
Date of dispatch of the sustainable material: 17.03.24		
1. General information		
Type of Product:	Co-processed oil to be used for replacement of jet fuel	
Type of Raw Material	Used cooking oil (UCO)	
Additional Information (voluntary):		
Country of Origin (of the raw material):	Italy	
Quantity:	1.000.000 mt ☐ m ³ ☒ metric tons	
Energy content (MJ):	43.000.000 MJ	
EU RED Compliant material ³	☒ Yes	
ISCC Compliant material (volunt.) ⁴	☐ Yes	
Chain of custody option (voluntary)	Mass balance	
Country of biofuel production	USA	
Start date of biofuel production ¹	17.02.2024	
If applicable, start date of bioliquid/biomass fuel use ^{1,2}		
2. Scope of certification of raw material		
The raw material complies with the relevant sustainability criteria according to Art. 29 (2) - (7) RED II ⁶	☒ Yes ☐ No	
The agricultural biomass was cultivated as intermediate crop (if applicable)	☐ Yes ☒ No	
The agricultural biomass additionally fulfills the measures for low ILUC risk feedstocks (if applicable)	☐ Yes ☒ No	
The raw material meets the definition of waste or residue according to the RED II ⁶	☒ Yes ☐ No	
If applicable, please specify waste or animal by-product permit number	Company-specific number for UCO	
Was support for the production of the fuel or fuel precursor received? ⁵	☐ Yes ☒ No	
If yes, please specify support nature and scheme		
3. Greenhouse Gas (GHG) emission information		
Total default value according to RED II applied ☐ Yes ☒ No		
$E = E_{ec} + E_i + E_p + E_{td} + E_u + E_{sca} - E_{ccs} - E_{ccr} = 35 \text{ gCO}_2\text{eq/MJ}$		
Allocated heat: 0 gCO ₂ eq/MJ heat Allocated electricity: 0 gCO ₂ eq/MJ electricity		
GHG emission saving⁸: 62,8% Biofuels for transport		
100,0% Bioliquids/ Biomass fuels for the production of electricity 100,0% Biomass fuels for the production of electricity in the outermost regions.		
100,0% Bioliquids/ Biomass fuels for the production of useful heat, as well as for the production of energy for heating and/or cooling 100,0% Biomass fuels for the production of useful heat, in which a direct physical substitution of coal can be demonstrated		
This form is valid without signature. By issuing this PoS, the issuing party guarantees that all information made on this Proof of Sustainability are correct, in compliance with the requirements of ISCC and the RED II, and that the biofuel or bioliquid has not already been used to fulfil a national quota obligation.		

Example Case 3 – Completed PoS Template for RSB ICAO CORSIA

Proof of Sustainability (PoS)	
Batch ID Number:	Batch 12345
Number of the Delivery Note	Invoice 54321
Date of Shipment:	09 April 2024
Date of Issuance:	17 April 2024
	
Supplier (name of certified operator who issues the PoS)	
Name:	Address:
London Fuels Ltd	Address 123, London, UK
Supplier - site from which the product is forwarded (if different from the supplier above)	
Name:	Address:
Customer	
Name:	Address:
Belfast Aviation Ltd	Address 321, Belfast, UK
Information if site is managed by a third party (in case of warehouses, distributors centers etc). Mark is not applicable	
Name:	Address:
If the site from which the product is forwarded is managed by an external third party	
Certification Information	
RSB Certification Scheme:	Valid RSB Certificate Number:
RSB ICAO CORSIA	4576
Certification body:	Chain of Custody Model:
SCS Global	Mass Balance
RSB Short claim:	
RSB ICAO CORSIA	
General Information	
Product Description:	SAF-HEFA
Raw Material:	UCO
Country of Origin:	France
Quantity of Certified Product:	10 MT
Original Batch Producer Information (Only for SAF Producer)	
This information should be reproduced along the supply chain with future PoS	
Date of Original Production:	09 April 2024
Original Batch Number (Unique Number):	Invoice 54321
Mass of Original Batch (MT):	10

Continuation from previous page

Original Batch Producer Information (Only for SAF Producer)			
This information should be reproduced along the supply chain with future PoS			
Date of Original Production:	09 April 2024		
Original Batch Number (Unique Number):	Invoice 54321		
Mass of Original Batch (MT):	10		
Only for wastes, residues and by-products (materials or products):			
Raw material is eligible as waste, residue or by-product under the RSB ICAO CORSIA certification scheme (refer to Annex III - Positive List, in RSB-STD-12-001)			
	☒ Yes	☐ No	
Greenhouse Gas Information			
GHG Intensity:	30	g CO ₂ e/kg	Default value (if no, specify disaggregated actual values at item 7 below)
			Yes
GHG value contains transport emissions?	☒ Yes ☐ No	If no: Transport	type Distance km
For final products:			
GHG Savings (g CO ₂ eq/MJ):		Fossil fuel comparator (g CO ₂ eq/MJ)	89
GHG Savings (%)	60	Lower heating value (MJ/kg):	

Example Case 4 – Completed PoS Template for RSB EU RED

Proof of Sustainability (PoS) - version 4.0	
Batch ID Number (PoS Number):	Batch 12345
Number of the Delivery Note	Invoice 54321
Date of Shipment:	09 April 2024
Date of Issuance:	17 April 2024
Date and place of physical loading en	05 April 2024 - London, UK
Date and place of physical loading ex	06 April 2024 - Belfast, UK
	
Supplier (certified operator who issues the PoS)	
Name:	Address:
London Fuels Ltd	Address 123, London, UK
Supplier - site from which the product is forwarded	
Name:	Address:
Name and address of production/storage/ transmission and distribution site(s) and site from which the product is forwarded or biomethane exit point	
Customer (buyer company)	
Name:	Address:
Belfast Aviation Ltd	Address 321, Belfast, UK
Information if site is managed by a third party	
Name:	Address:
Include name and address if the previous production/processing/ transmission and distribution site is managed by an external third party	
Certification Information	
Certification System:	Valid RSB Certificate Number:
RSB EU RED	4576
Certification body:	Chain of Custody Model:
SCS Global	Mass Balance
RSB EU RED Short claim:	
RSB EU RED Compliant SAF	
General Information	
Product Description:	SAF-HEFA
Raw Material:	UCO
Country of Feedstock Origin:	France
Country of Fuel production:	UK
Date production plant entered in operation (for fuel plant only)	2015
Quantity of Certified Product:	10 ton
Energy Quantity (Fuels only):	For the calculation of the energy quantity, conversion factors in Annex III to Directive (EU) 2018/2001 must be used MJ per unit
Support provided for the production of consignment	RFT0
Raw material/Fuel	
Compliance with the sustainability criteria according to Article 29 (2) to (7) of Directive (EU) 2018/2001 was audited and certified?	
☒ Yes ☐ No	
Is the raw material a HIGH ILUC risk feedstock as defined by Delegated Act C(2019) 2055?	
☐ Yes ☒ No	
Is the raw material/fuel certified as LOW ILUC risk as defined under the EU RED?	
☐ Yes ☒ No	
Is the raw material/fuel listed in Annex IX of Directive 2018/2001/EU (see Annex VI of RSB Standard for EU Market Access)?	
☒ Yes ☐ No	

Continuation from previous page

Raw material/Fuel			
Compliance with the sustainability criteria according to Article 29 (2) to (7) of Directive (EU) 2018/2001 was audited and certified?	☒ Yes	☐ No	
Is the raw material a HIGH iLUC risk feedstock as defined by Delegated Act C(2019) 2055?	☐ Yes	☒ No	
Is the raw material/fuel certified as LOW iLUC risk as defined under the EU RED?	☐ Yes	☒ No	
Is the raw material/fuel listed in Annex IX of Directive 2018/2001/EU (see Annex VI of RSB Standard for EU Market Access)?	☒ Yes	☐ No	
Only for wastes/residue materials and waste/residue based products:			
Does the raw material meet the EU definition for waste and residues? Note: Substances that have been intentionally modified or contaminated are not covered by this definition	☒ Yes	☐ No	
Waste or animal by-product permit number (if applicable)			
Only for renewable gases			
Has the material received incentive/subsidy?	☐ Yes	☐ No	
If yes, specify type of support (RES sector and country)			
Greenhouse Gas Information			
GHG Intensity:	30	g CO ₂ eq/MJ fuel	Default value Yes
Additional specification in case (disaggregated) default values are used (in line with Annex V and Annex VI of Directive (EU) 2018/2001):	Transported 150 miles to customer in tanker		
GHG Components in case actual values are used:	State GHG emissions value in g CO ₂ equivalent/MJ of fuel for biofuels / bioliquids / biomass fuels / renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels) and g CO ₂ equivalent / dry-ton feedstock (biomass and intermediaries). (Separate values for emissions from: the extraction or cultivation of raw materials; Annualized emissions from carbon stock changes due land use change processing; transport and distribution) and Emissions savings from: soil carbon accumulation via improved agricultural management, carbon capture and geological storage; carbon capture and replacement; excess electricity from cogeneration)		
eSCA cap to be applied by biofuel producer: (emissions savings from soil carbon accumulation)	45 g CO ₂ eq/MJ	☐	25 g CO ₂ eq/MJ ☐
GHG value contains transport emissions?	☒ Yes ☐ No	If no: Transport	type Distance km
For final products:			
GHG Savings (g CO ₂ eq/MJ):	64.0	Fossil fuel comparator (g CO ₂ eq/MJ)	94
GHG Savings (%)	60%	Lower heating value (MJ/kg):	

Appendix II: Key common principles of a robust SAF accounting approach

	Key Principle	Description	Example
1	Immutable tracking	Prescribing a method for achieving immutable tracking so that once data is registered into the system, it cannot be altered or edited, thereby preserving data integrity while tracking it securely throughout the supply chain.	Using blockchain technology, cloud database, or centralized electronic ledgers.
2	Transparency	Achieving the level of transparency needed to provide confidence and clarity for SAF use and adoption, while allowing data protection and security to safeguard commercially sensitive data and to avoid market distortion.	Providing different access levels for different parties/entities on a need-to-know basis only. Batch of SAF claimed under a certain incentives/subsidies shown as a tick box without specifying pricing information.
3	Verifiable environmental attributes	Incorporate procedures for certifying and auditing environmental attribute claims and maintaining transaction processes to include the retirement of credits and eliminate the possibility of double counting.	Prescribe the RSB, ISCC or CoSAFA, etc. SAF accounting methodology.
4	No double claiming	The emissions reduction from the same batch of SAF cannot be claimed more than once under the same scope.	The same emissions reduction under the same scope risks being used to meet both domestic and international targets simultaneously.
5	No double issuance	More than one emissions reduction cannot be issued from the same batch of SAF.	The emissions reduction from the same batch of SAF risks being issued in more than one operating registries.
6	No double usage	The emissions reduction from the same batch of SAF cannot be used more than once.	The same emissions reduction from the same batch of SAF risks being used in two different registries.
7	Inter-operability	Interoperability between registries so that unique IDs can be identified for specific batches of SAF within different operating systems to ensure no double issuance, usage, and claiming.	Emissions reduction from the same batch of SAF is recognizable in all operating SAF accounting platforms/registries.
8	Agnostic	The ability to consider different types of SAF feedstocks and production pathways as well as evolving voluntary and regulatory GHG frameworks would allow claiming to take place safely, securely, and in accordance with internationally recognized standards or best practices.	Ability to prescribe the appropriate chain-of-custody accounting methods for different types of SAF or low carbon fuels and consider different sustainability requirements for different regulatory or voluntary GHG frameworks.
9	Stacking	The environmental attributes could be used to comply with different obligations and commitments if these mutually allow such claims/reporting and with an adequate level of transparency.	To use SAF to meet any volumetric-based mandate for CORSIA or EU ETS as long as allowed by the authority, and no double counting of the same scope happens.
10	Divisibility	The ability to split the environmental attributes of the same batch of SAF between multiple entities/buyers.	The same batch of SAF certified under the same certificate and delivered to the same airport, could be split between two or more different buyers.
11	Permanence	Once the emissions reduction has been allocated to the rightful buyer, the transaction is considered as permanent and irreversible.	Once retired, the emissions reduction from the same batch of SAF cannot be unclaimed/put back into a registry for another claim.
12	Vintage	SAF vintage refers to the year that its associated emissions reduction occurred, i.e., the year when the SAF is being produced/uplifted/combusted.	At current time, there are no specific restrictions on SAF vintage under aviation regulatory frameworks such as CORSIA and EU ETS, but this is currently being considered and discussed under voluntary frameworks.