

2026

Sustainable Aviation Fuels:

Market Trends, Certification Frameworks
and Digital Traceability Solutions



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Introduction

The aviation sector looks forward to significantly reduce its carbon dioxide (CO₂) emissions as it meets growing global demand. While battery or hydrogen powered airplanes appear as the most straightforward way to decarbonize air transport, the technology challenges associated will only be solved in the very long-term. To achieve the commitments of climate neutrality in the EU by 2050 and the Paris Agreement goals, the EU sets out the need to reduce transport emissions by 90% by 2050 (compared to 1990 levels). The aviation sector will, thus, have to contribute to this reduction by boosting the development of alternative fuels. In this context,

Sustainable Aviation Fuels (SAF) emerge as one of the most promising solutions to accelerate the decarbonization of the sector considering their higher energy intensity compared with batteries or hydrogen. In addition, SAF compatibility with the existing fleet and value chains allows for an immediate CO₂ emissions reduction. This paper explores the key concepts, market trends and technological (IT) opportunities surrounding SAF deployment at the EU level, providing a comprehensive view of its current and future role in the sustainable transformation of the aviation industry.



Concepts and SAF context

Sustainable Aviation Fuels (SAF)

SAF are viable aviation fuels that are produced sustainably, meeting stringent sustainability criteria covering both climate and environmental aspects. They can be blended with conventional aviation fuels and used in aircrafts without the need for engine modifications, industry.

These sustainable fuels provide for:

- Up to 80% reduction in carbon emissions over their lifecycle.
- Use of renewable feedstocks such as Used Cooking Oil (UCO), agricultural waste, and other non-biological sources such as captured CO₂. Additional feedstocks include forestry residues, algae-derived bio-waste, and other advanced bio-resources like ligno-cellulosic materials (e.g., wheat straw, corn stover, and sugarcane bagasse).
- Flexibility in SAF application due to their compatibility with existing fuel storage, distribution infrastructures and engines.

Aviation sector decarbonization

2.5%

Aviation industry contribution to global CO₂ emissions.

2050

Net zero goal target for the aviation sector

Up to
80%

Reduction of carbon emissions in SAF lifecycle

5-50%

Allowed blending ratios

Feedstocks and production routes for SAF

The main production routes for SAF nowadays include:

- **HEFA (Hydro processed Esters and Fatty Acids)**: dominant in the current market, using waste fats and oils as feedstocks.
- **AtJ (Alcohol-to-Jet)**: Converts alcohols such as ethanol into aviation fuels.
- **E-fuels**: Synthetic fuels derived from renewable electricity and captured CO2.

Each route faces challenges such as feedstock availability, production costs and industrial scalability.

In addition, the combination of technologies such as AtJ and e-fuels

is gaining more attention due to their potential to leverage diversified feedstocks and their alignment with mid/long-term sustainability goals established by EU regulations.

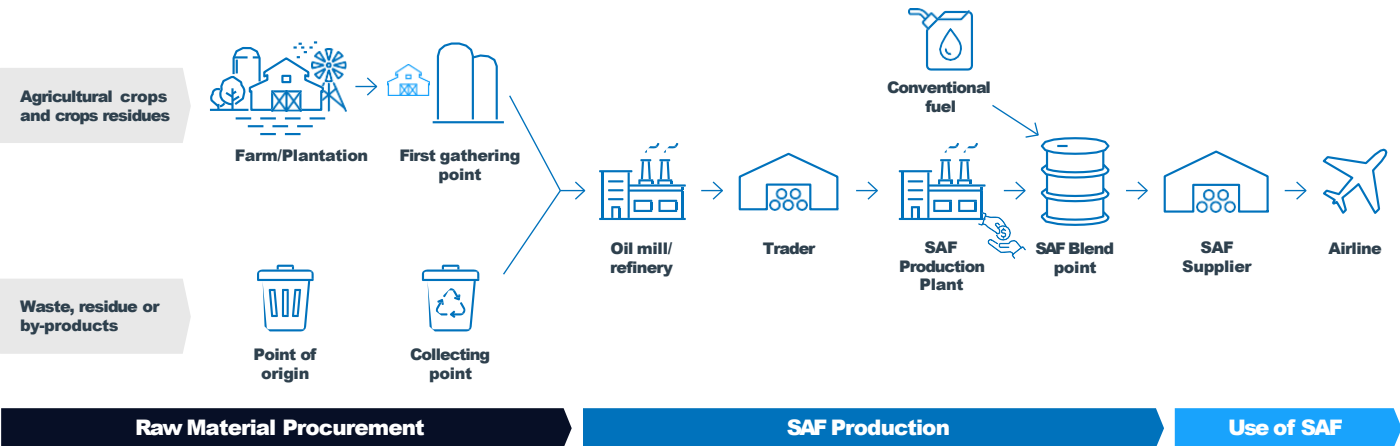
Used Cooking Oil (UCO) - SAF value chain

Feedstocks for SAF include, among others, UCO, agricultural residues, forestry residues and non-biological sources such as waste gases and captured CO2. Globally, UCO is the main feedstock for SAF production.

The UCO-based SAF value chain is complex and involves different stages, ranging from raw materials collection up to the fuel final use in aircrafts. It includes:

- **Points of origin**: UCO collection sources, such as restaurants and food industries.
- **Collection and storage**: Filtering and cleaning process to remove contaminants.
- **Processing**: UCO conversion through HEFA or other production routes in industrial plants.
- **Distribution**: SAF blending with traditional fuels and transportation to airports.
- **End use**: SAF consumption in aviation engines.

All stages in the value chain must be subject to compliance with robust sustainability and traceability certification requirements.



In addition, the adoption of digital technologies such as Blockchain and advanced traceability systems will be an essential catalyst to ensure transparency, sustainability and efficiency across the entire SAF supply chain, as analysed below in Section 5. Beyond improving operational performance, these digital solutions facilitate alignment with stringent regulatory frameworks at the EU (Renewable Energy Directive - RED

II/III, ReFuel EU Aviation) and global (Carbon Offsetting and Reduction Scheme for International Aviation - CORSIA) level, enabling SAF economic operators and involved stakeholders to ensure compliance with biofuels sustainability criteria, enhance fuel traceability and provide transparent and reliable data to comply with audits, accounting and reporting requirements.

SAF Impacts and Market Trends in Europe

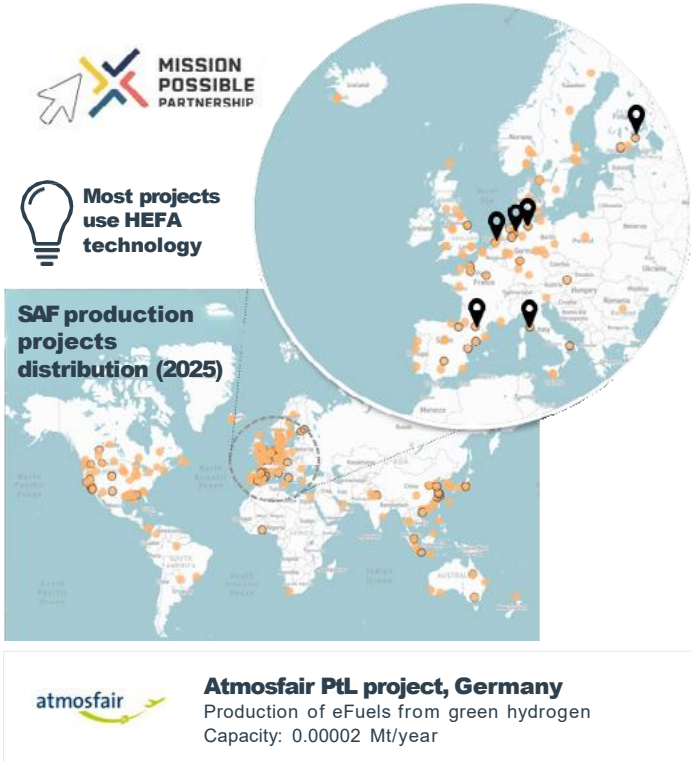
Status and development of the European UCO market

Europe leads the SAF market with above 15 operational plants and 75 projects under development. However,

SAF faces several challenges, including limited availability worldwide and the increasing competitive demand for sustainable fuels in other sectors (i.e., road and maritime transport) which require the same raw material as SAF.

Relevant examples include the growth of SAF production hubs in regions such as the Netherlands and Finland, where companies like Neste or Total Energies have established large capacity SAF production projects.

	Renewable fuels Project, France Production of biojet fuel from UCO Capacity: 0.1 Mt/year
	PtL Project, Germany Production of eFuels from green hydrogen Capacity: 0.0002 Mt/year
	Neste Renewable Fuels Project, Netherlands SAF production from Lipid based sources Capacity: 0.45 Mt/year
	Lappeenranta Biorefinery, Finland SAF production from wood based tall oil Capacity: 0.13 Mt/year
	Livorno Refinery, Italy SAF production from cooking oils Capacity: 0.01 Mt/year



Global projects map, Mission Possible Partnership (MPP)



Key players in the European SAF-UCO market

The SAF-UCO market is characterized by a complex and interdependent ecosystem of stakeholders including diverse economic operators (from feedstock suppliers, fuel producers, hydrogen and energy providers, airlines to airports), research institutions, certification and regulatory bodies, as well as financial and investment entities, among others. Each value chain actor plays a distinct yet interconnected role in enabling feedstock sourcing, fuel production, certification, financing, distribution, and final uptake, collectively shaping the scalability, sustainability, and competitiveness of SAF deployment in Europe



At the corporate level, companies such as Neste, TotalEnergies and BP are leading SAF development and production in Europe, driving capacity expansion and market integration. On the technology side, platforms such as Circularise and Bioledger are enhancing supply chain transparency and operational efficiency by providing innovative digital traceability solutions. These tools support compliance with EU and international sustainability frameworks while strengthening data integrity and enabling more streamlined and reliable SAF accounting across the value chain.



Future SAF trends and challenges in Europe

Following the projected trajectory of SAF production and demand in the EU for the next decades, by 2030 an overall 3.2 million tons (Mt) will be required to reach the 6% target of SAF blend in all departing flights from EU airports. While current production capacity is insufficient, the expected potential capacity could be reached if all existing biofuel facilities in Europe were optimized for SAF production. To this end, most of the feedstock for SAF is expected to come from UCO, animal fats, waste oils, and sustainable biomass. In addition, more than 60% of the European SAF supply in 2030 is estimated to be covered by HEFA and Alcohol-to-Jet pathway fuels.

Beyond 2030, achieving the EU SAF production capacity targets expected for 2040 (14.8 Mt) and 2050 (27.6 Mt) will require overcoming significant challenges, requiring technological advancements and investment in infrastructure and resources with high financial costs. The aviation industry will require a substantial increase in SAF production. In addition, the production of Power-to-Liquid (PtL) fuels, a key component of the SAF mix, will demand a significant share of the EU's renewable electricity generation.

Key highlights

SAF is an essential tool for accelerating the decarbonization of the aviation sector and supporting the achievement of the EU climate targets aimed to reduce 55% emissions in 2030 and achieve climate neutrality in 2050. However, the success of SAF will depend on the effective collaboration among corporations, governments and international organizations in the aviation sector, as well as sustained investment in research and development to ensure its technical, environmental and economic viability. Through a joint approach, the aviation industry will have the potential to lead the way to a cleaner and more sustainable future.

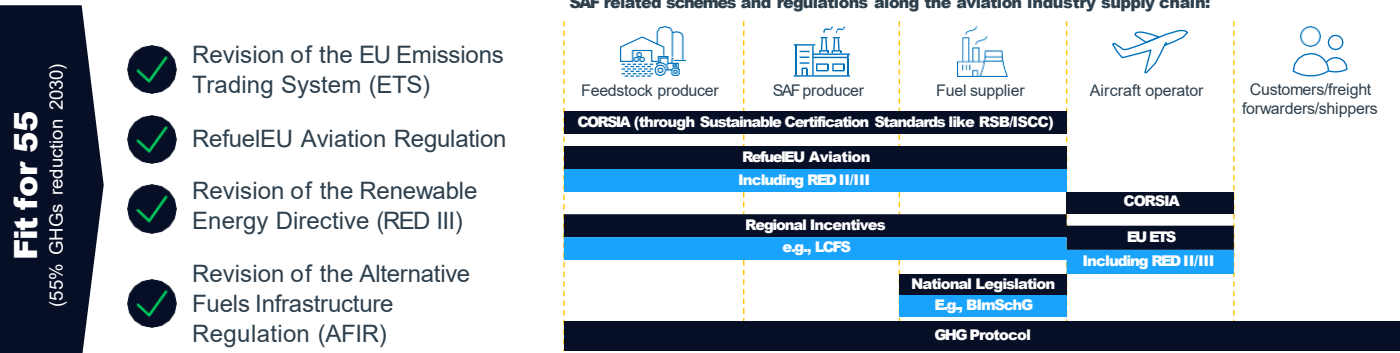
SAF Regulatory Framework in Europe

The European sustainability regulatory framework is driven by the European Green Deal and the EU Climate Law, which set the roadmap for the achievement of 55% GHG emission reduction by 2030 and climate neutrality by 2050. Following the FitFor55 Legislative Package, key regulatory initiatives include, among others:

- **ReFuelEU Aviation Regulation:** From 1 January 2025 establishes a minimum SAF supply obligation across the EU (starting at 2% in 2025 up to 70% in 2050) with a dedicated synthetic-fuel sub-mandate from 2030, as detailed below.

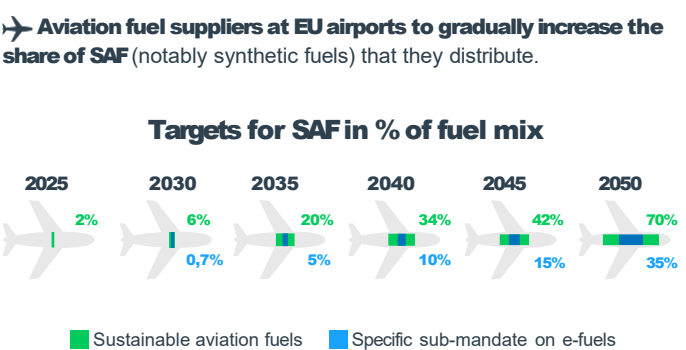
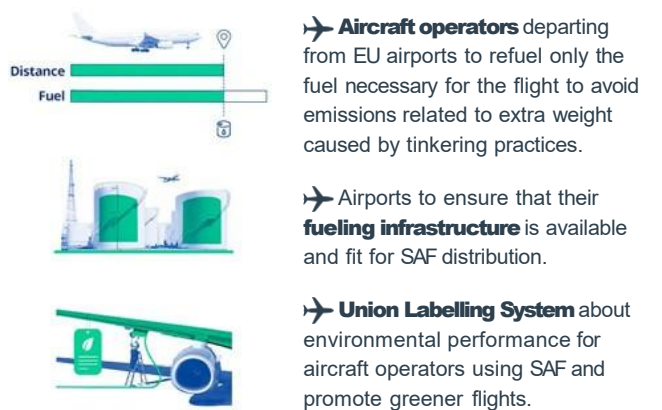
- **Revision of the Renewable Energy Directive (RED II/III):** The revised RED III increases the binding renewable energy target to 42.5% by 2030 and promotes stricter sustainability criteria for biofuels.
- **Revision of the EU Emissions Trading System Directive (EU ETS):** Provides financial incentives to reduce GHG emissions, including specific benefits for the use of SAF.

EU regulatory framework for SAF



In particular, the **ReFuelEU Aviation Regulation** sets ambitious mandatory targets for fuels suppliers to progressively distribute SAF and increase its share in aviation fuels at EU airports, starting from an initial 2% of fuel mix by 2025 up to 70% in 2050. Investment in technological innovation and infrastructure are key

drivers for achieving the EU mandatory targets over the next decades. In addition, it introduces an environmental labelling system to encourage more sustainable flights and ensures the availability of fuel infrastructures for SAF distribution at EU airports.



Market-based measures to reduce emissions

The EU ETS acts as a cap-and-trade system that gives airlines a financial incentive to reduce their emissions and to trade allowances saved.

CO₂ emissions from aviation have been included in the EU ETS since 2012. It applies within the EU and flights operating within European Economic Area (EEA) countries – including the UK and Switzerland – required to monitor, report and verify their emissions, and to surrender allowances against those emissions. It provides an **incentive**

for airlines to use SAF certified as compliant with the EU RED II/III sustainability criteria, by attributing them zero emissions under the scheme and reducing airlines' reported emissions and the ETS allowances they need to purchase.

In addition, the ICAO CORSIA scheme complements these measures for international flights. From 2027, all flights operated by European airlines will be covered by one of these two carbon market schemes.

National perspective

Countries such as France, Germany and Sweden are implementing national mandates to promote SAF uptake at national level.

These instruments are being actively adapted to align with the ReFuel EU Aviation Regulation. For example:

- **France:** Introduced a 1% SAF blending mandate for 2022 and long-term targets up to 50% by 2050.
- **Germany:** Prioritizes PtL fuels in its national hydrogen strategy and in its roadmap to drive SAF from renewable sources.
- **Sweden:** Promotes mandatory emission reduction targets for jet fuel suppliers (SAF blending targets from 1% in 2021 up to 30% in 2030) and an industry roadmap for fossil-free aviation.

Some European States are introducing policies to incentivize the future uptake of SAF in the EU



NORWAY

Since January 2020, Norway introduced a SAF blending mandate of 0.5% from 2022 with an ambition to increase over time. The goal is to reach 30% by 2030. The Norwegian government has stipulated that the biomass to produce it should come from wastes and residues and it is planning to increase the blending obligations for 2026-2027.



FRANCE

France defined its SAF roadmap in 2019 "French roadmap for the deployment of sustainable aeronautical biofuels", having set an annual SAF blending mandate of 1% starting in 2022 and 2% by 2025, 5% by 2030, and 50% by 2050. Since 2024 is aligning its national roadmap with ReFuel EU Regulation and positioning SAF deployment within its broader industrial strategy for renewable fuels and energy sovereignty.



SWEDEN

Since 2021, Sweden has applied a GHG reduction obligation for jet fuel suppliers, requiring progressively higher SAF blending levels (from 1% in 2021 to 30% by 2030). In May 2025, amendments aligned national legislation with EU sustainable fuels rules and expanded eligible fuel categories under sustainability criteria. Sweden also maintains a fossil-free aviation roadmap under the *Fossil Free Sweden* initiative, supporting SAF and electric aviation development.



GERMANY

Germany is focusing on PtL fuels as part of its National Hydrogen Strategy with an objective to ramp up production to 200 thousand tons by 2030 (2% of German jet fuel sales in 2019). In 2021 adopted the PtL Roadmap for Aviation, a joint roadmap for the market ramp-up of SAF from renewable energy sources. Most advanced EU Member State in embedding synthetic SAF into binding national frameworks.



SPAIN

SAF deployment is framed within the updated National Energy and Climate Plan (NECP) 2023-2030, submitted in 2024, with recognizes SAF as a strategic vector for advanced biofuels and aviation decarbonisation. Spain relies on the ReFuelEU Aviation Regulation mandate as the binding instrument, while using the NECP as a strategic roadmap.



THE NETHERLANDS

Public policy debate is considering a 14% share of SAF by 2030 and to completely replace fossil-based jet fuel by 2050. Its National SAF Roadmap (2025-2030) provides a structured pathway for scaling fuel production and uptake.



AUSTRIA

In 2024 Austria has developed a national SAF Roadmap as a key measure of its Aviation Strategy 2040+. Binding obligations derive from EU legislation, while national policy focus on strategic stakeholders and supply chain coordination.

Corporate SAF policies have evolved from early exploratory commitments to structured, target-driven strategies aligned with regulatory trajectories and long-term decarbonisation objectives. Overall, airlines are shifting from ambition-setting to implementation and risk management, placing greater focus on long-term offtake agreements, synthetic SAF sourcing, supply security and cost competitiveness. Some representative examples include:

Corporate policies



International Airlines Group

IAG has committed to use 10% SAF by 2030 (33% of SAF towards 2030 target already procured), positioning as the primary lever for aviation decarbonization.



Ryanair

Ryanair has partnered with Trinity College Dublin to launch innovative actions that will accelerate the goal of powering 12.5% of its flights with SAF by 2030.



Air France - KLM Group

Air France - KLM Group has set a target of 10% of SAF by 2030 by signing offtake agreements and MoUs with SAF producers. To reach this goal KLM adds 1% SAF to every flight from Amsterdam.



Airlines for America

A4A pledged in March 2021 to facilitate the commercialization of 6M tonnes of SAF in U.S. by 2030 (10% of their forecast 2030 jet fuel consumption).

Key highlights

The European regulatory framework is actively driving the transition toward a more sustainable aviation industry, with SAF positioned as a central decarbonization lever. Several regulatory initiatives at global (CORSIA), EU ((RED II/III and ReFuelEU Aviation), and national policy levels are reshaping the SAF value chain and reinforcing the

importance for economic operators to ensure compliance with stringent sustainability and traceability requirements to ensure credible emissions reductions.

However, the complexity and evolving nature of the regulatory landscape underscore the need for stable, clear and predictable regulatory instruments that ensure legal certainty and effective market incentives.

By balancing clear regulatory mandates, targeted financial support, and innovative technological solutions the EU can be in the position to lead the global deployment of SAF and promote the achievement of its long-term climate objectives.

SAF sustainability traceability and certification

Sustainability certification for SAF is based on structured schemes that assess the environmental, social and economic performance of fuels throughout the supply chain, and are aimed to ensure:

- Transparent compliance with regulatory biofuels sustainability requirements,
- Traceability of sustainable materials,
- Verified GHG emissions reductions.

These schemes operationalize and implement Sustainability Certification Standards (SCSs) through accreditation, auditing and certification processes, ensuring consistency and credibility in biofuels certification. Since 2024, two SCSs have been recognized by ICAO to demonstrate compliance with sustainability criteria

applying to SAF:

- **The International Sustainability and Carbon Certification (ISCC):** This scheme is widely recognized by both the EU and the ICAO CORSIA. It offers certification for the entire value chain, including raw materials, production and end use. It stands out for its focus on traceability and mass balance, ensuring that fuels comply with RED II/III and CORSIA certification requirements. Companies such as Neste and TotalEnergies rely on ISCC to ensure the sustainability of their operations.
- **The Roundtable on Sustainable Biomaterials (RSB):** This scheme is an advanced standard that assesses the social and environmental impact

of fuels. It includes strict criteria related to land use, human rights and GHG emissions, and remains particularly relevant for innovative projects such as PtL fuels, where sustainability is key from the design stage.

Both SCSs allow for SAF certification through different types of sustainability standards applying under CORSIA and EU RED frameworks based on the scope of the fuel certification (regulatory or voluntary market) and the type of fuels. These standards depend on the targeted market; while UCO-SAF sold in the EU requires ISCC EU/RSB EU RED standards, UCO-SAF sold in non-EU market is subject to CORSIA compliance.

Global sustainability scheme provider	SAF Certification Scheme		
	Regulatory compliance with ICAO CORSIA	Regulatory compliance with EU RED II/III	Voluntary market
	ISCC CORSIA	ISCC EU	ISCC CORSIA, ISCC EU, ISCC PLUS
	RSB ICAO CORSIA	RSB EU RED	RSB ICAO CORSIA, RSB EU RED, RSB Global

ISCC and RSB SAF certifications comparison

		Compliance			Type of products included				Regional predominance of issued certificates		Total certificates issued	
		Compliant with RED II (EU ETS)	Compliant with CORSIA	Voluntary markets	Can include SAF	Only SAF	Biofuels	Non-energy products	In Europe	Out of Europe	Total	Valid (August 2024)
	RSB EU RED	✓		✓	✓		✓	✓	✓		39	18
	RSB ICAO CORSIA		✓	✓	✓	✓				✓	9	9
	RSB GLOBAL			✓	✓		✓	✓		✓	52	31
	EU ISCC	✓		✓	✓		✓	✓	✓		45.196	6.992
	ISCC PLUS			✓	✓		✓	✓	✓		13.034	4.630
	ISCC CORSIA		✓	✓	✓	✓				✓	195	142
	ISCC CORSIA PLUS		✓	✓	✓	✓				✓	71	26

Certification process

SAF sustainability registration and certification typically follow a structured five-step process. Operators are required to undergo **re-certification every 12 months** to maintain compliance, supported by annual audits to ensure the continued validity of certificates.



SCSs cover the entire SAF value chain, allowing full traceability of sustainable materials from the initial stage of feedstock collection through processing, storage, and trading steps, until the final delivery of SAF to the point of uplift (blending). This step-by-step traceability ensures that economic operators comply with **SAF-UCO sustainability and traceability**

- requirements** under ISCC and RSB schemes which mainly include:
- Adoption of appropriate management systems and performance of mandatory regular audits,
 - Compliance with Chain of Custody (CoC) models and periodic reporting to the EU,
 - Fulfillment and submission of specific documentation and information requirements to demonstrate the sustainability of traced materials across the value chain through different documents, including Proof of Sustainability (PoS) and Sustainability Declarations (SD).



The sustainability and traceability requirements under the EU and CORSIA frameworks are largely aligned, facilitating the consistency and compliance for operators certified under both schemes. Nonetheless, economic operators across supply chains must remain fully informed of applicable sustainability and traceability requirements at each step to prevent non-compliance while opening doors to more competitive and sustainable markets.

SAF traceability challenges

The implementation of traceability in the SAF value chain faces multiple challenges. One of the most critical is the **misclassification of raw materials** such as UCO, especially in non-EU countries, where oversight can be limited and incentives for fraud are greater. This complicates verification of regulatory compliance and puts the integrity of certification systems at risk. Another challenging aspect is **data management**, which requires digitized systems capable of handling large volumes of information and ensuring its accuracy. The lack of

standardization in the platforms and tools used generates inefficiencies and increases the administrative burden for operators. On-site audits, necessary to ensure compliance at points of origin and collectors, present logistical difficulties and significant costs, especially in remote or high-risk regions. A third challenge for traceability compliance originates from the need of **further capacity-building**. Economic operators involved in the SAF market need constant training to manage advanced traceability systems and

comply with evolving sustainability and energy regulations. This is especially critical for small collectors of raw materials in non-EU countries, where language and technology barriers make it hard to understand the functioning of SAF value chain and evolving regulatory requirements. Despite these challenges, the industry is working on **collaborative solutions** to improve transparency and traceability, relying on technologies such as blockchain and IoT sensor networks to strengthen real-time monitoring and verification.

ADVANTAGES	CHALLENGES
 Transparency and trust: They facilitate the monitoring and validation of fuel traceability throughout the supply chain. They reduce the risk of fraud, such as double counting or false declarations.	Implementation and operating costs: Setting up, maintaining and upgrading platforms can be costly, especially for small and medium-sized companies. 
 Regulatory compliance: They enable companies to comply with sustainability and certification requirements mandated by regulations such as RED II (EU) and CORSIA (ICAO). Automate the generation of reports for the authorities.	Limited interoperability: Lack of seamless connection between national, regional and global platforms, complicating traceability in international supply chains. 
 Global standardization: Provide an harmonized framework for all stakeholders to use common rules, facilitating cross-border trade of Processed Animal Substances (PAS) and biofuels.	Technical complexity: Integrating data from multiple stakeholders, from UCO collectors to Processed Biofuels Substances (PBS) producers and air operators, requires robust technological infrastructures. 
 Data access and analysis: They offer real-time reporting on volumes, certifications and carbon emissions, helping companies to optimize their operations.	Training and adoption: Users must be trained to operate the platforms, which can slow initial adoption, especially in less technologically developed regions. 
 Facilitate auditing: They centralize documentation, making the audit and third-party validation process more efficient.	Cybersecurity risks: By centralizing sensitive data, platforms are potential targets for cyber attacks. 
 Facilitates international market access: Platforms allow producers and operators to demonstrate compliance with global regulations, opening up opportunities to participate in international markets and trade agreements that demand high sustainability standards.	Resistance to change: Stakeholders, especially in traditional markets, may be reluctant to adopt new platforms for fear of complexity or additional costs. 

Market perspectives

To address market challenges, the **EU Clearing House**, managed by the European Union Aviation Safety Agency (EASA), was launched in July 2024 as a technical support platform aimed to facilitate the approval, qualification, and sustainability assessment of renewable and low-carbon aviation fuels, supporting producers and equipment manufacturers in accelerating market entry and deployment.

In parallel, while the ReFuelEU Aviation Regulation introduces certain **flexibility mechanisms**, the European Commission is continuing to assess potential SAF accounting approaches, including options that could enable virtual trading of SAF certificates through market-based instruments. However, no formal Book & Claim (B&C) mechanism has been adopted or recognised under EU law to date, despite ongoing industry advocacy supporting such a framework as a means to enhance SAF accessibility, increase market liquidity, and provide greater long-term investment certainty.

Key highlights

SCSs are fundamental pillars for the adoption and scalability of SAF, ensuring step-by-step traceability and compliance across the entire value chain while aligning with global and regional regulatory frameworks to safeguard environmental integrity and market credibility. However, SAF traceability continues to face key challenges (i.e., raw material misclassification risks, limited technical and integration capacity among operators, fragmented data systems, and weak interoperability across platforms) that should be addressed through robust digital infrastructure, harmonized data frameworks and continuous monitoring to prevent double counting and fraud risks.

Streamlining administrative processes, strengthening operators' capabilities, and reinforcing cybersecurity and data governance will thus be essential to ensure compliance, build market confidence, and support the scalable deployment of SAF.



IT Systems for SAF traceability and accounting

The growing demand for SAF in the global market has underscored the importance of implementing advanced technological systems to ensure accounting, traceability and regulatory compliance. This section explores both institutional and market-based IT solutions, emphasizing their role in improving transparency and sustainability in the entire SAF supply chain.

Institutional SAF traceability solutions

Union Database for Biofuels (UDB)

The European UDB, established under the RED II, acts as a centralized database designed to ensure traceability of renewable fuels, including biofuels, bioliquids, and certain RFNBOs, across the EU supply chain. It aims to prevent double counting and fraud by requiring economic operators to register transactions, upload sustainability information, and validate compliance data digitally.

Typology and Existing Solutions

Market IT solutions are grouped into four main levels:



The UDB is intended to strengthen data integrity, transparency, and harmonisation across Member States. However, challenges remain regarding data consistency, alignment with national systems, and integration with broader EU fuel traceability frameworks, particularly in the context of SAF reporting under ReFuelEU Aviation.

Following several postponements, the UDB has been gradually phased into operation during 2024–2025, with mandatory registration and transaction reporting requirements progressively applying to relevant economic operators under RED III implementation rules. The system is now operational, although its full functionality and interoperability with certification schemes continue to be refined.

CORSIA Traceability Solutions

The CORSIA scheme, managed by ICAO uses the CORSIA Central Registry (CCR) as its main monitoring tool. Although CORSIA does not have a database dedicated exclusively to tracking SAF, it employs CoC models such as mass balance and B&C to ensure sustainability and regulatory compliance. Limitations of this system include lack of direct interoperability with external databases and challenges in real-time data verification.

Operational SAF Traceability solutions

The market has responded to the need for SAF-UCO traceability with a variety of technology solutions designed to address different levels of the supply chain. These platforms not only provide specific tools to track the product from its origin to its final destination, but also ensure regulatory compliance and improve transparency for all stakeholders.

- **Field Level:** Employs technologies such as IoT sensors and monitoring devices to collect real-time data from source points like restaurants or waste processing facilities. I.e., platforms integrated with transportation systems to monitor the quality and quantity of UCO collected.
- **Operational Level:** Includes Enterprise Resource Planning (ERP) systems and operations management tools, allowing companies to optimize logistics and administrative processes in real time. I.e., SAP GreenToken, which connects operational data with sustainability traceability.
- **Strategic Level:** Focuses on broader solutions such as blockchain ensuring the immutability of data and trust between chain actors. I.e., Circularise, which allows materials to be tracked without revealing sensitive data.
- **Compliance Level:** Solutions specifically designed for auditing and certification, ensuring that data complies with standards such as ISCC and RSB. I.e, Bioledger, which verifies the sustainability of SAF batches via blockchain.

Featured Platforms

Technology platforms play an essential role in SAF traceability and sustainability, providing innovative tools that strengthen transparency, compliance and operational efficiency in the supply chain. The following highlights some of the most relevant IT market solutions, each with unique capabilities and specific use cases that demonstrate their impact on the SAF industry.

IT solution name	Solution Type	Intended Use	Advantages	Developer	User company
Circularise	Blockchain-based digital traceability platform for supply chain transparency.	Tracks sustainable materials like SAF from origin to end-use, ensuring compliance with standards.	Provides extreme transparency while protecting sensitive business data; reduces administrative costs.	Circularise	Neste, BASF, and other stakeholders in ISCC-certified pilot projects.
Source Intelligence & ChainPoint	Cloud-based modular traceability platform	Used by SkyNRG, a key SAF supplier, to ensure traceability and sustainability in its supply chain.	Flexibility to adapt to different supply chains. Integration with technologies such as RFID and IoT.	ChainPoint BV (Source Intelligence)	SkyNRG
Circulor	Blockchain platform to track supply chains and ensure sustainability	Companies such as BP have evaluated Circulor to track SAF and other sustainable fuels throughout their global supply chain.	High transparency and immutable traceability. Automated data verification through smart contracts.	Circulor Ltd.	BP
Spherity	Blockchain-based digital identity solution	Adopted by Neste in pilot projects to ensure data authenticity in the SAF supply chain.	Security in the management of digital identities for SAF batches.	Spherity GmbH	Neste
Bioledger	Blockchain platform for traceability specific to biofuels and UCO	Used by Greenergy to track SAF-UCO used in the production of PBS, guaranteeing its origin and compliance with EU RED regulations.	Designed specifically for biofuels.	Bioledger Ltd.	Greenergy

The most relevant IT platforms include:

- **Circularise:** Collaborated with Neste and other companies in pilot projects to implement blockchain in SAF certification and traceability. This solution is distinguished by its ability to protect sensitive data while ensuring transparency in the supply chain.
- **ChainPoint:** Used extensively in complex supply chains, this modular platform allows data from multiple sources to be integrated. SkyNRG has

used ChainPoint to track SAF from production to end use, facilitating audits and regulatory compliance.

- **Circulor:** Has worked with BP on the integration of SAF data, using advanced interfaces that connect suppliers, producers and regulators. Its focus on real-time traceability enables companies to comply with requirements under EU RED and CORSIA.
- **Spherity:** Recognized for its use of decentralized digital identities,

this platform offers solutions that facilitate the traceability of raw materials like UCO and fuels such as SAF. Its modular approach allows seamless integration with other certification systems.

- **Bioledger:** Has tested its solution in collaboration with Greenergy, ensuring that each batch of SAF is backed up by digital documentation and verifications. This platform also facilitates remote auditing, reducing costs and time for operators.

These platforms go beyond addressing current SAF traceability and compliance challenges by also introducing innovative approaches to optimize supply chain management..

To assess the effectiveness and differentiate the market impact of these IT solutions, a detailed benchmark analysis has been conducted, evaluating key dimensions such as scope, compatibility with certification schemes, interoperability with other systems, usability, and scalability. This assessment highlights both the strengths and the areas for improvement of each solution within the evolving SAF ecosystem.

Comparative analysis of the key features and potential of the 5 main IT solutions for biofuels traceability currently in operation at the EU market.	Typology Level Level of detail and accuracy to track the origin transport and use of the SAF.	Traceability Capabilities Level of detail and accuracy to track the origin transport and use of the SAF.	Certification Support Compliance with standards such as ISCC, RSB, CORSIA and UDB.	Interoperability & Usability Ability to integrate with other supply chain platforms and systems and ease to use.	Geographic Coverage Global, regional or national reach of the tool.	Scalability and Costs Adaptability to different volumes of SAF-UCO and cost-benefit ratio.
 Circularise is a traceability platform for supply chain compliance. Drives sustainability across the supply chain with Circularise's advanced traceability platform.	 Compliance Level  Strategic Level  Operational Level  Field Level	 Blockchain for SAF and UCO with mass verification support, transparency and immutability.	 ISCC compliant and aligned to biofuel mass balance regulations.	 Interoperable with certifiers such as ISCC, with an interface focused on transparency and easy to use after basic training.	 Global, with key projects in Europe and international collaborations for SAF and UCO.	 Adaptable scalability according to project, managed costs with collaboration support.
 Strategic, scalable, and sustainable solutions for managing supply chain data collection, analysis, and reporting.	 Strategic Level  Operational Level  Field Level	 Offers modular traceability from raw material to final product. Flexible for SAF and UCO.	 Compatible with standards such as ISCC and RSB.	 Broad, connects to enterprise systems and supply chains. Intuitive with configurable interfaces.	 Global application, with a focus on transnational chains.	 Highly scalable for large enterprises, moderate costs.
 Circulor uses blockchain and other advanced technologies to ensure traceability and transparency in supply chains.	 Compliance Level  Strategic Level  Operational Level  Field Level	 Full traceability through blockchain with real time visibility.	 Adapt your system to ISCC standards and regional verifications.	 Interoperable with platforms and blockchain solutions. Complex but customization-oriented interfaces.	 Mainly used in key European and global markets.	 Scalable but with high costs due to its advanced approach.
 Spheryty leverages the use of digital identity, providing seamless, automated solutions that integrate effortlessly into the existing systems.	 Compliance Level  Strategic Level  Operational Level  Field Level	 Traceability based on decentralized identity and verifiable tokens.	 Integration with certifications such as ISCC, aligned with European regulations.	 Designed to interact with identity networks and certifications. Technical interfaces require training but are robust.	 Used by European companies, focused on SAF and compliance.	 Scalable in large networks; variable costs depending on the case.
 BioLedger is a tool for the traceability of sustainable biofuels in compliance with the US and EU regulations. Develops simpler and safer sustainable supply chains.	 Compliance Level  Strategic Level  Operational Level  Field Level	 Tracks biofuels, including SAF, from their origin with digital audits.	 Focused on compliance with ISCC and other biofuel standards.	 Focused on biofuel supply chains, moderate integration. Simplified for auditors and biofuel producers.	 Predominantly in Europe with focus on SAF-UCO.	 Medium scalability, ideal for local markets; affordable costs.

Reference values:

 High value
  Mid value
  Low value

Key highlights

From institutional platforms (UDB) to market-based tools such as ChainPoint, Circularise, Spherity, Circulor and BioLedger, among others, IT solutions are transforming how economic operators manage SAF traceability, compliance, and transparency. These systems facilitate alignment with sustainability certification standards and regulatory requirements by strengthening accountability, streamlining documentation and risk management, and simplifying audit processes.

By integrating CoC real-time data collection and validation, sustainability documentation, and reporting obligations into structured and auditable workflows, digital platforms enhance data integrity, reduce administrative burdens, and mitigate risks such as double counting and fraud. However, their effectiveness depends on interoperability with certification schemes, regulatory alignment, cybersecurity safeguards, and the scalability of digital infrastructure across the SAF ecosystem.



SAF Accounting and book & claim systems

SAF Accounting Systems

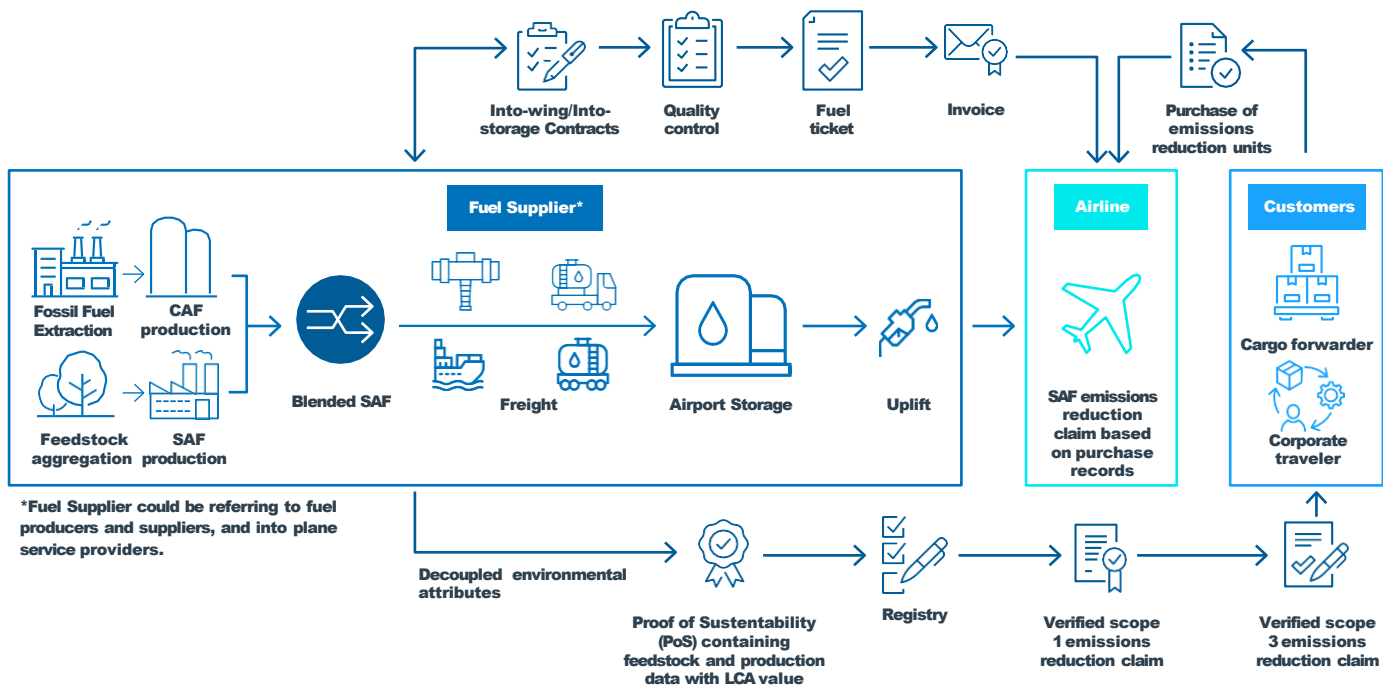
SAF accounting systems employ CoC models such as physical segregation, mass balance and B&C. The B&C model stands out for allowing the separation of the physical

and administrative flows of SAF, facilitating access to environmental benefits for operators without physical access to the fuel.

Book & Claim Initiatives

Various initiatives are driving the

adoption of digital platforms to streamline SAF transactions and manage environmental benefits. These platforms leverage blockchain technology to prevent double counting and enhance transparency in credit allocation.



In addition, some solutions enable the efficient management of SAF certificates while integrating with operational systems, such as flight management tools. These B&C platforms are also designed to ensure alignment with sustainability standard requirements, ensuring accurate accounting and reporting of emissions in compliance with regulatory frameworks.

Challenges and Opportunities

The role of technology will become increasingly critical. From blockchain to advanced interoperability, the innovations we are seeing today are just the beginning. Despite their advances, IT solutions face challenges calling for

attention such as the lack of harmonization between global and regional standards, the complexity of system implementation and the need for operators training and capacity-building.

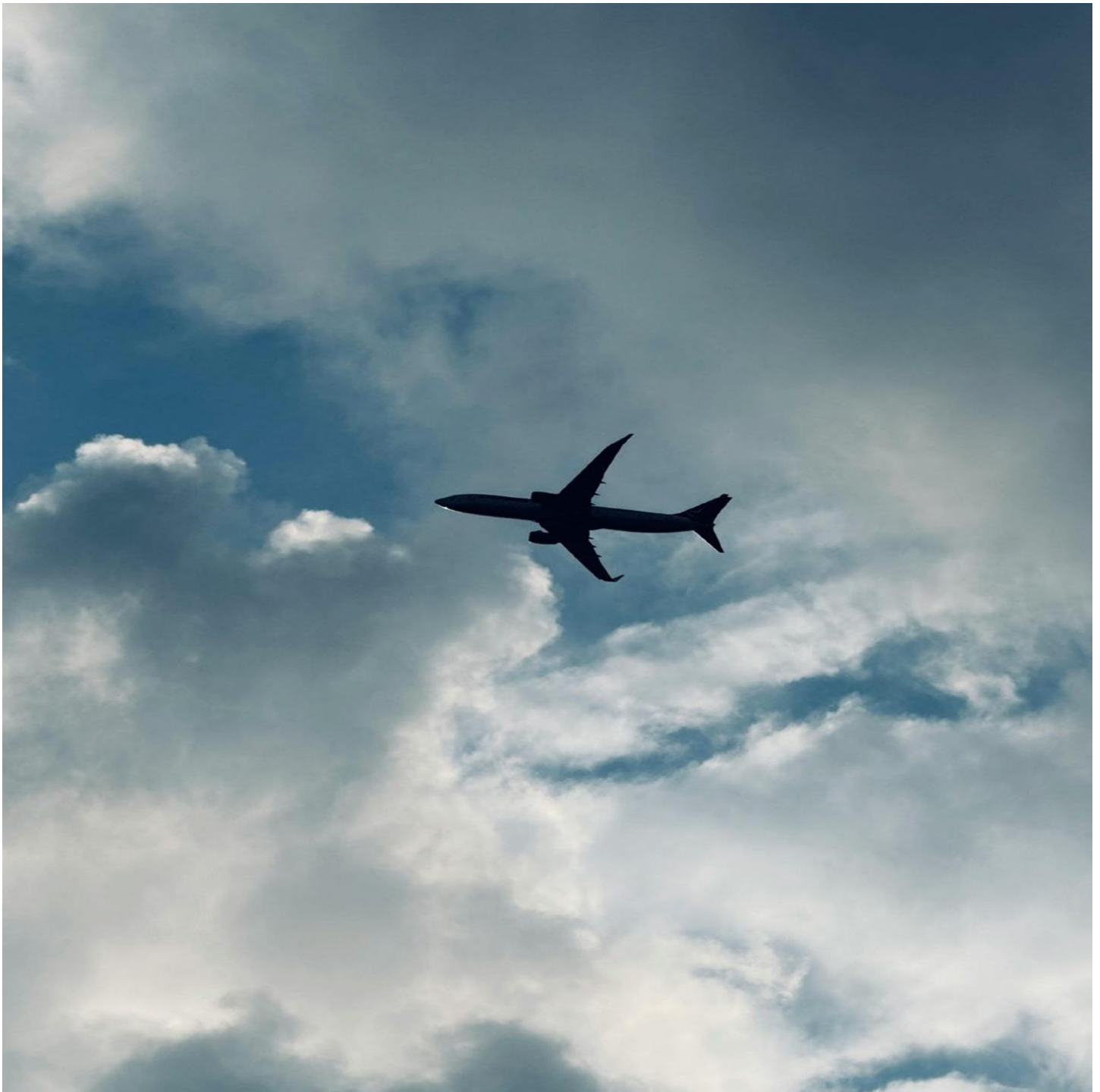
However, IT systems present significant opportunities to optimize SAF traceability management and accounting, facilitating regulatory compliance and strengthening transparency, reliability and innovation in supply chains, which significantly contributes to the sustainable transition of the aviation industry. The integration of advanced technologies such as blockchain and digital identity platforms will lead the way to wider and more effective adoption of SAF in the European and global markets.

Name	Description of the promoter or initiative	Guidance/Methodology	Registry	Verification/auditing	Existing platform	Region	Reference
Aieq	Aviation initiative for renewable energy in Germany.	●				Germany	Link
CST	Clean Skies for Tomorrow is a World Economic Forum coalition.	●				Global	Link
Environmental Defense Fund (EDF)	NGO that tackles climate change and other environmental issues.	●				USA	Link
Science-Based Target Initiative (SBTi)	Global businesses initiative.	●				Global	Link
SFC and MIT (Bi claim global community)	Smart Freight Centre is a globally active non-profit organization for climate action in the freight sector; join efforts with aviation partners and heavy transport players.	●				Global	Link
4AIR	Organization that provides sustainability solutions for the aviation industry.		●		✓	Global	Link
Airline's Programs (SkyNRG)	Company that supplies, blends and distributes SAF. Private registry.		●			Netherlands	Link
Avelia	B&C solution for SAF led by Shell, Accenture, EnergyWeb.		●	●	✓	Global	Link
Board Now (SkyNRG)	Is a program launched by SkyNRG to promote the use of SAF and reduce carbon emissions from business air travel. Private registry.		●			Global	Link
FBO World Fuel Services	Fix Base Operation by World Fuel Services that offers a platform for on SAF Suppliers which allows transactions.		●		✓	Australia, Canada, France, Germany, UK and South Africa	Link
Fly-i	Fly-i is a CEF registry platform developed by Evident (partnered with RSB).		●		✓	Global	Link
SABA	Sustainable Aviation Buyer Alliance, promotes the investment and adoption of SAF.	●	●			Global	Link
COSAFA	Council on Sustainable Aviation Fuels Accountability. Its mission is to ensure consistency in SAF transactions.	●		●		Global	Link
IATA	International Air Transport Association.	●	●	●		Global	Link
AZERA CELESTE	Online platform that allows carbon credit trading, acquisition of SAFs via B&C system and a complete management and categorization of emissions into compliance markets.	●	●	●	✓	Global	Link
RSB	Roundtable on Sustainable Biomaterials, it is a sustainability certification system.	●	●	●	✓	Global	Link
ISCC	International Sustainability and Carbon Certification, it is a sustainability certification system.	●	●	●	✓	Global	Link

Key highlights

SAF accounting and B&C systems complement physical traceability by enabling the structured issuance, transfer, and retirement of SAF certificates, thereby facilitating demand aggregation and market access beyond physical supply constraints. By decoupling environmental attributes from fuel delivery, these mechanisms can accelerate corporate uptake and strengthen investment signals, provided that robust governance and double-counting safeguards are ensured.

Several market-based B&C platforms are already operational (including 4AIR, [AZERA CELESTE](#), Avelia, Fly-I and others) offering digital infrastructure for certificate management and transaction tracking, although their scope varies across jurisdictions. Ultimately, the credibility and scalability of these solutions will depend on regulatory clarity, harmonized sustainability criteria, and interoperable digital infrastructures aligned with EU and international climate frameworks and standards.



Conclusion

The move towards a sustainable aviation sector driven by the deployment of SAF represents one of the industry's most significant challenges and opportunities. This paper provides a comprehensive overview of the key elements shaping the SAF ecosystem, from foundational concepts and market dynamics to regulatory frameworks, sustainability certification schemes, and the critical role of digital and IT solutions in enabling robust traceability and accounting.

The global context of SAF highlights its critical role in the climate and energy transition, offering a viable pathway to reduce carbon emissions in aviation. However, reaching the production and distribution scale required to meet the EU's 2030 and 2050 climate targets will depend not only on technological innovation and sustained investment in research and development, but also on

effective collaboration between public and private stakeholders to ensure the technical, environmental, and economic viability of SAF.

At the regulatory level, the EU is actively shaping the transition toward a more sustainable aviation sector, with SAF positioned as a central decarbonisation lever. A combination of global (CORSIA), EU-level (RED II/III and the ReFuelEU Aviation Regulation), and national policy instruments is driving SAF uptake while reinforcing strict sustainability, traceability, and compliance requirements across the entire value chain. In this context, certification schemes such as ISCC and RSB play a critical role in verifying sustainability criteria and ensuring traceability, thereby strengthening market confidence and regulatory integrity. However, the complex and evolving regulatory landscape entails significant compliance

challenges for economic operators, highlighting the need for clear mandates and stable and coordinated incentives and market-based mechanisms.

At the same time, digital and IT solutions are becoming key enablers of SAF deployment. Advanced technologies (including IoT-enabled monitoring systems, blockchain-based traceability platforms, and digital registries) are enhancing transparency, data integrity, and operational efficiency across the SAF supply chain.

Platforms such as ChainPoint, Circularise, Bioledger, and Avelia illustrate how digital tools can support traceability and accounting requirements. In parallel, emerging Book & Claim initiatives are expanding access to SAF procurement models, offering additional pathways to scale demand while maintaining environmental integrity.



The central conclusion of this paper is clear: successful adoption of SAF depends not only on technological and regulatory advances, but also on the industry's ability to integrate these market opportunities and challenges in a coordinated and efficient manner. As we move forward towards a more sustainable future, IT innovation, stakeholders' collaboration and regulatory stability will be the key drivers to ensure that SAF plays a central role in the decarbonization of global aviation.

Why is NTT DATA the ideal partner to lead this transformation?

At NTT DATA we have the experience, technological capabilities and industry knowledge necessary to lead and accompany the transition towards an efficient and sustainable SAF ecosystem. Our track record in high-impact global projects and our advanced solutions position us as a key player in this transformation:

- **Experts in key technologies:** Our proficiency in cutting-edge technologies such as blockchain, artificial intelligence, IoT and cloud solutions enables us to deliver robust, transparent and scalable traceability systems that respond to the specific needs of the SAF market.
- **Sector expertise and reference projects:** We are established partners for pioneering initiatives for the digitalization and automation of the energy sector, including main fuel supply players leading the SAF production. We are collaborating

with key market players in the development of customized solutions for SAF accounting, traceability and compliance.

- **Global vision and local adaptability:** With a presence in more than 50 countries, NTT DATA combines a global perspective with a deep understanding of local regulatory and market contexts, ensuring that our solutions are perfectly aligned with the specific objectives of each region.
- **Commitment to sustainability:** Our dedication to sustainability is reflected in the implementation of projects that generate a positive environmental impact, ensuring compliance with the highest international standards in every solution we develop.
- **Capabilities integration :** We understand that success in the SAF ecosystem requires effective collaboration between different stakeholders. Our integrative approach connects producers, operators, regulators and consumers, optimizing interoperability and facilitating the creation of transparent and sustainable supply chains.

In a context where technological innovation is at the core of achieving aviation's climate goals, NTT DATA is positioned not only to provide effective solutions, but also to lead the transformation to a greener, more sustainable industry. With our unique capabilities, we are poised to be the strategic partner that drives our customers towards a sustainable aviation future.



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