



Embarking on a Low-Carbon Future for Freight: Insights and Prospects on Demand-Side Actions for Sustainable Aviation Fuel in China

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About the Smart Freight Center

The Smart Freight Centre was established in Amsterdam, the Netherlands, in 2013 as an international non-profit organization dedicated to reducing greenhouse gas emissions from freight transportation. Its mission is to collaborate with global partners to quantify environmental impacts, identify solutions, and promote logistics decarbonization strategies. Since 2014, the Smart Freight Centre has been operating in China, where initiatives such as mechanisms for the promotion of green freight technology, our Smart Fleet Manager training program, the Smart Freight Forum, Smart Shipper Alliance, Zero Emission Freight Initiative, and localization of the GLEC Framework, have gained recognition, support, and active participation from the logistics and freight industries. The organization's role is to guide companies toward zero-emission logistics, advocate for supportive policies and programs, and raise awareness about zero emissions.

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1

1 Background



The global aviation industry is facing immense pressure to reduce emissions. According to data from the Energy Transitions Commission, an aviation industry group, the sector accounted for nearly 3% of global human-generated carbon dioxide emissions in 2020. Without robust action, this proportion could rise to over 22% by 2050 [1].

China is also facing increasingly severe pressure to reduce aviation emissions. Most immediately, international mechanisms are about to impose stricter requirements on China's aviation industry. According to the International Civil Aviation Organization's (ICAO) CORSIA scheme [2], starting from 2027, China will be included in the mandatory compliance phase, which means that Chinese aviation operators will have to fulfill relevant obligations. This process will significantly increase the pressure on China's aviation industry in the area of carbon cost management. In addition to this, China's own climate commitments at the national level are also becoming stricter. In September 2025, President Xi Jinping announced China's new Nationally Determined Contributions (NDCs) in his speech at the United Nations Climate Change Summit, saying that by 2035, China's economy-wide net greenhouse gas emissions will decrease by 7%-10% from peak levels [3]. This means that as China transitions toward green and low-carbon development, its aviation industry must not only address international compliance requirements, but also align with domestic emissions control measures and industrial policy integration.

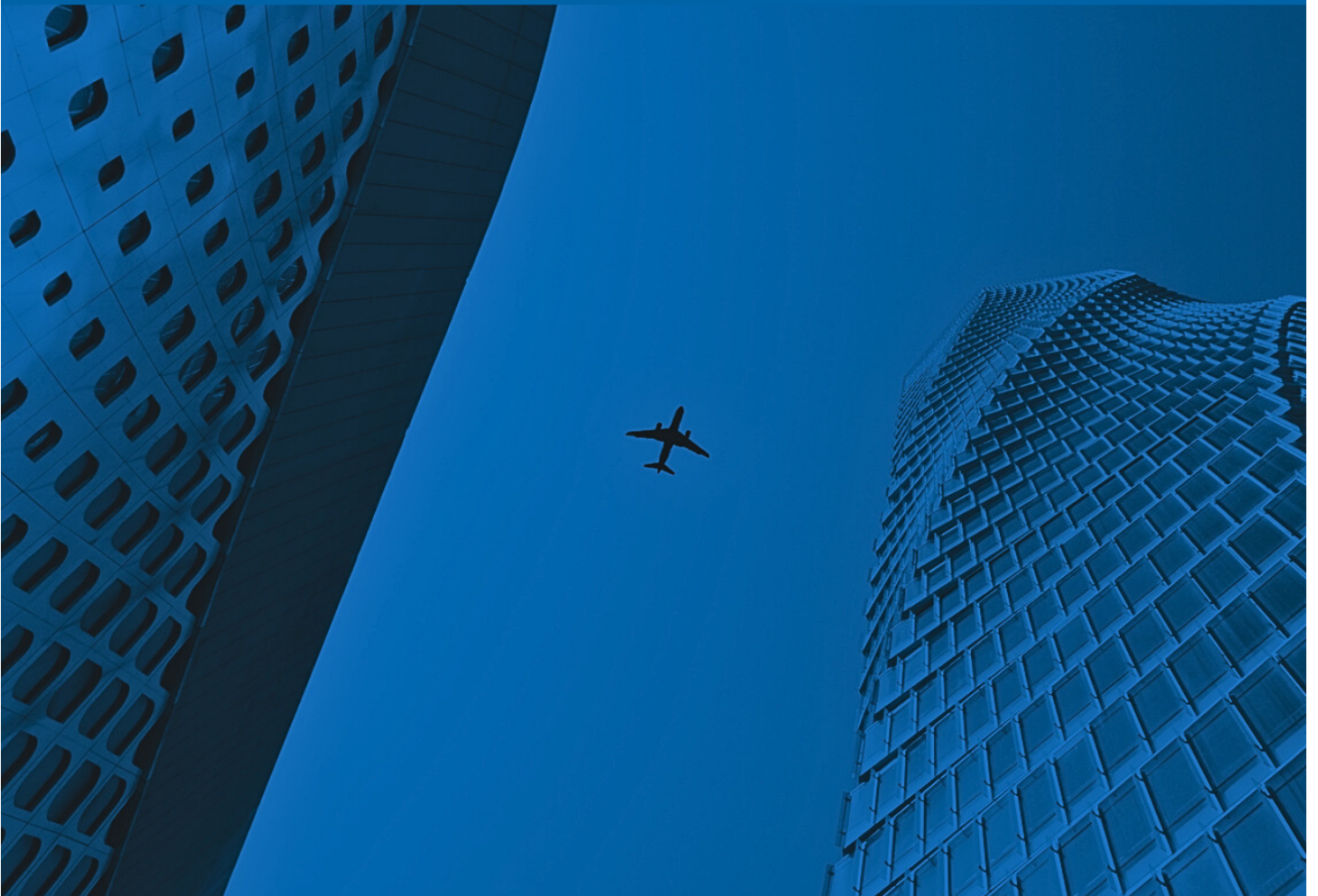
According to the ICAO definition, **Sustainable Aviation Fuel (SAF)** refers to alternative fuels produced from renewable resources such as biomass, waste materials, etc. [4]. Unlike conventional aviation fuels, SAF demonstrates significant carbon reduction potential, capable of reducing lifecycle carbon emissions by up to 80% [5], **making it one of the key pathways for decarbonizing the aviation industry**. According to projections by the International Air Transport Association (IATA), SAF is expected to play a decisive role in the aviation industry's carbon reduction efforts by 2050, accounting for approximately 65% of emission reductions [6].

Globally, while the production of SAF is growing rapidly, **its large-scale application still falls far short of the levels required to meet global decarbonization targets**. In 2023, global SAF production reached 500,000 tons, a 100% year-on-year increase, yet this accounted for only 0.53% of total global aviation fuel demand—significantly below the level needed to achieve global emission reduction goals [7]. This paradox of "high growth but low share" is a worldwide issue and influenced by multiple factors. One critical factor is the lack of stable demand-side commitments in the SAF market, which fails to provide sufficient certainty to support large-scale investments. Meanwhile, development drivers also vary at the regional level with Europe relying on mandatory targets and carbon market mechanisms to stimulate demand, **while China, despite its vast potential demand, remains in the exploratory and pilot phase**.

Deep decarbonization of the aviation industry will necessitate the large-scale application of SAF, which in turn depends on the creation of stable and sustainable demand signals. Only when downstream stakeholders such as shippers, logistics service providers, and airlines demonstrate clear and consistent demand, can investments and capacity expansion on the supply side follow, enabling genuine supply-demand synergy. Therefore, **exploring the drivers, practices, and challenges on the demand side is critical to advancing the maturity of the SAF industry chain**.

2

2 Objective



Using a wide range of industry research, this report collected insights on the motivations, current practices, and challenges related to the use of Sustainable Aviation Fuel (SAF) in China's cargo transportation through interviews with multiple shippers, logistics service providers (LSPs), airlines, and express delivery companies. These findings were analyzed and summarized alongside existing case studies. Despite being a market with a great deal of potential in SAF production and consumption, China is still in the exploratory and experimental phase of SAF development. Whether stable and sustainable demand can be created will have a direct impact on the potential of subsequent industrial expansion and cost reductions. In light of this, the study aims to:

- 1) Clarify the roles and motivations of the demand side in SAF applications.
- 2) Summarize the current state of SAF adoption in the Chinese market.
- 3) Identify the key challenges on the demand side in promoting the adoption of SAF in China.
- 4) Present a forward-looking perspective and call to action to encourage the industry to conduct more pilot projects and lay the groundwork for subsequent research.



3

3 Stakeholder Analysis



To better understand the current state and development potential of China's SAF market, it is essential to first clarify what is meant by the "demand side," including the key entities involved, underlying drivers, and their respective roles in SAF adoption. The position and functions of different types of enterprises within the SAF value chain determine their level of awareness, willingness to procure, and behavioral patterns regarding SAF, which in turn shape the overall demand structure and diffusion pathways of the SAF market. To this end, **this chapter, through preliminary research and analysis, identifies the main demand-side participants—including cargo owners, logistics service providers (LSPs), and carriers (airlines)—and summarizes their motivations and roles in promoting SAF.** This systematic overview aims to provide a reference for subsequent market analysis and policy recommendations in China.

3.1 Cargo Owners

In the logistics sector, the core value of air freight for cargo owners lies in its unparalleled speed and efficiency. Compared to sea or rail transport, air freight significantly reduces cross-border transit times, enabling businesses to seize orders and avoid stockouts in a highly competitive global market. Typically, cargo owners utilize air freight at critical junctures in the supply chain, particularly during long-haul intercontinental segments or the "first mile" and "middle mile" stages, swiftly transporting goods from production sites to overseas hubs. This approach compresses overall delivery times and mitigates the risk of stockouts and price depreciation. This means that the primary demands of cargo owners on air freight center are speed, reliability, and predictability, rather than mere cost control. Consequently, **companies that depend on air freight often share common traits, such as high unit-value products, short turnover cycles, time-sensitive sales windows, or goods that require specific environmental conditions during transit.** Thus, **the companies that are most dependent on air freight are mainly in industries such as electronics and information technology, pharmaceuticals and chemicals, luxury goods, and fast-moving consumer goods (FMCG).** Cargo owners in these sectors are the main drivers of global air cargo demand. Currently, in China, cargo owners with a high awareness of, or interest in, SAF are mostly enterprises with multinational operations or international brands that have manufacturing bases in China.

SAF Market Drivers

In recent years, a growing number of cargo owners have joined international emissions reduction initiatives such as the Science Based Targets initiative (SBTi) and incorporated Scope 3 emissions reduction targets into their medium- to long-term strategic plans. Some companies have further refined these targets to include the logistics and supply chain segments, setting emissions reduction KPIs for different stages and modes of transportation. Within overall Scope 3 emissions, the transportation segment is often a key focus, with air freight standing out prominently. Cargo owners widely recognize that although air freight typically accounts for only around a tenth or even single-digit percentages of total transportation volume, the amount of carbon emissions it produces is significantly higher than other modes of transport, frequently making it a major source of Scope 3 emissions. **This "low volume, high emissions" phenomenon makes air freight the most challenging segment to address when working to reduce supply chain emissions.**

Due to the inherently high costs of air transport, many cargo owners tend to reduce their reliance on air freight to cut emissions by planning shipments in advance and using sea or rail transport or setting up forwarding warehouses near destinations to shorten delivery routes. However, company interviews have shown that, in many cases, air transport remains difficult to replace. Whether this is due to time-sensitive delivery cycles or the pace of the market, requirements for shorter transit times and controlled environments, or the need to reduce risk for high-value cargo and respond to sudden changes in external conditions, **companies often have to rely on air transport to ensure supply chain stability and predictability.**

Despite corporate efforts to optimize transportation structures, it is clear that air freight remains an irreplaceable option in specific industries and application scenarios. Faced with this reality, companies typically adopt measures such as improving loading efficiency, optimizing flight routes, and using higher-quality emission data for carbon accounting to reduce carbon emissions in air transport. When the impact of these measures cease to further reduce emissions in a significant way, SAF offers another key option for achieving industry goals to reduce aviation emissions. **As long as time costs continue to outweigh transportation costs, air freight will retain its strategic position in global supply chains,** which means that SAF will remain an indispensable tool for cargo owners looking to reduce aviation emissions.

According to the survey results, several leading domestic Chinese companies have already budgeted for low-carbon transportation costs in their procurement plans to cover the additional premiums associated with measures such as the use of SAF. However, the majority of enterprises continue to take a wait-and-see attitude, preferring to delay investment decisions until policies, pricing, and availability become clearer. However, this cautious approach has prevented potential demand from cargo owners making its way to downstream markets, which has made it difficult to establish sustainable procurement signals and a stable demand foundation.

Cargo Owner Roles in the Value Chain

Cargo owners play a decisive role in the SAF value, both initiating demand and providing market signals. When cargo owners explicitly express their need for low-carbon transportation, logistics service providers and airlines adjust their product offerings and capacity arrangements accordingly. Such signals also offer certainty for upstream SAF producers in terms of production capacity investment and long-term planning. Cargo owners also act as amplifiers of demand by providing a predictable foundation for demand through advanced planning and stable procurement commitments, thereby driving large-scale procurement and proactive responses from the supply side. This means that the strategic choices and concrete actions of cargo owners directly determine the pace and depth of SAF adoption within the supply chain.

3.2 Logistics Service Providers (LSPs)

LSPs are service providers that directly respond to cargo owners' demands for low-carbon transportation. Research indicates that currently in the Chinese market, LSPs focusing on or promoting the application of SAF are primarily those with multinational business backgrounds. These include both

international LSPs with branches in China and Chinese enterprises that serve international clients and provide cross-border transportation services. Such companies also typically possess well-established global route networks and mature customer relations.

With well-established mechanisms and strong emission reduction management capabilities, the LSPs are capable of accessing and incorporating SAF products and mechanisms from international sources earlier than others. This demand generally comes from clients that are primarily cargo owners with overseas operations or export-oriented businesses, whose interest in SAF often stems from emissions reduction requirements in international supply chains. Overall, by leveraging extensive customer networks and economies of scale, these LSPs can consolidate fragmented demand requirements from cargo owners into executable procurement and transportation solutions, making them a key driving force in promoting the market adoption of SAF.

SAF Market Drivers

The impetus for LSPs to develop SAF-related services stems from two primary factors. The first is **customer demand**, because an increasing number of global brands set clear targets for Scope 3 emission reductions, requiring LSPs to offer SAF options to meet client demand for low-carbon transportation and retain customer loyalty in a competitive landscape. The second is **business model innovation**, which responds more accurately to market needs and enables LSPs to position SAF as a standardized, but still very customizable, low-carbon energy product. This not only provides customers with a more diverse range of choices, it also unlocks new value dimensions for their own service systems.

LSPs Roles in the Value Chain

In the SAF value chain, the role of LSPs is manifested at two levels. The first of these is as **demand aggregators**, which consolidate the fragmented demands of multiple shippers into large-scale orders, thereby reducing the costs and uncertainties associated with airlines' procurement of SAF. In addition to this, **LSPs also design and coordinate comprehensive solutions as part of their service offerings**. By packaging SAF-related services into comprehensible and actionable emission reduction solutions for their clients, and by balancing demand, cost, and compliance, they enable cargo owners to more easily integrate SAF into their own decarbonization pathways. It is precisely through this integration and transformation capability that LSPs convert fragmented market signals into executable solutions, driving the steady integration of SAF into air cargo transportation.

3.3 Carriers(Airlines)

In the SAF value chain, carriers(airlines) are direct consumers of fuel products and key links between upstream and downstream sectors. As major corporate players, China's three major airlines (Air China, China Eastern, and China Southern) often spearhead policy-related pilot programs that pioneer industry development. While current scale of SAF adoption among these carriers remains limited, once under clear guidance provided by national-level strategic planning programs, they will consistently define the direction of industry development. Meanwhile, other carriers or airlines that focus

more on cargo operations or international routes, such as SF Airlines in Mainland China and Cathay Pacific in Hong Kong, pioneer more market-driven pathways. Through innovative projects and competitive pricing mechanisms, they explore commercial models for SAF, promoting the formation and expansion of the industry ecosystem.

SAF Market Drivers

There are three key factors that drive the adoption of SAF among domestic carriers. First is a **response to national policy directives**. China has launched a series of SAF pilot programs in 2024[8] and its 14th Five-Year Plan for Civil Aviation Green Development set specific targets for SAF application, providing a certain degree of guidance in exploring and deploying SAF technologies. Second is **customer and market demand**. As more multinational cargo owners and major brands make low-carbon transportation a key part of their procurement requirements, carriers or airlines that offer SAF-related services address specific sustainability needs while also enhancing their own market competitiveness and strengthening partnerships. Finally, jet fuel represents the main source of **Scope 1 emissions** for airlines, which are facing increased internal pressure to reduce emissions, and with the exception of fleet upgrades, SAF has emerged as the most promising solution to significantly reduce carbon emissions in the short term.

Carrier(Airlines) Roles in the Value Chain

Carriers(airlines) play an essential role within the SAF value chain. Firstly, as direct consumers of the fuel by fueling their aircraft with SAF, they are **the most immediate operators** within the value chain, making SAF flights possible. Secondly, they act as **technology promoters** by signing long-term offtake agreements, participating in the development of new fuels, and making investments, which all send demand signals to upstream producers and reduce the risk of investment in the industry. Finally, they also serve as **coordinators**, functioning as a bridge between policy and the market. On one hand, they are the ones who ultimately put policy plans into action, but on the other, they also work with industry organizations to promote the creation of more efficient market mechanisms, placing them at the center of the SAF value chain.

Cargo owners, LSPs, and carriers(airlines) each have distinct yet complementary motivations and roles in the adoption of SAF. While this report focuses on the demand side, improvements on the supply side are equally critical to the development of the SAF market. Fuel producers provide essential support through raw material development, production capacity planning, and cost optimization, while continued improvements in the refueling infrastructure makes it more possible for SAF to be seamlessly integrated into airline operations and other end-use applications by customers. Proactive exploration on the demand side depends on support from the supply side, while continued investment on the supply side needs clear signals from the demand side. The synergy between the two will collectively drive the market from the pilot phase toward real-world commercialization.

While analysis of the motivations and roles of various players in the SAF industry is necessary, what will truly determine the successful large-scale application of SAF is how key stakeholders connect in practice. The next chapter will summarize some of the exploration and practical application that has already taken place in China, which is based on information collected during our interviews and will serve to illustrate the current state of practical application on the demand side.

4

4 China's Current Practices



Current market-driven adaptation of SAF is primarily driven by demand-side initiatives, typically revolving around four core stages – setting emissions reduction targets, creating demand, ensuring procurement and carrying out accurate emissions accounting (Figure 1).

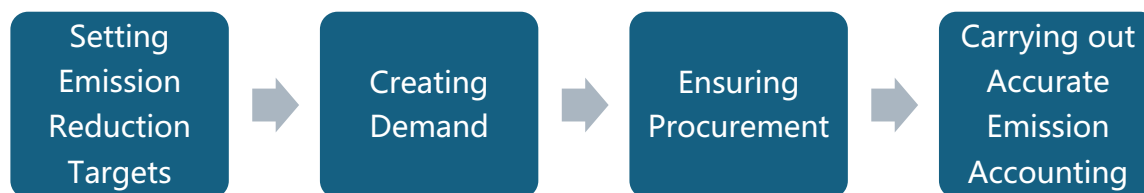


Figure 1 SAF Procurement Implementation Process in Voluntary Market

Many cargo owners are now setting their own SBTi or net-zero targets, further breaking down their Scope 3 emissions reduction goals based on specific aviation transport metrics. This creates clearly quantified tasks, defining the required emissions reductions (in tons of CO₂e) or SAF usage on an annual or project-cycle basis. Throughout this process, shippers consider overall reductions in emissions as well as factors such as cost, budget, timeliness, and implementation methods.

Then demand can be met through procurement by LSPs or direct negotiation between cargo owners and carriers (airlines) or fuel suppliers, using different execution paths that are typically chosen based on budget and feasibility. Currently, SAF adoption is being driven through various chain of custody (CoC) mechanisms, including refueling at qualified airports (through **segregated or mass balance CoC**) and trading SAF credits via registration platforms through **book and claim**. After procurement and implementation, carriers, LSPs, or shippers account for the corresponding SAF emissions in their Scope 1 or Scope 3 inventory based on the terms of relevant contracts and accounting methods, followed by disclosure through official reports and audits. Methods for accounting SAF emissions varies depending on a range of factors such as corporate accounting boundaries and chain of custody mechanisms, on which we will not elaborate here. For further details on accounting methods, please feel free to contact us for discussion or refer to other reports from the Smart Freight Centre [9].

This chapter, based on our research, summarizes the current implementation pathways for SAF that have been adopted by different types of enterprises on the demand side, providing readers with insights into the present state of SAF application in the Chinese market. It should be noted that the content herein is solely a presentation of research and inductive results and does not constitute operational guidance or recommendations. The recently released “SAF Insights – A Practical Guide for Freight and Aviation Stakeholders: by the Smart Freight Centre offers a systematic overview of key issues related to global SAF application—including implementation pathways, accounting and marketization mechanisms, and international experiences. Readers are advised to consult this guide for more comprehensive background and technical details [9].

This chapter discusses three chain of custody mechanisms: **Segregated**, **Mass Balance**, and **Book & Claim**. The basic definitions of related concepts primarily reference international standards such as ISO 22095. Without altering their core elements, this report supplements examples of the implementation of each mechanism in the context of SAF application in China.

4.1 Model 1: SAF Direct Refueling via Segregated CoC

Among currently observable domestic SAF adoption practices in the early exploratory phase in China, **segregated** dedicated injection represents a relatively typical model. This approach, primarily adopted in the initial stages of SAF implementation, enables clear verification of fuel flow direction, usage patterns, and aircraft operational safety, thereby establishing a reliable foundation for subsequent technical evaluations and mechanism design.

Under **segregated** CoC, this fueling model ensures a clear distinction between SAF and conventional aviation fuel during storage, transportation, and refueling processes, guaranteeing controllable usage ratios and verifiable outcomes. Under this model, carriers (airlines) in China typically deliver and utilize SAF through independent transportation and refueling methods rather than relying entirely on existing airport fuel pipeline systems. This approach enables precise physical delineation of SAF input, usage, and consumption boundaries, providing a stronger verifiable foundation for subsequent accounting, auditing, and technical evaluations. Carriers (airlines) can directly demonstrate the actual SAF usage of their flights using complete refueling records and validation data.

In China, both the first phase of the Civil Aviation Administration of China (CAAC)'s SAF application pilot program and SF Airlines' [10] early exploration of SAF application adopted a targeted refueling approach based on **segregated** CoC.

The **first phase of the CAAC's SAF application pilot program** [8] was implemented from September to December 2024, selecting four domestic airports, namely Beijing Daxing, Chengdu Shuangliu, Zhengzhou Xinzheng, and Ningbo Lishe at which twelve commercial flights operated by Air China, China Eastern Airlines, and China Southern Airlines departing from these airports were arranged to conduct formal SAF refueling. The initiative focused on researching and exploring key aspects such as fuel supply assurance, fuel quality monitoring, safety operations, and effectiveness evaluation. At the corporate level, SF Airlines [10] is one of China's domestic cargo carriers that has been actively exploring practical SAF refueling operations. On December 19, 2024, **a B737 freighter operated by SF Airlines** completed the first commercial SAF flight for a domestic freighter on their Ningbo–Ezhou Huahu route. By physically segregating SAF from conventional jet fuel during the refueling process, the airline achieved actual SAF usage and verifiable consumption. During the flight, SF Airlines engaged a third-party certification body to quantify, calculate, and verify the greenhouse gas emissions corresponding to the aircraft's fuel consumption during the flight, which provided an auditable data foundation for emissions accounting under actual SAF usage scenarios.

It should be noted that in the early stages of SAF application, a **segregated** CoC-based dedicated injection systems plays a significant role for referencing and clarifying the actual usage boundaries of fuel, verifying accounting methods, and exploring pathways for environmental attribute management. However, this model typically requires specialized coordination among carriers, fuel suppliers, and refueling service providers to enable the actual use of SAF under independent transportation, storage, and refueling conditions. This model places relatively high demands on China's current aviation fuel supply and refueling system in terms of operational conditions, coordination costs, and operational

flexibility, making it difficult to rapidly replicate and promote on a larger scale. As relevant technical pathways and management mechanisms gradually mature, both the subsequent phases of the CAAC's SAF application pilot and SF Airlines' practical trials have begun transitioning toward more flexible models such as **mass balance**, thereby creating conditions for the scalable adoption of SAF.

4.2 Model 2: SAF Refueling via Mass Balance CoC

Refueling via the **mass balance** CoC is gradually emerging as a key pathway for scaling up SAF in China's current aviation fuel supply and refueling system, from early-stage pilot programs to widespread application.

China currently adopts a centralized procurement model for SAF or conventional aviation fuels, primarily managed by the China National Aviation Fuel Group (CNAF). Under the **mass balance** CoC, SAF is procured by CNAF and mixed with conventional jet fuel using existing aviation fuel pipeline networks at airports equipped with blending facilities. The blended fuel is then integrated into the airport's fuel supply system for flight operations. Unlike **segregated** CoC, the physical flow of SAF no longer corresponds to specific flights. Instead, SAF usage is verified at the system level through methods such as blending ratio control, ledger management, and internal accounting.

Based on survey interviews and industry exchanges, **the second phase of the CAAC's SAF application pilot program** (officially disclosed as being implemented throughout 2025) has further evolved to **mass balance** CoC. The focus is no longer limited to single or targeted validations but rather explores feasible pathways for the application of SAF across a broader operational scope on a regular basis.

At the enterprise level, **SF Airlines' related explorations** have also gradually shifted from single refueling verification to more flexible and scalable operational optimization, while **Cathay Pacific** in Hong Kong introduced low-carbon air transport services based on SAF blending applications at a relatively early stage. Overall, the chain-of-custody logic in the refueling methods of these practices aligns more closely with **mass balance**.

In this mode, SAF is physically consumed, but whether specific flights can be confirmed as "actually using SAF" or "how much SAF was used," and whether the corresponding environmental attributes possess the foundation for further transfer, critically depends on whether the fuel supply and refueling processes can provide clear, verifiable documentation. The challenge is that if the use of SAF at the airline or flight aggregation level cannot be clearly defined, the associated environmental attributes generally lack the conditions for transfer to downstream customers. However, compared with **segregated** CoC, mass balance does offer a more flexible pathway for the broader application of SAF while balancing operational safety and system feasibility.

It should be noted that blending and injection models using **mass balance** CoC are often constrained by the operational scope of specific airports, airlines, and the coverage boundaries of fuel supply systems. When the transportation needs of cargo owners or LSPs do not fall within the relevant airport or flight networks, or when they seek more flexibility in accessing SAF in terms of time and location,

segregated and **mass balance** often fail to meet these needs. In this context, the market is gradually exploring a method to decouple the environmental attributes of SAF from specific physical flows, enabling cross-route and cross-regional attribute allocation and utilization. This has resulted in initial scenarios for the so-called **book & claim** mechanism.

4.3 Model 3: SAF Environmental Attribute Trading via Book & Claim CoC

The **Book & Claim** model decouples the physical flow of SAF from its environmental attributes. In this model, SAF is blended, dispensed, and consumed in actual operations, while the resulting environmental attributes, after accounting and registration, can be independently transferred via a registration platform to entities on the demand side that did not physically use SAF. This mechanism overcomes the challenges of airport availability, fixed flight routes, and limited infrastructure, enabling shippers or LSPs without the means to physically utilize SAF to participate in SAF-related emission reduction practices.

Under this model, **shippers typically purchase environmental attribute certificates for SAF from fuel suppliers, airlines, or others**, based on their Scope 3 emission reduction targets, while LSPs may do so to meet their clients' emission reduction needs. They then account for the corresponding emissions in their greenhouse gas inventories based on the emission factors of SAF as documented in relevant certification documents, applicable accounting rules, and the volume purchased. In this process, shippers and LSPs may not physically use SAF, but can claim emissions reduction benefits equivalent to the actual consumption of SAF by purchasing its environmental attributes. It should be noted that the prerequisite for issuing such SAF environmental attribute certificates is that the corresponding amount of SAF must be currently in use or already have been used (eg. been blended into aviation fuel systems). This transaction does not mean that the demand-side entity has actually used SAF, but that the aforementioned actual usage results have been allocated and declared at the operational level.

At present, China does not have a unified and open book-and-claim system in use and relevant transactions are primarily completed using overseas registration platforms. Enterprises that use **book & claim** are typically shippers or LSPs with both Chinese and international business operations. Based on this research and industry observations, the common operational approach domestically is for shippers to procure air transport services through LSPs and express their demand for SAF usage. The LSPs then centrally purchase SAF environmental attribute certificates through their headquarters and, in accordance with their client's requirements, assign the corresponding environmental attribute declarations to the clients' air transport activities within China.

While some international shippers have recently expressed interest in procuring environmental attributes from Chinese SAF through book-and-claim CoC, China's lack of such a system and the fact that regular blending and commercial SAF is scarce makes this difficult. Currently, the foundation for a domestic SAF book-and-claim mechanism is not yet fully mature.

Generally, the book-and-claim mechanism offers demand-side enterprises a low-entry-barrier and rapidly deployable pathway for emissions reductions through SAF. It also helps aggregate demand and send market signals in the early stages of development, thereby driving upstream capacity expansion. However, it should be noted that current mainstream international guidelines or initiatives (such as GHG Protocol and SBTi) have not yet established clear and detailed guidance on how greenhouse gas emissions under the book-and-claim model should be accounted for in Scope 3 inventory. Freight owners should clearly disclose the accounting methods and assumptions used in their reports while being aware of the associated risks. The Voluntary Market Based Measures Framework for Logistics Emissions Accounting and Reporting [11] published by the Smart Freight Centre provides enterprises with clear and credible guidance, enabling them to effectively incorporate SAF use into their corporate emission reporting systems, regardless of the chain of custody mechanism adopted.

In summary, China is currently undertaking varying degrees of practical exploration in pathways such as segregated, mass balance, and book-and-claim, but as it is constrained by infrastructural factors, its current institutional environment, and lack of market maturity, different entities often need to select or combine implementation pathways suitable for their specific circumstances based on their position in the value chain, resource endowment, and capability boundaries during practical application. Overall, domestic demand-side exploration remains in the experimental and verification phase, with market participants continuously iterating and refining procurement mechanisms, accounting methodologies, certificate management, and service delivery. Although these efforts have not yet coalesced into unified standards, they have provided valuable experiences for future systematic and large-scale adoption of SAF in China.



5

5 Challenges



While in China, some companies have taken the lead in exploring SAF-related initiatives, market participation on the demand side overall remains limited. For most companies, SAF remains a relatively new and complex realm. In promoting the adoption of SAF, practical challenges persist in areas such as policy support, economic feasibility, supply chain maturity, and the level of industry collaboration. Numerous domestic and international studies and reports have summarized and analyzed the major obstacles to the development of China's SAF market. Based on research interviews and daily exchanges with stakeholders that we have conducted for this study, this article further identifies four types of challenges that are particularly significant for the demand side within the context of the Chinese market.

5.1 Policy Systems: Initial Explorations Still Being Perfected

In recent years, the government has placed high importance on the green and low-carbon transformation of China's aviation industry and views SAF as one of the key pathways for reducing emissions in civil aviation. Since the 2021 passage of China's 'Action Plan for Carbon Dioxide Peaking Before 2030', which proposed "promoting green and low-carbon transportation" the CAAC has successively introduced policy documents including a '14th Five-Year Plan for Civil Aviation Development' and '14th Five-Year Plan for Green Development in Civil Aviation.' These documents outline initiatives for piloting the regular adoption of SAF, establishing a sustainable certification system and setting a target of cumulative consumption reaching 50,000 tons during the 14th Five-Year Plan period.

Shortly after this, the Ministry of Industry and Information Technology and three other departments issued the 'Green Development Outline for the Aviation Manufacturing Industry (2023–2035),' further proposing pilot programs for SAF use in domestically produced civil aircraft and improving airworthiness certification methods. Clearly, the current policy framework and demand-side focus on SAF has gradually shifted from macro-level planning to validating practical applications, emphasizing pilot programs, establishing standards, and developing certification systems, the ultimately goal being the accumulation of experience for future market-oriented promotion and laying institutional and technical foundations. However, incentive mechanisms and guidance measures for downstream demand entities such as airlines, logistics companies, or cargo owners, have not yet been established. **The demand side remains in a period of "policy observation".**

Internationally available references include the European Union's ReFuelEU Aviation Regulations, which mandate that from 2025, aviation fuel suppliers must blend at least 2% SAF into the fuel provided at airports within the EU, increasing to 6% by 2030 and 70% by 2050 [12]. Although this regulation places demands directly on fuel suppliers, it also ensures predictable SAF availability for airlines, creating a relatively stable demand foundation. Simultaneously, the EU Emissions Trading System (EU ETS) also introduced additional support mechanisms to encourage airlines to use SAF. In September 2025, the European Commission officially approved the allocation of approximately 100 million euros in free carbon emission allowances to 53 airlines using SAF [13]. **Overall, Europe's combination of mandatory and incentive policies helps establish stable market expectations and enhances industry investment confidence in the early stages of SAF development.**

Compared to Europe, China's policy framework still primarily focuses on macro-level planning and technological validation, which places it in a transitional phase between "direction-setting" and "mechanism refinement." Currently, there is no dedicated policy or economic incentive system targeting the demand side for SAF, resulting in a lack of stable incentive signals and long-term policy guarantees for demand-side stakeholders. This has led most enterprises to adopt a wait-and-see approach in investment decisions and long-term procurement.

5.2 Economic Hurdles: High Costs and Signal Challenges

Globally, the price of SAF is generally 2–5 times higher than that of conventional aviation fuel [14]. This premium reflects its significantly higher production and supply costs compared to fossil fuels. According to the International Air Transport Association (IATA), the cost of SAF is determined by multiple factors, ranging from feedstock acquisition, process pathways and equipment investment, overall yield (conversion efficiency) to fuel quality requirements, operational expenses, financial costs, and even logistics and certification. **The cost structure of SAF is also complex, with different combinations of feedstocks, technologies, production scales and other factors influencing its final cost.** In the most common Hydroprocessed Esters and Fatty Acids (HEFA) pathway, the feedstock alone faces limited supply and high prices. Furthermore, existing refining processes have not yet achieved economies of scale, resulting in higher unit production costs than fossil fuels. Coupled with additional costs from feedstock collection, logistics, transportation, and certification, the overall price remains elevated [14].

In terms of pricing mechanisms, there is currently no unified market pricing system for SAF. Based on IATA's summary and market practices, current SAF pricing practices primarily involve the following three methods [14]:

- **Benchmark Price + Premium:** A SAF premium is added on top of the traditional jet fuel price index to cover the additional costs and risks associated with SAF, typically with the supplier bearing risks associated with feedstock prices and cost fluctuations, and the buyer assuming risks related to the market price volatility of conventional jet fuel.
- **Cost-Plus:** The supplier forms a quotation by adding a reasonable profit margin to all costs incurred in producing SAF. Under this model, buyers typically bear the risks associated with cost fluctuations, such as raw material prices, while suppliers can expect relatively stable profit margins.
- **Institutional Assessment:** During the early stages of marketization or periods of supply instability, some SAF transactions may be conducted as short-term or one-off purchases, with suppliers referencing market assessment prices published by price reporting agencies. These transactions offer high flexibility but typically come with elevated costs.

The high and opaque prices of SAF directly impact the willingness of demand-side companies to procure SAF. In internal budgeting and investment evaluations, such "premium expenditures" often fail to deliver substantial returns on investment. **While SAF significantly enhances environmental benefits, companies struggle to justify its economic rationale, making it difficult to build a strong business case for internal decision-making.** As a result, only a few companies are attempting procurement based on brand or strategic considerations, while the majority of buyers remain on the sidelines. This high cost and premium also create a "signal dilemma" between supply and demand: the demand side needs a stable and affordable supply from the supply side to facilitate long-term planning, while the supply side in turn needs clear procurement signals from the demand side to secure financing and expand production capacity. Essentially, both sides are waiting for the other to "make the first move," resulting in a lack of market certainty.

This dilemma is particularly pronounced in China, where the domestic SAF market is still in its early stages, which means that pricing mechanisms remain opaque and there is a lack of established public pricing information or unified standards. Most companies surveyed currently feel that SAF is overly expensive and the absence of clear policy guidance or incentives creates uncertainties in cost and risk sharing. **Overall, the market has yet to develop strong procurement momentum.**

5.3 Fuel Supplies: Preparation Still Ongoing

Even if market demand continues to increase in the future, raw materials and the supply chain system will remain one of the key factors restricting the large-scale adoption of China's SAF.

In terms of raw materials, SAF in China is still produced mainly using used cooking oil (UCO). As one of the world's largest sources of UCO, China has a significant advantage in raw material reserves, but also faces limited supply elasticity. With per capita edible oil consumption expected to peak around 2030, the overall output of UCO is expected to stabilize or even decline [15]. If other raw material pathways fail to achieve commercial breakthroughs, the supply bottleneck in UCO will become a key constraint and possibly affect SAF production levels and costs. Raw material scarcity would both further drive up production costs and may also limit domestic SAF production capacity and future expansion potential.

Regarding the supply chain system, while China has initiated pilot projects for SAF blending and refueling for designated hub airports and airlines, the overall supply chain remains locked in a stage of "localized experimentation" that has yet to be fully integrated. There is no commercially viable linkage mechanism between production, transportation, storage, blending, and refueling, meaning that **the bridge between "production" and "application" is yet ready**. This makes it challenging for potential buyers to make regular purchases, because while supply exists, implementation remains difficult. This has become one of the significant factors limiting the practical adoption of SAF.

5.4 Value Chain: Cognitive Disparities and Fragmented Actions

Currently, coordination and synergy among supply and demand stakeholders remain one of the most limiting factors for the promotion of SAF in China. Although some have shown a certain degree of interest and willingness, there are still disconnects in terms of awareness, communication, and collaboration.

On the theoretical level, demand-side entities generally exhibit moderate interest, but lack a strong willingness and clear pathways for implementation. Although some airlines, cargo owners, or logistics companies recognize the importance of decarbonization in aviation, they lack a systematic understanding of SAF's product attributes, accounting rules, certification mechanisms, and implementation pathways, making it difficult to incorporate SAF into corporate strategies or supply chain planning. For most enterprises, SAF remains perceived as a "conceptual" product rather than an actionable emissions reduction solution.

On the collaboration level, communication between supply and demand ends as well as intermediate links predominantly occur at the point-to-point level and there is a lack of a sustainable multi-party collaborative platform. Although airlines, fuel suppliers, LSPs, and cargo owners occasionally cooperate, such efforts are mostly confined to specific pilot projects or bilateral agreements, with no stable market communication mechanisms or standardized processes yet established. This fragmented landscape results in low transactional efficiency and slow information transmission, making it difficult to aggregate or validate potential demand, thereby further undermining the supply side's confidence in expanding production capacity.

In addition, **there is an urgent need in the industry for entities that can serve as "neutral coordinators" to integrate diverse demands, align standards, and facilitate the mutual recognition and sharing of information.** Experiences at the global level shows that such roles are often assumed by industry platforms, trade associations, or neutral institutions, which can play a crucial role in building trust and reducing uncertainty.

Currently in China, the understanding among companies varies when it comes to SAF-related emission reduction certifications, accounting methods, and verification and trading systems, reflecting the need for industry coordination and standard alignment. Research shows that companies commonly encountered multiple types of certification documents from diverse sources when procuring or declaring emissions reduction results, such as sustainable fuel certificates, SAF trading platform records, annual audit reports by LSPs, or third-party verification results. Due to the lack of unified standards and mutual recognition mechanisms, enterprises often struggle to assess the authenticity, applicability, and disclosure suitability of these certificates in practical situations. This not only increases compliance risks but also underscores the importance of establishing a unified industry communication and verification framework.

In summary, there are multiple structural challenges in the promotion of SAF in China. At the policy level, the transition from planning to implementation has resulted in a lack of long-term incentives for the demand side. Economically, high costs and unclear pricing mechanisms dampen buyer willingness. On the supply side, feedstock bottlenecks and inefficient supply chains constrain market enthusiasm. Meanwhile, insufficient awareness and lack of consensus at the coordination level prevent effective alignment between supply and demand.

However, from another perspective, these very challenges represent critical turning points for the growth of the SAF market. As experience gained through pilot programs increases, technological pathways diversify, and inter-industry communication mechanisms gradually develop, China's SAF ecosystem is poised to achieve synergistic breakthroughs in its transition from exploration to maturation.



6

6 Outlook & Suggestions



Although China's SAF market is gradually taking off, it remains largely stuck in a phase in which all players are accumulating experiences by exploring and verifying pathways. The challenges mentioned, including policy support, economic viability, feedstock availability, and related synergies—indicate expanded production capacity on the supply side and stronger demand signals and improving mechanisms on the demand side are needed in the promotion of SAF. Future priorities should focus on streamlining mechanisms, aggregating demand, lowering barriers to entry, and creating favorable conditions for early adopters.

6.1 Policy Support and Incentive Mechanisms to Drive Implementation by Pioneers

Currently, there is a lack of policy support and incentives targeting the demand side of SAF. To truly kickstart the market going forward, it is essential to shift the policy focus partially downstream and establish a more operational support system for end-users. The focus of policy incentives should transition from "general encouragement" to "targeted support," **concentrating limited resources on pioneering enterprises that already possess the capacity and capability to act.** Efforts should focus on areas such as **incentives for pilot programs, fiscal or tax benefits, and streamlined policy facilitation.** This would foster a willingness among companies looking at SAF to successfully transition from intention to adoption, reduce transactional and operational costs, and thereby establish a model for market initiation and speed up the creation of a positive cycle of development.

One possibility is the promotion of specialized pilot or demonstration projects that could be established to provide prioritized support including financial subsidies, tax incentives, or carbon credits to airlines, logistics service providers, or cargo owners that demonstrate both willingness and operational readiness to adopt sustainable fuels. This would help offset their initial economic burdens. Another is for policymakers to make procedures more convenient in terms of procurement and refueling, specifically by streamlining procedures and improving inter-departmental coordination to reduce administrative hurdles. Such measures would enable market participants to carry out procurement, certification, and refueling more efficiently.

By encouraging and supporting pioneers, we can not only promote the development of replicable and scalable cases, providing a basis for subsequent institutional improvements, but also establish stable signals through a "point-to-area" approach, guiding more enterprises to follow suit. This will accelerate the transition of the SAF market from the pilot phase to systematic development.

6.2 Innovative Market Mechanisms and Lower Adoption Thresholds

In the early stages of SAF adoption, factors such as limited physical refueling options, high costs, and supply-demand mismatches significantly raise the barriers to corporate involvement. Against this backdrop, market mechanisms such as the **book-and-claim model offer a more flexible and feasible solution for the initial adoption of SAF**. Such mechanisms help create a positive cycle of ‘demand aggregation → demand signal release → supply response’ in the early phases. If demand-side entities’ can participate in SAF practices despite the physical refueling restrictions, the earlier formation of observable and easily aggregated market demand will be formed, thus providing critical reference points for upstream capacity building, financing decisions, and medium-to-long-term planning.

Domestically, there has been a wide range of preliminary exploration in the registration, verification, and management of the environmental attributes of green fuels [16] [17]. These efforts have driven the development of methodological frameworks, process design, and data management. They have provided actionable pathways for demand-side participation in reducing emissions through the use of green fuels as well as valuable experiences in the creation of a localized verification and traceability system. Building on this foundation, future efforts may leverage policy guidance and support for pilot programs to encourage more market entities to participate in practical application across various scenarios, which will **help clarify feasibility boundaries and potential risks, continuously refine rule design through real-world practices and achieve a smooth transition from concept validation to large-scale application**.

As this mechanism gradually matures, a SAF book and claim system will be built based on existing domestic resources and practices, integrating China's unique regulatory systems, energy characteristics, and market structures, while drawing on mature domestic and international experiences. Meanwhile, standardized accounting methods, a traceable registration system, as well as a transparent and reliable market environment should be enhanced to contribute to the establishment of a clear and verifiable emissions reduction value chain.

In addition, several publications released by the Smart Freight Centre in recent years, including ‘SAF Insights – A Practical Guide for Freight and Aviation Stakeholders’ [9], ‘Voluntary Market-Based Measures Framework’ [11], ‘Market-Based Measures Specifications’ [18], and ‘Principles and Best Practices for Book and Claim Systems in Heavy Transport’ [19], **systematically address key issues related to the practical application of SAF**. These works provide explanations on accounting and reporting under book-and-claim mechanisms, as well as cross-sectoral recognition, offering valuable information for companies seeking to understand international mechanisms, explore localized pathways, and design verifiable transaction and reporting processes.

Overall, innovations in market mechanisms can stimulate proactive action by companies without relying on large-scale fiscal investment. More flexible trading mechanisms, clearer accounting rules, and more efficient registration systems would collectively reduce the institutional costs for companies looking to adopt SAF, facilitating a gradual shift from "policy-driven" to "market-driven" approaches and achieving sustainable commercial development.

6.3 Industry Consensus and Collaboration to Drive Joint Action

Current exploration on both the supply and demand sides of China's SAF market remains fragmented. While some airlines, cargo owners, logistics service providers, and fuel-related entities have initiated

pilot projects or demonstrated clear intention to participate in SAF development, constraints remain due to divergent understandings of application models, the value of reducing emissions, implementation boundaries, and insufficient cross-entity communication. This has hindered the formation of stable, sustained collaborative networks and the formation of a unified conceptual framework within the industry. Such fragmented exploration not only increases the barriers to mutual understanding and alignment among enterprises, it also weakens the ability of participants to advance synergy between demand signals and the overall market.

Against this backdrop, **cross-industry and cross-value-chain collaboration has become a critical foundation for scaling the application of SAF.** Firstly, continued industry dialogue and shared knowledge-building will gradually narrow the gaps in understanding between different stakeholders regarding the practical applications of SAF. Secondly, the consensus formed through communication and interaction among stakeholders will pave the way for alignment in key areas such as accounting standards, information disclosure, and attribute management. Through collaboration, fragmented individual practices can evolve into systematic collective action, significantly accelerating the market's learning curve. **This will not only speed up the adoption of SAF in China but also facilitate a shift from isolated exploration to coordinated advancement,** laying the groundwork for a more mature, transparent, and credible low-carbon aviation ecosystem.

The promotion of SAF is a critical step in driving the deep decarbonization transformation of the air transport industry. And while the Chinese market is still in the early stages of this transformation, it has demonstrated strong exploratory momentum and diverse innovative practices. In the future, as policy frameworks are gradually refined, mechanisms and standards become clearer, and industrial collaboration strengthens, the application of SAF is expected to progress from pilot demonstrations to large-scale development.

Smart Freight Center looks forward to collaborating with more industry partners to jointly promote the adoption and popularization of SAF in China. We aim to explore implementation pathways suited to local realities, accumulate replicable and scalable experiences, and contribute to the green transformation of the air transport sector in China and globally. Organizations and enterprises interested in these efforts are welcome to engage with us for further discussion, working together to advance the development and refinement of a low-carbon aviation ecosystem.

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