

## Model for an aviation climate club

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## 1 Abstract

The aviation industry faces the challenge of significantly reducing its net greenhouse gas emissions by 2050 in order to meet global climate goals. From today's perspective, this is only possible through the substantial use of sustainable aviation fuels (SAF) and, in the long term, the use of new technologies.

Despite technological advances and regulatory measures that have already been adopted, such as the ReFuelEU Aviation regulation of the European Union (EU), the available quantities of SAF remain insufficient. At the same time, the investment risks, production costs and market prices are high compared to those for fossil kerosene, leading to considerable financial challenges for the EU's aviation industry. As the ReFuelEU Aviation regulation only regulates blending quotas within the European Union, EU airlines with direct connections to destinations outside the EU are at a competitive disadvantage, particularly with respect to airlines from the Bosphorus and Gulf States.

These challenges can be overcome through coordinated collaboration between all states and stakeholders. One key factor in successfully overcoming these challenges is a suitable organisation that coordinates this collaboration and can adopt measures itself if necessary. One potential solution could be to establish an aviation climate club.

This study analyses and evaluates three model options for an international aviation climate club with a view to achieving carbon-neutral aviation through the use of alternative fuels by 2050. The three models are: 1) the broker model, 2) the management model and 3) the investment model. The results of this evaluation identify the management model as being the most suitable. The benefits of this model lie in the targeted procurement of SAF, the management of market ramp-up, protection against distortions of competition, and networking, research and development activities – and the model's feasibility is still assessed as being within an acceptable range.

## 2 Introduction

Air transport makes a key contribution to a globally networked economy and system of mobility, but it has a considerable impact on the climate. Indeed, global aviation is currently responsible for 2.5% of CO<sub>2</sub> emissions (IEA, 2024a) as well as other non-CO<sub>2</sub> effects. In the EU, greenhouse gas emissions from international and EU-wide air transport rose by 86% between 1990 and 2022 (Europäische Kommission, 2024a) due to considerable growth in passenger and freight volumes (Europäische Kommission, 2024b).

With the Paris Climate Accords, 195 states committed to limiting global warming to well below 2°C and, if possible, to 1.5°C relative to pre-industrial levels (United Nations, 2015). The necessary reduction in emissions from aviation within the EU is regulated by the EU Emissions Trading System (EU ETS), while the emissions from international aviation are covered by the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) of the International Civil Aviation Organization (ICAO) (Europäische Kommission, 2024c).

Given the need to reduce the climate impact, the challenge for European and global air transport is to identify sustainable solutions. One key component is the use of sustainable aviation fuels (SAF), which include not only fuels produced from biogenic raw materials in chemical processes (such as HEFA<sup>1</sup> SAF) but also synthetic aviation fuels – known as power-to-liquid SAF (PtL SAF).

To promote the market ramp-up of SAF in the EU, binding blending quotas are established in Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 “on ensuring a level playing field for sustainable air transport” (hereinafter “the ReFuelEU Aviation regulation”). Since 1 January 2025, aviation fuel suppliers have been required to ensure that the fuel made available at every airport in the EU contains a minimum share of 2% SAF. This share is set to rise to 70% in stages by 2050. In addition, subquotas apply to the use of PtL SAF from 2030 onwards.

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<sup>1</sup> Hydroprocessed esters and fatty acids (HEFA): conversion (hydrogenation and refinement) of esters and fatty acids, such as used cooking oil, into kerosene.

However, the establishment of binding quotas within the EU carries competitive risks for the European aviation market as well as the risk of simply relocating the CO<sub>2</sub> emissions. Due to the additional costs of SAF over fossil kerosene, airlines that have their main operations in the EU and operate flights internationally could suffer a competitive disadvantage relative to airlines that operate non-EU hubs. In addition, the effectiveness of a binding SAF quota in the EU for reducing global emissions could be undermined by additional emissions outside the EU. For example, this would happen if international airlines opted for longer flight routes in order to make intermediate stopovers at non-EU hubs. Despite longer flight routes and travel times, this could be economically beneficial because only the leg from an EU airport to the hub outside the EU would be subject to the SAF quota.

The global market introduction of SAF requires comprehensive investment in production infrastructure and technologies. Although an initial regulatory framework has been put in place, there are still some considerable challenges – especially the substantial price difference between fossil kerosene and SAF – when it comes to ensuring the availability of SAF in the future and establishing its use in air transport. For example, worldwide production of SAF ran to a million tonnes in 2024 and therefore corresponded to just 0.3% of global fuel production. Although this represents a doubling compared to the previous year, the quantity is significantly below the 1.5 million tonnes expected for 2024 (IATA, 2024a).

Promoting the market ramp-up of SAF therefore requires close collaboration between the countries that want to push forward with the ramp-up, as well as all stakeholders at all stages of the value chain, such as airlines, airports, aircraft manufacturers and producers of SAF.

One potential solution for a globally coordinated ramp-up of SAF could be to establish an aviation climate club based on the concept of the climate club popularised by William Nordhaus (2015), who describes climate clubs as voluntary associations of states that commit to ambitious climate protection measures. Through coordinated measures and incentives, an aviation climate club could promote collaboration between different stakeholders, create the prerequisites for fair competition in the aviation market and therefore accelerate the market penetration of SAF.

## Objectives of the study

The aim of this study is to analyse the extent to which an aviation climate club could contribute to the global establishment of SAF and how such a model could be designed in concrete terms.

The first part of the study (section 3) will establish the basis for the development of an aviation climate club. This section provides an overview of the European aviation market and the regulatory framework, as well as an analysis of the potential risks and distortions of competition in connection with the ReFuelEU Aviation regulation. In particular, the analyses take two studies published as part of InnoFuels as their starting point: “Obstacles and challenges to the market ramp-up of SAF” (InnoFuels, 2024a) and “Overview of relevant laws and industry standards for the market ramp-up of sustainable aviation fuels” (InnoFuels, 2024b). Four interviews were also conducted in the period from 26 September to 18 October 2024: two with representatives of network airlines and one each with a low-cost airline and a freight airline.

In the second part of the study (section 4), a model for an aviation climate club is developed and evaluated. The theoretical basis is provided by the climate club model developed by William Nordhaus (2015) as well as the “Frankfurt model” designed by CENA Hessen (CENA Hessen, 2021).

## 3 Analysis of risks and competitive disadvantages associated with the compulsory use of SAF in the EU

### 3.1 Aviation market in Europe

The compulsory use of SAF in the EU as a result of the ReFuelEU Aviation regulation (Amtsblatt der Europäischen Union, 2023a) carries risks for certain stakeholders in the EU aviation market and could change the market structure in the long term. Due to the binding SAF quotas, fuel costs rise for airlines on routes departing from or arriving at an EU airport.

The EU aviation market is a complex and multilayered system encompassing various different stakeholders and segments. From the late 1980s onwards, the previously isolated national aviation markets have been gradually consolidated into a competitive EU internal aviation market through a series of regulatory measures. From an EU perspective, aviation is considered the principal – and, to this day, only – mode of transport for which there is a fully integrated internal market (Europäisches Parlament, 2024).

There now follows an introduction to the aviation market, which distinguishes between the three clusters:

- network airlines
- low-cost carriers
- freight airlines

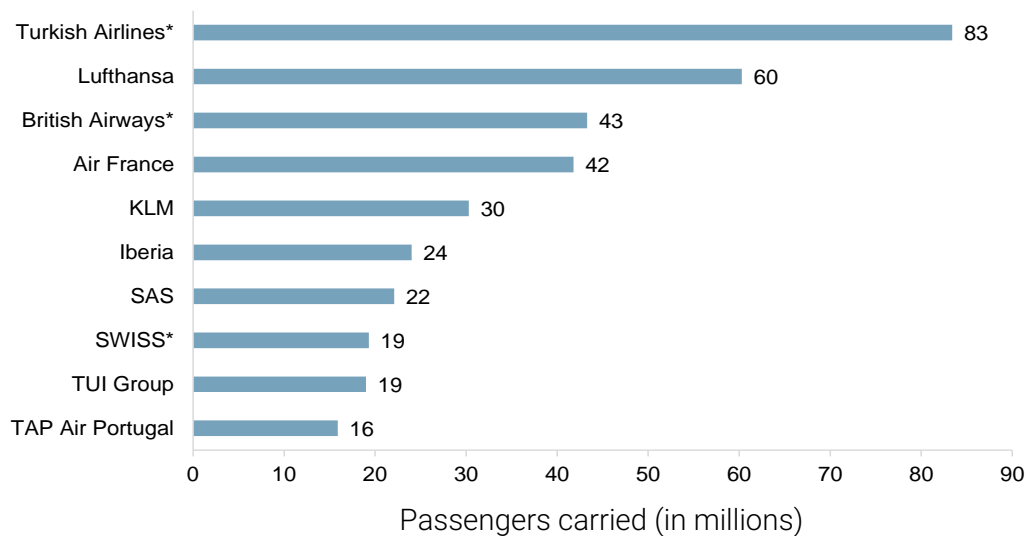
This division allows the particular challenges of each cluster to be analysed specifically with regard to the compulsory use of SAF. Among other things, the introduction provides an overview of the biggest airlines by turnover. It also explains the characteristics of each cluster, including the route patterns and hubs used. Lastly, it provides an outline of the market and competitive environment of each cluster.

#### 3.1.1 Network airlines

Network airlines are characterised by their comprehensive and complex route patterns, which encompass both short- and long-haul flights. These airlines operate one or more hubs, which act as central nodes for passenger and freight transport. Hubs are strategically important airports at which flights from various regions come together in order to relay passengers and freight efficiently. The “hub-and-spoke” system used by network airlines (in

which local airports, or “spokes”, offer flights to a central airport, or “hub”) allows extensive range and high flexibility, clearly distinguishing these operators from low-cost carriers, which rely on point-to-point connections. Examples of large airlines’ hubs in the EU include Frankfurt and Munich (Lufthansa, among others) or Paris-Charles de Gaulle and Amsterdam Schiphol (Air France–KLM, among others). These airports are some of the biggest and busiest in Europe (Europäische Kommission, 2024a).

Figure 1 shows the ten largest network airlines in Europe by passenger numbers in 2023 (CAPA, 2024).<sup>2</sup>



**Figure 1: Passenger numbers of the largest network airlines in Europe, 2023.**

**\* These airlines are not based in the EU but belong to Europe geographically.**

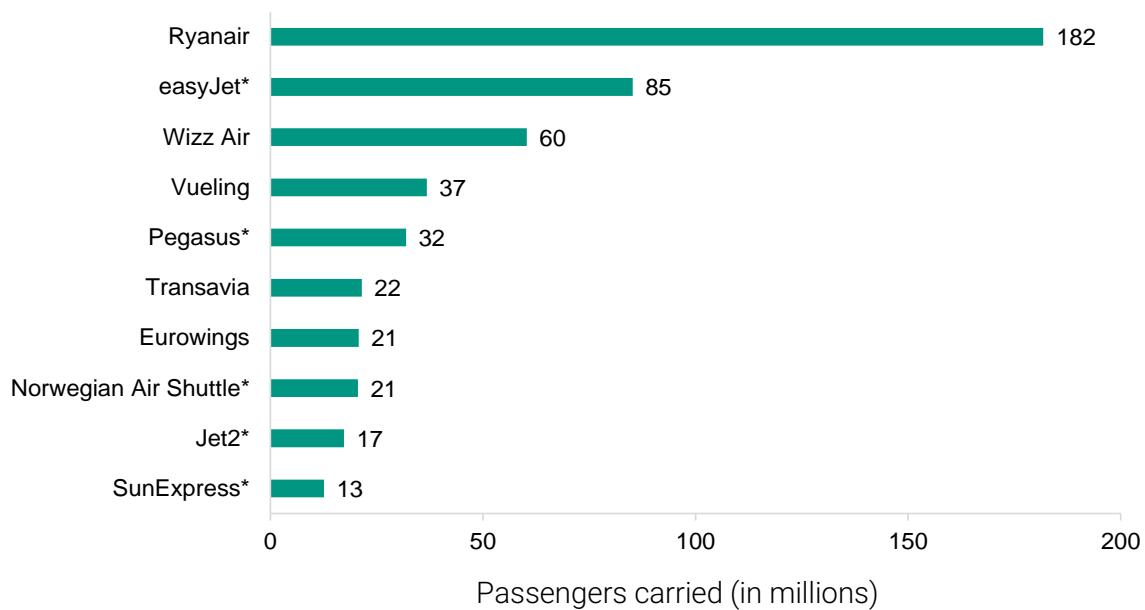
In 2023, Turkish Airlines, Lufthansa and British Airways carried the most passengers in this cluster. They have large fleets and are members of global alliances (for example, Star Alliance, SkyTeam, oneworld), which boost their range and market presence.

These airlines face an intense competitive environment, as they compete not only with one another but also with low-cost carriers. Network airlines generally offer a high service level (in other words, a “full-service concept”) and an extensive range of services and are therefore particularly attractive for intercontinental flights. At the same time, they are under pressure to reduce their operating costs without significantly compromising on service quality (Majerová, et al., 2023).

<sup>2</sup> Without considering Russian airlines, which no longer fly within EU territory due to EU sanctions.

### 3.1.2 Low-cost carriers

Low-cost carriers are characterised by the fact that they offer cheap flights and a large number of destinations. Their market share has grown considerably since the early 2000s, achieving a share of 32.5% in Europe in 2022 (Eurocontrol, 2022). Figure 2 shows the ten largest companies in Europe by passenger numbers in 2023 (CAPA, 2024).<sup>3</sup>



**Figure 2: Passenger numbers of the largest low-cost carriers in Europe, 2023**

\* These airlines are not based in the EU but belong to Europe geographically.

Based on data from 2023, Ryanair and easyJet are the largest companies by passenger numbers and have secured considerable market shares through targeted pricing strategies and extensive route patterns. EasyJet operates over 1,000 routes in more than 35 countries and uses its cost leadership and strategic network positions to offer cheap fares and operational efficiency on point-to-point connections (Aquisdata, 2024). Wizz Air and Vueling stand in third and fourth place in this cluster and are continually expanding their market share (Wizz Air Holdings PLC, 2023; IAG, 2023).

Airlines in this cluster often operate point-to-point connections instead of using complex hub systems, helping to keep operating costs low. Low-cost carriers generally use

<sup>3</sup> Without considering Russian airlines, which no longer fly within EU territory due to EU sanctions.

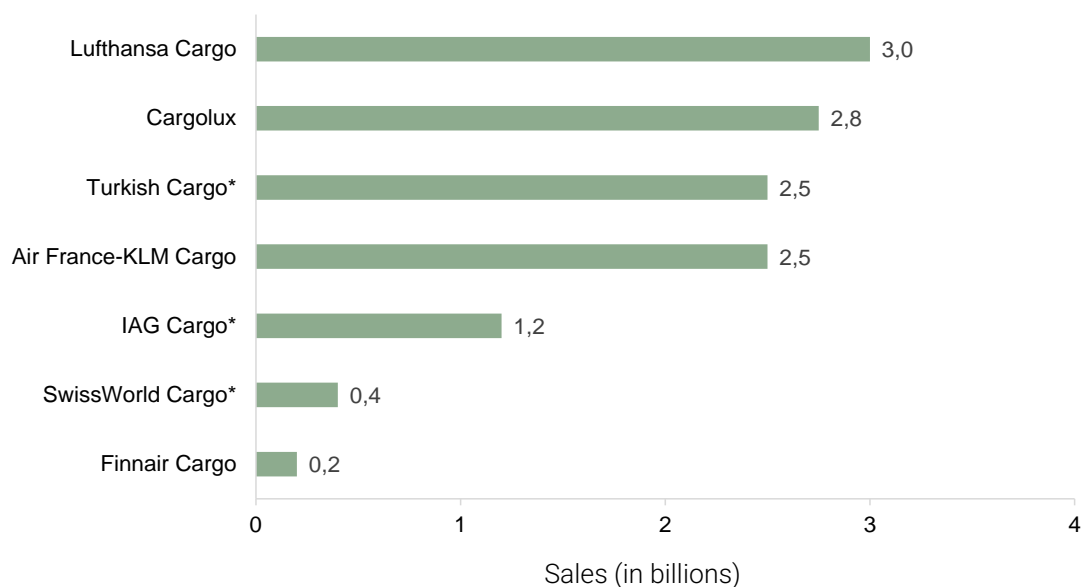
secondary airports<sup>4</sup> in order to minimise airport charges and maximise efficiency (Halm, 2006).

The competitive environment in this cluster is intense, as providers are competing for price-sensitive customers. The airlines pursue an approach of high load factors and short turnaround times (times between landing and departing again).

### 3.1.3 Freight airlines

Freight airlines are characterised by their specialised fleets and global networks and are often focused on specific routes and airports. In 2023, the global market share of European freight airlines was 21.8% (IATA, 2024b).

The turnover of the key participants in this sector (with the exception of integrated express carriers) is shown in Figure 3 (IBISWorld, 2024; Deloitte analyses).<sup>5</sup>



**Figure 3: Key participants in the European air freight sector based on IBISWorld (2024); turnover figures based on annual reports for 2023.**

**\* These airlines are not based in the EU but belong to Europe geographically.**

<sup>4</sup> Compared with primary airports (such as hubs in Frankfurt and London), secondary airports play a less central role in the air transport network. However, they are often characterised by high passenger volumes and are largely used by origin-and-destination traffic. Secondary airports often also benefit from an attractive catchment area (Mitusch, 2023).

<sup>5</sup> The list of key participants published by IBISWorld includes DHL Express. As this is an integrated express carrier, however, the company is not included in Figure 3.

Lufthansa Cargo and Cargolux are leading participants in this segment, with extensive fleets and global networks. These airlines operate large hubs that act as central transshipment points for freight. Examples include Frankfurt (Lufthansa Cargo, among others), Luxembourg (Cargolux, among others) and Istanbul (Turkish Cargo, among others). These hubs allow efficient connections between different continents and markets.

The competitive environment in this cluster is intense. Freight airlines compete with the available freight capacities of classical passenger airlines, where the freight is accommodated in the hold of the aircraft along with passenger luggage (“belly freight” or “belly cargo”).<sup>6,7</sup> In addition, freight airlines compete with significantly cheaper container forwarding by ship and/or railway.

Strategic alliances and partnerships help to exploit synergies and bolster the market position. One example is the partnership between Lufthansa Cargo and Cathay Pacific Cargo, which allows the use of shared freight capacity and resources. Collaborations of this kind allow companies to offer more-efficient connections between Europe and Asia.

A special role within the cluster is played by integrated express carriers, which operate their own freight airlines within the group. In addition to DHL, the key stakeholders in the European market include UPS (United Parcel Service) and FedEx (Federal Express). These companies use their own fleet for the fastest possible transport of parcels, letters and time- and temperature-critical special cargo (medical and life science products such as vaccines) over longer distances (DHL, 2024). As only these three integrated express carriers operate worldwide, the competitive environment is less intense (oligopoly). In this segment, key criteria include the speed and reliability of delivery, as well as compliance with other requirements (such as ensuring a constant temperature). The customers are therefore significantly less price-sensitive than those of freight airlines (Helmke, 2005).

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<sup>6</sup> One example is Condor, which commercialises available belly capacity through various providers (including ESC Group, cargo.one, CargoAi and WebCargo) (Condor, 2025). However, Condor does not operate a freight airline either itself or within the group.

<sup>7</sup> In some cases, freight airlines use and commercialise the belly capacity of passenger aircraft within the group and that of their partner companies (e.g. Cathay Pacific Cargo) (Lufthansa Cargo, 2024a).

## 3.2 Compulsory use of SAF: Regulatory framework

The use of SAF is currently seen as the greatest lever available to the aviation industry in order to contribute to achieving the Paris climate goals. To promote the market ramp-up of SAF, a series of regulatory measures have been introduced internationally. Norway was the first country with a binding blending quota. Since 2020, suppliers of aviation fuel in Norway have been obliged to ensure a minimum share of 0.5% biofuel (Norwegian Government, 2019). With the adoption of the ReFuelEU Aviation regulation in 2023, the EU was the first region in the world to establish binding blending quotas for SAF, which will rise until 2050. A series of other countries are planning or have already defined SAF blending quotas, including the United Kingdom (Legislation UK, 2024), Japan, Malaysia, Canada, Turkey and Indonesia (SkyNRG, 2024).

Below, we present the regulatory framework conditions at the global level, at the EU level and for Germany that should be taken into account when it comes to developing an aviation climate club. This analysis is based on the InnoFuels report “Overview of relevant laws and industry standards for the market ramp-up of sustainable aviation fuels” (InnoFuels, 2024b), which presents the regulatory framework in the aviation sector in detail.

### 3.2.1 Global

The climate ambitions of international aviation are defined by the ICAO, a specialized agency of the United Nations. The ICAO’s long-term goal is to achieve net zero emissions by 2050. In addition, the Third ICAO Conference on Aviation and Alternative Fuels (CAAF/3) committed to the goal of reducing CO<sub>2</sub> emissions by 5% by 2030, which is to be achieved through the use of sustainable and lower-carbon aviation fuels as well as other sustainable energy sources (ICAO, 2023a). The most important tool for reducing the sector’s global emissions is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

The International Air Transport Association (IATA), whose members are airlines, has also committed to causing no further net CO<sub>2</sub> emissions from 2050 onwards in order to support the Paris climate goals (IATA, 2023a). One key objective in the area of SAF is the promotion of harmonised transnational and cross-sector guidelines independently of the technology and of the fuel that is used (IATA, 2023b).

## *Carbon Offsetting and Reduction Scheme for International Aviation (CORSA)*

As a tool for achieving net carbon-free growth of international aviation, the ICAO Assembly approved the introduction of the market-based climate protection measure CORSIA in 2016. CORSIA is an offsetting system in which airlines are required to compensate for their increase in net CO<sub>2</sub> emissions. As of 2021, emissions that exceed the 2019 level must therefore be offset by purchasing a corresponding number of certificates, minus the reduction achieved through the use of sustainable fuels. For the period from 2024 to 2035, the reference value is reduced by 15%.

CORSIA was trialled in a pilot phase from 2021 to 2023. A total of 126 countries have voluntarily committed to participating in Phase 1 of implementation (2024 to 2026) (ICAO, 2023b). On commencement of Phase 2 (2027 to 2035), all ICAO member states are obliged to participate (ICAO, 2024a).

### 3.2.2 EU

Based on the EU's obligations under the Paris Agreement, the European Climate Law stipulates that, relative to 1990, EU-wide emissions are to be reduced by 55% by 2030 and that climate neutrality must be achieved by 2050 (Amtsblatt der Europäischen Union, 2021). To achieve this goal, aviation and other modes of transport must reduce their emissions by 90% by 2050 (Europäische Kommission, 2019).

In the EU, the compulsory use of SAF is governed by the ReFuelEU Aviation regulation, which was adopted as part of the Fit for 55 package. In addition, the Renewable Energy Directives, the EU Emissions Trading System (EU ETS), the planned revision of the Energy Taxation Directive, and potentially the EU Carbon Border Adjustment Mechanism (CBAM) are relevant to the market ramp-up of SAF. The key cornerstones of these mechanisms are outlined below.

#### 3.2.2.1 ReFuelEU Aviation regulation

The ReFuelEU Aviation regulation (Amtsblatt der Europäischen Union, 2023a) is a key element of the EU's Fit for 55 package in order to ensure that the aviation industry makes a significant contribution to the reduction of greenhouse gas emissions. The regulation, which was adopted on 18 October 2023 and entered into force on 1 January 2024, establishes SAF blending quotas, among other things. Options for complying with the quotas include synthetic aviation fuels (renewable fuels of non-biological origin, RFNBOs),

biofuels for aviation, and recycled carbon-containing aviation fuels. These fuels are subject to the criteria set out in the Renewable Energy Directive II (RED II) (Amtsblatt der Europäischen Union, 2024). For example, the use of synthetic fuels must result in a greenhouse gas saving of at least 70% relative to fossil kerosene.

One key part of the regulation are the blending quotas for SAF, which have stood at 2% since 1 January 2025 and will rise gradually to 70% by 1 January 2050. In addition, subquotas are also established for synthetic fuels (Amtsblatt der Europäischen Union, 2023a). As of 1 January 2025, aviation fuel suppliers must ensure that all aviation fuel made available at every airport in the EU has the minimum shares set out in Table 1. A flexibility mechanism that applies in the period from 2025 to 2034 allows fuel suppliers to fulfil the minimum shares through the weighted average of all fuels that they deliver to EU airports.

Year	2025	2030	2032	2035	2040	2045	2050
SAF	2%	6%	6%	20%	34%	42%	70%
PtL SAF	0%	1.2%	2%	5%	10%	15%	35%

**Table 1: SAF blending quotas and average subquotas for synthetic fuels in accordance with Article 4 Annex I of Regulation (EU) 2023/2405**

There is a general requirement for aircraft operators<sup>8</sup> to refuel before departure from a given EU airport (see preamble 28 of the ReFuelEU Aviation regulation) and, in doing so, to cover 90% of their annual fuel requirement for flights departing from that airport<sup>9</sup>. This is intended to avoid the risk of “tankering” – that is, the practice of taking on more than the required amount of fuel for a flight in order to entirely or partially avoid refuelling for the next leg at the destination.

<sup>8</sup> Art. 3 of Regulation (EU) 2023/2405 defines aircraft operators as “a person that operated at least 500 commercial passenger air transport flights, or 52 commercial all-cargo air transport flights departing from Union airports in the previous reporting period or, where it is not possible for that person to be identified, the owner of the aircraft” (Amtsblatt der Europäischen Union, 2023a).

<sup>9</sup> Preamble 28 defines the fuel requirement as follows (Amtsblatt der Europäischen Union, 2023a): “The amount of fuel uplifted prior to the departure from a given Union airport should be commensurate with the amount of fuel necessary to operate the flights departing from that airport. The requirement ensures that equal conditions apply to Union and foreign aircraft operators across the Union, while ensuring a high level of environmental protection.”

In order to enforce the blending quotas, the regulation provides for comprehensive reporting requirements as well as steep fines for non-compliance for fuel suppliers and aircraft operators as well as other stakeholders.

### 3.2.2.2 Renewable Energy Directive

The Renewable Energy Directive (RED) (Amtsblatt der Europäischen Union, 2023b) defines EU-wide goals for the use of renewable energies, including a subgoal for SAF in the transport sector. It also sets out the categories of fuels that are recognised as SAF in the EU within the framework of the ReFuelEU Aviation regulation and the corresponding sustainability criteria.

With the amended Renewable Energy Directive (RED III) that entered into force in November 2023, the binding EU target for the total share of renewable energies in the gross final consumption of energy in 2030 increases to at least 42.5% – with the aim of increasing this share by a further 2.5 percentage points. There is a general requirement for EU Member States to implement the new version of the Directive into national law by May 2025. For the transport sector, Member States can choose to define either a minimum share of 29% of final energy consumption or a greenhouse gas intensity reduction of at least 14.5%. There are also minimum shares of renewable fuels of 1% in 2025 and 5.5% in 2030, as well as a 1% subquota for synthetic fuels in 2030 (Rat der Europäischen Union, 2023). In order to calculate these minima, the share of advanced biofuels and RFNBOs in aviation and shipping are considered to be 1.2 and 1.5 times their energy content, respectively, in accordance with Article 27(2)(e).

The related Delegated Regulations (EU) 2023/1185 (Amtsblatt der Europäischen Union, 2023c) and (EU) 2023/11852 (Amtsblatt der Europäischen Union, 2023d) establish the methodology for determining greenhouse gas savings and requirements for the production of synthetic fuels in the transport sector.

It is important to note that compliance with the quota in the general transport sector cannot be used to meet the quota in air transport. The ReFuelEU Aviation regulation must be complied with independently.

### 3.2.2.3 European Emissions Trading System (EU ETS)

The EU ETS (Europäische Union, 2024) was established in 2005 as a central tool for the implementation of climate protection goals in the EU. Sectors that fall under the EU ETS

must acquire certificates to offset their greenhouse gas emissions. The quantity of certificates issued is gradually reduced in order to achieve the EU's climate goals ("cap-and-trade system").

Since 2012, air transport has fallen under the EU ETS, which applies to all flights that take off and land within the European Economic Area (EEA) (EU27, Iceland, Liechtenstein and Norway) as well as flights to the United Kingdom and Switzerland. Airlines must offset the CO<sub>2</sub> emissions caused by these flights with emissions certificates, which are currently either issued for free or auctioned. However, the free issuing will be phased out by 2026. Whereas most of the certificates were issued for free until 2023, the number of these certificates was reduced by 25% in 2024 and 50% in 2025. In principle, no further emissions certificates will be issued for free from 1 January 2026. There is, however, an exception for a certain quantity of certificates that are issued for free to airlines provided they use SAF. For this, a total of 20 million certificates (Fuels Eligible for ETS Support FEETS or SAF Allowances) are available in the period from 1 January 2024 to 31 December 2030. This is intended to reduce the price difference between fossil fuels and SAF or compensate for it altogether. Sustainable aviation fuels are also treated as having zero emissions in the EU ETS provided they meet the sustainability criteria set out in the Renewable Energy Directive. From 1 January 2025 onward, airlines have for the first time been required to report on non-CO<sub>2</sub> effects within the framework of the EU ETS (Europäische Kommission, 2025a). These effects are defined as "effects on the climate of the release, during fuel combustion, of oxides of nitrogen (NO<sub>x</sub>), soot particles, oxidised sulphur species, and effects from water vapour, including contrails" (Europäische Kommission, 2024d).

By 31 July 2026, the EU will review whether the ICAO is implementing the CORSIA program ambitiously enough to bring emissions in aviation down to net zero by 2050. If this is not the case, one possible measure under consideration by the European Commission is that, from 2027 onwards, the EU ETS be applied to flights from airports in EEA states to airports outside the EEA as well as to flights departing from airports outside the EEA but landing inside it. This scope of application was established in the original legislation but has repeatedly been overridden by temporary exceptions, as the EU supports the CORSIA program as a global tool for emissions reduction.

### 3.2.2.4 Energy Taxation Directive

The European Commission is planning an amended version of the Energy Taxation Directive that moves from volume-based taxation to taxation based on the energy content and CO<sub>2</sub> emissions of energy sources. The planned amendment of the directive is an important tool for reducing the current cost difference between SAF and fossil kerosene. Annex I to the draft Energy Taxation Directive (Europäische Kommission, 2021a) envisages taxing fossil kerosene at a rate of at least 10.75 EUR/GJ (0.37 EUR/l) and synthetic kerosene at 0.15 EUR/GJ (0.005 EUR/l). At the time of the completion of this study in late August 2025, the Council is still debating plans for an exemption for aviation (and shipping) from the amended version until 2035 and to then subject the sector to a renewed assessment (Rat der Europäischen Union, 2024). An agreement is expected in November/December 2025 at the earliest, at which point Denmark will hold the rotating presidency of the Council.

### 3.2.2.5 Carbon Border Adjustment Mechanism (CBAM)

As part of the Fit for 55 package, the EU is relying on two key measures for the decarbonisation of energy-intensive industries: the phasing out of free certificates under the EU ETS and the analogous introduction of a carbon price on imported goods (CBAM). The CBAM aims to avoid carbon leakage – that is, the relocation of production (and therefore CO<sub>2</sub> emissions) to countries without or with lower carbon prices (Amtsblatt der Europäischen Union, 2023e). The CBAM is intended to compensate for the competitive disadvantage faced by European companies due to the EU ETS.

The CBAM applies to imports of steel and iron, aluminium, cement, fertilisers, hydrogen and electricity into the EU. In 2026, importers will for the first time be required to offset the CO<sub>2</sub> emissions of their imports by purchasing CBAM certificates. The CBAM will be introduced gradually and will enter into force in full from 2034, coinciding with the end of the free issuing of EU ETS certificates.

Whereas the current version of the regulation limits the accounting scope for the CO<sub>2</sub> emissions of imported goods to the emissions from the production of the goods, including the generation of the power used for production, the Commission will present a report by mid-2025 evaluating the possibility of expanding this scope (Amtsblatt der Europäischen Union, 2023e). This encompasses emissions linked to the transport of CBAM goods, as well as the inclusion of transport services as an additional CBAM sector.

### 3.2.3 Germany

In light of the obligations under the Paris Agreement, the Federal Climate Action Act stipulates a gradual reduction of greenhouse gas emissions by 65% by 2030 and 88% by 2040, ultimately achieving climate neutrality in 2045 (Bundesministerium der Justiz, 2019). For the transport sector, which also includes domestic aviation, as well as for other sectors, Annex 2a additionally sets out annual maximum emission budgets for the period from 2020 to 2030. According to the annex, the greenhouse gas emissions of the transport sector must fall by 43% over that period.

The purpose of the Federal Immission Control Act (BImSchG) is to “protect human beings, animals and plants, soil, water, the atmosphere and the climate, as well as cultural objects and other material goods, against any harmful effects on the environment.” Among other things, the act implements the EU’s Renewable Energy Directive into national law (Bundesministerium der Justiz, 2024) (see section 3.2.2.2).

At present, section 37a(4a) – which regulates the obligations for distributors of fuels – is particularly relevant to aviation. This subsection states that distributors of jet fuel in Germany must ensure the prescribed minimum shares of fuels from renewable energies of non-biological origin. The withdrawal of the quota was agreed in the coalition agreement of April 2025 (CDU, CSU und SPD, 2025).

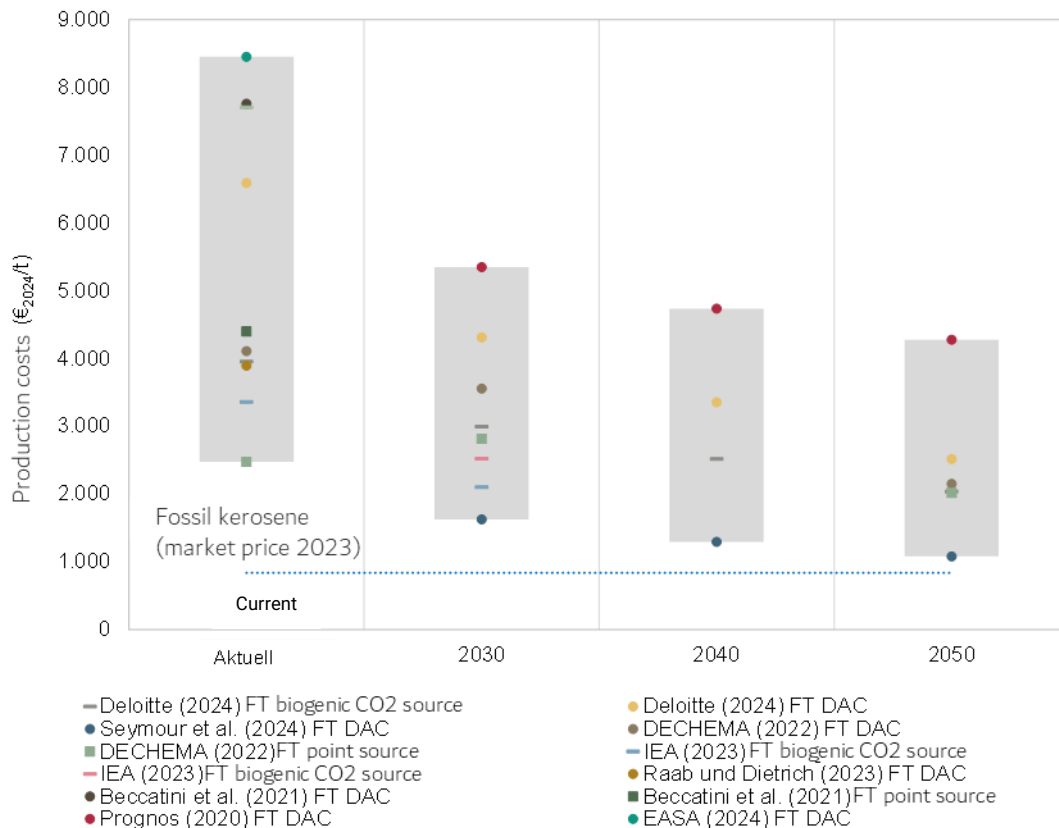
## 3.3 Risks due to compulsory use of SAF

### 3.3.1 General risks and market risks

#### 3.3.1.1 Market price risks

The market price risks include high price volatility as well as the significantly higher price level compared with fossil kerosene. Higher prices for sustainable aviation fuels result from the high energy demand and costs involved in production. The European Union Aviation Safety Agency (EASA, (2024), which is tasked with setting reference prices for fuels within the framework of the ReFuelEU Aviation regulation, estimates that the average price of HEFA SAF in the EU was around 340% of the price of fossil fuels in 2023. Given the limited availability of biogenic SAF, power-based sustainable aviation fuels (PtL SAF) are seen as vital to replacing fossil kerosene in the EU in the long term (Europäische Kommission, 2021b).

At present, PtL SAF is not yet produced on the industrial scale. Cost estimates for SAF vary considerably in the literature due to the underlying assumptions regarding economies of scale, electricity and CO<sub>2</sub> acquisition costs, and the costs and efficiencies of electrolysis and synthesis plants. The wide range in the estimates results from uncertainties regarding the future development of these influencing factors. For SAF produced by Fischer–Tropsch (FT) synthesis, it is forecast that costs in 2030 will reach between 2 and 4.5 times the average price of 825 EUR/t for Jet A-1 in 2023 (IATA, 2024c) (see Figure 4).



**Figure 4: Estimates of production costs of FT SAF<sup>10</sup>**

The range shown is based on a selection of studies into production costs with a focus on the production or availability of SAF in the EU. Sustainable aviation fuel produced with CO<sub>2</sub> from biogenic sources or carbon capture from point sources is generally cheaper than

<sup>10</sup> Sources: EASA (2024), Deloitte (2024), Seymour et al. (2024), IEA (2023), Raab and Dietrich (2023), DECHEMA (2022), Beccatini et al. (2021), Prognos (2020). Notes: The figures from the literature are adapted to the price level for 2024 for better comparability. A calorific value of 44 MJ/kg for SAF was used to convert the energy-based values (Official Journal of the EU 2023b). The estimates of current costs relate to production years between 2021 and 2023.

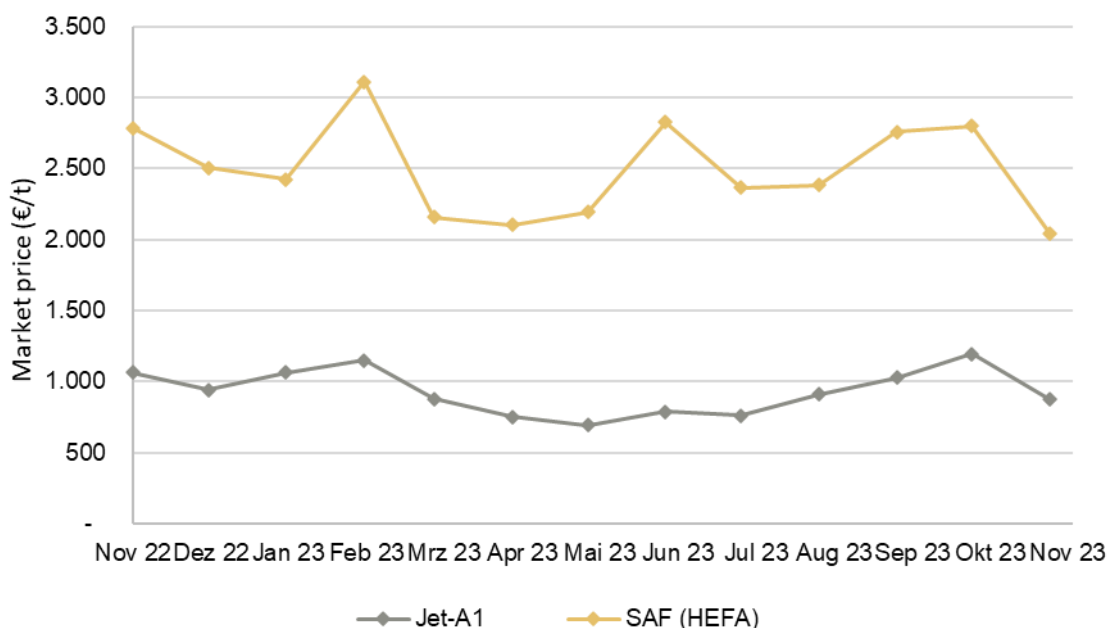
production with CO<sub>2</sub> from direct air capture (DAC). However, availability is limited – particularly in the case of biogenic sources.

The higher market prices for sustainable aviation fuels represent a considerable price and cost risk, particularly as fuel costs make up some 25–30% of total flight costs (IEA, 2024b).

Another risk for airlines is the greater volatility of prices that can be observed on the market, which can be attributed to the following causes (MarketsandMarkets, 2023):

- Availability and prices of source materials: HEFA SAF is largely produced from biogenic source materials (including used cooking oil). The availability of these source materials is limited, and its use also competes with other sectors – such as the production of biofuels for road transport.
- Limited production capacities: The production capacities of HEFA SAF are limited. PtL SAF is not yet produced on an industrial scale. Additional demand can only be met successively as production capacities increase.
- Low market volume: The volume of HEFA SAF available on the market is currently low, at 1.5 million tonnes in 2024 (IATA, 2024a). As yet, PtL SAF is only used in very small quantities and primarily for research purposes and is not produced on a large/industrial scale (Sharma, et al., 2021) (CENA Hessen, 2024a).

Figure 5 shows the greater volatility of SAF relative to fossil kerosene from November 2022 to November 2023 (Reuters, 2023).



**Figure 5: Market price volatility of fossil kerosene (Jet A-1) and SAF**

This high volatility represents an additional market price risk for airlines. Market price risks for Jet A-1 can be hedged via derivative financial instruments (swaps, options, collars)<sup>11</sup>. As the hedging instruments for SAF are not yet available on the market, the only means of hedging market price risks lies in long-term supply contracts for SAF (Koscâková, et al., 2022).

### *Results from interviews with experts*

In the view of the representatives of passenger airlines, the market price risks are very high (see Figure 6), as the additional costs of SAF compared with fossil kerosene are considerable and the fuel costs represent a significant cost factor. Moreover, the prices for SAF show considerable volatility, further complicating financial planning. There are considerable uncertainties in relation to future market prices due to low experimental values, as well as gaps in the regulatory framework. Two of the surveyed companies expect rising SAF prices in the short term as a result of increased demand due to quotas.

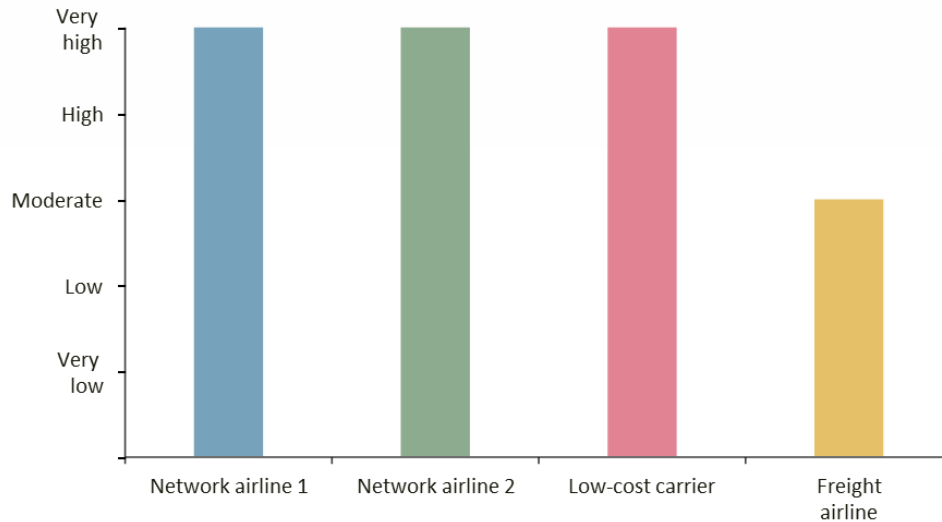
The interviewees from freight airlines classify market price risks as mid-range, as business customers in particular want sustainable express logistics solutions and their willingness to pay is therefore correspondingly higher. On the one hand, the desire for sustainable express logistics solutions stems from the requirement to reduce Scope 3 emissions<sup>12</sup> in compulsory sustainability reporting in accordance with the Corporate Sustainability Reporting Directive (CSRD). On the other hand, sustainable express logistics solutions are also increasingly in demand for marketing and image reasons.

Figure 6 shows the assessment of market price risks by experts from the surveyed airlines.

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<sup>11</sup> Derivatives are financial instrument whose value is derived from another asset, such as shares, indexes, raw materials or currencies. Their price depends on the price trend of the underlying asset, meaning that changes in the underlying asset also influence the price of the derivative. (Schäfer, 2011)

<sup>12</sup> Scope 3 emissions are indirect greenhouse gas emissions that are produced across a company's value chain, including emissions from purchased goods and services, business travel, transport and disposal (World Resources Institute; World Business Council for Sustainable Development, 2004).



**Figure 6: Interviewees' assessment of market price risks**

### 3.3.1.2 Regulatory risks

One key regulatory risk relates to the penalties imposed for non-compliance with the established blending quota under the ReFuelEU Aviation regulation. The EU Member States each establish the fines for non-compliance and are responsible for their enforcement. The amount of the fines is based on the minimum fines established in the ReFuelEU Aviation regulation (Amtsblatt der Europäischen Union, 2023a):

- Minimum fines for distributors: Twice the difference between the price of SAF and the price of Jet A-1, multiplied by the quantity of aviation fuel that exceeds the quota.
- EU airports: The structure of fines for airports is established individually by the EU Member States.
- Minimum fines for aircraft operators (airlines): Twice the annual average price of Jet A-1, multiplied by the refuelled quantity. This measure is intended to prevent the practice of tankering, as described in section 3.2.2.1.

The airlines face the additional risk that the penalties for distributors and airports could be passed on to them.

Another regulatory risk of SAF use relates to the eligibility of the source materials used for SAF. The EU directives (see section 3.2.2.2) define criteria that sustainable fuels must meet in order to be eligible for the SAF quotas. These criteria encompass the permitted raw

materials, the production methods and the achieved reduction in greenhouse gas emissions.

The ReFuelEU Aviation regulation includes an adjustment clause (Article 14) that provides for regular review and, if necessary, adjustment of the quotas for the use of SAF and the criteria for eligibility. Should the criteria for eligibility in the regulations change, quantities that have already been contracted may potentially no longer be eligible.

### Results from interviews with experts

From the point of view of the passenger airlines surveyed in the expert interviews, the regulatory risks are assessed as being very high (see Figure 7). One reason for this is the possibility of penalties being directly or indirectly imposed in the event of non-compliance with the quotas. Another reason is the complexity of the regulations and administrative requirements, which represent a particular challenge for smaller airlines.

The regulatory risk is evaluated as less severe by the freight airline, which classes it as a moderate risk. The fact that the regulatory framework is not yet definitively established and that there are differences in the existing rules (for example, ReFuelEU Aviation and CORSIA) is perceived as a significant risk.

Figure 7 shows the assessment by experts from the surveyed airlines.

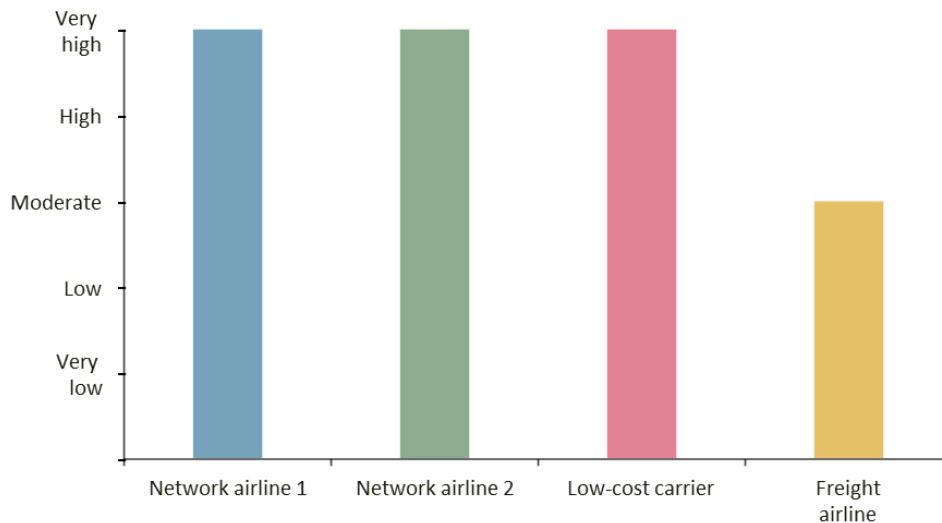


Figure 7: Interviewees' assessment of regulatory risks

### 3.3.1.3 Sustainability of SAF

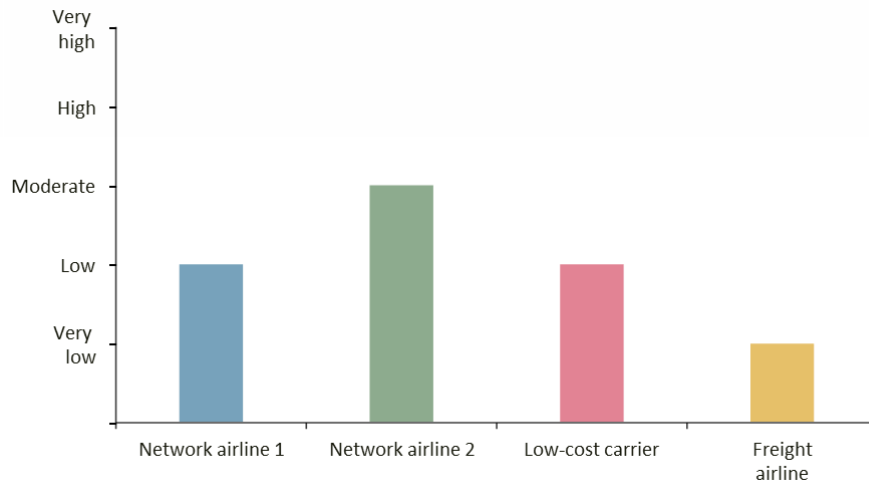
There is a risk that the production of SAF is not sustainable or that passengers do not perceive it as such. This is particularly the case when food and feed crops such as maize, cereals, rapeseed, or palm or soybean oil are used for the production of biogenic SAF (“first-generation biofuels”) (WWF Deutschland, 2020).

In the EU, the approved raw materials for the eligibility of SAF are regulated. In accordance with the Renewable Energy Directive, SAF can only come from specific, sustainable sources in order to be eligible (see overview in Appendix 1). Among other things, these raw materials include waste materials and residues that are listed in Part A of Annex IX to the directive (Amtsblatt der Europäischen Union, 2023b). The risk that food and feed crops such as maize, cereals, rapeseed, or palm or soybean oil are used in the production of biogenic SAF is therefore low.

#### *Results from interviews with experts*

The risks that SAF is not sustainable or not perceived as such by customers were assessed as very low to moderate by the experts (see Figure 8). In principle, image risks could arise in connection with the use of SAF in the future, as not all types of SAF are produced sustainably and factors such as the sustainability of raw material sources play an important role in public perception. It is therefore vital to continue focusing on the use of sustainably produced fuels, particularly through the exclusion of fuels based on palm oil. Through their own sustainability efforts, business customers are engaging with SAF and recognise its importance for the defossilisation of aviation.

Figure 8 shows the assessment of the experts from the surveyed airlines.



**Figure 8: Interviewees' assessment of sustainability risks**

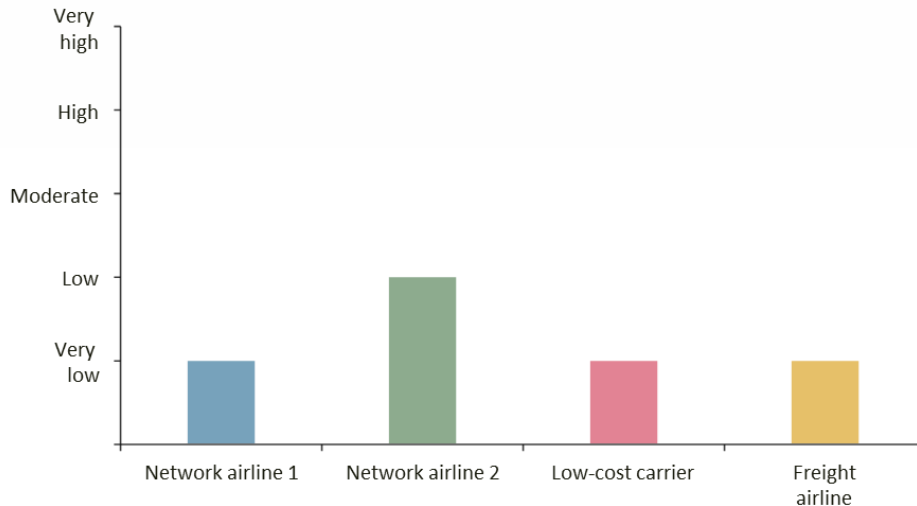
### 3.3.1.4 Technical risks

There are no technical risks if the permissible blending quota according to the American Society for Testing and Materials (ASTM) is not exceeded. A potential technical risk could, however, emerge if the permissible blending quota of SAF is exceeded – in other words, if an unauthorised fuel is used. As aromatic-free SAF has a different chemical composition from fossil Jet A-1 fuel, it is impossible to rule out long-term effects on seals, hoses and other materials made of plastic (Hamilton, et al., 2024). These effects could lead to premature material fatigue and increased maintenance requirements.

### Results from interviews with experts

In the view of the surveyed experts, only low to very low technical risks are associated with the compulsory use of SAF, provided that the permissible blending quotas are not exceeded. Overall, all approved types of SAF have undergone strict approval procedures, and no adverse effects have so far occurred from regular operation with SAF. From a technical perspective, SAF also offers the advantage that it burns better, meaning that the materials are subjected to less combustion residues.

Figure 9 shows the assessment of experts from the surveyed airlines.



**Figure 9: Interviewees' assessment of technical risks**

### 3.3.2 Business risks

#### 3.3.2.1 Financial risks

The key financial risk are the high prices of SAF compared to conventional Jet A-1 fuel. Here, it is important to note that fuel costs are one of the biggest cost items for airlines, making up around 25–30% of total operating expenses, and are several times higher than earnings before interest and taxes (EBIT).<sup>13</sup>

It can be assumed that only part of the additional fuel costs can be passed on to end customers. This share depends strongly on the price elasticity of demand. The higher the elasticity, the more strongly demand responds to price changes and the less scope there is to pass additional fuel costs on to customers.

#### Network airlines

Within the network airlines, the price elasticity of demand from customers varies strongly between business and private customers as well as between short-, medium- and long-haul flights. Business customers and (business and private) customers of long-haul flights react

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<sup>13</sup> For example, according to the Annual Report of the Lufthansa Group, expenditure on fuel for passenger airlines was approx. EUR 7,552 million. This corresponds to approx. 27% of total operating expenses, which run to approx. EUR 27,730 million. The (adjusted) EBIT of passenger airlines in the Lufthansa Group were approx. EUR 2,033 million in 2023 (Lufthansa Group, 2024b).

less strongly to increases in ticket prices (Gillen, et al., 2009). It can also be assumed that there is greater demand from business customers for more sustainable flights with a view to reducing their own Scope 3 emissions (see the results of the interviews with the freight airline in section 3.3.1.1). In some cases, specific CO<sub>2</sub> targets are already incorporated into corporate travel guidelines.

Overall, it can be assumed that only part of the additional fuel costs can be passed on to end customers, although a greater burden can be placed on business customers and customers of long-haul flights due to the low price elasticity of demand from such customers. The proportion of the additional fuel costs that cannot be passed on will have an adverse effect on EBIT and profit margin and therefore weaken the financial situation of network airlines.

### *Low-cost carriers*

Low-cost carriers operate in markets characterised by intense competition at the same time as high price elasticity of demand (Gillen, et al., 2009). Demand is therefore affected by even slight SAF-induced price increases. Unlike network airlines, low-cost carriers also transport significantly fewer business customers and no customers in first or business class, to whom at least part of the additional costs could be passed on.

The SAF-induced increases in price affect all low-cost carriers in the EU equally. Based on current knowledge, it is not possible to predict how exactly these additional costs will affect demand for flights and customers' travel behaviour in the overall market.

Overall, it can be assumed that only part of the additional fuel costs can be passed on to end customers, which will have an adverse effect on EBIT and profit margin and therefore weaken the financial situation of low-cost carriers. Particularly given the limited scope for passing the fuel costs on to end customers, the financial risk for low-cost carriers tends to be higher than for network airlines.

### *Freight airlines*

Within the freight airlines, price elasticity varies between dedicated cargo airlines and integrated express carriers. Overall, price elasticity in the airfreight business is lower than for network airlines and significantly lower than for low-cost carriers (Lo, et al., 2015; Chi, et al., 2012).

It can also be assumed that part of the additional fuel costs cannot be passed on to end customers and could therefore have an adverse effect on EBIT and profit margin and therefore on the financial situation, with integrated express carriers less affected than dedicated cargo airlines due to the lower price elasticity of demand.

### Results from interviews with experts

From the perspective of the surveyed experts, the financial risks due to the compulsory use of SAF are assessed as being very high. This is due to the already high market prices of SAF. With the introduction of the compulsory SAF quota from 2025 onwards, it is expected that the additional demand for SAF could lead to rising prices, putting additional pressure on the financial situation of airlines.

The experts from the passenger airlines assess the financial situation to be economically challenging with the rising blending quota from 2030, since only part of the additional costs can be passed on to customers. The assessment of the experts from the freight airline is slightly more optimistic, as the additional fuel costs can be passed on more readily due to a greater willingness to pay on the part of integrated express carrier customers. There is also greater demand for sustainable logistics solutions from this customer segment.

Figure 10 shows the assessment of experts from the surveyed airlines.

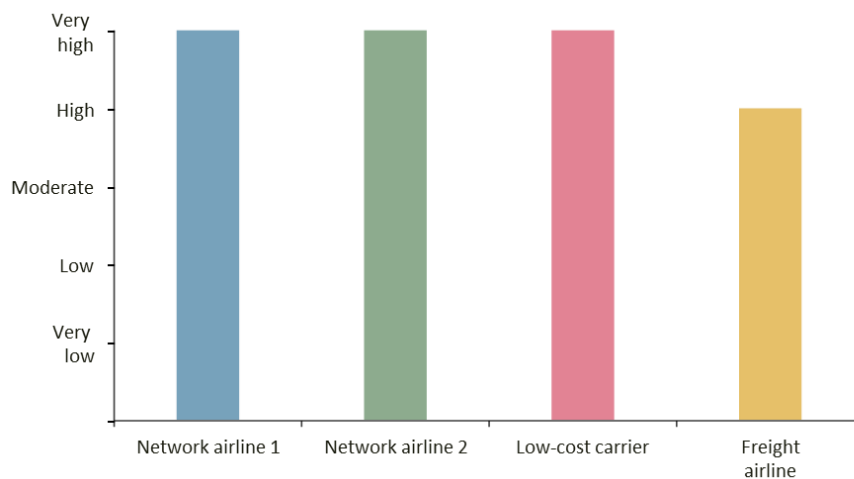


Figure 10: Interviewees' assessment of financial risks

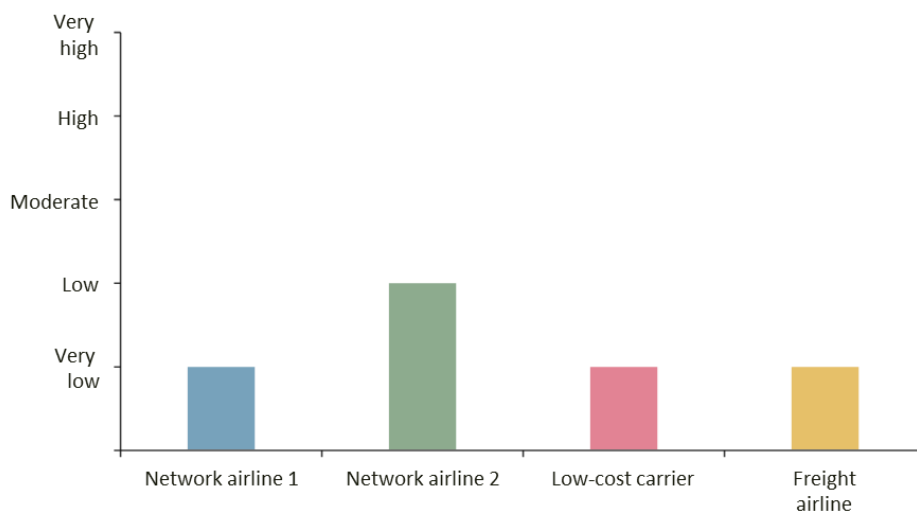
### 3.3.2.2 Operational risks

Operational risks are risks that could have a negative impact on the operations of airlines.

### Results from interviews with experts

From the point of view of airlines, operational risks due to the compulsory use of SAF are assessed as being low to very low. There are currently no plans for regulations requiring parallel or multiple refuelling infrastructures. Insofar as SAF is only used within the permissible blending quota, there is also no need to adjust the maintenance intervals or protocols. Moreover, in the airlines' practical operations, no abnormalities have been observed during maintenance. Overall, experiences with the use of SAF have been very good so far. No problems or limitations have been identified, although the quantities currently being used are still very low.

Figure 11 shows the assessment of experts from the surveyed airlines.



**Figure 11: Interviewees' assessment of operational risks**

## 3.4 Possible competitive disadvantages due to compulsory use of SAF

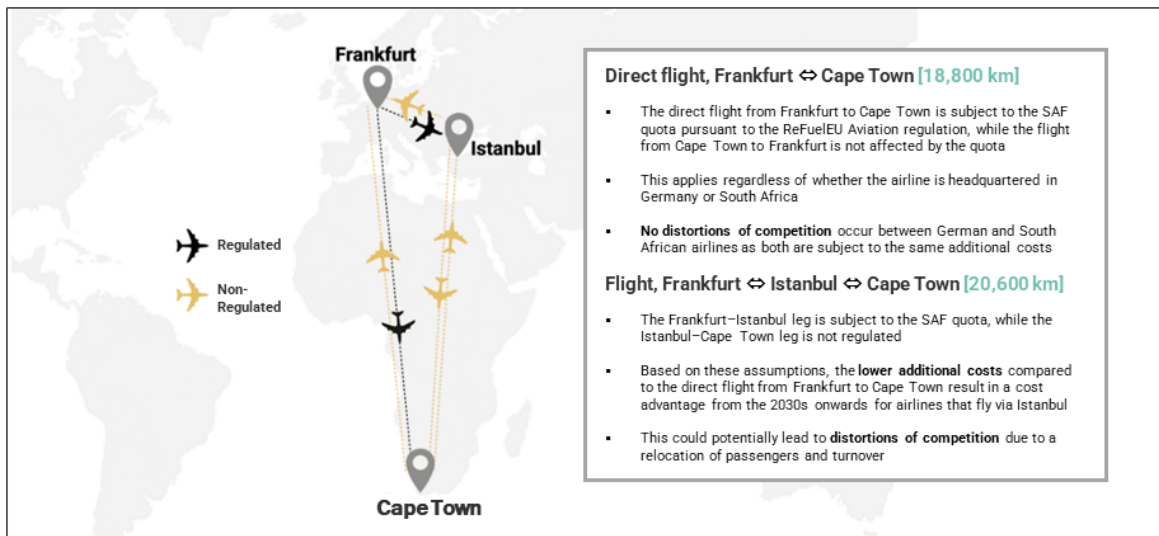
### 3.4.1 Potential distortions of competition

#### 3.4.1.1 Illustrative additional costs on selected routes

Distortions of competition arise when the market is influenced by unfair advantages or disadvantages of individual participants. This can be due to state interventions, monopolies, cartels or other factors that limit free competition. Distortions of this kind can lead to an inefficient allocation of resources, as they disrupt the market mechanism and

therefore prevent the optimum production and pricing of goods and services (Blanchard, et al., 2021).

The binding SAF blending quotas lead to additional costs for EU and non-EU airlines that take on fuel in EU Member States. The example below quantifies the potential costs that could arise for German, South African and Turkish airlines on connections between Frankfurt and Cape Town (FRA–CPT), both as a direct flight and via Istanbul (IST) (see Figure 12).<sup>14</sup>



**Figure 12: Selected flight routes for calculating illustrative additional costs due to the ReFuelEU Aviation regulation**

The calculation assumed that the PtL subquotas are met and the remaining share is covered by HEFA SAF. The cost assumptions for PtL SAF are based on estimates for fuel produced in Germany by direct carbon capture from the atmosphere (DAC) based on Deloitte (2024) – 3,600 EUR/t SAF in 2030, 2,800 EUR/t in 2040 and 2,100 EUR/t in 2050 – and relate to the production costs of the fuel. For HEFA SAF, the average market price in 2023 (2,844 EUR/t) (EASA, 2024) was taken as a base figure and kept constant until 2050. This assumption was made based on the projected costs for HEFA SAF within the framework of the impact assessment for the ReFuelEU Aviation regulation, which assumes almost constant prices (Europäische Kommission, 2021b). All figures are expressed in 2024 prices (i.e. without taking account of inflation).

<sup>14</sup> Lufthansa and Condor offer this connection as a direct flight and Turkish Airlines offers it via Istanbul. South African Airways cancelled this connection as a result of the COVID-19 pandemic and insolvency, but there are plans to begin operating it again.

For fossil kerosene, a tariff of 838 EUR/t is set based on the average price in 2023 (EASA, 2024), which is kept constant until 2050. According to the IEA (2024c), the oil price – the largest cost factor in the production of kerosene – will no longer exceed the 2023 level until 2050 in any of the modelled scenarios. Nevertheless, the kerosene price in the EU could increase in future due to stronger carbon pricing, as is intended as part of the proposed revision of the EU Energy Taxation Directive, as well as future changes to the design of the CBAM or EU ETS (see section 3.2.2). Based on the described assumptions and parameters, the additional costs would be as set out in Table 2.

	EU airlines		South African airlines		Turkish airlines	
	FRA-CPT	CPT-FRA	CPT-FRA	FRA-CPT	FRA-IST-CPT	CPT-IST-FRA
<b>ReFuelEU Aviation</b>	✓	X	X	✓	✓ (FRA-IST)	X
<b>Distance (km)</b>	9,400	9,400	9,400	9,400	10,300	10,300
<b>Fuel consumption (t)</b>	61	61	61	61	68	68
<b>Kerosene costs:</b>						
<b>2024: 100% Jet A-1</b>	51,000	51,000	51,000	51,000	57,000	57,000
<b>2030: 1.2% PtL, 4.8% HEFA SAF, 94% Jet A-1</b>	60,000	51,000	51,000	60,000	59,000	57,000
<b>2040: 10% PtL, 24% HEFA SAF, 66% Jet A-1</b>	96,000	51,000	51,000	96,000	66,000	57,000
<b>2050: 35% PtL, 35% HEFA SAF, 30% Jet A-1</b>	130,000	51,000	51,000	130,000	71,000	57,000

**Table 2: Case study to illustrate the additional costs due to ReFuelEU Aviation.**

Example calculation for selected flights due to admixture of PtL SAF (DAC) and HEFA SAF compared with kerosene costs in 2024. Sources: myclimate (2024) (flight kilometres); ICAO (2024b) (fuel consumption figures for a Boeing 787-9); Deloitte (2024) (production costs for PtL DAC 2030: 3,600 EUR/t SAF, 2040: 2,800 EUR/t, 2050: 2,100 EUR/t); EASA (2024) (price of fossil kerosene: 838 EUR/t; HEFA SAF: 2,844 EUR/t)

The additional costs for SAF set out in Table 2 would be lower depending on what share of the quota could be covered by PtL with CO<sub>2</sub> from point sources. Some countries outside the EU have planned or already implemented blending quotas that were not taken into account in this calculation. For example, Turkey is planning a quota of 1% in 2025 and 2026, which is set to rise to 5% SAF by 2030 (SkyNRG, 2024). It is also assumed that South Africa will not impose binding blending quotas.

Airlines based in Germany and South Africa are equally affected by the additional costs on the Frankfurt–Cape Town connection, so there would be no distortion of competition. With a stopover in Istanbul, however, the quantity of SAF that must be refuelled in accordance with the ReFuelEU Aviation regulation decreases. From the early 2030s onwards, despite the greater overall distance, there will therefore be a slight cost advantage for airlines that operate this route. This cost advantage could lead to the relocation of customers and turnover to this route combination (distortion of competition). As this does not reduce the CO<sub>2</sub> emissions but rather relocates them to countries outside the EU, it would also result in a carbon leakage effect.

#### 3.4.1.2 Potential competitive disadvantages by cluster

The potential competitive disadvantages due to the ReFuelEU Aviation regulation vary depending on the type, business activity and market environment of the respective companies. For airlines, disadvantages only arise if they compete with airlines that are less affected by the ReFuelEU Aviation regulation. The three clusters are therefore affected differently by the illustrative additional costs set out in Table 2, and this differing impact is explained below based on the findings from the market analysis in 3.1.

##### Network airlines

Given their numerous intercontinental connections and the difficulty of fully passing the additional costs on to end customers, network airlines are the worst affected by potential distortions of competition. As Figure 12 and Table 2 show, the regulation is particularly beneficial for airlines with hubs close to the EU's external borders, such as the Bosphorus and Gulf airlines (which are subject to no or lower SAF blending quotas). This cost advantage increases with the distance of the connection between the hub at the EU external border and the destination airport.

On the other hand, non-EU airlines that offer direct flights into the EU are just as affected by SAF quotas as EU airlines, because they must bear the additional costs due to SAF quotas on their return flights. This is analogous to the situation of EU airlines that offer flights to non-EU countries and are affected by SAF quotas on their outbound flights.

Due to the prohibition on tankering (see section 3.2.2.1) as part of the ReFuelEU Aviation regulation, these airlines are also unable to avoid the SAF quota on the return flight (for example, by carrying additional fuel on the outward flight or by making intermediate stops to refuel). On the other hand, no connections within the EU are affected by distortions of competition, as all airlines are equally impacted by the additional costs due to the compulsory SAF quotas.

### *Low-cost carriers*

The impact of distortions of competition is expected to be small for low-cost carriers, as these carriers primarily operate routes within the EU, and the cost burden due to the ReFuelEU Aviation regulation is therefore similar for all competitors.

The few destinations offered in non-EU countries are located relatively close to the external borders of the EU (including Egypt, Morocco and Tunisia), such that there are no or only very slight cost advantages to flight combinations via non-EU hubs. Annex 2 sets out an example calculation of the additional costs for the route Frankfurt–Hurghada (Egypt), which was carried out according to the same methodology as Table 2. Account must also be taken of the time and costs involved in the necessary additional take-off and landing procedures, as well as the airport fees, meaning that potential distortions of competition either do not occur in this cluster or are concentrated on a few routes (for example in the case of Eurowings, which operates flights to Oman) with only small disadvantages.

### *Freight airlines*

Cargo airlines are affected by potential additional costs in light of their route networks with numerous connections outside the EU and particularly on intercontinental connections. Regardless of whether they use their own cargo aircraft or the belly capacities of network airlines, the impact is comparable to that for network airlines, and readers are therefore referred to the remarks for network airlines (see above). However, it can be assumed that a greater share of the additional costs can be passed on to end customers than is the case for passenger airlines.

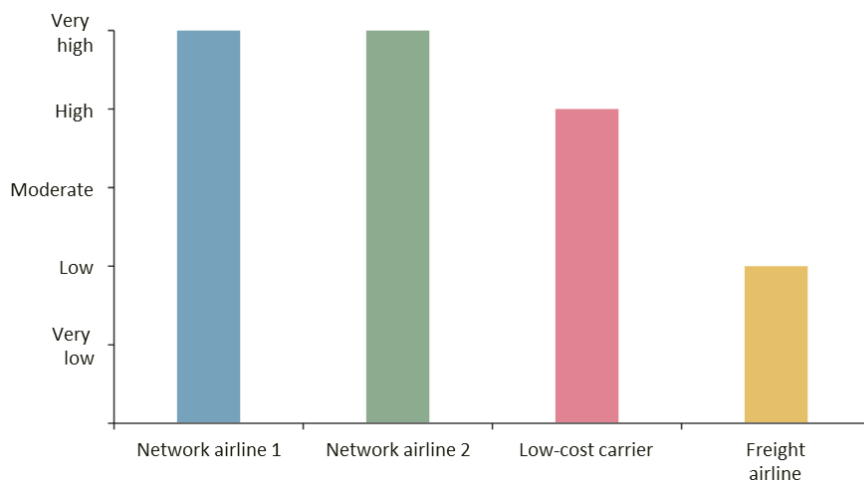
Integrated express carriers, on the other hand, are not or only slightly affected by distortions of competition, as there are no direct competitors with hubs close to the external borders of the EU. The competitors based in the United States (UPS, FedEx) face the same additional costs due to the SAF blending quota on transatlantic connections to the EU, such that there are no competitive disadvantages or distortions of competition.

### Results from interviews with experts

In the view of the surveyed experts, the ReFuelEU Aviation regulation could lead to considerable changes in the competitive environment. Particularly in the case of passenger airlines, the risk of distortions of competition and carbon leakage are classed as being high to very high.

One exception is the freight airline, which classified the risk of distortions of competition as being low, as there are no direct competitors with hubs in the vicinity of the EU’s external borders.

Figure 13 shows the assessment of the experts from the surveyed airlines:



**Figure 13: Interviewees’ assessment of potential distortions of competition**

### 3.4.2 Potential “free-riding”

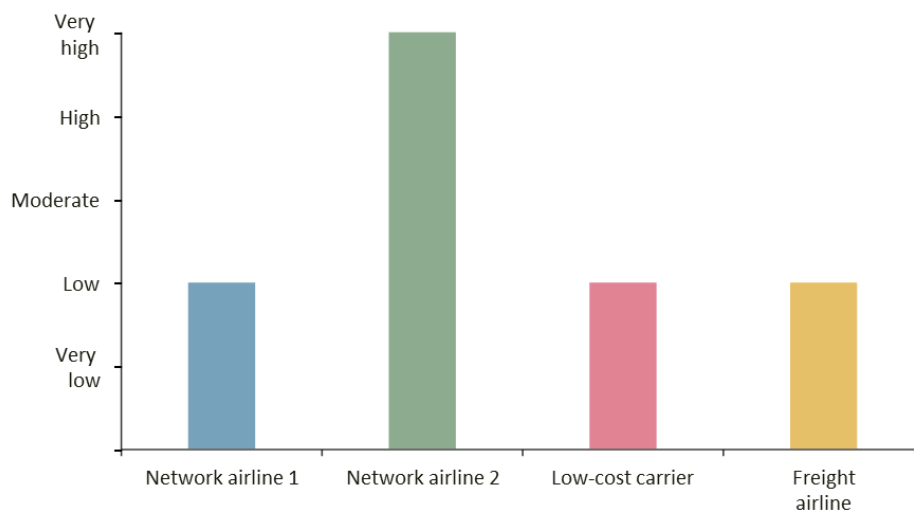
Airlines headquartered outside the EU could benefit from the ReFuelEU Aviation regulation without having to contribute to the costs. This “free-riding” by individual states with respect to measures aimed at tackling global climate change (Stahl, et al., 2017) – a well-known problem in international climate policy – can also occur with the companies of such states. As free-riders, these companies can profit from the stricter climate protection measures of

other states – in this case, from the reduction of CO<sub>2</sub> emissions from aviation due to the ReFuelEU Aviation regulation (Dodd, et al., 2021).

### Results from interviews with experts

The experts surveyed in the interviews gave very different assessments of the potential for free-riding. In this context, they were asked whether the ReFuelEU Aviation regulation leads to advantages for competitors from countries without or with very low SAF quotas without having to contribute themselves (such as a more sustainable image for aviation). The probability was assessed as being low by network airline 1 and by the low-cost carrier and the freight airline, whereas it was assessed as being very high by network airline 2. However, the assessment by network airline 2 also took account of potential competitive disadvantages – specifically the fact that international airlines with hubs outside Europe would benefit directly from low prices.

Figure 14 shows the assessment of the experts from the surveyed airlines.



**Figure 14: Interviewees’ assessment of potential free-riding**

## 3.5 Conclusion

The use of SAF plays a key role in the reduction of net CO<sub>2</sub> emissions from global aviation. However, the SAF industry remains in the early stages of development. Particularly in terms of the substantial price difference between fossil kerosene and SAF, there are considerable challenges when it comes to establishing a functioning market that not only ensures the future availability of SAF but also establishes its use in global aviation.

In the EU, the market introduction of SAF will be spurred on by binding quotas for distributors of fuels in the EU since 1 January 2025. The interviews carried out with representatives of EU airlines as part of this study clarified that the additional costs associated with the quotas represent a financial risk for the companies. Moreover, EU and non-EU airlines are not equally affected by the additional costs, resulting in a distortion of competition. The analysis of the market structure of the three analysed clusters of the European aviation market shows that network airlines potentially face the greatest risk of competitive disadvantages due to the SAF quota. These airlines compete on numerous intercontinental connections with non-EU airlines, which are less affected by the quota due to the use of hubs at the external borders of the EU, for example.

This distortion of competition also risks diminishing the effectiveness of the SAF quota when it comes to reducing (global) emissions. If the described distortion of competition were to provide non-EU airlines (with no or lower SAF quotas) with higher passenger demand at the expense of EU airlines, this would have the effect of diminishing the reduction in CO<sub>2</sub> emissions due to SAF use.

In addition, the market ramp-up of SAF is generally not promoted to a sufficient extent in regions outside the EU in order to ensure a global ramp-up of SAF. At present, similarly ambitious SAF quotas only exist in the United Kingdom. This lack of uniformity in climate protection ambitions in the aviation sector not only carries the risk of free-riding but also prevents the effective ramp-up of SAF at the global level.

These two principal problems – the potential distortion of competition at the expense of EU airlines, with the accompanying risk of carbon leakage, and the insufficient measures by other countries to promote the global ramp-up of SAF – represent central challenges. These challenges could be addressed by establishing a climate club for aviation.

## 4 Design of aviation climate club model

So far, the existing measures to promote the market ramp-up of SAF have failed to achieve the desired results. Despite technological advances and regulatory requirements, the quantities available on the market are limited.

The significant price difference between fossil kerosene and SAF is also hindering a faster SAF market ramp-up in Europe. In addition, the EU's SAF quota could lead to distortions of competition. There is therefore a need for new, innovative approaches in order to further reduce net CO<sub>2</sub> emissions and, at the same time, to promote the market ramp-up of SAF in the EU and globally.

### 4.1 Initial situation and competitive conditions

In order to promote the market ramp-up of SAF in the EU, the ReFuelEU Aviation regulation (Amtsblatt der Europäischen Union, 2023a) establishes Europe-wide, unified, binding blending quotas that are set to rise to 70% by 2050 – including, from 2030, binding subquotas for power-based PtL fuels. The EU-wide blending quotas and the associated additional costs present financial challenges for airlines as well as one-sided distortions of competition to the disadvantage of European airlines.

As a result of high investment costs, long investment cycles and uncertainties affecting demand and supply, there is also a risk that the quotas cannot be met from the supply side, particularly in the case of PtL SAF. For example, the final investment decision has not yet been made for any of the industrial-scale PtL production facilities that are planned in the EU (Europäische Kommission, 2025b). With a capacity of 2,500 tonnes of carbon-neutral fuel, the biggest PtL production facility so far was put into operation by the company INERATEC in June 2025 (INERATEC, 2025).

One approach to solving these challenges is an aviation climate club, which aims to minimise potential competitive disadvantages as well as market and business risks.

#### *Climate club according to the Nordhaus model*

Based on Nordhaus (2015), a climate club represents a voluntary association of states that commit to ambitious climate protection measures in order to drive a reduction in global emissions. The key goal is to solve the problem of free-riding, whereby some countries

benefit from global climate protection measures without making significant contributions themselves.

The climate club model according to Nordhaus is intended to solve this problem by providing incentives for members and sanctions for non-members. Members benefit from advantages such as trade facilitation, technological cooperation or financial incentives that make membership economically attractive. At the same time, trade measures (such as climate tariffs) motivate non-members to join the club and endorse its objectives. Based on economic theory, Nordhaus (2015) shows that a stable coalition of states with high emissions reductions can only be formed – and that free-riding can therefore only be effectively addressed – through sanctions.

For the successful implementation of the climate club model according to Nordhaus, the following requirements must be met:

1. Shared resources (public good): The common goal is climate stability – a global public good. Aviation makes a substantial contribution to global emissions, and a reduction in its footprint is beneficial to all.
2. Mutual benefit: The collaborative agreement is beneficial for all members.
3. Possibility of exclusion: Non-members can be excluded or sanctioned at relatively low cost to members.
4. Stable membership: The benefits are such that members are unlikely to leave.

### *A climate club for aviation: The Frankfurt model*

International aviation is particularly impacted by distortions of competition in the case of asymmetric climate measures, which lead to different additional costs between airlines. Against this backdrop, CENA Hessen, the Centre of Competence for Climate, Environment and Noise Protection in Aviation, has developed an initial outline of an aviation climate club (CENA Hessen, 2021). The “Frankfurt model” pursues three key objectives:

1. Carbon-neutral aviation in line with the Paris Agreement
2. Fair competitive conditions for all European airlines
3. Sustainability standards to promote SAF and low-emission technologies

The core elements of the Frankfurt model encompass a series of tools that address the specific challenges facing the aviation sector:

- joint procurement and use of SAF within the alliance with a view to scaling up production
- integration of the EU ETS for effective carbon pricing
- an international financing model that incorporates private investors in particular
- effective external protection through trade measures to avoid carbon leakage

### *A climate club as a solution*

Achieving the climate goals in aviation will rely on collaboration between the public and private sectors as well as international cooperation. An aviation climate club could play a key role in this – specifically when it comes to facilitating the SAF market ramp-up. The basic idea is the requirement that members use SAF. Through collaboration and the pooling of resources, the use of SAF becomes more economically attractive for member states, paving the way for a ramp-up. At the same time, a climate club could prevent distortions of competition by establishing uniform rules for all members. For example, airlines would not be incentivised to use hubs outside the EU in order to cut costs (carbon leakage). By joining forces, members of an aviation climate club can meet the challenges associated with the introduction of SAF more effectively by creating fair competitive conditions (CENA Hessen, 2024b).

The present study builds on these considerations and analyses three possible model options for an aviation climate club with regard to the vision, goals, organisation, business model and legal framework.

## 4.2 Development of three model options for an aviation climate club

The sections below develop and evaluate three model options for the establishment and organisation of an international aviation climate club. Work to develop and evaluate these three climate club model options took place in workshops with experts from InnoFuels.

Section 4.3 first sets out the key drivers that apply to all three climate club model options. According to this analysis, the order of the key drivers follows the logic that it is first necessary to define the vision, mission and objectives (Chandler, 1962). The next step is to develop the business and organisational model that is fundamentally suitable for achieving

the mission, vision and objectives. The space in which the climate club model options can be designed is defined by the legal framework.

Section 4.4 sets out the key differences between the three climate club model options. This begins with the derivation of a basic model, known as the “management model” (see section 4.4.3), from which two further model options with differing degrees of complexity are then derived: the “broker model” (see section 4.4.2) and the “investment model” (see section 4.4.4).

## 4.3 Unified drivers of the three climate club model options

### 4.3.1 Vision, mission and objectives

The overarching objective is derived from the goals of global climate protection – that is, to avoid emissions in the long term. This also results in the vision for the three climate club models: carbon-neutral aviation as a contribution to global climate protection. The derived mission is the achievement of carbon-neutral aviation by 2050 through the use of alternative fuels.

In order to implement the defined vision and mission, a series of goals were defined that apply to all model variants:

#### 1. Efficient and competitively neutral ramp-up of SAF

For European airlines, the planned admixture requirements represent a financial risk. On international connections, the European airlines also face competitive disadvantages. The climate club must therefore be designed so that EU airlines are not at a disadvantage when it comes to competing with non-EU airlines and so that the market ramp-up of SAF takes place as efficiently and cost-effectively as possible.

#### 2. Sustainable, strong and competitive aviation industry

The second shared goal of the model variants is linked to the first. With the market ramp-up of SAF, the aim is for the aviation industry to become more sustainable while also remaining strong and competitive.

#### 3. Self-financing

The transition to carbon-neutral aviation can only be financed jointly through significant contributions from all stakeholders in the value chain, including policymakers

#### 4. Open to all

The starting point for the climate club is the EU, and the aim is to facilitate and promote the entry of other states.

#### 5. Incorporation of all stakeholders

The plan is for all relevant stakeholders from the industry and value chain (e.g. airlines, airports, producers, distributors) to participate.

#### 6. Substitution of fossil fuels

The long-term goal is to replace the existing fossil fuels (kerosene) with sustainable aviation fuels.

#### 7. Availability and access to alternative fuels

The aim is to make sufficient SAF available within the club and provide all members with access. Biogenic fuels are currently only available to a limited extent, and power-based fuels are not yet available on the market on an industrial scale.

### 4.3.2 Business model

#### *Services to club members*

One key element of the climate club is the shared use of the airspace by its members. Countries that share the aims of the club also have the option of using the airspace. Countries that are not seeking to achieve carbon-neutral aviation therefore see their use of the airspace restricted. This sanction system aims to motivate non-members to join the club and serves to protect members from distortions of competition, free-riding and carbon leakage. Within the EU, there are existing structures that could be used by the climate club, such as the European Union Aviation Safety Agency (EASA).

Another key factor is access to sufficient SAF. Here, the club monitors compliance with sustainability criteria in order to ensure the fulfilment of its vision and mission. In this context, particular account must be taken of compliance with the established SAF quotas and any other self-commitments on the part of club members.

Another advantage for club members lies in the exchange of knowledge and experience within the organisation. Continuous efforts are also made to acquire new members with a view to strengthening the climate club and generating additional resources (membership fees) and expertise.

The climate club develops alternative financing instruments with the participation of private enterprise, such as carbon contracts for difference (CCfDs), in order to incentivise investment by producers while also reducing market and investment risks. The climate club also ensures implementation.

### *Revenue and expenditure*

All club variants have regular revenue from the club membership fees of member states in order to secure basic financing. In the case of international organisations (including the United Nations), it is customary for the payments to be annual (Deutsche Gesellschaft für die Vereinten Nationen e.V. , 2024).

Essential expenditure that is common to all three club variants comprises personnel expenses, including taxes and social security contributions, as well as the costs of office rental, IT equipment and services, other services (such as accounting, legal and tax advice, recruitment and marketing) and other expenses connected with the activities of the climate club (trade fairs, business travel).

### **4.3.3 Organisational model**

The organisational model encompasses several key functions that operationalise the business model.

### *Purchasing*

All club variants have a procurement function to a varying degree depending on the complexity of the model.

### *Legal and contract management*

The tasks of legal and contract management include the monitoring and administration of legal framework conditions and the administration of contracts. Monitoring is intended to ensure that all agreements meet the statutory requirements in order to ensure that legal risks are minimised.

### *Monitoring and sanctioning*

This function ensures the monitoring of compliance with the sustainability requirements developed in the climate club. If a non-member refuses to enter negotiations on the

reduction of CO<sub>2</sub> emissions in aviation, this could lead to the progressive imposition of sanctions. In this context, the most serious sanction would be restricting their access to the airspace.

### *International relations*

This function is responsible for the coordination and implementation of the necessary international cooperation, as well as the exchange of knowledge and experience in relation to best practices. The aim is to establish networks and partnerships with international organisations and institutions in order to exploit synergies and implement coordinated and, where necessary, harmonised standards and procedures.

### *Stakeholder management*

This function requires the incorporation and coordination of all relevant stakeholders in order to promote collaboration between different interest groups.

## 4.3.4 Legal framework

### 4.3.4.1 *Constitutional framework*

#### *Declaration of intent*

The institutional structure of a climate club in the aviation sector can begin with a joint declaration of intent by the interested states. This declaration serves as a political commitment to establishing coordinated, multilateral collaboration with a view to achieving carbon-neutral international aviation as a contribution to global climate protection and is the starting point for the establishment of binding structures and standards. One key subject of the declaration of intent is the founding of an international aviation climate club with the overarching goal of significantly and permanently reducing CO<sub>2</sub> emissions in international aviation through the targeted use of SAF. By doing so, the club seeks to achieve an efficient and competitively neutral market ramp-up of SAF that safeguards the international competitiveness of the aviation industry while also contributing to the substitution of fossil fuels.

The declaration of intent could also underline the aviation industry's commitment to its own responsibility for funding the transformation and emphasise the willingness to collaborate with all states and stakeholders throughout the value chain. Moreover, it could serve to formulate the objective of ensuring fair access to alternative fuels within the club and

achieving sufficient availability to ensure efficient and sustainable development of the aviation sector. Although the declaration of intent itself has no direct legal force, it highlights the political will to collaborate and establishes the normative and institutional foundation for the subsequent elaboration of binding agreements under international law.

### *Multilateral agreements as a starting point*

The legal framework of the aviation climate club should be based on a multilateral agreement between the interested states and future club members. This multilateral agreement creates a binding basis for cooperation and is based on established forms of international environmental law. A multilateral agreement is a treaty under international law that is adopted between multiple sovereign states with a view to establishing joint rules, procedures and institutions for a specific policy area. In the context of the climate club, the multilateral agreement could define the institutional, procedural and substantive basis for cooperation. It would specify which rights and duties the member states enter into, which standards are to be binding in the area of sustainable aviation, and how the decision-making processes within the club are structured.

At the same time, the agreement could perform several key functions. It could make political commitments binding, regulate responsibilities and procedures, establish a shared framework of standards – for example with regard to SAF quotas, the exchange of data, monitoring, and sanction mechanisms – and serve as a framework for future developments. In its role as a founding and governance instrument, the agreement could be based on precedents such as the United Nations Framework Convention on Climate Change (UNFCCC) or CORSIA, both of which are also based on multilateral agreements.

As a treaty between sovereign states, an agreement protects national legislative sovereignty while at the same time creating a legally binding foundation for the implementation of joint measures. For example, this is achieved by establishing uniform sustainability standards, commitments to meet reporting and verification requirements, and procedures for dispute resolution. Embedding the agreement in the international legal system creates legal certainty and strengthens the mutual obligations of member states. At the same time, an agreement provides instruments for the introduction of consultation procedures or dispute resolution mechanisms in the event of non-compliance and therefore for securing the integrity of the club in the long term.

## Founding agreements

As a supplement to the multilateral agreement, the contractual arrangement should regulate the founding modalities of the climate club. In particular, these include the establishment of the club's legal status as an international organisation, the choice of headquarters, the statutes and the articles of association.

The articles of association, which would act as a constitutive document, regulate the fundamental principles of collaboration, the rights and duties of members, the raising of capital and resources, and internal decision making. For example, similar agreements appear in the founding of the International Energy Agency (IEA) or the Global Green Growth Institute (GGGI) or in the form of the constitutional treaty of the World Trade Organization (WTO).

These documents define the structure, responsibilities and procedural rules of the club's principal bodies. Furthermore, by analogy to the statutes of international organisations, the founding agreements regulate the internal procedures for the admission of new members, the financing of the organisation, the adoption or modification of technical standards, and the introduction of sanction mechanisms for breaches of club rules.

One classic example of these institutional rules is the Chicago Convention of the International Civil Aviation Organization (ICAO, 1944), which not only determines the legal status of the organisation but also includes detailed specifications regarding the mandate, structure and decision-making pathways. Likewise, the design of the climate club's articles of association should also be aligned with that of comparable international founding instruments. One example here is the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT, 2000), whose convention defines not only technical objectives but also explicit institutional structures, financing mechanisms and participation formats.

The process of acquiring institutional and legal independence would create an independent body with authority to act that would secure the realisation of the club's objectives in the long term. Here, the articles of association act not only as statutes in the classical sense but also as an integration instrument that would provide club members with a transparent, legally binding and, at the same time, flexible platform for jointly shaping their sectoral climate policy.

#### 4.3.4.2 *Internal rules*

##### *Membership agreements*

Admission to the aviation climate club should be via membership agreements that are to be ratified individually. In addition to the recognition of the multilateral agreement, these agreements would include specific obligations that a member state enters into on admission. Depending on the design of the climate club model, these obligations include, for example, the national implementation of agreed SAF blending quotas, the introduction of transparent reporting and certification systems, or participation in joint research and development activities. Furthermore, the membership agreements regulate questions of contribution payments, institutional representation within the club bodies, or dispute resolution. This agreement structure allows account to be taken of member states' different starting conditions while also establishing uniform, measurable standards within the club. It therefore serves to operationalise the multilateral agreement and ensures a binding and legally secure framework for cooperation.

##### 4.3.4.3 *External agreements*

##### *Protection against distortions of competition, free-riding, sanction mechanisms and compliance with aviation law*

One key objective of the legal framework is to safeguard the climate club against distortions of competition and free-riding. Analogously to the Nordhaus model, the aviation climate club is explicitly intended to create incentives to join the climate club while also developing mechanisms that minimise the economic benefits of not participating. For example, this includes access to exclusive market platforms for SAF, access to preferred flight routes or infrastructure, and mutual recognition of sustainability certificates.

The legal design of exclusion mechanisms calls for a precise examination of their compatibility with existing requirements under aviation law, particularly within the framework of the Chicago Convention (Deutscher Bundestag, Wissenschaftliche Dienste, 2022) as well as the rules and regulations of the ICAO. To remain legally sound, measures for discriminating against non-members of the climate club must always be based on proportionate, transparent and objectively comprehensible criteria. In cases of doubt, the legal framework of the climate club therefore allows recourse to an independent arbitration procedure in order to examine the legality of such measures.

As the utmost consequence and most severe sanction for free-riders or members that do not adhere to the binding requirements of the club, the airspace could also be closed to the corresponding aircraft. This is comparable to established procedures in international aviation law. From a legal perspective, under Article 1 of the Chicago Convention, states have complete and exclusive sovereignty over their respective national airspace, which gives them the fundamental right to close it to aircraft of certain operators.

In addition, further measures can be adopted that are already provided for as sanctions within the framework of the ReFuelEU Aviation regulation. These include financial sanctions such as fines in the event of non-compliance with SAF quotas, operating restrictions in terms of access to airports or airspace, and public naming and shaming. These measures, which are monitored and, where applicable, implemented by the European Union Aviation Safety Agency (EASA), could also serve as effective instruments within the climate club in order to ensure compliance with the agreed standards.

It is important to emphasise, however, that these strict sanction mechanisms should always be seen as a last resort. The aviation climate club primarily seeks to achieve cooperative and incentive-based collaboration. But if these measures are ineffective or are deliberately circumvented, sanctions could represent a legitimate and legally sound way of preserving the club's integrity and effectively preventing free-riding.

### *Liability aspects*

Although the aviation climate club is primarily based on voluntary cooperation, the legal framework provides for limited regulation of liability issues. This relates in particular to responsibility for breaches of the climate club's rules. Liability regimes are enshrined in the membership agreements and are aligned with common principles of international environmental agreements. The aim is to establish trust in the club's integrity while also precisely defining the legal responsibility of members without unreasonably limiting their sovereignty.

## 4.4 Presentation of the three climate club model options

### 4.4.1 Overview

The three model options have identical definitions in terms of mission and vision (see section 4.3) but differ in their objectives, business models, organisational functions and legal framework. Table 3 provides an overview of the key features of the three models.

The **broker model** focuses on the brokerage of SAF and building up a member base without market intervention by the club itself. This means low expenditure but also limited scope for influence.

In contrast, the **management model** extends the degree of institutionalisation through active market interventions (including through the procurement of SAF) and offers members greater control but necessitates greater financial and organisational resources.

Lastly, the **investment model** pursues a transformative approach by relying on in-house production and investments to ensure long-term security of supply. This model is associated with considerable financing needs and the highest level of organisational complexity.

In the sections below, the three model options are presented in order of increasing complexity and degree of institutionalisation.

	Model option 1 Broker model	Model option 2 Management model	Model option 3 Investment model
<b>Vision</b>	Carbon-neutral aviation as a contribution to global climate protection		
<b>Mission</b>	Carbon-neutral aviation by 2050 through the use of alternative fuels		
<b>Objectives</b>	The aim is the <b>brokerage of SAF</b> . Here, the climate club acts as a broker of SAF.	The aim is to <b>secure sufficient availability of SAF</b> through <b>procurement and commercialisation</b> within the climate club.	The aim is to <b>ensure</b> long-term availability of SAF through <b>investment in SAF production facilities</b> and self-production.
	<i>Protection of competition as an additional overarching goal in all models</i>		
<b>Business model</b>	A <b>lean brokerage model</b> that focuses on <b>integration and the exchange of knowledge</b> . It barely intervenes in the SAF market and remains cost-effective but offers <b>little influence on SAF production</b> and supply.	<b>Active management model</b> that <b>intervenes directly in markets</b> , especially through the purchasing and commercialisation of SAF. It offers <b>greater security of supply</b> but is <b>more organisationally and financially complex</b> .	<b>Transformative model</b> with <b>direct participation in production and infrastructure</b> . It offers independence and <b>security of supply</b> but requires <b>substantial investments and is associated with business risk</b> .
<b>Organisational model</b>	Functional organisational model with <b>lean structure</b> and <b>primarily a coordinating role</b> with a focus on the <b>brokering function</b> and stakeholder management.	The functional basis is expanded by <b>agile working and project groups</b> as well as the integration of <b>innovation and sustainability management</b> .	Besides the purchasing and administrative functions, the organisation takes on responsibility for <b>investment, provision of venture capital</b> and <b>project implementation</b> .
<b>Legal framework</b>	<b>Limited agreements and legal obligations</b> ; <b>manageable reporting duties</b> and <b>liability conditions</b> .	<b>More detailed reporting duties</b> , <b>liability conditions</b> and stronger institutional anchoring. <b>Transfer of sovereign rights may be necessary</b> .	<b>More detailed reporting duties</b> , <b>liability conditions</b> and stronger institutional anchoring. <b>Transfer of sovereign rights may be necessary</b> . <b>Complex legal arrangements</b> to secure the investment and production structures.

Table 3: Comparative overview of model options for the aviation climate club

#### 4.4.2 Model option 1: Broker model

In the broker model, states join forces as an aviation climate club with the aim of meeting specific SAF quotas and, to that end, providing sufficient quantities of SAF for all club members via a club broker. Non-members only have access to the airspace if they also adhere to these rules or pay corresponding penalties. The use of traffic rights and other suitable rules as a sanction mechanism ensures that non-members cannot be better off than members. The broker model represents the leanest model of an aviation climate club in terms of structure and organisation.

The concept focuses on the brokerage of SAF and on building up a broad member base without the club actively intervening in the market itself or assuming responsibility for production or investment. Revenue comes primarily from membership fees and income from commissions. Members benefit from the provision of services, such as market integration, exchange of knowledge and core support functions. This model is lean and cost-effective but limited in its influence and business activities.

##### *Brokering of SAF*

At the core of the broker model is the brokerage of SAF, whereby the club pools demand for SAF from various airlines and negotiates prices for them (in their name and for their account). The club receives a commission for the successful conclusion of SAF supply contracts between airlines and producers. This represents an additional source of revenue to the membership fees.

This system allows members to procure SAF efficiently and reduces administrative effort. The situation would prove particularly beneficial for smaller airlines. The aim is to negotiate fair market prices with the producers of SAF (see 3.3.1.1).

The broker function could be realised in combination with existing brokering platforms, such as H2Global (H2Global Stiftung, 2025).

The brokering of SAF calls for an organisational unit with specialist personnel who are experienced in the procurement of SAF. In addition, there is a need for a legal- and contract-management function staffed by personnel with legal expertise. Additional financial resources must be made available in order to implement these two functions. The commissions should at least offset the additional staffing costs.

### 4.4.3 Model option 2: Management model

The key difference between the management model and the broker model is that, in this variant, the climate club actively intervenes in the market, procures sufficient SAF for its members, and then markets it to them. This model offers members greater added value and control but requires greater organisational and financial resources. The legal and institutional requirements are more extensive, requiring the clear establishment of rights and duties as well as the assumption of responsibility. This management model is of medium complexity and expands the role of the aviation climate club through active management and market intervention.

#### *Purchase and commercialisation of SAF*

One key aspect of the management model is that the climate club purchases SAF in its own name and for its own account. This implies that the climate club takes on the role of the distributor of SAF.

The key advantage of the procurement of SAF as opposed to mere brokerage is that the climate club has significantly greater negotiating power with respect to SAF producers and is therefore better placed to negotiate lower prices for SAF. The pooling of demand and the establishment of longer-term supply contracts allow the climate club to establish a longer-term offtake agreement for producers and thus to promote the expansion of SAF production. The club is required to procure at least the same quantity of SAF as is necessary for meeting the objectives and the self-defined quotas. In contrast to the broker model, the risk of failing to achieve the established objectives is therefore lower.

One key disadvantage of this variant lies in the substantial financing needs and the financial risks assumed by the climate club. These include:

- Default risks with respect to the customers and possibly also with respect to the SAF producers. These risks can be mitigated through corresponding risk surcharges or by adapting the modes of payment (for example, prepayment in the case of customers with poor creditworthiness).
- Offtake risks with regard to quantities acquired on the market. These risks can be reduced by corresponding contractual arrangements (such as offtake agreements).

- Market price risks, insofar as the date of purchase and date of offtake differ. These risks can be mitigated through corresponding hedges (for example, by means of derivative financial instruments such as swaps or options; see 3.3.1.1 Market price risks) or contractual arrangements (such as offtake at purchase price rather than market price).

Several possibilities exist for the delivery and financing of SAF:

1. Auctioning: the procured quantities of SAF could be auctioned off.
2. Levy: the procured quantities of SAF could be refinanced via a levy.
3. Financing from ETS certificates: the procured quantities of SAF could be refinanced via ETS certificates.

The procurement and commercialisation of SAF by the climate club gives rise to considerable financial expenditure and revenue streams, which necessitate financial controlling along with the management of receivables, liquidity and cash. For the financial controlling, purchasing and contract management, functions in the organisation are to be staffed with appropriately qualified personnel.

Procurement and commercialisation are carried out according to the book-and-claim process – that is, the club members do not physically buy SAF but can claim the associated emissions reductions.

In addition to the financial risks, there is also the risk that centralised procurement by the club could violate competition and antitrust law. However, this risk can be significantly mitigated through targeted legal and structural design of the joint purchasing model. Experiences from comparable sectors show that it is possible to implement not only cooperative association structures – as with the EDEKA model – but also centrally coordinated procurement departments with state involvement – as with Trading Hub Europe (THE) – successfully and in a legally sound manner.

These proven approaches to cooperation can be used to derive potential starting points for the further development of the climate club model in accordance with antitrust law. For example, the cooperatively organised EDEKA group (Edeka-Verbund, 2020) demonstrates that legally sound and yet pro-competitive cooperation can be facilitated between economically independent stakeholders through suitable governance structures, the avoidance of discriminatory practices and the centralised coordination of purchasing. In comparison, the state-coordinated model of THE (Bundesverbandes der Energie- und

Wasserwirtschaft, 2024) in the energy sector shows that centralised purchasing is possible even when various market actors are involved – provided there is clear regulation of roles, responsibilities and transparency requirements.

Applied to the aviation climate club, this means that its role as a central market actor should be further consolidated by designing its purchasing activities in a transparent, non-discriminatory manner. It is essential that there be a clear separation of information flows – particularly with regard to sensitive competitive data of the members – as well as a binding regulatory framework that defines internal governance, admission requirements and membership obligations. Analogously to the role of the state in THE, another option could be regulatory integration or protection by relevant competition authorities in order to create legal certainty for all participants and stabilise the model on a long-term basis.

The key thing is for the club to act as an independent market actor and that the exchange of competitively sensitive information between members be consistently ruled out. One centralised purchasing body – for example, in the form of a neutral coordinating unit within the club – could pool demand, issue calls for tenders and sign contracts without the airlines or airports being involved in direct negotiations. In addition, transparent conditions for participation, non-discriminatory access and clear earmarking would help to dispel concerns relating to antitrust law.

### *Financing instruments and further development of alternative fuels*

Another objective of the management model is the focused promotion of research and development in the field of alternative fuels. In a heterogeneous technological situation, as is the case with the production of SAF, centralised procurement can be a sensible approach. Auctioning can be used strategically, for example, to specifically further the technological development of production pathways. The development and implementation of alternative instruments for financing the transformation, such as carbon contracts for difference, aim to offset the higher costs of climate-friendly or climate-neutral production processes in comparison with conventional processes and products. This leads to a reduction in investment risks for the producers of SAF and to a reduction in the price difference between kerosene and SAF for the airlines, particularly in the first years of production.

Targeted research and development activities, as well as the development and implementation of alternative financing instruments, result in additional costs that must be offset by membership fees or a surcharge between SAF procurement and

commercialisation. The financial resources for the alternative financing instruments are provided by the club members.

Given the considerable complexity of the two topics, the recommendation in this model variant is to set up two additional organisational units, which are to be staffed with appropriately qualified personnel.

#### *Working and project groups*

Given that the management model is characterised by a sufficiently large organisation, it seems sensible to set up flexible and topic-specific working and project groups in addition to the rigid organisational units. The implementation of these flexible organisational elements allows a timely response to changing internal and external requirements.

#### *Compliance management*

One key aspect of the management approach lies in establishing sustainability criteria and monitoring measures aimed at complying with previously defined standards. Reinforced control mechanisms are implemented in this model variant in comparison with the broker model. The transfer (delegation) of sovereign rights is a key aspect that should be taken into account in the event of political feasibility. This includes the authority to sanction airlines that fail to meet the club's sustainability criteria or that do not agree to implement them, at least in the long term.

#### **4.4.4 Model option 3: Investment model**

The investment model is a transformative concept that aims to secure the availability of SAF in the long term through investments in SAF production facilities and, supporting this, the in-house SAF production. This model includes all characteristics of the management model and combines market management with direct participation in the value chain, paving the way for independence and security of supply. In addition to purchasing and management functions, the club makes investments, provides venture capital and implements complex projects. The model has significant transformative potential but is associated with high financial and business risks.

#### *Investments in SAF production facilities and projects*

One of this model's key objectives is to increase and secure the quantity of SAF available on the market through investments in SAF production facilities, so that all club members

have access to enough SAF to meet the established objectives and quotas. In this model, production does not replace but rather supplements the procurement of SAF.

Advantages of in-house production over procurement:

- **Avoidance of penalties:** In order to enforce blending quotas, the ReFuelEU Aviation regulation provides for stiff fines for fuel suppliers in the event of non-compliance. It can be assumed that fuel suppliers will pass these fines on to airlines.
- **Resilience:** In-house SAF production makes the aviation industry more resilient to international crises and price shocks. In addition, worldwide production of SAF is currently too low to meet rising demand from aviation. In-house production capacities ensure a more stable and independent supply of SAF.
- **Reinforcement of the aviation industry:** Given the high production costs, the prices of SAF are also very high (at least in the first years of production). These high prices are further aggravated by poor availability and high demand with a view to meeting quotas. Production within climate club member countries could bring down prices locally and at least partially relieve the burden on the aviation industry.
- **Job and value creation:** The construction of SAF production facilities is highly capital-intensive. As most of the value creation of building the required infrastructure takes place within the climate club, jobs are retained or created and value creation is secured.
- **CO<sub>2</sub> reduction thanks to regional supply chains:** Some of the emissions in aviation are caused not only by the flying itself but also by the complex global supply chains for fossil fuels. If SAF is produced in Germany and supplied directly to airports, there is no need for long transport routes by ship or HGV. This reduces the overall carbon footprint, thereby further contributing to emissions reduction.

The disadvantage of this model variant are the very high capital requirements and the high complexity. To compound matters, building and operating one's own SAF production facilities requires considerable specific expertise that is hard to come by on the market.

The planning, construction and operation of SAF production facilities result in significant financial expenditure that is not likely to be covered by current revenue. In particular, the investment costs (CapEx) must be at least partially financed by the club members. The operating costs (OpEx) for PtL SAF are also very high, such that financial participation may also be required from club members in this regard.

The planning, construction and operation of SAF production facilities requires a significantly larger organisation compared with the management model, involving several additional organisational units (including planning, project management, operation, financing) that must be staffed by appropriately qualified personnel. The size and complexity of the model have an impact on the service functions, which must be planned on a significantly larger scale in this variant. It is of paramount importance that the legal and contract management function be equipped with experts for highly complex procurement contracts.

### *Private equity and venture capital*

Another objective of the investment model is to provide access to venture capital for start-ups for the research and development of alternative fuels and drives. The funding of SAF production facilities by private equity investments could be considered as a possible supplement.

## 4.5 Evaluation of aviation climate club model options

The evaluation of the three aviation climate club model options and the selection of the most suitable model variant are based on the technique of cost-utility analysis (scoring method) (Thormälen, 1977), which is frequently used in practice. The benefits of this technique lie primarily in the easy traceability of the evaluation results and in the systematic approach to identifying relevant evaluation criteria and integrating them into the evaluation model.

As a starting point, the technique defines suitable evaluation criteria, which are used to evaluate the model options. These evaluation criteria are weighted according to the relative significance attributed with respect to the overall result. The total utility is then calculated based on the evaluation of the criteria, and the model with the highest total utility is the variant that is to be recommended.

Thormälen (Thormälen, 1977) points out that subjective influences can affect how the relative significance of the individual evaluation criteria is weighted and that the weighting should therefore be evaluated critically. Intrinsic subjectivity was reduced by analysing and discussing the definition and weighting of the evaluation criteria with a group of stakeholders comprising representatives from the areas of research, aviation and the public sector, as well as by subsequent joint evaluation of the criteria.

#### 4.5.1 Selection of evaluation criteria

The evaluation of the aviation climate club model options requires the establishment of clearly defined evaluation criteria. For the evaluation of the model options, the evaluation criteria described in the table below were selected:

Evaluation criterion	Description
<b>Degree of objective achievement</b>	The degree of objective achievement serves to evaluate how suitable the model options are for achieving the vision, mission and established objectives.
<b>Practical feasibility</b>	This criterion evaluates how quickly, easily and smoothly the models can be put into practice. The bigger and more complex the models, the harder and less likely their practical implementation. This includes the consideration of technical, economic and regulatory framework conditions.
<b>Protection of competition</b>	The protection of club members against distortions of competition and the prevention of free-riding are fundamental requirements for a successful aviation climate club. This criterion evaluates how suitable the variants are when it comes to protecting members against competitive disadvantages and free-riding.
<b>Financial strength</b>	A club's financial strength is reflected in how effectively it can finance itself. The more revenue sources are available and the more self-sufficiently these can be managed, the greater the financial strength. This can be achieved through membership fees, state funding or partnerships with the private sector.
<b>Strategic orientation towards SAF ramp-up</b>	This criterion evaluates how well suited the model options are to promoting SAF market ramp-up and new technologies. The greater the organisational and financial capabilities, the more likely the club is to be able to promote SAF market ramp-up and new technologies.

Evaluation criterion	Description
<b>Agility of the organisation</b>	Evaluating the agility of an organisation involves examining how flexible and adaptable it is when it comes to responding to new challenges and changes in its environment. A lean organisational structure with flexible teams is particularly well suited to the efficient management of ramp-up, financing and the protection of competition.
<b>Incorporation of stakeholders</b>	This criterion evaluates how suitable the model options are for actively incorporating all relevant stakeholders (including SAF producers, airlines, airports, aircraft manufacturers, politicians and financiers). This includes collaboration with governments, industry, business and civil society to ensure broad support for and acceptance of the measures.

**Table 4: Overview of evaluation criteria**

#### 4.5.2 Weighting of evaluation criteria

Each evaluation criterion was then assigned a weighting factor that defines its influence on the overall evaluation (see Table 5). The scaling of these weighting factors was such that the sum of the individual factors came to 100%. It could therefore be ensured that all criteria are adequately reflected in the overall result.

Evaluation criterion	Weighting factor
<b>1. Degree of objective achievement</b>	20%
<b>2. Practical feasibility</b>	20%
<b>3. Protection of competition</b>	20%
<b>4. Financial strength</b>	15%
<b>5. Strategic orientation towards SAF ramp-up</b>	10%
<b>6. Agility of the organisation</b>	10%

Evaluation criterion	Weighting factor
<b>7. Incorporation of stakeholders</b>	5%

**Table 5: Weighting of evaluation criteria**

A review was then carried out and the weighting was adjusted where necessary in order to ensure that the intended priorities and objectives of the analysis were reflected correctly. In accordance with the established criteria, priority was given to the aspects of “degree of objective achievement”, “feasibility” and “protection of competition” in the evaluation of the models. On the other hand, lower weighting was assigned to aspects such as the agility of the organisation or the incorporation of stakeholders.

### 4.5.3 Evaluation of results

In the next step, each model was evaluated using the established evaluation criteria and the designated weighting. Fulfilment of the respective requirements was then measured on a scale from 0 to 4. This evaluation scale runs from 0 (“not at all”) to 1 (“to a limited extent”), 2 (“partly”), 3 (“mostly”) and 4 (“completely”). The weighted evaluations were then added up to determine the total utility value for each model (see Table 6). This method allows objective comparison of the models and supports decision-making by setting out the strengths and weaknesses of each model in a transparent manner.

	Option 1		Option 2		Option 3	
	Broker model		Management model		Investment model	
Evaluation criteria	Evaluation	Partial utility value	Evaluation	Partial utility value	Evaluation	Partial utility value
1. Degree of objective achievement (20%)	1	0.2	3	0.6	4	0.8
2. Practical feasibility (20%)	3	0.6	2	0.4	1	0.2
3. Protection of competition (20%)	1	0.2	4	0.8	4	0.8
4. Financial strength (15%)	3	0.5	3	0.5	2	0.3
5. Strategic orientation towards SAF ramp-up (10%)	0	0	3	0.3	4	0.4
6. Agility of the organisation (10%)	3	0.3	2	0.2	2	0.2
7. Incorporation of stakeholders (5%)	3	0.2	4	0.2	4	0.2
<b>Total utility</b>		<b>2.0</b>		<b>3.0</b>		<b>2.9</b>

**Table 6: Overview of evaluations**

In the overall score as part of the cost-utility analysis, the management model achieved the highest overall utility of 3.0. The investment model also achieved an excellent and almost identical score of 2.9. The broker model, on the other hand, proved less suitable, with a total score of 2.0 once weighting was taken into account.

The next three sections include a detailed evaluation of the three models based on the seven evaluation criteria.

#### 4.5.4 Evaluation of results for broker model

The broker model is the least suitable model based on its low total utility of 2.0. With this model, there are considerable risks that the vision, mission and objectives cannot be implemented. Given that the model is limited to the brokerage of SAF, it seems doubtful that the SAF market ramp-up could succeed and that sufficient SAF would be available at every given moment to meet the climate club's objectives. Favourable aspects include easy practical implementation and low financial risk. The evaluations of the individual evaluation criteria are explained below:

##### **Degree of objective achievement: 1**

The model shows considerable weaknesses in terms of objective achievement. There is a considerable risk that the vision, mission and objectives cannot be achieved. The model neither envisages in-house SAF production nor incentivises production through purchasing. Moreover, this model is presumably unable to close the supply gaps. It therefore seems unlikely that this model will allow the SAF quotas to be met. Overall, it can be assumed that the model cannot fulfil the vision, mission or established objectives.

##### **Practical feasibility: 3**

The model has some strengths in terms of practical feasibility. Highlights include the low financing needs, the simple organisational and governance structure, and the low founding and development costs. There is no need for an intervention into the existing European institutions. Overall, it can be assumed that the cost of founding and developing the club is relatively low and that no significant obstacles are to be expected.

### **Protection of competition: 1**

There are significant weaknesses in terms of the protection of competition that the model affords. It offers few mechanisms for protecting club members against distortions of competition and free-riding. In this model variant, it is difficult to exclude non-members from the airspace. Overall, it can be assumed that the model provides relatively poor protection of competition.

### **Financial strength: 3**

There are some positive aspects in terms of financial strength. The model's strengths include its low and low-risk expenditure and its simple revenue structure. Overall, it is likely that self-financing could be secured; the risks in terms of long-term security of financing are relatively low.

### **Strategic orientation towards SAF ramp-up: 0**

This model does not provide for a strategic orientation towards SAF ramp-up or the promotion of new technologies. There is a lack of financial resources and instruments for promoting new technologies and managing the ramp-up of SAF.

### **Agility of the organisation: 3**

There are both strengths and weaknesses when it comes to the agility of the organisation. The lean organisational structure allows rapid adaptability, but the limited human resources mean there is little scope to assume new or additional tasks in the short or medium term. Overall, the model is agile thanks to its lean organisational structure and can respond more quickly to exogenous changes; additional new tasks cannot be assumed in the short term or can only be assumed by external resources.

### **Incorporation of stakeholders: 3**

The model's small size facilitates the incorporation of – and strong participation – by various stakeholders. However, given the model's streamlined orientation towards the brokerage of SAF, the group of stakeholders is more limited in comparison with alternative models (for example, venture capital providers are not represented).

## **4.5.5 Management model**

With a total utility of 3.0, the management model is the option with the highest score. Particularly in light of the various instruments for promoting SAF market ramp-up, one

advantage is the high degree to which the model is expected to achieve the objectives and protect competition. In comparison with the broker model, disadvantages include the greater financing needs and the associated greater financial risks – although the model is feasible in principle. The evaluations of the individual evaluation criteria are explained below:

### **Degree of objective achievement: 3**

The strengths of the management model relate in particular to the achievement of the mission, vision and objectives. This model offers more mechanisms and scope for action through joint purchasing and is considered suitable for achieving the objectives, particularly by means of procurement, management and financing of the SAF ramp-up. Greater pressure is also exerted on non-members of the club to introduce SAF quotas. One weakness of the model is that it does not envisage the in-house SAF production, and there is therefore a small risk that the other instruments will not be sufficient to produce enough SAF on the market. In summary, it can be assumed that the model is likely to achieve the vision, mission and established objectives, although there remains a small risk that it will fail to achieve them due to a lack of in-house production.

### **Practical feasibility: 2**

There are some challenges when it comes to the model's practical feasibility. Weaknesses include the substantial financing needs and the need for complex organisational and governance structures. Although there is some scope to use existing structures (including EASA<sup>15</sup>, EUROCONTROL) that make it easier to found the club, there is likely to be substantial effort involved in founding and building up the club.<sup>16</sup>

### **Protection of competition: 4**

This model offers the strongest protection of competition. Strengths include the greater protection of club members against distortions of competition and free-riding. This protection is reinforced by the possibility of excluding non-members of the club

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15 European Union Aviation Safety Agency

16 Initial approaches have already been put into practice in other areas, such as the European Centre for Critical Raw Materials

from the airspace as a last resort in the event of unfair competitive behaviour. Overall, a very high level of protection of competition can be assumed, and the envisaged sanction mechanisms point to a high level of effectiveness.

### **Financial strength: 3**

This model has both strengths and weaknesses from a financial perspective. Strengths include the diversification of revenue sources, for example from membership fees and income from the commercialisation of SAF. However, there are substantial financing needs due to the centralised procurement of SAF as well as further legal and operational risks. Overall, it is likely that self-financing could be ensured despite the substantial financing needs. Despite the diversified revenue sources, there are risks in terms of the long-term security of financing.

### **Strategic orientation towards SAF ramp-up: 3**

One strength is that the strategic orientation towards SAF ramp-up demonstrates innovation management through future purchasing and auction models. However, weaknesses include the lack of venture capital components in order to support new technologies. Overall, although the model in principle provides for SAF ramp-up through the promotion of new technologies, this is exclusively via third parties rather than through the club's own funding (venture capital).

### **Agility of the organisation: 2**

The agility of the organisation shows both strengths and weaknesses. The size of the organisation offers sufficient resources to perform new or modified tasks even at short notice. However, agility is reduced by the large and complex organisational structure. Overall, the model is not as good at responding to exogenous changes. It is essential to take agility into account when building up this model (including via "flexible teams").

### **Incorporation of stakeholders: 4**

The incorporation of stakeholders is one of the outstanding strengths of this model. Stakeholders are incorporated into the club's activities through a broad set of opportunities for participation.

#### 4.5.6 Investment model

The investment model has a total utility of 2.9 and is therefore the option with the second-highest score, just behind the management model. Given the broad set of instruments for promoting SAF market ramp-up, this model has the highest degree of expected objective achievement and protection of competition. However, the relative advantages of this model over the management model are slightly outweighed by the greater financing needs and the greater financial risks. In principle, however, this model also offers practical feasibility. The evaluations of the individual evaluation criteria are explained below:

##### **Degree of objective achievement: 4**

With regard to the degree of objective achievement, the investment model achieves the highest score. It offers more mechanisms and greater scope for action through joint purchasing and is considered appropriate for achieving the established objectives, particularly through targeted investment, procurement, management and financing of the SAF ramp-up. In addition, greater pressure is exerted on non-members of the club to introduce SAF quotas, and the management and safeguarding of a sufficient supply of SAF are facilitated by targeted investment in SAF production facilities as well as the in-house SAF production if the SAF gap cannot be closed by other means. Overall, it can be assumed that the model will completely fulfil the vision, mission and established objectives.

##### **Practical feasibility: 1**

At the same time, compared to the other two models, this model's practical feasibility shows considerable weaknesses due to the very substantial financing needs and the need for very complex organisational and governance structures. Overall, it can therefore be assumed that the effort involved in founding and building up the club is very high and that obstacles are likely to be encountered along the way.

##### **Protection of competition: 4**

Like the management model, this model offers the highest level of protection of competition for club members. It protects against distortions of competition and free-riding and, as a last resort, allows for the potential exclusion of non-members of the club from the airspace in the event of unfair competitive behaviour. Overall, the model

can therefore be assumed to provide very strong protection of competition, and the sanction mechanisms point to a high level of effectiveness.

### **Financial strength: 2**

This model has both strengths and weaknesses from a financial perspective. Despite diverse revenue sources, there is a substantial need for investment and financing, particularly due to the centralised procurement and in-house SAF production. Considerable risks stem from the necessary investments in SAF facilities. Overall, self-financing of the model appears possible, although there are moderate risks that the financing could not be ensured in the long term.

### **Strategic orientation towards SAF ramp-up: 4**

The model offers a broad set of tools for the strategic orientation of SAF ramp-up through the promotion of new technologies from the idea to industrial production. Overall, this model envisages broad and successful promotion of new technologies as well as the necessary financial resources.

### **Agility of the organisation: 2**

The organisation is less agile in this model. The size of the organisation offers sufficient resources to perform new or modified tasks even at short notice. However, the large and complex organisational structure also reduces agility. Overall, the model is therefore not as good at responding to exogenous changes. It is essential to take agility into account when building up this model (including via “flexible teams”).

### **Incorporation of stakeholders: 4**

This model allows for excellent incorporation of numerous stakeholders, which are incorporated into the club’s activities through a broad set of opportunities for participation. This stakeholder component is similar to the management model, although the investment model also envisages the incorporation of venture capital.

## **4.6 Prioritisation of model variants**

Based on the cost-utility analysis, the management model achieves the highest score as an option for founding and building up an international climate club for the promotion of SAF. With a total utility of 3.0, it slightly surpasses the investment model (2.9) and shows clear strengths in terms of objective achievement, particularly through

targeted procurement and management of SAF market ramp-up, in comparison to the investment model, with moderate financial risks.

The implementation of an international aviation climate club based on the management model has the following potential benefits, particularly in relation to feasibility, regulatory complexity and economic viability.

Potential of a climate club based on the management model:

- **Efficient ramp-up of SAF:** Through coordinated procurement strategies and management mechanisms, it would be possible to accelerate the scaling up of sustainable aviation fuels (SAF), thereby improving availability and profitability.
- **Creation of fair conditions for competition:** A harmonised international approach would minimise distortions of competition due to different national SAF requirements and reduce the risk of carbon leakage.
- **Long-term security of investment:** Through a binding club structure and strategic planning, it would be possible to specifically promote investments in SAF production capacities and reduce financing risks.
- **High stakeholder incorporation:** The management model allows excellent integration of aviation stakeholders, governments and private investors, which increases acceptance and opportunities for implementation.

In comparison, the broker model shows considerable weaknesses in terms of objective achievement, as it neither envisages in-house SAF production nor incentivises ramp-up through purchasing. Insufficient objective achievement can therefore be expected.

In contrast, the investment model achieves the highest score in terms of objective achievement and shows strong strategic orientation towards the SAF market ramp-up, but the associated financial risks are significantly greater.

## 4.7 Outlook

This study presents three model options for founding an aviation climate club: the broker model, the management model and the investment model. Based on a cost-utility analysis, the management model was identified as the most suitable option, albeit with only a slight advantage over the investment model.

When it comes to implementing the model, the first step should include – as part of a feasibility study – a sound analysis of the risks and challenges with a focus on the following areas of action:

- **International coordination and political acceptance:** The agreement on unified regulatory mechanisms, market mechanisms and club rules requires extensive diplomatic discussions and strong political commitment on the part of member states.
- **Financing needs and economic viability:** Setting up and operating a club of this kind requires considerable capital investment, particularly for SAF procurement and infrastructure development. Long-term financing must be ensured through diversified revenue sources (such as membership fees, public subsidies and carbon pricing).
- **Market influence of external stakeholders:** Non-members could gain competitive advantages due to lower fuel costs outside the club unless effective trade protection measures (such as trade tariffs) are implemented.
- **Technological uncertainties:** Future technological advances, particularly in relation to synthetic fuels (PtL SAF) and alternative drives, could influence the economic and environmental significance of a SAF-based climate club in the long term.

Concrete measures must be implemented in the next steps, and the following aspects must be weighed up:

### 1. Clarification of political and regulatory framework

- **Definition of international governance structures:** Clarification of the organisation(s) that could assume the coordination and governance of the climate club (such as the ICAO, the EU, national governments or multilateral initiatives).
- **Harmonisation with existing climate protection mechanisms:** Coordination with CORSIA, the EU ETS, the CBAM and national governments to avoid overlapping burdens and inconsistencies.

- **Analysis of legal feasibility:** Clarification of aspects of the climate club relating to international law, trade policy and competition law, particularly in relation to potential climate tariffs and market access rules for non-members.

## 2. Further development of financing and investment models

- **Development of a financing framework:** Analysis of how the club can be made financially viable in the long term (for example through membership fees, carbon pricing, public funding or private investment).
- **Involvement of private investors:** Development of incentive systems for companies and financial institutions in order to provide capital for SAF production and infrastructure.
- **Cost-benefit analysis for airlines and states:** Determination of the level of additional financial burdens for member states and airlines and economic advantages that could arise through market mechanisms and economies of scale in the long term.

## 3. Analysis of market and competition effects

- **Analysis of effects on the global aviation market:** Simulation of how a climate club could affect flight routes, ticket prices and market concentration.
- **Examination of carbon leakage effects:** Analysis of the risk that more demand is covered by connections via hubs outside the EU.
- **Integration of non-club states into the market mechanism:** Development of cooperation models with third countries to allow gradual incorporation into the club's structures.

## 4. Consideration of technological development

- **Evaluation of long-term prospects of SAF technologies:** Evaluation of feasibility of making PtL SAF available in sufficient quantities by 2050.
- **Incorporation of alternative, low-emission aviation technologies:** Consideration of hydrogen drives, electric aircraft and hybrid solutions in the club's long-term strategies.

- **Optimisation of production and logistics chains for SAF:** Identification of the best locations for SAF production, analysis of transport and distribution infrastructure.

## 5. Intensification of stakeholder dialogue

- **Deepening of collaboration between states, industry and science:** Establishment of a multinational forum to address regulatory, economic and technical challenges together.
- **Incorporation of airlines and airports into the design of the climate club:** Ensuring that operational aspects of the aviation industry are realistically reflected.
- **Public relations work and boosting acceptance:** Development of communication strategies to raise awareness of the need for an aviation climate club among political decision-makers, investors and society.

In terms of implementation, thought should also be given to the prospect of evolving from a management to an investment model. Although the latter is more complex in terms of implementation, it promises even better achievement of objectives.

Lastly, the study shows that the management model offers substantial potential for an aviation climate club, whose success will rely on international coordination, the political framework conditions and sustainable financing. However, implementation will require further economic, regulatory and technological analyses, particularly with a view to developing a viable financing model, a governance structure and effective incentives for member states. In addition, intensive stakeholder dialogue will be decisive in order to identify obstacles at an early stage and build political consensus. Only through close collaboration can a climate club drive forward the market penetration of SAF and contribute to the defossilization of aviation.

# Appendices

## Appendix 1

The figure below shows the permitted starting materials for the production of SAF according to RED II.

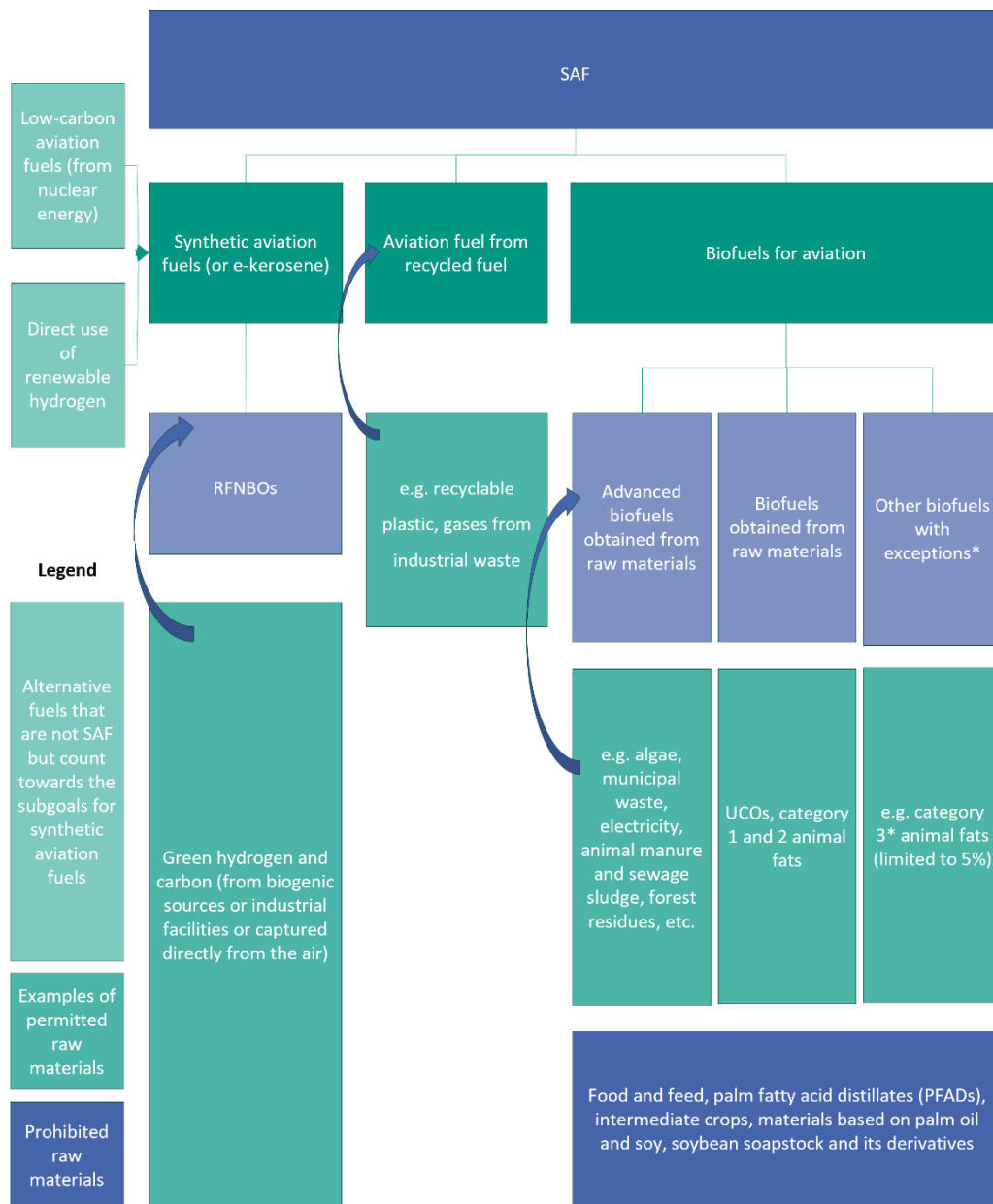


Figure 15: SAF according to the Renewable Energy Directive (Amtsblatt der Europäischen Union, 2023b)

## Appendix 2

The table below sets out an illustrative calculation of the additional costs for the route from Frankfurt to Hurghada, which was carried out according to the same methodology as Table 2 (see section 3.4.1.1).

	EU airlines		Turkish airlines	
	Frankfurt– Hurghada	Hurghada– Frankfurt	Frankfurt– Istanbul– Hurghada	Hurghada– Istanbul– Frankfurt
<b>Flight kilometres (km)</b>	3,300	3,300	3,500	3,500
<b>Aircraft fuel consumption (t)</b>	22	22	24	24
<b>Kerosene costs:</b>				
<b>2024: 100% Jet A-1</b>	18,000	18,000	20,100	20,100
<b>2030: 1.2% PtL, 4.8% HEFA SAF, 94% Jet A-1</b>	22,600	18,000	23,000	20,100
<b>2040: 10% PtL, 24% HEFA SAF, 66% Jet A-1</b>	37,000	18,000	31,400	20,100
<b>2050: 35% PtL, 35% HEFA SAF, 30% Jet A-1</b>	44,100	18,000	35,700	20,100

**Table 7: Case study to illustrate additional costs due to PtL (DAC) on selected flights in comparison with kerosene costs in 2024.**

**Sources:** flight kilometres (myclimate 2024); fuel consumption based on a Boeing 787-9 (ICAO, 2024); production costs for PtL DAC (Deloitte, 2024); price for fossil kerosene (IATA, 2024c). The calculation relates to a situation in which 100% of the EU blending quotas are covered by PtL.

## List of abbreviations

Abbreviation	Meaning
<b>ASTM</b>	American Society for Testing and Materials
<b>BImSchG</b>	Federal Immission Control Act
<b>CAAF/3</b>	Third ICAO Conference on Aviation and Alternative Fuels
<b>CapEx</b>	Capital expenditure (investment costs)
<b>CBAM</b>	Carbon Border Adjustment Mechanism
<b>CCfD</b>	Carbon contract for difference
<b>CORSIA</b>	Carbon Offsetting and Reduction Scheme for International Aviation
<b>CSRD</b>	Corporate Sustainability Reporting Directive
<b>DAC</b>	Direct air capture
<b>DLR</b>	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
<b>EASA</b>	European Union Aviation Safety Agency
<b>EBIT</b>	Earnings before interest and taxes
<b>EU</b>	European Union
<b>EU ETS</b>	EU Emissions Trading System
<b>EUMETSAT</b>	European Organisation for the Exploitation of Meteorological Satellites
<b>EEA</b>	European Economic Area
<b>FedEx</b>	Federal Express
<b>FEETS</b>	Fuels Eligible for ETS Support (assignment of certificates for the use of permitted aviation fuels under the EU ETS)
<b>FT</b>	Fischer–Tropsch
<b>GGGI</b>	Global Green Growth Institute
<b>HEFA</b>	Hydroprocessed esters and fatty acids (conversion of esters and fatty acids into kerosene)
<b>IATA</b>	International Air Transport Association
<b>ICAO</b>	International Civil Aviation Organization
<b>IEA</b>	International Energy Agency

Abbreviation	Meaning
<b>OpEx</b>	Operating expenditure (operating costs)
<b>PtL</b>	Power to liquid
<b>RED</b>	Renewable Energy Directive
<b>RFNBO</b>	Renewable fuels of non-biological origin
<b>SAF</b>	Sustainable aviation fuels
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>UPS</b>	United Parcel Service
<b>WTO</b>	World Trade Organization

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