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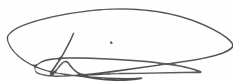
Global Sustainable Aviation Fuel

About

Our Global Sustainable Aviation Fuels (SAFs) market report adds to our continued series of key energy transition focused industry reports. The collective works are the result of a valued research collaboration between ourselves and Alchemy Research and Analytics, a leading industry research group working actively across the energy transition markets. The report draws on macroeconomic data from multilateral institutions and industry-specific data from sources such as industry associations, government authorities / statistical departments, and the International Energy Agency (IEA). This was supplemented by news reports, trade journals, and related sources.

The report provides a current market overview of the global SAF industry, including first-movers, key challenges, policy drivers, economics and outlook in major countries across Europe and the Americas. The structure of the report begins with an introduction to the principals behind the technology and industry. It then delves into detailed chapters on major topics, offering a holistic view of the possible industry directions, and highlighting growth opportunities, demand drivers, and investment considerations.

CleanBridge's INSIGHTS series of industry reports, aims to provide a comprehensive understanding of the key characteristics and trends prevalent in major markets for various technologies that will shape the energy transition over the coming decades. We hope you find our annual review of the Global SAF market informative and enjoyable to read and we look forward to briefing you on other energy transition technologies in the upcoming months.

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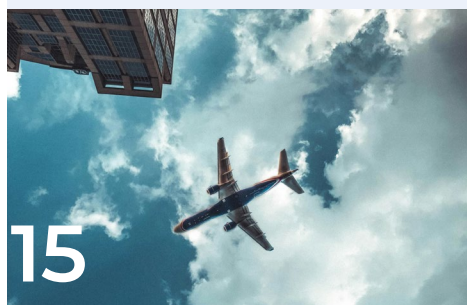
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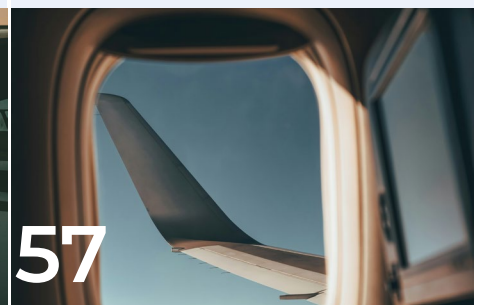
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Executive Summary



Executive Summary

The global aviation industry is at a crossroads, needing to balance increasing travel demand with the imperative to reduce carbon emissions. Sustainable Aviation Fuels (SAFs) are central to achieving the industry's net-zero emissions target by 2050. This report analyzes SAF initiatives and regulatory frameworks in Canada, the European Union, and the United States, highlighting each region's strategies to promote SAF adoption and production.

Canada's regulatory framework for SAF is driven by the Clean Fuel Regulations (CFR) and various provincial initiatives. British Columbia leads with its Low Carbon Fuels Act (LCFA), setting SAF blending mandates and significant carbon intensity reduction targets. These provincial efforts illustrate the critical role of local leadership in advancing SAF adoption nationally.

The EU's ReFuelEU Aviation initiative, part of the "Fit for 55" package, sets phased SAF blending mandates from 2025 to 2050. The EU Emission Trading Scheme (ETS) further incentivizes SAF by allowing airlines to offset SAF costs against their ETS obligations. This comprehensive approach combines regulatory mandates with financial incentives, establishing the EU as a global leader in SAF regulation.

Post-Brexit, the UK has developed its own SAF regulatory framework, including specific mandates under the Renewable Transport Fuel Obligation (RTFO). This independent approach has driven substantial investment in SAF, demonstrating the UK's commitment to sustainable aviation.

The U.S. approach includes the Inflation Reduction Act (IRA), which offers graded tax credits for SAF production, and the FAA's Fuelling Aviation's Sustainable Transition (FAST) program, which supports SAF infrastructure. State-level policies in California, Illinois, and Oregon further bolster SAF adoption, highlighting the importance of sub-national efforts.

Despite strong regulatory frameworks, challenges remain, including high production costs, technological barriers, and significant infrastructure investments. However, advancements in production technologies and economies of scale, supported by clear policies and financial incentives, present substantial opportunities for reducing aviation's carbon footprint.



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Achieving net-zero aviation emissions by 2050 requires a coordinated approach involving governments, the private sector, and international collaboration. Governments must provide long-term policy support and financial incentives, while the private sector must invest in scaling SAF production technologies. Harmonizing global standards and practices is crucial for a seamless transition to sustainable aviation.

Canada's regional initiatives, the EU's comprehensive ReFuelEU framework, and the multifaceted U.S. approach demonstrate effective strategies for advancing SAF. The U.S. combines federal tax credits, targeted funding, and state-level initiatives to support SAF production and adoption. The EU integrates binding mandates with financial mechanisms like the ETS, providing a model for holistic policy design. Canada's provincial leadership, particularly in British Columbia, showcases how local initiatives can drive national progress.

To overcome existing challenges, sustained innovation and investment are essential. Governments need to refine and expand policy frameworks, while the private sector must proactively develop and scale new SAF technologies. International collaboration, through platforms like the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), will be critical for harmonizing standards and fostering a global SAF market.

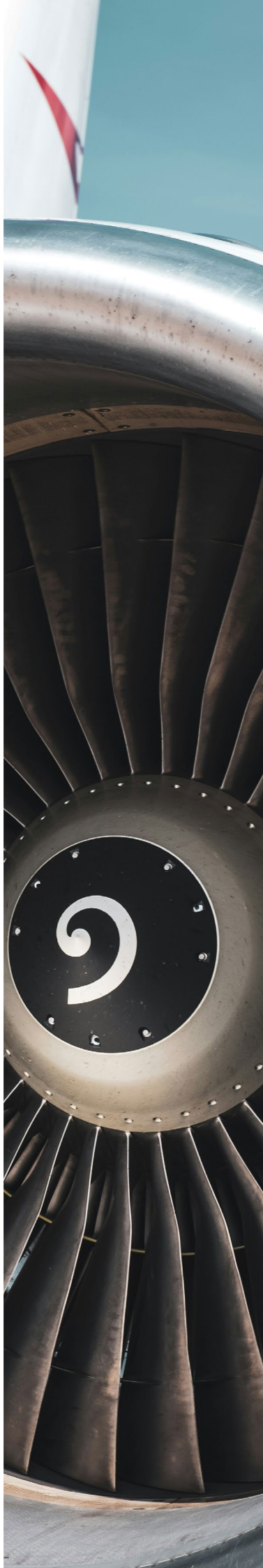
In summary, the path to sustainable aviation is clear but requires concerted effort from all stakeholders. The insights and strategies outlined in this report provide a foundation for continued progress, underscoring SAF's critical role in achieving a net-zero aviation industry by 2050. With sustained commitment and collaboration, the aviation industry can meet this challenge and secure a greener future.



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02

Introduction to SAF



Introduction to SAF

Aviation is a cornerstone of the global economy, facilitating trade, tourism, and cultural exchange. However, it is also a significant contributor to greenhouse gas (GHG) emissions, accounting for approximately 2-3% of global CO₂ emissions. As the demand for air travel continues to grow, the environmental impact of aviation is becoming increasingly scrutinised. This has spurred the search for avenues to make air travel more environmentally friendly. With over 99% of the CO₂ emission coming from fuel burnt during flight operations this had led to the development of sustainable aviation fuels (SAFs).

SAFs represent a pivotal innovation in the aviation industry, offering a potential pathway to significantly reduce its carbon footprint. These fuels are derived from renewable resources and waste materials, providing a more sustainable option compared to traditional fossil-based aviation fuels. SAFs can reduce life-cycle GHG emissions by up to 80%, providing a substantial opportunity to mitigate the environmental impact of air travel. International agreements such as the Paris Agreement set ambitious targets for carbon reduction, putting the aviation industry under pressure to innovate and adopt cleaner technologies. SAFs play a crucial role in this context due to several key reasons:

Emission Reductions: SAFs have the potential to reduce life-cycle GHG emissions by up to 80% compared to conventional jet fuels. This significant reduction is achieved through the use of renewable feedstocks and advanced production technologies that minimize carbon emissions during the fuel's lifecycle.

Economic Benefits: The development and deployment of SAFs can stimulate economic growth, create jobs, and foster technological innovation. Investing in SAF production infrastructure and research can also position countries as leaders in the emerging green aviation sector.

Compliance with Regulations: As environmental regulations become stricter, SAFs provide a viable solution for airlines to meet emissions targets and avoid penalties. This is particularly relevant in regions with stringent carbon reduction mandates and aviation emissions trading schemes.

Despite the promising potential of SAFs the industry is still very much in its nascent stages, with several challenges that must be addressed to achieve widespread adoption:

Cost: SAFs are currently more expensive to produce than conventional jet fuels, primarily due to the high costs of feedstocks and production technologies.

Feedstock Availability: Ensuring a sustainable and scalable supply of feedstocks is critical. Competition with food production and land use constraints are potential issues.

Regulatory and Policy Support: Strong regulatory frameworks and incentives are needed to support the development and commercialization of SAFs. This includes subsidies, tax credits, and mandates for SAF blending.

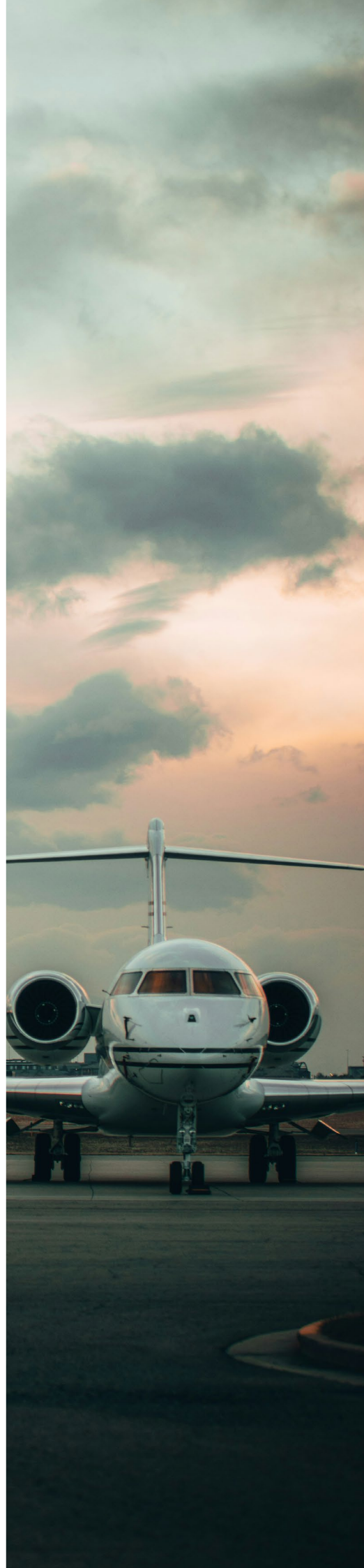
Technological Advancements: Continued research and development (R&D) are essential to improve the efficiency and cost-effectiveness of SAF production technologies.

Industry Collaboration: Collaboration across the aviation industry, including airlines, fuel producers, and governments, is crucial to overcoming these challenges and achieving large-scale SAF adoption.

SAFs represent a vital innovation in the quest to make air travel more sustainable. By leveraging renewable resources and advanced technologies, SAFs offer a viable path to reducing the environmental impact of aviation. While significant challenges remain, continued investment in SAF development, supportive policies, and industry collaboration will be key to unlocking their full potential. As the aviation industry navigates the transition to a more sustainable future, SAFs will undoubtedly play a central role in achieving its environmental and economic goals.

03

Market Overview



Market Overview

The global market for SAF is in a nascent yet rapidly developing stage, driven by the urgent need to reduce carbon emissions in the aviation sector. There has been significant progress in SAF production, adoption, and regulatory support over the past few years. While challenges related to cost and scalability remain, the concerted efforts of governments, industry players, and technological innovators provide a promising outlook for the future of SAFs. The next few years will be pivotal in determining the extent to which SAF can transform the aviation industry and help achieve a more sustainable future for air travel. This chapter sets out a high-level view of the current state of the SAF industry, its key stakeholders and the economic forces at play.

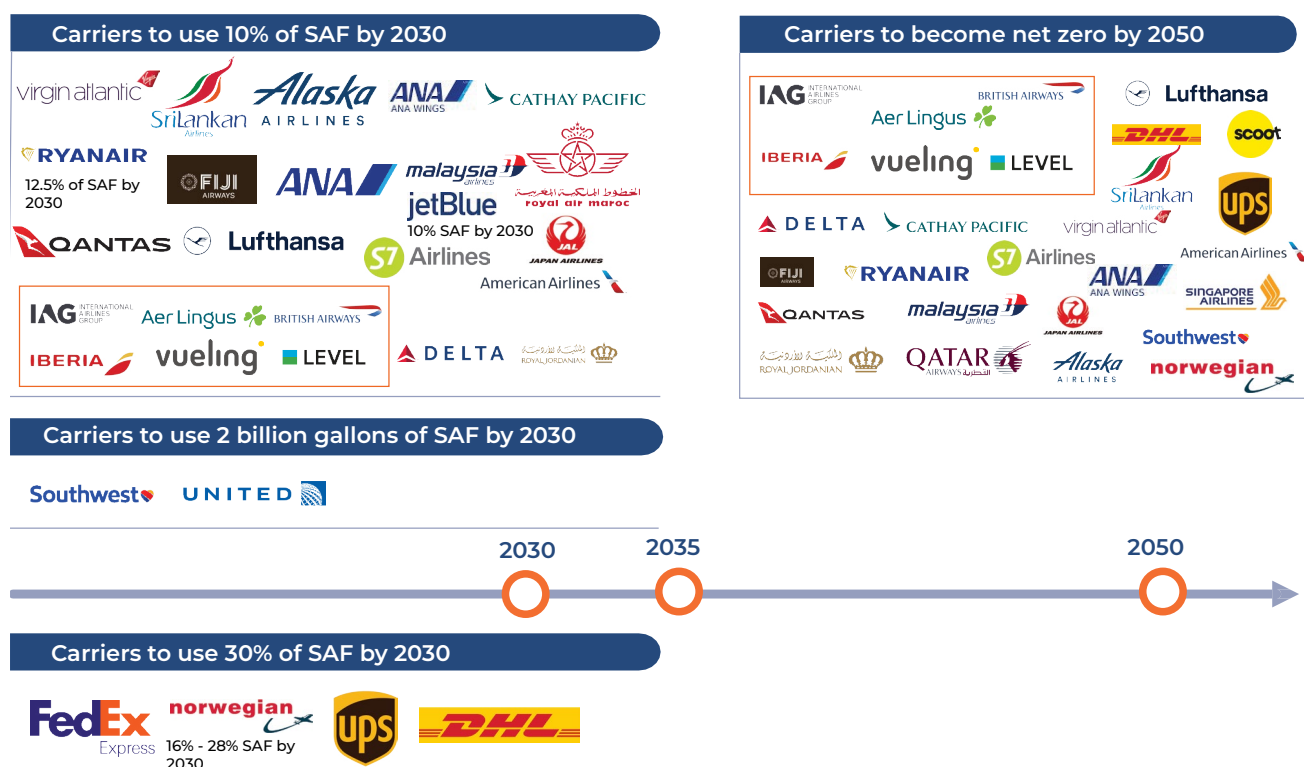
The annual production capacity for SAF is still relatively limited compared to the total jet fuel demand. Estimates suggest that SAF production in 2023 was around 0.1% of the total aviation fuel consumption, though this number is expected to increase significantly in the coming years. The International Air Transport Association (IATA) estimates indicate that during 2024, even after anticipated increases in supply, the share of SAF may reach 0.5% of total aviation fuel

consumption (IATA, 2023). These small percentages contrast starkly versus projections indicating that SAF could constitute up to 10% of global jet fuel demand by 2030, contingent on continued investment and supportive policies.

Decarbonization targets set by governments and associated policies that necessitate the aviation industry to move to greener fuels give guidance to future demand trajectories. Several countries have introduced blending mandates requiring airlines to use a certain percentage of SAF, these are crucial for driving demand and encouraging investment in SAF infrastructure. For example, the European Union's ReFuelEU Aviation initiative aims for a 2% SAF blend by 2025, increasing to 63% by 2050.

To complement policy driven requirements, and to support commitment to state level targets, governments in the United States, European Union, and other regions have implemented subsidies, tax credits, and grant incentives to promote SAF production and use. The U.S. Inflation Reduction Act (IRA), for instance, provides significant financial incentives for SAF production.

Figure 1: SAF Blending Commitments by Airline Carrier



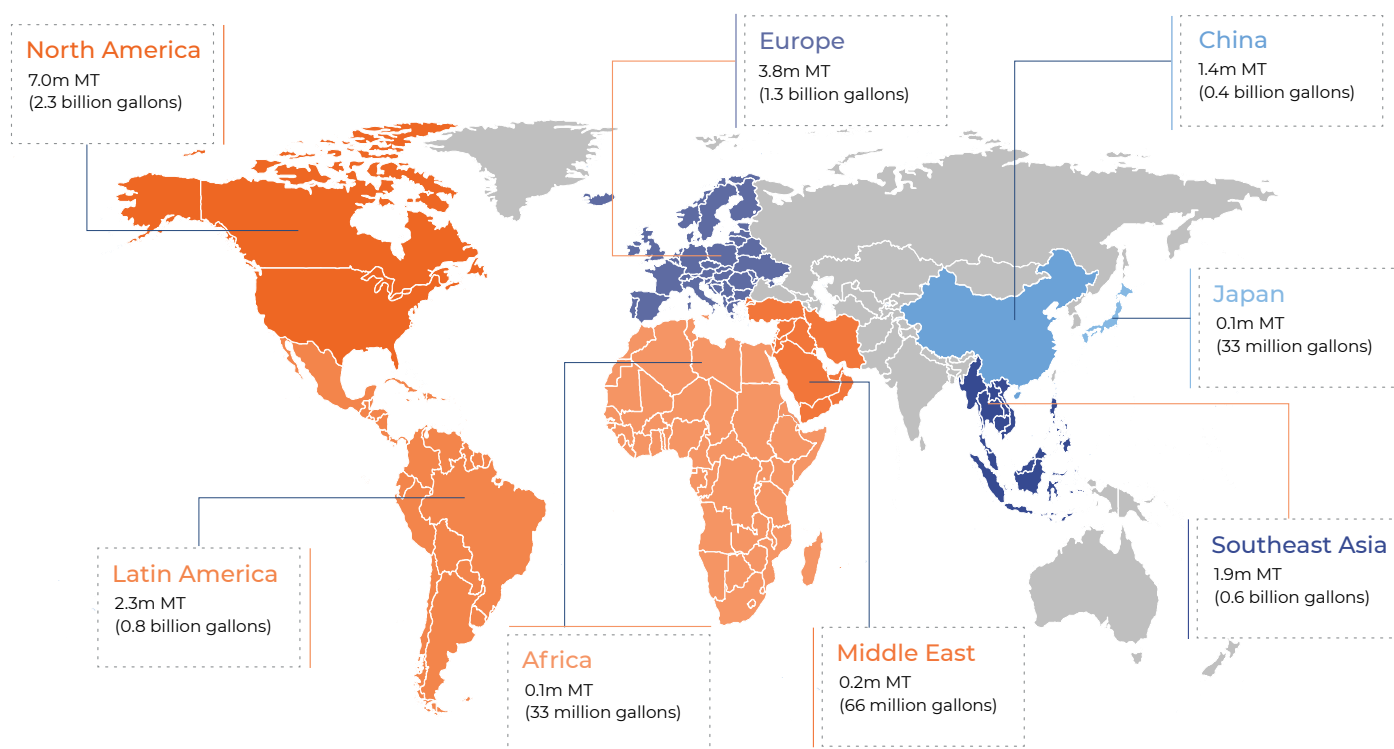
Source: HCS Group, 2023

Voluntary commitments to SAF by airlines are bolstering demand projections. Instead of relying solely on conventional carbon offset routes, airlines are increasingly adopting SAF offtake agreements to reduce their carbon footprints. As of December 2023, more than 43 airlines have made voluntary commitments to blend SAF into their fuel supply (HCS Group, 2023). In alignment with these commitments, the IATA, the trade association for the world's airlines, comprising 330 members, has committed to reach net zero CO₂ emissions by 2050 (IATA, 2023).

Whilst voluntary commitments are not legally binding, and policy makers can change course, the unified

signaling from industry participants provides a clear direction for the SAF industry as a whole. Forecasts done by Dutch fuel supplier SkyNRG show an increase in SAF production capacity to 17.3 million tonnes by 2030, up significantly from 4 million tonnes in 2023. Similarly, to reach its decarbonization targets, the IATA estimates global demand will be in the region of 360 million tonnes by 2050, representing a 99.9% increase from current levels. Landmark legislation on SAF in the EU, the US, and the UK will act as the primary demand driver. SkyNRG estimates that Europe and the US could have around 120 million tonnes of SAF capacity installed by 2050 (SkyNRG, 2024).

Figure 2 - 2030 Projected Global Capacity by Region, Based on SAF Announcements and SAF Policies Implemented and Announced

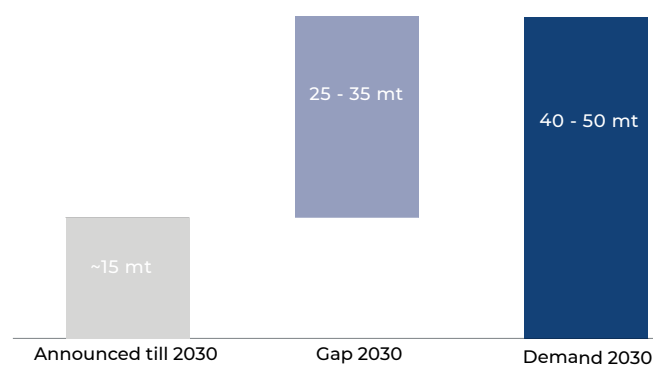


Source: SkyNRG

Supply Gap & SAF Economics

The current global supply of SAF falls significantly short of the estimated requirement needed to meet decarbonization goals. The World Economic Forum (WEF) has estimated that between 40 to 50 million tonnes of SAF will be necessary to achieve these targets (WEF, 2024). However, existing offtake contracts account for only a small fraction of this requirement, with the IATA estimating around 13 million tonnes (IATA, 2023). This presents a compelling case for the SAF business case and growth opportunity whereby announced SAF production capacities cover only 30% to 40% of the projected SAF demand by 2030.

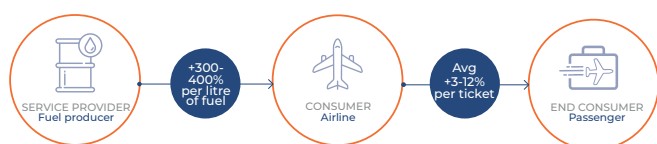
Figure 3: Projected Demand-supply Gap in Million Tonnes



Source: WEF, 2024

The supply gap essentially represents a lack of confidence from industry participants in committing to the future SAF economics and adoption. Several factors contribute to this uncertainty, including technology risks, financing dynamics, policy risks and country-specific challenges.

Figure 4: Premium Associated with SAF vs Conventional Fuels



Source: WEF, 2024

The economics of SAF production and adoption present several challenges. Rapid growth in commercial-scale production is crucial to reducing SAF costs, but currently, SAF trades at a significant premium over conventional aviation fuel. This cost disparity discourages widespread adoption, creating a dislocation and commercial friction within airlines,

requiring either reductions in margins or else passing higher costs on to consumers which is likely to adversely impact sales. It is difficult for airlines to have confidence in how willing end consumers will be to pay premium airfares to compensate for the increased cost of green-fuels.

Figure 5: Price Premium of SAF over Conventional Jet Fuel



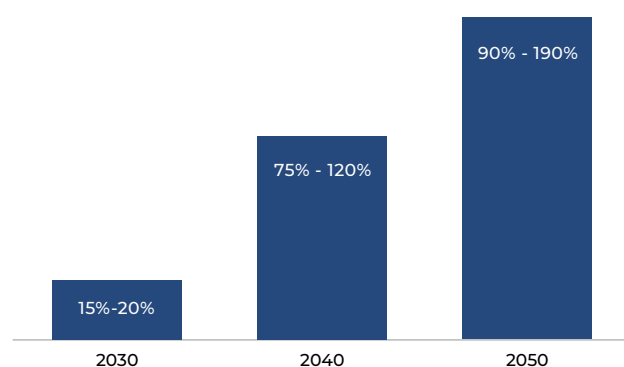
Source: WSJ, 2023

SAF's share in total aviation fuel consumption (currently less than 1%) is typically exchanged at prices more than twice as expensive as conventional fuel. The SAF market, being relatively nascent with limited volumes, also suffers from opaque pricing based on private negotiations rather than market forces. The total cost for purchasing SAF, produced using the currently most commercially viable 'Hydrotreated Esters and Fatty Acids' (HEFA) method, is estimated to be 2.0 to 2.5 times higher than that of conventional fuel (WEF, 2023). For airlines, this translates to an estimated 300% increase in fuel costs, which significantly hinders large-scale adoption and commercial scalability. Although policy directives focus on stimulating demand through regulation they do not solve the challenge of increasing pricing across the supply chain and ultimately for the end customer. This creates a dislocation within the industry disincentivising airlines from being a first-mover. The absence of final investment decisions in Europe for green-premium production methods such as Power-to-Liquid (PtL) projects, which use exclusively renewable energy sources to produce SAF, highlights the cost challenges faced by financiers.

Looking ahead, the average energy cost in the aviation industry will depend on the share of renewable fuels, their production costs, and aircraft fuel efficiency. A 13% to 15% share of SAF by 2030 could increase average fuel costs by 15% to 20%. However, by considering aircraft fuel efficiency, the cost increase per revenue passenger kilometre might be significantly offset

by improvements in fuel consumption. By 2050, the Mission Possible Partnership organisation estimates a fully decarbonized aviation sector could see a 90% to 190% rise in average fuel costs (MPP, 2022). Technological advancements, such as battery-electric aircraft and hydrogen-based fuels, could help reduce costs on a per passenger kilometre basis, however these projections carry significant uncertainty. Diversifying production pathways beyond HEFA, such as AtJ, may be key to finding more commercially viable avenues to SAF production and reducing costs.

Figure 6: Projected Average Cost Rise Relative to the Fossil-based Jet Fuel Cost as of 2022



Source: MPP, 2022

To meet the increasing demand for SAF, substantial investment in infrastructure is crucial. By 2050, an estimated \$2.4 trillion investment will be required for upstream infrastructure alone, encompassing refineries, storage facilities, and distribution networks. However, currently, less than 1% of the necessary infrastructure is in place globally, indicating a significant gap in investment (WEF, 2024).

The reluctance of infrastructure investors to commit to SAF projects stems from uncertainty regarding the business case and how costs will be distributed. The narrow profit margins and high capital costs associated with such projects further deter private equity (PE) involvement. To mitigate risk and attract investment, early-stage technologies like PtL may require state-level funding or public-private partnerships (PPP) to de-risk private sector involvement. Additionally, existing biofuel refineries could repurpose their facilities for SAF production, provided there are incentives and opportunities to do so.

The next 2-3 years will be crucial for scaling up SAF production, with approximately €1 trillion in capital expenditure (CAPEX) needed to establish 450-950 new production sites by 2030 (PwC, 2023). As production volumes increase and efficiencies improve, capex

costs are expected to decline. Economies of scale in advanced technology systems that form integral parts of the production process such as electrolyzers and carbon capture will be critical to improvements in project economics.

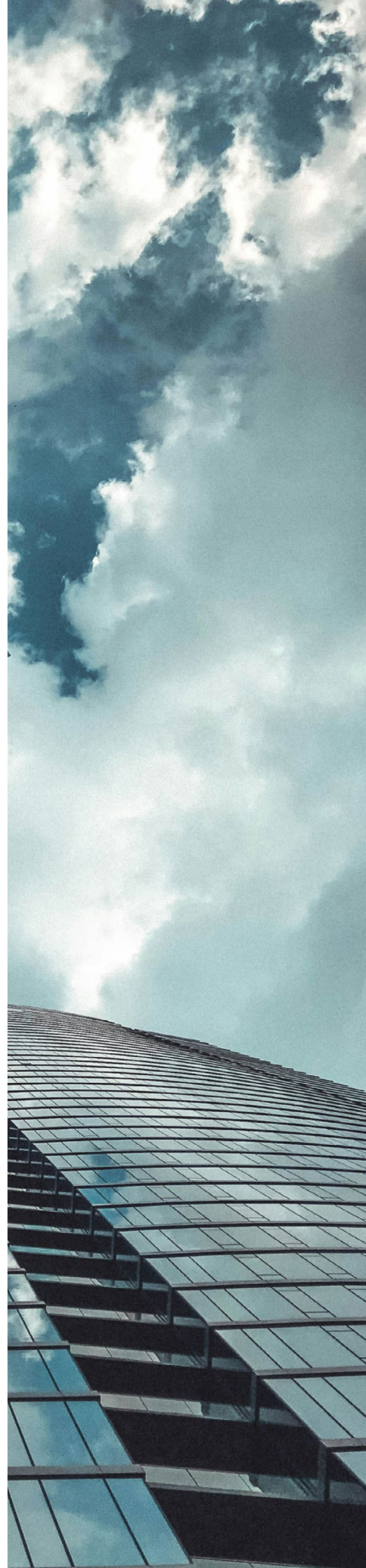
Regions with high renewable energy penetration will be particularly attractive for investment, given the importance of renewable electricity in SAF production, especially for e-kerosene projects. Focusing on renewable energy sources not only supports the sustainability of SAF production but also enhances the long-term economic viability of such projects.

Several non-financial challenges also impede the growth prospects of SAF. Allocating agricultural land for biomass feedstock supply is particularly challenging in regions like Europe, where land for biomass feedstock might conflict with food production. For instance, meeting the UK's biofuel demand with crops like rapeseed could require 68% of the country's agricultural land. Competing land uses for renewable energy projects, such as wind and solar PV generation, also create conflicts (Institution of Mechanical Engineers, 2023). Other growing sectors with similarly high land requirements include nature-based carbon removal/sequestration and hydrogen storage (ScienceDirect, 2023). Unplanned land diversion for SAF energy crops could negatively impact the carbon footprint by releasing stored carbon from forests and reducing their sequestration capacity (WRI, 2023). A renewed focus on sustainable agriculture is fostering mutually beneficial ventures between producers and biomass feedstock suppliers (Greenair, 2023). Furthermore, new production pathways can diversify the feedstock requirements which may alleviate agricultural challenges.

The implication of the supply gap and economic challenges of SAF is an industry that is heavily dependant on, and therefore sensitive to, policy frameworks. Changes in regulations or incentives have the potential to significantly shape or alter the path to transition and decarbonization of the aviation industry. The lack of visibility on green airfare price elasticity and the degree of commitment from policy makers to require the aviation industry to go green creates a maze for investors and industry participants to navigate in determining the pathway to SAF uptake. Feedstock producers, SAF producers, ancillary fuel service providers, their development programmes and airlines will all form an important part of a collaborative effort to decarbonise aviation, whilst competing for the same policy driven economics.

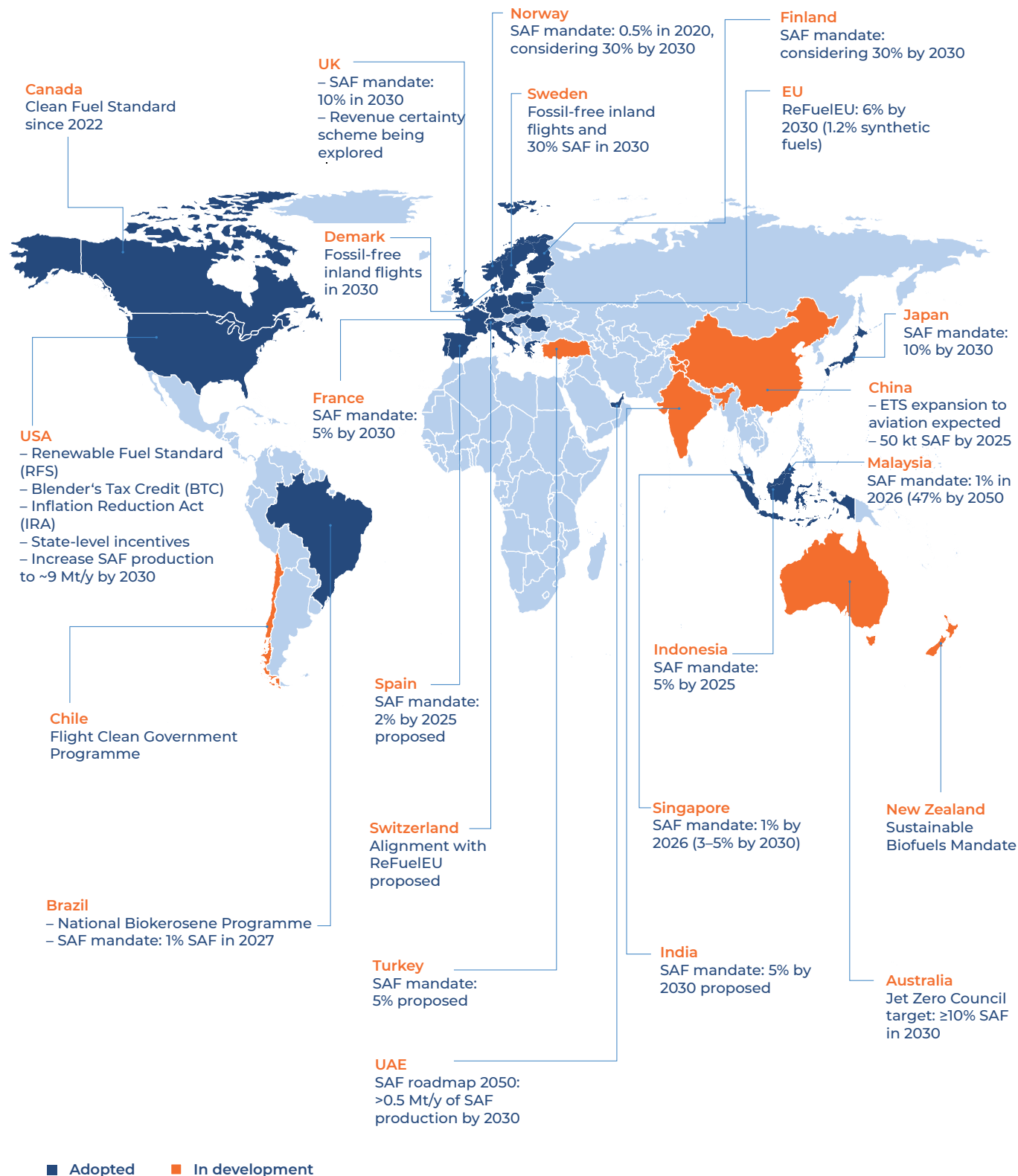
04

Policy and Regulation



Policy and Regulation

Figure 7: SAF-related Policies Under Development or Already Adopted Globally as of March 2024



Source: WEF, 2024

Achieving the global aviation industry's decarbonization objectives by 2050 necessitates unified and strategic actions to facilitate the widespread adoption of SAFs. To reach net-zero emissions, all industry stakeholders—including governments, airlines, fuel producers, and investors—must align their efforts. Addressing the cost disparity between SAF and traditional fuels requires innovative financial mechanisms and policies that account for the carbon footprint of each fuel type. While many countries have yet to establish definitive policies to advance SAF adoption, there is a gradual shift towards implementing blending targets. This trend highlights the importance of reviewing SAF policies and regulations at the country or regional level.

This chapter introduces the policy and regulatory strategies that are fostering the growth of SAFs along with carbon pricing and market mechanisms. This is followed by region-specific details, focussing on leading regions for SAF-specific policy-making: Canada, European Union, and USA.

Mandates and Targets: Governments play a crucial role in setting clear mandates for SAF blending ratios, which are expected to increase incrementally over time. Establishing long-term targets for SAF adoption that align with net-zero goals provides certainty and direction for all stakeholders involved. Figure 7 shows a global map of adopted and in-development mandates and targets related to SAF as of March 2024.

Incentives and Subsidies: Financial incentives are vital for bridging the cost gap between SAFs and traditional jet fuels. These may include tax credits, grants, and subsidies aimed at both SAF producers and airlines. Implementing carbon pricing mechanisms that reflect the environmental impact of traditional fuels can also enhance the competitiveness of SAFs. Governing bodies may also effect policy to fund and support R&D needed to advance SAF production technologies. PPP can help share the investment risks associated with new SAF facilities, while simplified regulatory approval processes can accelerate their establishment. Regulation requiring sustainable feedstock sourcing ensures a steady and environmentally responsible supply for SAF production. Incentives encouraging the development of diverse feedstock types can mitigate supply chain risks and enhance sustainability.

International bodies like the International Civil Aviation Organization (ICAO) establish global standards and guidelines for SAF usage. Collaboration between countries is crucial to harmonize policies and avoid regulatory fragmentation that could hinder SAF adoption, whilst robust certification systems ensure SAFs meet stringent sustainability criteria. Initiatives

such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) can incentivize emissions reductions and support SAF adoption.

Carbon Pricing: Carbon pricing mechanisms internalize the environmental costs of traditional aviation fuels, making SAFs more attractive by comparison. Revenue generated from carbon pricing can fund SAF development and adoption initiatives.

Market Mechanisms: Developing and supporting carbon markets allow airlines to trade emissions credits, providing financial incentives for using SAFs. Encouraging voluntary commitments and corporate pledges to use SAFs leverages corporate social responsibility to drive demand.

The remainder of this chapter covers region-specific SAF policy and regulatory frameworks in sub-sections covering Canada, Europe, USA, and Other Countries.



Canada

Canada has taken significant strides towards the adoption and integration of SAFs as part of its broader commitment to reducing GHG emissions and achieving a net-zero economy by 2050.

The country's approach to SAF policy and regulatory frameworks includes a mix of mandates, incentives, and collaborative efforts with industry stakeholders.



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Canada's federal government has set ambitious targets for reducing GHG emissions across all sectors, including aviation. The Aviation Climate Action Plan, released by Transport Canada, outlines specific targets for reducing aviation emissions, with a clear emphasis on the role of SAFs.

The Clean Fuel Regulations (CFR) are a cornerstone of Canada's strategy to mitigate transportation sector emissions, including aviation. The CFR requires fuel suppliers to gradually reduce the lifecycle emissions of their products from 2023 to 2030, replacing the previous Renewable Fuels Regulations (Canada Government, 2023). A key feature of the CFR is the

introduction of a voluntary credit system for emissions reductions achieved by suppliers. These tradeable credits aim to create a market for lifecycle emission reductions and attract investments in clean fuels. From January 2024, suppliers can also contribute to the Emissions Reduction Funding program to meet up to 10% of their annual carbon intensity reduction requirements, although credits from such contributions are not tradeable and are subject to an expiry date.

While Canada has yet to implement specific federal SAF blending mandates, discussions are ongoing to establish mandatory blending ratios similar to those seen in other jurisdictions. However, the provincial governments have taken the lead in this regard, with British Columbia notably issuing the first SAF mandates in North America under its Low Carbon Fuels Act (LCFA) (Carbon Pulse, 2023).

Canada offers a range of financial incentives to support the production and use of SAFs. The Clean Fuel Standard (CFS) aims to reduce the carbon intensity of fuels used in Canada, providing credits for SAF producers to make their products more competitive against traditional jet fuels. In 2021, the Canadian government allocated C\$1.5 billion to promote clean fuel production, which includes potential benefits for the SAF sector. This funding supports various initiatives, including R&D, to advance SAF technologies and improve their commercial viability.

Canada promotes collaboration between government agencies, research institutions, and private companies to foster innovation in SAF production. These partnerships aim to share risks and leverage combined expertise to accelerate the development of viable SAF solutions. The country employs rigorous monitoring and reporting mechanisms to track the progress of SAF adoption and its impact on emission reductions. Annual reports and sustainability assessments ensure transparency and accountability, enabling continuous improvement of policies and practices. Regular reviews of SAF policies and frameworks are conducted to reflect technological advancements and market developments. This adaptive approach ensures that Canada's SAF strategies remain effective and aligned with both national and international environmental goals.

The Canadian aviation industry has shown proactive engagement with SAF adoption. Airlines such as Air Canada and WestJet have participated in SAF trials and pilot programs, demonstrating the feasibility and benefits of using sustainable fuels. These initiatives are often supported by government funding and regulatory facilitation.

British Columbia has been at the forefront of SAF policy development with the introduction of the LCFA in January 2024. The LCFA mandates a graded and escalating structure for the required share of renewable fuels in total jet fuel use: 1% in 2028, 2% in 2029, and 3% in 2030 and subsequent periods. Additionally, the LCFA requires a reduction in carbon intensity for jet fuels, starting at 2% from 2026 and increasing by two percentage points each year until reaching 10% in 2030 (BC Government, 2023).

In **Manitoba**, significant efforts are being made to support SAF production. In January 2024, the provincial government, along with the federal government and the Canada Investment Bank (CIB), invested C\$12.3 million in a front-end engineering and design study by Azure Sustainable Fuels to assess the feasibility of producing SAF from local feedstocks such as canola and soybean oil (Airport Technology, 2024).

To conclude, Canada's comprehensive approach to SAF policy and regulatory frameworks demonstrates a strong commitment to sustainable aviation. Through a combination of mandates, incentives, collaborative efforts, and regional initiatives, Canada is creating a conducive environment for the adoption and growth of SAFs. This multi-faceted strategy not only supports the country's decarbonization goals but also positions Canada as a leader in the global effort to reduce aviation carbon emissions.



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Europe

The European Union (EU) has established a comprehensive policy and regulatory framework to promote the adoption of SAFs as part of its ambitious climate goals. With the overarching objective of achieving net-zero emissions by 2050, the EU has implemented a range of mandates, incentives, and collaborative efforts to drive the aviation sector towards sustainability.



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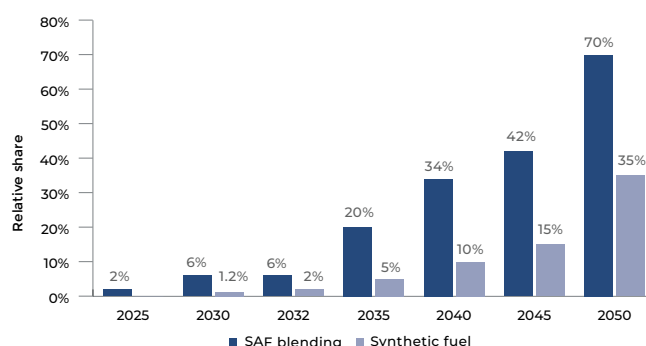
The European Green Deal is the EU's strategic plan to become climate neutral by 2050. This comprehensive framework addresses all sectors, including aviation, and emphasizes the crucial role of SAFs in reducing emissions.

A cornerstone of the EU's SAF strategy is the ReFuelEU Aviation initiative, part of the broader "Fit for 55" package aimed at reducing GHG emissions by 55% by 2030 compared to 1990 levels. The ReFuelEU regulations of 2023 stipulate volume-based blending mandates for SAF, through a phased structure between 2025 and 2050. This initiative applies to the entire EU aviation industry and has emerged as a pivotal regulatory direction globally for the SAF sector. The targets for SAF blending are shown in Figure 8.

In addition to overall SAF blending targets, there is a

sub-quota for synthetic aviation fuels, based largely on the nascent Power-to-Liquid (PtL) technology. Penalties for non-compliance are significant, with fines at least twice the difference between the annual average price of fossil jet fuel and SAF, multiplied by the relevant targeted quantity. The fines collected will finance low-emission aviation technologies and systems through a Sustainable Aviation Fund.

Figure 8: ReFuelEU's SAF Blending Targets - Synthetic Jet Fuels are Defined as those of Non-biological Origin (such as Hydrogen and renewable energy)



Source: SkyNRG, 2024

Eligible fuel types include certified biofuels, renewable fuels of non-biological origin (RFNBO), and recycled carbon aviation fuels complying with RED-III sustainability and emission-saving criteria, up to a maximum of 70%, except for biofuels from food and feed-based crops, as well as low-carbon aviation fuels (European Council, 2023). Aircraft operators must ensure that the yearly offtake quantity of aviation fuel at an EU airport is at least 90% of the annual requirement. Both suppliers and operators are obligated to adhere to data collection and reporting requirements of the SAF regulations. Additionally, an EU-wide labelling scheme will be established to enhance consumer awareness about aircraft operators' environmental performance.

The EU's Emission Trading Scheme (ETS) has recently been revised to better incorporate SAF. As of February 2023, the European Council and Parliament agreed to revise ETS rules for the aviation industry, making EU ETS applicable only for intra-European flights (European Council, 2023). The revised rules involve phasing out free emission allowances for aviation: 25% in 2024, 50% in 2025, and fully auction-based thereafter. A separate allocation of 20 million free allowances is available to incentivize fuels instrumental in decarbonization.

Under the revised ETS, all fuels eligible under the ReFuelEU initiative are also eligible for SAF allowances. Airlines can deduct the cost of SAF (and other eligible fuels) from their total ETS bill, with varied price differentials defined by fuel types (e.g., 95% of the price for RFNBOs, 70% for advanced biofuels, and 50% for other eligible fuels). This mechanism will be valid until 2030.

The EU provides substantial funding to support the development and adoption of SAFs. The Horizon Europe program allocates significant resources for research and innovation in sustainable aviation technologies, including SAFs. Additionally, the Connecting Europe Facility (CEF) supports projects that enhance the EU's transportation infrastructure, including those related to SAF production and distribution.

The European Investment Bank (EIB) plays a crucial role in financing projects that contribute to the EU's climate goals. The bank offers loans and investment support for SAF production facilities, infrastructure development, and research initiatives. Separately, the €40 billion EU Innovation Fund, based on ETS credit auctions, provides grants for innovative low-carbon technologies, including SAF projects. This fund supports the scale-up of SAF production and the commercialization of new technologies. For instance, a Swedish SAF production plant is one such project in line for support from the EU Innovation Fund (European Commission, 2023).

The EU promotes collaboration between government agencies, industry stakeholders, and research institutions to advance SAF adoption. Initiatives like the Clean Sky Joint Undertaking and the SESAR Joint Undertaking foster PPP to develop and implement sustainable aviation technologies.

European airlines and fuel producers are actively participating in SAF development and deployment. Major airlines, including Lufthansa, Air France-KLM, and British Airways, are involved in SAF trials and pilot programs, supported by EU funding and regulatory frameworks.

EU member states are required to develop national implementation plans that align with EU-wide SAF mandates and targets. These plans detail the specific measures each country will take to promote SAF production and use, tailored to their unique circumstances and capabilities. Several EU countries have already taken significant steps to advance SAF adoption. For instance, the Netherlands has established a dedicated SAF production plant and implemented policies to support its growth. Similarly,

France has introduced incentives for SAF production and committed to increasing SAF usage in its aviation sector.

Nordic Cooperation: The Nordic countries, including Sweden, Finland, and Norway, are leaders in promoting SAFs. These countries have implemented ambitious national targets for SAF blending, supported by robust financial incentives and strong industry collaboration.

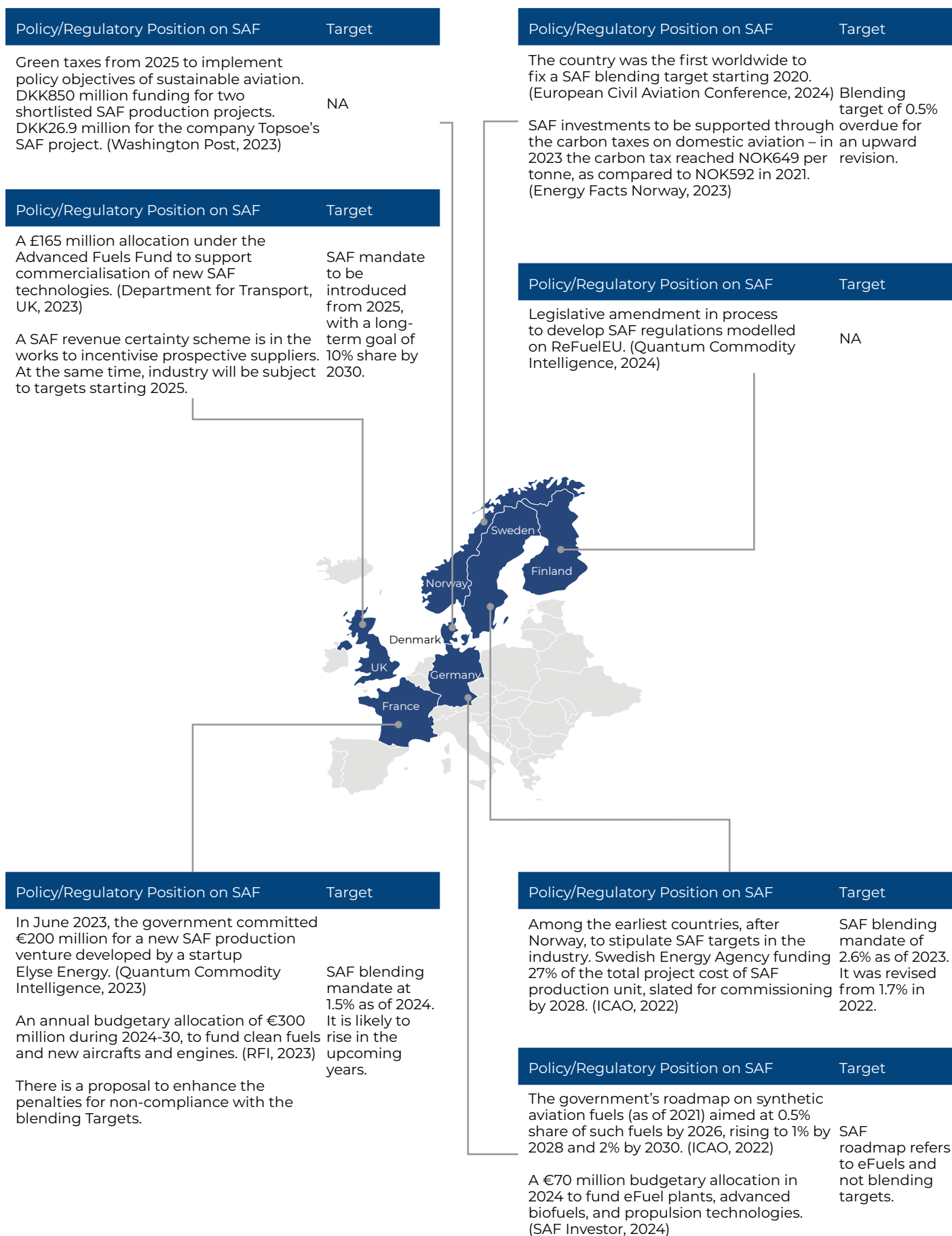
UK: Although the UK is no longer a part of the EU, it plays a significant role in the region's SAF landscape through its independent policies and regulations. The UK has established its own SAF mandates and incentives, aligning closely with EU objectives. The UK government has committed to a SAF strategy, including a "Jet Zero" plan that sets ambitious targets for SAF adoption. The UK is investing in SAF production facilities and providing substantial funding to support R&D in this field. Collaborative efforts between the UK and EU member states continue to bolster the overall SAF market in Europe, creating a cohesive approach towards decarbonizing the aviation industry.

The comprehensive approach to SAF policy and regulatory frameworks in Europe demonstrates a strong commitment to sustainable aviation. The major European policies, regulations and targets are summarised in Figure 9 - Major European SAF Policy Directives. Through a combination of mandates, incentives, collaborative efforts, and member state initiatives, the EU is creating a conducive environment alongside its European neighbours for the adoption and growth of SAFs. This multi-faceted strategy not only supports the EU's decarbonization goals but also positions the region as a leader in the global effort to reduce aviation's carbon footprint. The UK's parallel efforts further complement this regional momentum, highlighting the importance of cooperative and aligned strategies across Europe.



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Figure 9: Major European SAF Policy Directives



US

The US has taken significant strides in developing and implementing policies to promote the adoption of SAFs as part of its broader strategy to decarbonize the aviation sector. In this section the relevant federal level schemes are introduced followed by state-level policies that have specifically targeted local growth in the SAF industry.



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Sustainable Aviation Fuel Grand Challenge (SGC):

Launched in 2021, the SAF Grand Challenge is a collaborative initiative between the U.S. Department of Energy (DOE), the Department of Transportation (DOT), and the Environmental Protection Agency (EPA). The goal of this initiative is to produce 3 billion gallons of SAF per year by 2030 and achieve 100% SAF by 2050. The Grand Challenge outlines a multi-agency approach to accelerate the research, development, demonstration, and deployment of SAF technologies. Various tax incentives complement the SGC policy's goals, although it does not entail any binding targets for the industry and instead relies on voluntary SAF purchases.

Inflation Reduction Act (IRA):

The flagship US legislation that took effect in August

2022 seeks to incentivize domestic clean energy investments. The IRA categorizes SAF fuels as fuel mixtures that emit less than 50% GHG than petroleum-based jet fuel. Based on GHG emissions reduction, there is a production tax credit ranging from \$1.25 to \$1.75 per gallon. The tax credit provision is graded by the GHG improvements, with an incremental credit worth \$0.1 per gallon (up to \$0.50) for every additional percentage point of GHG reduction. SAF producers must register with the Internal Revenue Service to avail of the IRA's incentives. The offered tax benefit for 2023 and 2024 is limited to SAF blenders, while for 2025-2027, the coverage is for all producers of low-carbon fuels, including SAF. This latter phase of the tax credit, estimated to be worth \$3 billion, is critical for expanding the local SAF production base (WSJ, 2022) (US Govt Treasury, 2023).

The U.S. DOE's GHG, Regulated Emissions, and Energy Use in Transportation (GREET) model lays down the IRA methodology to calculate lifecycle GHG emissions related to SAF. An updated version of this model, originally targeted for March 1, 2024, is awaited. The GREET model will determine tax credit eligibility and corresponding disbursement for 2023 and 2024. The country's biofuel producers and agricultural feedstock suppliers are significantly impacted by the delayed GREET model update (Farmweek Now, 2024).

Administered by the EPA, the Renewable Fuel Standard (RFS) mandates the blending of renewable fuels into the nation's fuel supply. While primarily focused on biofuels for road transportation, recent amendments have started to recognize SAF as part of the renewable fuel categories, providing additional incentives for its production and use.

The Federal Aviation Administration (FAA) allocated \$244.5 million under Fuelling Aviation's Sustainable Transition (FAST) to support facilities in SAF production, blending, storage, and transportation. Additionally, there is a \$47 million allocation for organizations engaged in the development of low-emission aviation technology and enhanced test and demonstrate capabilities (Aviation Week, 2023). The FAA also supports the Commercial Aviation Alternative Fuels Initiative (CAAIFI), fostering PPP to promote SAF development and commercialization.

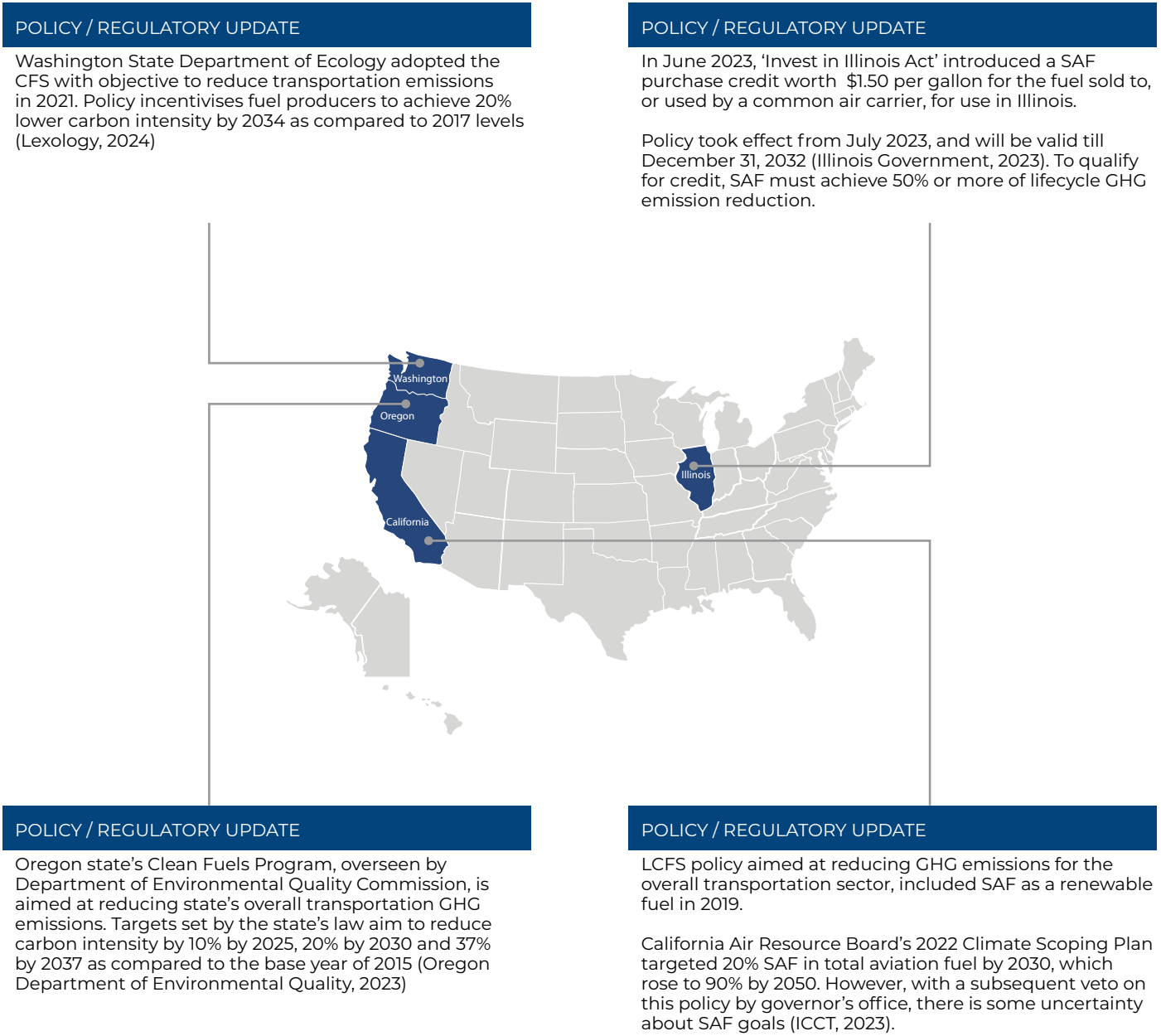
In addition to federal level-policies, supportive to the growing of the USA SAF industry, there are several state-level Regulations and Initiatives. **California** leads the nation in SAF policy with its Low Carbon Fuel

Standard (LCFS). Implemented by the California Air Resources Board (CARB), the LCFS incentivizes the production and use of low-carbon fuels, including SAF, by setting carbon intensity reduction targets. SAF producers can generate LCFS credits, which can be traded in the market, providing a financial incentive for SAF production. California's early start in this direction has significantly impacted biofuel production and supply, with the state showing a high concentration of biofuel production and distribution. **Washington** state has introduced the CFS, similar to California's LCFS, which sets carbon intensity reduction targets for transportation fuels. This standard

encourages the production and use of SAF by allowing producers to generate credits for compliance. Other states like **Illinois and Oregon** are also leading in SAF-related policies and regulations. These states are developing frameworks and incentives to support SAF production and adoption.

In summary, the United States has established a robust framework to support SAF adoption through federal initiatives, state-level regulations, and financial incentives. However, the success of these efforts depends on continuous collaboration among stakeholders and addressing the financial and technological challenges in SAF production

Figure 10 - SAF-related Policy in Key US States



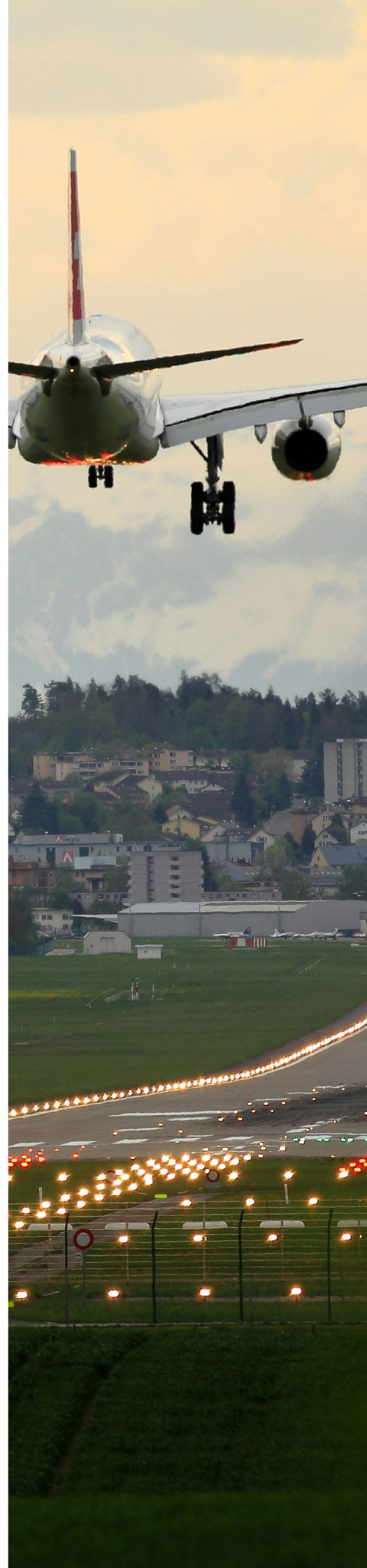
Other Countries

Figure 11- Snapshot of SAF-related Policy Initiatives in Select Countries

Country	Policy Measures
Japan 	Japan has been proactive in promoting SAF adoption through various initiatives. The country aims to achieve net-zero aviation emissions by 2050 and has set a target to replace 10% of its aviation fuel with SAF by 2030. (InfluenceMap, 2023) Japanese government supports SAF development through funding for research and pilot projects, collaborations between airlines and fuel producers, and efforts to streamline regulatory approval process for new SAF technologies. (Foreign Agriculture Office, USDA, 2022)
China 	China is gradually ramping up its efforts to integrate SAFs into its aviation sector. The country has established pilot programs and demonstration projects to test and scale up SAF production. China's aviation regulator, the Civil Aviation Administration of China (CAAC), is working on creating a supportive regulatory framework to encourage SAF adoption. Additionally, China is investing in R&D to explore various feedstock options for SAF production, leveraging its significant agricultural and waste resources. (Deloitte, 2023; The China Project, 2023)
South Korea 	A bill passed in the Parliament in September 2023 enabled SAF-based fuel sourcing for aviation. Quality standards for SAF are to be formulated within 2024. SAF blending mandates could be stipulated from 2026 onwards. (Business Korea, 2024; Quantum Commodity Intelligence, 2023)
Australia 	Australia is making strides in the SAF sector through a combination of government initiatives and private sector investments. Government has launched the "Aviation White Paper," which outlines strategies to reduce aviation emissions, including the promotion of SAFs. Key measures include financial incentives for SAF production facilities, partnerships with research institutions, and commitments from major airlines to incorporate SAFs into their fuel supply chains. (AIN, 2023; Australian Jet Zero Council, 2023)
India 	In November 2023, National Biofuels Coordination Committee announced an indicative target of 1% SAF blending in 2027, rising to 2% by 2028 (S&P Global, 2023). These will initially apply to international flights. In February 2023, the state-owned refining company Indian Oil Corporation partnered with US-based LanzaJet to build a SAF production facility (LanzaJet, 2023).
Singapore 	Policy framework on SAF, which is part of larger aviation decarbonization goals, was officially passed in February 2024 (Civil Aviation Authority of Singapore, 2024). Target is 1% SAF use for all departing flights from two Singapore airports by 2026, rising to 3% -5% by 2030 SAF initiatives are to be funded by a levy on outgoing travellers' tickets (Civil Aviation Authority of Singapore, 2023; CNBC, 2024; Greenair, 2023)
Brazil 	Brazilian government is exploring policies to promote SAFs, focusing on using biofuels derived from sugarcane and other crops. Brazil has launched several pilot projects to test the feasibility of SAFs and is working on regulatory frameworks to facilitate their commercial use (Quantum Commodity Intelligence, 2023). Brazil's national energy policy includes provisions for biofuels, which are expected to extend to SAFs as the industry develops (Apex Brazil, 2023).
Mexico 	Initiated collaborations between government agencies, airlines, and fuel producers to explore SAF opportunities (Mexico Business, 2024). Mexico's strategy includes developing a regulatory framework for SAF certification, providing financial incentives for production, and fostering international partnerships to leverage technological expertise.
United Arab Emirates 	Government invests in SAF R&D through entities like Etihad Airways and the Abu Dhabi National Oil Company (ADNOC) (Etihad, 2023; The National, 2023). UAE aims to position itself as a regional hub for SAF production, leveraging its advanced infrastructure and strategic location. The country is also participating in global initiatives and partnerships to promote SAF adoption (Arab News, 2023).
Qatar 	Qatar is focusing on developing a sustainable aviation sector as part of its broader environmental goals. Qatar Airways is actively involved in SAF research and pilot programs (Gulf Times, 2022). The Qatari government is supporting these efforts through regulatory measures and potential financial incentives to encourage SAF production and use (The Peninsula, 2023).
South Africa 	South Africa is exploring the potential of SAFs as part of its national biofuels' strategy. The country has identified SAFs as a key area for reducing aviation emissions and is investing in research to identify suitable feedstocks and production technologies. South Africa's approach includes fostering PPP and seeking international collaborations to build capacity in the SAF sector (WWF, 2023).
Kenya 	Kenya is in early stages of developing its SAF framework, leveraging its agricultural sector to explore feedstock options such as sugarcane and other bio-based materials. Aims to create a supportive policy environment for SAF production and use, focusing on regulatory approvals and international cooperation (Biofuels International, 2023).

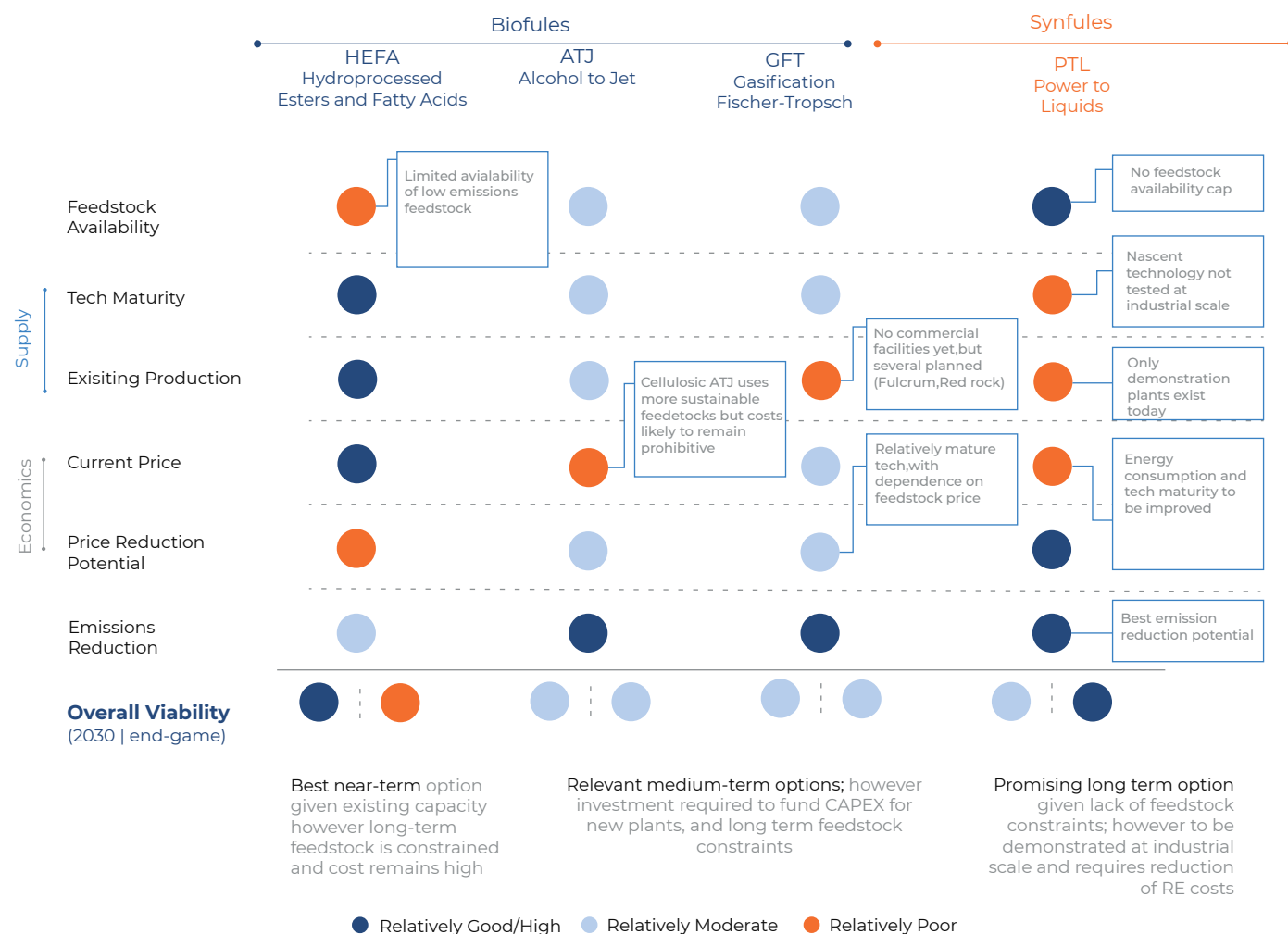
05

Production Pathways and Feedstock



Production Pathways

Figure 12 - Comparative View of the Leading Technologies across Maturity Stages



Source: BCG, 2023

The commercialization and diversification of SAF production technologies have been limited thus far. Currently, the hydroprocessed esters and fatty acids (HEFA) process dominates the production pipeline due to its proven commercial viability. While the HEFA pathway is currently the most mature and widely adopted method for SAF production, its limitations highlight the necessity for diversifying production pathways.

The HEFA pathway primarily depends on lipid-rich feedstocks such as used cooking oil (UCO), animal fats, and oilseed crops. However, the availability of these feedstocks is limited, and there is potential competition with food production and other biofuel applications. This dependency poses a risk to the scalability and sustainability of SAF production.

Diversification in production pathways is essential to address these limitations, enhance feedstock availability, and ensure a stable and resilient supply chain for SAF.

By exploring various production pathways, we can tap into a broader range of feedstocks, leverage different technological processes, and mitigate the risks associated with over-reliance on any single method. This chapter delves into the different production pathways for SAF, examining their feedstocks, processes, advantages, and limitations.

There are various SAF production pathways, each at different levels of commercialization. These pathways differ in their feedstock sources and have varying limitations when it comes to blending with

conventional jet fuel. The industry is exploring multiple options to develop and scale up SAF production, reflecting the diverse approaches being pursued in this field. This chapter focuses on four key pathways which are summarised in Figure 12 : HEFA, ATJ, Gasification Fischer-Tropsch (GFT), and PtL.

HEFA currently dominate the SAF market, accounting for over 90% of production. HEFA utilizes oil-based feedstocks such as jatropha, algae, camelina, and yellow grease. It has a blending limitation of 50% and is at an advanced stage of commercialization. However, it faces significant constraints in sustainable feedstock supply, which may impact its long-term scalability.

Emerging technologies like ATJ and GFT are at earlier stages of commercialization but show promise in unlocking more abundant and lower-cost feedstocks. ATJ, for instance, utilizes cellulosic biomass and can blend up to 50%. This pathway is still developing but offers significant potential for scaling up using diverse biomass sources. GFT, which can also blend up to 50%, uses municipal solid waste and energy crops as feedstocks. GFT is poised to leverage the vast amounts of waste materials available, thus presenting a viable route for large-scale SAF production in the future.

PtL represents a cutting-edge approach by offering a fully synthetic route to carbon-neutral fuels. While PtL is still in the early stages of commercialization, it promises to produce SAF with a minimal carbon footprint by synthesizing fuels from carbon dioxide and water using renewable energy. This pathway can achieve a 50% blend with conventional jet fuel and is expected to become a critical technology for long-term sustainability in aviation.

The remainder of this chapter presents four leading SAF production pathways, focusing on their technology readiness, current production capacity, cost competitiveness, highlights notable projects and partnerships exemplifying the status and trajectory of each technology. Finally, we will share our perspective on how the SAF production mix is likely to evolve in the near, medium, and long term.

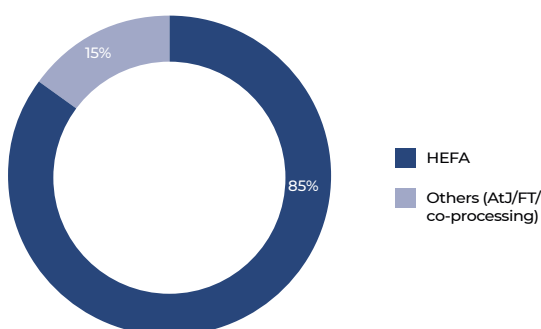


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HEFA: Constrained by Feedstock Availability

HEFA is the most technologically and commercially mature SAF pathway, accounting for over 90% of expected production through 2028 according to IATA estimates. In the HEFA process, waste oils, fats, and greases are hydrotreated and hydrocracked to remove oxygen and produce a drop-in jet fuel.

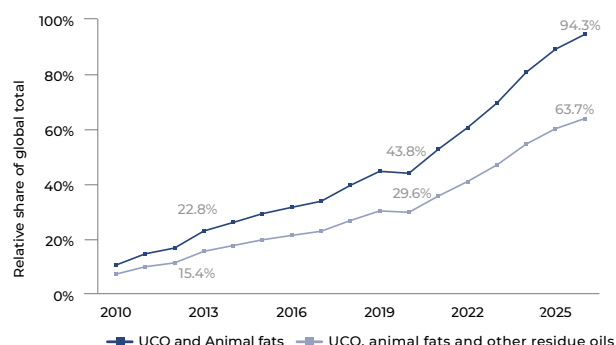
Figure 13 - HEFA Share in Expected Production till 2028



Source: IATA, 2023

Multiple standalone HEFA refineries are operating worldwide, with major producers like Neste, World Energy, and Diamond Green Diesel rapidly expanding capacity. The World Economic Forum projects HEFA could scale to nearly 15 billion litres annually by 2030.

Figure 14 - Biofuel Demand Share of Global Wastes and Residues

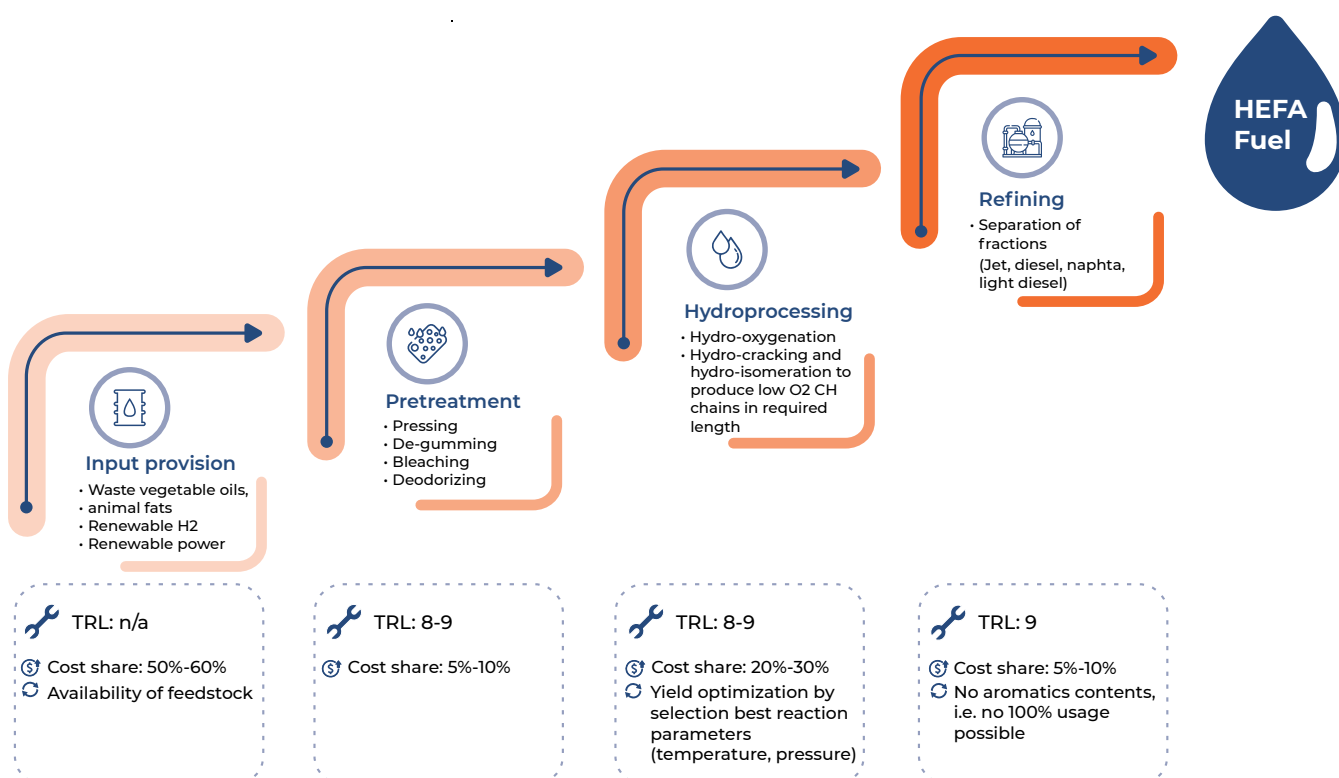


Source: IEA, 2023

However, HEFA growth is constrained by the availability of waste oil feedstocks, primarily UCO and animal fats. As shown in Figure 14, UCO and animal fat demand for biofuel production could exceed 60% of the total supply by 2025, crowding out food and oleochemical uses.

Virgin vegetable oils like soybean and canola can supplement the feedstock pool but risk displacing food crops and generating indirect land use change emissions. Governments may need to incentivize UCO collection and aggregation to keep pace with HEFA demand. Importing UCO from regions like Asia is another option being explored (Capgemini, 2023).

Figure 15 - Illustrating the HEFA Value Chain and its Cost Distribution



Source: SkyNRG, 2024

Alcohol-to-Jet: Abundant Feedstocks, Scaling Challenges

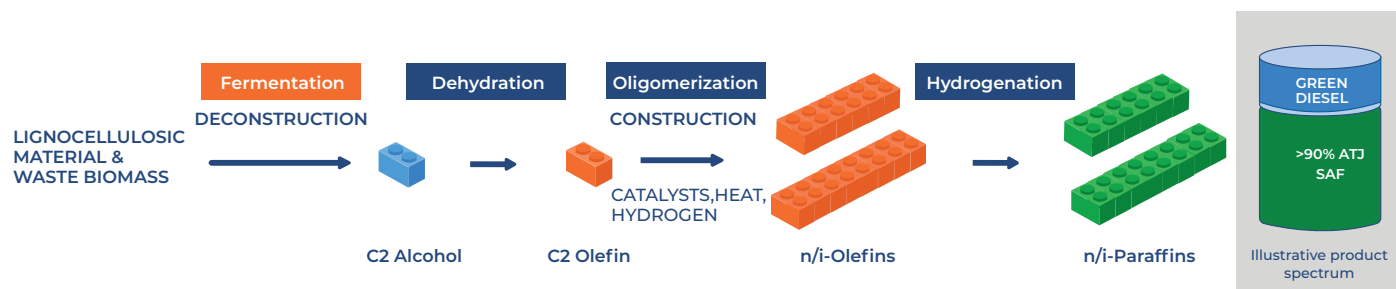
ATJ technology converts alcohols derived from various sources into jet fuel. The process, also known as alcohol oligomerization, utilizes alcohols such as methanol, ethanol, butanol, and long-chain fatty alcohols as feedstocks. ATJ offers a promising pathway for developing drop-in or fungible SAF, overcoming the blend wall limitation of ethanol in gasoline-powered vehicles, which is typically capped at 10-15%. One notable subset of ATJ is methanol-to-jet (MTJ), which specifically focuses on converting methanol into jet fuel.

Companies at the forefront of ATJ commercialization, such as Lanzajet, Gevo, and Velocys, are retrofitting existing facilities or constructing new ones to convert diverse feedstocks into SAF. Lanzajet focuses on retrofitting ethanol plants to minimize environmental impact, while Gevo utilizes corn starches, and Velocys converts municipal waste. The ability to use

abundant, lower-cost waste materials as feedstocks is a significant advantage of ATJ, potentially providing a more sustainable and economical method of SAF production compared to traditional oils. MTJ, as a subset of ATJ, also benefits from these advantages, as methanol can be derived from various sources, including biomass, municipal waste, and industrial gases.

However, ATJ face several challenges in scaling up to commercial production. The capital costs associated with ATJ facilities are higher compared to traditional refineries, which can hinder investment and adoption. Additionally, the technology needs to demonstrate its viability at a commercial scale to attract further investment and support. To boost ATJ's viability and accelerate its deployment, policy support through incentives such as tax credits, loan guarantees, and LCFS is crucial.

Figure 16 - Illustration of the AtJ Production Route



Source: HCS Group, 2023

Gasification Fischer-Tropsch: Waste-to-Fuel Potential

GFT is another promising method for converting various types of waste materials such as municipal solid waste (MSW), agricultural residues, and forestry wastes into SAF. This process involves several steps: first, biomass undergoes gasification to produce syngas, a mixture primarily composed of carbon monoxide (CO) and hydrogen (H₂). This syngas is then purified and conditioned to remove impurities before being converted into liquid fuels (DoE, 2023).

GFT offers distinct advantages, particularly the utilization of non-food feedstocks at relatively low costs. Historically, GFT technology has been employed to produce liquid fuels from coal and natural gas. However, adapting it to handle heterogeneous waste streams poses challenges, particularly in ensuring the syngas purity meets the stringent requirements for efficient Fischer-Tropsch catalysis (Worley, 2024).

In terms of commercialization, GFT is still in its early stages compared to other SAF production methods like HEFA and ATJ. Currently, a few companies are pioneering commercial-scale GFT biorefineries:

Fulcrum BioEnergy is launching a plant in Nevada designed to process 175,000 tons of household garbage annually (WEF, 2024).

Red Rock Biofuels is constructing a facility in Oregon aimed at converting 136,000 tons of wood waste into 15 million gallons of GFT jet and diesel fuel annually (WEF, 2024).

Velocys is developing a GFT plant in Mississippi with plans to process 100,000 tons of wood waste annually, yielding 20 million gallons of SAF (WEF, 2024).

One of the primary challenges facing GFT is its high capital cost. For instance, Fulcrum BioEnergy's Nevada biorefinery required an investment exceeding \$500 million to achieve an annual output of 11 million gallons. To overcome this financial hurdle, developers have relied heavily on government grants, loan guarantees, and long-term offtake agreements to secure positive final investment decisions. Additionally, policies such as low carbon fuel standards in states like California, Oregon, and Washington are crucial as they enhance project viability and attract investment by improving financial returns as projects scale up and technology designs are optimized. These standards create a market demand for SAF, thereby supporting the economic feasibility of GFT facilities.

Power-to-Liquids: The Fully Synthetic Route

PtL represents the future vision for creating carbon-neutral jet fuels using renewable electricity, water, and atmospheric CO₂. This process, also known as electrofuels, starts with renewable power splitting water to produce green hydrogen. This hydrogen is then combined with captured CO₂ to synthesize liquid hydrocarbons using established methods such as FT or MTJ.

PtL technologies offer several advantages over traditional biofuel methods by eliminating the constraints and sustainability issues associated with biomass feedstocks. Unlike biofuels, which rely on agricultural or waste biomass, PtL processes use electricity and water, avoiding concerns like land use limitations, deforestation, and soil degradation. This makes PtL a more sustainable and scalable solution for fuel production.

Geographically, PtL can be deployed wherever there is access to low-cost renewable energy sources such as solar, wind, or hydroelectric power. This capability allows for fuel production in regions unsuitable for biomass cultivation, decentralizing production and reducing transportation emissions and costs. By utilizing abundant renewable energy sources, PtL enhances energy security and market stability.

From an environmental standpoint, PtL offers near-zero lifecycle GHG emissions by capturing CO₂ from the atmosphere to synthesize fuel. By using renewable energy throughout the process, PtL minimizes additional GHG emissions, aligning with global climate objectives and reducing dependence on fossil fuels. This sustainable approach to carbon recycling helps mitigate the overall carbon footprint of the fuel.

The fuels produced by PtL meet all specifications required for jet fuels and are compatible with existing jet engines without modifications (McKinsey, 2022). This compatibility facilitates a seamless transition from fossil fuels to sustainable alternatives, accelerating the adoption of cleaner aviation fuels and significantly reducing the environmental impact of the aviation industry.

However, PtL faces significant economic and scaling challenges. The cost of renewable hydrogen from water electrolysis is currently higher than hydrogen derived from fossil fuels, and carbon capture is energy-intensive. Under optimistic conditions of low-cost renewable electricity and affordable carbon capture technologies, PtL could potentially achieve cost parity with petroleum jet fuel by 2040, but this would require substantial investment in renewable power capacity dedicated to hydrogen production (WEF, 2024).

Initial commercial PtL plants are expected to be much smaller than traditional refineries, producing between 10 to 100 million litres per year. For instance, Norsk e-Fuel is developing a 10 million litre PtL pilot plant in Norway using wind power and direct air capture, while Synhelion is piloting a novel solar thermochemical approach at a smaller scale in Germany, Spain, and Chile.

In essence, PtL represents a promising pathway towards SAF, leveraging renewable resources to produce drop-in fuels that meet stringent industry standards while minimizing environmental impact. However, overcoming economic and scaling challenges will be crucial for realizing its full potential.

Figure 17 - Key Partnerships to Secure SAF Feedstock

Date	Companies Involved	Rationale
Feb-23	Nippon Paper, Sumitomo Corp and Green Earth Institute Corp	Research partnership for woody biomass-based bioethanol production. This will aim to produce bioethanol from Nippon Paper's mills in 2027 to be used as a feedstock for SAF production (Reuters, 2023).
Aug-23	Idemitsu Kosan and LOPS Corp.	As part of the collaboration, the two companies will establish a stable feedstock supply chain to procure SAF feedstocks, including UCO, from various parts of Japan. Idemitsu Kosan will use its petroleum manufacturing technology, and LOPS will use its knowledge of animal and vegetable oils and fats, along with their respective supply chains, to procure SAF feedstocks (Biomass Magazine, 2023).
Dec-23	New Energy Farmers LLC	New Energy Farmers is a biomass aggregation company jointly owned by Iowa farmers and New Energy Blue. Its purpose is to supply clean, sustainable feedstock to the New Energy Freedom Biomass Refinery. A majority of New Energy Farmers' stock will be owned and managed by corn growers who have already committed to providing Freedom Biomass with excess corn stover (PR Newswire, 2023).
Jan-23	United Airlines, Green Plains and Tallgrass Energy Partners	United Airlines formed a joint venture with ethanol producer Green Plains and energy developer Tallgrass Energy Partners to develop a technology for converting corn-based ethanol into a SAF. Under the joint venture, Green Plains will supply the ethanol feedstock from its ethanol plants in the Midwest (DTNPF, 2023).
Mar-24	Repsol and Bunge	As a result of this partnership, Repsol will gain access to a wide range of low-carbon energy feedstocks for renewable fuels. Vegetable oils and derivatives producer Bunge will supply low carbon-intensive raw materials for production (Repsol, 2024).
May-23	Alfanar and N+P	The partnership will transform household rubbish into pellets at several specially built waste treatment facilities throughout the UK. In turn, Alfanar will convert the pellets into SAF (N+P, 2023).
Apr-23	Apical and Cepsa	A joint venture aims to create the largest biofuel plant in southern Europe and produce second-generation biofuels. The plant will secure the majority of its feedstock supply from Apical's agricultural waste and residue. Cepsa will contribute its technical expertise and experience to fuel production development (Apical, 2024).
Jan-22	Preem AB and LÍpidos S.A. (Lipsa)	As part of the agreement, Preem will secure access to feedstock raw materials essential to its conversion to renewable fuels (Bioenergy, 2022).

Leading energy companies are investing in PtL technology to gain an early-mover advantage. Sunfire and Climeworks are collaborating on PtL technology, while Lufthansa is exploring its integration into future fuel supplies.

Although PtL offers the most promising long-term solution for carbon-neutral aviation, its widespread adoption faces challenges. In the near term, HEFA will remain the dominant SAF production method, with ATJ and GFT beginning commercial-scale operations. Government support and industry commitments are crucial for improving economics and driving scale-up across all pathways through 2050.

The choice of SAF pathway depends on regional factors such as feedstock availability, costs, and carbon reduction goals. Increasing biofuel demand could strain agricultural production, highlighting the need to prioritize waste residues and synthetic PtL routes. A diversified approach across multiple pathways, guided by sustainability criteria and supportive policies, is essential to meet aviation's decarbonization targets.

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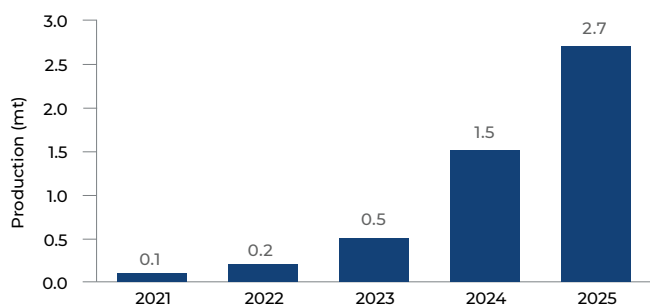
Supply & Development Pipeline



Supply & Development Pipeline

The outlook for SAF supply presents both promising short-term growth and challenging long-term targets. In the short term, the SAF market is expected to witness exponential growth, driven by an initial build-out from a relatively small production base. Projections indicate that by the end of 2024, total SAF production could reach 1.5 million tonnes or higher (S&P Global, 2023). The European region is poised to play a significant role, potentially contributing over half of the projected global SAF output, while the Americas and Asia are expected to share 23%-24% each. However, maintaining this production momentum may prove challenging. For instance, the projected production of 2.7 million tonnes by 2025 represents a relatively lower annual growth rate compared to the previous two years.

Figure 18 - Short-term Outlook on SAF Production [2023 production figure is estimated; 2021-2024 data from IATA, 2025 data from S&P Global]



Source: IATA, 2023; S&P Global, 2023

Looking further ahead, long-term projections suggest that 25%-30% of the total renewable fuel production should be dedicated to SAF by 2030 (IATA, 2023). Achieving this shift in renewable fuel supply towards SAF will heavily depend on policy support and incentives. Currently, leading biofuels such as ethanol primarily serve road transport due to favourable incentives. A better risk-reward balance, driven by supportive policies, could convince producers to pivot towards SAF production. The ICAO emphasizes that 2030 production levels are highly sensitive to the degree of policy support for SAF.

Figure 19 - Scenario-based Projected SAF Supply by 2030

Scenario	Implicit policy landscape	2030 SAF Production (kt/year)	SAF replacement ratio
Low	No policy support	3,059	-
Moderate	Some level of support but lower than road transportation biofuels	7,608	2.19%
High	A level-playing field between SAF and road transportation biofuels	13,713	3.98%
High+	SAF-emphasis in policies	16,973	5.01%

Source: ICAO, 2022

This chapter delves into the intricacies of the SAF supply outlook, exploring existing producers, the potential growth trajectories based on the current announced pipeline of projects, regional contributions, and the major players shaping the future of sustainable aviation development and fuel production.

Existing Producers

The global landscape of SAF production is currently limited, with only a few major entities operating at commercial scale. Neste and World Energy are the two largest producers globally, highlighting the nascent stage of SAF production infrastructure. The industry has seen limited incentives, which has resulted in many existing biofuel producers and refiners focusing on biodiesel and other mixed by-products rather than SAF. With improved demand prospects, many of the operational capacities currently equipped with SAF capabilities are expected to become active.

Recent policy measures are beginning to change this dynamic. In the United States, the IRA and in Europe, the ReFuelEU initiative, have provided significant impetus for setting up new production facilities and expanding existing ones. Despite these efforts, the planned capacities will take time to come online, leading to short-term capacity constraints as SAF demand continues to rise. To address this demand more swiftly, some existing refineries may be retrofitted or repurposed.

The US, and particularly California, has been a leader in SAF supply contracts and the establishment of fuel distribution hubs, demonstrating the impact of state-level incentives. However, most of the existing biofuel US capacity has been directed toward transportation fuels due to the stronger incentives available in that sector, and the current lack of competitive incentives specifically for SAF.

Despite the predominance of HEFA processes in the US biofuel industry, there are notable investment commitments towards alternative technologies. One prominent example is LanzaJet’s Ethanol-to-Jet production facility, which is scheduled to commence operations in 2024 (Greenair, 2024). This represents a significant step towards diversifying the technological base for SAF production.

Most existing US-based biofuel refineries are primarily aligned with producing renewable diesel and other fuel types. Transitioning these refineries to SAF production will require a combination of incentives and the creation of a robust demand opportunity. Given that the US accounts for 40% of global biofuel production (IEA, 2023), its producers are well-positioned to play a much larger role in the global SAF supply chain.

Figure 20 - US-based SAF Production Units

Company	Location	Technology	Capacity
Montana Renewable	Great Falls, MT	Hydrotreatment	2,000-4,000 barrels per day
World Energy	Paramount, CA	Hydrotreatment	5,000 barrels per day
Gevo	Silsbee, TX	Alcohol-to-Jet	(Pilot) 265m ³ /day

Source: demoplants, n.d.; CBC, 2023; SAF Magazine, 2024

World Energy, based in the US and the world’s second-largest SAF producer, exemplifies this potential. The company has announced plans to convert its renewable diesel plant to a SAF-focused facility by 2025 (AIN, 2023). This move underscores the significant role that existing biofuel producers in the US can play in scaling up SAF production, provided the right mix of policy support and market demand is in place.

The European region boasts a more extensive SAF production base compared to the United States. This advantage is partly due to the early adoption of renewable fuels, including renewable diesel, by many of its refiners. Regional directives, such as the ReFuelEU initiatives, along with country-level regulations, have significantly contributed to the early start of SAF production in Europe.

Neste, a Finnish company, stands as the world’s largest SAF producer, highlighting the leadership role Europe plays in this sector. The proactive regulatory environment has fostered a conducive atmosphere for SAF development, making Europe a frontrunner in SAF production.

In summary, while the US is gearing up to expand its SAF capabilities with strong state-level incentives and innovative technologies, Europe has leveraged its early start and supportive regulatory framework to establish itself as a leader in SAF production. Together, these regions are paving the way for a more sustainable future in aviation.

Figure 21 - Existing European SAF Producers [Data is indicative; existing refining plants also produce renewable diesel]



Source: BP, 2023; HCS Group, 2023; Eni, 2023; Oilfield Africa, 2023; Neste, n.d.; SAF Investor, 2023; St1, 2023; TotalEnergies, 2022

Development Pipeline

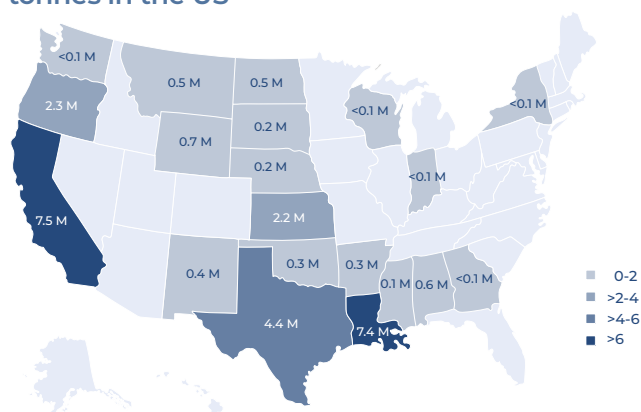
The development pipeline for SAF production in the US is marked by significant growth potential, with many ongoing projects expected to come online from 2025 onwards. The time required for these new capacities to ramp up production levels will play a crucial role in meeting the country's policy goals for reducing aviation emissions.

Currently, most of the existing SAF production and consumption in the US is concentrated in California, driven by favourable government incentives. This has created a robust project pipeline primarily based on agro-based biomass feedstock, with the HEFA production process dominating the upcoming capacities.

A study by the International Council on Clean Transportation (ICCT) on the US SAF pipeline indicates that while existing feedstock might be sufficient to meet the 2030 SAF production targets, it may fall short of achieving the 2050 Net Zero goal (ICCT, 2023). Reaching these long-term targets will likely require the development and scaling of alternative SAF production technologies to reduce reliance on biomass feedstock.

Alternative SAF production technologies to HEFA, such as AtJ and PtL, are currently in the minority among projects under development. However, there are notable developments in this area. In January 2024, LanzaJet inaugurated its ethanol-based SAF production facility in Georgia, which, once fully operational, will produce approximately 10 million gallons of SAF annually (LanzaJet, 2024). Additionally, the US-based startup Twelve is on track to commission the first PtL plant by the end of 2024, signalling a growing interest in diversifying SAF production technologies (Carbon Herald, 2024).

Figure 22 - Cumulative Announced SAF Development Production Capacity in metric tonnes in the US



Source: Boeing, 2023
Note: Data as of Jan 2024

The US SAF development pipeline is set to expand significantly in the coming years, with various projects aimed at increasing production capacity and exploring new technologies. This growth will be essential in ensuring the aviation industry can meet its decarbonization targets and transition to more sustainable fuel sources.

Europe is also experiencing a significant expansion in its SAF production capabilities. As of October 2023, there were 70 planned SAF projects across the continent, with Germany leading in the number of projects under development. The European SAF project pipeline is notable for its focus on PtL technology, a direct result of the requirements set forth under the ReFuelEU directives.

ReFuelEU mandates that e-kerosene blending must reach 1.2% by 2030, progressively increasing to 35% by 2050. This regulation has spurred a substantial number of e-kerosene projects within the European Economic Area (EEA). Among the SAF projects under development, there are 50 e-kerosene projects, which collectively exceed the 2030 target capacity (T&E, 2024). However, none of these projects have yet reached the final investment decision stage, raising concerns about their ability to meet the mandated blending levels in time.

The emphasis on PtL technology in Europe underscores the region's commitment to integrating more sustainable and innovative approaches to fuel production. The combination of regional and country-level regulations, alongside significant policy measures like ReFuelEU, has positioned Europe as a leader in the global SAF market. Despite these advancements, the need for final investment decisions remains a critical step in ensuring these projects can move from planning to production.

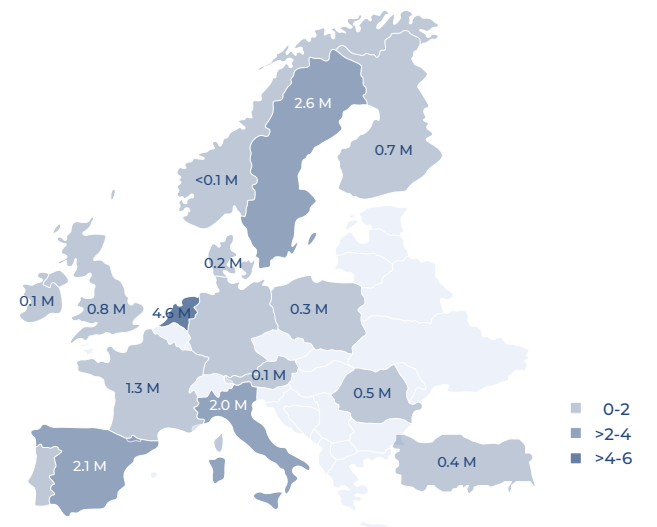
Several notable developments in Europe include: **Cepsa and Apical** constructing a biofuels plant in Huelva, Spain to produce 500,000 tons of SAF and renewable diesel. The plant is scheduled to begin production in 2026 with an investment of €1.2 billion. (Global Energy Infrastructure, 2024; Apical Group, 2024).

Velocys is setting up a plant with 20 million gallons per year of SAF capacity at Immingham in the UK in partnership with British Airways. The plant is expected to start production in 2028. The UK's Department of Transport has provided a grant of £27 million (\$34m). (Green Air, 2024; Velocys, 2024).

LanzaJet is establishing a 100 million litres per year SAF production facility in the UK with AtJ technology. The facility is expected to start production in 2026. The UK's DOT has granted £25 million for the project. (Ethanol Producer, 2024; Turley, 2023).

Overall, the development pipeline for SAF production in both the US and Europe shows promising growth trajectories. While the US focuses heavily on leveraging its substantial biofuel production capacity, Europe is pioneering in the adoption of advanced PtL technologies. Both regions face unique challenges and opportunities, but their combined efforts will be instrumental in scaling up SAF production to meet global aviation decarbonization goals.

Figure 23 - Cumulative announced SAF Development production capacity in metric tonnes in Europe



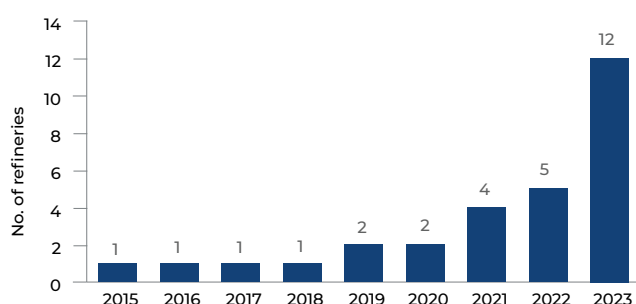
Source: Boeing, 2023
Note: Data as of Jan 2024



Repurposed or Reconfigured Refineries

The rising demand for SAF presents a significant opportunity for conventional refiners to consider a shift towards SAF production through the reconfiguration of existing capacities. Large-scale refiners, in particular, are well-positioned to undertake plant conversions due to the efficiencies of scale they possess. In the US market, this trend is evident as smaller and less competitive refineries gradually close their doors whilst over the past few years has seen a significant uptick in the number of refineries converting to renewable fuels production across SAF, renewable diesel, and other bio-fuels (McKinsey, 2023).

Figure 24 - US Refinery Conversions to Renewable Fuels



Source: McKinsey, 2023

Note: Data includes conversions done for renewable diesel, SAF and other marketable by-products; 2023 is estimated

Globally, ongoing refinery conversions underscore the impact of demand pressures on refiners' decisions to embrace sustainable fuel production. Notable instances of refinery conversions worldwide highlight the diverse strategies adopted by companies to tap into the growing SAF market. Some of these conversions involve partnerships with technology providers, leveraging proprietary processes to enhance efficiency and competitiveness. For example, Repsol in Spain and Eni in Italy have deployed Honeywell's Ecofin technology, while Swedish refiner Preem has adopted Topsoe AS technology.

Incentives play a crucial role in attracting existing biofuel refineries towards SAF production. Many biofuel refineries are already equipped to handle both SAF and biodiesel but have chosen to focus on biodiesel production. Given that biodiesel is the fastest growing subsegment in biofuels after ethanol, transitioning to SAF would require comparatively better incentives. Select examples of refiners currently in the process of converting their capacities to SAF highlight the potential driven by demand opportunities. Eni of Italy, for instance, is implementing reconfiguration to incorporate built-in

flexibility in its biorefineries, alongside greenfield SAF investments (Eni, 2023). Similarly, US-based Valero is converting half of its existing renewable diesel capacity to a SAF plant, demonstrating a strategic shift towards SAFs (PR Newswire, 2023).

Figure 25- Notable Instances of Refinery Conversions Completed or Underway Globally

Entity	Country	Particulars
TotalEnergies	France	With €500m investment, the converted biorefinery will be operational from 2025, with full capacity expected by 2027 (Oil & Gas Journal, 2023).
Eni SpA	Italy	Signed agreement in November 2023 for new and converted biorefineries, in partnership with Honeywell for Ecofining technology (Oil & Gas Journal, 2023).
Beyond Petroleum	Australia	In January 2024, secured regulatory approval to convert a refinery at Perth. This project is one of the company's five planned globally (FT, 2024).
Repsol	Spain	\$130m investment outlay to retrofit existing diesel plant into a biofuel refinery of 240,000 MT annual capacity (Reuters, 2023).
Phillips66	US	\$1.25b investment to convert Rodeo-based conventional refinery to one of biofuels. As of June 2024, the plant reached full production rates of about 50,000 b/d (800 million gal/year) (Oil & Gas Journal, 2023).
Preem AB	Sweden	Announced \$532m investment to convert its Lysekil diesel facility to one of biofuel, capable of producing SAF and bio-diesel by 2027 (Oil & Gas Journal, 2023).

Major Players

This table shows a summary of the major players in both the existing SAF supply and forthcoming supply of SAF in the development pipeline. More detailed company profiles can be found in the appendix of this report.

Company	HQ	SAF Supply Target	Role in SAF	Target Year
 NESTE	Finland	2.2 Mn Tons	Neste is one of the leading producers of SAF, renewable diesel and renewable feedstock solutions for the polymers and chemicals industry.	2026
 world energy	USA	1 Bn Gallons	World Energy is one of the world's first producers of SAF and has been producing renewable fuels for over 25 years.	2030
 TotalEnergies	France	1.5 Mn Tons	TotalEnergies is a multinational multi-energy company operating in oil and gas, renewable, and bioenergy segments and is one of the "Supermajor" oil companies worldwide.	2030
 Fulcrum BIOENERGY	USA	400 Mn Gallons	Fulcrum BioEnergy is a clean energy company focused on reducing CO ₂ emissions and wastes to pioneer renewable and transportation fuels from landfill waste.	NA
 gevo	USA	1 Bn Gallons	Gevo is one of the leading renewable chemical and advanced biofuels companies. Gevo operates in the sustainability sector, pursuing a business model based on the concept of the "circular economy".	2030
 LanzaJet	USA	1 Bn Gallons	LanzaJet was established with a primary focus on advancing SAF through the commercialization of cutting-edge, proprietary AtJ technology.	2030
 DG FUELS	USA	120 Mn Gallons	DG Fuels manufactures renewable hydrogen and biogenic-derived synthetic low-emissions aviation and diesel fuel. Through its synergistic process, it overcame the carbon utilization barrier, achieving an efficiency of up to 97% in carbon utilization.	2026
 VELOCYS	UK	NA	Velocys offers patented technology that facilitates the production of drop-in, net-zero SAF, allowing for safe and efficient manufacturing on a commercial scale.	NA
 SKYNRG	Netherlands	290,000 Tons	SkyNRG is one of the global SAF leaders, actively sourcing, blending, and distributing SAF to airlines worldwide while forming partnerships to boost SAF supply and production globally.	NA
 ALDER RENEWABLES	USA	NA	Alder Fuels, now Alder Renewables, is a new clean technology pioneering in advanced SAF production using forest and crop waste.	NA
 MONTANA RENEWABLES	USA	230 Mn Gallons	Montana Renewables is one of the leading producers of SAF in North America that specializes in alternative fuels, such as renewable diesel and SAF, utilizing waste materials as feedstocks.	2024
 NACERO	USA	Up to 1,462.2 MT per day of SAF	Nacero Inc is a clean fuels development platform that will produce Biomethanol, Sustainable Aviation Fuel ("SAF"), Low Carbon Aviation Fuel ("LCAF") and light fuels.	NA

07

SAF Offtake



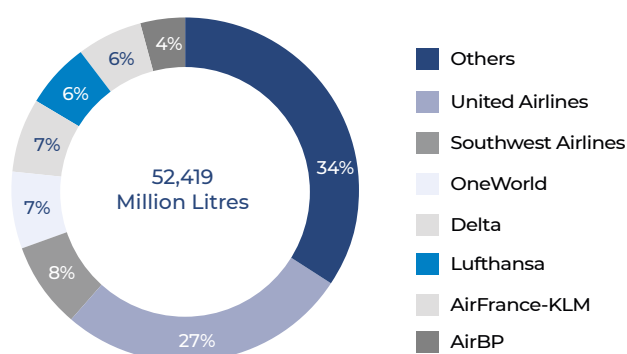
SAF Offtake

The global SAF offtake market is evolving rapidly, driven by regulatory mandates, corporate sustainability commitments, and advancements in production technologies. Governments worldwide are implementing policies to mandate or incentivize SAF usage. Regulatory frameworks such as the EU's ReFuelEU Aviation initiative, the United States' SAF Grand Challenge, and Canada's Clean Fuel Regulations are creating demand for SAF through blending mandates and financial incentives. These regulations are pivotal in driving market growth and ensuring a steady demand for SAF. This chapter explores the current state of the global SAF offtake market, including key players, market dynamics, offtake agreements, challenges, and future prospects.

Regulatory Drivers: Governments worldwide are implementing policies to mandate or incentivize SAF usage. Regulatory frameworks such as the EU's ReFuelEU Aviation initiative, the United States' SAF Grand Challenge, and Canada's Clean Fuel Regulations are creating demand for SAF through blending mandates and financial incentives. These regulations are pivotal in driving market growth and ensuring a steady demand for SAF.

Corporate Sustainability Commitments: Airlines and aviation companies are making significant sustainability commitments, often in response to shareholder pressure and consumer demand for greener travel options. Major airlines have announced ambitious targets for SAF usage, entering into long-term offtake agreements to secure supply and demonstrate their commitment to reducing emissions.

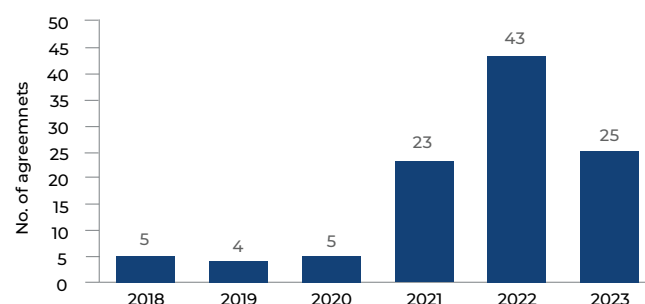
Figure 26 - Major Purchasers by Offtake Volume
Data refers to ICAO's tracked total of 120 offtake agreements as of the end of February 2024.



Source: ICAO, 2024

Globally, by November 2023, airlines had entered into forward purchase agreements on SAF worth \$45 billion. In volume, these contracts outstripped the existing availability, indicating that airlines are securing the supplies they need for fuel transition and suppliers are leveraging these contracts for capacity expansion (IATA, 2023). These commitments highlight the cost burden that the industry must bear, with airlines incurring an additional \$500 million in costs due to SAF purchases in 2022. ICAO's latest estimates from the tracked 120 offtake agreements show a volume of over 52 billion litres, with seven airlines holding two-thirds of the total offtake volume, and United Airlines alone holds over a quarter in share.

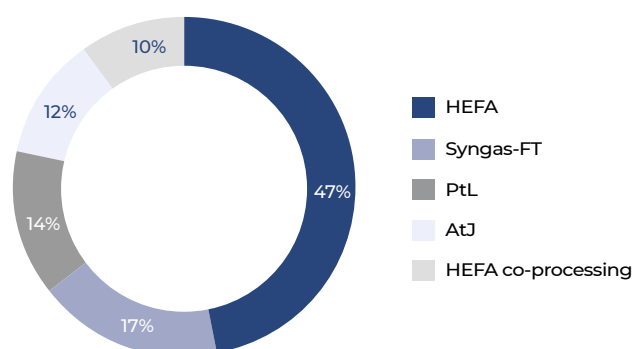
Figure 27 - Offtake Agreements Announced



Source: ICAO, 2024

As shown in Figure 27 announced offtake agreements have been on the rise over the past 6 years, with a rush for deals by the end of 2022 in response to the Refuel EU Aviation package. In many cases, offtake agreements are also related to SAF production. This has been the case in the US, where long-term offtake agreements are, in effect, agreements for production (Fastmarkets, 2024). However, the SAF offtake market lacks depth due to limited transactions. Pricing often does not reflect the market condition as contracts are based on one-on-one negotiations. Many agreements are open-ended and refer to the airline's right to purchase, instead of a firm long-term procurement. The absence of a spot market makes the commercials challenging for SAF producers and buyers to close deals.

Figure 28 - Distribution of Offtake Contracts by Production Processes [mid-2023]



Source: IATA, 2023

Another consideration is the proportion of offtake volume associated with each production method. IATA's estimates as of mid-2023 indicate that 85% of the contracted volume is based on the HEFA process (IATA, 2023). However, HEFA ranks lowest in scalability for the upcoming fuel requirements. Airlines must consider this factor in emerging procurement scenarios. In February 2024, the International Airlines Group (IAG) announced a 14-year contract for 785,000 tonnes of SAF based on PtL using renewable energy and CO₂. This contract, to be met by the US-based producer Twelve, will support IAG's five European airlines, namely British Airways, Iberia, Aer Lingus, Vueling, and LEVEL. This deal made IAG the first European airlines group to place such an order for PtL-based SAF. In January 2024, Norwegian Air Shuttle and Cargolux Airlines International committed to purchasing 140,000 tonnes of PtL fuel from Norway's Norsk e-fuel (Cargolux, 2024). Furthermore, both companies will extend strategic support for additional production facilities by 2030.

The SAF offtake market is poised for significant growth, driven by regulatory support, technological advancements, and strong corporate commitments. However, several challenges need to be addressed:

High Production Costs: SAF production is currently more expensive than conventional jet fuel, primarily due to high feedstock and production technology costs. Bridging this cost gap is essential for the commercial viability of SAF.

Regulatory Hurdles: While regulatory frameworks are driving demand, the lack of harmonized global standards for SAF certification and usage can create market fragmentation and operational challenges for airlines operating in multiple jurisdictions.

Figure 29 -Offtake Agreements to Commence in 2024

Seller	Buyer	Technology	Volume ('000 m3)
	Air bp	HEFA-SPK	1,000
	Shell	HEFA-SPK	2,500
	Lufthansa Group	ATJ-SPK	151
	Scandinavian Airlines System	ATJ-SPK	19
	Delta Airlines	HEFA-SPK	946
	One World	-	1,325
	American Airlines	HEFA-SPK	424
	Avfuel Corp.	HEFA-SPK	3,785
	Lufthansa Group	Various (HEFA-SPK, PtL-SPK)	2,250
	Cathay Pacific	FT-SPK	1,375
	Emirates	HEFA-SPK	4

Source: S&P Global Commodity Insights

Corporate Purchase

Corporate purchase agreements play a critical role in the offtake of SAF, driving the market forward through long-term commitments and strategic partnerships. These agreements, often formed between airlines and SAF producers, serve as a foundational mechanism to ensure a stable demand for SAF, thereby facilitating investment in production infrastructure and advancing the commercialization of sustainable fuels.

Corporate purchase agreements provide a reliable and predictable demand for SAF, which is essential for producers to justify the significant capital investments required for production facilities. These long-term contracts offer financial security to SAF producers, encouraging them to scale up production and innovate in cost-reduction technologies. The guaranteed offtake volumes under these agreements help mitigate the risks associated with the volatility of fuel prices and market fluctuations.

Key Examples of Corporate Purchase Agreements:

Lufthansa Group: Lufthansa has committed to increasing its use of SAF and has entered into several long-term offtake agreements. For instance, in 2021, Lufthansa signed a deal with Shell Aviation to purchase SAF over multiple years, ensuring a consistent supply to meet its sustainability targets.

Delta Air Lines: Delta has secured SAF offtake agreements with producers such as Gevo and Neste. These agreements are part of Delta’s broader sustainability strategy to reduce its carbon footprint and demonstrate its commitment to greener aviation.

British Airways: British Airways has partnered with LanzaJet and Velocys to secure SAF supplies, supporting its goal of achieving net-zero emissions by 2050. These agreements highlight the strategic moves by airlines to lock in future SAF supplies.

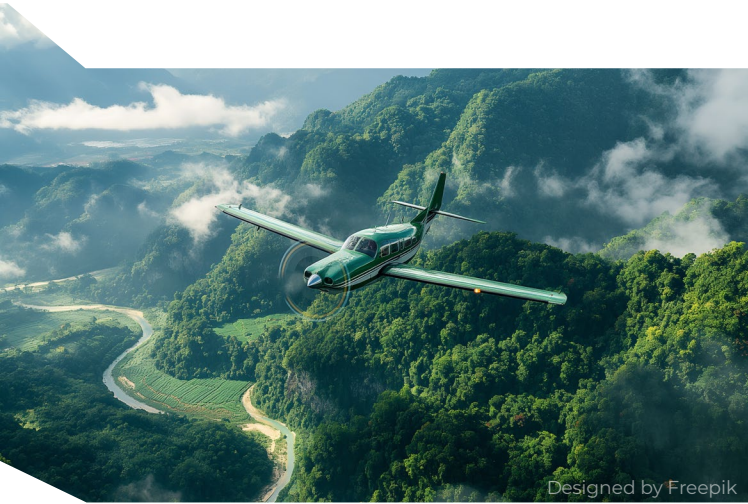


Figure 30 - Select Partnership Agreements by Corporate Buyers

Buyer	Partner	About the Arrangement
Deloitte.	Delta Airlines	Supply agreement with airlines for SAF fuel, with Neste as the producer
BCG BOSTON CONSULTING GROUP	SkyNRG	8-year partnership signed in September 2021 to offset carbon footprint of BCG's business flights
Google	Shell-backed Avelia	Avelia's 'book and claim' tool for SAF will generate the credits for SAF against business travel
Microsoft	International Airlines Group	Agreement for a co-funded SAF procurement with Phillips 66 as the producer

Source: Business Traveller, 2021; Airport Technology, 2024; Carbon Credits, 2023; Green Air, 2021

Corporate Purchases through Fuel Credit Systems: Corporate purchases of SAF through fuel credit systems represent another emerging and significant aspect of the offtake market. Major corporate customers of air travel use such purchase commitments to avail of credits that they can claim for environmental benefits. While physical fuel volume is not acquired, the certificates secured in the process contribute to expanding the pool of buyers and boosting producers' revenue streams.

Microsoft's Initiatives: Microsoft is a notable example in this context. The company tied up with IAG SA and Philips 66 to co-fund the purchase of about 5 million gallons of SAF. Furthermore, Microsoft signed a contract with SAF producer World Energy to buy credits equivalent to about 44 million gallons of SAF over the next 10 years. These agreements highlight the role of corporate buyers in supporting the SAF market through innovative purchasing mechanisms (Luxembourg Times, 2023).

Ad Hoc Partnerships with Airlines: In July 2022, Microsoft signed a Memorandum of Understanding (MOU) with the US-based technology startup Twelve and Alaska Air Group. The goal was to launch a demonstration flight based on the SAF produced through Twelve's proprietary technology. Multi-year commitments, such as Microsoft's, can also partly compensate for airlines' reluctance to sign such long-term contracts, providing additional market stability (T&E, 2023).

Joint Procurement: Collective engagement in joint procurement allows corporate buyers to have better bargaining power to negotiate sourcing terms. An example of this is the Sustainable Aviation Buyers Alliance (SABA), launched in 2021 by RMI and the US Environmental Defense Fund to further the goal of Net Zero Aviation. Founding members include Bank of America, BCG, Meta, Deloitte, Microsoft, and JetBlue. In April 2023, the alliance announced plans to collectively purchase SAF certificates, which could then be used by the organizations to buy Scope-3 emission credits for their respective businesses. Scope-3 emission credits are a mechanism for companies to offset their indirect emissions by investing in projects or activities that reduce GHG emissions elsewhere. This initiative involves SABA's members buying certificates for nearly 850,000 gallons of SAF to be produced by World Energy (Argus, 2023).

Figure 31 - Book and Claim Platforms for Corporate Buyers

	About the Arrangement
	Neste launched a platform in March 2024, providing third-party verified reports for the SAF purchase
	In a tie-up with 360 Jet Fuel Ltd., Jetex's global customers are offered a book and claim facility for reporting
	A blockchain-enabled platform by Shell, Accenture and American Express Global Business Travel, targeting business travel segment

Source: T&E, 2023; BTN, 2024; Green Air, 2022; Jetex, 2024

Aggregator Models and Book-and-Claim Platforms: Aggregator models and book-and-claim platforms offer corporate buyers a certification through third-party verified reporting to claim for Scope-3 emissions offsets. Such platforms also face constraints, including geographical dependence in the accounting of credits or the possibility of overlaps when multiple schemes might be involved. While SAF producers are taking the lead in these platforms, other entities, such as travel management companies, are also participating.

In conclusion, corporate purchase agreements are vital for the growth and stability of the SAF market. They drive demand, support production capacity expansion, incentivize technological advancements, mitigate cost challenges, and facilitate regulatory compliance. As the SAF market continues to evolve, these agreements will play an increasingly crucial role in the global effort to decarbonize aviation and achieve sustainability targets.

Figure 32 - Corporate SAF Schemes on Offer through Various Platforms

Companies Involved	Description	Type of SAF produced
Travel Management Platforms		
	Sustainability-focused travel management platform, using booking revenues to purchase biofuel on behalf of customers.	Biofuels generated from UCOs and waste animal fats
	Digital CO ₂ compensation platform for SAF in air travel or to sponsor certified climate protection projects as compensation for individual emissions	Biofuels generated from oils, UCOs and fats, supplied to Lufthansa Group
	It offers platform users an opportunity to purchase a percentage of SAF	Biofuels generated from UCOs.
Dedicated Platforms		
	With this platform, companies travelling from BCN or MAD airports could reduce the emissions of their flight through the use of SAF.	SAF based on waste oils and fats.

Source: T&E, 2023

Role of Emission Trading and Credits

The integration of emission trading systems (ETS) and the use of emission credits play a crucial role in the SAF offtake market. These mechanisms provide economic incentives for reducing greenhouse gas (GHG) emissions and create a structured market for trading emission allowances and credits.

Emission trading systems are market-based approaches to controlling pollution by providing economic incentives for achieving reductions in the emissions of pollutants. Governments set a cap on the total amount of GHG emissions and issue emission allowances, which can be traded in the market. Companies that need to increase their emission allowances must buy them from others willing to sell, thereby encouraging companies to reduce their emissions in the most cost-effective way.

In the context of SAF, ETS play a significant role in driving demand for cleaner fuels. The European Union's ETS, for instance, includes aviation and requires airlines to hold enough emission allowances to cover their emissions from flights within the EEA. The cost of these allowances incentivizes airlines to reduce their carbon footprint by using SAF, which has a lower carbon intensity compared to conventional jet fuel.

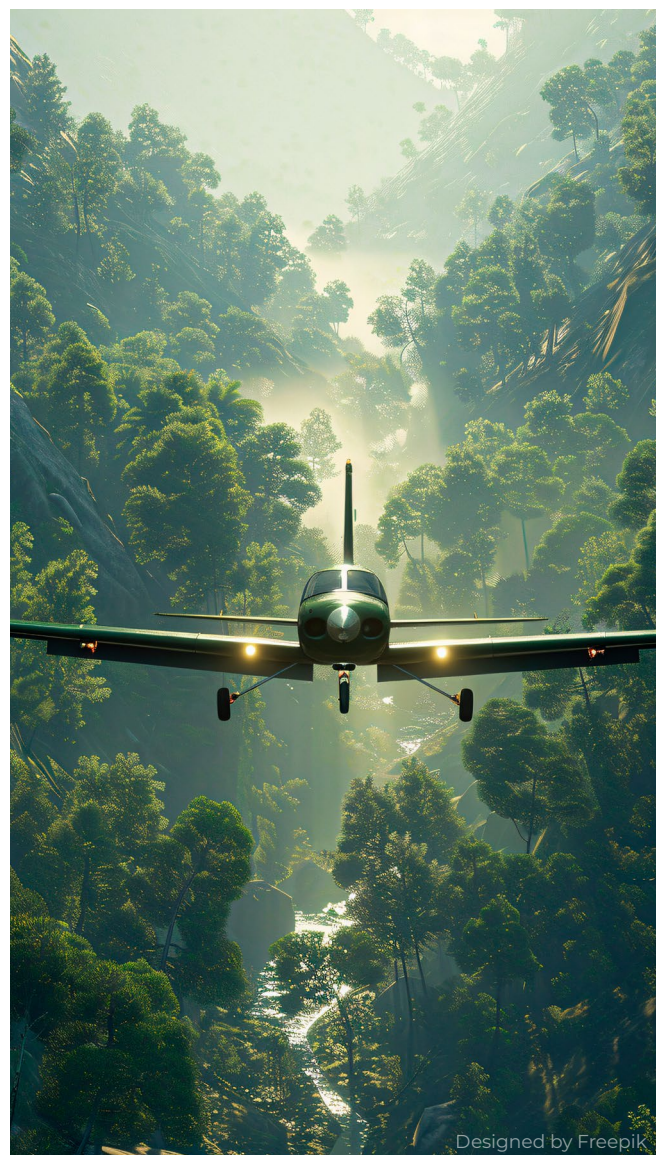
CORSIA and SAF Certification

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is another critical market-based measure designed to offset carbon emissions. CORSIA allows for the certification of carbon mitigation technologies and their use in offsetting emissions. In June 2023, SAFs were certified for the first time under the CORSIA framework, with nine batches of SAF based on agro-waste produced in China, the Netherlands, and the US receiving certification (ICAO, 2023). This successful certification sets a precedent for incorporating SAF sourcing into the overall process of carbon offsets by airlines, reinforcing the importance of SAF in achieving emission reduction targets.

CORSIA's offsetting requirements have been in force since 2021. Airlines must demonstrate compliance by canceling an appropriate number of emission units for each three-year compliance period. The scheme's phased implementation means that, until 2026, only flights between states that volunteer to participate will be subject to the offsetting requirements. Figure 33 illustrates the global map of participating and exempt states under the CORSIA framework.

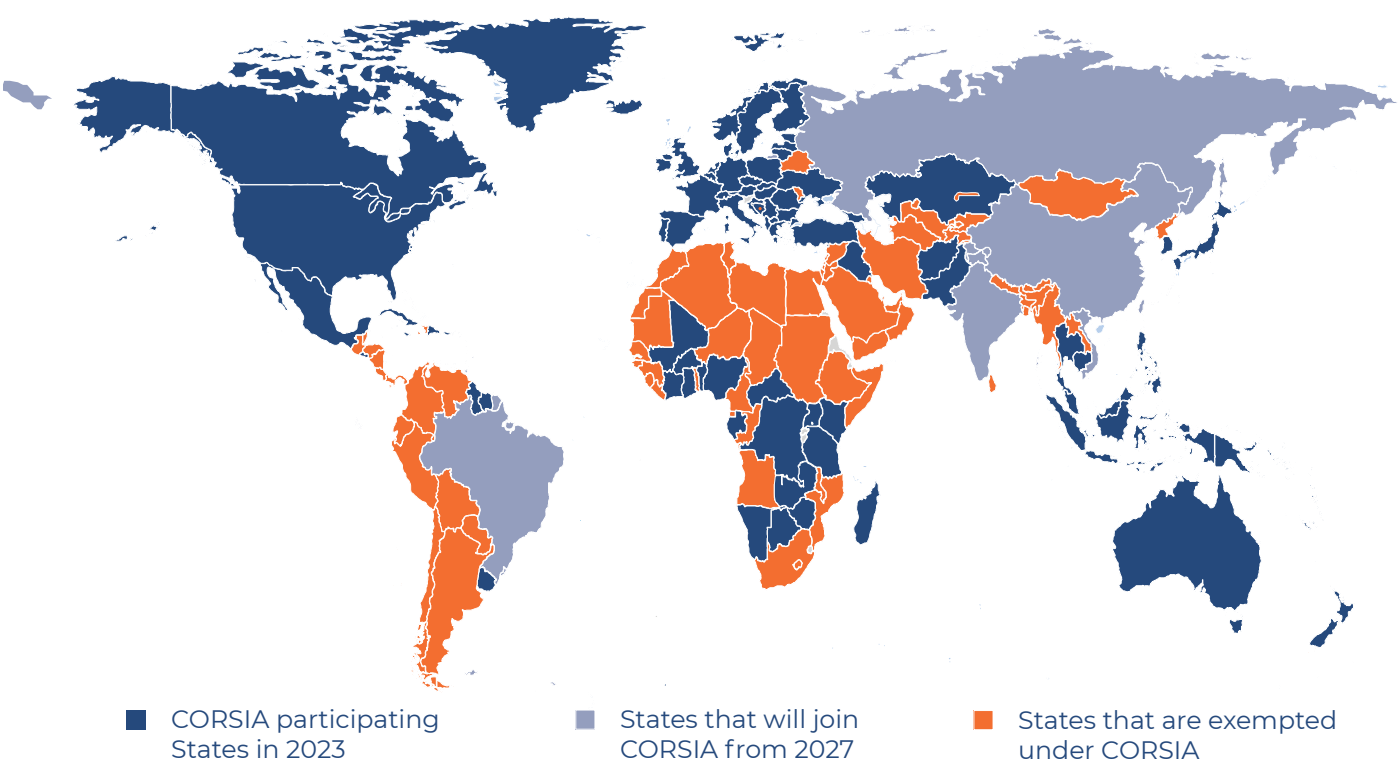
Under various ETS frameworks, SAF can generate emission reduction credits or allowances, which airlines can use to offset their carbon liabilities. For example, in the EU ETS, SAF usage can reduce the number of emission allowances airlines need to purchase. This creates a financial incentive for airlines to adopt SAF, as it can directly lower their compliance costs.

The SAF credits are typically generated based on the amount of GHG emissions avoided by using SAF instead of traditional fossil fuels. These credits can be traded in the market, providing a revenue stream for SAF producers and further promoting the development and adoption of SAF. In turn this supports the offtake of SAF by reducing the economic burden on consumers.



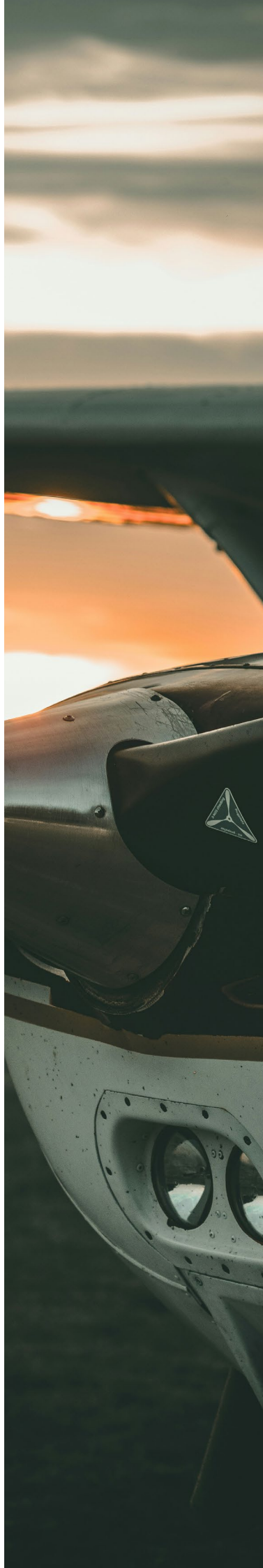
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Figure 33 - Participating and Exempt Countries Under the CORSIA Framework



08

Funding and Investment Ecosystem



Funding and Investment Ecosystem

The funding landscape for SAFs is diverse and dynamic, encompassing public grants, private investments, international financing, and innovative financial instruments. This multifaceted investment ecosystem is crucial for accelerating the development and deployment of SAF, ultimately contributing to the aviation industry's sustainability goals. As the demand for cleaner air travel grows, continued support from both public and private sectors will be essential to scale SAF production and integrate it into the global aviation fuel supply chain. This chapter delves into the primary funding and avenues for SAF projects and outlines some of the financing and revenue mechanisms that support the private investment ecosystem.

Public Funding and Incentives

Governments globally are significantly contributing to the advancement of SAF through an array of grants and subsidies. These financial aids are primarily directed towards R&D, pilot projects, and early-stage commercial production, thereby nurturing innovation and scaling within the SAF sector. This section gives a high-level overview of the public funding structures, whilst a more detailed account of the individual schemes is discussed in 04 - Policy and Regulation.

In the United States, substantial funding is provided by the U.S. DOE and the Federal Aviation Administration (FAA) through initiatives such as the Bioenergy Technologies Office (BETO) and the Continuous Lower Energy, Emissions, and Noise (CLEEN) Program. Moreover, the IRA of 2022 has introduced tax credits specifically aimed at SAF producers, further stimulating the market.

Across the Atlantic, the European Union supports SAF via several initiatives, including Horizon Europe and the European Green Deal. The Renewable Energy Directive (RED II) is instrumental in this regard, mandating an increase in the share of renewable energy within transportation, thereby bolstering SAF adoption. Similarly, the United Kingdom's Jet Zero strategy is backed by substantial funding, exemplified by the Green Fuels, Green Skies competition, which is focused on commercializing innovative SAF technologies.

Tax incentives and credits are also critical in reducing financial barriers to SAF production. These mechanisms effectively lower the tax burdens on both SAF producers and users, thereby enhancing the economic viability of SAF. For instance, the Blender's Tax Credit in the U.S. offers financial incentives per gallon of SAF blended with conventional jet fuel, encouraging its integration into the existing fuel

supply chain. In Europe, the EU Emissions Trading System (EU ETS) encompasses aviation, incentivizing airlines to use SAF as a means to mitigate their carbon tax liabilities.

PPPs are another vital component, fostering collaboration between governments and private entities. These partnerships leverage public funds to attract private investments, thereby accelerating SAF development. Governments frequently collaborate with industry leaders and academic institutions on large-scale SAF projects, as seen with the EU's Clean Sky 2 and the UK's ATI Program, which support joint R&D initiatives.

Multilateral development banks (MDBs) such as the World Bank, the EIB, and the Asian Development Bank (ADB) play a crucial role in financing SAF projects, especially in emerging markets where access to private capital is often limited. These institutions offer a range of financial products including loans, guarantees, and technical assistance, aimed at supporting the development of SAF infrastructure and production facilities. Additionally, the Global Environmental Facility (GEF) funds projects that underpin the development of sustainable biofuels, including SAF, in developing countries.

Private Investment in SAF

Venture capital (VC) and PE firms are increasingly channelling investments into SAF startups and companies that are developing breakthrough technologies. These investments are essential for transitioning innovative solutions from laboratory research to commercial production. In recent years, there has been a marked increase in both the number and size of investments in the SAF sector. Firms like Breakthrough Energy Ventures, founded by Bill Gates, are making significant investments in SAF technologies, demonstrating the growing interest and potential in this field.

High-profile deals are also drawing attention to the sector. For example, investments in companies like LanzaTech, which employs gas fermentation technology to produce SAF, and Fulcrum BioEnergy, which converts municipal solid waste into SAF, highlight the diverse approaches and substantial financial commitments being made.

In addition to VC and PE, major corporations, particularly in the aviation, energy, and chemical sectors, are investing in SAF through strategic alliances and direct investments. Airlines such as Delta, United, and British Airways are forming strategic partnerships with SAF producers to secure long-term supply agreements and invest in production facilities. Similarly, traditional energy companies like BP, Shell, and TotalEnergies are diversifying their portfolios by investing in SAF production technologies and projects,

recognizing the potential of SAF to complement their renewable energy strategies.

Alternative funding mechanisms are also playing a crucial role in the SAF investment ecosystem. Green bonds and sustainability-linked loans are innovative financing instruments that tie funding to environmental performance indicators. Issued by governments and corporations, green bonds raise capital for projects with environmental benefits, including SAF production facilities. Sustainability-linked loans, on the other hand, provide borrowers with financial incentives to achieve sustainability targets, such as increased production of SAF.

Additionally, dedicated SAF funds have emerged as a specialized funding mechanism, focusing exclusively on investments in SAF technologies and projects. These funds pool capital from various investors, including institutional investors, corporations, and governments, to support the development and scaling of SAF production. By concentrating financial resources and expertise in the SAF sector, these dedicated funds may play an important part in accelerating the commercialization of SAFs.

These various funding mechanisms and investment strategies are collectively driving the growth and development of SAFs, contributing to a more sustainable future for the aviation industry. The remainder of this section goes into more detail on each of the VCs and PEs, airlines and dedicated funds.

Venture Capital and Private Equity

VC and PE firms are well-suited to invest in high-risk, high-reward ventures, making them ideal partners for SAF startups that require substantial capital to develop and scale their technologies. These investments often target companies developing novel processes for producing SAF, such as advanced biofuel conversion technologies, waste-to-fuel processes, and synthetic fuels derived from carbon capture.

Over recent years, there has been a significant uptick in both the volume and value of VC and PE investments in the SAF sector. This surge is driven by a growing recognition of the environmental and economic potential of SAFs. Notably, prominent VC firms such as Breakthrough Energy Ventures, founded by Bill Gates, are leading the charge in funding SAF technologies. These firms are drawn by the promising returns and the significant impact on reducing aviation's carbon footprint.

The investment theme of SAF-led decarbonization has propelled significant interest in the VC segment, particularly in looking at up and coming technologies such as PtL SAF. To date, the majority of startup ventures focus on biogenic SAF production, however future investments are likely to explore a broader range of technologies. Key areas to watch include technology validation of innovations such as production processes based on concentrating solar thermal power generation for green hydrogen-based SAF synthesis (e.g., Synhelion), CO₂ extraction processes from existing industrial combined heat and power plants (e.g., Dimensional Energy), and commercialization of hydrogenation production processes based on CO₂ (e.g., OXCCU).

Funding trends amongst VC and PE groups indicate high investor interest, with Bloomberg New Energy Finance (BNEF) estimating that \$590 million was

invested from 2021 towards PtL SAF production technology, accounting for over 70% of the total investment in SAF (Bloomberg, 2023).

Figure 34 - Funding in Major SAF-based Startups



Source: IEA, 2024

Institutional investors, including pension funds, insurance companies, and university endowments, are increasingly entering the SAF investment landscape. These investors are typically drawn to the long-term growth potential and environmental benefits of SAF technologies, aligning with their broader goals of sustainable and responsible investing. Investment committees are increasingly focussed on evaluating the underlying carbon footprint and potential contribution to a Net Zero path. This trend is particularly pronounced amongst infrastructure investment teams. By the end of 2023, the top general partners (GPs) raised over \$1 trillion in capital under the infrastructure asset class (Infrastructure Investor, 2023).

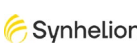
Institutional investments in SAF startups are often facilitated through VC and PE funds specializing in clean energy and sustainable technologies. These funds pool capital from institutional investors and deploy it into high-potential SAF ventures, spreading the risk and increasing the chances of significant returns. Aside from projects and ventures pursuing R&D into new feasible SAF technologies, there are investment opportunities into developers and Engineering, Procurement, and Construction (EPC) providers specialising in SAF production facilities.

The influx of institutional capital into the SAF sector provides startups with the financial resources needed to advance their technologies and scale their

operations. This support is crucial for moving from the proof-of-concept stage to full commercial production, which often requires substantial funding for building production facilities, securing supply chains, and meeting regulatory requirements.

VC and PE investments offer several strategic advantages for SAF startups. Beyond capital, these firms often provide startups with valuable industry expertise, strategic guidance, and access to a broader network of contacts. This support can be instrumental in navigating technical challenges, regulatory hurdles, and market entry strategies. With the backing of VC and PE funds, SAF startups can accelerate their growth trajectories, moving more swiftly from R&D to commercialization. This rapid scaling is essential in the competitive and fast-evolving field of sustainable fuels. Moreover, securing investment from reputable VC and PE firms can serve as a strong market validation for SAF startups. This endorsement can attract additional investors, partners, and customers, further enhancing the startup's growth prospects.

Figure 35 - Select VC/PE-funded SAF companies/projects and their Milestones (part-funding by United Airlines amongst other investors)

	Milestone/progress
	Pilot plant in Houston, US, for establishing the technology involving CO ₂ emissions as feedstock for valuable bio-commodities (Cemvita, 2023).
	With funding, the Oxford University-based venture plans to commission the first pilot within 2027 (Renewable Carbon, 2023).
	CO ₂ capture and synthesis technology demonstration plant commissioned at Lafarge Canada's cement plant (Svante, 2023).
	The company specializes in electrolyzer technology for green hydrogen production. With funding in October 2023, the venture will aim at establishing capacity for green hydrogen-based SAF (Chemanalyst, 2023).
	In June 2024, the Lufthansa-backed SAF startup inaugurated the world's first industrial-scale plant to produce synthetic fuels based on solar energy at Jülich, Germany (Synhelion, 2024).

Sponsoring Entity	Background	Transaction Details
EU Global Gateway Infra Fund	The EU's infrastructure fund has committed to invest 50% of its €300 billion corpus in Africa to counter the Chinese One Belt-One Road project.	Announced a €4 million capacity-building project aimed at SAF feasibility studies and certification in 11 African countries and India.
Macquarie Asset Management	Macquarie GIG Energy Transition Solutions (MGETS) Fund raised \$1.95 billion at first close. It is expected to exceed \$2 billion. This transaction follows a series of investments by Macquarie Asset Management in emerging green technologies.	In Nov 2023, announced an initial investment of €175 million in SAF producer SkyNRG, support SAF facilities in Europe and the US by 2030.
Canada Infrastructure Bank (CIB)	C\$500 million in commitment for priority areas under the Project Acceleration initiative. The scope was expanded to include FEED (Front End Engineering and Design) Capex by the Canadian private sector's energy transition projects.	CIB has provided C\$8.4 million funding to Azure Sustainable Fuels Corp. (Azure) to complete a FEED study for SAF production in Canada. It is on track to be completed in 2024. The funding will help support Azure's critical path of producing SAF by 2027.
IFM Investors	IFM's portfolio includes every major airport in Australia and other airports globally. IFM has been exploring the feasibility of increasing the use of SAF at its airports. Manchester Airport Group (MAG) was the first airport to announce a partnership with Fulcrum BioEnergy in 2022 to support the development and delivery of SAF.	Signed an MoU in November 2023 with GrainCorp to conduct feasibility studies on SAF production in Australia, through long-term domestic feedstock supply. GrainCorp is the largest processor of renewable feedstocks in Australia and New Zealand.
Japan Overseas Infrastructure Investment Corporation for Transport & Urban Development (JOIN)	JOIN is mandated to support Japanese carriers' decarbonization plans by actively participating in overseas SAF projects in partnership with Japanese companies. The first such investment was a JPY 0.9 billion investment in US-based Fulcrum BioEnergy in 2018 in collaboration with Japan Airlines Co. (JAL) and Marubeni Corporation.	Signed an MoU with ANA in December 2022 to co-operate on initiatives aimed at manufacturing and producing SAF overseas.

Airlines

Airlines are at the forefront of SAF investing, driven by the dual imperatives of regulatory compliance and rising consumer demand for greener travel options. Recognizing the necessity of reducing their carbon footprint, airlines are channelling significant investments into SAF initiatives through strategic partnerships, long-term supply agreements, and direct investments in production technologies and facilities.

Figure 36 summarises the key investments and commitments by airlines into SAF in a table, whilst this section gives a brief commentary to some of the different avenues that airlines have made investments accompanied by examples.

Delta Air Lines has entered into a partnership with Gevo, a leading renewable chemicals and advanced biofuels company (Biofuels International, 2019). This agreement allows Delta to purchase up to 10 million gallons of SAF annually, reinforcing its commitment to carbon neutrality. Similarly, United Airlines has invested in Fulcrum BioEnergy, which converts municipal solid waste into SAF (PR Newswire, 2015). This partnership includes both a significant equity investment and a long-term purchase agreement, positioning United as a leader in sustainable aviation. British Airways, on the other hand, has partnered with Velocys to develop waste-to-fuel plants in the UK, producing SAF from household and commercial waste and significantly reducing lifecycle carbon emissions (Aerospace Technology, 2017).

In addition to partnerships, many airlines are making direct investments in SAF production facilities and technologies. Lufthansa Group, for example, has invested heavily in SAF, including substantial stakes in synthetic fuel production (Lufthansa Group, n.d.). The airline has signed various agreements with SAF producers to ensure a steady supply for its fleet, underscoring its commitment to sustainable aviation. Similarly, Air France-KLM has committed to significant investments in SAF development and production (Air France KLM, 2023). The airline group has entered multiple agreements with SAF suppliers and invested in new production facilities, supporting the broader adoption of SAF in the industry.

Long-term supply agreements between airlines and SAF producers are vital for providing the financial stability and demand assurance necessary for scaling SAF production. These agreements typically involve multi-year commitments to purchase specified volumes of SAF, enabling producers to secure financing and expand their operations.

American Airlines, for instance, has entered into a long-term agreement with Neste, a leading producer of renewable diesel and SAF. This agreement will see American Airlines purchasing millions of gallons of SAF over several years, supporting its goal of reducing GHG emissions. Similarly, Qantas has signed a multi-year agreement with BP to purchase SAF for its flights out of London, aligning with its commitment to achieving net-zero emissions by 2050. Figure 26 (Chapter 7 : SAF Offtake) shows the representative proportional for the biggest airline offtake agreements announced.

Beyond individual partnerships and investments, airlines are making broader corporate commitments to SAF as part of their sustainability strategies. These commitments often include specific targets for SAF usage and investment, reflecting the airline industry's recognition of SAF's critical role in achieving carbon neutrality.

International Airlines Group (IAG), the parent company of British Airways and Iberia, has committed to powering 10% of its flights with SAF by 2030 and pledged to invest \$400 million in SAF development over the next two decades (IAG, 2024). Lufthansa Group aims to become carbon neutral by 2050, with interim goals to halve its CO₂ emissions by 2030. As part of this strategy, Lufthansa plans to significantly increase its use of SAF and invest in new production technologies.

As regulatory pressures increase and the economic viability of SAF improves, the airline industry's commitment to funding SAF is expected to grow. Airlines will likely continue to expand their partnerships, direct investments, and long-term supply agreements to ensure a robust and scalable SAF supply chain. Additionally, corporate commitments to sustainability will drive further investment in SAF, accelerating the transition to a more sustainable aviation industry.

Figure 36 - List of the Major Airlines SAF Investment Commitments

Airline		Investment Size (Mn)	Investment Details
	Qantas	US\$200	Qantas' sizeable investment will allow the company to meet its goal of using 10% SAF in its fuel mix by 2030 and 60% by 2050 while hitting its net zero emissions target by then. The first investment of \$1.34 mn will be spent on a biofuel refinery being set up in Australia's Queensland State to broaden the option beyond current sourcing from London (10m litres from 2023) and California (20m litres from 2025). (Airbus, 2022)
	Air France - KLM	US\$4.7	Air France and the KLM group made a \$4.7mm investment in DG Fuels' SAF production plant in Louisiana, USA to enable their 10% SAF incorporation target by 2030 through an acquisition of an option to purchase up to 25 mn gallons / 75,000 tons of SAF annually over a multi-year period starting in 2029 (Reuters, 2023).
	Lufthansa	US\$250	Lufthansa has signed a letter of intent with HCS Group for the production and supply of SAF from a planned new 60,000 metric ton per year biogenic facility (ESG Today, 2023).
	British Airways	US\$11.2	Project Speedbird aims to transform agricultural and wood waste from sustainable sources into 102mn litres of SAF per year through a facility located in North East England, with SAF production expected to commence by 2026 (PR Newswire, 2023). British Airways also received £9mn from the British government's Advanced Fuels Fund competition, which is looking to allocate £135 mn in grant funding to support UK advanced fuel projects until 31 st March, 2025 (British Airways, 2022).
	Delta Airlines		Delta Airlines has signed a 7-year deal with DG Fuels in September 2022 to purchase 385mn gallons of SAF starting in 2027 (Green Air News, 2022) and signed a 2-year deal with Shell Aviation in April 2023 to purchase 10mn gallons of SAF at its LAX hub (Biofuels International, 2023). Delta also established the Minnesota SAF Hub as part of the greater MSP Partnership with BoA, Ecolab and Xcel Energy (Delta News Hub, 2023).
	American Airlines	US\$2,750	American Airlines signed an agreement with Gevo to procure 100 million gallons of SAF annually for five years with deliveries starting 2026 (Gevo, 2022) and signed a different offtake agreement with Infinium to source SAF from the latter's West Texas based facility, touted to be North America's largest PtL project (ESG Dive, 2023).
	Singapore Airlines		Singapore and Scoot, the two airlines within the SIA Group portfolio, have committed to sourcing 5% of their total fuel requirements from SAF by 2030. Discussions on offtake agreements are ongoing (Singapore Airlines, 2023).
	Qatar Airways		Qatar Airways signed a multi-million-dollar deal with Shell to supply 3,000 MT of SAF at Amsterdam Schiphol Airport. Qatar Airways is looking to use at least a 5% SAF blend over the contract period for the fiscal year 2023-24 (Aerotime, 2023).
	ANA and Japan Airways		ITOCHU to import neat SAF from Neste into Japan (Reuters, 2023) where it will be locally blended with conventional fossil jet fuel in cooperation with Fuji Oil Company to follow SAF offtake agreements such as JAL's agreement signed in 2022 to buy SAF from Gevo beginning in 2027, and ANA sourcing SAF from Neste (Neste, 2023).
	International Airlines Group		IAG's SAF programme has committed \$865 million in future SAF purchases and investments at the end of 2022. In addition, IAG and Microsoft signed the largest co-funded purchase agreement (IAG, 2024) as per which MS will co-fund the purchase of 14,700 tonnes of IAG's SAF purchase in 2023. IAG also signed a 14-year sourcing contract with Twelve to supply 785,000 tonnes of e-SAF (PtL) to support its five European airlines (British Airways, Iberia, Aer Lingus, Vueling and LEVEL). This deal enables IAG to reach one-third of the SAF needed to reach its 2030 target of 10% SAF by 2030.
	Southwest	US\$30	Southwest Airlines has invested \$30 million in LanzaJet to fund the development of a SAF production facility and collaborate to advance the operations of a corn stover to ethanol technology company in which Southwest is invested: SAFFIRE Renewables, LLC (SAFFIRE) (PR Newswire, 2024).
	Emirates	US\$200	Emirates announced the commitment of US\$200 million (Emirates, 2023) to fund R&D into SAF and other aspects of sustainable aviation, to be disbursed over a 3-year period. Emirates also signed an agreement with Neste to supply 3 million gallons of SAF in 2024 and 2025 (Emirates, 2023).

Dedicated SAF Funds

Funds targeting SAF are crucial in advancing the development, production, and commercialization of SAF technologies. These funds, established by institutional investors, VC firms, PE groups, and corporate ventures, provide the essential financial resources needed to scale innovative solutions and drive the transition to a sustainable aviation industry. Several prominent examples of such funds are Breakthrough Energy Venture founded by Bill Gates, Clean Energy Finance Corporation (CEFC) in Australia, and the Green Climate Fund (GCF), a global initiative aimed at supporting climate mitigation and adaptation projects in developing countries.

Two stand out funds that have gone a step further by dedicating their mandates to SAF entirely are the Fly Green Fund and the United Airlines Ventures (UAV) Sustainable Flight Fund. The strategic importance of dedicated SAF funds lies in their ability to provide targeted financial support for the development and scaling of SAF technologies. These funds mitigate the financial risks associated with pioneering new production methods and offer a stable source of capital to early-stage startups and established companies alike. By focusing exclusively on SAF, these funds can drive innovation, reduce production costs, and accelerate market adoption.

Fly Green

Launched in 2014, the Fly Green Fund is a notable example of a non-profit funding arrangement designed to mobilize private sector resources within the SAF ecosystem. Focused on the Nordic region, the Fund was founded by SkyNRG, Karlstad Airport, and the Nordic Initiative for Sustainable Aviation (NISA), with support from Swedish airport operators Swedavia and the Swedish Regional Airport Association (ICAO, n.d.)

The Fly Green Fund allocates three-quarters of its total outlay towards bridging the additional cost of SAF relative to conventional fuel. The remaining funds support supply chain projects, market development, knowledge sharing, and research. Since its inception, the Fund has raised \$4.2 million and supplied approximately 1.85 metric tonnes of SAF to Swedish airports. This focused financial support has been instrumental in promoting the adoption and production of SAF within the Nordic region.

Figure 37 - SAF Projects Supported by Fly Green Fund

Project	Details
Luleå University of Technology	Preparatory study for SAF production from Swedish forest-based residues based on Fischer-Tropsch (FT) synthesis.
Forestry-2-Jet	Swedish state-owned research project to convert forest residue-based ethanol to SAF.
Electro Fuel	A project led by Swedish Environmental Research Institute for SAF production based on CO ₂ extraction from a cogeneration plant.

Source: ICAO, n.d.

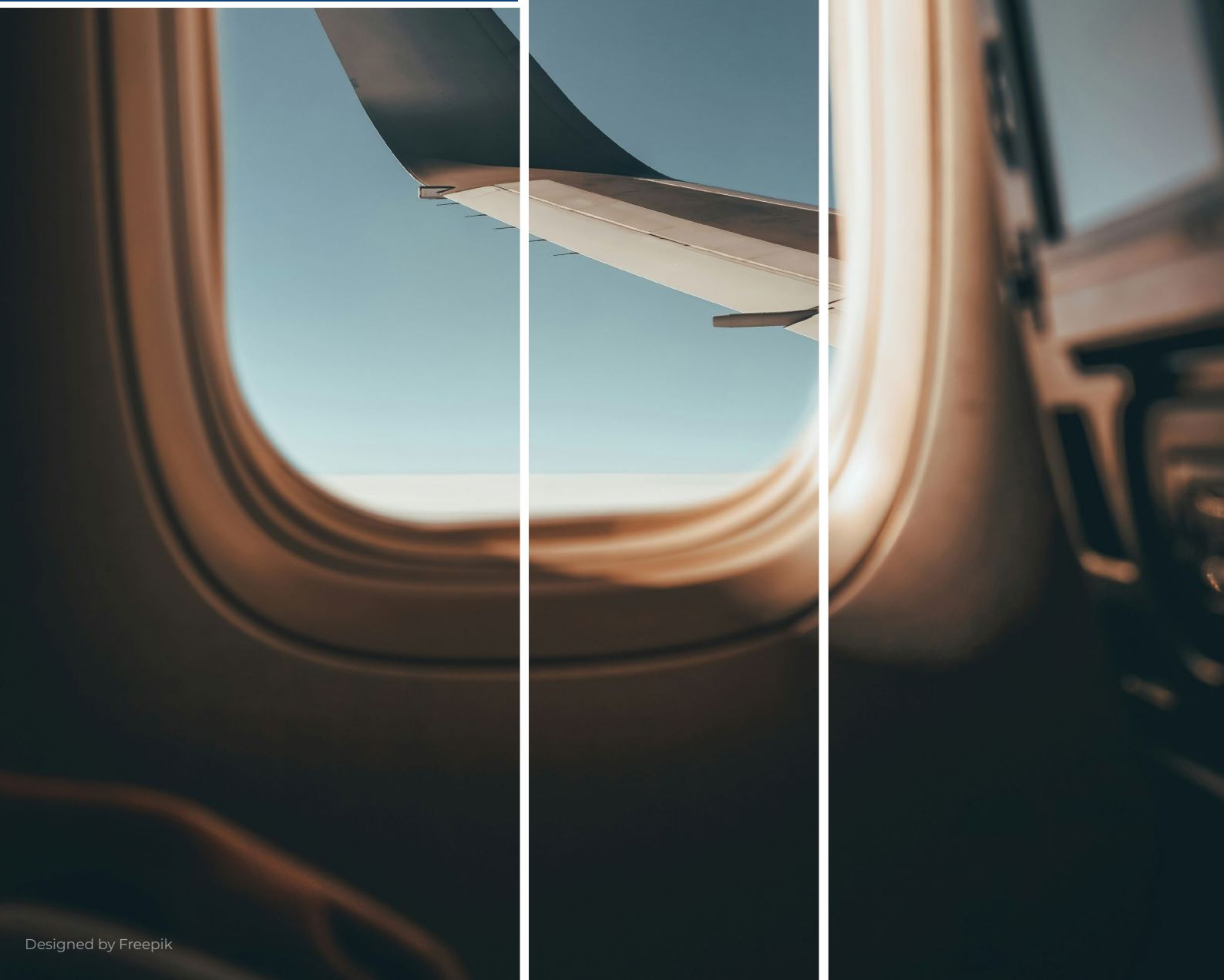
United Airlines Ventures Sustainable Flight Fund

The UAV Sustainable Flight Fund, launched in February 2023, represents a pioneering initiative towards channeling private investments into SAF. With over \$200 million in investment commitments from United Airlines and its corporate partners, and more than \$450,000 in contributions from its customers, the Fund demonstrates significant traction and interest in sustainable aviation solutions (United, 2024). By the end of February 2024, the Fund comprised 22 corporate partners, including notable entrants such as Google and Embraer (International Airport Review, 2024). This diversified partner base underscores the unique and collaborative nature of the Fund, distinguishing it from other venture initiatives.

The UAV Sustainable Flight Fund supports a broad spectrum of activities, including startup ventures, research, production, and technology development. Recently, the Fund has made strategic investments in emerging SAF supply technologies, further enhancing its impact on the market. The Fund’s portfolio companies have achieved significant milestones, showcasing the practical outcomes of targeted investments in SAF technologies.

09

Conclusion



Conclusion

The global aviation industry is at a pivotal juncture, balancing increased travel demand with the imperative to significantly reduce its environmental footprint. Sustainable Aviation Fuels (SAFs) are recognized as a key solution to achieving the sector's net-zero emissions target by 2050. Here is a summary review of some of the major insights globally, together with the initiatives and regulatory frameworks in key markets including the US, Canada, and the European Union.

Key Insights and Regional Approaches

Canada's regulatory landscape for SAF is primarily shaped by its CFR, which replaced the Renewable Fuels Regulations. The CFR mandates progressive reductions in lifecycle emissions for transportation fuels and includes a voluntary credit system to encourage further emission reductions. Despite the absence of federal production-linked incentives or binding SAF blending mandates, provincial initiatives demonstrate leadership in the field. For instance, British Columbia's LCFA not only sets SAF blending mandates but also targets significant reductions in carbon intensity, positioning the province as a frontrunner in regional SAF policy innovation. These regional efforts underscore the importance of provincial leadership in driving national SAF progress.

The European Union has established a robust and ambitious regulatory framework for SAF through the ReFuelEU Aviation initiative, part of the broader "Fit for 55" package. ReFuelEU regulations stipulate phased SAF blending mandates from 2025 to 2050, with specific targets for synthetic aviation fuels produced via Power-to-Liquid (PtL) technologies. These mandates apply uniformly across the EU aviation sector, setting a global benchmark for SAF regulation. The EU Emission Trading Scheme (ETS) further bolsters the financial attractiveness of SAF by allowing airlines to offset SAF costs against their ETS obligations, providing significant economic incentives for SAF adoption. The EU's approach illustrates a comprehensive strategy that combines regulatory mandates with financial mechanisms to promote SAF uptake.

Although no longer part of the EU, the United Kingdom remains a significant player in the European SAF landscape. Post-Brexit, the UK has crafted its own regulatory framework for SAF, aligned with its broader environmental policies and the goal of achieving net-zero emissions by 2050. The UK's Renewable Transport Fuel Obligation (RTFO) includes specific SAF mandates that have driven substantial investment and development within the SAF sector, demonstrating the UK's proactive stance in fostering sustainable aviation independently from the EU framework. This approach underscores the UK's commitment to maintaining its leadership in sustainable aviation through targeted policies and incentives.

The United States has adopted a multifaceted approach to promote SAF, primarily through landmark legislations like the Inflation Reduction Act (IRA) and initiatives such as the Sustainable Aviation Fuel Grand Challenge (SGC). The IRA, effective from August 2022, offers graded tax credits based on GHG emission reductions, significantly incentivizing SAF production. The Federal Aviation Administration's (FAA) Fuelling Aviation's Sustainable Transition (FAST) program allocates substantial funding to support SAF infrastructure and technological advancements. State-level policies, particularly in California, Illinois, and Oregon, also play a crucial role in advancing SAF adoption, highlighting the importance of sub-national efforts in the broader national strategy.

Challenges and Opportunities

Despite robust regulatory frameworks and incentive structures, several challenges impede the widespread adoption of SAF. High production costs, technological barriers to scaling production, and substantial investments required for infrastructure development remain significant hurdles. Furthermore, the variability in policy support and incentives across regions complicates efforts to establish a cohesive global market for SAF.

However, the opportunities presented by SAF are substantial. Advancements in production technologies, economies of scale, and supportive policies can significantly reduce aviation's carbon footprint. Establishing clear regulatory mandates, financial incentives, and fostering international collaboration are crucial steps towards driving the transition to sustainable aviation.

Path Forward

Achieving the ambitious decarbonization goals set for 2050 necessitates a unified and coordinated approach involving all stakeholders in the aviation industry. Governments must provide consistent, long-term policy support, including binding targets and substantial financial incentives. The private sector must invest in research, development, and scaling of SAF production technologies to meet future demand. Additionally, international collaboration is vital to harmonize standards and practices, ensuring a seamless global transition to sustainable aviation.

The journey towards a sustainable aviation future is multifaceted and requires sustained efforts from governments, industry players, and other stakeholders. The policies and initiatives detailed in this report offer a roadmap, but continuous innovation, investment, and collaboration will be essential to fully realize the potential of SAFs and achieve a net-zero aviation industry by 2050. The path forward is challenging but achievable, and the actions taken today will shape the future of aviation for generations to come.

The Role of Key Policies and Initiatives

The analysis of Canada, the European Union, and the United States highlights the critical role of targeted policies and financial incentives in advancing the SAF agenda. Canada's regional initiatives, the EU's comprehensive ReFuelEU framework, and the multifaceted U.S. approach exemplify how different regions are leveraging their unique strengths to promote SAF. Each region's experience underscores the importance of a tailored approach that considers local market dynamics, regulatory landscapes, and stakeholder needs.

The United States' combination of federal tax credits under the IRA, targeted funding through the FAST program, and state-level initiatives illustrates a robust framework that supports SAF production and adoption from multiple angles. The EU's integrated approach, combining binding mandates with financial mechanisms like the ETS, provides a model for holistic policy design. Canada's regional leadership, particularly in provinces like British Columbia, showcases how local initiatives can drive national progress.

Future Directions

Looking ahead, it is imperative to address the existing challenges through sustained innovation and investment. Governments must continue to refine and expand their policy frameworks, ensuring they provide the necessary support to overcome technological and financial barriers. The private sector must play a proactive role in developing and scaling new SAF technologies, leveraging public incentives and collaborative opportunities.

International collaboration will be crucial to harmonize standards, share best practices, and foster a cohesive global market for SAF. Initiatives like the International Civil Aviation Organization's (ICAO), Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) can provide a platform for such collaboration, aligning global efforts towards a common goal.

In summary, the path to a sustainable aviation future is clear but requires concerted effort from all stakeholders. The insights and strategies outlined in this report provide a foundation for continued progress, underscoring the critical role of SAF in achieving a net-zero aviation industry by 2050. The journey is complex, but with sustained commitment and collaboration, the aviation industry can rise to meet the challenge and pave the way for a greener future.

10

Regional Market Overviews



Key Regional Markets - Europe



Denmark

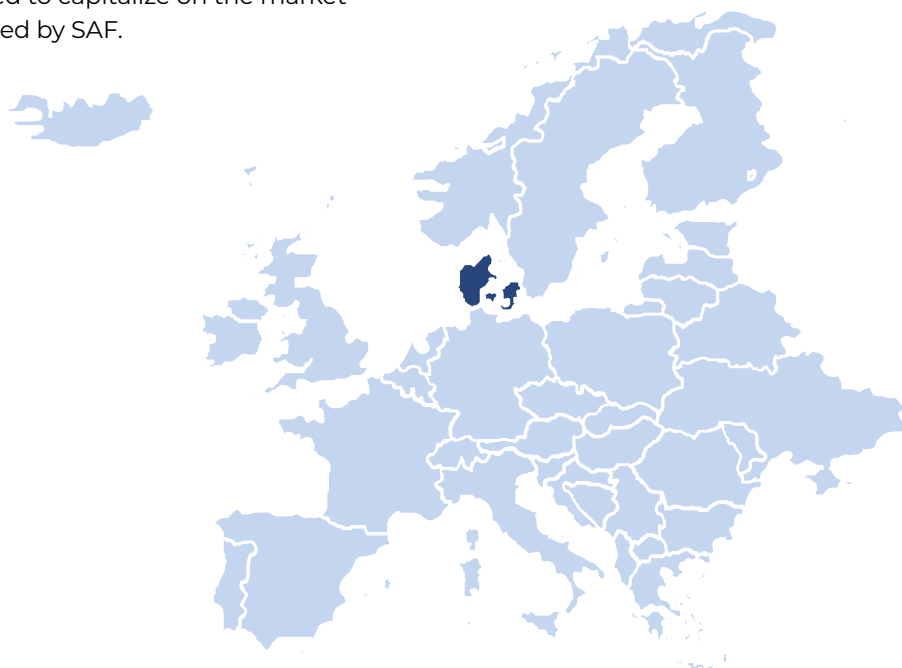
Whilst the Danish SAF market is still in its nascent stages, it is evolving rapidly, a testament to the country's commitment to renewable energy and climate action, having pioneered the commercial wind energy industry in the 1970s.

A supportive policy framework is at the heart of this, with the Danish government committing funds to incentivize the commercial-scale production of SAF, as it targets ambitious decarbonization milestones, such as the first "green domestic route", a flight fuelled entirely by SAF, by 2025, all of which entails approximately 10,000.0 tons of SAF (MeSAF, n.d.). This policy support has spurred investment activity, leading to a large pipeline of domestic SAF development projects set to start to producing SAF as early as this year.

Whilst progressive policy support will continue to foster SAF investments, the Danish industry is not immune to the challenges faced globally, including the high cost of production compared to traditional jet fuel, the growing need for technological advancements to improve SAF economics, and a globally coordinated consensus on the adoption of SAF to foster the investment required. However, the country's abundance of domestic renewable energy, particularly offshore wind, as well as its long history of biofuel technology development, means Denmark is uniquely positioned to capitalize on the market opportunity presented by SAF.

Economic Indicators	GDP (current prices, \$ 2022)	400 Bn
	Real GDP growth forecast 2023-27	1.66%
	10-year govt bond yield (12-month rolling average)	2.59
	Country credit rating	AAA
Average daily flights	820	
Existing Fuel Consumption	1 million metric tons	
Usage Mandate	100% SAF by 2030	
Projected SAF Capacity Under Development (MT/Year)	305,277 by 2030	
Policy Support	• DKK 1.8 billion will be allocated to boost demand for SAF by 2025. • Green Tax Reform aims to make SAF more competitive by taxing fossil fuels, thereby encouraging the adoption of sustainable alternatives in the aviation industry.	

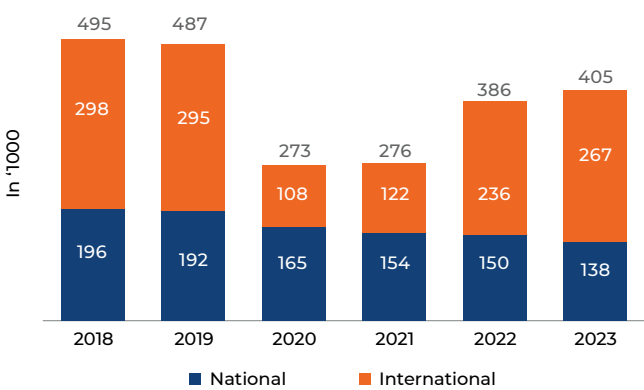
Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Denmark

Aviation Industry Backdrop

Flight operations on larger, manned Danish airports¹



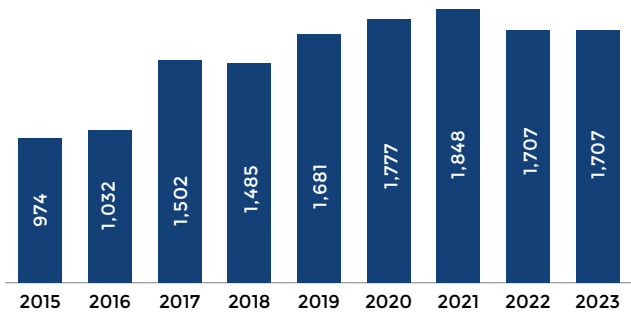
Source: Statistics Denmark

Flights operated in Denmark are expected to surpass pre-COVID levels, during the second and third quarters of 2024, marking the full recovery of its aviation industry just over four years after the start of the pandemic (Air Service One, 2024). In particular, Denmark’s primary hub of Copenhagen is witnessing wide-scale growth, having secured 25 new routes scheduled to be launched in 2024 (Air Service One, 2024). This follows a 21.0% increase in passenger numbers in 2023, which saw a record ~26.8 million people travel through its airport (Schengen, 2024). Additionally, serving as a Ryanair base since 2022, Denmark’s second busiest airport, Billund, has already achieved record traffic levels, surpassing its annual 2019 record, (Air Service One, 2024).

Accordingly, emissions from domestic aviation are expected to increase from 0.15 million tonnes CO₂e in 2019 to 0.17 million tonnes CO₂e in 2030, largely owing to increasing flight numbers and the resulting uptick in jet-fuel consumption, posing a significant threat to Denmark Net Zero ambitions (The Brussels Times, 2022) (Danish Energy Agency, 2021).

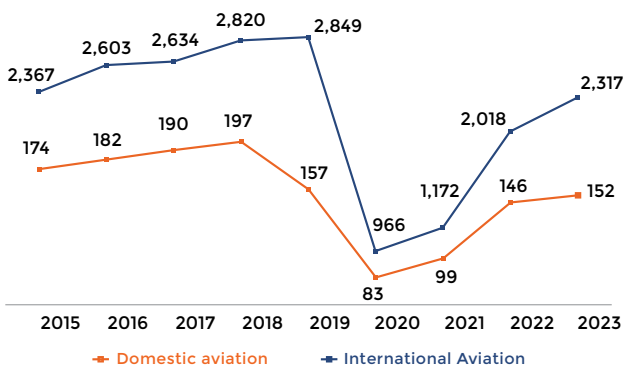
Whilst government support is being enacted to help address this issue, major airlines are taking matters into their own hands, voluntarily committing to emission reduction targets in pursuit of corporate ESG objectives.

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



Denmark

Largest Airlines Operating in Denmark	Commitments Towards Emission Reduction
Scandinavian Airlines or SAS (flag carrier for Denmark)	Reducing CO2 emissions by 25.0% by 2025 and fuel all their domestic flights with fossil-free aviation fuel by 2030 (SAS, n.d.) (SAS, 2024) (SAS, n.d.)
Norwegian Airlines	Reducing carbon emissions by 45.0% by 2030 through a combination of fleet renewal, operational efficiency, and SAF adoption (Norwegian Air Shuttle ASA, n.d.)
Ryanair Airlines	Using 12.5% SAF by 2030 and Net Zero emissions by 2050 (Eni S.p.A., 2024)

Biofuels are expected to play an increasingly important role in the decarbonisation of Denmark’s transportation sector. They presently account for only about 6.0% (IEA, 2023) of the total final energy consumption of the transportation sector, with road transport taking the predominant share. With the aviation sector in focus, voluntary commitments by the airlines, and the rise in eFuel R&D investments, SAF is poised for a much more prominent place in the Danish biofuel sector.

Policy and Regulation

Denmark is targeting a 70.0% reduction in its carbon emissions by 2030 compared to 1990 levels (State of Green, 2022) and Net Zero by 2045, five years earlier than set out in the 2016 Paris Agreement.

The aviation industry poses a significant challenge to these global Net Zero commitments. The vast amount of energy consumed by airliners and the inherent impact of aircraft weight on its fuel consumption mean targeted policy support will be required if the aviation industry is to have a sustainable future. As renewable energy, such as wind and solar PV, continue to shift from subsidised to unsubsidised business models, governments are increasingly focusing their efforts on these hard-to-abate industries.

The Danish Government is no different in this regard, as it has introduced a comprehensive suite of policy support and taxation measures to fund and subsidize the ongoing development of the domestic SAF market. Some of the major policy targets include launching a 100.0% sustainable domestic flight route by 2025 and finalising green domestic routes by

2030. In September 2022, the government enhanced the budgetary outlay for the domestic SAF industry by over DKK1.8 billion (€0.2 billion), supplementing its previous DKK3.0 billion (€0.4 billion) allocation (Ministry of Foreign Affairs of Denmark, n.d.) (State of Green, 2022).

Other strategic initiatives are underway to complement the policy funding. The Danish PtX flagship project, ‘Green Fuels for Denmark’ (GFDK), aims to enable the transition required for green fuels in domestic aviation by 2027. It is fully funded by the government and has already received DKK600 million to kickstart the initial phases, focusing on large-scale production of renewable hydrogen and green fuels (Bioenergy International, 2022) (State of Green, 2022) (Everfuel, 2022) (Ørsted, 2022).

GFDK sets an ambitious policy target of fulfilling the country’s aviation decarbonisation goals three years ahead of schedule (State of Green, 2022). The government’s commitment towards eFuel technologies, like power-to-liquid, adds to the planned measures of the flagship project. For instance, in March 2022, the Danish Parliament had an agreement among all main political parties to scale up “power-to-X” (PtX) production, which can help boost local supply of green fuels for both domestic and export markets (Bioenergy International, 2022) (Aviation Week Network, 2022). Also, Denmark’s high share of renewable energy places it in a leadership position in future rollout of eFuel technologies. Such a cohesive strategy not only supports Denmark’s green energy targets but also sets a precedent for other nations looking to transition to sustainable fuel solutions.

Demonstration projects, funded through government grants, are contributing to the critical need for achieving commercial scale in new SAF technologies. The support from the Energy Technology Development and Demonstration Program (EUDP) is one notable instance. One of EUDP’s major projects, the MeSAF, aims to produce the first eSAF at a pre-commercial scale in Aalborg. Its total budget is \$2.6 million, of which the EUDP funded \$1.4 million. The remaining amount was from the project partners, including European Energy, Kosan Gas, Vertimass, Aalborg University, Aalborg Airport, Port of Aalborg Logistics and Cemtec Fonden (Biobased Diesel Daily, 2023) (EUDP, 2023).

Denmark

The supportive policy measures also include fiscal initiatives to improve SAF competitiveness. In December 2023, the government announced a plan to levy tax on air passengers to raise resources for fuel subsidies. The proposed tax, to be phased in from 2025 and fully implemented by 2030, ranges from €6.7 to €55.0 per flight based on distance. The estimated revenue collection by 2030 is €73.8 million, which could help promote emerging technologies such as power-to-X and hydrogen (ETIAS.COM, 2023) (Aviation Week Network, 2023).

Additionally, the Danish government, in conjunction with EU funding programs like Horizon Europe and the European Green Deal, is providing substantial financial support for research and development to ensure the competitiveness of domestic suppliers in the global SAF market.

Market Opportunity

Progressive government policy will continue to foster a favourable environment for SAF investment within Denmark, with opportunities present across the value chain, from continued research, development and innovation, aiming to lower production costs and increase energy yields, to the development and construction of SAF facilities that will deliver the SAF capacity required to transition the industry towards a sustainable future. In this context, some of the ongoing projects indicate the rising investor interest in tapping into the opportunity.

Haldor Topsøe, a Danish catalysis and process technology company, is currently building a facility in Herning, Denmark, focused on producing SOEC (solid oxide electrolysis cell) electrolyzers. Such facilities are crucial for scaling up and optimizing production, potentially reducing costs and increasing manufacturing efficiency. This technology could be pivotal for the future of eSAF, as it supports Power-to-Liquid processes and facilitates advancements in methanol and, consequently, the Methanol-to-Jet pathway (Topsoe, 2024).

There are multiple R&D projects underway that are aiming to reduce the cost of producing SAF. For example, in June 2023, the Danish Energy Agency's EUDP granted DKK26.9 million in funding to Topsoe A/S for FrontFuel, a SAF demonstration project. The project has been launched as a pioneering initiative to

design, test, and install the world's first demonstration facility for producing SAF which will be obtained by converting CO₂, water, and renewable electricity to synthetic crude. This production facility also aims to demonstrate the integrated processes involved in SAF production, from feedstock conversion to final fuel output, using Topsoe technology (Aarhus University, 2023) (Chemical Engineering, 2023) (Green Car Congress, 2023).

Among other notable other developments, Copenhagen Airport is involved in a proposal to establish an aviation climate fund, which is to be funded using passenger levies on flight tickets that could generate annual revenues of up to DKK750.0 million. These funds would then be invested into SAF R&D. (Technical University of Denmark, 2022).

As the SAF industry is still in its nascent stages, collaborations and partnerships are becoming increasingly common, which allow for the diversification of risk and pooling of resources.

Notable SAF Projects	Collaborating Entities	Project Details
MeSAF	Aalborg Airport, Kosan Gas, Vertimass and European Energy	A pilot plant is to be established in Aalborg, which will start producing SAF from 2024. The SAF will be produced from CO ₂ and green hydrogen and will pave the way for Denmark's first 100.0% SAF-fuelled domestic flight route (Kosan Gas, 2023)
First commercial eFuels-for-aviation plant in Denmark	Arcadia eFuels, Sasol, Topsoe, KGAL GmbH	Once operational in 2026, the plant will deliver eFuels for the Danish and European aviation markets. The plant will be located in Vordingborg and will produce ~100.0 million litres of eFuels annually (Biofuels International, 2023) (Renewables Now, 2023) (KGAL GmbH & Co., 2023)
Green Fuels for Denmark	Ørsted, DSV, Maersk and DFDS, Copenhagen Airports, SAS, Topsoe, Neste, HOFOR, BIOFOS, CTR and VEKS	Major Power-to-X (PtX) project; large-scale production of sustainable eFuels (Bioenergy International, 2022) (Ørsted, n.d.)

Denmark

eSAF facility	Metafuels AG, European Energy	Synthetic sustainable aviation fuel (eSAF) facility near Padborg in southern Denmark; the facility will produce approximately 4.4 million litres of eSAF per year (Biofuels International, 2024)
First large-scale SAF storage	DCC & Shell Aviation	In September 2023, a record quantity of SAF was supplied at Oiltanking Copenhagen's terminal at Prøvestenen, with an aim to establish a large inventory of SAF. This storage facility will act as the central hub for ensuring a consistent and reliable supply of SAF to meet the needs of key stakeholders across the Danish aviation sector (Mabanaft, 2023) (Flightchic, 2023)
Pilot SAF project at Baltic Eagle Wind Farm	Vestas, HeliService, DCC & Shell Aviation Denmark A/S (SAF provider)	The pilot project entails Vestas technicians and jack-up vessel crew using helicopters partly powered by SAF to transport themselves to and from the Baltic Eagle wind farm during the construction phase of 50 offshore wind turbines. The project is scheduled to take place in September 2024. (Navingo, 2024) (Vestas, 2024)

Source: Kosan gas, Renewables Now, Biofuels International, Mabanaft, Flightchic, Navingo, Vestas

approximately 20.0% of an airline's cost base. Despite this, several airlines have committed to SAF adoption and carbon emissions reduction targets as they come under increasing pressure to decarbonize and align with IATA objectives.

Whilst the rollout of SAF production facilities is expected to continue, producing cheaper SAF is paramount if the industry is to have a subsidy-free future. Government support has been and will continue to be, an essential enabler of the research and development required to ensure SAF is commercially viable in the long term.

Outlook

Like many globally, the Danish SAF industry is still in its nascent stages. However, with targeted policy support, a natural endowment of renewable energy and a long history of successful biofuel technology development, the sector is uniquely positioned to capitalise on the market opportunity presented by SAF and the decarbonization of a notably hard-to-abate sector.

Investor sentiment already reflects this. Several landmark projects are well underway in Denmark, some of which are set to reach commercial operations by 2024, with several more announced across research, development and construction following the continued policy support provided by both the Danish government and EU.

Cost remains a key barrier to SAF's viability in the long term, with SAF priced at 2.0x – 5.0x its traditional, carbon-intensive alternative and fuel making up

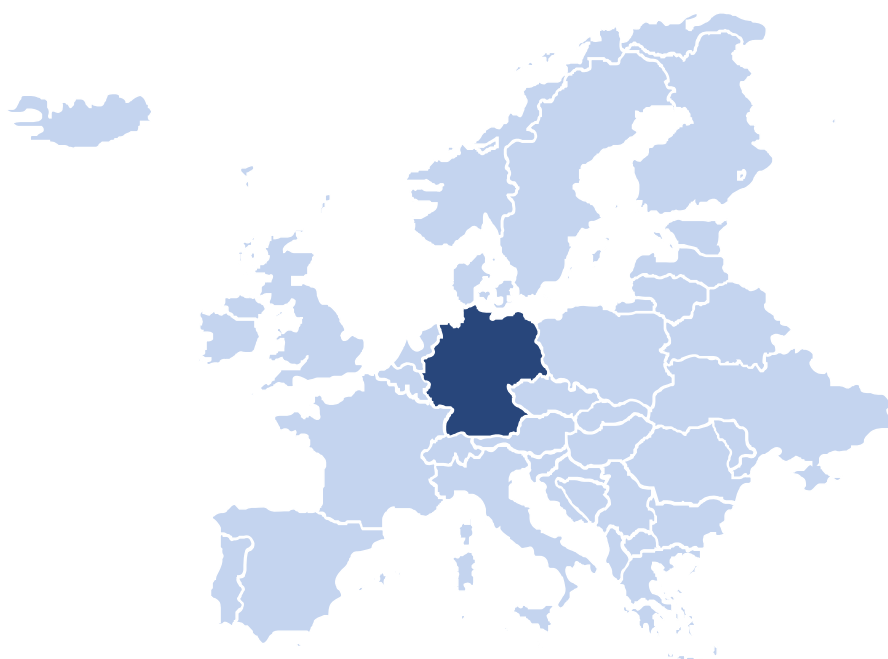
Germany

Germany is the largest aviation market in Europe, a central hub for European aviation research (e.g., DLR), and a key location for aircraft manufacturing. These position Germany perfectly to offer technological support for the development of the sustainable aviation fuel (SAF) industry.

The market opportunity for SAF in Germany is strengthened by robust public-private collaborations and significant investments in SAF production technologies. Companies like Neste, Sunfire, and UPM are leading initiatives, including the establishment of commercial-scale PtL facilities and biorefineries. These efforts make the outlook very positive, with projections of 1.5 million tons of SAF production by 2030, despite challenges such as increased flying taxes and potential funding cuts that may hinder growth and competitiveness in the sector.

Economic Indicators	GDP (current prices, \$ 2023)	4,457 Bn
	Real GDP growth forecast 2024-28	0.97%
	10-year govt bond yield (12-month rolling average)	2.43
	Country credit rating	AAA
Average daily flights	4,532	
Existing Fuel Consumption	10.66 million metric tons	
Usage Mandate	0.5% SAF by 2026, rising to 1% in 2028 and 2% in 2030	
Projected SAF Capacity Under Development (MT/Year)	498,508 by 2030	
Policy Support	- Targeted levy to prevent carbon leakage - Creation of financial investment incentives for eSAF - Development of a book-and-claim mechanism	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Germany

Aviation Industry Backdrop

Germany's aviation industry has experienced significant growth since the mid-1990s, with revenues surpassing €40 billion in 2023, making it one of the country's most innovative and best-performing sectors (Statista, 2023). In 2023, total aircraft movements across major German airports exceeded 2 million, a 5% increase from the previous year, while passenger numbers reached 194 million, a 19% growth compared to 2022 (Munich Airport, 2023).

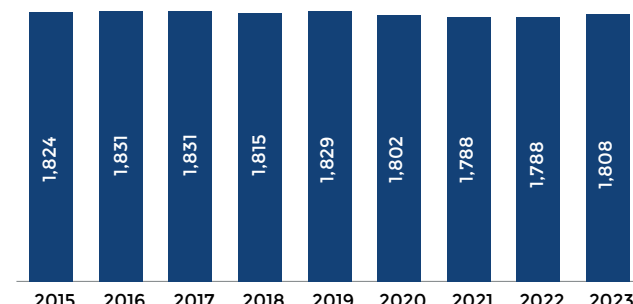
Despite the steady post-pandemic recovery in air traffic, Germany's jet fuel consumption has not yet returned to its 2019 pre-pandemic level of 221,100 barrels per day (bpd). However, anticipating a gradual increase in jet fuel consumption, the German government agreed with the aviation industry and regional authorities on a roadmap for the development and use of "green" aviation fuel (Reuters, 2021) to be on track with its overall decarbonization goals. The country aims to reduce CO₂ emissions by 42% across the entire transport sector by 2030 and decrease in-flight emissions of soot particles from aircraft engines using PtL kerosene by 50-70% (Evalueserve, n.d.).

Year	U SAF Blending Quotas	Aireg SAF Utilization Targets (Germany)	EU PtL Blending Quotas	Aireg PtL Utilization Targets (Germany)
2025	2%	2%	0.5% (Only Germany 2026)	0.5%
2030	6%	10%	1.2%	3%
2035	20%	30%	5%	20%
2050	70%	100%	35%	50%

Source: (aireg – Aviation Initiative for Renewable Energy in Germany e.V., 2024)

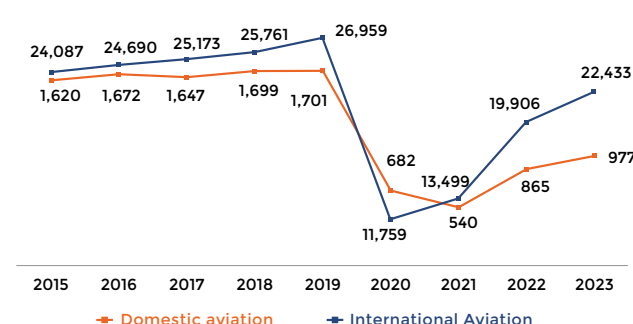
In this regard, a notable private sector initiative is the aireg – "Aviation Initiative for Renewable Energy in Germany e.V.", established in Berlin in 2011 by air carriers, airports, research institutions, and other partners. This non-profit organization promotes the availability and use of renewable energies in aviation to help the industry achieve its ambitious CO₂ reduction targets (The Emirates Group, 2024). Aireg has set specific 2030 goals, including operating at least one commercial SAF production plant in Germany and constructing and operating a PtL research and demonstration platform. (LinkedIn, 2024)

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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Germany

Policy and Regulation

Germany's advanced SAF policies and regulations are closely aligned with broader EU initiatives like ReFuelEU, demonstrating the country's commitment to sustainable aviation.

The German National Strategy, part of the country's target to achieve GHG neutrality by 2045, includes a 2% PtL quota for aviation fuel suppliers by 2030. In May 2021, the German government and industry representatives agreed on a "PtL roadmap" involving a €1 billion investment to establish PtL production in Germany, optimize technology, define sustainability criteria, and establish binding targets for renewable kerosene purchase and sale. The German Aerospace Centre (DLR) would lead concept development with industry and scientific partners, aiming to produce at least 200,000 metric tons of sustainable kerosene annually for German air traffic by 2030, potentially reducing emissions from one-third of all domestic flights.

In addition to government support, financial assistance is also available from the EU in terms of funding support for SAF projects through Horizon Europe and the European Green Deal. These funds are aimed at research, development, and scaling up production capacities.

These proactive policies and strategic investments highlight Germany's role as a key player in the global transition to sustainable aviation, reinforcing its leadership in the shift towards greener skies.

Market Opportunity

Germany's SAF market presents significant opportunities driven by strong government support, ambitious policy targets, a robust investment and funding ecosystem, and particular strengths in Power-to-Liquid (PtL) technologies. Several initiatives are underway to establish commercial-scale PtL facilities for SAF production. In June 2024, a working group of government and industry leaders urged political and industry commitments to support SAF market expansion. In its pursuit of a fossil-free aviation industry, Germany has also explored the potential of synthetic jet fuel produced from green hydrogen and sustainable CO₂, as part of an initiative led by the

German Energy Agency (Clean Energy Wire CLEW, 2024).

The aviation sector further benefits from strong collaborations between public and private sectors and partnerships among fuel producers, airlines, and technology providers, with several notable initiatives underway:

Notable Company/Industry Initiatives

- **Sunfire's Strategic Plans:** Sunfire, a German cleantech company, is developing a PtL technology that converts renewable electricity and CO₂ into synthetic crude oil, which can be refined into SAF. The company is collaborating with Lufthansa and other partners to establish a commercial-scale PtL facility in Germany.
- **UPM's Biofore Platform:** UPM, a Finnish company with a strong presence in Germany, is investing in a biorefinery project in Leuna, Germany. The facility will produce a range of renewable fuels, including SAF, utilizing sustainable feedstocks such as wood-based biomass and residues.
- **Airline Initiatives:** German airlines, such as Lufthansa and Condor, are actively participating in SAF projects, forming alliances with fuel producers to secure SAF supplies and reduce their carbon footprint. These collaborations often include long-term purchase agreements and joint research efforts to optimize SAF use in commercial flights. By integrating SAF into operations, these airlines are helping to create a market demand for sustainable fuels, encouraging further innovation and investment in this area.
- Along these lines, in a separate development, Lufthansa Group and HCS Group signed a Letter of Intent regarding the production and supply of SAF in Germany, compliant with Europe's Renewable Energy Directive RED II (Lufthansa Group, 2023). Lufthansa aims to halve net carbon emissions by 2030 from 2019 levels through reduction and offsetting measures, striving for carbon neutrality by 2050 (Lufthansa Group, n.d.).

Germany

International collaborations: In June 2024, Emirates joined aireg, underscoring its commitment to improving the sustainability of its operations and supporting the development of SAF. This pledge involves the airline contributing to efforts to boost locally produced SAF in Germany, aiding the country's ambition to become a hub for SAF production (aireg, 2024). Earlier, in November 2023, Boeing also joined aireg, highlighting the company's commitment to advancing sustainable aviation fuel (aireg, 2023). In September 2023, German logistics giant DHL signed an agreement with energy firm HH2E and South African petrochemicals firm Sasol to build a joint production facility for SAF in Eastern Germany. The facility will use green hydrogen to produce SAF and is expected to produce at least 200,000 tonnes per year, with the potential to scale up to 500,000 tonnes per year (ESG News, 2023).

SAF Supply & Infrastructure: In July 2024, Mönchengladbach Airport (EDLN) in Germany became the country's pioneer in providing uninterrupted access to SAF. While other German airports have previously offered renewable fuel, EDLN near Düsseldorf has established a partnership with TotalEnergies, ensuring consistent deliveries of blended SAF on a regular basis (AIN Media Group, 2024).

as research and demonstration facilities (CENA Hessen, 2023).

Despite a positive outlook, recent tax hikes might hinder SAF growth in Germany. On 1 May 2024, German flying taxes increased by 19% to €15.53-70.83 per passenger, depending on the route, reducing the country's competitiveness and affecting its air transport recovery (IATA Airlines magazine, 2024). The government may also cut over €2 billion in SAF research and infrastructure funding (Informa Markets, 2024). These recent initiatives could be detrimental to the decarbonization of the German aviation sector and the broader Net-Zero goal.

Outlook

Overall, Germany's sustainable aviation market is set to expand significantly over the next decade, driven by clear policy directives, substantial investment, and a robust commitment to research and innovation. Germany's approach not only supports its domestic aviation needs but also strengthens its potential as an exporter of SAF technologies and solutions, solidifying its leadership in the international market.

The CENA SAF Outlook 2024-2030 forecasts nearly 30 million tonnes of global SAF production by 2030, with Germany contributing about 1.5 million tonnes. According to the same projection, Germany's PtL kerosene demand is projected to reach 50,000 tonnes in 2026, 100,000 tonnes in 2028, and 200,000 tonnes in 2030 (CENA Hessen, 2023). Among the 144 global SAF projects, 20 are located in Germany, with 18 being PtL projects. Most are still in planning or conceptual stages, with six plants under construction or operating

France

France is emerging as a global leader in the SAF market, driven by its commitment to decarbonizing air travel and achieving ambitious climate goals. The French government has set progressive SAF incorporation targets, aiming for 1.5% in 2024, 2.0% by 2025 and 5.0% on all flights by 2030. Additionally, the target also includes a mandate of incorporating synthetic fuels as a specific proportion of the fuel blend (1.2% in 2030, 2.0% in 2032 and 5.0% in 2035, to gradually reach 35.0% by 2050) (Air France-KLM Group) (Scaling Up Sustainable Aviation Fuel Supply, 2024).

To further support these objectives, France has implemented policies and incentives to drive SAF development and adoption. These include investing €500.0 million in low-carbon aviation, extending the TIRUERT tax scheme to incentivize SAF use, and supporting research into novel SAF production technologies. Additionally, leading French airlines such as Air France and Transavia, are actively participating in SAF projects and collaborating with fuel producers to optimize SAF use in commercial flights.

Economic Indicators	GDP (current prices, \$ 2023)	3,022 Bn
	Real GDP growth forecast 2024-28	0.01%
	10-year govt bond yield (12-month rolling average)	2.99
	Country credit rating	AA
Average daily flights	3,999	
Existing Fuel Consumption	8.85 million metric tons	
Usage Mandate	1.5% SAF in 2024, rising to 2% in 2025	
Projected SAF Capacity Under Development (MT/Year)	888,000 by 2030	
Policy Support	Allocated €200 million to enhance the industrial production of SAFs	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



France

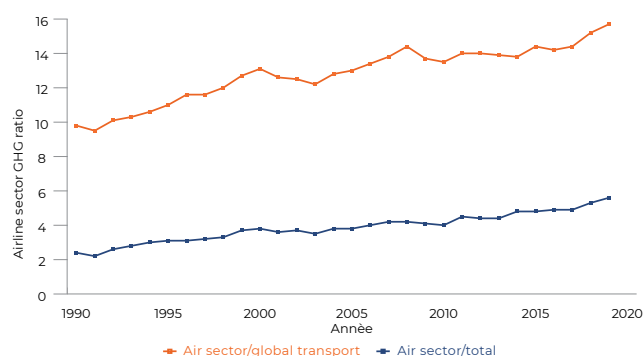
Aviation Industry Backdrop

France boasts a robust and innovative aviation industry, holding a significant position globally across aircraft manufacturing, airline operations and aerospace technology. The country is home to major industry players such as Airbus, Safran, and Air France-KLM.

In terms of air traffic, France has the 14th largest airline market worldwide based on the number of scheduled seats for 2023. The majority of the traffic is concentrated around Paris, with Charles de Gaulle, Orly, and Beauvais accounting for 56.0% of all departing seats (Cirium Diio, 2023). French airports saw an average of 3,999 flights per day in 2023, representing a 7.0% increase over 2022 (EUROCONTROL, 2024).

Passenger numbers in France reached 94.5% of pre-pandemic levels in 2023, totalling just under 170.0 million, according the Direction Générale de l'Aviation Civile (DGAC). While international traffic recovered, domestic flights within mainland remained at 80.0% of 2019 levels due to increased train travel and video conferencing (Barron's, 2024). Despite the pandemic's impact, France's flight market grew by 31.0% in 2023 compared to 2022, reaching over \$18.0 billion. Forecasts indicate that the market will grow slightly over the next few years, reaching \$18.8 billion in 2027 (Statista, n.d.).

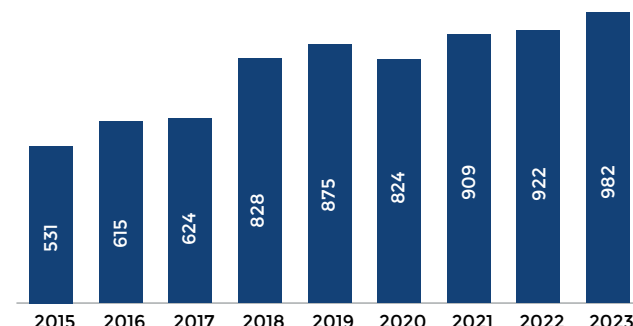
Evolution of Relative Emissions from the Aviation Sector in France



Note: In France, the aviation sector's share of national emissions has doubled in 25 years

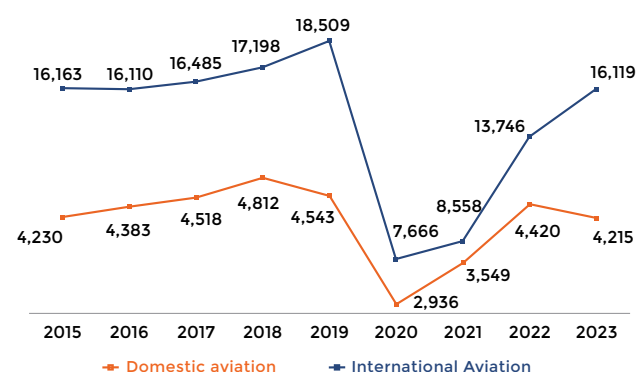
Source: (NATIONAL ACADEMY OF TECHNOLOGIES OF FRANCE, 2023)

Biofuel Installed Capacity (MW)



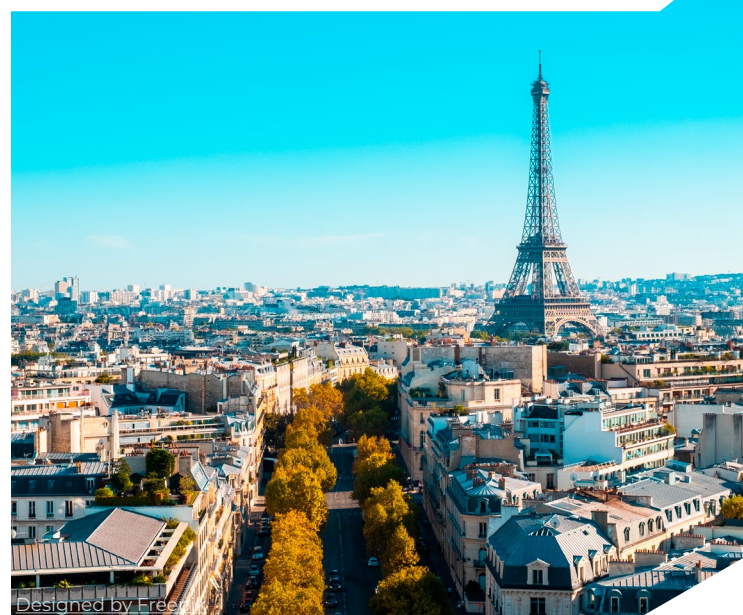
Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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France

As of 2022, France's annual greenhouse gas emissions totalled 403.8 million tons of CO₂ equivalent (Mt CO₂ eq), with transport being the leading emitting sector at 130.5 Mt CO₂ eq or 32.3% of the total emissions (Statista, n.d.). The aviation sector's share of GHG emissions has been growing steadily over the past 30 years, despite technological improvements (NATIONAL ACADEMY OF TECHNOLOGIES OF FRANCE, 2023). Under such a circumstance, SAF is expected to contribute 60.0% to the reduction of aviation-related CO₂ emissions, with the remainder being achieved through the optimisation of technologies and operational processes (NATIONAL ACADEMY OF TECHNOLOGIES OF FRANCE, 2023).

Air France-KLM, the dominant airline in France, estimates it will require 1.0 million tonnes of SAF annually by 2030, with its subsidiary Air France consuming half of that amount (Air France-KLM Group). To meet its goals of reducing CO₂ emissions per passenger/km by 30.0% and incorporating at least 10.0% SAF by 2030, the group has secured future supplies, invested in SAF production capabilities, and engaged customers through dedicated programs (Air France-KLM Group).

Policy and Regulation

The French government's ambitious and progressive SAF incorporation and synthetic fuel blending targets are expected to reduce the carbon footprint of the aviation sector and stimulate job creation and innovation. Towards this end, the country has implemented policies and incentives to curb emissions in the aviation sector and support the development and adoption of SAF.

In June 2023, the French government committed to invest a total of €500.0 million to advance low-carbon aviation (Clean Energy Wire, 2024). The investment includes €300.0 million for research into low-carbon aircraft and engines, €200.0 million to upgrade industrial production of SAF, and a goal to build the first low-carbon plane by 2030 (RFI, 2023) (Reuters, 2023).

To incentivize SAF use, France has extended the Taxe Incitative Relative à l'Utilisation d'Énergie Renouvelable dans les Transports (TIRUERT) scheme to air transport (Lhyfe Heroes, 2024). This tax system penalizes operators who do not meet blending obligations for advanced biofuels (ePURE, 2023). The initial SAF integration target was set at 1.0%

for 2023, increasing to 1.5% by January 2024 with non-compliance resulting in a penalty of €168.0 per missing hectolitre. Following amendments to the draft finance bill for 2024, the TIRUERT penalty will be reduced to €125.0 per hectolitre in 2024, and a proposed increase to €280.0 in 2025 has been removed (Senate, 2023). The scheme is expected to drive significant adoption of renewable energy in aviation, with an estimated 80.0GWh to 120.0GWh of renewable electricity to be marketed through TIRUERT in 2024 (Lhyfe, 2024).

These policies and investments demonstrate France's commitment to decarbonizing aviation and promoting the widespread use of sustainable aviation fuels. The country's approach combines financial incentives, research and development support, and regulatory measures to accelerate the transition to cleaner air travel.

Market Opportunity

The French SAF market is on the cusp of a transformative journey, driven by collaborative efforts of aviation industry stakeholders, biofuel producers, research institutions, and government bodies. These partnerships are key to scaling up SAF production, improving efficiency, reducing costs, and increasing its availability in the market. by stimulating demand and promoting the industrialization of French production sectors.

To enhance the sustainability and economic viability of biojet fuels, researchers are focusing on developing novel SAF production technologies. With limited biomass feedstock, synthetic jet fuel technology is important to meet the growing demand for SAF (NATIONAL ACADEMY OF TECHNOLOGIES OF FRANCE, 2023). Innovations in feedstock diversity, conversion processes, and lifecycle assessments are also at the forefront of these development efforts.

The French SAF production pipeline is picking up pace, with multiple projects due to come online in the coming years. Once completed, these projects will help to reduce the country's dependence on imported energy sources and lead to increased exports of SAF.

France

SAF Initiatives:

Company	Particulars
H2V and Hy2Gen	H2V and Hy2Gen, prominent players in sustainable energy solutions, have united their expertise to establish a pioneering production unit for e-SAF. This partnership, operating as a temporary consortium, aims to establish a production capacity of 50,000.0 tonnes of e-SAF by 2030 (ChemAnalyst, 2024)
Engie and Infinium	Engie and Infinium announced plans to build a project called Reuze to develop synthetic fuel production with ArcelorMittal Dunkirk's factory for air and sea transport. Reuze will utilize 300,000.0 tonnes of CO2 captured at ArcelorMittal's steel plant to produce 100,000.0 tonnes of synthetic fuels (Industry Decarbonization Newsletter, 2024) (Nord France Invest, n.d.)
Engie and Air France	ENGIE partnered with Air France to build a synthetic fuels production unit for air transport and green chemistry. Feasibility studies are underway, with final investment decisions set to be made by 2025. Construction is expected to start in 2026 and upon completion, annual kerosene production will reach approximately 70,000.0 tons (Reuters, 2023) (Haropa Fort, n.d.)
Hy2Gen, Technip Energies, Bionext, and Axens	Technip Energies, a strategic shareholder of Hy2gen, through its subsidiary Hy2gen France is aiming to deploy BioTfuEL technology on an industrial scale as part of the Hynovera project. The project cost is estimated at €460.0 million and feasibility studies are underway. The final investment decisions are set to be made by Q2 2026, with a target of starting commercial operations by Q4 2029. Once completed, production is estimated to reach 32,000.0 tons per year for e-SAF, and 700.0 tons per year for e-Diesel (hy2gen, n.d.) (Offshore Energy, 2022)
Elyse Energy and Khimod	Elyse Energy and Khimod entered into a partnership to produce power-to-liquid sustainable fuels for air transport through the AVEBIO collaborative project. The funding is being provided by Hy24, a clean hydrogen infrastructure fund, and Mirova, an investment management company specializing in sustainability financing. The funding will support Elyse's plans to produce 200,000.0 metric tons of SAF and 1.0 million tons of e-methanol per year (Aviation Week Network, 2023)
Total Energies	TotalEnergies, has committed to producing SAF at its refineries. The company aims to produce significant quantities of SAF by converting its existing facilities to support biofuel production, leveraging advanced technologies to ensure high efficiency and sustainability (TotalEnergies, 2023)
Engie	Engie is investing in SAF production through partnerships with technology providers and research institutions. Engie plans to utilize its extensive refinery network to produce SAF, contributing to the country's overall production capacity (ENGIE, 2023)
Carbios	Carbios is developing a commercial-scale plant in Longlaville, France, focusing on enzymatic recycling of PET plastics. While not directly related to SAF, the technological advancements and expertise gained from this project are expected to contribute to the development of sustainable fuel production in France (Chemical Engineering, 2024)

Source: ChemAnalyst, Industry Decarbonization Newsletter, Nord France Invest, Reuters, Haropa Fort, hy2gen, Offshore Energy, Aviation Week Network, TotalEnergies, ENGIE, Chemical Engineering

Airline Initiatives: Leading the charge in this green revolution are airlines such as Air France and Transavia, actively participating in SAF projects and forming alliances with fuel producers. These collaborations often involve long-term purchase agreements and joint research efforts to optimize SAF use in commercial flights. For example, Air France-KLM, has signed strategic agreements with Neste and DG Fuels to secure a supply of 1.6 million tonnes of SAF between 2023 and 2036 (Air France-KLM Group).

Outlook

As the aviation industry sets its sights on decarbonisation, SAF is poised to play a pivotal role in this transition. Its production compatibility with existing infrastructures makes its adoption easier. The current decade is crucial for establishing a realistic industrial trajectory to ensure its effective availability on the right scale and at the right time.

France is well-positioned to lead in SAF production, thanks to its largely decarbonized electricity mix from solar, wind, and nuclear power. However, to support this growth, the government must implement a

proactive industrial policy to expand low-carbon electricity beyond current needs (NATIONAL ACADEMY OF TECHNOLOGIES OF FRANCE, 2023).

The French SAF market is on the brink of a promising future, propelled by technological advancements, policy support, and industry collaboration. As sustainability and environmental stewardship become increasingly essential, France aims to be at the forefront of the transition towards sustainable aviation fuels, contributing to a greener future for the aviation industry and beyond.

Spain

Spain is emerging as a significant player in the SAF market, driven by its commitment to reducing carbon emissions in the aviation sector and aligning with the European Union's Green Deal objectives. The country's strategic focus on renewable energy sources and its robust infrastructure make it an attractive hub for SAF investments. In collaboration with aviation stakeholders, prominent energy companies have already made important investments in the sector. These collaborations are crucial for scaling and integrating SAF production into the existing aviation fuel supply chain. Spain's commitment to SAF is evident through its increasing investment activity and a robust pipeline of SAF projects that are expected to be developed, constructed, and operated over the next 5-10 years.

Decarbonizing the Spanish aviation sector is expected to require around 5 million tons of SAF annually by 2050. To achieve this, Spain would need to establish between 30 and 40 production plants nationwide, which would be sufficient to cover its entire national demand. A report by Iberia Airlines suggests Spain's production capacity could significantly exceed local needs by 2050, and building additional plants could enable the country to export substantial volumes of SAF to the international market (PwC, 2024) (Iberia, 2023).

Economic Indicators	GDP (current prices, \$ 2023)	1,581 Bn
	Real GDP growth forecast 2024-28	1.81%
	10-year govt bond yield (12-month rolling average)	3.45
	Country credit rating	A
Average daily flights	4,616	
Existing Fuel Consumption	7.48 million metric tons	
Usage Mandate	-	
Projected SAF Capacity Under Development (MT/Year)	272,860 by 2026	
Policy Support	Aims to construct 30 to 40 SAF production plants and inject €56 billion into the country's GDP by 2050	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Spain

Aviation Industry Backdrop

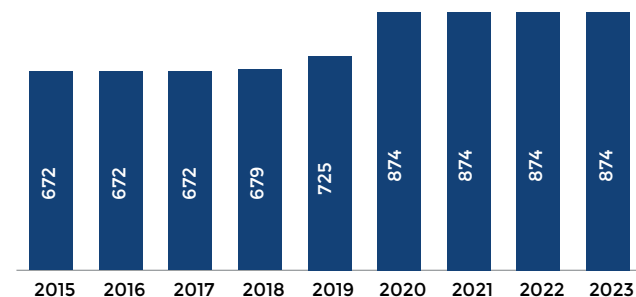
Spain's aviation industry has grown to become the top air passenger market in Europe, with passenger traffic hitting record highs in 2023 (Eurostat, 2023) (Statista, 2024). Additionally, the airports saw a surge in the daily number of flights in 2023, with an average of 4,616 flights, which was 9.0% higher in comparison to 2022 (Eurocontrol, 2024). The revenue of the flight market in Spain is projected to reach \$14.0 billion in 2029, growing at a CAGR of 3.7% from \$11.3 billion in 2023 (Statista, 2024).

The expansion of the aviation industry is having notable environmental repercussions resulting from higher fuel consumption and CO₂ emissions. Spain's jet fuel consumption was at the level of 7.5 million metric tons of oil equivalent in 2023, up 13.1% from the previous year (Knoema, n.d.). This rising trend in fuel consumption has corresponded with a rise in CO₂ emissions, which reached 20.0 million tons in 2023, representing 12.0% of the share of total aviation emissions in Europe (Murcia Today, 2024) (Breaking Travel News, 2024).

This trend underscores the urgent need for the aviation sector in Spain to address its environmental impact, making decarbonization imperative to curb rising emissions. Among the various strategies to achieve this, biofuels—particularly biodiesel, Hydrotreated Vegetable Oil (HVO), and bioethanol—have emerged as a promising solution in Spain's pursuit of cleaner aviation fuels. In 2023, the volume of biodiesel and bioethanol consumed across Spain totalled 4,400.0 metric tons and 85.0 metric tons, respectively (Statista, 2024) (statista, 2024).

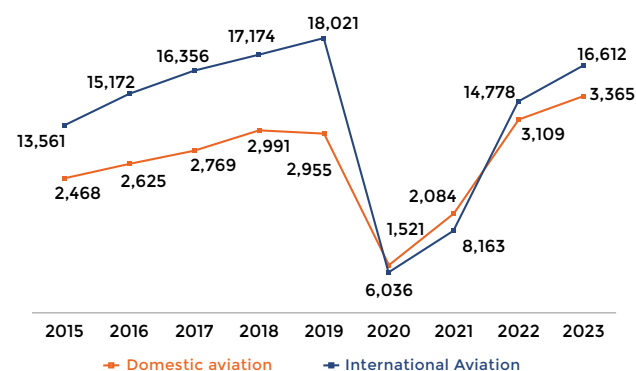
Additionally, Spain stands out in Europe for its innovative approach to producing renewable diesel. The country leads in co-processing vegetable oil with fossil diesel at oil refineries to produce renewable diesel, offering a lucrative opportunity to produce SAF.

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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Spain

Policy and Regulation

Decarbonisation and SAF targets: The Spanish government's SAF target aligns with ReFuelEU's goal of achieving 2% SAF usage in all aviation fuel by 2025 (ICAO, 2022) (Ecologistas en Acción, 2021). Further, the National Integrated Energy and Climate Plan 2021-2030 sets a target of 5.0% biofuels, of which 0.7% are synthetic fuels, in line with ReFuel Aviation (Transport & Environment, 2023).

The Spanish Climate Change Law enables the government to establish annual renewable energy targets in the aviation sector, focusing on advanced biofuels and other renewable fuels of – non-biological origin (ICAO, 2022) (Ecologistas en Acción, 2021). The regulations mandate biofuel targets reaching 12.0% by 2026. Also, advanced biofuel targets were set to reach 3.5% by 2030 (IEA, n.d.).

Multiple government funding programs have been introduced to support nationwide SAF initiatives:

Earmarked Investments and Funding for SAF: The Spanish government has allocated €250.0 million for the development of a dedicated large-scale renewable diesel and SAF production facility in Cartagena (SAF Investor, n.d.). The National Integrated Energy and Climate Plan 2021-2030 also suggests using carbon market revenues to fund public investments in green hydrogen and eFuel production, allocating 25% of the revenues generated from the ETS to aviation and shipping (Transport & Environment, 2023).

Deployed Investments and Projects: In June 2024, the Ecological Transition and Demographic Challenge Commission approved a legislative proposal outlining key points for the policy-led growth in SAF, including SAF production incentives, R&D funding, and public-private partnerships to enable adoption of SAF technologies and facilitating feedstock sourcing strategies (Travel And Tour World, 2024).

Financing Mechanisms: The National Integrated Energy and Climate Plan 2021-2030 recommends adopting Carbon Contract for Difference schemes, financed via revenues raised from the application of the polluter-pays principle. The plan also suggests promoting and facilitating private investments in the development of clean fuels and zero-emission technologies (Transport & Environment, 2023).

In addition to government support, financial

assistance is also available from the EU in terms of funding support for SAF projects through Horizon Europe and the European Green Deal. These funds are aimed at research, development, and scaling up production capacities, ensuring that Spain remains competitive in the global SAF market.

Market Opportunity

The SAF project pipeline in Spain is expanding due to several initiatives being put in place. Investments are directed towards the development of infrastructure necessary for the production and distribution of SAF. The combined efforts of Repsol, Cepsa, and Solarig signal a robust future for the SAF industry, and government bodies are collaborating with private companies to capitalize on expertise and investment to scale up SAF production and distribution efficiently.

Airline Initiatives: Major airlines, such as Iberia and Vueling, have voluntarily committed to individual emission-reduction targets, surpassing regulatory requirements by vowing to employ 10.0% SAF by 2030—a higher percentage than the 2.0% mandated in Europe (Iberia, n.d.) (Vueling, n.d.). These airlines are actively participating in SAF projects, forming alliances with fuel producers to secure SAF supplies and reduce their carbon footprint.

SAF Initiative: Significant investments have fuelled the shift to large-scale production, with Repsol planning to invest over €120.0 million to retrofit a diesel plant into a biofuel refinery (Reuters, 2023), and a €780.0 million venture announced by Solarig and the regional government of Castilla y León for a new facility in Soria (ChemAnalyst, 2024). Additionally, the Cepsa, in a JV agreement with Bio-Oils, is constructing the largest second-generation biofuels plant in southern Europe, aiming to produce 500,000 tonnes of HEFA SAF & renewable diesel annually (Biobased Diesel Daily®, 2023).

Spain

Outlook

Overall, Spain is emerging as a key player in the European SAF market, with the potential to become a significant global contributor. With a combination of regulatory support, strategic funding, and investment in new technologies, Spain's SAF market is well-positioned to grow rapidly.

Future SAF production facilities in Spain will be able to leverage the country's well-established renewable diesel industry, which includes several refineries already producing substantial amounts of hydro-processed renewable diesel. This capacity could potentially be reoriented to produce hydro-processed esters and fatty acids (HEFAs) jet fuel. However, the current reliance on palm oil as a feedstock poses sustainability challenges. To meet the sustainability requirements proposed in the ReFuelEU regulation, the industry needs to transition from food-oils to waste oils. This shift may impact the production

capacity of diesel and renewable diesel if the relevant units are reoriented to jet fuel production. As a result, it is more likely that new dedicated facilities producing a high share of HEFA jet output will be required and that existing co-processing capacity will continue to produce renewable diesel (ECODES, n.d.) (Ecologistas en Acción, 2021). For example, Cepsa has plans to produce HEFA SAF & renewable diesel in its second-generation biofuels production facility in Huelva (Energy Intelligence, 2024).

In the future, the focus is expected to shift towards more advanced biofuels, such as those derived from a combination of CO₂ and green hydrogen. Companies like Solarig are currently developing these technologies. Notably, Spain is projected to be one of the most competitive and cost-efficient locations in Europe for green hydrogen production (Financial Times, n.d.).

Italy

Although the Italian SAF market is still in its early development stages, it is progressing rapidly due to the aviation sector's need for decarbonization, driven by the country's high air traffic volume. This underscores the importance of adopting SAF to mitigate aviation's environmental impact. Italy is targeting an ambitious SAF production capacity of 150,000 tons by 2024, demonstrating its commitment to fostering a robust SAF industry (A&D Market Reports, 2023).

Economic Indicators	GDP (current prices, \$ 2023)	2,256 Bn
	Real GDP growth forecast 2024-28	0.53%
	10-year govt bond yield (12-month rolling average)	4.17
	Country credit rating	BBB
Average daily flights	3,500	
Existing Fuel Consumption	5.22 million metric tons	
Usage Mandate	-	
Projected SAF Capacity Under Development (MT/Year)	150,000 by 2024	
Policy Support	Politecnico di Torino and the Italian Ministry signed an agreement to promote the use of SAF in the transport sector	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Italy

Aviation Industry Backdrop

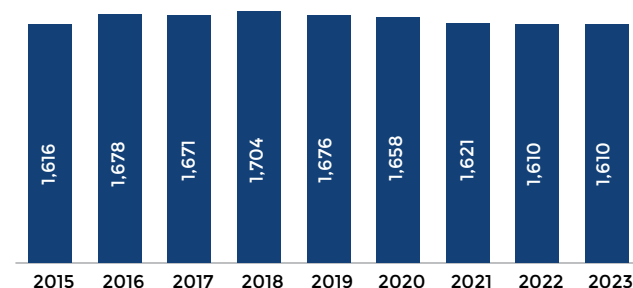
In 2023, Italy ranked fifth in Europe for daily average flight numbers, with 3,500 arrivals and departures, which is 3.0% below pre-COVID levels but 11.0% higher than in 2022 (Eurocontrol, 2023). Italian airports accommodated a record 197.2 million passengers in 2023, a 2.1% increase compared to the previous record set in 2019, marking a full revival of the international segment (Schengen.News, 2024). In November 2023, Italy's jet fuel sales surpassed pre-pandemic levels, signalling a potential boost for air travel (Bloomberg, 2023). The growth of the aviation sector is anticipated to persist, with the annual jet fuel demand projected to reach 5,467 kton in 2025 and 5,740 kton in 2030 (Roland Berger, 2024).

With the surge in fuel consumption resulting from the ongoing expansion, the aviation sector has become a significant source of emission, posing a growing environmental challenge. Italy ranked as the 15th largest source of passenger-related aviation emissions globally in September 2022, with c.1.0 million tonnes of CO₂ emitted (RDC Aviation Ltd, 2022). As the sector continues to expand, it becomes increasingly urgent to focus on decarbonization to address the mounting environmental issues.

In the path to decarbonizing the aviation sector, Italy, ranking fifth in Europe for biofuel production, is leveraging its existing capabilities to support the broader adoption of sustainable biofuels in aviation. This effort includes participation in international agreements like the Turin Joint Statement on Sustainable Biofuels, which seeks to emphasize actions for G7 countries to accelerate sustainable biofuel deployment to align with a net-zero pathway by mid-century (IEA Bioenergy, 2023) (Roland Berger, 2024).

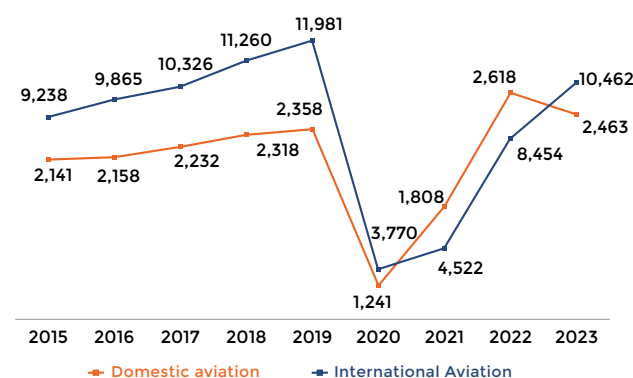
SAF, with its potential to play a relevant role in decarbonizing the aviation sector, is expected to rapidly scale up, supported by regulations. SAF incorporation targets have been set at 2.0% yearly between 2025-29 and 6.0% in 2030, in line with ReFuelEU (Roland Berger, 2024).

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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Italy

Policy and Regulation

Italy's national legislation on SAF closely aligns with EU laws aimed at reducing emissions in the transportation sector. The Italian Civil Aviation Authority (ENAC) established the "National Observatory on SAF" to create a technical board involving key ministries and stakeholders interested in SAF development. In 2022, ENAC collaborated with these stakeholders to define a "Roadmap on SAF in Italy," focusing on potential incentive policies and aligning with the "RefuelEU Aviation" context (ENAC, 2023).

In April 2022, "The Pact for the Decarbonisation of Air Transport" was established to help the aviation industry meet sustainability targets, aiming for Net Zero Emissions by 2050 (Decarbonizzazione Trasporto Aereo, n.d.). This initiative, launched by Decarbonizzazione Del Trasporto Aereo, involves key players such as airlines, airports, fuel producers, and government organizations. The pact emphasises stakeholder cooperation in transitioning to sustainable air transport, promoting public-private partnerships for low-carbon technologies, and implementing policies that incentivise sector decarbonisation (Logistica, 2023).

Further, the Italian government, in conjunction with EU funding programs like Horizon Europe and the European Green Deal, is providing substantial financial support to SAF projects. These funds are aimed at research, development, and scaling up production capacities, ensuring that Italy remains competitive in the global SAF market.

Market Opportunity

The Italian SAF market presents a promising opportunity for growth and development, driven by collaborative efforts of biofuel producers, aviation companies, research institutions, and government agencies. The market benefits from international collaborations, joint R&D initiatives, and technology transfers, enhancing expertise and boosting the country's competitiveness in the global SAF market (A&D Market Reports, 2023).

Leading Italian energy companies, such as GreenOil and EcoFuel, are investing heavily in SAF production by converting refineries and leveraging advanced technologies to improve efficiency and sustainability. These companies are also forming partnerships with technology providers and research institutions to enhance their production capacity. For example, Italian energy company Eni has partnered with Rome's airport operator, Aeroporti di Roma (ADR), to supply sustainable fuels for both aircraft and ground vehicles (Warwick, 2021).

Airlines, including Alitalia and Air Italy, are actively participating in SAF projects by forming alliances with fuel producers to secure SAF supplies and reduce their carbon footprint. These collaborations often include long-term purchase agreements and joint research efforts to optimize SAF use in commercial flights. For example, in January 2024, Ryanair and Enilive announced a letter of intent for the long-term supply of up to 100,000 tons SAF at selected Ryanair airports across Italy (SAF Investor, 2024). Additionally, to encourage the use of SAF, airport operator SEA Prime announced in May 2024 that it would offer a € 1,000 incentive to SAF purchasers at its airports. The incentive is available from the second half of 2024 with a cap of €50,000 (SAF Investor, 2024).

With the growing project pipeline, strategic planning, policy support, and collaboration among stakeholders, Italy is well-positioned to sustain and enhance its competitive edge in the SAF market. As the demand for sustainable aviation fuel continues to rise, Italy's SAF industry is poised for significant growth and development in the coming years.

Outlook

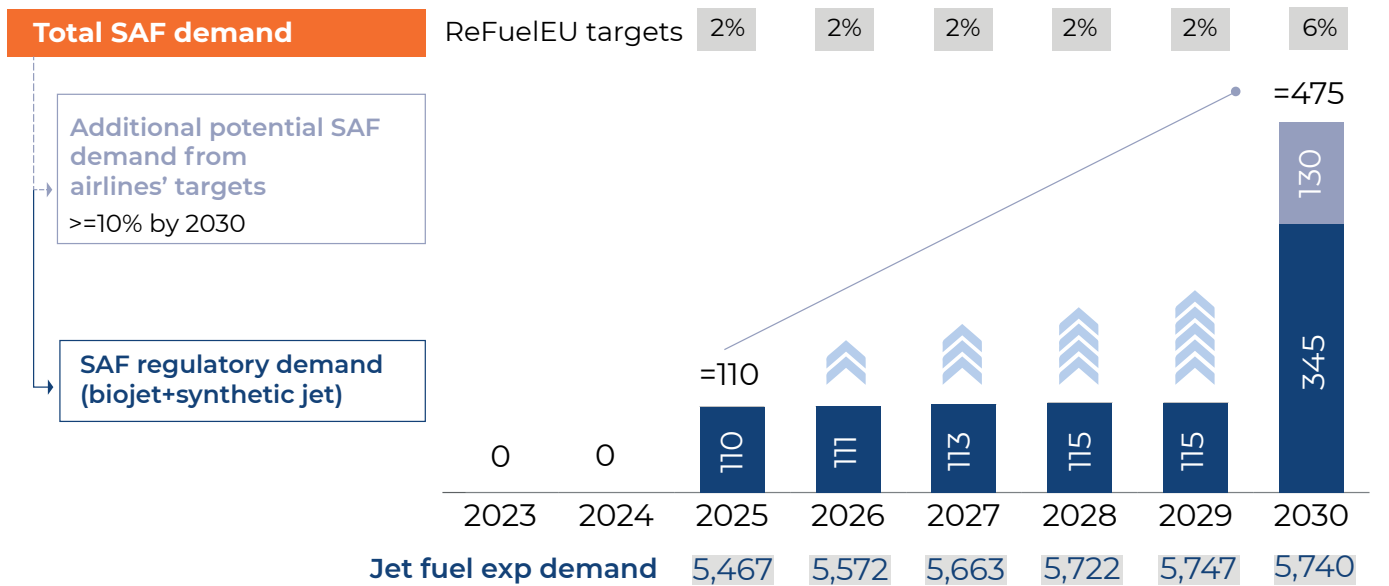
Italy’s SAF market is poised for significant growth, with an estimated regulatory demand of around 350,000 tonnes by 2030. However, additional demand from airlines aiming to exceed regulatory limits for their decarbonization plans is expected to push total SAF demand to approximately 500,000 tonnes by the same year.

Domestic production plans are on track to meet Italy’s biofuel demand through the use of Hydroprocessed Esters and Fatty Acids (HEFA) technology. HEFA will play a critical role in fulfilling the SAF requirements by 2030. However, the challenge of meeting the specific target for synthetic fuels, which is around 70,000 tonnes by 2030, is compounded by the current lack of

consolidated technologies in this area. The projected rise in the share of SAF – 6.0% by 2030 and 70.0% by 2050 -- entails a rapid scale-up, requiring Italy to act swiftly by supporting new technologies like synthetic jet and bio-jet (Roland Berger, 2024).

To achieve a successful SAF market at scale, Italy must address multiple challenges, including scaling up production and distribution capacities, developing cost-effective production processes, and establishing a reliable and sustainable supply chain. Favourable policies and subsidy support will be crucial in incentivizing SAF as the biofuel of choice (A&D Market Reports, 2023).

SAF demand in Italy [k ton; 2023-2030]



Source: Roland Berger, 2024

Netherlands

The Netherlands has emerged as a European frontrunner in the SAF market, being one of the few countries worldwide where large-scale SAF production is taking place. The country's strong focus on sustainability, existing chemical industry cluster with deep biorefining expertise, and robust logistics infrastructure make it an ideal location for SAF production. The Dutch government's ambitious goals to blend 14.0% SAF into aviation fuel by 2030 and 100.0% by 2050 have created an environment conducive to SAF innovation and adoption.

The Netherlands' commitment to SAF is evident through its increasing investment activity and a robust pipeline of SAF projects that are to be developed, constructed, and operated over the next 5 years. The fact that companies like Shell and Neste are increasingly focusing on developing and expanding their SAF production capabilities demonstrates this. While there are significant opportunities, the SAF industry in the Netherlands also faces challenges, including the high cost of production and the need for technological advancements to make SAF more economically viable. However, ongoing investments, government support, and strong industry collaboration are helping to address these challenges.

Economic Indicators	GDP (current prices, \$ 2023)	1,117 Bn
	Real GDP growth forecast 2024-28	1.50%
	10-year govt bond yield (12-month rolling average)	2.78
	Country credit rating	AAA
Average daily flights	1,521	
Existing Fuel Consumption	3.76 million metric tons	
Usage Mandate	14% SAF by 2030, and 100% by 2050	
Projected SAF Capacity Under Development (MT/Year)	777,780 by 2027	
Policy Support	Dutch government's €20m investments for the construction of SAF plant in Rotterdam which is expected to produce 50,000 tons of SAF annually once fully operational.	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol

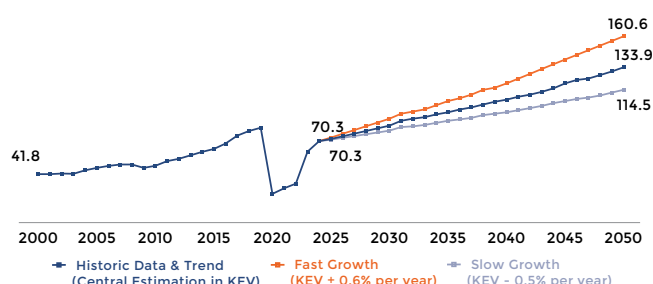


Netherlands

Aviation Industry Backdrop

The Netherlands is one of the leading players in the global aviation industry. According to the Dutch Bureau of Statistics, 71.3 million passengers travelled via airports in the Netherlands in 2023, an increase of 16.0% over 2022, but still below pre-pandemic levels (New Zealand Foreign Affairs & Trade, 2024). In 2023, the total number of commercial flights amounted to 505,989, marking an increase of 9.0% over 2022. In the first five months of 2024, the total number of flights amounted to 214,271, thereby reaching c.42.0% of annual 2023 numbers (Netherlands, 2024).

Historic Data and Autonomous Future Development of the Number of Passengers at Dutch Airports (in million)

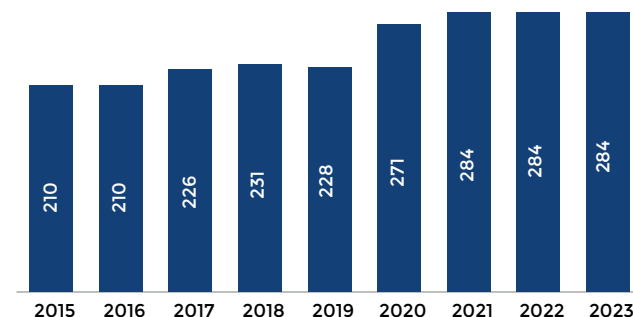


Source: (Hilbers, 2024)

In comparison to 2022, CO₂ emissions in the aviation sector increased by 11.0% in 2023 (NL Times, 2024). A report from the Netherlands Aerospace Centre estimated that the nation's aviation activity accounted for 1.2% of total global emissions from aviation, and that 96.0% of the nation's CO₂ was generated at Schipol airport. Additionally, the report states that 80.0% of all Dutch flights were intra-EU and contributed to about 20.0% of total aviation CO₂ emissions, whereas 15.0% of the longest distance flights (over 5,000 km) were responsible for 75.0% of emissions (Greenair Communications, 2024).

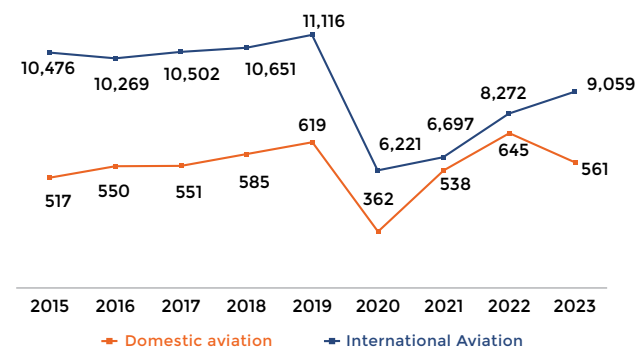
The Dutch aviation sector is projected to grow from 71.0 million passengers in 2023 to between 98.0 and 138.0 million in 2050, although the growth rate will be significantly lower than pre-2019 levels (Hilbers, 2024). The projected revenue for the flight market in the Netherlands is estimated to reach US\$3.4 billion by 2024. Furthermore, the market is expected to exhibit a CAGR of 3.7% between 2024 and 2029, resulting in

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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Netherlands

a projected market volume of US\$4.1 billion by 2029 (Statista, 2024).

Accordingly, the demand for jet fuel in the Netherlands is expected to continue increasing due to the rise in air travel and the expansion of airline fleets. However, demand dynamics will also be influenced by various factors, such as efficiency improvements, the adoption of SAF, and regulatory mandates. In general, although traditional jet fuel demand will continue to grow, the increased focus on SAF and efficiency improvements is likely to moderate this growth. Furthermore, local incentives, such as renewable fuel units (HBEs), have encouraged the use of SAF, thereby displacing jet fuel demand to an extent (Argus Media Group, 2023).

Policy and Regulation

The Netherlands is committed to reducing its carbon emissions in line with the European Union's targets and the Paris Agreement. The Dutch government's target to blend 14.0% SAF into aviation fuel by 2030 puts the country ahead of the already ambitious EU targets to achieve 6.0% SAF by 2030. To support its short- and long-term targets, the government has introduced various policies and incentives (Invest in Holland, 2024).

The national policy focuses on voluntary agreements to limit emissions, restrictions on noise pollution, and the taxation of air travel (Hilbers, 2024). In January 2024, 31 parties active within the Dutch aviation industry presented their joint vision for a Future-Proof Aviation for the Netherlands, including 10 concrete commitments. A constructive discussion was held among the group and members of Parliament and policymakers regarding, among other things, scaling up the production of sustainable fuels (KLM, 2024) (Agreement, 2024).

The Dutch government has introduced tax breaks and subsidies to incentivise SAF adoption. KLM Royal Dutch Airlines, for instance, has taken advantage of these incentives and has committed to using SAF on all flights from Amsterdam to Los Angeles starting 2024. The government has also invested €20.0 million in a SAF plant in Rotterdam, a collaboration with SkyNRG, that will produce 50,000.0 tons of SAF per year once it is fully operational (SAF Investor, 2023).

As part of its efforts to reduce CO2 emissions, the government tripled air passenger taxes starting in January 2023 (€26.43 per passenger, per flight), representing an effective increase of €18.48 over 2022 (Schengen News, 2023). As of 1 January 2024, the travel tax was again revised to €29.05, representing a further increase of €2.62 over 2023 (Transavia, n.d.). The tax increase was approved by the government on 21 December 2023 with the aim of using part of the revenue to make aviation more sustainable and reduce its environmental impact (ch-aviation GmbH, n.d.).

Dutch airport operators are also gradually aligning themselves with national requirements as a result of the Dutch government's ambitious SAF mandates. Rotterdam The Hague Airport (RTHA) set a minimum goal of blending 8.0% SAF beyond the European target of 6.0% as of 2024 (SAF Investor, 2023). Amsterdam Airport Schiphol is also taking steps to decarbonise its ground operations by 2030. The airport is part of the EU-funded TULIPS project, which aims to reduce carbon emissions from European airports through the implementation of innovative, sustainable technologies (CORDIS, 2024).

Market Opportunity

The Netherlands provides a robust, synergistic ecosystem to support diverse types of operations and plentiful partnership opportunities. Within the Dutch chemical ecosystem, several companies are already delivering SAF to customers, while others are building projects that are expected to become operational within the next few years (Netherlands Foreign Investment Agency, 2024).

One key area of opportunity lies in harnessing the Netherlands' abundant domestic renewable energy resources, particularly offshore wind. The country's strong focus on renewable energy and extensive infrastructure makes it an ideal location for eFuel technologies like power-to-liquid SAF production. Several projects are underway to leverage this abundant renewable energy for SAF production, thereby presenting opportunities for investors and developers to enter the market.

Netherlands

Major e-SAF Projects in the Pipeline

Company	Particulars
Shell	After supplying KLM with 500.0 litres of certified synthetic kerosene in 2021, the company is continuing the work closely with partners to further develop synthetic kerosene and is involved in projects in the Netherlands to produce synthetic kerosene (Shell, n.d.)
Synkero (KLM, Port of Amsterdam, City of Amsterdam, and Schiphol Group)	Launched in 2021, project Synkero aims to develop a commercial scale facility in the port of Amsterdam to produce E-SAF from green hydrogen and CO ₂ . The facility is scheduled to be completed in 2027, with an aim of producing 50,000.0 tons of E-SAF annually (SKYNRG, n.d.)
INERATEC, Zenith Energy Terminals	Ineratec and Zenith collaborated to build a Power-to-Liquid (PtL) plant in the Port of Amsterdam. The plant is scheduled to be completed in 2027, with a target of producing up to 35,000.0 tonnes of eFuels per year (Industry & Energy, 2023)
GreenCo	GreenCo aims to convert its existing facilities to support biofuel production, leveraging advanced technologies to ensure high efficiency and sustainability
DutchFuel	DutchFuel, is investing in SAF production through partnerships with technology providers and research institutions. With its extensive refinery network, it plans to produce SAF, contributing to the country's overall production capacity
Shell	Shell is building a plant in Rotterdam where it aims to deliver immense quantities of Hydrotreated Esters and Fatty Acids (HEFA)-based SAF by 2025. Rotterdam The Hague Airport (RTHA) has signed a long-term agreement with the company to supply SAF for all refueling aircrafts
Neste	Neste is investing in expanding its Rotterdam refinery to produce more SAF and renewable diesel
Zaffra	South African Sasol and Denmark-based Topsoe are teaming up in the Netherlands to bring SAF to market through their joint venture Zaffra
Gunvor	Gunvor has partnered with VARO Energy to build a large-scale SAF manufacturing facility in Rotterdam
Koole Terminals	Koole Terminals, a Dutch logistics and energy company, is expanding distillation capacity to triple SAF production by 2025 (Netherlands Foreign Investment Agency, 2024)

Source: Shell, Skyng, Industry&Energy, Netherlands Foreign Investment Agency

Another crucial aspect of the Dutch SAF market is research and development. Dutch companies and research institutions are at the forefront of SAF technology development, with organizations like SkyNRG, actively involved in various projects and collaborations. The Dutch government and the European Union are providing substantial funding for SAF research and development projects to drive innovation and improve the commercial viability of SAF, thereby creating opportunities for technology providers and research institutions.

Airline initiatives also play a significant role in the Dutch SAF market. Major airline companies such as KLM and Transavia are actively involved in SAF projects, forming alliances with fuel producers to secure supplies and reduce carbon emissions. For example, in November 2023, KLM invested in DG Fuels to support the development of its Louisiana-based SAF plant, securing an option to purchase up to 75,000.0 tons of SAF annually over a multi-year period beginning in 2029 (Biofuels International, 2023). These airline initiatives present opportunities for SAF producers and suppliers to establish long-term partnerships and secure offtake agreements.

Government and EU funding is another key driver of the Dutch SAF market. The Dutch government, in conjunction with EU funding programs like Horizon Europe and the European Green Deal, is providing substantial financial support to SAF projects. These funds aim to incentivise market operators and stakeholders, ensuring that the Netherlands remains competitive in the global SAF market. This funding support creates opportunities for companies and research institutions to access capital and accelerate the development of SAF technologies and production facilities.

As the SAF industry is still in its early stages, collaborations and partnerships are becoming increasingly common, allowing for the diversification of risk and pooling of resources. The Netherlands' strong SAF supportive ecosystem makes it an attractive location for such collaborations. Investors and industry players can explore opportunities to form strategic partnerships and joint ventures to accelerate the development and commercialization of SAF in the Netherlands.

Netherlands

Outlook

The Netherlands offers a thriving ecosystem of firms and research institutions pursuing SAF solutions, enabling it to support the global aviation industry's goal of achieving net-zero emissions by 2050. Its extensive logistics infrastructure enables more efficient operations, while Dutch chemical expertise and talent fuel the future commercialization of SAF in the region and worldwide (Netherlands Foreign Investment Agency, 2024).

However, all current SAF capacity is being sold in long-term contracts and unlocking supply remains a key issue for the Dutch market rather than demand. To boost SAF usage in commercial aviation, companies must focus on diverse operations, including production, logistics, R&D for innovation, and headquarters for coordinating supply chains, commodity trading, and business growth (Netherlands Foreign Investment Agency, 2024).

Furthermore, additional financial incentives should be made available for SAF technology pathways other than HEFA. HEFA is currently the least costly SAF pathway, and the other technologies will have difficulty reaching commercial scale without support. Additionally, new SAF technologies are marked by investment uncertainties. For example, Shell's Rotterdam SAF project, planned originally for commissioning in 2026, has been delayed with the development work being temporarily paused by the company to address project delivery and ensure future competitiveness given changing market conditions (Shell, 2024).

Hydrogen is emerging as an alternative fuel option in aviation. There is policy support to promote the ongoing technology demonstration projects. Depending on commercial viability, such fuel options can emerge as a competitive option to SAF over time. The Dutch public-private partnership Hydrogen Aircraft Powertrain and Storage System (HAPSS) aims to build a commercial passenger aircraft that uses liquid green hydrogen as fuel. It is expected that a lab-scale version of the system will be available by 2025, and several commercial flights will take place by 2028. This HAPSS project is part of the Aviation in Transition innovation program for which the Netherlands National Growth Fund allocated €383.0 million (Agro & Chemistry, 2022).

Creating sub-targets, incentives, and CfD mechanisms can play a crucial role in the development of these technologies. On the other hand, it is paramount for the aviation industry to focus on feedstock diversification to meet the growing demand for biobased fuels, materials and chemicals and to secure a competitive market for sustainable feedstocks. This will in turn help the Netherlands to secure a domestic SAF market, thereby mitigating the risks associated with SAF imports (WDB, 2021).

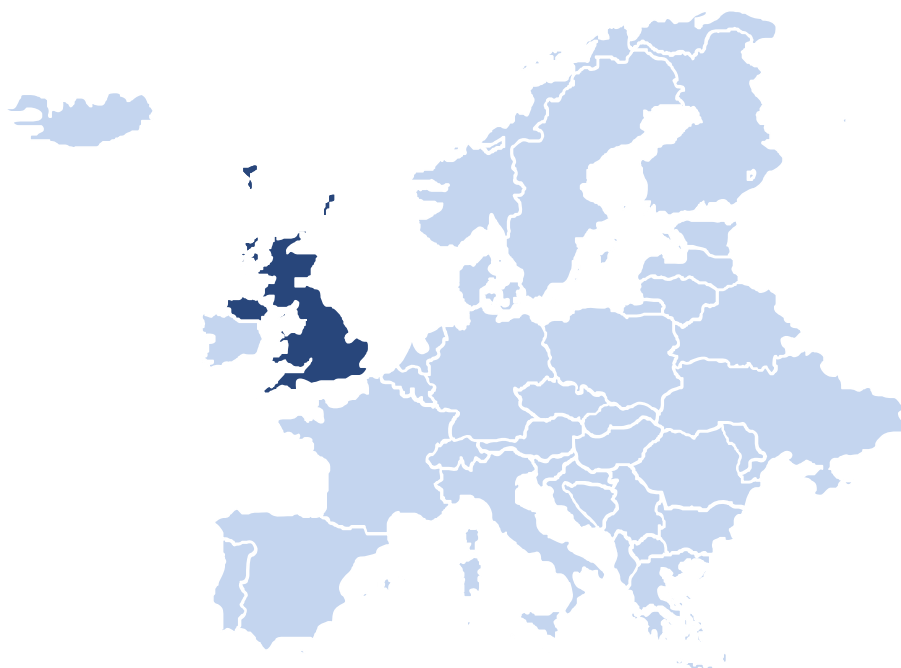
United Kingdom

SAFs are one of the key technologies available to the UK government to decarbonize aviation, while alternative technologies such as hydrogen or battery-powered aircraft remain unavailable for use in commercial aviation. SAF is one of the six key measures in the UK government's Jet Zero Strategy published in July 2022 (Transport, 2023). Other measures in the strategy include system efficiencies, zero emission flight (ZEF), markets and removals, influencing consumers, and addressing non- CO2 (UK Department for Transport, 2022).

The UK's aviation industry being one of the global pioneers, recognizes the importance of SAF in achieving its decarbonization goals. Data released by the UK's Department for Transport (Dft) showed that SAF used in the country jumped by 188.0% year-on-year to 138.1 million litres compared to 48.0 million litres in 2022, clearly indicating the active progress in SAF uptake (SAF Investor, 2024).

Economic Indicators	GDP (current prices, \$ 2022)	3,100 Bn
	Real GDP growth forecast 2023-27	1.12%
	10-year govt bond yield (12-month rolling average)	4.18
	Country credit rating	AA
Average daily flights	5,290	
Existing Fuel Consumption	12.46 million metric tons	
Usage Mandate	2% SAF by 2025, rising to 10% SAF by 2030	
Projected SAF Capacity Under Development (MT/Year)	885,700 by 2030	
Policy Support	- Incentivize SAF production through tradable certificates with a monetary value - Government's £165 million Advanced Fuel Fund gives investors reassurance to invest in UK SAF production	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



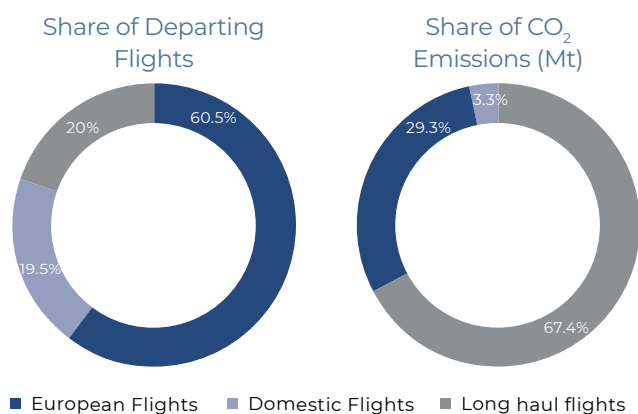
United Kingdom

Aviation Industry Backdrop

The UK has the third largest aviation network in the world, after the USA and China. In addition to generating £65.0 billion of output, it generates £13.0 billion in employee income from over 370,000 jobs and £24.0 billion in gross value added (contribution to national GDP) (Airlines UK, 2024). Driven by increasing demand for air travel and the industry's continued recovery from the pandemic, the economic benefits of UK airlines are expected to grow and generate £111.0 billion of output and £41.0 billion of gross value added by 2050 (Flight Training News, 2023).

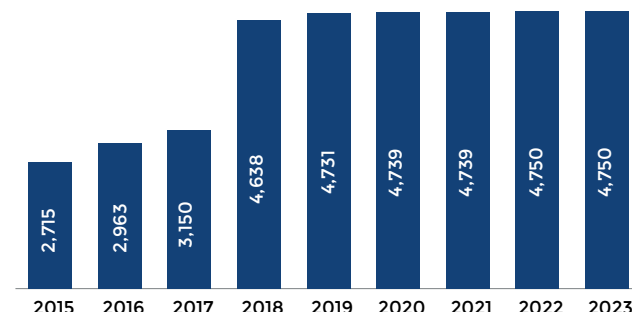
In 2023, approximately 940,000 flights departed from UK airports, registering 32.0 Mt of CO₂ emissions. In comparison with 2022, this represented a total flight growth of 15.8% and CO₂ emissions growth of 22.8%. The business is gradually recovering to reach the pre-pandemic peak - by the end of 2023 air traffic was at 87.6% of the 2019 level of total flights and 89.8% of CO₂ emissions (UK Transport & Environment, 2024). EasyJet, British Airways and Ryanair are the three major players in the market and together account for well over half of UK departing flights and about 60.0% of carbon emissions (UK Transport & Environment, 2024). It is likely that 2024 will have higher emissions than 2023 based on current emission growth trends (UK Transport & Environment, 2024).

Share of Departing Flights from the UK and CO₂ Emissions



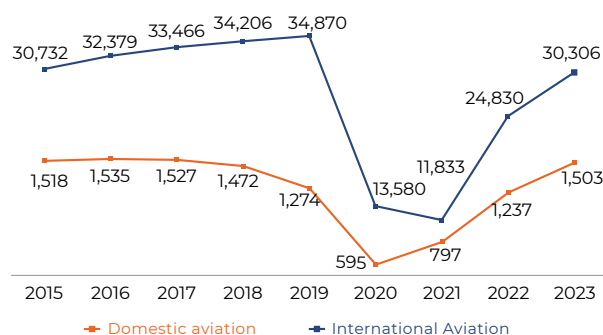
Source: OAG

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



United Kingdom

The UK Government's Jet Zero Strategy forecasts aviation emissions to reach 39.0MT (million tonnes) of carbon dioxide equivalent (CO₂e) in 2030, decreasing to 29.5MT in 2050. To achieve net zero, the remaining CO₂e must be addressed using both in-sector (SAF) and out-of-sector (carbon removal) mechanisms. The government expects 1.2MT of SAF to be needed in 2030, and 7.0MT by 2050 to achieve net zero (in a central case with 75.0% of residual carbon addressed by SAF) (ICF, 2023).

Policy and Regulation

Following its departure from the European Union, the UK has developed an independent regulatory framework for SAF, demonstrating its commitment to sustainable aviation. The UK's approach combines demand and supply-side mechanisms to drive investment and adoption of SAF (IATA, 2024).

The UK SAF Mandate, effective from 1 January 2025, sets progressive targets for aviation fuel suppliers, requiring them to provide increasing amounts of SAF, reaching 10.0% of total jet fuel by 2030 and 22.0% by 2040. On the supply-side, government support has been extended in the form of a £135.0 million allocation under the Advanced Fuels Fund to support the commercialisation of new SAF technologies (Department for Transport, UK, 2023).

The government has also launched a consultation on a revenue certainty mechanism to support the development of the UK's domestic SAF industry. The mechanism aims to reduce the risks of uncertain revenues for new SAF plants and attract investment. The consultation includes options such as a guaranteed strike price (GSP), buyer of last resort (BOLR), mandate auto-ratchet (MAR), and mandate floor price (MFP) (Transport U. D., 2024).

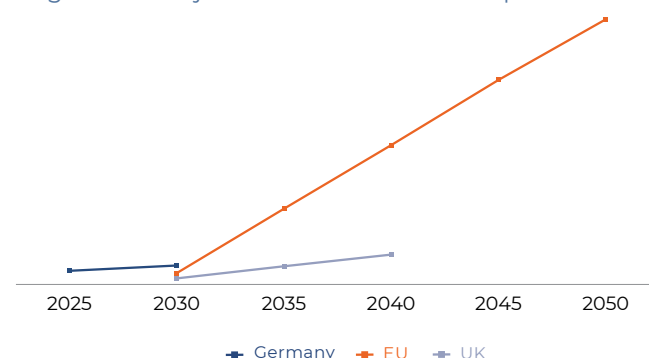
A new green tax on airline passengers is also being proposed. In December 2023, the Environmental Audit Committee (EAC) recommended that the government develop policies to reduce carbon emissions in the aviation sector, including a frequent flyer levy (POLITICO, 2024).

Similar to ReFuelEU, the UK's SAF policy includes a sub-mandate on power-to-liquid (PtL) fuels, aiming to support this type of high-integrity SAF due to its high GHG emissions savings potential and low land

use change risk. The target for PtL fuels will start in 2028 at 0.2% of total jet fuel demand, reaching 0.5% in 2030 and 3.5% in 2040 (Climate Catalyst, 2024) (Carbon Brief, 2024). Additionally, the UK has introduced a cap on HEFA fuels to allow for newer SAF technologies to compete effectively. The HEFA cap starts at 2.0% in 2025 and rises to 7.8% by 2040. The mandate also includes a buy-out mechanism that penalizes jet fuel providers if they do not provide enough SAF, with a price of £4.7 per litre for the main SAF obligation and £5.0 per litre for the PtL obligation. (Climate Catalyst, 2024)

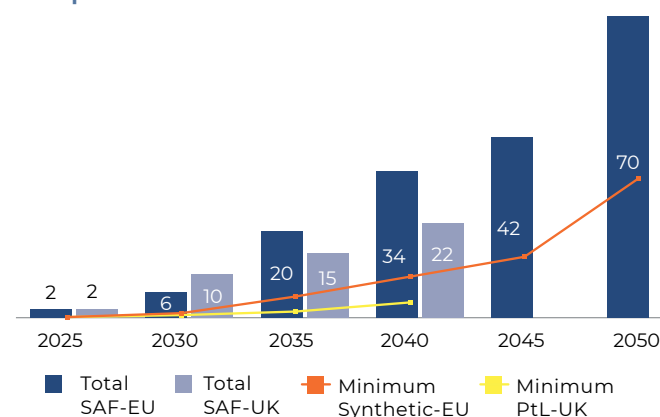
The UK's Target for Power-to-liquid Jet Fuel are Less Ambitious than its European Counterparts

Targets for % of jet Fuel that is Power-to-liquid Fuel



Source: (Carbon Brief, 2024), (Climate Catalyst, 2024)

SAF blending targets in the UK SAF mandate compared to ReFuelEU Aviation mandate



Source: (Carbon Brief, 2024), (Climate Catalyst, 2024)

United Kingdom

Market Opportunity

In 2023, as a percentage of total fuel supplied, SAF made up just 0.28% compared to 0.10% in 2022 (SAF Investor, 2024). Starting in 2025, 2.0% of the jet fuel supplied in the UK must be SAF which relates to approximately 230,000 tonnes compared to only 64,000 tonnes of SAF produced in 2023 (Norton Rose Fulbright, 2024). Thus, a transitional ramp-up of SAF production is required in order to close the gap between requirement and production. On a positive note, the UK’s SAF project pipeline is growing, with several notable initiatives underway. The latest developments indicate a trend towards partnerships and collaborations among various parties to develop SAF, with support from government funding.

SAF Initiatives: GreenCo, a major British energy company, aims to produce significant quantities of SAF by converting its existing facilities to support biofuel production, leveraging advanced technologies to ensure high efficiency and sustainability. This initiative is expected to contribute to the UK’s SAF production capacity and help meet the growing demand for sustainable aviation fuels.

EcoFuel, another leading energy company in the UK, is investing in SAF production through partnerships with technology providers and research institutions. By utilizing its extensive refinery network, EcoFuel plans to produce SAF on a large scale, further strengthening the UK’s position in the global SAF market.

BioTech, a global specialty chemicals company, is developing a commercial-scale plant in Leeds that focuses on producing cellulosic ethanol, which can be an essential component in SAF production. The technological advancements and expertise gained from this project are expected to benefit the UK’s SAF industry as a whole, driving innovation and improving production processes.

To further strengthen SAF production, in November 2023, the administration established the SAF Clearing House. The programme is funded by the DfT and provides cross-industry support for the development, testing, qualification, and production of sustainable aviation fuels (Ricardo, n.d.).

Airline Initiatives: Airlines such as British Airways and easyJet are actively participating in SAF projects, forming alliances with fuel producers to secure SAF supplies and reduce their carbon footprint. These

collaborations often include long-term purchase agreements and joint research efforts to optimize SAF use in commercial flights. In November 2023, the UK Civil Aviation Authority (CAA) issued Virgin Atlantic with a permit to fly the first ever 100.0% SAF fuelled transatlantic flight (Civil Aviation Authority, 2023).

Government Funding: The British government, in conjunction with EU funding programs like Horizon Europe and the European Green Deal, is providing substantial financial support to SAF projects. In November 2023, UK DfT through its Advanced Fuels Fund, awarded £6.0 million funding to ExxonMobil (a member of the Solent Cluster). The funding will be used to assess the potential SAF production using ExxonMobil proprietary Methanol to Jet (MtJ) technology (Exxon Mobil, 2023) (The Solent Cluster, 2023).

UK Live Funding Mechanisms Relevant to Sustainable Aviation Fuels

Fund name	Organisation(s)	Total fund
Strategic Programme	- Aerospace Technology Institute (ATI) - Department for Business and Trade (DBT) - Innovate UK	£685 million to 2025, with industry co-funding taking the total to >£1 billion.
Future Flight Challenge Fund	- DBT - UK Research and Innovation (UKRI) - Innovate UK	£300 million co-invested by government and industry.
Accelerating research outcomes to deliver a prosperous net zero	Engineering and Physical Sciences Research Council (EPSRC)	£7,500,000.
UKRI SME innovation loans	UKRI	Not specified.
Tomorrow’s Engineering Research Challenges	EPSRC	£7,000,000.
Emerging Energy Technologies Fund (EETF)	Scottish Government	£180 million.

Source: Climate Catalyst, 2024

United Kingdom

Outlook

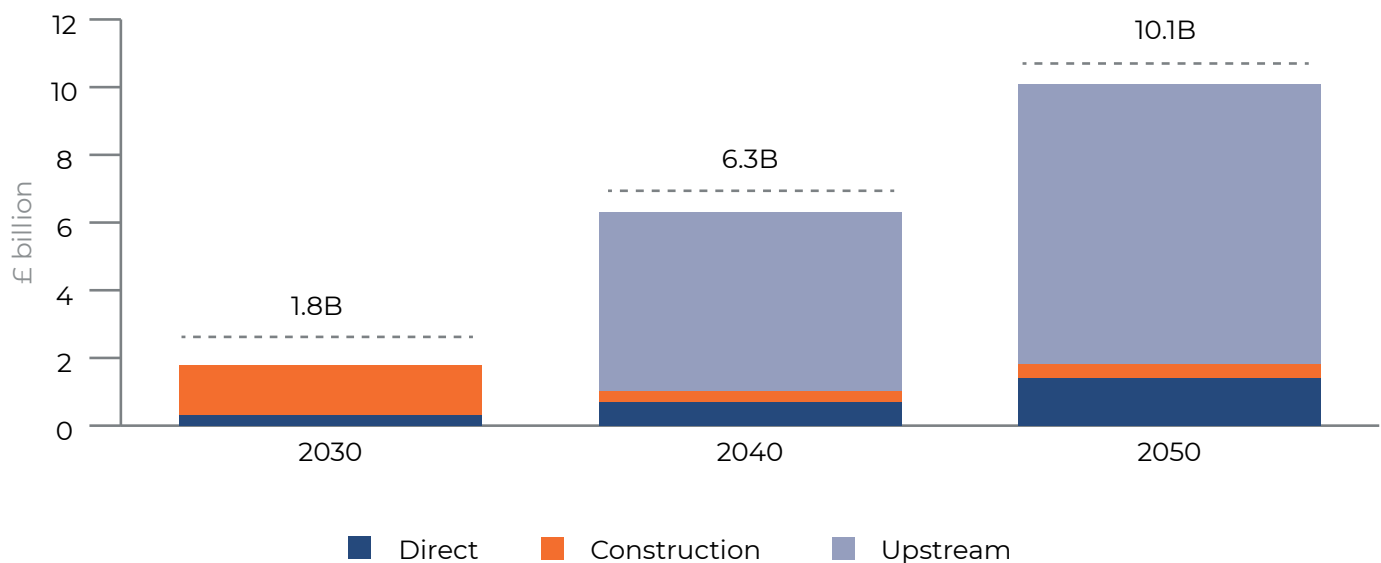
The Jet Zero Council, formed of senior industry representatives and policymakers, provides strategic oversight of the government’s plans as key stakeholders in the aviation sector’s transition. SAF is poised to be one of the key levers available to government and industry to accelerate the transition to net-zero aviation. A collaborative effort between government and industry is expected to result in five plants being under construction by 2025. The government has a leading role in delivering this huge opportunity by establishing a sustainable, high-integrity SAF market for the UK and beyond (Climate Catalyst, 2024).

Besides existing policy support, the government is continually exploring new ways to curb emissions and boost SAF adoption. It is possible that emission reduction assumptions for using SAF under the UK Emissions Trading Scheme (ETS) may change to consider a lifecycle analysis of the fuel type used, which will incentivize PtL fuels more than biofuels. Additionally, the UK is also exploring a long-missing kerosene tax in aviation that will help to level the playing field between the cost of conventional jet fuel and SAFs, and particularly PtL fuels. Estimates suggest that revenues generated through taxation could be c.£6.7 billion per year (Climate Catalyst, 2024).

Economic growth and national well-being will be significantly boosted by the growth of the SAF industry. According to ICF analysis, by 2030, the UK’s SAF industry could contribute £1.8 billion in gross added value, with much of it coming from upstream activities. As of 2050, this may amount to £10.1 billion, of which £1.7 billion could come from direct/construction and the remainder from upstream value chains (ICF, 2023).

However, the UK faces certain roadblocks on its path to becoming a leading SAF market. For example, EPC capabilities with respect to SAF plants are stretched and are likely to remain so given the anticipated pipeline of infrastructure and energy projects. Additionally, SAF projects are also hindered by a high dependence on debt financing. SAF projects typically carry a cost ticket of between £500.0 million and £1.0 billion. It is too big for venture capital, and since the initial projects will be the first of their kind, it is too risky for most private equity or hedge fund investors. In order to offer debt financing at a reasonable cost of capital, significant safeguards need to be in place. The primary challenge is to develop a mechanism that will give sufficient revenue confidence to make a project bankable and quickly deployable (New, 2022).

Gross Value Added by a UK SAF Industry, Central Case



Source: Sustainable-Aviation-SAF-Roadmap-Final.pdf (sustainableaviation.co.uk)

Key Regional Markets - North America



Canada

Canada's aviation industry is making concerted efforts to reduce greenhouse gas emissions, with Canada's Aviation Climate Action Plan, 2022-2030, setting a target of a 10% reduction in emissions by 2030. SAF is seen as a critical pathway to achieving this goal. Canada is uniquely positioned to advance this aviation sector's decarbonisation objectives, given its existing refining capacity, abundant and sustainable feedstock, and innovative technology providers, it is uniquely positioned to progress the aviation sector's decarbonisation goals.

However, attracting the necessary investments for SAF production remains a near-term challenge. Beyond funding avenues like the Clean Fuels Fund and Strategic Innovation Fund, targeted incentives for developers may be needed. Moreover, the current project pipeline for upcoming SAF capacities could face competition from the US, where the biofuel producers anticipate generous tax credits for domestic production.

Economic Indicators	GDP (current prices, \$ 2023)	2,140 Bn
	Real GDP growth forecast 2024-28	1.74%
	10-year govt bond yield (12-month rolling average)	3.46
	Country credit rating	AAA
Average daily flights	14,328	
Existing Fuel Consumption	7,013 million litres	
Usage Mandate	10% SAF by 2030, rising to 25% by 2035	
Projected SAF Capacity Under Development (MT/Year)	1,514,000 by 2027	
Policy Support	\$500 million support per year through Clean Fuel Regulations compliance payments and \$776.3 million over the next six years under the Clean Fuels Fund - Combined \$6.2 million to support SAF in Manitoba (Includes \$5 million from the Clean Fuels Fund)	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Canada

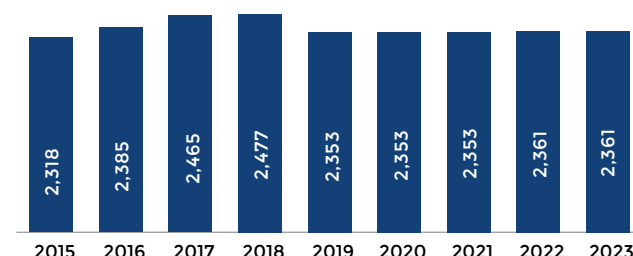
Aviation Industry Backdrop

Canada's total air transport passenger volume grew 27% year-on-year in 2023 but still lag pre-pandemic levels (Statistics Canada, 2024). Jet fuel consumption trends mirror the aviation sector's business recovery - in December 2023, total jet fuel use reached 612 million litres, approaching the 670 million litres in December 2019 (Canada Energy Regulator, 2024). Total 2023 fuel consumption rose 21% over 2022. Within the North American, Canada's aviation market closely rivals Mexico's in available seat capacity (Air Service One, 2024).

Aerospace manufacturing is a globally competitive segment of Canada's aviation. This export-oriented sector saw revenue jump 30% in 2023 (AIAC, 2024). Canadian-designed aircraft like the Bombardier C series(now Airbus 220) have been environmental pioneers, with the A220 being the first to receive an Environmental Product Declaration (Government of Canada, 2022). The manufacturing sector is key to Canada's long-term aviation net zero goals. The National Research Council's Aerospace Research Centre develops technologies for sustainable aircraft configurations, electric propulsion, clean fuel, and batteries (Government of Canada, 2024). In June 2023, the government announced a CAD350 million investment in the new Initiative for Sustainable Aviation Technology (ESG Today, 2023).

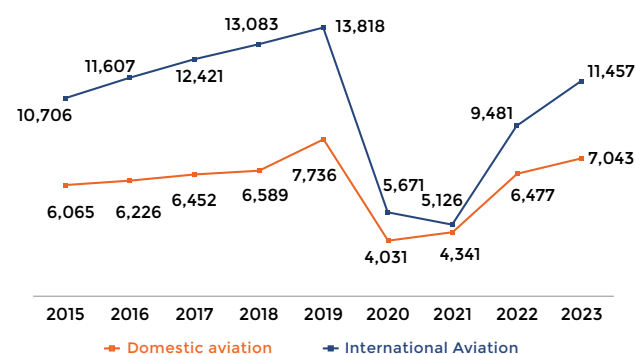
Biofuels already see strong Canadian demand, largely from the transport sector, driven by clean fuel regulations to cut emissions. Canada is the top market for US ethanol, with 2023 imports surging 40% to reach 1.76 billion litres. Federal funding for new domestic biofuel facilities further boost demand (CBC, 2024). The emerging SAF market presents a ripe opportunity for prospective Canadian renewable fuel suppliers.

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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Canada

Policy and Regulation

The Canadian Net Zero Emissions Accountability Act mandates a binding national net zero target by 2050. The Aviation Climate Action Plan outlines the roadmap for net zero aviation emissions by 2050 with SAF as a cornerstone. The Plan aims for a 10% SAF use by 2030 (Transport Canada, 2022), but enabling a domestic SAF ecosystem is a challenge. Supportive measures include funding support for SAF projects. Some which are mentioned below:

- The Strategic Innovation Fund supports nascent industries like SAF. In May 2023, for instance, the government allocated CAD86 million to convert an oil refinery into a biorefinery producing renewable diesel and SAF (Biomass magazine, 2023).
- The CAD1.5 billion Clean Fuel Fund, de-risks capital investments in low-emission fuel projects, including SAF (Government of Canada, 2024). For example, Azure Sustainable Fuels Corporation secured CAD5 million for a SAF project feasibility study (NRC, 2024).

Regulations like the Clean Fuel Regulation (CFR) complement policy goals. CFR requires fuel suppliers to reduce lifecycle emissions from 2023 to 2030. The reduction requirement starts at 3.5 gCO₂e/MJ in 2023, increasing by 1.5 gCO₂e/MJ each year, reaching 14 gCO₂e/MJ in 2030 (What are the Clean Fuel Regulations). A voluntary credit system incentivises supplier emission reductions. Budget 2024 aims to boost SAF through annual CFR compliance payments of CAD500 million and CAD776.3 million under the Clean Fuels Fund over the next six years (Government of Canada, 2024).

Provincial regulations also play a role. British Columbia's ("BC") Low Carbon Fuels Act sets SAF blending mandates and ambitious carbon intensity reduction targets. BC requires fuel suppliers to blend 1% SAF by 2028 and 3% by 2030 (Ethanol, 2024). In January 2024, Manitoba and the federal government jointly invested CAD6.2 million, including CAD5 million from the Clean Fuels Fund, to assess SAF production feasibility from local canola and soybean oil, as part of a CAD12.3 million project (Travel and Tour World, 2024).

Market Opportunity

Canada's aviation market is dominated by Air Canada and WestJet, both of which have engaged in SAF trials and pilot programs, demonstrating the feasibility and benefits of using sustainable fuels. Air Canada committed CAD50 million to SAF and low-carbon aviation fuel development (Air Canada, 2021), and signed strategic SAF offtake agreements in 2023. In November 2022, WestJet operated all San Francisco to Calgary flights with SAF for a three-month period (WestJet, 2022).

Notable SAF Off take Deals by Canadian Airlines

	Particulars
Air Canada	• A strategic collaboration with Air Company, as of July 2023, to source SAF based on the Power-to-Liquid technology (Canadian Biomass, 2023). • In April 2023, Air Canada expanded its collaboration with SAF supplier Neste, with an additional 2.5 million contracted supply (SAF Investor, 2024).
WestJet	• In April 2024 the airline announced its planned SAF purchase from Shell Aviation (Neste, 2023).

Source: Canadian Biomass Magazine, SAF Investor and Neste

A collective effort from all industry stakeholders is evident as Canadian aerospace manufacturers are also investing in sustainable technologies, including greener aircraft systems and alternative propulsion. In 2022, Bombardier launched the EcoJet Research Project, aiming to cut emissions by 50% through aerodynamic and propulsion enhancements (Bombardier, 2023).

SAF manufacturing investments are driven by government funding support through the Clean Fuel Fund and partnerships. Refinery conversions have attracted investor interest to leverage existing biofuel capacity, but most prospective suppliers expect subsidies or fiscal incentives to establish production facilities.

Canada

Major Initiatives in SAF Supply

	Particulars
Skyservice Business Aviation	In 2021, Skyservice became the first private aviation company in Canada to offer SAF for private aircraft clients (Skyservice, 2021).
ABB and Cap Clean Energy	In March 2024, ABB (Bioenergy Times, 2024), a leader in electrification and automation technology partnered with Cap Clean Energy in establishing SAF production facilities across Manitoba, Alberta and Saskatchewan provinces in Canada.
Braya	A \$300 million preferred-equity investment from Energy Capital Partners towards Braya's biorefinery conversion (biodiesel, SAF and other fuels) projects in Canada (BDD, 2023).
Tidewater Midstream and Infrastructure	Front-end Engineering Design work is underway for the planned SAF project in British Columbia, which is based on Tidewater's Prince George refinery and its recently commissioned renewable diesel facility (BDD, 2024).

Source: Skyservice, Bioenergy Times, and Biobased Diesel Daily

Outlook

By 2035, Canada is expected to produce enough SAF to meet 25% of its total jet fuel demand, potentially reducing emissions from Canadian departures by 15-20% (Bennett Jones, 2023). In this regard, many projects have been planned, involving biorefinery conversions or producing SAF as a by-product of renewable fuel facilities.

Despite increasing demand for SAF, Canada has insufficient supply-side initiatives and trails the US in offering producer incentives. The US offers incentives up to \$1.75 per gallon of SAF, along with additional state measures. Unless matched by Canada, the US

Inflation Reduction Act's biofuel producer incentives could divert potential SAF developers to build US facilities instead.

The market would need additional government support to drive adequate investments. Domestic SAF incentives are vital to fostering Canada's entire SAF ecosystem, including developers, suppliers, technology providers, airlines, and aerospace companies. All the same, maintaining a long-term commitment to Canada's aviation emission reduction targets will drive continued demand for SAF.

Projected SAF Output from Existing and Proposed Renewable Fuels Facilities (million litres)

Facility	SAF fraction (estimated)	2024	2025	2026	2027	2028	2029	2030
Braya	15%	122	122	313	313	313	313	313
Tidewater	15%	26	26	26	26	26	26	26
Covenant	15%	48.8	48.8	48.8	48.8	48.8	48.8	48.8
ReFuel	15%	26	26	26	26	26	26	26
Green Energy Transformation	15%				56.6	56.6	56.6	56.6
SAF+	100%				30	30	30	30
RETI	15%					25	25	25

Source: C-SAF

United States

By the end of 2023, SAF production in the US reached 12.1 million gallons, marking a 53% rise year-on-year. Though SAF supply is still a minuscule share of total jet fuel consumption, there is a growing pipeline of upcoming SAF production capacities seeking to capitalize on the market opportunity. The projections from the US Energy Information Administration indicated a 15-fold rise in SAF production by the end of 2024 if the projects under development materialise as planned.

Policy measures help boost the demand for SAF. State-level policy measures in California, Illinois, and Oregon are notable examples. At the Federal level, an ambitious policy initiative is the SAF Grand Challenge, which aims for 100% SAF supply by 2050. The Inflation Reduction Act of 2022 is the other major federal policy that sets incentives for local SAF supply.

Incentives are likely to play an important role in attracting investments in the US SAF market. A key factor is the well-established biofuels industry, which already caters to transportation sector demand and would need attractive returns to divert resources towards SAF supply. Furthermore, the new e-SAF technologies must be supported with initial funding to enable commercial scale in the business.

Economic Indicators	GDP (current prices, \$ 2023)	27,358 Bn
	Real GDP growth forecast 2024-28	2.18%
	10-year govt bond yield (12-month rolling average)	4.09
	Country credit rating	AA+
Average daily flights	45,000+	
Existing Fuel Consumption	18.5 billion gallons	
Usage Mandate	100% of aviation fuel demand by 2050	
Projected SAF Capacity Under Development (MT/Year)	10,326,799 by 2030	
Policy Support	- SAF producers are eligible for a tax credit of \$1.25 to \$1.75 per gallon - The U.S FAA provides grants up to \$46.5 million to support the development of SAF under its FAST-SAF program	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



United States

Aviation Industry Backdrop

The US aviation sector is witnessing a significant rebound in business. In 2023, Core 30 airport operation numbers* rose by 3.8%, from 11.8 million in 2022 to 12.2 million. The number of passengers flown by air carriers increased by 13.9%, reaching 1,044.8 million in 2023. This is slightly below the pre-pandemic level of 1,057.6 million passengers in 2019 (FAA, 2024). US and foreign air carriers transported 237.4 million passengers between the US and the rest of the world for the year ended December 2023, up 25% from the same 12-month period a year earlier (DoT, 2024).

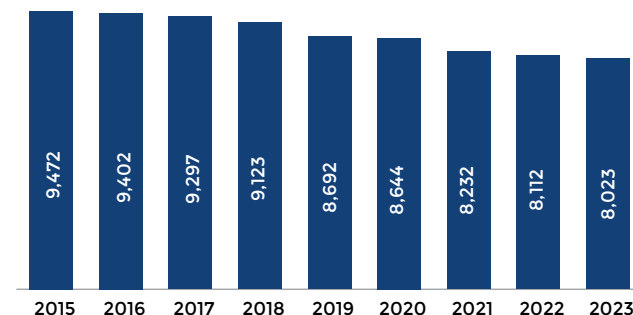
With the resumption of the aviation business, its emission profile has assumed significance. The US domestic flights contributed 150 million metric tons of CO₂ emissions in 2019, representing almost 3% of the country's total emissions. The commercial segment of aviation accounted for another 2% (US DoE, 2023). The US aviation sector's greenhouse gas (GHG) emissions make up 9%–12% of the total transport sectors' GHG emissions (US DOE, n.d.) (US EPA, n.d.). Aviation sector emissions in the US are anticipated to almost double by 2050 (World Resources Institute, 2024).

SAF adoption, as among the key measures towards decarbonisation in aviation, is gradually gaining momentum. According to the US Environmental Protection Agency (EPA), the industry produced 12.1 million gallons of SAF in 2023, up from 7.9 million gallons in 2022, and imported another 12.2 million gallons of SAF. Though SAF production grew by over 53% in 2023, it is an insignificant part of the total jet fuel supply. In 2023, the US consumed 25.9 billion gallons of jet fuel, suggesting a blending rate of only 0.1% of domestic aviation fuel consumption (Fast Markets, 2024).

SAF in the US market should also be seen against the backdrop of the country's biofuel market. This is because existing SAF production processes draw heavily from the biofuel supply chain. Biofuels are already an integral part of the US transportation sector's decarbonisation efforts. In 2022, they held about a 6% share of the sector's total energy consumption. Ethanol's share was about 4%, and the share of biodiesel, renewable diesel, and other biofuels combined was about 2% (EIA, 2023). Presently, SAF holds a negligible share in the country's biofuels market.

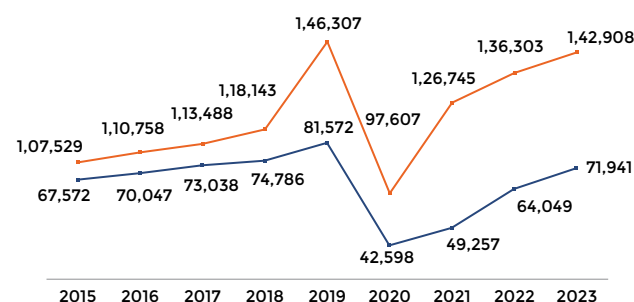
*Airport operations are the sum of the number of airport arrivals and departures. Each flight has a departure and arrival, meaning each flight roughly consists of two airport operations

Biofuel Installed Capacity (MW)



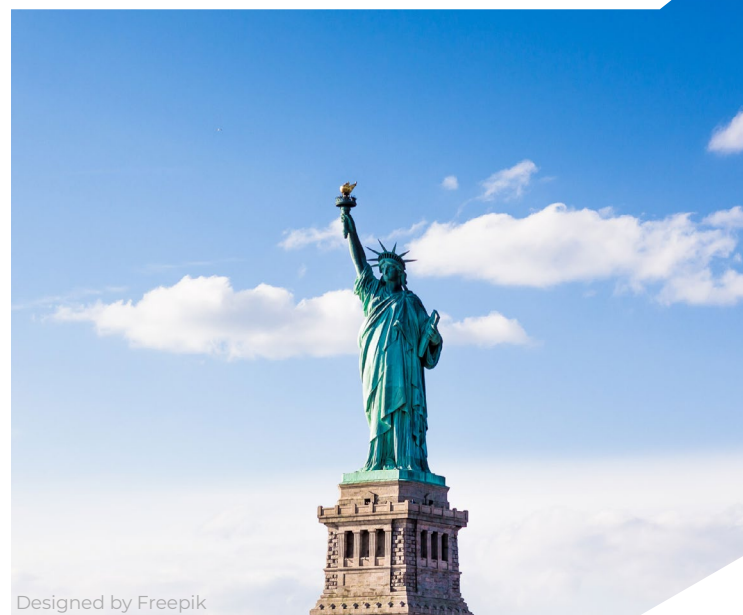
Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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United States

Policy and Regulation

The US government has launched several government-wide initiatives to assist in the decarbonization of the aviation industry, such as the SAF Grand Challenge. Launched in 2021, the SAF Grand Challenge (SGC) is a collaborative initiative between the US Department of Energy (DoE), the Department of Transportation (DoT), and the EPA to develop a comprehensive strategy for scaling up new SAF technologies.

Through the SGC initiative, a goal has been set to supply sufficient SAF to meet 100% of aviation fuel demand by 2050. Along with that, an ambitious government-wide commitment has been set to scale up the production of SAF to 35 billion gallons per year by 2050. A near-term goal of 3 billion gallons per year is established as a milestone for 2030. The SGC outlines a multi-agency approach to accelerate the research, development, demonstration, and deployment of SAF technologies. Various tax incentives complement the SGC policy's goals, although it does not entail any binding targets for the industry and instead relies on voluntary SAF purchases (US DoE, 2023) (US DOE, 2022).

The flagship US legislation, the Inflation Reduction Act (IRA), that took effect in August 2022, seeks to incentivize SAF to promote its wider adoption. The IRA instituted a standalone blenders tax credit for SAF known as 40B, named for the section of IRA where it can be found. The 40B credit, made available to domestic SAF producers for the calendar years 2023 and 2024, is based on the carbon intensity of the fuel's production, including the feedstock that is used to produce it.

In practical terms, IRA's 40B credit results in a higher credit for any SAF that generates lower GHG emissions in its lifecycle. The credit value is equal to \$1.25 per gallon of SAF plus \$0.01 for each per cent of lifecycle GHG emissions reduction below 50% compared to petroleum-based aviation fuel. If SAF does not achieve at least a 50% reduction in carbon intensity, the fuel does not qualify for the 40B credit. The maximum credit per gallon is \$1.75. On January 1, 2025, the 40B program will expire, and the 45Z Clean Fuel Production Credit will begin. The new tax credit amount is \$0.35 per gallon for SAF.

For facilities that satisfy the prevailing wage and apprenticeship requirements, the credit amount is \$1.75 per gallon. While the tax credit for 2023 and 2024 was limited to SAF blenders, the one for 2025-2027 covers all producers of low-carbon fuels, including SAF. This latter phase of the tax credit, estimated to be worth \$3 billion, is critical for expanding the local SAF production base (WSJ, 2022) (US Govt Treasury, 2023) (American Soybean Association, 2024) (US DOE, n.d.) (Growth Energy, 2023) (NBAA, 2023).

The US DOE's GHG, Regulated Emissions, and Energy Use in Transportation (GREET) model lays down the IRA methodology to calculate lifecycle GHG emissions related to SAF. An updated version of this model, originally targeted for March 1, 2024, is awaited. The GREET model will determine tax credit eligibility and corresponding disbursement for 2023 and 2024. The country's biofuel producers and agricultural feedstock suppliers are significantly impacted by the delayed GREET model update (Farmweek Now, 2024).

Other federal policy measures include the renewable fuel standard (RFS) program that mandates the blending of renewable fuels into the nation's fuel supply. While primarily focused on biofuels for road transportation, recent amendments have started to recognize SAF as part of the renewable fuel categories, providing additional incentives for its production and use. (US EPA, n.d.). Another scheme, the Clean Fuels & Products Shot™, part of the DOE Energy Earthshots™ initiative, supports the feedstocks and conversion technologies and SAF research and development (R&D) through funding opportunities. (US DoE, 2023)

Separately, state-level policies and regulations are driving the SAF market at different speeds and directions. California, for instance, had an early start. It leads the way through its Low Carbon Fuel Standard that incentivises low-carbon fuels including SAF, by setting carbon intensity reduction targets. SAF producers can generate LCFS credits which are tradeable in the market.

Washington state introduced the Clean Fuels Standard (CFS), similar to California's LCFS, to set carbon intensity reduction targets for transportation fuels. This standard encourages the production and use of SAF by allowing producers to generate credits for compliance. Other states like Illinois and Oregon have similarly introduced SAF-related policies and regulations to support its production and adoption.

United States

States	Particulars
California	- LCFS policy aimed at reducing GHG emissions for the overall transportation sector, included SAF as a renewable fuel in 2019. - California Air Resource Board's 2022 Climate Scoping Plan targets 20% SAF in total aviation fuel by 2030, which rises to 90% by 2050. However, with a subsequent veto on this policy by governor's office, there is some uncertainty about SAF goals (ICCT, 2023).
Washington	Washington State Department of Ecology adopted the CFS with objective to reduce transportation emissions in 2021. Policy incentivises fuel producers to achieve 20% lower carbon intensity by 2034 as compared to 2017 levels (Lexology, 2024).
Oregon	Oregon state's Clean Fuels Program, overseen by Department of Environmental Quality Commission, is aimed at reducing state's overall transportation GHG emissions. Targets set by the state's law are to reduce carbon intensity by 10% by 2025, 20% by 2030 and 37% by 2037 as compared to the base year of 2015 (Oregon Department of Environmental Quality, 2023)
Illinois	- In June 2023, 'Invest in Illinois Act' introduced a SAF purchase credit worth \$1.50 per gallon for the fuel sold to, or used by a common air carrier, for use in Illinois. - Policy took effect from July 2023, and will be valid till December 31, 2032 (Illinois Government, 2023). To qualify for credit, SAF must achieve 50% or more of lifecycle GHG emission reduction.

Market Opportunity

Government funding opportunities, voluntary SAF adoption commitments from leading airlines and technological advancements in the production process have led to a growing pipeline of projects in the US. The country's upcoming SAF production capacity by 2030 could be the highest in North America and globally (GlobalData, 2023).

Airline Initiatives: In July 2022, American Airlines committed to purchasing 500 million gallons of SAF from Gevo, Inc. over a five-year period. The agreement brought the Airline's total low-carbon fuel commitments to more than 620 million gallons — fulfilling roughly 20% of the airline's goal to replace 10% of jet fuel usage with SAF by 2030 (American Airlines, 2022). Similar goals have been set by Delta Air Lines and Southwest Airlines — to replace 10% of jet fuel with SAF by 2030 (Reuters, 2023).

Dallas-based Southwest Airlines launched, in February 2024, the Southwest Airlines Renewable Ventures (SARV), a wholly-owned subsidiary dedicated to creating more opportunities for Southwest to obtain scalable SAF. As part of its SARV investment portfolio, Southwest also announced a \$30 million investment in LanzaJet Inc., a SAF technology provider and producer with a patented ethanol-to-SAF technology.

As part of its agreement with Southwest, LanzaJet intends to build an ethanol-to-SAF facility to produce

SAF primarily for Southwest. That facility includes capabilities to convert SAFfIRE's cellulosic ethanol into SAF, which can produce greater quantities of SAF from SAFfIRE ethanol over time (Dallas Innovates, 2024).

Grants: The US DOT's Federal Aviation Administration (FAA) introduced the "Fueling Aviation's Sustainable Transition" (FAST) discretionary grant program, which is aimed at making investments to accelerate the production and use of SAF and the development of low-emission aviation technologies to support the US aviation climate goal.

The FAST Grant Program is made possible by the IRA of 2022. The SAF portion of the program, termed FAST-SAF, will provide \$244.5 million in grants to support the build-out of infrastructure projects related to SAF production, transportation, blending, and storage. The low-emission technology portion of the program, termed FAST-Tech, will provide \$46.5 million in grants to develop and demonstrate new aviation technologies to improve fuel efficiency and reduce emissions. (FAA, 2023) (Holland & Knight, 2023).

Furthermore, the FAA launched, in July 2024, a \$1 billion fiscal year (FY) 2025 funding opportunity that could help US airports develop infrastructure to increase access to SAF (Ethanol Producer Magazine, 2024).

United States

In January 2023, the US DOE awarded \$108 million in funding to 13 SAF projects as part of the SAF Grand Challenge. These projects are a mixture of pre-pilot, pilot, and demonstration projects by private companies and universities. The DOE also awarded \$10 million to 4 Gen-1 Corn Ethanol Emission Reduction projects (SAF Investor, 2023).

In September 2023, the US DOE announced \$16.7 million in funding via Bioenergy Technologies Office (BETO) for five projects to advance the production of affordable biofuels and biochemicals that will significantly reduce GHG emissions (US DOE, 2023).

Through financial grants, the government is also promoting technological innovation in the SAF production process. In July 2024, the US DOE granted Atlantic Biomass \$199,180 for a project titled “Low-Cost Production of SAF from Perennial Feedstocks using Simultaneous Ball Milling and Enzyme Hydrolysis.” The Atlantic Biomass grant was part of the BETO initiative, which selected 13 small businesses across 10 states to advance bioenergy R&D (ChemAnalyst, 2024).

SAF Production Investments:

- In December 2022, the Montana Renewables facility in Great Falls, Montana, began production with an initial annual output of ~30 million gallons of neat, unblended SAF. Once completed, an expansion of this facility could boost SAF output to 230 million gallons annually.
- World Energy’s Paramount refinery in California is investing \$2 billion to upgrade its plant capacity to 340 million gallons of annual SAF output by 2025. The company also announced plans for the conversion of its biorefinery in Houston into a SAF hub, producing 250 million gallons per year by 2025 (Aviation Week Network, 2022)
- In April 2024, Energy products manufacturer Phillips 66 announced the conversion of its San Francisco oil refinery in Rodeo, California, to process only renewable feedstocks and is now producing approximately 30,000 barrels of renewable diesel per day. The company announced in 2022 its plans to convert the refinery into the Rodeo Renewable Energy Complex, which would no longer process crude oil and will instead use waste oils, fats, greases, and vegetable oils to produce 800 million gallons per year of renewable transportation fuels, including renewable diesel, renewable gasoline, and SAF (ESG Today, 2024).
- In December 2023, Canadian SAF project developer Azure Sustainable Fuels Corp. announced plans to develop a SAF production facility in Cherryvale, Kansas (KS) in the US. Once fully operational in 2027, the Cherryvale facility is estimated to produce ~135 million gallons per year of renewable fuels, primarily SAF (Bioenergy International, 2023).
- In September 2023, Airbus partnered with DG Fuels with an aim to support DG Fuels’ goal of launching the equity process and reaching a final investment decision on building DG Fuels’ first SAF plant in the US. DGF’s plant aims to have an initial production capacity of 120 million US gallons of SAF per year on average (Airbus, 2023).

Innovation in Production Process: Companies are undertaking innovation in conversion technologies with an aim to make SAF production more efficient and scalable. For instance:

- LanzaJet’s Freedom Pines facility in Soperton, Georgia, which became operational in January 2024, represents the world’s first ethanol-to-SAF production facility using Next-Gen SAF Technology. At full capacity, it will produce 10 million gallons of SAF or renewable diesel a year (AgroSpectrum Asia, 2024) (AIN Media, 2024).
- In April 2024, DG Fuels selected Fischer Tropsch (FT) CANST™ technology, which is co-developed by Johnson Matthey and energy giant bp, for the production of SAF in its planned \$4 billion plant near the Mississippi River in Louisiana. Expected to be in operation by 2028, this project would be the largest announced FT SAF production operation in the world with a planned capacity of around 120-135 million gallons of SAF annually. DG Fuels has already secured offtake purchase deals with Delta Air Lines and Air France-KLM and has a strategic partnership with Airbus to scale up the use of SAF globally (Greenair, 2024) (IANS, 2024).

United States

Outlook

The US biofuels market is expanding rapidly, and in the upcoming years, there will be a greater demand for SAF and renewable diesel, which will lead to another spike in output. Looking ahead to 2035, the US is expected to dominate production of both ethanol and diesel, as well as advanced biofuels. Biofuel production in the US is projected to increase by about 53% by the middle of next decade, jumping from 850,000 barrels of oil equivalent per day (boepd) in 2023 to about 1.3 million boepd in 2035. The 2035 production capacity is expected to account for 40% of the total global output (Rystad Energy, 2024).

Looking at the supply project pipeline, commercial airline demand, and the continuation of policy support for SAF production, domestic US SAF production is anticipated to increase from 1,700 bpd in 2023 to about 190,000 in 2035 (Rystad Energy, 2024).

However, the US goal of rapidly ramping up production of SAF may encounter strong headwinds as producers struggle with low margins for biofuel and some airlines flag concerns over the costly switch. The US jet fuel currently retails at around \$2.85 per gallon, while SAF prices are at \$6.69 per gallon (Reuters, 2023).

Despite the incentives for SAF production in the US, there are still significant challenges in narrowing the cost gap between SAF and conventional jet fuel. In the absence of incentives, the policymakers may find it challenging to divert existing biofuel production to SAF. The pipeline based on planned or announced SAF projects so far suggests that the local supply may fall short of SGC's 2030 target. Deliberate and timely initiatives will be needed to mobilise the required investments for targeted SAF adoption.

Mexico

The SAF market in Mexico is still in its infancy, with limited traction largely due to the absence of targeted policy support and regulatory frameworks. Despite having plentiful biofuel feedstock resources like sugarcane and corn, the SAF industry in the country has yet to leverage them. However, recent voluntary commitments and collaborations from major airlines and industry stakeholders signal a growing interest in developing a domestic SAF supply chain. Mexico's policy stance on energy transition and decarbonization goals under the newly elected government will play a crucial role in shaping the future of the SAF market.

Economic Indicators	GDP (current prices, \$ 2023)	1,789 Bn
	Real GDP growth forecast 2024-28	1.97%
	10-year govt bond yield (12-month rolling average)	9.19
	Country credit rating	BBB
Average daily flights	2,588	
Existing Fuel Consumption	4.62 million metric tons	
Usage Mandate	-	
Projected SAF Capacity Under Development (MT/Year)	-	
Policy Support	-	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Mexico

Aviation Industry Backdrop

Mexico's aviation industry experienced a strong recovery, with an 11.5% annual growth in total incoming air travel passengers, reaching 119 million as of end-2023 (Mexico Business News, 2024). Domestic travellers accounted for over half of the total passenger traffic, while the North American region dominated the international air transport business, with an 85% share of total international air passengers. The US alone contributed 27 million visitors to Mexico's international passenger traffic in 2023.

In the post-pandemic era, Mexico's aviation sector has demonstrated remarkable resilience, becoming one of the first countries in the region to recover its domestic air traffic (KPMG, 2024). In 2023, Mexico surpassed Brazil as the largest aviation market in Latin America for the first time (IBS, 2023). The restoration of Mexico's Category-1 air safety status by the US Federal Aviation Administration in 2023, after a two-year gap, further boosted the industry's growth prospects (Airport Technology, 2023).

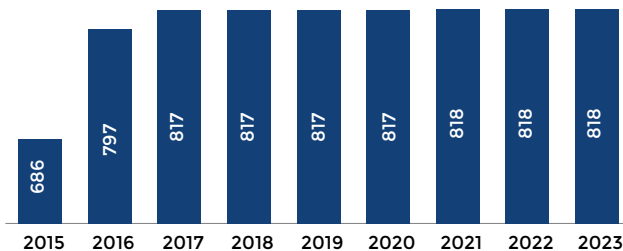
However, despite this strong recovery, decarbonization efforts within Mexico's aviation sector have been limited due to the absence of clear policy guidelines and specific emission reduction targets. The country has a stated goal of reducing greenhouse gas (GHG) emissions by 35% by 2030 compared to 2000 levels, but the roadmap for achieving this target across various sectors, including aviation, remains unclear (Argus, 2024).

Policy and Regulation

The SAF market in Mexico lacks a comprehensive policy and regulatory framework to support the adoption and production of SAF. The absence of supply-side incentives and clear guidelines has hindered the growth of the domestic SAF market, resulting in negligible production and consumption levels (Mexico Now, 2023).

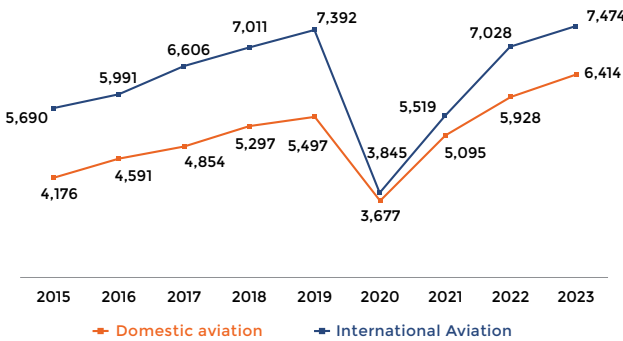
The country's biofuel industry, despite its resource potential, operates without the typical regulatory norms seen in other markets. For instance, the fuel ethanol content requirement has remained stagnant at 5.8% since 2018. A proposed amendment in 2020 to increase the blending mandate for gasoline was

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



Mexico

stalled in the courts, leading to a regulatory impasse (CZ, 2024).

Expectations are high that the newly elected Mexican President, set to take office in October 2024, will bring a favourable outlook to energy transition and decarbonization efforts. The incoming administration is widely regarded as having an objective view on the importance of reducing GHG emissions, despite concerns about political compulsions (BBC, 2024).

Market Opportunity

Mexico's aviation industry is well-positioned to benefit from the growing global demand for SAF, especially given its rich biofuel feedstock sources like used cooking oil, agricultural waste, and animal fats. However, while these resources offer great potential, the current high cost of SAF compared to conventional jet fuel presents a significant barrier. To overcome this, the development of a robust SAF supply chain will require both strategic investments and policy incentives that make SAF production more viable and cost-effective (AMI, 2024).

Recognizing the importance of establishing a local supply chain, Mexican airlines have started collaborating with industry stakeholders to develop sustainable, scalable solutions. Volaris, one of Mexico's leading low-cost carriers, recently partnered with Airbus to evaluate proposals for scalable and affordable SAF development in Mexico (Mexico Business, 2024). This partnership has the potential to kickstart local SAF production and reduce reliance on costly imports.

In addition to partnerships, Volaris has announced a groundbreaking \$50 million investment agreement in collaboration with key industry players (PR Newswire, 2023) to enable SAF production based on a technology developed by CleanJoule, a North American startup. By focusing on producing high-performance and cost-effective SAF from agricultural waste and organic residues, Volaris is poised to significantly increase its SAF supplies, promoting a greener aviation industry.

Moreover, the increasing focus on achieving zero CO₂ emissions in the airline industry has led carriers like Aeroméxico to establish ambitious goals (IBS Software, 2023). The airline aims to have 5% of its aviation fuel comprised of SAF by 2030, with 20% sourced from domestic production (Mexico Business,

2024). This strong push for sustainability is spurring increased demand for competitive and sufficient supplies of SAF in Mexico.

VivaAerobus, another major Mexican airline, has joined industry peers in actively soliciting proposals to scale up domestic SAF production. A recent purchase agreement between Viva Aerobus and SAF producer Neste marked a crucial milestone in SAF offtake for flights between the US and Mexico (Neste Corporation, 2023).

Outlook

The high production costs of SAF, biomethane, and renewable diesel have slowed their adoption among Mexican producers and consumers. One of the major roadblocks remains Mexico's regulatory framework, which lacks incentives for cleaner fuel production. Currently, biomethane producers receive equal compensation for any gas injected into the national grid, regardless of its sustainability profile (AMI, 2024). The absence of targeted subsidies and legislation focused on promoting sustainable fuel production has further deterred major players, such as Engie, from advancing biomethane projects within the country.

Despite these challenges, partnerships between leading aviation companies like Airbus and research institutions to develop scalable and affordable SAF production solutions (Airbus, 2024) suggest growing momentum to address these cost barriers. These collaborations signal a promising shift towards increasing SAF accessibility in the Mexican market.

There is optimism that the incoming administration will introduce new biofuel laws and mandates aimed at accelerating the demand for sustainable fuels (AMI, 2024). Latin America is projected to produce over 15% of the total global SAF output by 2030, presenting a significant opportunity for Mexico to capture a substantial share of the market if the right policies are in place (AMI, 2024).

Key Regional Markets - South America



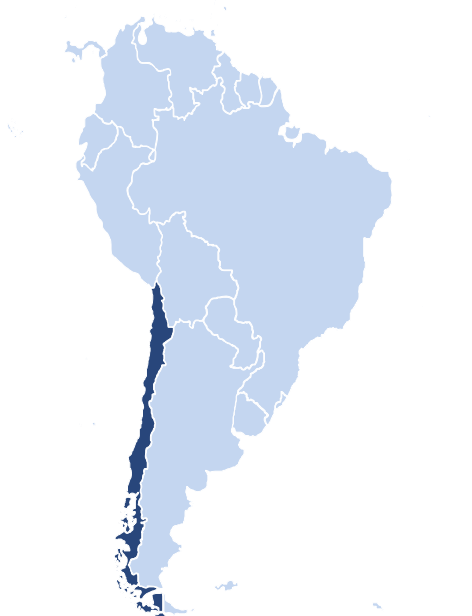
Chile

Chile is taking significant strides to establish itself as an important player in the global SAF market. Recognizing the crucial role of SAF in decarbonizing the aviation industry, the country is proactively investing in the development of a robust domestic SAF production capacity. By leveraging its abundant renewable energy resources and collaborating with local industries, Chile aims to create a supportive environment for the growth of the SAF market.

With the urgency of sustainable aviation practices in mind, the Chilean government has set ambitious goals, including the establishment of its first large-scale SAF production facility by 2030 and a target to produce 50% of its jet fuel from sustainable sources by 2050. As air travel demand continues to rise, Chile recognizes the urgent need to mitigate the environmental impact of the sector. Through strategic investments, supportive policies, and industry partnerships, Chile is positioning itself to become a leader in sustainable aviation, driving economic growth while contributing to the global fight against climate change.

Economic Indicators	GDP (current prices, \$ 2023)	336 Bn
	Real GDP growth forecast 2024-28	2.30%
	10-year govt bond yield (12-month rolling average)	5.67
	Country credit rating	A
Average daily flights	654	
Existing Fuel Consumption	1.21 million metric tons	
Usage Mandate	50% SAF by 2050	
Projected SAF Capacity Under Development (MT/Year)	-	
Policy Support	-	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Chile

Aviation Industry Backdrop

The aviation market in Chile has experienced significant growth and development in recent years, becoming one of the most dynamic and competitive in Latin America. In 2023, Chile recorded nearly 25 million air passengers, representing a 22.5% increase compared to the previous year. However, this figure is still 4.5% below the 2019 pre-pandemic level, when over 26 million travellers were recorded (AméricaEconomía, 2024).

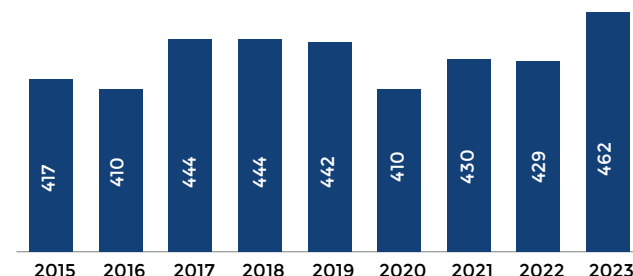
Jet fuel consumption in Chile mirrors a similar recovery trend and is yet to return to its pre-pandemic level of 28,640 barrels per day (bpd) in 2019. In 2022, fuel consumption reached 22,040 bpd, up from 15,930 bpd in 2020 (TheGlobalEconomy.com, 2022). With Chilean aviation contributing approximately 0.3% of the total global GHG emissions from air transport, the urgency for decisive government action is clear (ICAO, n.d.).

Chile's biofuel feedstock potential is limited for commercially viable first-generation fuels like ethanol. Instead, there is a better scope for second-generation fuels based on non-edible energy crops. Despite being resource-rich, biofuel use is nascent in Chile, unlike its South American counterparts. This presents an opportunity for Chile to increase biofuel usage towards its 2050 SAF target (IEA Bioenergy, 2023). Moreover, Chile's high renewable energy penetration with c.61% generation (including hydro) presents a significant and untapped potential for e-SAF technologies (SAF Investor, 2024) (EMBER, 2024).

Policy and Regulation

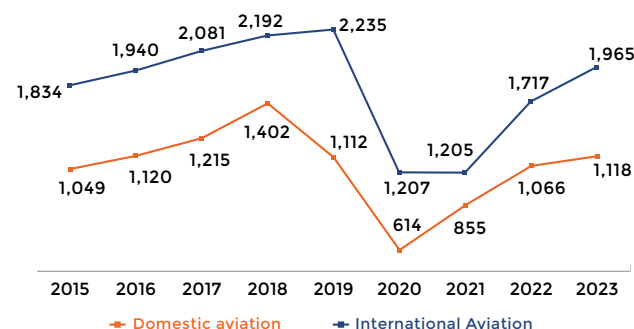
As Chile seeks to strengthen its standing in the global biofuel market, it faces competition from other South American nations that have more mature and widespread biofuel practices. Countries like Brazil and Argentina have long been at the forefront of biofuel adoption, establishing robust policies and infrastructures to support their biofuel sectors. In contrast, Chile's journey in implementing biofuel policies has been more gradual. However, the country is actively working to bridge this gap by fostering a more supportive environment for renewable energy, including biofuels (IEA Bioenergy, 2023).

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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Chile

In this context, the Chilean government is providing substantial financial support to SAF projects through various funding programs aimed at research, development, and scaling up production capacities. In May 2023, Chile formalized its commitment to advancing the decarbonization of air transport by joining the ICAO SAFs assistance, capacity building, and training program known as ACT-SAF (JAC (Junta de Aeronáutica Civil) Chile, 2023).

Chile's SAF Roadmap 2030, announced in April 2024, outlines ambitious goals, including establishing a large-scale SAF production facility by 2030 and aiming to replace 50.0% of jet fuel with SAF derived from oils, fats, biological, and municipal waste by 2050 (Avfoil News, 2024). Additionally, the Vuelo Limpio (Clean Flight) program, launched in 2020, invites domestic airlines to adopt tools that reduce GHG emissions. This public-private collaboration aims to improve efficiency in the civil aviation industry and promote good energy management practices (Gobierno de Chile, 2021).

Looking ahead, Chile plans to leverage its local forestry, agriculture, and hydrogen industries to support SAF development and make it cost-competitive with traditional jet fuel. The country is also conducting a comprehensive study on the long-term viability and economic feasibility of large-scale SAF production (Avfoil News, 2024).

Market Opportunity

As the demand for SAF grows worldwide, driven by countries and airlines seeking to reduce their carbon footprint, Chile's early investments and strategic partnerships in SAF production are expected to give the country a competitive edge as a global supplier.

Several notable companies are contributing to Chile's growing SAF project pipeline through various strategic initiatives:

Airlines such as LATAM and Sky Airline are equally committed, actively participating in SAF projects by forming alliances with fuel producers to secure sustainable fuel supplies and reduce their carbon footprints. With air traffic in Chile projected to double by 2040, SAF will remain a crucial element in meeting the country's decarbonization goals.

Company	Initiatives
EnergyX (a major Chilean energy company)	The company is converting its refineries to produce SAF using advanced technologies for high efficiency and sustainability
GreenFuel (a leading energy company)	The firm is investing in SAF production through partnerships with technology providers and research institutions, leveraging its extensive refinery network
BioTech (a global specialty chemicals company)	BioTech is developing a commercial-scale plant in Valparaíso to produce cellulosic ethanol, a crucial SAF component, bringing technological advancements and expertise to Chile
Copec (Chile's leading fuel distribution company)	In May 2023, Copec signed an agreement with German eFuel technology developer Ineratec to develop a 3,500-ton power-to-liquid (PtL) plant to produce eFuels in Chile (SAF Investor, 2024)
Porsche (a German automobile manufacturer specializing in luxury, high-performance sports cars)	In December 2022, the company started production of synthetic fuel in a pilot project involving partnership with Siemens Energy in Punta Arenas, Chile, backed by a €20 million investment (TechCrunch, 2022)

Outlook

Despite Chile's ambitious targets, and a dedication to innovation, the widespread adoption of SAF faces challenges, including limited domestic supply, high production costs, low technological maturity for scaling production, and a lack of specialised knowledge in the SAF value chain. Moreover, the absence of specific national regulations concerning facility safety and product quality further complicates the path forward.

Nevertheless, the ongoing initiatives in biofuels and SAF demonstrate strong policy intent and investor interest in the segment. With the right combination of funding support and regulatory mandates, Chile has the potential to overcome these challenges and steer the industry's growth, positioning itself as a leader in mitigating aviation transport emissions and inspiring global efforts to combat climate change.

Brazil

Brazil's biofuels industry, especially its production of sugarcane-based ethanol, has positioned the country as one of the world's top biofuel producers. The country is well-positioned to capitalise on a growing market for special agricultural fuels. Its vast ethanol supply can serve as a key feedstock for both domestic and international SAF producers. Additionally, recent regulatory developments aimed at reducing aviation emissions are expected to boost domestic demand for SAF, presenting Brazilian ethanol producers with a significant opportunity.

Economic Indicators	GDP (current prices, \$ 2023)	2,174 Bn
	Real GDP growth forecast 2024-28	2.07%
	10-year govt bond yield (12-month rolling average)	11.1%
	Country credit rating	BB
Average daily flights	2,531	
Existing Fuel Consumption	5.33 million metric tons	
Usage Mandate	Cutting airline emissions by 1% of 2026's total emissions, rising up to 10% in 2037 (Effective January 2027)	
Projected SAF Capacity Under Development (MT/Year)	950,000 by 2028	
Policy Support	-	

Source: IMF, Fred Economic Data, S&P Global, Knoema, Eurocontrol



Brazil

Aviation Industry Backdrop

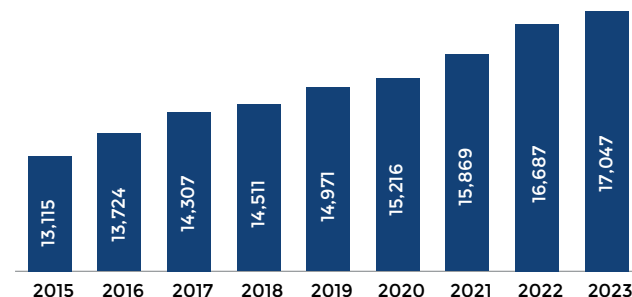
The Brazilian aviation market is among the largest in the Latin American region. In 2023, the total number of passengers using Brazilian aviation reached 113.0 million, registering a 15.3% year-on-year growth (Aviation Week, 2024). As of March 2024, domestic seat capacity had returned to 2019 levels by 96.0%, and international capacity had returned to 2019 levels by 96.5% (Aviation Week, 2024). The executive aviation business segment has a significantly strong position globally and is driven by Indigenous manufacturers like Embraer. The post-pandemic spike in demand for executive business aviation helped boost the industry. In this context, the jet fuel demand and spending can be assumed to play a critical role in the business.

Brazil government's Energy Research Office (EPE) reported a compound annual growth rate (CAGR) of 22.0% in jet fuel demand between 2021 and 2023. The report also noted that in April 2024, jet fuel demand increased month-on-month for the first time since the pandemic outbreak. The growth was 0.1% compared to April 2019 and 9.1% compared to April 2023 (EPE, 2024).

There is a vast untapped potential in SAF, considering Brazil's strong track record in biofuel production. It is the world's second-largest biofuel producer after the US, led primarily by its sugarcane-based ethanol supply. It similarly leads in biodiesel (third largest globally) and has an established policy and regulatory framework in the biofuels industry (Energy Institute, 2023). A rich resource endowment in sugarcane and corn, together with an established manufacturing base, ensures competitive biofuel supplies. The most recent data available indicates that till 2022, biofuels contributed to 22.0% of the country's total transportation sector energy (IEA, 2023).

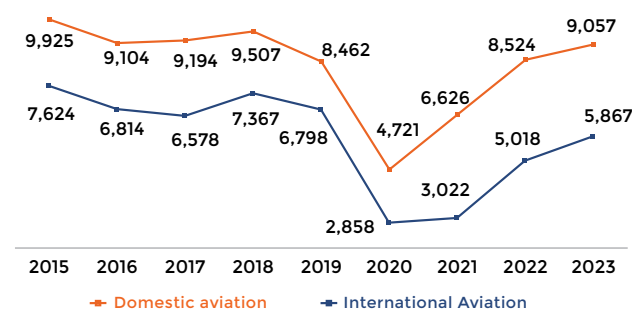
SAF does not have a commercial presence in Brazil. There are just two SAF plants under development in the South American region — one is in Paraguay, owned by Brazilian group ECB and scheduled to be operational in 2024. The second one is in North Brazil, being developed through a partnership between Brasil BioFuels and Vibra, expected to commence production in 2025 (S&P Global, 2024).

Biofuel Installed Capacity (MW)



Source: OECD.Stat, 2024

Estimated CO₂ emissions in line with UNFCCC inventories (territory principle)



Source: OECD.Stat, 2024

Note: Thousand tonnes of CO₂-equivalent



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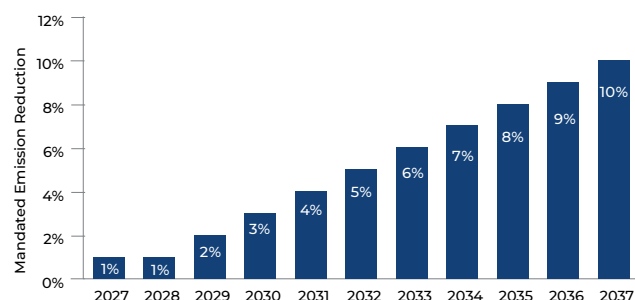
Brazil

Policy and Regulation

It is only recently that regulatory attention has been focused on SAF. Historically, Brazil's biofuel regulations have been focused on road transport fuels, especially gasoline and diesel (IEA Bioenergy, 2023). The regulatory mandates on compulsory ethanol blending in gasoline have been in place since the 1930s. Over the successive decades, the ethanol blend in Brazilian gasoline fluctuated and currently stands at 27.0%. The emphasis on biodiesel started in 1980, with a mandatory 30.0% blend based on vegetable oils or derivatives. The biofuel regulations were motivated initially to mitigate rising import dependence on gasoline and diesel and later to address transportation sector emissions. With SAF, there is a departure from the skew towards road transportation fuels. In doing so, the authorities are also aligning with the global practice of taking a holistic approach to managing the energy transition.

Brazilian regulatory authorities plan to introduce the SAF mandate, which will take effect in January 2027. The mandate will be based on an emissions reduction scheme, unlike the volume-based blending mandates in place for ethanol and biodiesel. While the nation's current requirement for biodiesel mix into diesel is 14.0% (S&P Global, 2024), there is a statutory 27.0% ethanol blend requirement for gasoline (ET Energy World, 2022). The SAF mandate will target cutting Brazil's aviation emissions by 1.0% (relative to emissions in 2026). This will progressively rise each year, reaching 10.0% by 2037 (IEA, 2023).

Mandated Emission Reduction for Aviation Operators



Source: IEA

The regulation is getting closer to enactment. In March 2024, it received parliamentary approval under the National Sustainable Aviation Fuel Programme (ProBioQAV) aimed at promoting research, production

and commercialisation of SAF. Notably, the draft regulations allow for alternate means to achieve the targeted emission reduction. Also, there could be exemptions for some operators who either have lower emissions than the targets or do not have access to SAF at any of the airports where they operate (Chamber of Deputies, 2024).

Different agencies and authorities will be involved in implementing and supervising the norms. The National Civil Aviation Agency (ANAC) will track annual emissions and monitor compliance. The National Agency of Petroleum, Natural Gas and Biofuels (ANP) will establish the values of total emissions equivalent in carbon dioxide per unit of energy produced by SAF. The values thus determined will help measure the decarbonisation against conventional aviation fuel.

Market Opportunity

The SAF market in Brazil is at a nascent stage and shows signs of gradually rising investor interest. Some of the leading global developers have begun securing land, feedstock, and other related resources for developing a manufacturing base. Brazil's high ethanol production capability is a huge advantage for SAF developers. In April 2024, Brazilian company Raizen executed the first export shipment of ethanol for the US-based developer LanzaJet's Georgia based SAF production facility (BNN Bloomberg, 2024). Currently, Raizen is exploring locations to set up an ethanol-based SAF production facility in Brazil with an annual capacity of at least 793,000 US gallons (Hydrocarbon Processing, 2024).

Brazil's ethanol production offers export opportunities. Like Raizen, many of Brazil's existing ethanol mills are certified to supply SAF feedstock that meets the required global standards. Some of the key entities in this regard are BP Bunge Bioenergia and Copersucar SA (Profarmer, 2024). In March 2024, the Brazilian corn-based ethanol producer FS received certification of compliance with global norms for SAF production feedstock. The certification proved that Brazilian ethanol produced from second-crop corn can be a low-carbon feedstock for the aviation sector (Argus, 2024). In November 2023, the ethanol producer Atvos announced its SAF market entry plans, with a planned investment of \$324.0 million towards SAF production from 2028 based on the certified alcohol-to-jet

Brazil

pathway. The company expects to invest \$324.0 million by the end of the 2025, and to invest similar amounts in 2026 and 2027 respectively (Argus, 2023).

In June 2024, BP announced its plan to acquire Bunge's 50.0% interest in the joint venture entity BP Bunge Bioenergia. It is among the leading biofuel-producing companies in Brazil, with a targeted bio-ethanol production of 30,000 barrels per day by 2030 (BP, 2023). Once the acquisition is done, BP will achieve a significant scale in the Brazil-based sugarcane and ethanol business with enhancements through its trade and technology capabilities (BP, 2024). In June 2024, Copersucar and Geo bio gas & carbon signed a memorandum of understanding to develop the technology for converting biogas to SAF, based on the Fischer-Tropsch methodology. A demonstration plant could be set up by 2025 to this end (Bioenergy Insight, 2024).

The Brazilian market opportunity for SAF is dominated by ethanol, however, other technologies are also being considered. Synthetic or eFuel, for instance, is one segment in Brazil's market that does not yet have a commercially viable proposition, but it has significant demand in the European market. A notable initiative in this direction is the planned development of a technology demonstration plant in Brazil to produce biosyncrude – a synthesised mixture from biogas and green hydrogen, which can then be used to produce SAF. The plant is funded by a €1.8 million grant from the German government, and marks the first of its kind in Brazil (Valor, 2024).

The US SAF market is important for Brazilian mills. With firm guidelines on incentives still pending, US-based SAF producers may primarily turn to Brazilian imports as their main source of ethanol in the short term. Japan, which targets 10.0% SAF blending by 2030, presents another promising export market for Brazilian ethanol producers. Simultaneously, many existing SAF producers are already testing and exploring ways to lock in ethanol supplies for future SAF production (Valor Agri, 2024).

Despite the clear demand, investment commitments may require incentives. Brazil does not have any subsidies or similar support for prospective developers and investors, and this may need to be revisited. With a negligible current domestic production base and few global-scale entities, the market is far from maturity and would need added support to ensure there are timely investments in expanding production capacity.

Outlook

As one of the largest producers and consumers of ethanol and biodiesel, the Brazilian market is ideally positioned to lead global ethanol-based SAF production. Increased domestic consumption of SAF due to the introduction of the 2027 SAF mandate paired with high international demand for ethanol-based SAF will open new avenues for increased production and export. According to estimates, about 20.0%—30.0% of SAF production by 2030 could be sourced from ethanol, for which about 9.0 billion—12.0 billion litres would be required annually. Even if Brazilian producers are not the primary supplier, they will play a key role considering their current share in the global ethanol trade (Valor Agri, 2024).

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About CleanBridge



About CleanBridge

CleanBridge has a deeply experienced team, combining professionals with financial expertise (investment banking, capital markets) and operational experience (engineering, project development, business process management). These complementary skill sets allow us to understand the most attractive opportunities for growth within the following value chains.

Sustainable Energy



Climate Finance



Sustainable Living



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Appendix

Major Players

Neste	Publicly Traded		NESTE
Neste is one of the leading producers of SAF, renewable diesel and renewable feedstock solutions for the polymers and chemicals industry.			
Key Facts	Year of Establishment	1948	
	Headquarters	Espoo, Finland	
	SAF Production Capacity	1 million tons annually	
	SAF Production Target	2.2 million tons by 2026	
	Revenue	€22,926 million (2023)	
	EBITDA	€2,548 million (2023)	
Current and Planned SAF Investments	- In December 2023, Neste began transforming its crude oil refinery in Porvoo, Finland, to a renewable and circular solutions refining hub with a total investment of about €2.5 billion. - In June 2022, Neste announced investing €1.9 billion for the Rotterdam refinery expansion project in the Netherlands, targeted to begin production by mid-2026.		
Tie-Ups	Avefuel Corporation	Mar 2024: Partnership extension till end-2027 to strengthen the SAF business leadership position and to increase SAF supply to Avefuel by 3x.	
	Emirates	Oct 2023: Partnership to supply over 3 million gallons of blended SAF over 2024 and 2025.	
	ITOCHU	May 2023: Extended collaboration using a licensing agreement to allow ITOCHU to distribute Neste's Renewables Diesel in Japan officially.	
	Viva Airbus	Apr 2023: Signed a new purchase agreement for one million litres of SAF.	
	Airbus	Nov 2022: Signed an agreement to advance the use of SAF within the aviation sector for speedy decarbonisation goals.	
	Air France-KLM Group	Oct 2022: Entered a SAF agreement to supply one million tons of SAF till 2031 starting in 2023.	
Financiers / Investors	Finnish State 44.2% Non-Finnish shareholders 36.8% Finnish institutions 10.6% Retail Investors 8.4%		
Other Information	- In 2022, World Fuel Services became Neste's authorised branded SAF distributor for several European locations, starting from France's Paris-Le Bourget Airport (LFPB) and targeting expansion in the UK and Germany. - In 2022, Neste made a historic achievement by successfully operating the first-ever SAF-powered Boeing 737-800, a Malaysian Airlines aircraft with onboard passengers. - In 2021, Neste unveiled its €500 million 7-year green bond, the "Green Finance Framework", to support financing and refinancing eligible projects and assets related to renewable and climate change solutions. - Neste's SAF Optionality Project targets to increase capacity by 500,000 tons annually with an investment of €190 million scheduled in early 2024.		

World Energy, LLC	Privately Traded		
World Energy is one of the world’s first producers of sustainable aviation fuel and has been producing renewable fuels for over 25 years.			
Key Facts	Year of Establishment	1998	
	Headquarters	Boston, Massachusetts, USA	
	SAF Production Capacity	38 million gallons per year (2019)	
	SAF Production Target	250 million gallons annually by 2024 and 1 billion gallons annually by 2030	
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	In 2022, World Energy collaborated with Air Products to construct and expand World Energy’s SAF production and distribution Hub in Paramount, California, with an investment of \$2 billion to increase its total capacity to 340 million gallons annually.		
Tie-Ups	Gulfstream Aerospace Corp.	Nov 2023: Partnered to complete the world’s first transatlantic flight using 100% SAF with no added aromatics or other impurities, marking a historic success.	
	DHL Express	Oct 2023: Inked a 7-year strategic contract to purchase ~668 million litres of SAF via SAF certificates (SAFc) till 2030 to accelerate the decarbonization of aviation logistics.	
	Microsoft	Oct 2023: Partnered for a first-ever 10-year purchase contract for replacing about 43.7 million gallons of petroleum jet fuel with SAF through SAFc to decarbonize Microsoft’s corporate air travel and supply chain cargo.	
	World Fuel Services	May 2023: Entered a 6-year purchase partnership for 27 million gallons of SAF.	
	Blue Biofuels	May 2023: Inked an MOU for the offtake of ethanol and SAF, as well as all its finished products.	
	Etihad Airways	Nov 2022: Signed a notable MOU to power the first net-zero flight using SAF via a Book & Claim system to decarbonize flights via in-sector emissions reductions.	
	Shell	Jan 2020: Partnered to increase the supply of SAF to the Lufthansa Group for flights in San Francisco International Airport (SFO).	
Financiers / Investors	Air Products, and Canadian investor Halifax.		
Other Information	In 2022, World Energy announced constructing its second SAF facility at its current Houston ship channel production and distribution hub to produce an additional 250 million gallons of SAF annually by 2025.		

TotalEnergies	Publicly Traded		
TotalEnergies is a multinational multi-energy company operating in oil and gas, renewable, and bioenergy segments and is one of the “Supermajor” oil companies worldwide.			
Key Facts	Year of Establishment	1924	
	Headquarters	Courbevoie, France	
	SAF Production Capacity	-	
	SAF Production Target	1.5 million tonnes per year by 2030	
	Revenue	\$218.9 billion (2023)	
	EBITDA	\$50.0 billion (2023)	
Current and Planned SAF Investments	• In June 2023, TotalEnergies unveiled its investment plan of €400 million to transform the Grandpuits facility into a no-crude platform, primarily for SAF production from circular feedstocks to produce 210,000 tons/y by 2025 and 285,000 tons/y of SAF by 2027. • In June 2023, the company announced investing €70 million to transform La Mède biorefinery by 2024 to produce biofuels and SAF by coprocessing using 100% cooking oil and animal fat waste. TotalEnergies invested €337 million to convert La Mède crude oil refinery to France's first biorefinery commissioned in 2019 that began producing SAF in April 2021. • In 2023, the company further unveiled its plan to increase production capacity at its Gonfreville refinery in Normandy to 40,000 tons from 2025 onwards.		
Tie-Ups	Airbus	Mar 2024: Collaborated to supply SAF to Airbus flights, reducing up to 90% of CO2 emissions over the lifecycle and decarbonizing the aviation system.	
	Aramco	Oct 2023: Ventured to own SATORP platform and successfully converted UCO through coprocessing into ISCC+ certified SAF.	
	Jet Aviation	May 2023: Partnered with TotalEnergies to provide SAF for owners and operators visiting its Geneva, Switzerland Fixed-Base Operator (FBO) during 2023 European Business Aviation Convention & Exhibition (EBACE).	
	Air France-KLM	Dec 2022: Signed an MOU to deliver more than 800,000 tons of SAF over ten years starting in 2023 for flights departing from France and the Netherlands.	
	Air Liquide	Nov 2022: Partnered to develop a hydrogen production unit with more than 20,000 tonnes/y capacity. Partially renewable low-carbon hydrogen will be used to produce SAF.	
	SARIA AS	Sept 2022: Partnered to secure UCO and animal fat supplies for SAF production, increasing Grandpuits SAF production capacity to 210,000 tons/y.	
	ENEOS Corporation	Apr 2022: Collaborated to develop SAF production and supply chain in the ENEOS refinery in Negishi, Japan, by 2025.	
	Masdar & Siemens Energy	Jan 2022: Collaborated to construct a demonstrator plant of a green hydrogen project and produce SAF (CO2 conversion) in Masdar City, UAE.	
Financiers / Investors	• BlackRock, Inc - 6.6%; Employee shareholders – 6.8%; Others – 86.6%		
Other Information	• In 2023, TotalEnergies unveiled its plan to produce an additional 150,000 tons of SAF by coprocessing HVO biodiesel produced at La Mède after its approval secured from the ASTM. • In December 2023, TotalEnergies and Masdar unveiled the first test flight to demonstrate methanol to SAF conversion to help unlock the use of e-SAF to decarbonize aviation. • In November 2022, TotalEnergies contracted Technip Energies for SAF at its Grandpuits refinery in France.		

Fulcrum		Privately Traded		
Fulcrum BioEnergy is a clean energy company focused on reducing CO2 emissions and wastes to pioneer renewable and transportation fuels from landfill waste.				
Key Facts	Year of Establishment	2007		
	Headquarters	Pleasanton, California, USA		
	SAF Production Capacity	-		
	SAF Production Target	Planned capacity of 400 million gallons of SAF annually		
	Revenue	-		
	EBITDA	-		
Current and Planned SAF Investments	- In April 2023, Jet2 plc announced plans to invest in Fulcrum's North-Point SAF project in Northwest England, with production to begin in 2027 to produce 26.4 million gallons/y of SAF. - In July 2022, SK Innovation invested \$20 million in Fulcrum to source SAF from Fulcrum in South Korea and some Asian regions, the second investment following a \$50 million investment made earlier in end-2021.			
Tie-Ups	Essar Oil (UK) Limited	Feb 2021: Collaborated to construct a new SAF conversion facility worth £600 million to produce SAF from non-recyclable household waste to supply airlines at UK airports.		
	Manchester Airports Group	Oct 2021: Partnered to secure direct supply of SAF to accelerate decarbonization in aviation and support post-pandemic employment recovery.		
	Marubeni Corporation, Japan Airlines, and Japan Overseas Infrastructure Investment Corporation	Sept 2018: Partnered for international project development, project license agreement, jet fuel offtake, and secure equity investment in Fulcrum.		
	Johnson Matthey	Sept 2018: Partnered to license JM's Fischer Tropsch (FT) technology to support biofuel production by converting municipal solid waste into biojet fuel.		
	BP	Nov 2016: Strategic partnership to accelerate new renewable jet-fuel plant construction and the offtake of 50 million gallons of low-carbon jet fuel per year.		
Financiers / Investors	- In February 2023, Fulcrum received \$20.2 million from the UK Department for Transport Advanced Fuels till 2025 to support the development of the North-point residual SAF facility. - In 2021, Indiana Finance Authority awarded \$500 million in Volume Cap to Fulcrum to support its Centerpoint Biofuel plant, and by end-2021 it completed its interim financing with \$375 million. - In 2016, BP made an equity investment of \$30 million for fuel offtake and construction of a renewable jet fuel facility. - In 2015, United Airlines invested \$30 million in the company to participate in waste-to-jet fuel facilities in North America and secure the supply of SAF. - In 2014, Cathay Pacific invested in Fulcrum BioEnergy, Inc. for a 10-year supply of an initial 375 million gallons SAF that meets the airline's technical requirements.			
Other Information	- In June 2023, Air New Zealand and the government selected Fulcrum Bioenergy and LanzaJet to analyse the technical, economical, supply chain, and environmental feasibility of establishing and operating a SAF production facility in the country with a combined fund of \$2.26 million. - In December 2022, Fulcrum Bioenergy produced the first-ever low-carbon synthetic crude oil using landfill waste at its Sierra BioFuels Plant.			

Gevo	Publicly Traded		
Gevo is one of the leading renewable chemical and advanced biofuels companies. Gevo operates in the sustainability sector, pursuing a business model based on the concept of the “circular economy”.			
Key Facts	Year of Establishment	2005	
	Headquarters	USA	
	SAF Production Capacity	-	
	SAF Production Target	1 billion gallons by 2030	
	Revenue	\$17.2 million (2023)	
	EBITDA	-\$62.83 million (2023)	
Current and Planned SAF Investments	Gevo intends to invest between \$236 million and \$286 million for the Net-Zero 1 project. The Net-Zero 1 (NZ1) project aims to produce SAF at an anticipated rate of approximately 55 million gallons per year starting in 2025		
Tie-Ups	McDermott	July 2023: McDermott secured a master services agreement (MSA) from Gevo, to provide front-end engineering and early planning services for Gevo's development of multiple SAF facilities in North America.	
	Hawaiian Airlines	March 2023: Hawaiian Airlines entered a collaboration with Gevo to procure 50 million gallons of SAF over the course of five years.	
	Axens	October 2021: A strategic alliance aimed at accelerating the commercialization of sustainable ETJ projects in the US.	
	Chevrons	September 2021: Jointly invest in building and operating new facilities that would process inedible corn to produce SAF. Additionally, Chevron would co-invest with Gevo in one or more projects and take about 150 million gallons per year to market to customers.	
	The Air Transport Action Group (ATAG)	September 2023: Gevo became a Strategic Associate of ATAG, committing to collaborative efforts and knowledge exchange to advance aviation decarbonization and scale up SAF for global aircraft operations.	
Financiers / Investors	Total SE, Chevron Corporation, BlackRock, Vanguard Group, Wellington Management, Fidelity Investments, Renaissance Technologies, State Street Corporation, Susquehanna International Group, H.C. Wainwright & Co.		
Other Information	Gevo presently possesses roughly 375 million gallons per year (“MGPY”) of mainly take-or-pay agreements for SAF and hydrocarbon fuel supply. These agreements are expected to facilitate project debt financing, with the projected demand necessitating the construction of multiple plants over the next four years. Based on current market projections and certain assumptions, these contracts collectively represent an estimated \$2.3 billion in annual sales. Notable offtake partners include Trafigura, Kolmar, Delta Airlines, American Airlines, Alaska Airlines, Finnair, Japan Airlines, British Airways, Aer Lingus, and SAS.		

LanzaJet	Privately Traded		
LanzaJet was established with a primary focus on advancing SAF through the commercialization of cutting-edge, proprietary ATJ technology.			
Key Facts	Year of Establishment	2020	
	Headquarters	USA	
	SAF Production Capacity	10 million gallons annually	
	SAF Production Target	1 billion gallons by 2030	
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	• In February 2024, Southwest Airlines announced an investment in LanzaJet for the development of a SAF production facility in the US. • In 2022, LanzaJet received a \$50 million financing for its ATJ SAF production plant in Soperton, Georgia, through the Microsoft Climate Innovation Fund. • In 2022, LanzaJet secured a \$50 million grant from Breakthrough Energy in the Freedom Pines ATJ production facility. • In 2020, Suncor and Mitsui invested \$15 million and \$10 million, respectively, in LanzaJet. Suncor secured a significant portion of the SAF and renewable diesel produced at the facility, offering sustainable energy choices to its jet fuel and distillate customers.		
Tie-Ups	Airbus	June 2023: The MOU between Airbus and LanzaJet initiated a collaboration to propel the development of SAF facilities utilizing LanzaJet's established and proprietary ATJ technology.	
	Technip Energies	September 2023: Technip Energies strengthened the collaboration to deploy LanzaJet's ATJ Process technology globally, integrating Technip Energies' Hummingbird Technology for ethanol-to-ethylene conversion in SAF production.	
	Jet Zero Australia	February 2024: Jet Zero Australia Pvt. Ltd collaborated to propel Project Ulysses, a North Queensland SAF endeavor utilizing LanzaJet's ATJ technology in Australia.	
	British Airways and Nova Pangaea Tech.	November 2022: LanzaJet, British Airways, and Nova Pangaea Technologies entered into a collaboration to accelerate Project Speed Bird, aimed at developing cost-effective SAF for commercial use in the UK.	
	Indian Oil Corporation (IOC)	February 2023: IOC partnered with LanzaJet to investigate the potential for SAF production in India.	
	Marquis SAF	Marquis SAF partnered to construct a 120 million gallons per year sustainable fuels plant in the US, using low-carbon feedstocks for SAF and renewable diesel production via LanzaJet™ AtJprocess.	
Financiers / Investors	Microsoft Climate Innovation Fund, Suncor, Mitsui, Shell, British Airways, Breakthrough Energy, Nippon Airways.		
Other Information	LanzaJet became a member of ATAG in 2023, a worldwide organization advocating for the aviation industry's pledge to achieve net-zero carbon emissions by 2050.		
	Air New Zealand and the New Zealand Government chose LanzaJet and LanzaTech to conduct a study on domestic SAF production in New Zealand. The study aligns with Air New Zealand's overarching goals to decarbonize and reach net zero emissions by 2050.		

DG Fuels	Privately Traded		
DG Fuels manufactures renewable hydrogen and biogenic-derived synthetic low-emissions aviation and diesel fuel. Through its synergistic process, it overcame the carbon utilization barrier, achieving an efficiency of up to 97% in carbon utilization.			
Key Facts	Year of Establishment	2010	
	Headquarters	USA	
	SAF Production Capacity	-	
	SAF Production Target	120 million gallons by 2026	
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	- In 2023, a 3,000-acre site in St. James Parish was considered for a low-emission biofuel plant with an investment of \$3.1 billion to produce SAF up to 120 million gallons annually. - During 2023, Air France-KLM contributed to the completion of the developmental work needed for DG Fuels' initial SAF plant in Louisiana. It provided a financial injection of US\$4.7 million into the SAF producer. - In 2023, DG Fuels received investment from two Japanese companies, Aviner & Co., Inc. and Chishima Real Estate Co., Ltd.		
Tie-Ups	Airbus	September 2023: Airbus collaborated to promote the production of SAF in the USA. The alliance would aid in the expansion of a promising technology for producing SAFs from cellulosic waste and residues.	
	Energy Vault	May 2022: Energy Vault entered into an energy storage agreement with DG Fuels to supply 1.6 gigawatt-hours (GWh) of energy storage capacity to support SAF projects anticipated to generate revenue of up to \$520 million across the three projects for Energy Vault	
	-	November 2022: DG Fuels executed an agreement for a \$4 billion-plus sale to an undisclosed industrial client for 230 million gallons of SAF.	
	Delta	August 2022: Delta partnered to broaden the sustainable fuel market, to deliver itself 385 million gallons of pure SAF, while simultaneously increasing SAF availability in underserved regions.	
	Black & Veatch	June 2023: Black & Veatch entered into a binding agreement and undertook a front-end loading (FEL-3) engineering report for DG Fuels' inaugural project in Louisiana.	
Financiers / Investors	Air France-KLM, Chishima Real Estate Co. Ltd, HydrogenPro, Aviner & co.		
Other Information	DG Fuels selected Emerson to deliver comprehensive automation and project engineering services, aiding in the transportation sector's efforts to decarbonize through the production of advanced biofuels.		

Velocys	Privately Traded		
Velocys offers patented technology that facilitates the production of drop-in, net-zero SAF, allowing for safe and efficient manufacturing on a commercial scale.			
Key Facts	Year of Establishment	2001	
	Headquarters	UK	
	SAF Production Capacity		
	SAF Production Target		
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	- In 2024, Velocys raised \$40 million (€ 37.1m) as part of a take-private deal completed on January 18. The growth capital comes from a group of climate investors, including Carbon Direct Capital, Lightrock, GenZero, and Kibo Investments. - Altalto Immingham Ltd, a wholly owned subsidiary of Velocys plc, received a grant of up to £27 million in 2022 from the UK Department for Transport's ("DfT") Advanced Fuels Fund for the Altalto Immingham SAF project.		
Tie-Ups	Toyo Engineering Corporation (Toyo)	Feb 2021: Velocys and Toyo Engineering Corporation (Toyo) commenced the development of commercial projects for producing SAF and other renewable fuels in Japan.	
	International Aviation Group (IAG)	Nov 2021: IAG signed an MoU with Velocys to buy 220,000 tonnes of SAF over ten years, representing one-third of Velocys' new Bayou Fuels project output in the US starting in 2026.	
	Bechtel	Jan 2023: Bechtel collaborated to create an EPC execution model for Velocys sustainable fuels projects. Additionally, under a distinct ongoing technical services agreement, Bechtel is also offering front-end project engineering and other technical support to aid in the advancement of the existing Velocys SAF project portfolio.	
	Southwest Airlines	Nov 2021: Southwest Airlines signed a 15-year offtake agreement with Velocys for 219 million gallons of SAF.	
Financiers / Investors	Carbon Direct Capital, Lightrock, GenZero, Kibo Investments.		
Other Information	Velocys became a part of Zero Carbon Humber (ZCH), a carbon capture, utilization, and sequestration (CCUS) hub currently being developed in northern England. Involvement in ZCH will facilitate the creation of carbon negative SAF at Velocys' proposed Altalto biorefinery.		

SkyNRG	Privately Traded		
SkyNRG is one of the global SAF leaders, actively sourcing, blending, and distributing SAF to airlines worldwide while forming partnerships to boost SAF supply and production globally.			
Key Facts	Year of Establishment	2010	
	Headquarters	Netherlands	
	SAF Production Capacity	-	
	SAF Production Target	290,000 tonnes annually (includes the upcoming three facilities – two facilities in the Netherlands and one in North America)	
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	- In 2023, Macquarie Asset Management invested up to €175 million in SkyNRG via the Macquarie GIG Energy Transition Solutions (MGETS) Fund. - In 2019, The Royal Schiphol Group invested €2 million in a SkyNRG project. The project is Europe's first dedicated SAF facility in Delfzijl, producing sustainable jet fuel, propane, and naphtha.		
Tie-Ups	KLM Royal Dutch Airlines and SHV Energy	May 2019: SkyNRG, KLM Royal Dutch Airlines, and SHV Energy collaborated for the development of Europe's first dedicated plant to produce SAF in Delfzijl, the Netherlands, with KLM under contract to purchase 75,000 tonnes of SAF annually.	
	Boeing	Jul 2021: Boeing, SkyNRG, and SkyNRG Americas partnered to increase the global availability and use of SAF. The project aims to produce around 90,000 metric tons of SAF annually, requiring an investment of \$600-800 million.	
	Shell	Nov 2019: Shell partnered on the DSL-01 production plant in Delfzijl, Netherlands, providing technical and commercial expertise, and securing the option to purchase SAF produced at the facility.	
	VistaJet	Sept 2020: VistaJet entered into a partnership with SkyNRG which extends access to SAF to all VistaJet customers globally.	
	Alaska Airlines	Apr 2021: MoU signed for a collaborative investment in SAF supply, production, and utilization.	
Financiers / Investors	Macquarie Asset Management, Royal Schiphol Group, Alaska Airlines, Boeing		
Other Information	- SkyNRG received certification to provide fuel under the CORSIA, marking it as one of the first bio jet supplier to achieve this distinction. It also empowered SkyNRG to furnish airlines with SAF that qualify for carbon reduction targets under CORSIA. - Key legislation in the EU, U.S., and UK regarding SAF is set to drive increased demand and supply. By 2050, potential SAF capacity could reach 120 Mt (42 Bgal) in Europe and the U.S., offering over \$600 billion in ESG investment opportunities.		

Alder Renewables	Privately Traded		
Alder Fuels, now known as Alder Renewables, is an emerging clean technology leader, pioneering advanced sustainable aviation fuel (SAF) production from forest and crop waste.			
Key Facts	Year of Establishment	2021	
	Headquarters	Boulder, Colorado	
	SAF Production Capacity	3 million gallons per year	
	SAF Production Target	-	
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	- In September 2022, Directional Aviation unveiled plans to invest in Alder fuels to analyse the production of SAF and industry adoption of low-carbon jet fuel. - In September 2021, United and Honeywell jointly invested in Alder Fuels to produce SAF from crop and forest waste using Alder technologies and the Honeywell Ecofining process.		
Tie-Ups	Rolls-Royce	Oct 2022: Signed a strategic MoU to test SAF on flights to enhance commercial scalability.	
	Enviva	Sept 2022: Collaborated for a long-term supply of 750,000 metric tonnes of woody biomass from Enviva from 2024 onwards.	
	NREL	Aug 2022: Partnered for scaling advanced SAF technology for commercial use.	
	Boeing	Jul 2022: Partnered to expand production of SAF worldwide and expedite aviation net-zero transition.	
Financiers / Investors	- In early 2023, the United Nations DOE awarded a Phase 1 Grant Award of \$2 million to Alder Fuels to support its first demonstration-scale plant in the Southeast US. - In June 2022, Arefuel Corporation announced investing in Alder Fuels to offtake 1 billion gallons of SAF over 20 years. - In 2021, United Airlines agreed to purchase 1.5 billion gallons of SAF over a 20-year.		
Other Information	In March 2023, Alder Renewables provided a high-tech analysis of a new and 100% sustainable SAF Alder SAF100 for replacing petroleum-based jet fuel.		

Montana Renewables	Privately Traded		
Montana Renewables is one of the leading producers of SAF in North America and specializes in alternative fuels, such as renewable diesel and SAF, utilizing waste materials as feedstocks.			
Key Facts	Year of Establishment	2021	
	Headquarters	Great Falls, Montana	
	SAF Production Capacity	30 million gallons annually	
	SAF Production Target	230 million gallons annually by 2024	
	Revenue	-	
	EBITDA	-	
Current and Planned SAF Investments	In February 2024, Calumet, Montana Renewables' 100% equity holder, announced MaxSAF investment plans for expanding its SAF production plant capacity to 15,000 barrels per day once the US DOE approves its loan application.		
Tie-Ups	Shell Aviation	May 2023 Signed a multi-year SAF offtake agreement to deliver for Shell's supply agreements with Delta Air Lines, Alaska Airlines, and JetBlue at Los Angeles International Airport.	
Financiers / Investors	- In 2022, Warburg Pincus agreed to invest \$250 million in Montana Renewables in the form of a participating preferred equity security. - In 2021, Calumet invested \$145 million, which was converted to common equity in August 2022. - Stonebriar Commercial Finance invested \$400 million between 2021 and 2022 through sale and leaseback contracts. - Other Financiers and loan institutions include OAKTREE, Wells Fargo, Macquarie, and the US DOE.		
Other Information	In August 2023, Montana Renewables secured ISCC CORSIA Certification for SAF from the International Sustainability and Carbon Certification (ISCC) developed by the ICAO, a next step towards increasing its SAF capacity.		

Nacero	Privately Traded		
Nacero Inc is a clean fuels development platform that will produce Biomethanol, Sustainable Aviation Fuel ("SAF"), Low Carbon Aviation Fuel ("LCAF") and light fuels.			
Key Facts	Year of Establishment	2015	
	Headquarters	Houston, Texas, USA	
	SAF Production Capacity		
	SAF Production Target	1st project: A biomethanol facility with up to 5,192.0 MT per day of biomethanol production 2nd Project: SAF development project with Up to 1,462.2 MT per day of SAF (~570.9 MT), LCAF (827.1 MT) and Naphtha (64.2 MT) production	
	Revenue	-	
	EBITDA	By Assets: Biomethanol Facility – Gulf Coast, Texas: \$242.9m (year 2 EBITDA ⁽¹⁾) SAF Development – West Texas: \$597.0m (year 2 EBITDA ⁽²⁾)	
Current and Planned SAF Investments	- A biomethanol facility that is at an advanced stage of development, located in the Gulf Coast, Texas - A SAF facility that is at an early stage of development - Nacero targets a ~\$2.3bn of project-level equity and debt capital raise, to be closed by Q4-25		
Tie-Ups	Topsoe	Nacero has a Memorandum of Understanding ("MoU") in place with Topsoe to utilise the latter's SynCOR Methanol and MTJet technologies, process license, catalyst and propriety equipments in Nacero's commercial-scale facilities	
	Methanol Institute	Nacero is a member of the Methanol Institute. Founded in 1989, the Methanol Institute serves as the global trade association for the methanol industry representing the world's leading methanol producers, distributors and technology companies	
	ASTM International	Mar 2023 TOPSOE, and Nacero are currently working with ASTM to qualify the methanol to jet pathway	
Financiers / Investors	Global Cleantech Capital, DRW, The University of Pittsburgh		
Other Information	- In May 2023, Nacero TX (a subsidiary of Nacero Inc.) was invited by the U.S. Department of Energy (DOE) to submit a Part II application for a loan guarantee through the Loan Programs Office's (LPO) Title XVII Innovative Clean Energy Loan Program for 75% of the capital needed for its multi-billion-dollar SAF facility in Texas. - In September 2021, Nacero announced the launch of Nacero NEON, the Company's renewable natural gas (RNG) acquisition platform.		

Note: 1. Year 2 refers to the second year of operations, as per the Business Plan

2. Year 2 refers to the second year of operations, as per the Business Plan, subject to Topsoe yield certification

Abbreviations

List of Abbreviations

ADB	Asian Development Bank	GDP	Gross Domestic Product
ADNOC	Abu Dhabi National Oil Company	GEF	Global Environmental Facility
ANAC	National Civil Aviation Agency	GFDK	Green Fuels for Denmark
ANP	National Agency of Petroleum, Natural Gas and Biofuels	GFT	Gasification Fischer-Tropsch
ARERA	Regulatory Authority for Energy, Networks and the Environment	GHG	Greenhouse Gas
ASCENT	Saf Testing and Analysis Aviation Sustainability Center	GP	General Partner
ATA	Air Transport Action Group	GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
ATJ	Alcohol-to-Jet	GWh	Gigawatt-Hours
BCAP	Biomass Crop Assistance Programme	HAPSS	Hydrogen Aircraft Powertrain and Storage System
BETO	Bioenergy Technologies Office	HEFA	Hydroprocessed Esters and Fatty Acids
BNEF	Bloomberg New Energy Finance	IATA	International Air Transport Association
BOEPD	Barrels of Oil Equivalent Per Day	ICAO	International Civil Aviation Organization
BP	Beyond Petroleum (Formerly British Petroleum)	IRA	Inflation Reduction Act
bpd	Barrels Per Day	IRS	Internal Revenue Service
CAA	Civil Aviation Authority	ISCC	International Sustainability and Carbon Certification
CAAC	Civil Aviation Administration of China	JAC	Junta De Aeronáutica Civil
CAAFI	Commercial Aviation Alternative Fuels Initiative	LCFA	Low Carbon Fuels Act
CAPEX	Capital Expenditure	LCFS	Low Carbon Fuel Standard
CARB	California Air Resources Board	LLC	Limited Liability Company
CCUS	Carbon Capture, Utilization, and Storage	LLLP	Limited Liability Limited Partnership
CEF	Connecting Europe Facility	MASE	Ministry of Environment and Energy Security
CFA	Chartered Financial Analyst	MaxSAF	Maximum Sustainable Aviation Fuel
CFD	Contract-for-Difference	MDB	Multilateral Development Bank
CFR	Clean Fuel Regulations	MGPY	Million Gallons Per Year
CFS	Clean Fuel Standard	MIT	Ministry of Infrastructure and Transport
CIB	Canada Infrastructure Bank	MOU	Memorandum of Understanding
CLEEN	Continuous Lower Energy, Emissions, and Noise	MSA	Master Services Agreement
CLEW	Clean Energy Wire	MT	Metric Ton
CO ₂	Carbon Dioxide	MTJ	Methanol-to-Jet
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation	NREL	National Renewable Energy Laboratory
DFT	Department for Transport	CBA	CleanBridge Advisors
DGAC	Direction Générale De L'Aviation Civile	PE	Private Equity
DOD	Department of Defense	PET	Polyethylene Terephthalate
DOE	Department of Energy	PLF	Property Linked Finance
DOT	Department of Transportation	PPP	Public-Private Partnership
EAC	Environmental Audit Committee	PtL	Power-to-Liquid
EASA	European Union Aviation Safety Agency	PTX	Power-To-X
EBACE	European Business Aviation Convention & Exhibition	R&D	Research and Development
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization	REAP	Rural Energy for America Programme
EBRD	European Bank for Reconstruction and Development	RED II	Renewable Energy Directive
EEA	European Economic Area	RED-III	Renewable Energy Directive Iii
EIB	European Investment Bank	RFNBO	Renewable Fuels of Non-Biological Origin
EJ	Exajoule	RFNBOs	Renewable Fuels of Non-Biological Origin
ENAC	Italian Civil Aviation Authority	RFS	Renewable Fuel Standard
EPA	Environmental Protection Agency	RTFO	Renewable Transport Fuel Obligation
EPC	Engineering, Procurement, and Construction	RTHA	Rotterdam The Hague Airport
EPE	Energy Research Office	SABA	Sustainable Aviation Buyers Alliance
eSAF	Synthetic Sustainable Aviation Fuel	SAF	Sustainable Aviation Fuel
ESG	Environmental, Social, and Governance	SARV	Southwest Airlines Renewable Ventures
ETJ	Ethanol-to-Jet	SESAR	Single European Sky Atm Research
ETS	Emission Trading Scheme	SGC	Sustainable Aviation Fuel Grand Challenge
ETS	Emission Trading System	SIPC	Securities Investor Protection Corporation
EUDP	Energy Technology Development and Demonstration Program	TIRUERT	Taxe Incitative Relative À L'Utilisation D'Énergie Renouvelable Dans Les Transports
FAA	Federal Aviation Administration	UAV	United Airlines Ventures
FAST	Fuelling Aviation'S Sustainable Transition	UCO	Used Cooking Oil
FBO	Fixed-Base Operator	USD	United States Dollar
FEL	Front-End Loading	USDA	United States Department of Agriculture
FINRA	Financial Industry Regulatory Authority	VC	Venture Capital
FT	Fischer Tropsch	ZCH	Zero Carbon Humber
FY	Fiscal Year		



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