Charting a greener course:
The role of Sustainable Aviation Fuels in the net-zero transition

Climate Catalyst

With input from

PRI Principles for Responsible Investment

About Climate Catalyst

Climate Catalyst works to compel our political leaders to take action at speed and scale. We do this by galvanising the collective power of businesses, investors and civil society to influence and accelerate policy change. Working behind the scenes we bring together new and diverse stakeholders to identify opportunities with the greatest potential for collaboration, share ideas and learnings and deliver creative campaigns that build power and secure decisive action by governments that reduce greenhouse gas emissions. Our vision is for a just, prosperous world in which global temperature rise is limited to 1.5°C.

Find out more at **www.climatecatalyst.org**

About PRI

The UN-supported Principles for Responsible Investment (PRI) works with its international network of signatories to put the six Principles for Responsible Investment into practice. Its goals are to understand the investment implications of environmental, social and governance (ESG) issues and to support signatories in integrating these issues into investment and ownership decisions. The PRI acts in the long-term interests of its signatories, of the financial markets and economies in which they operate and ultimately of the environment and society as a whole.

The six Principles for Responsible Investment are a voluntary and aspirational set of investment principles that offer a menu of possible actions for incorporating ESG issues into investment practice. The Principles were developed by investors, for investors. In implementing them, signatories contribute to developing a more sustainable global financial system.

More information: **www.unpri.org**

Acknowledgements

Climate Catalyst and PRI would like to thank:
Charlotte Dicker,
Oldfield Partners Llp,
Joe Horrocks-Taylor,
Columbia Threadneedle,
Tessa Younger,
CCLA Investment Management,
other PRI signatories
and Laetitia Pirson, Ceres,
for reviewing this resource for accuracy and relevance to institutional investors.

Climate Catalyst is a sponsored project of Rockefeller Philanthropy Advisors

Table of contents

Charting a greener course:
The role of Sustainable Aviation Fuels in the net-zero transition

- The use of sustainable aviation fuels — or SAFs — is one of the leading pathways to begin lowering the environmental impact of aviation. Investors can consider supporting SAFs that are truly net-zero aligned, alongside efficiency measures for fuel[1] and aircraft[2] and wider fuel policies.
- Discerning the sustainability and scalability of different types of SAF, which vary widely depending on their feedstocks and production pathway, is crucial for corporate engagement and company disclosures. Fuel alternatives such as e-fuels made from green hydrogen are currently the highest integrity option in terms of life cycle sustainability.
- Investors could play a critical role by contributing to emerging policy and regulatory developments related to addressing aviation's climate impact, while advocating for just transition, environmental and social considerations within these policy measures.

The aviation sector is at a critical juncture on a pathway to reaching net-zero emissions and opinion is divided on how the industry might achieve it. Around 2.4 per cent of global CO_2 emissions come from aviation; when non-CO_2 effects are considered, the sector accounts for up to 5 per cent of global warming[3]. Scientific understanding of the climate impact of non-CO_2 emissions is growing[4], but current consensus suggests their impacts 'could represent around 66 per cent of the effective radiative forcing on the climate'[5]. When the additional impact of contrails (the water vapour trails from aircraft exhausts) is taken into account, aviation emissions are warming the climate at approximately three times the rate of that associated with aviation CO_2 emissions alone[6]. To tackle the climate impact of aviation, both CO_2 and non-CO_2 emissions will therefore need to be reduced. Without action, aviation emissions could rise to 22 per cent of global emissions by 2050[7] and consume a quarter of the 1.5°C carbon budget by 2050[8].

The aviation industry trade association, the International Air Transport Association (IATA), asserts that sustainable aviation fuel (SAF) would achieve 65 per cent of carbon emissions abatement (not accounting for non-CO_2), with new propulsion technologies such as hydrogen delivering 13 per cent, carbon capture and storage and offsets making up 11 and eight per cent respectively, and the remaining three per cent coming from efficiency improvements[9]. Other actors including the European Commission[10] and Airbus[11] see the growing potential of hydrogen- and electric-powered flight.

Member airlines of the IATA committed in 2021 to achieving net-zero carbon emissions from their operations by 2050. Whether the aviation sector can reach its net-zero commitment[12] will depend on a range of factors (Figure 1), including the deployment of demand reduction and management measures alongside operational efficiency improvements, as well as the uptake of alternative fuels and the acceleration of zero-emission aircraft — those which produce little to no emissions through use of hydrogen and battery-electric technologies for varying market segments[13].

While the adoption and further development of these technologies are pursued, there are immediate actions the industry could consider in order to reduce its climate impact. Investors can play a crucial role in contributing to and influencing these actions. Examples include:

- Investing in new solutions for the industry, such as early stage capital for low-carbon e-fuel production sites,
- Funding R&D to establish the viability of existing and emerging solutions, including energy and operational efficiency improvements, and technologies such as hydrogen fuel-cells and electric propulsion, and;
- Engaging their portfolio companies, such as airlines, aerospace companies and oil and gas refiners, to ensure the appropriate practices and actions are being taken to truly transition the industry to a 1.5°C pathway.

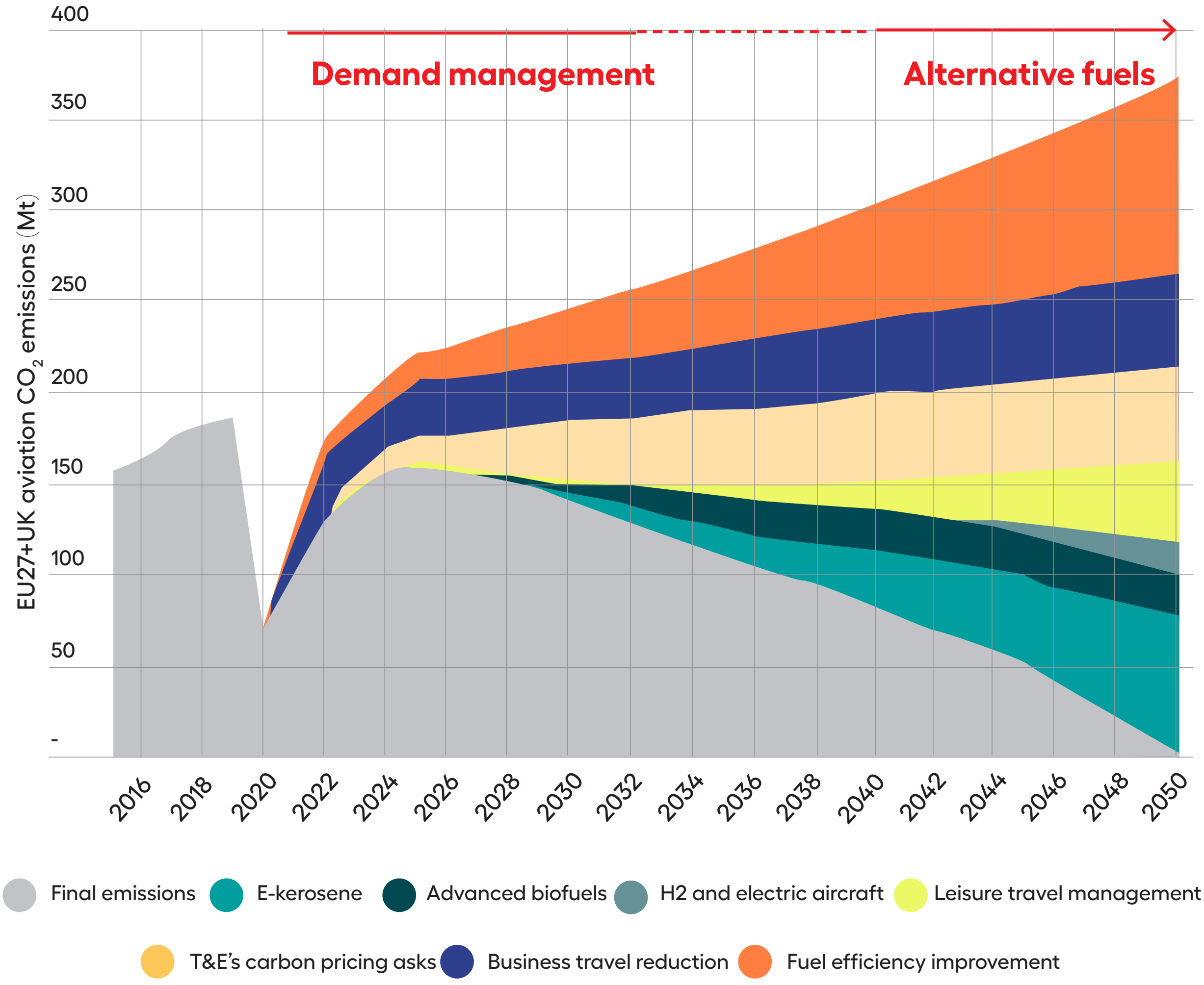

Figure 1: Forecast by Transport & Environment of the contribution of various measures to the decarbonisation of aviation in EU27+UK up to 2050. Source: Transport & Environment, 2022

Types of sustainable aviation fuels

Sustainable aviation fuels — or SAFs as they are known today — are alternative fuels that can be blended with kerosene to potentially reduce the life cycle emissions of jet fuel. Broadly speaking, SAFs can be categorised into one of two groups, which are fuels of a biological origin (or biofuels), and fuels of a non-biological origin (commonly referred to as e-fuels, synthetic or power-to-liquid fuels). Within those categories, there are substantially differing degrees of sustainability. Importantly, all SAFs emit a similar amount of CO2 as kerosene at point of use, with the term 'sustainable' primarily referring to the feedstocks and production pathways of these alternative fuels. As such, the catch-all term of 'sustainable aviation fuel' does not effectively represent the variability between each fuel pathway (represented in Figure 2). Nevertheless, the term 'SAF' has become widely adopted and will be referred to throughout this explainer, alongside the distinct sub-categories of 'biofuels' and 'e-fuels'.

Some SAFs can start to lower the environmental impact of aviation in the immediate term as they are compatible with the current aircraft fleet, infrastructure and workforce operations as a 'drop-in' solution*. Commercial aircrafts spend 30-plus years in operational service. Estimates show that 'the worldwide commercial aviation fleet will expand 33 per cent to over 36,000 aircraft by 2033'[14]. SAFs offer a way to avoid stranding these locked-in assets before zero-emission aircraft are available at scale.

There is growing demand for these fuels from airlines; however, SAF supply is low, accounting for 0.2 per cent of global aviation fuel use[15] with an increasing number of global initiatives and policies aimed at addressing this shortfall. Yet, it is evident that not all SAFs are created equal, with some being called 'a cure worse than the disease' due to their life cycle impacts[16]. Their production can vary drastically, ranging from crop-derived feedstocks to those that use recaptured CO_2 and green hydrogen, as shown in Figure 2.

SAFs can be produced from a wide range of feedstocks using 5 key processing pathways

Mapping of feedstocks to pathways

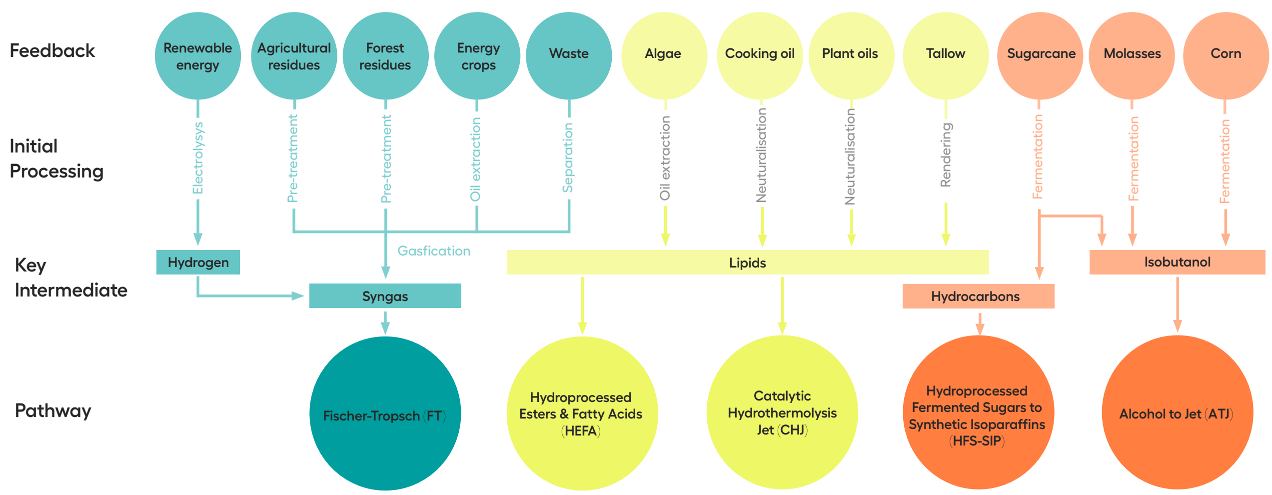

Figure 2: Mapping of different feedstock and processing pathways for SAFs. Source: Roland Berger, 2020

*A drop-in solution is one that is compatible with existing infrastructure and can be mixed with conventional jet fuel while resulting in a similar performance. Currently, SAF blending standards limit the proportion of SAF that can be mixed with jet fuel depending on its production pathway

The fuel must perform similarly to the conventional kerosene with which it is blended. This is because international standards currently permit up to a maximum certified blend of 50 per cent for several SAF pathways (as shown in Table 1). In late 2023, the UK's Civil Aviation Authority granted a permit to Virgin Atlantic to fly on 100 per cent SAF between the UK and US, which took place without incident[17]. Safety is paramount within the aviation industry, but there are still regulatory hurdles that need to be overcome for SAF to be used in higher percentage blends, and eventually at 100 per cent. This is also the case for feedstocks such as hydrogen — which is an essential component of some SAFs and zero-emission flight solutions — with work underway to ensure standards are in place that support its use[18].

TABLE 1: MAXIMUM CERTIFIED SAF BLENDS BY CONVERSION PATHWAY AS PER INTERNATIONAL STANDARDS. ADAPTED FROM SOURCE: INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) AND FUTURE BRIDGE ANALYSIS, 2023

Conversion pathway	Certification year	Maximum blend in kerosene (per cent)	Feedstock
Fischer-Tropsch synthesised paraffinic kerosene (FT-SPK)	2009	50	Organic wastes, municipal solid waste (MSW), biogas
Hydroprocessed esters and fatty acids (HEFA)	2011	50	Vegetable oils, used cooking oil
Synthesised iso-paraffins (SIP)	2014	10	Sugarcane, sugar beet
Fischer-Tropsch synthesised kerosene with aromatics (FT-SKA)	2015	50	Organic wastes, MSW, biogas
Alcohol-to-jet (ATJ)	2016	50	Sugarcane, sugar beet, sawdust, cellulosic waste
Catalytic hydrothermolysis (CHJ)	2020	50	Waste oils or energy oils
Hydrocarbon HEFA (HC-HEFA)	2020	10	Oils produced from algae

Environmental standards and eligibility criteria for these fuels also vary from country to country which can pose additional challenges for a sector that is international by nature. Life cycle assessments (LCAs) are the most common methodology for analysing the emission savings from different types of SAF. At the international level, ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) sets out a methodology for obtaining the life cycle emissions value of a specific SAF in order to claim emission reductions via the scheme (outlined further in the Emissions from SAFs section of this explainer). However, individual countries and regions are pursuing their own rules and sustainability criteria for assessing and approving these fuels, which has led to tensions. One example was in early 2024, when a legal challenge was mounted by US biofuel groups against the sustainability criteria within the EU's Renewable Energy Directive due to its implications for the exclusion of 'food and feed crops' feedstock in meeting the ReFuelEU aviation initiative[19].

Some of the variabilities in international regulatory frameworks for the categorisation of SAF are summarised in Table 2. Climate Catalyst has also produced detailed policy summaries of the current regulatory landscape for SAF in the UK, EU and US, including subsidies, mandates and standards, alongside possible future government interventions.

TABLE 2: EXAMPLES OF THE VARIABILITY IN SAF CATEGORISATION WITHIN INTERNATIONAL POLICIES & INITIATIVES

Geography	Framework	Criteria
International	CORSIA	To be eligible for CORSIA, SAF must achieve net GHG emissions reductions of at least 10 per cent[20] compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis, which analyses 'core life cycle assessment' and 'induced land-use change' emissions[21]
US	• Inflation Reduction Act • Renewable Fuels Standard • SAF-GREET Model	To be eligible, SAF must achieve at least a 50 per cent improvement in GHG emissions performance on a life cycle basis as compared with conventional jet fuel[22] in line with the GREET model[23]
EU	• ReFuelEU SAF Mandate • Renewable Energy Directive	To be eligible, SAF can be made either from biofuels (except those produced from food and feed crops), recycled carbon fuels or synthetic fuels. In order to qualify biofuels as renewable energy sources, fuels have to achieve a 65 per cent greater reduction in emissions against a fossil fuel baseline of 94 g CO2e/MJ[24]
UK	• Renewable Transport Fuel Obligation • SAF Mandate	To be eligible, SAF must be made from biofuels derived from wastes or residues, recycled carbon fuels, or power-to-liquids using low carbon electricity. SAF has to achieve a minimum GHG emissions savings threshold of 40 per cent against a fossil fuel comparator of 89 gCO2e/MJ[25]
Japan	SAF Mandate	To be eligible, SAF pathways of biomass gasification with Fischer-Tropsch synthesis, alcohol-to-jet, and algae-based fuels are prioritised[26]

Biofuels

Biofuels are SAFs of biogenic origin and can be broadly grouped by their primary feedstocks: crops or waste. BioSAFs are the only widely available alternative to conventional jet fuel today, with hydroprocessed esters and fatty acids (HEFA)-based biofuels accounting for over 95 per cent of all SAF flights to date[27]. Although they currently offer the cheapest SAF pathway, these fuels cannot be scaled up sustainably due to feedstock limitations and face competing needs from other sectors such as road transport and energy production, with many estimating they will only be sufficient to supply up to 50 per cent of SAF demand[28,29].

- **Crop-based biofuels:** These biofuels are made from food crops such as corn or sugarcane and intermediate or cover crops like miscanthus and oilseed. They are the type of SAF with the highest environmental impacts, as they use agricultural land or can displace agriculture to new lands often leading to the additional conversion of carbon-rich ecosystems for biomass production, thus resulting in further emissions. In fact, there is strong evidence that some crop-based biofuels actually increase net emissions[30]. Food crop-based biofuels also create wider impacts in terms of food security, biodiversity and water use[31]. In recognition of the significant environmental and social downsides of these types of fuels, the EU's SAF mandate, the 'ReFuelEU Aviation Initiative', excludes them due to their incompatibility with the Renewable Energy Directive (however cover crops grown on 'severely degraded land' are permitted for SAF). The US regulatory landscape is much more favourable towards this category of biofuels[32]. Notably, ethanol-based biofuels (those made from various plant materials such as corn[33]) are eligible for SAF tax credits under the Inflation Reduction Act due to the usage of the GREET model for calculating GHG emissions from fuel production and use[34,35].

- **Waste-based biofuels:** These bioSAFs are produced from organic wastes; fuels made from feedstocks such as used cooking oils, animal fats, forestry residues, and municipal waste are included in this group. Waste-based fuels are less environmentally harmful than crop-based ones as given their feedstocks are waste materials, they are unlikely to drive land use change and can avoid landfill emissions while supporting circular economy efforts. However, their supply is limited and should be reserved for applications in which there are fewer alternatives such as heavy-road transport and aviation in the short term, or in geographies where there is less access to cleaner feedstocks such as renewable energy and hydrogen as e-fuel supply grows in the mid to long term. Additionally, the fraud risk associated with these biofuels is high due to their supply chains and issues such as mislabelling, alongside possible links to indirect land use change[36]. These fuels have a role to play in addressing aviation emissions in the short term, however because of their limited supply and with increased action on reducing waste, their feedstocks are less scalable than e-fuels.

E-fuels

E-fuels, also known as 'electrofuels', 'synthetic fuels' or 'power-to-liquids' (PtL) are fuels made using electricity. 'E-kerosene' is the e-fuel counterpart to conventional kerosene jet fuel and is made by combining hydrogen (H_2) with CO_2[37]. Similarly to bioSAF, aviation is not the only sector in demand of these fuels, as shown in Figure 4.

E-fuels are often viewed as a distant solution due to the absence of fuel facilities currently built or in operation (as of May 2024). If airlines and energy players were to undertake offtake agreements and collaborate with e-fuel producers, it would create a more appealing investment opportunity for financiers who would see this type of fuel as a realistic, viable pathway. The role of airlines specifically is discussed later in this explainer. In addition, integration of this fuel is inevitable, as European mandates require sub-targets for e-fuel supply in varying percentages from 2030 onwards. With it taking five to 10 years on average for a SAF facility to be built and producing fuel[38], action is needed now to ensure supply is available in line with EU and UK policies.

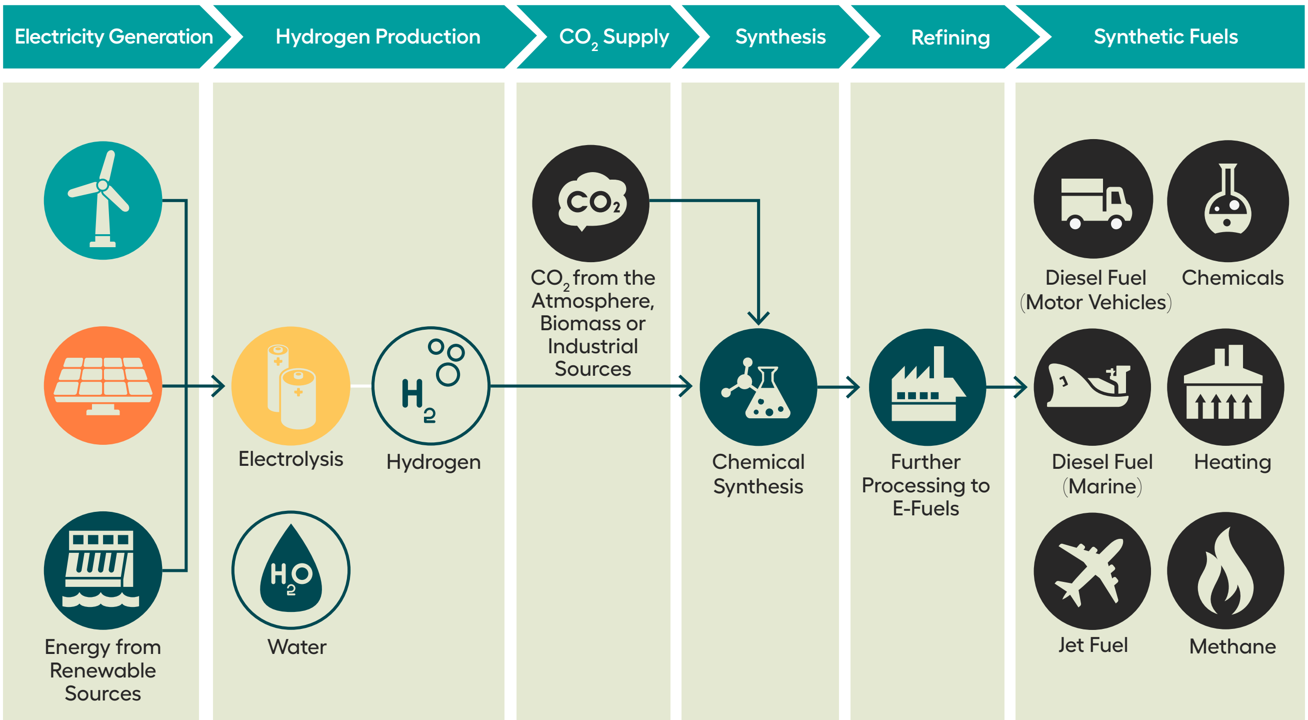

Figure 4: Production pathway and intermediary process for e-fuels, including potential end uses. Source: Haltermann Carless, 2022

Like bioSAF, e-fuels are also drop-in ready but are considered the more sustainable type of SAF[39] provided certain high integrity feedstocks are used in their production:

- **Hydrogen produced with renewable electricity:** The process and energy source used for hydrogen production determines its environmental impact. Hydrogen produced via electrolysis and powered by renewable electricity - so-called 'green hydrogen' - can be close to CO_2-neutral[40], but crucially, the renewable electricity must be 'additional' rather than be displaced from existing renewable energy requirements[41]. The ICCT has outlined the displacement risks of various SAF feedstocks including renewable energy, which poses a medium risk to the electricity sector if not appropriately managed[42]. The energy usage is also intensive. In a scenario where 40 per cent of aircraft run on liquid hydrogen and 60 per cent on synthetic fuel by 2050, estimates suggest 20 to 30 times the current renewable energy production of Europe would be needed[43]. In part this is due to renewable deployment in the EU slowing in recent years[44], but the pace has started to ramp up.

- **Responsibly-sourced carbon dioxide:** Ideally, the same amount of CO_2 produced during use of SAF should be re-captured for their production, or stored permanently. Direct air capture (DAC) is viewed as a preferable source for CO_2 in the long term, as alternative sources — biogenic and industrial point-source capture — risk incentivising emission-intensive industries. This is because some industries may use biogenic carbon capture to offset their emissions rather than reduce their own footprint, or continue to invest in fossil-based business-as-usual processes instead of transitioning to cleaner technologies thus allowing for the continued transfer of geologic carbon into the atmosphere. However, DAC itself comes with a significant energy demand and risks displacing renewable energy from other critical uses if not additional. It is also in high demand as a carbon removal and storage solution, not just for the capture of CO_2 as a feedstock. Point source and biogenic capture are seen as bridging technologies[45] due to the infancy of DAC and allow for emission abatement in the short term, alongside the ramp-up of carbon removal technologies more broadly. As such, the source of CO_2 for the production of e-fuels should be considered on a case-by-case basis in terms of life cycle emissions, sustainability and the just transition.

By the nature of their feedstocks, e-fuels are much easier to scale and are therefore considered a more sustainable sub-category of SAF than biofuels. If biofuels were exclusively used to meet aviation demand, it would require 4 times the current global biofuel production by 2030[46]. One of the main challenges facing e-fuels, however, is that they are currently much more expensive than conventional fuel and even their bioSAF counterparts. Production costs for e-fuels are currently on average around 3.2 to five times higher than jet fuel. Biofuels, meanwhile, vary quite substantially in cost compared to jet fuel (ranging from ~1.4 times for waste-based fuels to between 2.4 and seven times for some crop-based bioSAF[47]), yet are more commercially available[48].

This is changing as the price of renewable energy and infrastructure like electrolysers for hydrogen production decreases, but will remain high while these fuels struggle to be produced in marketable quantities due to a lack of plants reaching final investment decision[49].

Emissions from SAFs

As previously mentioned, both CO_2 and non-CO_2 emissions need to reduced to address the climate impact of aviation. SAF does not necessarily reduce overall emissions, and still produces CO_2 at point of use. In order for its climate impact to be understood, SAF needs to be assessed through a life cycle analysis and alignment on its sustainability criteria, such as the ICAO life cycle assessment values, based on Core Life Cycle Assessment emissions and Induced Land Use Change emissions.

The GHG savings achieved from the use of SAF depends on the production pathway and feedstock employed, which can vary vastly between a 27 and 98 per cent reduction[50]. As we know, CO_2 is not the only type of pollution aviation produces, and studies on the use of SAF blended into conventional jet fuel have shown that particulate matter emissions at cruising altitudes are reduced by 50 to 97 per cent, which can have benefits for air quality[51]. Some SAFs can also reduce other non-CO_2 emissions like nitrous oxides (NOx) and sulphur dioxide (SO2)[52] and efforts are still ongoing to assess their impact on contrails, which are known to contribute to the climate impact of aviation[53]. When looking to the future of aviation and zero emission solutions such as hydrogen-fuelled aircraft, the World Economic Forum has asserted that 'hydrogen combustion aircraft would eliminate CO_2 and soot emissions in-flight'; however, these aircraft produce more water vapour — and thus contrails — than SAFs[54].

The ICAO has published a methodology for understanding the life cycle GHG emission factors of SAFs, which establishes over 80 values, representing 22 different feedstocks from across six conversion technologies[55]. There are several other standards and guidelines that have been developed to assist SAF suppliers, airlines, corporate travellers, private aircraft owners and freight operators with emissions accounting, reporting and certification, expertly summarised in the World Economic Forum's Clean Skies for Tomorrow White Paper from 2022. The main considerations for each type of SAF are summarised in Table 3.

TABLE 3: SUMMARY OF THE DIFFERENCES BETWEEN THE MAIN TYPES OF SAFS

	Crop-based biofuels	Waste-based biofuels	E-fuels
Feedstocks	Crops such as corn, sugarcane or cover crops	Organic wastes, such as used cooking oils, animal fats, forestry residues, and municipal waste	Hydrogen (H_2), carbon dioxide (CO_2) and electricity (preferably renewable energy)
Supply and scalability	Variable but mostly limited due to environmental criteria and competition with food system	Very limited, and should be reserved for applications for which there are fewer alternatives such as heavy road transport	Feedstocks and production is much easier to scale due to renewable inputs. Renewable energy (RE) should be additional to avoid displacement
Emission reduction potential*	Dependent on feedstock and production pathway, with average of ~55 per cent CO_2 decrease compared to conventional fuel	Highly dependent on feedstock and production pathway, can range between 27 per cent (HEFA) to 77 per cent (most other waste pathways such as catalytic hydrothermolysis) CO_2 decrease compared to conventional fuel	Highly dependent on feedstock and production pathway, but assuming low-emission electricity and zero life cycle emissions from carbon feedstock, can range between 75 and 98 per cent CO_2 decrease compared to conventional fuel. Grid electricity 'can lead to very high emissions'.
Potential adverse environmental and social impacts	Can displace agriculture to new lands. Potential for wider impacts on food security, land rights, soil degradation, biodiversity loss and water scarcity.	Less likely to drive land use change and can avoid landfill emissions while supporting circular economy efforts. Faces resource competition and can produce other pollutants	Hydrogen production requires water and RE; all critical, scarce resources. Sustainability of CO_2 streams can vary and risks incentivising business as usual in emission intensive industries
Cost**	Can range between 2.4 and seven times the cost of conventional fuel depending on feedstock and pathway	On average ~1.4 times the cost of conventional of jet fuel	Estimates range between 3.2 and five times the cost of conventional fuel, but is expected to come down with falling costs of feedstocks
Policy coverage	Permitted under fewer policies, with stringent stipulations around feedstocks and life cycle emission reductions	Permitted under most existing policies including SAF mandates, with varying stipulations around feedstocks and resultant emissions reductions	Permitted under most existing SAF mandates. EU and UK have e-fuel sub-mandates, elsewhere facing some resistance e.g. at US state-level

Emission reduction potential (using studies that included cradle-to-grave analyses and less inclusive LCA scopes to produce averages)* and cost figures** are based on analysis by Watson et al. 2024 and the IEA, 2023

Success for higher-integrity, lower life cycle emission, scalable SAFs like e-fuels will depend on a supportive policy framework alongside strong partnerships between e-fuel producers, offtakers, traders and importantly, investors. One such example from Infinium's 'Project Roadrunner' e-fuel facility is detailed in a case study below.

Case Study:

In November 2023, Breakthrough Energy Catalyst, a clean tech investment platform, announced a $75 million project equity investment commitment to e-fuel maker Infinium's Project Roadrunner. As an early actor, the pioneering deal helps to accelerate the crucial production of fossil-free fuels for the aviation industry.

Project Roadrunner will convert waste CO2 from industrial capture and renewable power into SAF and other low-carbon fuels. Based in West Texas, the first-of-a-kind commercial-scale Power-to-Liquids (PtL) e-fuels facility is expected to be the largest PtL e-fuels project of its kind in North America once operational in 2026.

Infinium's existing assets previously operated as a commercial gas-to-liquids (GtL) facility, but the plant will now be updated to run on waste CO2 and green hydrogen, using additional renewable power assets that are being built specifically for the project.

The deal also enabled a firm offtake agreement between American Airlines and Infinium in tandem, acting as a critical enabler for further investment and illustrating a strong demand for e-fuels by airlines. This is one of many examples of willingness for offtake agreements in major airlines and a promising signal from the broader industry.

To support this, Citi and American Airlines have separately agreed to transfer the associated emission reductions to Citi, to support the scaling of e-fuels and help reduce a portion of Citi's Scope 3 emissions from employee travel. This book and claim approach enables corporate consumers to buy SAF certificates (called SAFc) that represent the certified life cycle emissions reductions from cleanly-fueled trips and then use them in corporate emissions reporting, with an auditable and credible trail of ownership.

The role of airlines

Along with increasing benchmarks and mandates in multiple jurisdictions to transition fuel supply for aviation, we have seen numerous airlines announce increased usage of SAFs, ranging between five to 30 per cent, which can be viewed in the ICAO Offtake Tracker. Notably, most of these agreements to date have been labelled as SAFs, though they are technically biofuel offtake agreements using various biogenic feedstocks, as outlined previously.

At least 43 airlines have already committed to use some 16.25 billion litres of SAF in 2030[56]. Specifying commitments to various types of fuels across the sector is critical to accurately capture the predicted growth of these alternative fuel markets, and to reveal potential biases towards one fuel pathway over another at the cost of environmental and equity integrity.

One way in which airlines can support the early scale up of high integrity SAF supply such as e-fuels by using floating market indexed pricing mechanisms[57] and the 'book-and-claim' system to support voluntary uplifts. Book-and-claim facilitates the purchasing of SAF by decoupling the physical fuel location and the environmental benefit, to facilitate and promote more efficient use of SAF volumes and their GHG emission reductions. Airlines can also enter into offtake agreements to enable projects to raise equity and access debt funding, so developers can quickly scale. Memorandum of Understandings (MoUs) are another avenue and indications of interest, though they are less valuable for developers.

A number of alliances are currently in place to support this, including:

- The Sustainable Aviation Buyers Alliance (SABA)
- The Eco-Skies Alliance
- The International Air Transport Association (IATA)
- The oneworld Alliance, consisting of airlines such as American Airlines, British Airways, Japan Airlines and Qatar Airways
- The Aviation Alliance Fit for 55 which includes several European airlines and airports
- The International Airlines Group (IAG), including several airline and cargo operators

In order for these alliances to be effective however, the industry will need to work towards a pro-competitive standardised system, which provides a robust set of principles to prevent double-counting, and accelerates net-zero aviation, paving the way for a dynamic, competitive, innovation-driven and more sustainable aviation market.

International fuel initiatives

Due to the global nature of air travel, several international initiatives have been advocating for a harmonised regulatory framework. These initiatives can spark action on SAF, and Table 4 outlines some of those that sit under the ICAO — the UN agency for international civil aviation — and their purpose. Furthermore, globally there are many policies targeting SAF supply and demand that are outlined in ICAO's Guidance on Potential Policies and Coordinated Approaches for the Development of Sustainable Aviation Fuels.

TABLE 4: ICAO SUSTAINABLE AVIATION FUEL INITIATIVES

Activity	Purpose
Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)	A global market-based measure established to address carbon emissions from international aviation. It aims to achieve carbon-neutral growth by requiring airlines to offset their emissions through the purchase of carbon credits. During the period 2021 - 2035, and based on expected participation, the scheme is estimated to offset around 80 per cent of the emissions above 2020 levels.
Global Coalition for Sustainable Aviation	The coalition includes stakeholders working on innovations and breakthroughs for aviation technologies, fuels, operations and infrastructure, acting together with CORSIA as the complementary measure to achieve ICAO's environmental objective.
Global Framework for Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF) and other Aviation Cleaner Energies	Adopted at the Conference on Aviation Alternative Fuels (CAAF3) in 2023, the framework was established to facilitate the development and deployment of SAFs, LCAF and other cleaner aviation energies on a global basis by providing 'greater clarity, consistency and predictability to all stakeholders', including those beyond the aviation sector such as investors.
Global Framework for Aviation Alternative Fuels (GFAAF)	A database with a variety of information related to aviation fuels, including news announcements dating back to 2005, details of past and ongoing projects, and facts and figures.
International Coalition for Sustainable Aviation (ICSA)	ICSA is a group of national and international NGOs that are official observers of ICAO, contributing to its environmental and climate activities including on SAFs.

Outside of ICAO, the work of IATA, which represents around 320 of the world's airlines or 83 per cent of total air traffic, also focuses on supporting SAF uptake by helping formulate industry policy and promoting partnerships between industry and policymakers.

Insights for investors engaging on high integrity fuel uptake

Amongst the various complex levers and strategies required for the aviation sector to decarbonise globally, the evolution of aviation fuels in the transition is one avenue to ensure emissions are reduced, while the adoption of existing and emerging technologies and solutions with associated enabling policies are accelerated.

To particularly accelerate and facilitate increased uptake of high integrity SAFs, and deter the use of low integrity SAFs, investors are invited to consider the following insights, alongside promoting other decarbonisation strategies for the air transport sector:

- **Investors and the aviation industry can clarify and differentiate between the several types of SAFs in the fuel transition that they invest in, to better clarify the trajectory of various alternative fuels categorised as 'SAFs'.** Investors could consider only prioritising SAFs that will result in a truly greener aviation industry, based on the sustainability, scalability and geographical considerations of various feedstocks, existing and emerging.
- **Institutional investors can consider opportunities to support e-fuels expansion as one pathway to transition aviation fuels to a net-zero trajectory.** With all SAFs currently available being technically categorised as biofuels, investment into e-fuels specific production for particular investors (e.g. private equity or venture capital) would increase e-fuels availability and market scaling, through supporting first of a kind (FOAK) sites, increasing green hydrogen and renewable energy infrastructure, R&D into new technologies for e-fuels production, and cross value chain partnerships to help the industry navigate its risks and challenges.
- **In their corporate engagement processes, investors can ask portfolio companies to increase disclosure on how they intend to decarbonise aviation, such as clarifying the types of feedstocks and production pathways they are using, or plan to use.** Distinguishing between different fuel types in company transition plans will result in greater transparency and discernment of high integrity fuels from airlines, aerospace companies and refineries, allowing investors to better understand the credibility of corporate SAF strategies. Increased disclosure of companies' fuel investment transition plans would also be welcomed, including SAF procurement policies and their criteria and due diligence to assess prospective SAF partners before entering offtake agreements, direct investments, firm offtake agreements, and venture capital investments in prospective e-fuel projects.
- **Investors can contribute to policy developments and emerging regulations on the fuels transition.** Understanding fuel policies, regulations, SAF mandates and corporate disclosure on a regional and global scale will allow investors greater opportunity to undertake policy advocacy activities where appropriate and ensure robust standards and policy developments for the aviation industry, for example through ICAO and CORSIA.

- **Investors can consider the just, equitable and environmental implications of the aviation sectors' fuel transition in relation to long term decarbonisation.** Investors could consider the prioritisation of factors such as biodiversity and land use change, when navigating the different strategies for decarbonising the aviation sector, to ensure supply chain activities do not contribute towards adverse impacts. From the perspective of biofuels and e-fuels, investors need to consider the role of conventional fuel distributors, as well as the long-term goal of achieving zero-emission flight.
- **As well as the fuel transition, it is important for investors to engage with other decarbonisation levers involved in the long term pathway to move the aviation sector to net-zero.** Investors can also consider opportunities to support genuinely net-zero aligned aviation, such as through the acceleration and adoption of hydrogen and electric aircraft and ground operations, while advocating for demand management and improved operational efficiency measures in the immediate term.

To find out more about Climate Catalyst's programmes, please get in touch with Madeleine Hill (madeleine@climatecatalyst.org).

For more information about the PRI's aviation work, please get in touch with Jude Otaibi (jude.otaibi@unpri.org) and Jasna Selih (jasna.selih@unpri.org).

Endnotes

1 LAPFF Response to Jet Zero consultation - LAPFF

2 Transatlantic Airline Fuel Efficiency Ranking, 2017 - ICCT

3 CO2 Emissions from Commercial Aviation, 2018 - ICCT

4 Updated analysis of the non-CO2 effects of aviation - European Commission

5 Jet zero: aviation's non-CO2 impacts on the climate – UKRI

6 Updated analysis of the non-CO2 climate impacts of aviation and potential policy measures pursuant to EU Emissions Trading System Directive Article 30(4) - European Commission

7 Making Net-Zero Aviation Possible - Energy Transitions Commission

8 Analysis: Aviation could consume a quarter of 1.5C carbon budget by 2050 - Carbon Brief

9 Net-Zero Carbon Emissions by 2050 - IATA

10 Quiet and green: Why hydrogen planes could be the future of aviation | Research and Innovation

11 ZEROe - Low carbon aviation - Airbus

12 Our Commitment to Fly net-zero by 2050 - IATA

13 Aerospace Technology Institute – FlyZero - Our Vision for Zero-Carbon Emission Air Travel - Figure 9

14 Global Fleet and MRO Market Forecast 2023-2033 - Oliver Wyman

15 net-zero 2050: sustainable aviation fuels - IATA

16 Feedback from: Transport & Environment | EU emissions trading system - countries considered to apply CORSIA in 2023 - European Commission

17 Virgin Atlantic granted Permit to Fly for historic transatlantic 100 per cent SAF flight - UK Civil Aviation Authority

18 Paving the way for new European standards to accelerate the roll-out of large-scale hydrogen solutions - European Commission

19 US biofuel groups challenge EU SAF regulation | Latest Market News

20 ICAO document - CORSIA Sustainability Criteria for CORSIA Eligible Fuels

21 ICAO - Life Cycle Emissions of Sustainable Aviation Fuels

22 U.S. Department of the Treasury, IRS Release Guidance to Drive American Innovation, Cut Aviation Sector Emissions December 15, 2023

23 U.S. Department of the Treasury, IRS Release Guidance to Drive American Innovation, Cut Aviation Sector Emissions April 30, 2024

24 European Parliament Briefing - Sustainable Aviation Fuels

25 Supporting the transition to Jet Zero: Creating the UK SAF Mandate Government response to the second consultation on the SAF Mandate

26 Sustainable Aviation Fuels Policy Status Report | International Transport Forum

27 The basics of SAF Technology | The HEFA process - SkyNRG

28 Fueling net-zero: How the aviation industry can deploy sufficient sustainable aviation fuel to meet climate ambitions - ICF

29 Bio-based feedstocks will likely only be able to provide half of SAF demand by 2050, finds ICF - Green Air News

30 Under New Guidance, 'Sustainable' Aviation Fuel in the US Could Be Anything But - WRI

31 Sustainable Aviation Fuels (SAF) Sustainability Guide for Corporate Buyers - Transport & Environment

32 Fact Sheet: EU and US policy approaches to advance SAF production - IATA

33 Ethanol explained - U.S. Energy Information Administration

34 STATEMENT: U.S. Treasury Department Issues New Guidance for Sustainable Aviation Fuel Tax Incentives, Boosting High-Emitting Crop-based Biofuels - WRI

35 Biden backs ethanol industry on low-emission aviation fuel tax credits - Reuters

36 80 per cent of Europe's 'used' cooking oil now imported raising concerns over fraud - study - Transport & Environment

37 E-fuels too inefficient and expensive for cars and trucks, but may be part of aviation's climate solution - Transport & Environment

38 Feasibility Study on the use of Sustainable Aviation Fuels - ICAO

39 Sustainable Aviation Fuels Sustainability Guide for Corporate Buyers - Transport & Environment

40 FAQ: the what and how of e-kerosene - Transport & Environment

41 Current and future cost of e-kerosene in the United States and Europe - ICCT

42 Assessing the sustainability implications of alternative aviation fuels

43 Hydrogen-powered aviation: A fact-based study of hydrogen technology, economics, and climate impact by 2050 - Clean Sky 2 JU and Fuel Cells and Hydrogen 2 JU

44 Share of energy consumption from renewable sources in Europe | European Environment Agency

45 Clean Skies for Tomorrow: Delivering on the Global Power-to-Liquid Ambition - World Economic Forum

46 Decarbonizing Aviation: Challenges and Opportunities for Emerging Fuels - Clean Air Task Force

47 Sustainable aviation fuel technologies, costs, emissions, policies, and markets: A critical review - ScienceDirect

48 Current and future cost of e-kerosene in the United States and Europe - ICCT

49 How is e-kerosene developing in Europe? - Transport & Environment

50 Sustainable aviation fuel technologies, costs, emissions, policies, and markets: A critical review - Watson et al. 2024

51 How sustainable are SAF? - EASA Eco

52 NASA-DLR Study Finds Sustainable Aviation Fuel Can Reduce Contrails - NASA

53 Contrail Mitigation: A Milestone Year for Advancing Industry Understanding and Experience - RMI

54 Target True Zero: Unlocking Sustainable Battery and Hydrogen-Powered Flight - World Economic Forum

55 Method for establishing lifecycle greenhouse gas emission factors for sustainable aviation fuels - ICAO

56 Sustainable Aviation Fuel production to triple in 2024 - Business Traveller

57 Sustainable Aviation Fuel - KPMG UK

With input from

W: www.climatecatalyst.org
E: info@climatecatalyst.org
T: @climacatalyst
L: linkedin.com/company/climate-catalyst-ngo

July 2024