The certification of sustainable aviation fuel is important to helping the aviation industry reduce its greenhouse gas emissions

Decarbonising the aviation sector

As every business and leisure traveller experiences at crowded airports and aircrafts operating at full capacity, air travel is booming. While the International Air Transport Association (IATA) counted 3.1 billion passengers in global air traffic in 2013, the estimate for 2018 is 4.3 billion passengers – an increase of 38% in just five years. Air travel is more accessible than ever. Today, air fares are less than half of what they were in 1995, and demand is driven in particular by increasing economic wealth in the Asia Pacific region. The number of passengers is expected to double over the next 20 years. In addition, the air cargo business is growing rapidly, with almost 64 million tonnes of freight forwarded in 2018. Five years earlier, in 2013, this figure was only 52 million tonnes. 38 million flights were required to deal with passengers and freight in 2018.[1]

Fuel consumption is increasing accordingly. It grew from 74 billion gallons of kerosene in 2013 to 94 billion gallons in 2018, reflecting a growth of 27%. Greenhouse gas (GHG) emissions increased by 26%, from 710 million tonnes in 2013 to 895 million tonnes in 2018.[2] By 2020, global international aviation emissions are projected to be around 70% higher than in 2005, with the International Civil Aviation Organization (ICAO).

Given this sector's growing contribution to global GHG emissions, aviation will play a key role in meeting the international climate targets set forth in the 2015 Paris Agreement. The global aviation industry responded to those challenges by setting ambitious targets to mitigate GHG emissions from air transport. These include carbon-neutral growth from 2020 and a 50% reduction of net aviation carbon emissions by 2050. Aviation is approaching the challenge of achieving its climate goals through a four-pillar strategy: developing new technology (including sustainable aviation fuel); more efficient operations; better use of infrastructure; and a global market-based measure for aviation emissions.[4]

Sustainable aviation fuel (SAF) is of paramount importance to reduce emissions in aviation. Currently, these fuels offer the only viable alternative to fossil liquid fuels for powering aircraft. They have the potential to cut emissions substantially when

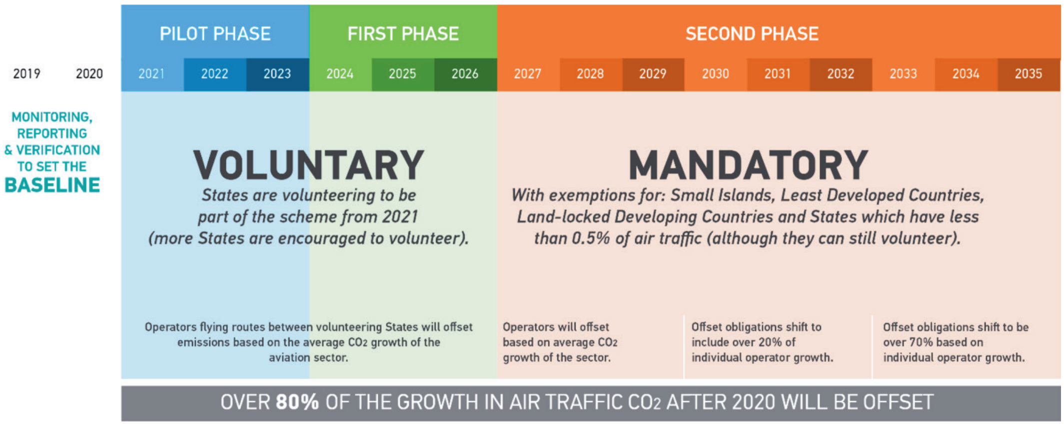


Figure 1. CORSIA's proposed timeline from 2019 to 2035. Source: IATA

	Annex	Conversion process	Abbreviation	Possible feedstocks	Blending ration by volume	Commercialisation proposals/projects
ASTM D7566	1	Fischer-Tropsch hydroprocessed synthetic	FT-SPK	Coal, natural gas, biomass	50%	Fulcrum Bioenergy, Red Rock Biofuels, paraffinic kerosene SG Preston, Kaidi, Sasol, Shell, Syntroleum
	2	Synthetic paraffinic kerosene produced from hydroprocessed esters and fatty acids	HEFA-SPK	Bio-oils, animal fat, recycled oils	50%	World Energy, Honeywell UOP, Neste Oil, Dynamic Fuels, EERC
	3	Synthetic iso-paraffins produced from hydroprocessed fermented sugars	SIP-HFS	Biomass used for sugar production	10%	Amyris, Total
	4	Synthetic kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	SPK/A	Coal, natural gas, biomass	50%	Sasol
	5	Alcohol-to-jet synthetic paraffinic kerosene	ATJ-SPK	Biomass from ethanol or isobutanol production	50%	Gevo, Cobalt, Honeywell UOP, LanzaTech, Swedish Biofuels, Byogy
ASTM D1655	Annex	Co-processing		Fats, oils and greases (FOG) from petroleum refining	5%	

Table 1. ASTM certified conversion processes. Source: ICAO

compared to fossil kerosene comparators. SAF offers the opportunity for the industry to significantly reduce actual emissions in aviation, contrary to offsetting measures in which other actors are being paid for reducing their emissions. Emission units generated from mechanisms under the United Nations Framework Convention on Climate Change and the Paris Agreement could be used in CORSIA, the Carbon Offsetting and Reduction Scheme for International Aviation. Examples include emission savings from landfill methane and REDD+ projects.

Regulative framework

Objectives, key elements and a roadmap for implementation to reduce emissions from international aviation are defined under CORSIA. This scheme, which is handled by ICAO, is the principal mechanism to meet aviation's long-term decarbonisation targets.

In 2016, states represented at ICAO agreed on the introduction of CORSIA, which is supported by the aviation industry. The scheme aims to stabilise GHG emissions at 2020 levels by requiring airlines to offset the growth of their emissions beyond 2020. Airlines will be required to monitor emissions on all international routes and to offset emissions. SAF consumption and the purchase of carbon offsets are two principal means to achieve CORSIA compliance, with the relative attractiveness of these dependent on their respective GHG avoidance costs.

Work is ongoing at ICAO to develop the necessary implementation rules and tools to make the scheme operational. Effective and concrete implementation and operationalisation of CORSIA will ultimately depend on national measures that will need to be developed and enforced at domestic level.[5]

The baseline for emission reductions under CORSIA is being set in 2019/2020. Since the beginning of 2019, all carriers are required to report their GHG emissions on an annual basis. During the pilot and first period, CORSIA is estimated to offset around 80% of emissions above 2020 levels. As of May 2019, 80 states (including all EU member countries), representing nearly 80% of international aviation, intend to voluntarily participate in CORSIA from its outset.[6] A regular review of the scheme is required under the terms of the agreement, which should allow for continuous improvement, including how the scheme contributes to the goals of the Paris Agreement.[7]

While CORSIA is applied to international flights, there are also regulations at national and regional levels aiming at offsetting or reducing GHG emissions in aviation. In the EU, for example, GHG emissions from aviation have been included in the EU Emissions Trading System (EU ETS) since 2012. Under the EU ETS, all airlines operating in Europe, whether European or international, are required to monitor, report and verify their emissions, and to surrender allowances against those emissions.[8] The EU ETS for aviation will be subject to a review in the context of implementing CORSIA. The EU's revised Renewable Energy Directive (REDII), which sets renewable energy targets for the transport sector, has a multiplier of 1.2 for SAF; according to the aviation industry, this is not sufficient to expand the production and consumption of SAF. Jet fuel is also included in other national or state legislation, such as the Renewable Fuel Standard in the US and California's Low Carbon Fuel Standard, which have set the aviation industry incentives to use SAF.

SAF pathways

Sustainable alternative fuels for aviation are fuels that have the potential to be sustainably

Conversion pro-cess	Abbreviation	Possible feedstocks	Commercialisation proposals	Notes
Catalytic hydrothermolysis jet/ high freeze point HEFA	CHJ/ HFP-HEFA	Bio-oils, animal fat, recycled oils	Chevron Lummus Global, Applied Research Associates, Blue Sun Energy	Bio-oils reacted with water under high temperature and pressure conditions. Could be used without blending
Co-processing bio-oils in existing refineries	Co-processing	Bio-oils	Chevron, Phillips66, BP	Co-processing is based on the processing of bio-oil with conventional middle distillates in existing refineries
Alcohol-to-jet synthetic paraffinic kerosene	ATJ-SPK (besides isobutanol)	Biomass used for starch and sugar production and cellulosic biomass for alcohol production	Gevo (butanol), LanzaTech (ethanol)	ASTM is reviewing production of jet fuel from butanol and ethanol in addition to isobutanol, which has already been approved as ATJ-SPK
Alcohol-to-jet synthetic kerosene with aromatics	ATJ-SKA	Biomass used for starch and sugar production and cellulosic biomass for alcohol production	Byogy, Swedish Biofuels	Fuel produced with bio-aromatics to allow for higher blend percentages
HEFA Plus	Green Diesel	Bio-oils, animal fat, recycled oils	Boeing	First test flights with a 15% HEFA-diesel ('green diesel' blend already took place

Table 2. Conversion processes within the ASTM approval process. Source: ICAO

produced and to generate lower carbon emissions than conventional kerosene on a lifecycle basis.[9] SAF includes fuels produced from biological feedstock (plant or animal material) or from alternative sources, including non-biological and fossil feedstock (for example, a gas-to-liquid produced from natural gas). SAFs are drop-in fuels, making them fully compatible, mixable and interchangeable with conventional jet fuel without the need for aircraft adaptations or additional infrastructure.

A pre-condition for the use of any SAF as aviation turbine fuel is an ASTM certification. Pathways that have already been certified include Fischer-Tropsch Synthetic Paraffinic Kerosene (FT-SPK), Hydroprocessed Esters and Fatty Acids (HEFA) and Alcohol-to-Jet Synthetic Paraffinic Kerosene (AtJ-SPK). Additional pathways are currently undergoing certification.[10]

Demand and supply

The International Energy Agency's (IEA) longer-term Sustainable Development Scenario (SDS) anticipates SAF reaching around 10% of aviation fuel demand by 2030, and close to 20% by 2040.[11] This would equal a SAF demand of 18 million cubic metres in 2025, and 35 million cubic metres in 2030. Today, demand is far below those estimates.

More than a decade ago, in early 2008, commercial airline Virgin operated the first airplane using a blend of jet fuel and SAF. Technical questions such as the impact on engines and aircraft performance were raised at the time, which resulted in the first testing of SAF blends. These questions have since been answered, and in 2011 regular commercial flights using drop-in SAF started. Lufthansa began using ISCC-certified HEFA kerosene produced by Neste in Porvoo, Finland, and in 2016 US airline United began using a tallow-based SAF produced by World Energy. Other airlines that have started to use SAF include KLM, SAS and Finnair, however, blend ratios and volumes are still low. Today, only six airports are regularly distributing blended alternative fuels, with just 150,000 flights (0.4% of total flights) using a blend of alternative

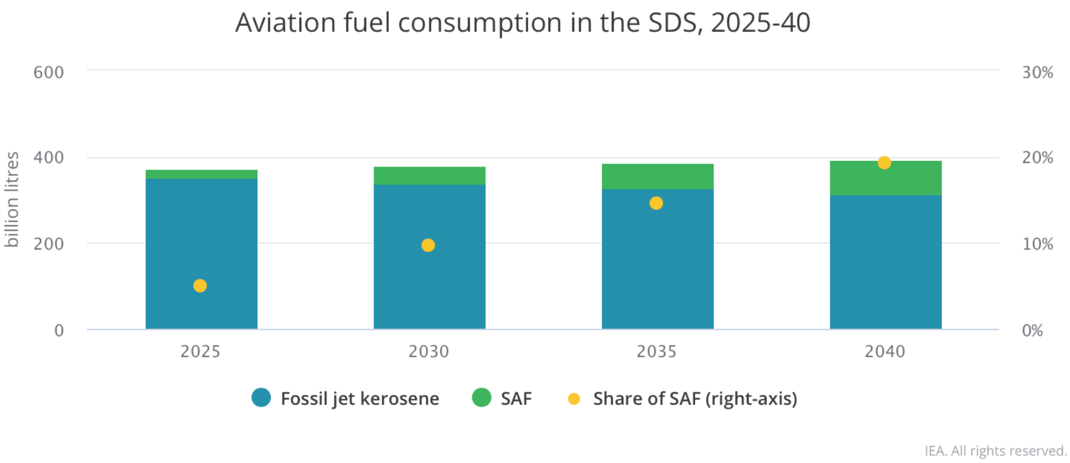
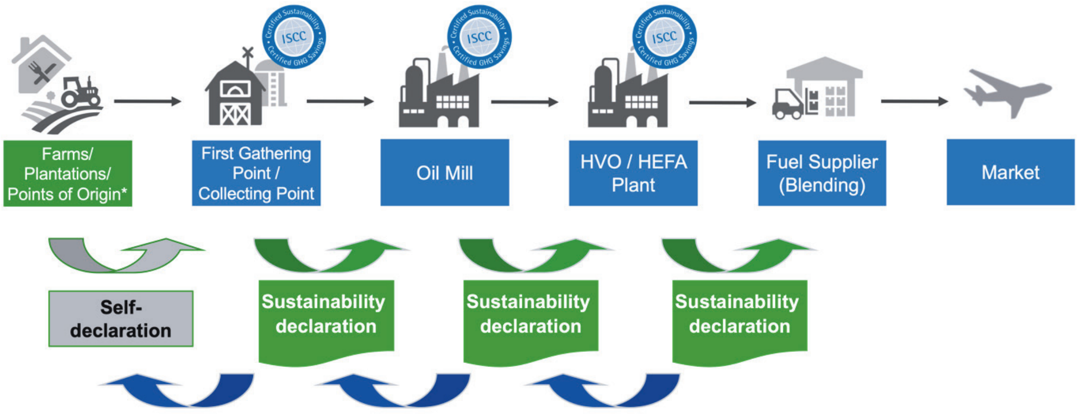


Table 2. Conversion processes within the ASTM approval process. Source: ICAO



* Farms/Plantations – Points of origin can get certified on a voluntary basis. Usually they are covered under the certificate of the First Gathering Point (FGP)/ Collecting Point (CP). In this case they issue a self-declaration to the FGP and are audited on a sample basis

Figure 3. Forwarding of sustainability information in a certified supply chain

fuels, according to ICAO.

Looking at the current demand and supply of SAF, many industry participants see a 'chicken and egg' scenario. While the aviation industry has ambitious long-term plans to use SAF, demand for the sustainable fuel is low. Only a handful of airlines currently fuel their flights with SAF on a continuous basis, and the fuel remains expensive with a very limited supply base. The financial feasibility of potential new supply projects could be at risk from the current low levels of demand. It is expected that a growing supply base would reduce production costs.

Blending obligations would definitely help to set predictable framework conditions for the industry, and to stimulate the required investments and production of SAF. As a forerunner, Norway has set a 0.5% SAF blending obligation from 1 January 2020; by 2030, the SAF share in aviation fuels should be at least 30%.[12] Sweden has an ambitious target of being fossil-free by 2045, announcing a proposal for decarbonising aviation in March 2019 that would see the country introduce a GHG reduction mandate for aviation fuel sold in Sweden. The reduction level would be 0.8% in 2021 and gradually increase to 27% in 2030 – equivalent to 340,000 tonnes of SAF in 2030.[13]

Such regulatory framework conditions may help to incentivise an increase in SAF production capacity. As it stands, however, continuous large-scale commercial production does not exist for most of the ASTM pathways. Neste, for example, produces HEFA on a batch-basis from hydrotreated vegetable oil. Fulcrum is currently constructing its first SAF plant in the US that will use municipal solid waste as feedstock, with plans for a second plant in India. LanzaTech produces ATJ from industrial waste streams, e.g. from steel mills. World Energy (through AltAir) continuously produces renewable jet fuel on a small scale. Gevo's ATJ has been used to power commercial flights since 2016, and the company also works on renewable jet fuel based on cellulosic feedstock.

Capacity build-up is essential to achieve decarbonisation objectives in the aviation sector. Signals from regulators and airlines are crucial to create the required confidence for investors. A key barrier to the wider use of SAF is that it is currently more expensive than conventional jet fuel. The sustainable production of sufficient volumes of SAF at affordable prices is key to the deployment of the fuel on a commercial scale.

Sustainability requirements

The term 'SAF' already highlights the sustainable nature of this type of jet fuel. ICAO and the wider aviation industry acknowledge the need for SAF to be developed and deployed in an economically feasible, as well as socially and environmentally acceptable, manner.

Under the current CORSIA framework, sustainable aviation fuels need to comply with sustainability criteria that include:

- A SAF must achieve at least 10% GHG emission reduction on a lifecycle basis. The reduction can be assessed by either using default values or actual lifecycle emission calculations.
- A SAF cannot be produced from biomass obtained from high carbon stock land that was converted after 1 January 2008.

CORSIA plans to approve Sustainability Certification Schemes (SCS) for certifying SAF based on its Eligibility Framework and Requirements for SCS. Compliance with the criteria will be confirmed based on audits carried out independently by certification bodies cooperating with the SCS.

The use of existing SCS, such as ISCC, RSB or RTRS, to show compliance with CORSIA will help to bring commercial SAF quantities to the market. It also reduces the organisational and cost burden on companies in the supply chain, and thus will increase acceptance. Many economic operators, such as agricultural producers, waste collectors, traders and fuel producers, in potential SAF supply chains are already certified and are familiar with sustainability requirements and GHG calculations.

Existing certification schemes have gained comprehensive experience with land use change verification, GHG values, and the forwarding of sustainability information in complex supply chains. ●

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