aireg
Aviation Initiative for
Renewable Energy in Germany e.V.

Sustainable Aviation Fuels to Mitigate Climate Change

A quantification of the climate impact potential until 2030

Content

Key Messages

Limiting the global average temperature increase to 1,5°C requires significant efforts to mitigate greenhouse gas emissions. The European Union has set an overall target of a 55% greenhouse gas (GHG) emission reduction by 2030 compared to 1990 levels ("European Green Deal"). Present proposals for a European blending mandate for SAF as outlined in the European Green Deal will provide an important signal to the market, but fall short of limiting global warming to 1.5°C. The climate impact from aviation results from the emission of CO_2 ("CO_2 effect"). Other emissions are NO_x, sulphur, water vapour and contrail formation, all of which are contributing to the so called "non-CO_2 effects".

Sustainable Aviation Fuels (SAF) can reduce CO_2 emissions by approximately 80% to almost 100% depending on their production pathways. Furthermore contrail formation is reduced due to lower particle emissions. Both effects will support the reduction of global warming.

The following key messages outline both the potential of SAF regarding climate impact reduction and the respective enablers to gain the maximum impact.

1. A targeted use of SAF on the most contrail relevant flight routes multiplies the effect by a factor of 3.3 compared to a uniform distribution. A volume of 10% SAF leads to a 7.5% climate impact reduction (energy forcing) when uniformly distributed whereas the same amount of SAF in blend ratios of 50% and used on the most contrail relevant flight routes reduces the climate impact by 25.1% (Teoh et al. 2022b).

2. A rapid increase of SAF consumption is indispensable. In European aviation, a SAF share of 10 % in 2030 is achievable. Key enabler is a political framework allowing for an immediate ramp up of production capacities. Supply and demand-side financial support is crucial to facilitate the capacities and to initiate the installation of industrial scale SAF production plants.

3. Biogenic SAF can achieve up to 90% reduction of life cycle CO_2 emissions, future next generation SAF, e.g. Power-to-Liquids produced from renewable energy, can reach even higher reductions. The target of 10% SAF in 2030 implies that all production pathways must be supported.

4. Contrail formation is dependent on local atmospheric conditions. Hence, a targeted use of SAF in contrail sensitive regions implies the availability of latest weather data.

5. To incentivize climate impact optimized operations an internationally acknowledged standard metric and methodology for a climate impact assessment of specific flights is a prerequisite.

International Climate Change Mitigation Targets and Aviation

1.1. International and European Mitigation Targets

The Paris Agreement (United Nations 2015) defines a clear target to mitigate climate change: "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1,5 °C" It requires UN member states to define nationally determined contributions (NDC), i.e. the contribution of a union of states or single nations towards reducing greenhouse-gas (GHG) emissions. For the European Union, the "European Green Deal" (European Commission 2023)is a central element of the European NDC and includes the target of a 55% GHG emission reduction in 2030 compared to 1990 levels. This target is the basis for the "Fit-for-55" Initiative published in 2021 (European Parliament 2020). Part of the "Fit-for-55" Initiative is the introduction of a blending mandate for SAF. The present proposal aims at a blending share of 5 % SAF in 2030.

The climate impact of aviation is not limited to GHG emissions. Global warming is intensified by net-warming effects of (persistent) contrails, NO_x, particles, sulphur and water vapour emissions ("non-CO_2 effects"). In contrast to CO_2 effects, the climate impact of contrails and NO_x varies significantly by place and time. Presently, non CO_2 effects are not included in any aviation regulation. In 2022, the European Parliament proposed (European Parliament 2023) to include non-CO_2 effects into the EU Emissions Trading Scheme (EU ETS). The calculation is supposed to use a flat multiplier for a transitional period. However, due to the regional and temporal variation of contrail and NO_x climate impacts (EC 2020), this would not incentivize a reduction of non CO_2 effects. More appropriate measures need to be developed.

1.2. The role of aviation for anthropogenic climate forcing

Historically, air transport capacity grows at average rates of ca 4 %/a, with fuel efficiency improvements of ca 1.5 %/a. After the Covid19 pandemic, a return to 2019 levels is assumed to take place until 2024 (ICAO 2022).

In general, aviation GHG emissions can be reduced by introducing modern, more fuel-efficient aircraft, increasing operational efficiency (e.g. by more direct routings or reduced taxi times) and by the use of SAF. The introduction of novel aircraft designs will most likely take until 2030. Fleet renewal will support the climate goals, but need to be complemented by further measures to achieve the European Green Deal. For this, continuous efficiency improvements and high volumes of SAF will be needed.

Therefore, aireg is advocating for SAF usage shares of at least 10% by 2030. Additionally, the use of SAF should be targeted towards routes with a high non CO_2 climate impact, in order to realize the maximum possible mitigation potential.

1.3. The potential of SAF to mitigate aviation's climate impact

Using SAF can reduce up to 90 % of CO_2 emissions on a lifecycle basis (Jong et al. 2017). However, the combination of feedstock and conversion pathway chosen to produce SAF has a significant effect on its lifecycle GHG emissions. Presently, the use of SAF is certified as blend with conventional kerosene up to a maximum blend ratio of 50% (for some SAF conversion pathways the limit is lower). The fuel specification body, ASTM, and all major engine and aircraft manufacturer presently collaborate on the certification of 100% SAF (Airbus 2021). This step is a prerequisite to achieve the climate targets for 2050.

Scientific understanding of climate forcing due to contrails is increasing steadily (Lee et al. 2021). In contrast to climate forcing by CO_2, climate forcing by contrails is effective at substantially shorter time-scales but at a higher intensity. Thus, reduction of contrail formation is a contributor to the climate warming mitigation. Studies indicate that using a high share of SAF can significantly reduce the climate impact by contrails.

In-flight measurements have shown that the use of a 50% SAF blend reduces the climate impact of contrails significantly (Voigt et al. 2021; Bräuer et al. 2021). Model studies (Teoh et al. 2022b) show that if such a reduction is achieved globally, radiative forcing from contrails could be reduced by approximately 50%. Hence, the use of SAF also allows to reduce non CO_2 effects significantly.

What is required to achieve the European greenhouse gas mitigation targets by 2030?

As described in the previous section, the use of SAF provides a significant potential to reduce CO_2 and non-CO_2 related climate impacts of aviation. As of today, the market share of SAF is below 0,1 %. The target of a 55 % reduction in GHG emissions by 2030 allows to draw several conclusions regarding the development of SAF:

2.1 Higher SAF market shares

Production capacities need to ramp-up very steeply. Market shares matching the presently targeted 5 % blending mandate for 2030 in the EU are not sufficient, as this would only yield a reduction of around 4 % in CO_2 and would accordingly fall short of limiting global warming to 1,5°C. Market shares of 10% seem achievable. *To reach these amounts, financial support to facilitate the market entry are fundamental.* The presently existing price gap between fossil and sustainable aviation fuels can diminish if demand for SAF is stimulated and the production cost of SAF are reduced.

2.2 Use all sustainable options

Capacities of several SAF feedstock are inherently limited (e.g. lipid-based waste and residues) while other are associated with high cost and energy requirements (e.g. carbon provision from direct-air-capture). To maintain aviation emissions in line with a 1,5 ° target, all available SAF options which comply with sustainability criteria need to be used to the greatest possible extent. Regulatory measures have to *support all available SAF production technologies. Funding should be technology open and accounting should fairly incentivize all available SAF options*

Higher market shares complemented by supportive measures would support the market ramp-up of SAF. Currently available SAF options achieve an 80% reduction in life cycle CO_2 emissions, next generation SAFs show a potential to reach 90% and more. However, if the climate target of 55 % in 2030 were only to be achieved by CO_2 reductions, SAF would need a not to be expected market share of around 66 % already in 2030. Additionally, around two thirds of aviation's climate forcing is caused by non CO2 climate effects (Lee et al. 2021). Therefore, a mitigation of solely CO_2 effects falls also short of maintaining aviation in line with a 1,5 °C mitigation goal.

2.3 Mitigate both, CO_2 and non CO_2 effects

Numerous studies and flight experiments evaluate options to mitigate the non CO_2 climate impact of aviation. For example, it was found that only 15 % of the flights across the North Atlantic cause more than 80% of the contrail climate impact in this region (Teoh et al. 2022a). For the Japanese airspace, only 2,2 % of flights contribute to 80 % of the climate forcing in this region. Diverting these flights outside of areas where contrails form would substantially lower the corresponding climate forcing. However, as this would most likely incur longer flight routes, higher CO_2 emissions would be an undesired side effect. Flight experiments studying the use of SAF have shown that their use causes less soot emissions and accordingly reduced ice crystal formation and contrail climate impact. The use of a 50 % SAF blend was found to achieve an 80% reduction of ice crystal number. Thus, the contrail climate impact could be reduced by around 40%. As this mitigation strategy would lower contrail climate impact and reduce life-cycle CO_2 emissions, both, non CO_2 and CO_2 climate impact would be lowered. *Therefore, a targeted use of SAF in contrail sensitive regions is particularly important to gain the maximum positive effect*.

For the targeted use of SAF on flight routes with the largest contrail-impact mitigation potential, a harmonized and physically based methodology for estimating the climate impact of aviation is required. To determine mitigations of climate impact, accounting of SAF use is crucial. These SAF accounting models should be designed in such a way that best help facilitate scale-up of production, access additional demand, as well as provide for high environmental integrity of SAF claims. A book-and-claim methodology fulfills these requirements. Within a book-and-claim system, the physical allocation of SAF volumes can in principle be steered towards particular airports/flights. This would allow for a targeted use of SAF in contrail sensitive regions.

Less than ten years are available to lower aviation emissions by more than their half. To achieve this ambitious goal, a combination of all measures listed above would be required. In terms of CO_2 effects, production capacities of all available conversion pathways need to grow steeply, incentivized by higher blending mandates, financial support for the scale-up of SAF production and reduced approval times for plant construction. Technology-open accounting of all available SAF options provides a central basis to utilize the available SAF options to the greatest extent possible. If a targeted use of SAF would be implemented and supported by regulatory schemes, it is possible to maintain the climate impact of aviation in line with the Paris Agreement's goal of limiting global warming to 1,5 °C.

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aireg – Aviation Initiative for Renewable Energy in Germany e.V.
Bundesratufer 10
10555 Berlin
Telefon: +49 (0) 178 184 30 41
E-Mail: kontakt@aireg.de
Website: www.aireg.de