Guidance to Natural Capital Partners on the Treatment of Aviation Emissions in The CarbonNeutral Protocol

Aviation Impact Factor and Sustainable Aviation Fuels/biofuels

John Murlis, January 2021

1. Introduction

The revised Offsetting Guidance, published in November 2019, found that the evidence for secondary impacts of aircraft on global warming was strengthening and that greater confidence could now be attached to the scale of the major components. It concluded that the case for applying an AIF (Aviation Impact Factor) to the carbon emissions to account for secondary effects was now strong enough to revise the approach in The CarbonNeutral Protocol. It proposed an AIF of 2 as the best estimate and concluded that this should be considered as a target value in the revised CarbonNeutral Protocol.

In response to the revised Guidance, The CarbonNeutral Protocol now includes a requirement for clients to consider the evidence for secondary aviation impact, following which they may elect to adopt a value higher than the default AIF, currently 1. Additionally, the default value will be increased from 1 to 2 over the 5 years for 2020 to 2025 to allow progressive adaptation to the higher value. This would ensure that, by 2025, all clients will be applying an AIF of 2 to reflect the direct engine emissions of carbon, the climate forcing impacts of non-carbon engine emissions and other secondary impacts due to flight operation (for example, contrail formation).

This guidance was based on the use of the conventional liquid hydrocarbon fuels (LHF) available widely for aviation. However, the aviation industry, in partnership with ICAO, the International Civil Aviation Organisation, has now, in the light of the UNFCCC Paris Agreement temperature goals of 2ºC and 1.5ºC, adopted a set of goals to reduce aviation’s climate impact. The measures required to reach these goals include operational changes to achieve more fuel-efficient routing of flights, more fuel-efficient aerodynamic aircraft design and changes to the aviation fuels in use. Of these, it is expected that changes to aircraft fuel will produce the greatest contribution to the reduction targets, with the progressive reduction of the proportion of conventional LHF in use through the introduction of Sustainable Aviation Fuels (SAF). SAFs come in many forms, including hydrocarbons produced from renewable or waste feedstocks and a range of alternative fuels including hydrogen or electricity.

Although both hydrogen and electricity are seen as potentially important fuels for the future, considerable further development is required to engines and airframes before they can be widely used. For the short term, SAFs are expected to be in the form of blends of conventional LHF and chemically equivalent materials that can immediately replace LHF. The blending components, derived from recycled waste streams such as used cooking oil or plant materials such as agricultural residues, are considered to be broadly renewable, reducing the final fuels’ dependence on fossil carbon. In general, SAFs tend to require higher inputs of carbon-based energy and other potentially climate forcing agents in their production and distribution than conventional crude-oil based fuels but have lower life cycle carbon emissions because the carbon released as the fuel is burnt is from renewable sources. The result is fuel blends that has lower emission of carbon from fossil sources in use and a lower life cycle carbon burden.

However, at current production volumes and current crude oil prices, SAFs carry a substantial additional cost, about 2 to 3 times the cost of conventional fuel. It is expected that at larger production volumes SAF will become more price competitive with LHF and various measures have been proposed to increase demand, closing this price gap, including financial support for refinery development, mandates and subsidies.

The immediate concern for carbon accounting is to determine the impact SAFs make on emissions and on the impacts of aviation on the climate system as a whole. It is the purpose of this Annex to the Revised Guidance to suggest how the impacts of SAFs on emissions might be estimated, including recommendations for assigning carbon emissions and accounting for secondary impacts.

2. Background

Aviation has a large and growing impact on the climate system. In recognition of the need to reduce these impacts, the international aviation industry set an aspirational goal of achieving carbon neutral growth from 2020 and a reduction of 50% in CO_2 emissions by 2050.

In 2016, member states of the International Civil Aviation Organisation (ICAO) agreed on a set of global measures for attaining this goal, including market-based measures (MBM), operational improvements, more efficient aircraft technology and the progressive adoption of Sustainable Aviation Fuels (SAF).

It was envisaged that the MBMs would in the form of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The average CO_2 emissions from international aviation covered by the scheme between 2019 and 2020 would form the baseline for carbon neutral growth. In any year from 2021, the sector’s offsetting requirements for that year would be the difference between the international aviation CO_2 emissions covered by the scheme and the baseline

The scheme is being implemented in phases over the period 2020 to 2035, with a pilot phase, a first, volunteer phase and a second mandatory phase applying to all participating States. All ICAO Member States with international flights are required to monitor, report and verify aviation CO_2 emissions. They can also decide to participate in CORSIA offsetting requirements from 2021. Offsetting requirements under CORSIA apply to all international flights on the routes between the participating States with airlines offsetting emissions above the baseline emissions. Offsets can be within the aviation industry or elsewhere but must conform to certification standards.

Overall, there have been considerable improvements in aircraft fuel efficiency in recent years, estimated by International Air Transport Association (IATA) to be on 1.5% per year over the last decade, and these rates of improvement, if sustained would make a contribution to the industry aims. Similarly, modifications to routing are expected to contribute by reducing the overall fuel requirement for flights, although there remain significant operational and political obstacles to changes in routing sufficiently radical to make a substantial difference. These measures will contribute but it is not expected that they will by themselves be sufficient to deliver the aviation industry’s aspirational goals.

The major burden of reducing emissions is therefore expected to fall on measures to increase the volume of SAF in the fuel mix. There is now considerable production and operating experience with SAF and at least five types have been authorised for use in commercial flights. The currently authorised fuels are “drop in” fuels that can substitute for LHF and can be used without engine modification. One fuel type in particular, hydroprocessed esters and fatty acids synthetic paraffinic kerosene (HEFA-SPK), made from waste vegetable oils, including used cooking oil, is currently technically mature and widely commercialised. It is expected to be the principal aviation biofuel in use over the short to medium term.

IEA scenario analysis suggests that SAF from currently authorised processes could account for 10% of aviation fuel by 2030 and 20% by 2040. Given the extensive experience of using SAFs in commercial flights, the principal barrier to uptake is cost. Currently costs are high, according to IEA, about double to triple those of LHF in the case of HEFA-SPK, reflecting the high investment levels required and the current low production volumes. It is expected however that, following further investment in production facilities, with returns from increased volumes, costs will fall until SAF is price competitive with LHV, given market crude oil costs. IEA estimates are that meeting 2% of annual jet fuel demand would produce the cost reductions needed to ensure a sustainable market for SAF. However, to provide investor confidence it is expected that some market intervention will be needed. Incentives, for example those provides by a combination of carbon limits and offsetting, are therefore required to drive demand for the fuel in the short term until the market for SAF is self-sustaining.

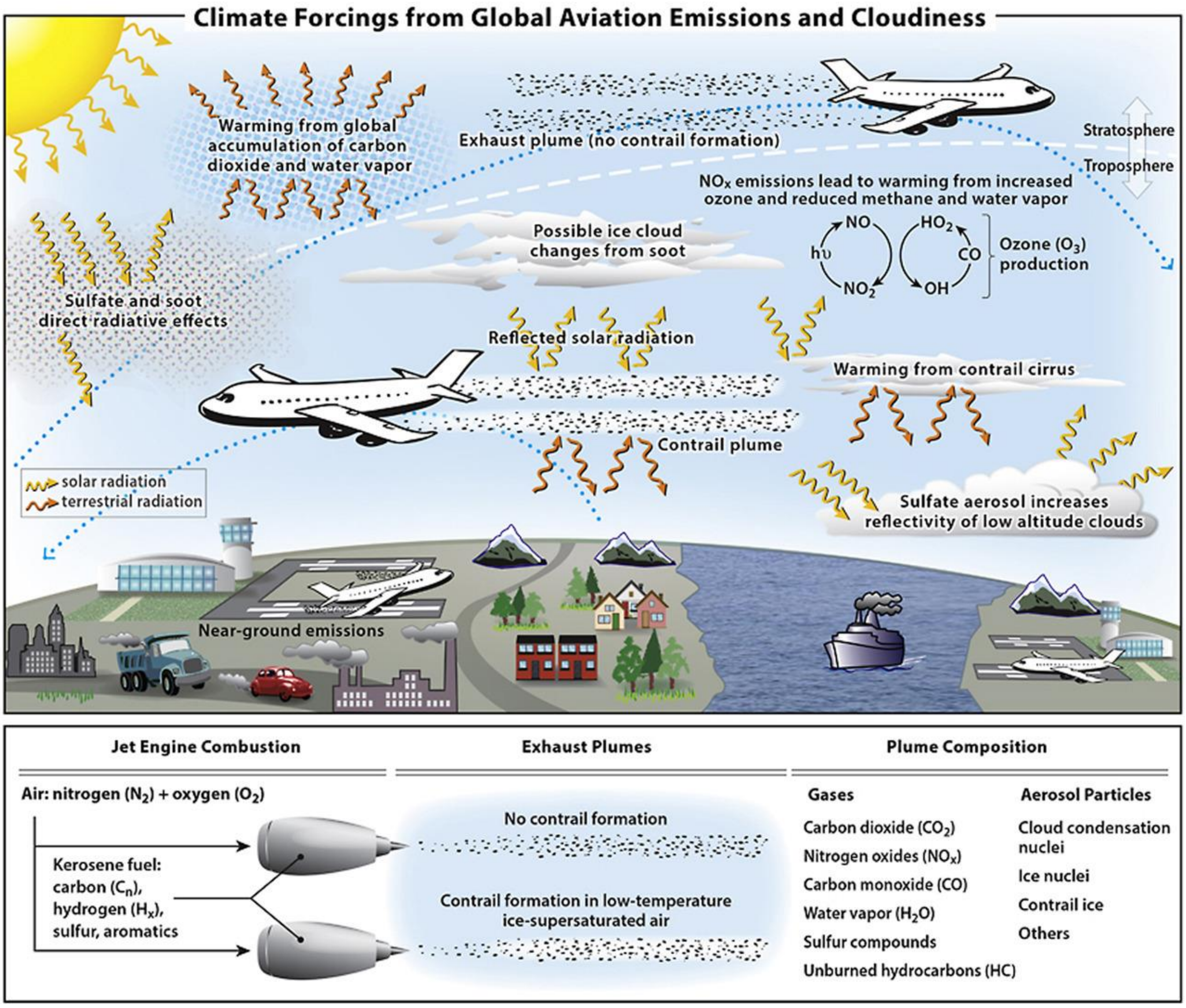
3. Benefits of Sustainable Aviation Fuels

If SAF is to provide a reliable, credible and reputable alternative to current LHF, its impacts on the global climate system relative to LHF must be clearly characterised and confidence would be needed that it is broadly sustainable, on the basis of recognised sustainability criteria.

3.1 Climate impacts

Aircraft flight impacts on the climate system in several ways. There is a direct effect on warming due to the emission of CO_2 from the engines. There are then two kinds of secondary effect: impacts on warming from other engine emissions, and effects on the atmosphere that arise from aircraft flight (such as contrails).

The figure below, taken from Lee et al. 2020, shows the emissions from aircraft engines and the different secondary impacts that should be considered in assessing benefits from SAF.



Lee et al. 2020

The illustration shows the different processes that derive from the aircraft flight, including the emissions from engines, notably CO_2, oxides of nitrogen (NOx) water vapour and sulphur compounds, and the impacts of flight itself, including the generation of contrails from wing-tip vortices, and the effects these have on global warming.

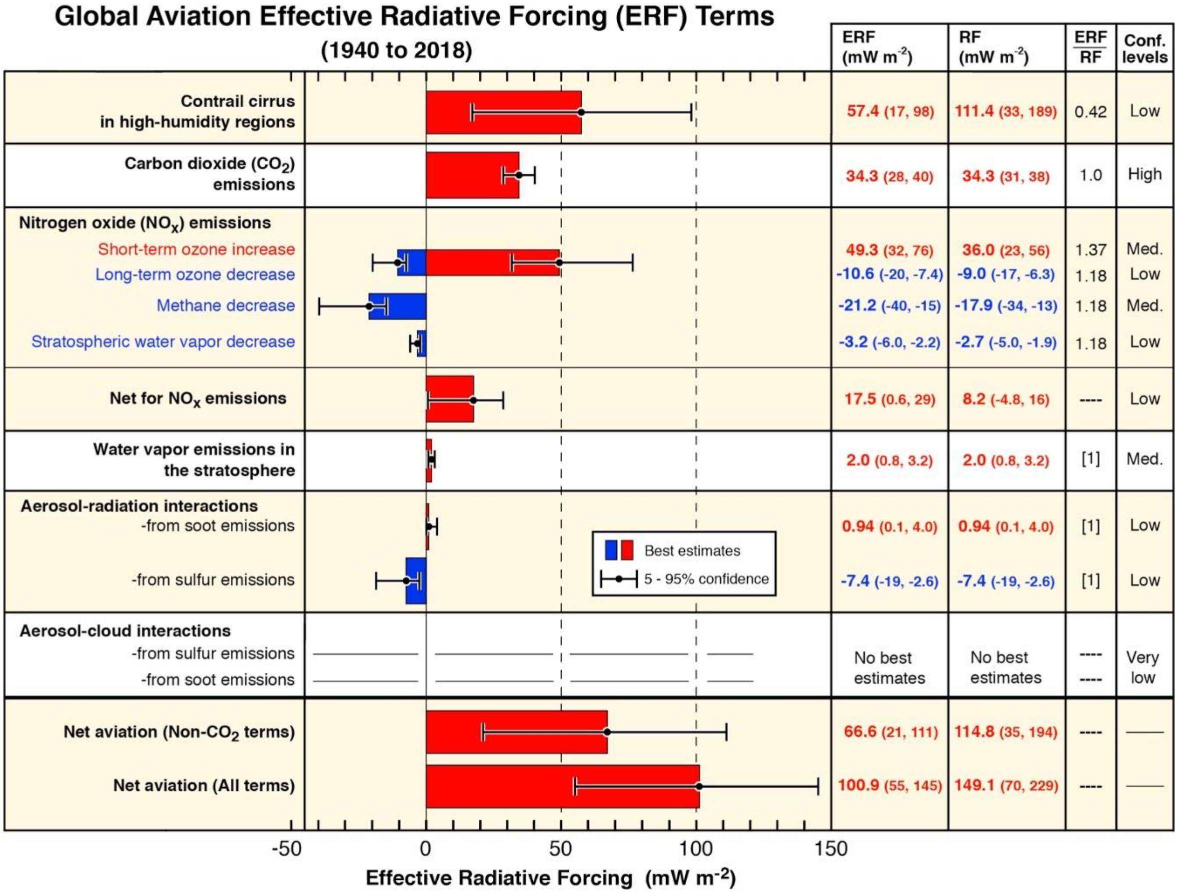
This shows that a complete assessment of aircraft flight impacts on the climate system will be complex and that the direct carbon emissions are just one aspect of them. Some of the processes illustrated are well characterised and impacts can be assessed with reasonable confidence, CO_2 effects for example. However, for many there are considerable uncertainties, either because they show variation geographically and temporally or because of the complexity of their interaction with the climate system. Estimating the impacts of contrails on cirrus clouds, for example, has proved particularly difficult.

Some engine emissions, notably CO_2, have clear and well characterised warming effects. Some are cooling agents, for example emission of sulphur create an aerosol that reflects incoming radiation. Others act to have both warming and cooling effects; NOx for example, has a warming effect, in a complex process of generation of atmospheric ozone but also, by removing methane, a cooling effect, although the net result of these processes is warming.

The impacts of contrails and the role they play in the production of cirrus clouds is recognised as an important factor in warming. There are two major aspects of this. The immediate effect of linear contrails, which are often seen streaming from the wingtips of aircraft and which, in areas where there is much air traffic, seem to cover a significant proportion of the sky, and the longer-term effects contrails have on the production of cirrus clouds, known as contrail-induced cirrus.

The 2019 Guidance contained an assessment of the scale of these different effects, according to the best information available then, evaluated and compiled in a paper by Lee et al. 2009. At that stage the evidence showed that effects of CO_2 and NOx were the major factors and were assessed as known to a good and a fair level of confidence, respectively. The impacts of linear contrails had been known to a reasonable degree of confidence for some time and they were included in the assessments that were the basis of the 2019 Guidance. However, the processes involved in contrail-induced cirrus are considerably more complex and the scale of these effects appears to be very variable across the globe and over daily cycles. They have proved hard to characterise and were not included in the 2019 guidance as the level of confidence in the available estimates was considered poor.

Since 2009, there has been progress in estimates of warming impacts, in particular in the estimation of warming from contrail-induced cirrus. The table below is an update, taken from Lee et al (2020). It reflects the progress in quantifying processes and improving levels of confidence from a greater number of studies. The table represents the contribution of aircraft over the last 60 years. Impacts are expressed in both in terms of radiative forcing (RF), the parameter used in the 2019 guidance and effective radiative forcing (ERF), a parameter that allows for relatively rapid processes in the troposphere and is considered a more useful indicator of real climate impacts over the short to medium term.



Lee et al (2020)

There are several important features of this new assessment. In general, the scale of the different elements of radiative forcing is known to greater confidence, particularly in the cases of CO_2, the net result of NOx and the cooling effect of sulphur aerosol. The new assessment also takes account of progress in the estimation of contrail impacts. The incorporation of improved models of cirrus inducing processes into general circulation models (Chen and Gettelman, 2013, Bock and Burkhardt, 2016) and observations (Schumann et al., 2017, Bhagwan et al, 2014) enabled Lee et al. (2020) to produce an improved synthesis reflecting the best current information on flight practice and aviation emission inventories. There is now a fairly robust value for the contrail-induced cirrus, although it remains subject to wide confidence limits. This is now a large proportion of the estimate for total warming and dominates the contribution from contrails. Linear contrails contribute just 10% of the total contrail impact (Burkhardt and Kärcher, 2011).

The new assessment suggests that, mainly following the re-evaluation of contrail-induced cirrus, the non-CO_2 warming should now be considered as a more significant factor in overall estimates of aviation impact on the climate system, approximately twice the value of the CO_2 term. This would imply that the overall impact of flight is equivalent to approximately three times the CO_2 emission. Although this is not accepted as current practice, it may become so in future and so is relevant to the assessment of impacts of SAF as a mitigation measure for aviation climate impacts.

This assessment assumes that the use of LHF and the assessment of SAF blends may require revised values of AIF, reflecting the impacts that SAF will have on engine emissions.

As the different authorised SAFs have very different production processes and a range of different feedstocks even within a particular production process, there is no single assessment of these factors and each fuel will have to be considered on its own merits. There are, however, some broad common features of a SAF assessment.

In current use, SAFs such as HEFA-SPK are added to LHF to create a blend that can be used without engine modification. They are designed to perform exactly as the LHF component of the blend. The carbon emission from the engine will therefore be unchanged by the use of SAF, so that the direct impacts on the climate system will be similar (Stratton et al. 2011, Elgowainy et al. 2012). However, if the carbon content of the SAF is considered to be renewable and to have no net climate impact, the overall effect of the SAF component will be to reduce the long-term impacts (de Jong et al. 2017). For a 10% blend, for example, close to current practice, the net climate impact would, assuming zero-fossil rating for the SAF in question, be 90% of LHF. For a 50% blend, according to ICAO (ICAO GFAAF, 2017) the potential for several of the approved fuels, including HEFA-SPK, the net climate impact would be half that of LHF.

The secondary, non-CO_2, impacts of SAF have also to be considered. Emission measurements show a very similar NOx emission to LHF, so that the net warming due to engine emissions would be unchanged (Caporal et al. 2011, Bhagwan et al 2014). SAF contains only trace quantities of sulphur, so that cooling from sulphate aerosol would be very low. There is evidence for an increase in water vapour which could have a slight warming effect, but this is small in relation to the overall total ERF. However, the production of contrails, the effects of which are likely to assume more significance in future, would be unaffected by the introduction of SFA alone. The conclusion of this is that the secondary impacts of SAF will be very similar to those of LHF, and this will dilute their direct benefit on Scope 1 emissions to some extent, on present assessments, with the possibility of substantially diluting them in future.

The overall benefits from the use of SAF are usually quoted in terms of their “Well to Wake” (WtWa) life cycle emissions, including Scope 2 emissions from extraction, growing or sourcing feed stock through processing and blending to distribution. The 2014 Guidance considered only scope 1 emissions in evaluating carbon impacts, from the use of the fuel in aircraft flights. For the fuel considered, LHF, the Scope 2 emissions due to extraction, production and distribution could be considered to be roughly level across the fuel supply industries. These are given in the 2015 European Commission study of actual GHG fuel production data and, although there is considerable variability across producers, they are roughly 15g CO_2e/MJ on average, about 17% of the WtWa emissions for LHF. For SAF, significantly lower WtWa is claimed. However, there is a very wide variability of WtWa emissions across the range of currently viable SAFs. According to a highly detailed analysis by de Jong et al (2017), the best performing SAF, produced by the Fischer-Tropsch process (FTP) of gasification and conversion of woody biomass, shows about 90% reduction of WtWa CO_2 equivalent emissions, (and may even greater than 100% if process side benefits are taken into account) but is a costly option. HEFA-SAF gives about a 70% reduction at roughly twice the cost of LHF.

The impact of SAF on the Aviation Impact Factor (AIF) depends on the specific SAF, the inclusion or not of Scope 2 emission (but note that Scope 2 emissions are not included in the AIF at present) and the assessment of secondary impacts of flight. Assuming a current HEFA-SAP at a 10% blend and current estimates of indirect emission impacts, an AIF which for LHF would be 2 would become 1.9. If, however, Scope 2 emissions are included and assuming FTP at a 50% blend, the AIF would be 1.55.

This creates a new position in which fuels are sharply differentiated by inclusion of Scope 2 emissions associated with their production and distribution. In some cases, for example FTP, the benefits of SAF go well beyond the displacement of fossil fuels from aircraft operations. It also suggests a case for requirement to consider Scope 2 emissions in Carbon Neutral certifications for air travel, passenger and logistic, more generally.

3.2 Sustainability

If SAFs are to be widely adopted they will become a large part of the total global production of biofuels. It will therefore be very important to ensure that they will confirm to high standards of sustainability. The history of biofuels contains many examples of unsustainable practice including diversion of food plants directly to biofuel, the displacement of diverse and sustainable agriculture for planting monocultures of feedstock vegetation and the use of valuable post-harvest waste for feedstock, depriving agricultural land of important nutrients (ref EASAC 2015). In promoting SAF as a major component of the aviation industry future strategy, the industry will need to ensure robust sustainability and a mechanism for removing unsustainable biofuels from the market.

The developers of SAF as a concept appear very aware of unfortunate antecedents and have themselves been at pains to set high sustainability criteria, based often on recognised standards for offsetting. ICAO requires that fuels in use in aviation should achieve net GHG emissions reduction on a life cycle basis, respect areas of high importance for biodiversity, conservation and for ecosystem services and contribute to local social and economic development. Competition with food and water should be avoided.

Examples of sustainability criteria for SAF in major treaty-backed trading/offsetting schemes illustrate the general approach.

ICAO, for example, stipulates that, “in order for an aviation fuel to be considered a sustainable aviation fuel (SAF), it will need to meet sustainability requirements” set within CORSIA, which focus on the issue of land use. They are that:

“Sustainable alternative fuel for reactors (jet engines) will generate net GHG reductions of at least 10% compared to fossil fuel for reactors, based on the life cycle.

“Sustainable alternative Fuel will not be produced from biomass obtained from land whose uses changed after 1st January 2008 and which has been from primeval forests, wetlands or peatlands, as all these lands have high carbon stocks.

“In the case of a change in land use after 1st January 2008, as defined on the basis of the IPCC land categories, emissions from direct land use change (DLUC) shall be calculated. If the greenhouse gas emissions from a DLUC exceed the default value of the land use change induced (ILUC), the value of the DLUC will replace the default value of the ILUC. “

Similarly, the sustainability criteria for SAF within the European Union Emission Trading Scheme (EU RED II, 2018) are, for GHG reduction, that:

“Greenhouse gas emissions from aviation sustainable fuels must be lower than those from the fossil fuels they replace: at least 50% for production facilities prior to 5 October 2015, a mandatory reduction of 60% for production facilities after that date and 65% for sustainable fuels (SAF) produced in facilities starting operations after 2021.”

and for land use, carbon stocks and biodiversity, that:

“raw materials for sustainable fuel production cannot be sourced from land with high biodiversity or high carbon stocks (i.e. primary and protected forests, biodiversity-rich grasslands, wetlands and peatlands). Other sustainability issues are set out in the Governance Regulation and may be covered by certification schemes on a voluntary basis.”

The key features of the criteria in these examples are that there is a life cycle requirement, although they seem rather modest in the CORSIA case set against industry claims of at least 60% reductions in carbon, and that there is a focus on land use provisions.

However, there are also organisations and companies offering higher standards and SAF with more onerous and specific criteria, relating, for example, to the specific exclusion of material derived from palm oil by products. The Roundtable on Sustainable Biomaterials, for example, has set high standards for sourcing bioenergy focussing on the achievement of the UN Sustainable Development Goals, including limiting harmful land use change and the protection of wildlife and biodiversity.

In practice, companies looking for ways of reducing carbon footprint, but aware of the reputational considerations associated with the use of biofuels, have sought SAF providers that can deliver SAF with high sustainability criteria. For example, a recent partnership between a large company in the IT sector, seeking to reduce impacts of corporate travel, has teamed with a supplier to provide SAF from waste oils for specific heavily used routes. The company in question has also agreed to buy SAF credits to be delivered to the airport fuelling system used by the route operator. **https://skynrg.com/press-releases/skynrg-and-microsoft-partner-to-scale-up-solutions-to-reduce-in-sector-carbon-emissions/**

4. Conclusions and Recommendations

There are now firm commitments from the aviation industry in partnership with the International Civil Aviation Organisation, to cap the total emission of fossil carbon from aviation over the period 2020 to 2035 and to reduce emission by 50% by 2050. Sustainable Aviation Fuels are expected to play a major part in achieving these aims.

Several SAFs have been authorised for use on passenger flights and there is now a substantial body of experience in using them. The most widely used SAFs are “drop in” fuels that can be substituted for conventional aviation fuels. The current leaders are derived from plant material or from recycled wastes and meet criteria for renewable fuels.

However, the cost of SAFs is considerably higher than conventional LHFs. The main barrier to price reduction is the investment required to grow the scale of production to economically sustainable levels. Market mechanisms based on offsetting have been proposed as a means of overcoming this market failure by incentivising uptake.

In use, SAF displaces conventional LHF, replacing the fossil carbon with renewable carbon so that the direct impacts of flight are reduced proportionally to the amount of SAF in the blend. However, the secondary effects of aircraft flight, including impacts of non-CO_2 engine emissions and of flight itself (contrails and induced cirrus) are currently recognised as of a similar order to the direct impacts and emerging evidence suggests that future assessment may put them of an order twice the direct impacts of total engine CO_2 emissions. This dilutes the direct benefits of SAF by factor of approximately 2 now but possibly more in future. There are, then, direct Scope 1 gains from the use of SAF, but, at current blending levels they are relatively modest.

However, for some emerging biofuels, the life cycle benefits of SAF are also in Scope 2 emissions, in reduced non-renewable energy use for collection, processing and distribution compared to LHF. Estimates of this are that SAF could, at expected future blend rates of 50%, produce a reduction of AIF by over 20%.

Realising this advantage will require mechanisms to incorporate Scope 2 emission in carbon calculation for both SAF and LHF and ensuring that certification schemes have ambitious life cycle carbon reduction requirements.

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