The First Use of Sustainable Aviation Fuel (SAF) In Antarctica

The Less Widely Known Environmental Benefits of SAF
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A Brief History of SAF

Biofuels are not a new product. I recently found my BSc Environmental Science degree notes from a course on “Energy from Biomass”, where aviation fuels were discussed. I had submitted a course paper on potential options for aviation fuels produced from biomass… in 1999.

Fast forward to 2019, at the Aviation and the Environment conference at Cranfield University, I heard a presentation by the International Airlines Group on an ongoing Sustainable Aviation Fuel (SAF) production project. Over those 20 years, SAF had clearly evolved from an academic subject matter to an innovative and viable product.

Of the numerous aviation projects I was working on at the time, my project in Antarctica with White Desert seemed like the perfect environment and opportunity to potentially use SAF. With the support and interest of White Desert, within three years (the 2021 Antarctic summer season) White Desert became the first organisation to purchase SAF for use in Antarctica.

Interest in and demand for SAF has grown considerably since then, due to the lower carbon emissions it provides. It is an existing solution for reducing carbon emissions for the aviation industry, as it can be used as a "drop-in" fuel which does not require adaptation of aircraft or airport infrastructure.

By 2025, SAF will have completed its journey from an innovative product to a mandatory product required under legislation.

This legislation requires 2% of the total fuel supplied at EU airports to be SAF, increasing to 70% by 2050. The UK has followed suit, with the proposed SAF Mandate to be introduced in 2025. The SAF Mandate would require at least 10% of jet fuel to be made from sustainable feedstocks by 2030.

The additional environmental benefits provided by SAF are less widely discussed but are equally as important.

These include the contribution to the Circular Economy when produced from waste, lower impacts on air quality with virtually no sulphur and lower nitrogen oxides. There are also indications that SAF produces fewer contrails leading to less atmospheric warming. It was these other environmental benefits which made SAF a desirable fuel to use for operations in Antarctica.

Circular Economy

SAF is not currently approved to be used in its pure form; it is required to be blended with petroleum based, traditional jet fuel (Jet A1). Current permissible blends can be up to a maximum of 50%, though SAF blends can be purchased as low as 2%. I was interested in a higher percentage blend in order to increase the benefits and we were able to secure a supply of SAF which provided a 29.7% blend of SAF.

There are also a number of production methodologies which vary depending on the feedstock. There are currently nine approved processes with a further eight production methods in the process of approval.

The main approved production methodologies include the use of:

- Fischer Tropsch synthesized isoparaffinic kerosene (FT-SPK)
- Synthesized isoparaffins (SIP)
- HH-SPK (Hydroprocessed Hydrocarbonssynthesized isoparaffinic kerosene) or HC-HEFA
- Hydro-processed fatty acid esters and fatty acids (HEFA)
- Catalytic Hydrothermolysis Jet fuel (CHJ)

In particular, I was interested in production methods which use a waste product as this contributes to the Circular Economy avoiding the use of bio-crops and their associated environmental impacts. The SAF procured for our project uses HEFA which are then converted to aviation fuel. The feedstock for this production method can vary but our feedstock was yellow grease, a food industry waste product, composed of waste oils and greases. The use of a waste product in the production of SAF diverts waste oils from landfill and results in recycling of waste oils contributing to the Circular Economy. As well as diverting waste oils from landfill sites, the commercial value of waste oils also means that it is less likely to be illegally discarded causing water or land pollution.

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Photograph 1 Wolf's Fang Blue-ice Runway

SAF Production and Supply

Though there are a number of SAF production plants under construction or in the feasibility stage, there are currently only a few SAF plants in operation, including in the USA, Singapore and the Netherlands. Demand greatly exceeds supply.

In 2022 total SAF volumes production was estimated to be 300 million litres, a trifold increase on the 2021 production of 100 million litres per annum . For our project, we were able to secure a supply of 40,220 litres (or 10,625 US gallons) blended SAF which comprised 11, 927 litres (3,151.47 US gallons) of neat SAF with the 29.7 % blend. For a relatively small organisation specialising in the niche area of Antarctic logistics and travel, it represented a significant step in the direction of travel.

Carbon Savings

Our supply came from Los Angeles. As transport via cargo ships has a significantly lower carbon footprint (per tonne of cargo, per kilometre travelled) than overland haulage using heavy goods vehicles, we were still able to achieve carbon savings, as well as the other environmental benefits.

The carbon savings of SAF are realised through the feedstock which, as an existing waste product of the food industry, is considered to have a carbon footprint of zero.

Neat SAF typically provides approximately 80% less carbon than petroleum-based Jet A1 depending on the production methodology used. For our project, the neat SAF provided a saving of 83% using hydrotreatment production methods. Taking the blending percentage into account, this provided an overall carbon reduction of 24.7%.

The independent Life Cycle Analysis (LCA) for our SAF considered the carbon footprint from the production plant in the USA, to the port in Cape Town, where the SAF was shipped to Antarctica on an existing shipment route. Taking the transportation into account, the LCA indicated that the neat SAF provided 72% lower carbon footprint than fossil fuel JetA1, an overall saving of 21%.

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Reduction In Contrails and Reduced Atmospheric Warming

Most of the focus in using SAF is around the reduction in carbon emissions it provides. As an environmental scientist, I am interested in all aspects of the environment.
Contrails from aircraft form when air condenses around soot and ice particles, or condensation nuclei. Under certain conditions, such as high moisture in the atmosphere, contrails form contrail cirrus clouds which can have a warming affect on the atmosphere by

trapping heat. Generation of contrails is considered an adverse environmental impact of aviation which needs to be addressed.

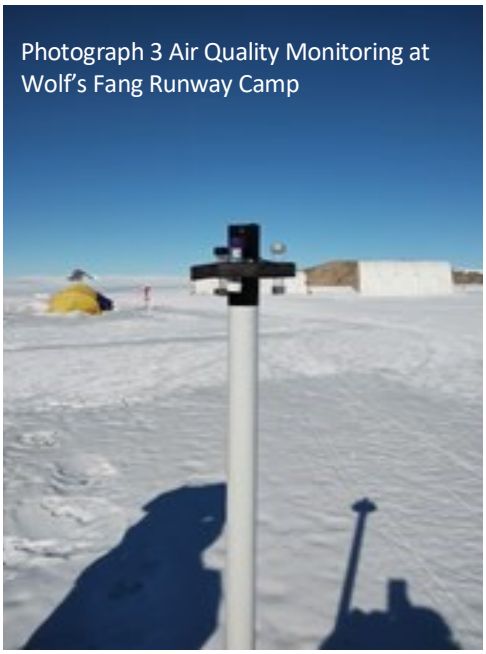
Research indicates that in comparison to petroleum based JETA1, SAF blends produce fewer contrails, with some indications of a 50-70% reduction in soot and ice particles concentrations and an increase in ice crystal size. Reduced contrails result in less warming of the atmosphere which is another benefit of SAF requiring further research and consideration.

Photograph 2 Basler Aircraft at Wolf's Fang Runway Photograph © White Desert

Local Air Quality Improvements and SAF

Other measured environmental benefits in terms of air quality include virtually no sulphur emissions and a significant reduction in particulate matter in comparison to JetA1.

There are indications of reductions in nitrogen oxides and moderate reductions of carbon monoxide and unburnt hydrocarbons, through testing of emissions in flight. Research has also been carried out in order to measure local air quality around airports when using SAF blends in comparison to petroleum JetA1 . This has also shown improvements in local air quality parameters.



Photograph 3 Air Quality Monitoring at Wolf’s Fang Runway Camp

Air quality emissions of SAF is an area where further research is required, however initial indications have been positive.

According to the WHO, 99% of the global population breathes air which exceeds WHO air quality limits. Air quality in Antarctica is considered pristine. Antarctica is the only continent without any exceedances in air quality against the

WHO standards and the atmosphere is virtually free of anthropogenic pollutants such as nitrogen oxides and particulate matter.

Therefore, the troposphere is considered to be a very sensitive and valuable environmental receptor in Antarctica. This needs to be taken into account not only as part of the environmental assessment process but also during the environmental management and operations we undertake in Antarctica.

Operating in a pristine air quality environment highlights the important benefits of using SAF for aircraft operations in Antarctica, through the reduction of air pollutants.

This has the added benefit of lower deposition of particles such as soot on the Antarctic blue-ice environment.

There are published air quality data for different regions and locations in Antarctica collected by National Antarctic Programmes. The data identifies very low levels of nitrogen oxides and sulphur dioxide. However, there was no published air quality data for the region within Dronning Maud Land where White Desert's Wolf's Fang Runway is located.

To help understand the air quality in the environment where we operate, this year we carried out initial air quality monitoring at Wolf's Fang Runway, one of five blue-ice runways in Antarctica. This included air quality monitoring at the Wolf's Fang skiway, the staff camp as well as background air quality measurements upwind. The results were in line with other monitoring carried out in Antarctica.

This season formed an air quality monitoring baseline at the runway. Our plan is to continue and expand the air quality monitoring at the runway and skiway in order to assess and measure changes in the local air quality through the use of SAF blended fuels in future seasons. By establishing the baseline, we will be able to compare the use of traditional JetA1 with SAF and identify any local air quality benefits.

The Future

The strategy is to increase the use of SAF so that all of White Desert's flights within Antarctica are carried out using SAF. This could also be extended to include the flights to Antarctica from Cape Town. This will not only help enable the Science Based Targets and Pledge Net Zero to be met. Equally as important, this will help realise the other environmental benefits for air quality in Antarctica, play a role in the creation of a circular economy and inspire other organisations operating in Antarctica to take similar steps.

Author

Eleni is a Project Environmental Lead for aviation and infrastructure projects, with more than 20 years experience in the Environmental Impact Assessment and environmental management of projects in challenging environments, such as Antarctica and military airfields.

Photograph 4 Antarctic Site Visit 2023

Recent achievements include launching the first use of Sustainable Aviation Fuel in Antarctica in 2021, becoming Vice Chair of the first dedicated environmental science body at the UK Institution of Environmental Sciences in 2021.

Eleni is an Environmental Scientist, Chartered Environmentalist, Full Member and Vice Chair of the Institution of Environmental Sciences where she established the EIA Community and has helped shape the organisation's strategy since 2016.

[1] According to the International Air Transport Association (IATA) website

[2] Cleaner burning aviation fuels can reduce contrail cloudiness, https:// doi.org/10.1038/s43247-021-00174-y

[3] Cleaner burning aviation fuels can reduce contrail cloudiness, https:// doi.org/10.1038/s43247-021-00174-y

[4] Sustainable Aviation Fuel: Greenhouse Gas Reductions from Bay Area Commercial Aircraft, Gladstein, Neandross & Associates, October 2020

[5] https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data

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