Aviation is responsible for 2% of global carbon dioxide emissions

THE ROAD TO RENEWABLE FUEL

In the global race to decarbonize the airline sector, Brazil could fulfill a leading role through the production of an alternative to fossil-based kerosene

Frances Jones

At the end of 2023, British airline company Virgin Atlantic flew a Boeing 787 from London to New York, which was completely powered by sustainable fuel. As the first transatlantic flight of a major commercial aircraft without the use of fossil-based aviation kerosene, this historic event made headlines around the world. The airline stated that alternative fuel, prepared from used cooking oil, animal fat, and 12% synthetic aromatic kerosene—which does not originate from fossil sources—could reduce greenhouse gas (GHG) emissions by up to 70% compared with those when flying the same route involving traditional jet fuel.

Virgin Atlantic obtained special authorization for this demonstration flight. Current regulations issued by the American Society for Testing and Materials (ASTM), followed by those issued by Brazil's National Petroleum, Natural Gas and Biofuels Agency (ANP), only allow airlines to use a maximum of 50% of sustainable aviation fuel (SAF).

Various technologies and raw materials can be used to produce SAF, ranging from oilseeds to ethanol and urban solid waste. What all these inputs share in common is that they contain carbon, which is the main precursor of the hydrocarbons for preparing SAF).

The aim is for planes to be fueled with aviation kerosene, SAF, or a mixture of the two. SAF molecules are practically identical to those of fossil-based kerosene, indicating that no changes in aircraft engines and fueling infrastructure are needed.

The amount of SAF in the fuel mix is restricted to 50% for safety reasons. "Not all SAF production methods lead to a sufficient amount of aromatic hydrocarbons, which are essential to ensure that the produced fuel maintains the same viscosity and does not freeze at high altitudes," explained Fernando Catalano, director of the São Carlos School of Engineering at the University of São Paulo (EESC-USP).

Fossil kerosene consists of a mixture of various hydrocarbon types and usually contains between 10% and 25% aromatics, which are considered pollutants but are necessary substances. "It is a problem that has not yet been resolved, but it will have to be overcome at some point," noted Catalano, highlighting two other existing obstacles to the large-scale adoption of SAF: the global production capacity is still very low compared to the demand, and the estimated cost varies between three and five times that of aviation kerosene.

Brazilian aerospace company Embraer, headquartered in São José dos Campos, has also tested the use of SAF in its planes. In June 2022, one of its E195-E2 commercial jets completed a flight with 100% biofuel in one of its two engines. Later, in October 2023, two of the company's executive jets completed test flights powered entirely by SAF.

BARRIERS TO DECARBONIZATION

Sustainable aviation fuel is the airline sector's best hope for quickly reducing its carbon footprint. Aviation is responsible for approximately 2% of all global carbon dioxide (CO_2) emissions, releasing 800 million tons of gas into the atmosphere every year. It is considered one of the most difficult sectors to decarbonize, and airplanes are among the most polluting modes of transport.

In 2022, the member states of the International Civil Aviation Organization (ICAO) approved a global target of zero carbon emissions in the sector by 2050. At a meeting in the United Arab Emirates at the end of 2023, they further committed to reducing the CO_2 emissions of international aviation by 5% by 2030.

More than 600 million liters of SAF was produced in 2023, which is double that in the previous year, according to the International Air Transport Association (IATA). Production is expected to triple this year. Despite this increase, the expected volume represents only 0.53% of the global demand for aviation fuel. The USA, China, Japan, Singapore, Germany, Norway, and Mexico currently manufacture SAF.

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"It is still unclear who will be the major suppliers of SAF in the future, but they will most likely be the oil companies that currently produce aviation kerosene," said Catalano, who is also a member of the independent panel for the environmental impact of aviation of the ICAO.

With growth in the airline sector expected in the coming years, which is still recovering from the pandemic, emission reductions achieved through technological innovation, new, more efficient aircraft, and optimized operations are unlikely to be enough. Alternative fuels are needed to achieve the zero-carbon target. "The IATA estimates that SAF will contribute more than 60% toward net zero emissions by 2050," noted Catalano.

In a global industry that is still in its infancy, according to experts, Brazil exhibits an opportunity to position itself as a central player due both to the country's experience producing biofuels and the amount of biomass available to manufacture SAF. "If there is one place in the world where the large-scale production of SAF will succeed, it's Brazil," emphasized Glaucia Mendes Souza, a biochemist of USP's Chemistry Institute and one of the managers of the FAPESP Bioenergy Research Program (BIOEN).

"We have an abundance of various inputs needed to produce this fuel, including ethanol. However, for now, the method for converting ethanol into sustainable aviation fuel, known as the alcohol-to-jet (ATJ) method, is not economically competitive," said the researcher. "The hydroprocessed esters and fatty acids (HEFA) method offers better value. However, the problem with this approach is sustainability. Some countries, mainly in Europe, do not want to use palm oil, which is associated with the highest oilseed productivity in Brazil."

THE AIRLINE SECTOR HAS SET A GLOBAL TARGET OF ZERO CARBON EMISSIONS BY 2050

The two production methods most commonly approved are the HEFA and ATJ techniques, with the former being used in the Virgin Atlantic demonstration flight, accounting for more than 80% of the total current global SAF production. Europe does not consider palm oil sustainable because it is often produced via predatory practices involving the destruction of native forests, especially in Southeast Asia.

Sustainable aviation fuel is not yet being produced on a commercial scale in Brazil, but several projects are making headway. In Natal, Rio Grande do Norte, the Senai Institute for Innovation in Renewable Energy (ISI-ER), launched a pilot SAF plant in September last year, called the Hydrogen and Advanced Fuels Laboratory (H2CA).

Its current aim is to increase production from 200 milliliters (mL) per day to approximately 5 liters (L) per day. "We have already produced synthetic oil in the laboratory, the composition of which contains SAF, using a method known as the Fischer–Tropsch (FT) process," said chemist Fabiola Correia, project coordinator at ISI-ER. "We are now optimizing the process conditions to increase the production efficiency."

The main raw material used at the pilot plant is glycerin obtained from the production of bio-

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Aircraft produced by the European manufacturer Airbus is fueled with aviation biofuel

SAF sample produced at the Senai Institute for Innovation in Renewable Energy in Natal, Rio Grande do Norte

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diesel. "In the oil transesterification process, 90% of the output is biodiesel, with 10% glycerin. Glycerin is polluted and contains contaminants, creating a liability for the biodiesel industry. We had the idea of converting this glycerin, together with the contaminants contained in it, into a product of great industrial demand, i.e., SAF." Currently, almost all the glycerin generated in Brazil is sold to China at very low prices.

In another project at the laboratory in Natal, the raw material for producing synthetic gas—with which SAF is produced via the FT process—is CO_2 captured from air and green hydrogen (a clean fuel generated by breaking down water molecules; *refer to* Pesquisa FAPESP *issue no. 317*). "We currently work with these two different processes that yield glycerin and CO_2 captured from air. We chose the FT method owing to its versatility, since it can be used with a variety of raw materials," noted Correia.

In addition to ISI-ER, at least four other companies have already announced plans to produce SAF in Brazil: Acelen in Bahia; Petrobras in Cubatão, São Paulo State; Brasil BioFuels in Amazonia; and Geo Biogás in Paraná. The Brazilian holding company ECB Group announced that its subsidiary Be8 Paraguay will build a biorefinery in the neighboring country to produce 20,000 barrels of advanced biofuels per day, including SAF.

In mid-2023, Raízen, the largest sugarcane ethanol producer in the world, announced that it had received ISCC CORSIA Plus certification, allowing the ethanol generated at one of its plants to be used to manufacture SAF. The objective of ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is to ensure that biofuels are manufactured in a sustainable manner.

Similar to many airlines, aircraft manufacturers generally support SAF research, development, and production. Boeing is funding the third phase of the SAF Maps project in Brazil, led by the University of Campinas (UNICAMP), which is seeking additional information to meet CORSIA's sustainability criteria. The platform includes biomass data on six agricultural crops (sugarcane, eucalyptus, soy, maize, palm oil, and macaw palm) and two biomass residues (beef tallow and steelmaking gases) in 13 Brazilian states.

Moreover, Embraer was involved in tests for the approval of HEFA and SIP (synthesized isoparaffins produced from fermented hydroprocessed sugars) technologies. The company is also engaged in projects linked to studies on the impact of land use in Brazil, thereby mapping the opportunities and challenges of the SAF chain in the country and Europe. It is also part of the BioValue initiative, led by the National Biorenewables Laboratory (LNBR) at the Brazilian Center for Energy and Materials Research (CNPEM).

Funded by FAPESP, BioValue comprises 20 Brazilian scientific and technological institutions and companies that work together with European researchers on the development of biofuels, especially for aviation. In 2023, FAPESP and Embraer opened the Engineering Research Center for Future Air Transport at the Technological Institute of Aeronautics (ITA), with the goal of increasing the competitiveness of the aeronautical industry of Brazil. One of the focuses of this center is the reduction in GHG emissions.

LEGISLATION

Experts in this area consider that investment in SAF production will increase after the approval of Bill 4.516/2023, which is currently being debated in the Brazilian Congress. Referred to as the "Fuel of the Future" bill, it provides for the creation of a National Sustainable Aviation Fuel Program (ProBioQAV). "The main objective is to promote the SAF industry in Brazil," stated Darlan Santos of the National Civil Aviation Agency (ANAC). The bill requires airlines to reduce emissions from 2027 onward, primarily through the use of SAF. In the first year, the mandatory reduction is 1%, increasing to 10% in 2037.

"As written, the bill allows for the fuel to be stored in hubs—main airports, such as Guarulhos—near production sites. This would also minimize the emissions generated by transporting the liquid," argued Santos. According to Santos, approximately four years are needed to build an SAF plant that is ready to start supplying fuel. Many of the plants that have already been announced will begin operating between 2025 and 2026. ■

The projects consulted for this report are listed in the online version of this article.

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