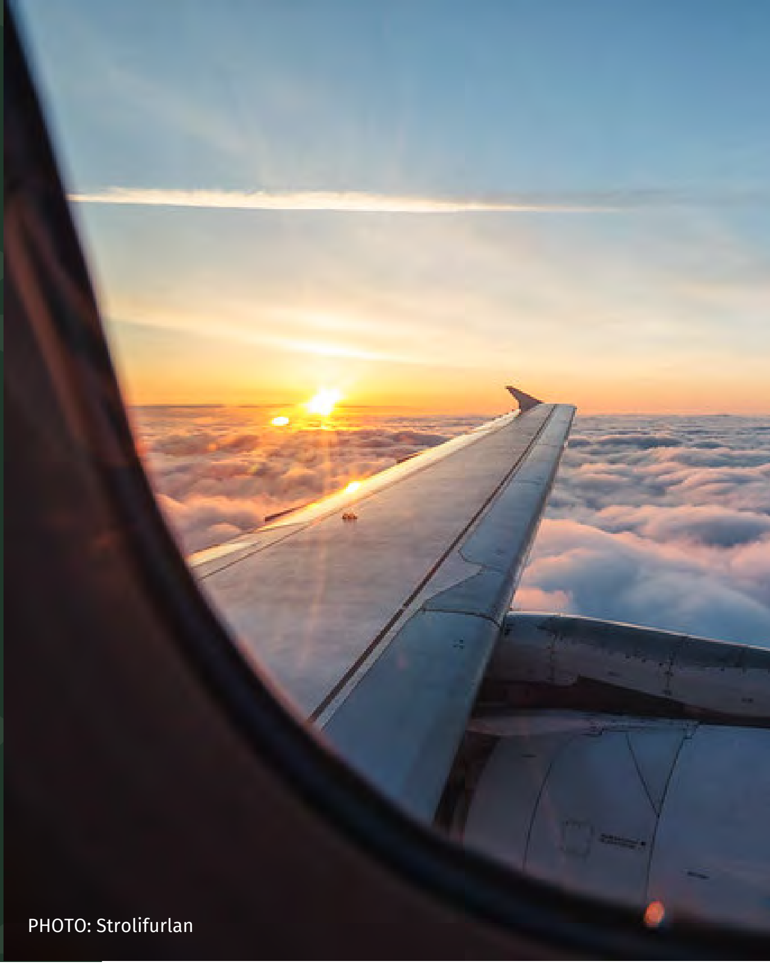
The Future of Sustainable Aviation Fuel

Powering air transport without harming the climate will require new fuels that reduce or eliminate greenhouse gas emissions while also preventing the destruction of important wildlife habitat.



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As the United States and other nations rush to reduce greenhouse gas (GHG) emissions that are altering the climate, the transportation sector stands out as one that has received a lot of attention and, yet, remains one of the more difficult to decarbonize. Transportation is now the largest source of domestic GHG emissions, responsible for about 28.9 percent.[1] While electrification of light-duty on-road vehicles has picked up steam recently, this is not an option for most types of aviation, which currently accounts for 11.5 percent of the petroleum used in transportation, as well as maritime shipping.[2] This share is only expected to grow over time as more people fly and on-road emissions decline.

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In the face of rising demand and lack of electrification potential, policymakers and the aviation industry have turned their attention to promoting sustainable aviation fuels (SAFs) as the primary route to decarbonization. SAF has been produced in small quantities for decades, with many companies and various policies attempting to find a way to produce it at scale and at comparable cost to traditional, petroleum-based fuel. This is a key hurdle for the industry to jump, particularly in the short time between now and mid-century decarbonization goals.

Defining What Qualifies as "Sustainable"

In the most general terms, SAF is fuel that is not made from petroleum but still meets all of the standards and protocols to safely and efficiently power aircraft. They are produced as drop-in fuels, meaning they can fully replace or be mixed in with traditional fuels in current aircraft designs. Beyond that, however, there is no consistent definition across industry, state and federal policy, and international boundaries.

Recognizing that "non-petroleum" was not a sufficient definition of SAF, the National Wildlife Federation joined with industry, scientists, and other organizations representing conservation and social justice to launch in 2007 the Roundtable on Sustainable Biofuels (now the Roundtable on Sustainable Biomaterials, or RSB). The RSB developed robust standards for social and environmental sustainability, including GHG emissions, land use change, water consumption, and more.[3] This has become the gold standard for SAF and other bio-based products, but is not yet universally adopted by industry or in policy.

The United Nations' International Civil Aviation Organization (ICAO), of which the United States is a participating member, has produced its own criteria and methodologies for defining and classifying SAF, drawing on the RSB standards.[1] The European Union has further deemed that crop-based fuels made from traditional sources like corn, soy oil, and palm oil do not qualify for its SAF mandates.[4]

As for the United States, the Biden Administration's SAF Grand Challenge, launched in 2021, defines SAF as, "drop-in fuel from wastes, renewable materials, and gaseous sources of carbon that achieves a minimum of 50% reduction in life cycle GHG emissions compared to conventional fuel."[5] The Inflation Reduction Act that was signed into law in 2022 includes a SAF production tax credit for fuels that meet the 50 percent life-cycle reduction threshold as determined by the ICAO procedure, or a "similar" methodology.

Sources, Benefits, and Potential Pitfalls

To date, production of SAF outside of the laboratory has consisted of fuels derived from oils, also known as fatty acids, from plant and animal sources. The largest share comes from virgin vegetable oils such as soy, palm, and canola, with the rest coming from wastes such as used cooking oil and tallow from livestock slaughter and processing. Biodiesel has been powering cars and trucks for decades and can be refined further into jet fuel. Newer processes can also convert ethanol from starchy sources such as corn and sugar cane into jet fuel, as well as from ligno-cellulosic sources like corn stalks and wood residue. Various synthetic processes have also been developed or researched to produce jet fuel from abiotic sources, such as through the electrolysis of carbon dioxide in water to produce hydrocarbons that can be refined into jet fuel. None of these newer pathways, however, has been produced at commercially viable cost or scale.

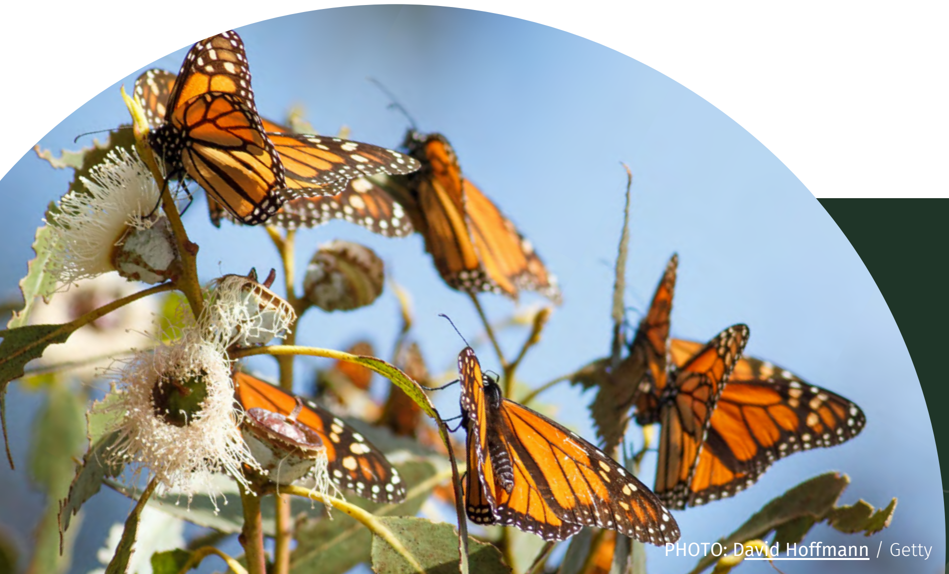

PHOTO: David Hoffmann / Getty

Bringing back butterflies. Various types of grasses and other annual plants have the potential to produce the building blocks for sustainable aviation fuel without harming the landscape.

While challenges exist to their commercialization, the potential benefits of these fuels are enormous. They can provide fuels that match the performance of fossil fuels with half, or even 10 percent, of the GHG emissions on a life-cycle basis.[6] In some production scenarios they could even be carbon-negative.[7] SAF combustion also emits lower levels of other pollutants like benzene and particulate matter, improving health and safety especially in communities surrounding airports. They would avoid the need for drilling and extraction on environmentally sensitive or culturally important lands while providing new revenue streams for rural and urban communities across the country.

However, SAFs can also have a significant negative impact if appropriate safeguards and monitoring are not put in place. Crop-based biofuels are poised to dominate SAF production in the near term. Yet, a growing body of scientific research posits that industrial farming of corn and soy for domestic biofuels has led to increased habitat destruction, water pollution, and even GHG emissions from loss of soil carbon.[8] The additional refining of starchy or cellulosic materials, and especially synthetic fuels, will require larger energy inputs that must be drawn from carbon-free sources. And, if the various models that are used to qualify a fuel as "sustainable" don't account well enough for issues like land use change, soil carbon gains and losses, and power sources, these fuels could be credited and rewarded for climate gains that might not exist while creating environmental harms at the same time.

Charting a Successful Path Forward

It is clear that SAFs must and will play an important role in reducing aviation's climate footprint over time. The industry needs additional support with research, development, and demonstration of new technologies and diverse feedstocks, and financial interventions to achieve cost-competitiveness. With clear-eyed policy support that balances the potential benefits while avoiding, minimizing, and compensating for the risks, the industry can flourish.

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[1] EPA, U.S. Greenhouse Gas Inventory Draft 2024 Report https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022
[2] Ibid.
[3] RSB Principles and Criteria https://rsb.org/framework/principles-and-criteria/
[4] ICAO https://www.icao.int/environmental-protection/pages/SAF.aspx
[5] EU Renewable Energy Directive 2018, Annex IX https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC
[6] U.S. Government, SAF Grand Challenge Roadmap 2022 https://www.energy.gov/sites/default/files/2022-09/beto-saf-gc-roadmap-report-sept-2022.pdf
[7] CORSIA 2021, https://doi.org/10.1016/j.rser.2021.111398
[8] U.S. Department of Energy, SAF in Action
[9] See Lark 2022, US EPA Third Triennial Report to Congress