Sustainable Aviation Fuel: Decarbonizing the Skies

by Wesley Hovatter

The wider adoption of Sustainable Aviation Fuel (SAF) can help contribute to a greener and more sustainable future for air travel.

Conventional jet fuel is undoubtedly a carbon-inefficient fuel. With nearly 7 pounds of carbon dioxide (CO_2) emitted per pound of traditional jet fuel consumed, the aviation sector currently emits over 250,000 tons of CO_2 per year in the United States alone. This sector accounts for 3% of the United States' total emissions and 2.8% of global emissions,[1] and if left unchecked, it is predicted jet fuels could be responsible for 0.1 °C of warming by 2050.[2] Although all industries have faced mounting pressures to reduce their carbon emissions, with this level of emissions, it is no surprise that the aviation sector has drawn particular attention for its reliance on carbon-intensive fuels.

Sustainable Aviation Fuel

Fortunately, this past May, as part of the Biden administration's Inflation Reduction Act (IRA), the U.S. Department of the Treasury unveiled a tax credit scheme to promote the widespread adoption of cleaner alternatives, one of the most promising being Sustainable Aviation Fuel (SAF).[3] SAF is particularly compelling because it is typically created from a wide range of renewable feedstocks including municipal and industrial food waste, woody biomass, sugars, starches, as well as fats, oils and greases, including from used cooking oil. Additionally, SAF can be blended with conventional jet fuel at various levels, typically between 10% and 50%, making it compatible with pre-existing fuel infrastructure.[4] Over 450,000 commercial flights annually already use SAF, representing a 430% growth in annual fuel usage since 2021, and continued growth can be expected in the next few years due to the new IRA tax incentive (see Figure 1).[2,5]

Compared to conventional jet fuels, SAFs produces no nitrous oxide or sulfur dioxide emissions, and typically reduce particulate matter emissions by 30% and CO_2 and methane emissions by 50%–90%, depending on which renewable feedstock it is produced from.[2] SAF can be produced through various processes; currently eight are certified for SAF production in commercial aviation. Among others, these include Catalytic Hydrothermolysis, Fischer-Tropsch synthesis, Hydrotreated Esters and Fatty Acids (HEFA), and alcohol-to-jet synthesis. Each process has its own set of advantages and challenges. For instance, HEFA is one of the most mature technologies and can utilize a variety of feedstocks, including used cooking oil and animal fats. Fischer-Tropsch synthesis, on the other hand, can convert biomass directly into liquid fuels, providing a versatile and scalable solution.[4]

SAF Incentives

Unfortunately, SAF is prohibitively expensive for mass adoption, with production costs for SAF ranging from 128% to 700% more than fossil-based jet fuels, necessitating incentives like the IRA.[6] Further, the U.S. Departments of Energy, Transportation, and Agriculture are actively supporting research and development efforts to advance SAF technologies and infrastructure to meet CO_2 emissions targets.[4] Additionally, the scalability of SAF production is constrained by the availability of sustainable feedstocks and the current production capacity. To address these challenges, ongoing research is focusing on improving the efficiency of SAF production processes and exploring new feedstocks that do not compete with food crops.

The International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) aim to cap net CO_2 aviation emissions at 2020 levels until 2035 and achieve net-zero carbon by 2050.[7] Along with other incentives in the IRA, like the carbon oxide sequestration credit, the SAF tax credit will help to achieve and surpass these goals.

Globally, different regions are adopting various policies to support SAF. In Europe, the European Union has set ambitious targets for SAF usage under its "Fit for 55" package, aiming for a 63% reduction in aviation emissions by 2050.[8] In the Asian-Pacific markets, development has been significantly boosted by various countries. Australia is expediting support for a low-carbon liquid fuel sector, while Japan and Malaysia are collaborating to supply SAF to help Japan achieve its 2030 targets. Additionally, Thailand is gearing up to launch a new refinery by 2025, with a focus on the development of SAF production from used cooking oil.[9]

The U.S. Department of Treasury's recent guidance on tax credits for SAF production marks a significant advancement in promoting cleaner aviation fuels. The IRA established the SAF tax credit to incentivize fuels that reduce emissions by 50% compared to traditional petroleum-based jet fuel.[3] Initially, the IRA did not include corn ethanol or biofuels from vegetable oil as qualified SAF. However, the new guidance incorporates the Greenhouse gases, Regulated Emissions, and Energy Use in Transportation (GREET) model to determine greenhouse gas emissions, which allows corn ethanol and other food crop-based fuels to qualify.[3] The adoption of this new GREET model offers significant incentives for refiners and ethanol-based SAF producers. Refiners can earn a credit of up to US$1.75 per gallon for SAF production, which is a notable compared to the US$1.00 per gallon credit available for typical non-aviation biodiesel blends.[3,10] Additionally, ethanol-based SAF becomes eligible for credits if corn farmers adopt "climate-smart agriculture" practices, such as sequestration, which aim to balance emission reduction with agricultural sustainability.[3]

Looking Ahead

The future of SAF appears promising. Technological advancements in areas such as synthetic biology and catalytic conversion hold the potential to further reduce production costs and increase the yield of SAF, making it a more viable alternative to traditional jet fuels. Synthetic biology could enable the engineering of microorganisms to produce biofuels more efficiently from various feedstocks, while catalytic conversion technologies could streamline the process of converting these feedstocks into high-quality aviation fuel.[11] Further, the development of more efficient production methods and the optimization of feedstock usage can significantly enhance the sustainability and economic feasibility of SAF.

As the aviation industry navigates the evolving regulatory landscape, the adoption and advancement of SAF is crucial for sustainability in this field and requires a multi-faceted

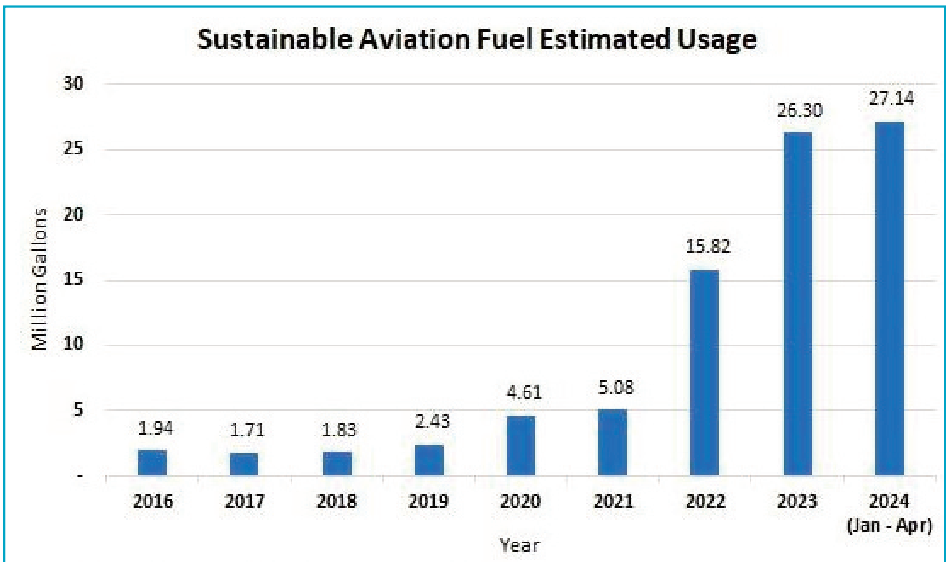

Figure 1. SAF estimated usage.
Source: U.S. Environmental Protection Agency (EPA).

approach, addressing technical, economic, and regulatory challenges. Research and tax incentives are essential for SAF development and adoption, enabling it to play a role in achieving global sustainability goals. By engaging in the transition toward sustainable aviation practices, industry players can mitigate environmental impacts and contribute to broader sustainability objectives. The path to decarbonizing aviation is complex, but with continued innovation and support, SAF can significantly contribute to a greener and more sustainable future for air travel. **em**

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