

# Aviation Biofuel

By John Benson

April 2026

## 1. Introduction

*Aviation biofuel (also known as bio-jet fuel, sustainable aviation fuel (SAF), or bio-aviation fuel (BAF)) is a biofuel used to power aircraft. The International Air Transport Association (IATA)<sup>6</sup> considers it a key element in reducing the environmental impact of aviation. Aviation biofuel is used to decarbonize medium and long-haul air travel. These types of travel generate the most emissions.<sup>1</sup>*

Although this post will focus on the title-subject, as described in the above paragraph, the other method to greatly reduce greenhouse gas (GHG) emissions from air-borne battery electric vehicles (BEVs) is to charge them with renewable electricity. I covered air-borne EVs in an earlier post summarized and linked below.

**A Short (& Fast) Hop:** *I have been tracking air-borne electric vehicles as part of my interest in electric vehicles (EVs) in general. Although there are major differences in the different types of EVs, they also share major technologies.*

*With respect to the title of the post, air vehicles (EVs and most others) tend to be much faster than the other categories, but if they are battery-electric (I can't think of any other reasonable air-borne method of obtaining electric power), they are also very range-limited with today's battery technologies.*

<https://www.energycentral.com/energy-biz/post/a-short-fast-hop-X88CuzAcoUhkPyu>

The good news with the title-subject of this paper, it will work with pretty much any jet aircraft, and thus could be quickly implemented, assuming adequate supplies of bio-jet fuel are available.

## 2. A Deep Dive into Aviation Biofuel Production

The excerpt below is from my primary reference, pages 135 to 137.<sup>2</sup>

*Making improvements in fuel properties can be envisioned in two ways: creating a different fuel or obtaining that fuel more efficiently. Let us look at a recent example. A cyanobacterium, Synechocystis, was shown to produce mostly saturated lipids containing 16 carbon atoms. These lipids would represent more of a diesel fuel-type molecule due to the length of the carbon chain; however, some researchers were really interested in generating a biofuel that could be used as a jet fuel which need lipids that are slightly shorter than typical diesels, only containing 12-14 carbon atoms. In order to try to engineer the cyanobacterium to produce these shorter lipids, they looked at the biosynthetic pathway involved in the production of lipids. Within this pathway, it is known that the length of a given carbon chain is generally controlled by the very last enzymatic function in the pathway known as the thioesterase.*

---

<sup>1</sup> Wikipedia article on "Aviation biofuel," [https://en.wikipedia.org/wiki/Aviation\\_biofuel](https://en.wikipedia.org/wiki/Aviation_biofuel)

<sup>2</sup> Carla S. Jones and Stephen P. Mayfield, "Our Energy Future, Introduction to Renewable Energy and Biofuels," 2016, <https://www.amazon.com/Our-Energy-Future-Introduction-Renewable/dp/0520278771>

*In this case, the native thioesterase has a long binding pocket that allows the carbon chain of the lipid to continue to grow until it reaches the end of the pocket, utilizing exactly 16 carbon atoms; thus, the length of the pocket determines the length of the chain. Therefore, these scientists set out to replace this original thioesterase with an engineered thioesterase that had the potential to produce more of the 12 and 14 carbon atom length lipids. Through a series of steps involving directed mutagenesis of a thioesterase from *Escherichia coli*, another bacterium, they were able to increase the production of these shorter lipids while decreasing the amount of 16 carbon atom length lipids produced. Thus, a cyanobacterium was genetically engineered to generate a higher quantity of the desired shorter lipid in a similar fashion to what was discussed above for longer carbon chains.*

## **2.1. Optimizations**

*While working with this *E. coli* thioesterase, the authors also found that it contained a signaling peptide instructing the *E. coli* to keep the lipids inside the cell. However, if that peptide fragment was removed, then the lipids would be excreted. When this thioesterase from *E. coli* was introduced into the *Synechocystis* strain of cyanobacteria without the signal peptide, the cyanobacterium also began excreting lipids. Therefore, not only could they produce a lipid with a specific desired length, but they were also able to have the organism excrete the lipid, making extraction easier. This experiment is an excellent demonstration of how identifying a single gene within an organism and using metabolic engineering technologies can make a big impact on the production and control of biofuel molecules.*

## **2.2. Bio-jet Fuel**

*Metabolic engineering can also be used for the production of new and better biofuels. One example is the production of biobutanol, rather than bioethanol, during fermentation. Biobutanol has a higher energy content by volume than bioethanol, is less likely to absorb water during storage, and has a better blending ability; however, biobutanol is not normally produced by the commonly used yeast species for fermentation. That said, engineering key enzymes from the natural butanol biosynthetic pathway from the bacterium *Clostridium acetobutylicum* into these yeast species has been shown to allow for the production of this fuel during the process of fermentation.*

*All of these examples of metabolic engineering for the advancement of biofuels stem from one source: nature. Nature provides a host of resources for the production of these fuels, but these resources must be used responsibly and safely. In general, metabolic engineering results in a genetically modified organism or GMO. To be considered a GMO, an organism must contain DNA from a different species and have been manipulated through recombinant DNA technologies such as metabolic engineering. GMOs have recently resulted in a significant level of controversy. While many people are concerned with the spread of altered genetic materials between crops and the effects of genetically manipulated crops on human health, the reality is that genetically modified foods have existed for a long time. But this does not dismiss the need for careful regulation of the use of these technologies and testing and research on the potential for negative consequence to humans and the environment in the future. It will be critical to establish responsible practices so that GMOs are not allowed to contaminate native species or alter established ecosystems.*

*Biofuels are biomass-derived fuels from plants, animals, or waste; depending on which type of biomass is used, they could lower CO<sub>2</sub> emissions by 20–98% compared to conventional jet fuel. The first test flight using blended biofuel was in 2008, and in 2011, blended fuels with 50% biofuels were allowed on commercial flights. In 2023 sustainable aviation fuel (SAF) production was 600 million liters, representing 0.2% of global jet fuel use. By 2024, SAF production increased to 1.3 billion liters (1 million tonnes), representing 0.3% of global jet fuel consumption and 11% of global renewable fuel production. This increase came as major US production facilities delayed their ramp-up until 2025, having initially been expected to reach 1.9 billion liters.*

*Aviation biofuel can be produced from plant or animal sources such as *Jatropha*, algae, tallows, waste oils, palm oil, *Babassu*, and *Camelina* (bio-SPK); from solid biomass using pyrolysis processed with a Fischer–Tropsch process (FT-SPK); with an alcohol-to-jet (ATJ) process from waste fermentation; or from synthetic biology through a solar reactor.*

*Sustainable aviation fuel (SAF) technology faces significant challenges due to feedstock constraints. The oils and fats known as hydrotreated esters and fatty acids (Hefa), crucial for SAF production, are in limited supply as demand increases. Although advanced e-fuels technology<sup>3</sup> presents a promising solution, it is still under development and comes with high costs. To overcome these issues, SAF developers are exploring more readily available feedstocks such as woody biomass and agricultural and municipal waste, aiming to produce lower-carbon jet fuel more sustainably and efficiently.*

### **2.3. SAF History**

*The first flight using blended biofuel took place in 2008. Virgin Atlantic used it to fly a commercial airliner. This biofuel used feedstocks such as algae. Airlines representing more than 15% of the industry formed the Sustainable Aviation Fuel Users Group<sup>4</sup>, with support from NGOs such as Natural Resources Defense Council and “The Roundtable for Sustainable Biofuels” by 2008. This group pledged to develop sustainable biofuels for aviation. That year, Boeing was co-chair of the Algal Biomass Organization, joined by air carriers and biofuel technology developer UOP LLC (Honeywell).*

*In 2009, the International Air Transport Association (IATA) committed to achieving carbon-neutral growth by 2020, and to halve carbon emissions by 2050.*

*In 2010, Boeing announced a biofuel-target 1% of global aviation fuels by 2015.*

*By June 2011, the revised Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons (ASTM D7566) allowed commercial airlines to blend up to 50% biofuels with conventional jet fuel. The safety and performance of jet fuel used in passenger flights is certified by ASTM International. Biofuels were approved for commercial use after a multi-year technical review from aircraft makers, engine manufacturers and oil companies. Thereafter some airlines experimented with biofuels on commercial flights. As of July 2020, seven annexes to D7566 were published, including various biofuel types:*

---

<sup>3</sup> E-fuels, or electro-fuels, are synthetic fuels produced from renewable electricity, water, and captured carbon dioxide, designed to serve as carbon-neutral replacements for conventional fossil fuels.

<sup>4</sup> <https://www.icao.int/SAF/stakeholder-action-groups-projects-sustainable-aviation-fuel-user-group-safug>

- Fischer-Tropsch Synthetic Paraffinic Kerosene
- Hydro-processed Esters and Fatty Acids Synthetic Paraffinic Kerosene
- Hydro-processed Fermented Sugars to Synthetic Isoparaffins
- Fischer-Tropsch Synthetic Paraffinic Kerosene with Aromatics
- Alcohol to Jet Synthetic Paraffinic Kerosene
- Catalytic Hydrothermolysis Synthesized Kerosene

*In December 2011, the FAA awarded US\$7.7 million to eight companies to develop drop-in sustainable fuels, especially from alcohols, sugars, biomass, and organic matter such as pyrolysis oils, within its CAAFI and CLEEN programs.<sup>5</sup>*

*Biofuel provider Solena filed for bankruptcy in 2015.*

*In 2019, 0.1% of fuel was SAF: The International Air Transport Association (IATA) supported the adoption of Sustainable Aviation fuel, aiming in 2019 for a 2% share by 2025: 7 million m<sup>3</sup> (1.8 billion US gal).<sup>6</sup>*

*In early 2021, Boeing's CEO Dave Calhoun said drop-in sustainable aviation fuels are "the only answer between now and 2050" to reduce carbon emissions.*

*In May 2021, the International Air Transport Association (IATA) set a goal for the aviation industry to achieve net-zero carbon emissions by 2050 with SAF as the key component.*

*The 2022 Inflation Reduction Act introduced the Fueling Aviation's Sustainable Transition (FAST) Grant Program. The program provides \$244.5 million in grants for SAF-related "production, transportation, blending, and storage." In November, 2022, sustainable aviation fuels were a topic at COP26.*

*As of 2023, 90% of biofuel was made from oilseed and sugarcane which are grown for this purpose only.*

---

<sup>5</sup> CAAFI = Commercial Aviation Alternative Fuels Initiative, <https://www.caafi.org/> ; CLEEN = Continuous Lower Energy, Emissions, and Noise. The FAA's CLEEN program: <https://www.transportation.gov/advancing-next-generation-aviation-technologies>

<sup>6</sup> In 2024, SAF production volumes reached 1 million tonnes (1.3 billion liters), double the 0.5 million tonnes (600 million liters) produced in 2023. SAF accounted for 0.3% of global jet fuel production and 11% of global renewable fuel.

This is significantly below previous estimates that projected SAF production in 2024 at 1.5 million tonnes (1.9 billion liters), as key SAF production facilities in the US have pushed back their production ramp up to the first half of 2025.

In 2025, SAF production is expected to reach 2.1 million tonnes (2.7 billion liters) or 0.7% of total jet fuel production and 13% of global renewable fuel capacity.

<https://www.iata.org/en/pressroom/2024-releases/2024-12-10-03/>