SABA EDUCATION SERIES

Module SAF Basics   Topic Production Pathways

Introduction

High-integrity SAF is derived from renewable sources, such as biomass and non-food crops, waste oils, agricultural residues, and waste carbon, all of which are referred to as "feedstocks" in the production process.

SAF can be produced through several "production pathways," each involving specific feedstocks and conversion processes, i.e., technologies used to convert a feedstock into aviation fuel, primarily through chemical reactions to produce hydrocarbons.

There are currently four main SAF production pathways that are either already at commercial scale or with near-term potential to achieve it: (1) Hydrogenation of esters and fatty acids (HEFA); (2) Gasification and Fischer-Tropsch (FT); (3) Alcohol-to-Jet (ATJ); and (4) Power-to-liquid (PTL).

Four predominant SAF production pathways

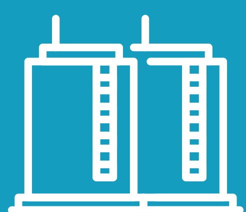
Hydrotreated Esters and Fatty Acids (HEFA)

Feedstocks: Waste and residue fatty acids

HEFA is the most common SAF production pathway today. Maturation of the HEFA pathway is due partly to policy and incentive programs to reduce emissions from road transportation, which have allowed HEFA production technology to develop and scale.

HEFA refines the lipid chains which make up oil products into hydrocarbons using hydrogen as a process input. These hydrocarbons are then broken down and further processed to produce renewable fuel outputs.

Fischer-Tropsch (FT)



Feedstocks: Any carbon-containing material, most commonly agricultural and forestry residues, and municipal solid waste

The FT process is flexible with respect to suitable feedstocks, and therefore represents great potential for supplying SAF into the future, though current SAF supply from FT production is limited.

The FT process takes any carbon-containing material and breaks it into a mixture of CO, H2, and CH4 through gasification. This mixture of gases, called synthesis gas, is cleaned for impurities and conditioned to be run through FT synthesis. In FT synthesis, CO and H2 gases react in the presence of a catalyst to form liquid hydrocarbons. These liquid hydrocarbons often require further processing to produce the desired performance qualities, which can be done at the FT liquid production facility, or by taking the FT liquids to a conventional refinery for co-processing.

Alcohol-to-Jet (ATJ)

Feedstocks: Biomass from agricultural and forestry residues, municipal solid waste, and cellulosic energy crops

The ATJ pathway involves the processing and fermentation of biomass into alcohols such as ethanol or iso-butanol, which is then typically processed through various catalytic reactions, using hydrogen as an input to produce hydrocarbons suitable for use as jet fuel.

Power-to-liquid (PTL)

Feedstocks: Captured CO2 and green electricity

PTL is an advanced production pathway that combines captured CO2 with hydrogen to produce jet fuel.[1]

The PTL process shows high potential as a sustainable pathway for fuel production due to the use of fully renewable inputs, but sourcing of clean electricity at scale remains a challenge. Theoretically, if infrastructure for clean electricity is expanded, PTL fuels production can be scaled exponentially as the feedstock is virtually limitless and not tied to any agricultural or biomass commodity such as the feedstocks used to produce HEFA and ATJ fuels.

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1 The current industry standard for PTL production is to use the Fischer-Tropsch (FT) process to synthesize the hydrogen and CO2 into a hydrocarbon. However, due to significant high-level differences, PTL is considered a unique SAF pathway.

Co-processing

Note that SAF can also be produced at conventional refineries at small ratios to fossil jet fuel. In a refinery that is co-processing, vegetable oils, FT liquids, or waste fats such as tallow or used cooking oil are fed into the refinery in small quantities along with crude oil. The output products of the refinery, which include jet fuel, will accordingly include a small quantity of fuel with a biogenic content and a lower emissions impact. This small quantity of fuel can also be considered SAF.

How feedstocks affect the sustainability of SAF

Lifecycle emissions from SAF are heavily influenced by which feedstock and production pathways are used to produce the fuel. For example, the use of renewable electricity to produce hydrogen and/or capture CO2 for PTL SAF would result in very minimal feedstock sourcing emissions, whereas the cultivation and production of soybean oil for SAF often leads to significant emissions.

For an understanding of how the use of different feedstocks impacts the overall emissions of SAF, please reference CORSIA's Default Lifecycle Emissions Values. Note that indirect land use change (ILUC) emissions may also be a significant contributor to the emissions related to many feedstocks. ILUC may occur when the growth of biofuel feedstocks takes place on arable land, displacing existing or future food production. This can lead to the conversion of natural lands to compensate for the food production lost in favor of biofuel feedstock growth and result in increased GHG emissions, as well as other unintended environmental consequences, from food insecurity to habitat and biodiversity loss. As part of its overall estimate for the lifecycle emissions for various feedstocks, CORSIA estimates the emissions related to ILUC for all feedstocks.