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Sustainable Aviation Fuel (SAF): Production Pathways

Many in Congress have expressed an interest in sustainable aviation fuel (SAF)—a nascent industry. SAF may potentially provide market opportunities for both agricultural producers and biofuel producers; it meets international aviation requirements (e.g., ReFuelEU Aviation regulation); and it may satisfy consumer requests for more environmentally friendly aviation fuel. With these potential opportunities come potential challenges such as producing a large amount of SAF within a certain time frame at a preferred cost; satisfying SAF tax credit criteria (e.g., domestic production criteria, lifecycle greenhouse gas emissions reduction criteria); and ascertaining what the primary feedstocks and production pathways for SAF in the United States will be for the near and long term. In 2024, both chambers of Congress formed sustainable aviation caucuses: the House Congressional Sustainable Aviation Caucus and the Senate Sustainable Aviation Caucus.

SAF must be produced to qualify for SAF government programs, tax incentives, and more, as explained in CRS In Focus IF12757, *Sustainable Aviation Fuel (SAF): An Overview of Current Laws and Legislation Introduced in the 118th Congress*. SAF production can occur in a variety of ways. This CRS product provides a general summary of SAF production pathways; it is not a technical or comprehensive explanation.

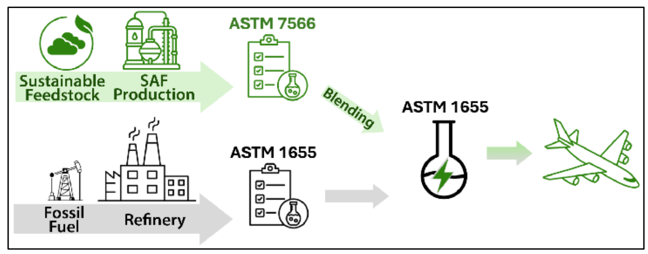
SAF Production Pathways

There are currently 11 ASTM International (ASTM)-approved SAF production pathways. There is an ASTM technical standard specification for sustainable aviation fuel (D7566) and petroleum-based jet fuel (D1655). ASTM reports that aviation fuel that meets the requirements of D7566 also meets the requirements of D1655 and should be regarded as D1655 aviation fuel. In short, SAF must meet the requirements for D7566 to then satisfy the requirements for D1655 and be a substitute for petroleum-based aviation fuel (see **Figure 1**). ASTM developed a standard practice (D4054) for the evaluation of new aviation fuels (i.e., a process standard to evaluate SAF). ASTM reports that D4054 defines the process and D7566 defines the end product. SAF that meets the D7566 technical standard specification can be blended with conventional fuel (D1655) only up to an approved maximum blend limit (e.g., 50%). SAF is considered a drop-in fuel, that is, it is a fuel capable of being used with existing infrastructure.

Three of the 11 ASTM-approved SAF production pathways are co-processing pathways, all of which fall under ASTM D1655 Annex A1. In general, co-processing is when an existing refinery simultaneously processes two or more feedstocks, such as an approved renewable feedstock along with a petroleum-based feedstock. Co-processing advantages include potentially producing SAF more quickly by using existing refinery equipment and processes, with minor modifications. Co-processing disadvantages include a potentially lower volume of SAF needed due to the maximum blending rate (e.g., 5%) for the co-processing SAF production pathways compared to the other SAF production pathways.

The National Renewable Energy Laboratory reports there are multiple additional SAF production pathways currently under review by ASTM. Also, the Commercial Aviation Alternative Fuels Initiative reports it "is aware of a significant number of additional prospective pathways that are currently being pursued by multiple entities, but have yet to enter the ASTM Qualification Process."

Figure 1. Schematic of Jet Fuel and SAF Production Pathways



Source: Climate Drift, *The Sustainable Aviation Fuel (SAF) Solution Framework*, May 21, 2024.

Data Reporting

As of September 2024, Argus reports there are three SAF facilities operating in the United States that have production capacities of 10 million gallons per year (MGPY) or more. Two of the three facilities use the HEFA-SPK pathway and the other facility uses the AtJ-SPK pathway (see **Table 1**).

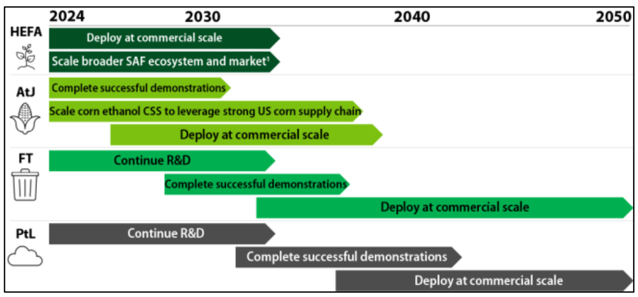
Some U.S. government agencies provide SAF production data. For example, the Environmental Protection Agency provides data on renewable jet fuel for the Renewable Fuel Standard. In addition, there is a federal interagency initiative—led by the Department of Energy (DOE), the Department of Agriculture, and the Federal Aviation Administration—to track SAF metrics, including actual and potential SAF production, to help meet the Synthetic Aviation Fuel Grand Challenge (SAFGC), originally called the Sustainable Aviation Fuel Grand Challenge when introduced under the Biden Administration in 2021.

SAF Production Pathway Considerations

Federal policy could shape any potential contribution SAF may have toward meeting various energy, transportation, agricultural, and environmental goals. There is much Congress could consider regarding SAF federal policy. Four potential considerations include (1) which SAF production pathways show the most potential, and over what time frames; (2) how many SAF facilities will come online; (3) what impact existing policies will have on SAF production over different time frames; and (4) whether modification of existing policies or development of new policies is warranted.

Few SAF production pathways are expected to be front-runners for actual SAF production in the near term. DOE estimates that the HEFA (Hydroprocessed Esters and Fatty Acids) pathway and the AtJ (Alcohol-to-Jet) pathway will, together, make up approximately 89% of the expected 2030 SAF production (HEFA at 66% and AtJ at 23%). DOE also asserts that more investment is needed in "more nascent pathways in order to diversify feedstocks and production capabilities." Such pathways could include Alcohol-to-Jet, Fischer-Tropsch (FT), and Power-to-Liquid (PtL), as shown in **Figure 2**. In short, while ASTM may have approved a SAF production pathway, that does not mean there is or will be an operational facility producing SAF via that pathway in the United States.

Figure 2. DOE Timeline for Potential Commercialization of Different SAF Production Pathways



Source: U.S. Department of Energy, *Pathways to Commercial Liftoff: Sustainable Aviation Fuel*, November 2024.

Notes: HEFA = Hydroprocessed Esters and Fatty Acids. AtJ = Alcohol-to-Jet. FT = Fischer-Tropsch. PtL = Power-to-Liquid. R&D = research and development.

Some observers expect that SAF production will come from both new SAF facilities and the conversion of existing renewable diesel facilities into SAF facilities. There have been several announcements about forthcoming SAF facilities. One source reports over 30 planned SAF facilities for the United States. DOE reports that "[t]o reach liftoff, the SAF market requires 8-12 commercial-scale (with an average 100 MGPY capacity each) plants in operation by 2030."

It is unclear if Congress in the future will support SAF production goals set by the past, or present, Administration. For example, in 2021 the Biden Administration launched the SAFGC with a target of 3 billion gallons of annual SAF production by 2030, among other things. Legislative action focused on SAF production for the near term—which, if defined as the next five years, would get the country to 2030 for the first SAFGC SAF production target.

Since 2022, Congress has passed legislation that supports SAF. In a November 2024 report, DOE identified both gaps and barriers related to the SAFGC—including the need for "[d]urable policies that clearly and rigorously demonstrate the near-, medium-, and long-term commitment of the U.S. Government to domestic production and use of SAF can play a key role in catalyzing effective private investment in SAF projects that will bring about the environmental, economic, and social benefits of the SAF Grand Challenge." Some stakeholders requested that the 118th Congress take action on a short-term tax package, including an extension of the sustainable aviation fuel tax credit, "to ensure energy and agriculture market stability and predictability." One agricultural news outlet reported in October 2024 that some were pushing "for stable and consistent policies, with defined and transparent environmental tracking" along with SAF that is "more cost effective and palatable to airlines through regulatory policy or environmental attributes." If Congress chooses to continue its support of SAF, it may consider whether additional action is needed to support SAF production and what that action could entail. Alternatively, Congress could consider maintaining the status quo and not take any action. Another option is to reduce policy support for SAF.

Table 1. Selected ASTM-Approved Sustainable Aviation Fuel Production Pathways

Pathway Name (Abbreviation)	Maximum Blend Limit (By Volume)	ASTM Designation (Certification Date)
Fischer-Tropsch synthetic paraffinic kerosene (FT-SPK)	50%	ASTM D7566, Annex A1 (2009)
Hydroprocessed Esters and Fatty Acids (HEFA-SPK)	50%	ASTM D7566, Annex A2 (2011)
Alcohol to jet synthetic paraffinic kerosene (AtJ-SPK)	50%	ASTM D7566, Annex A5 (2016 for isobutanol; 2018 for ethanol)
Fats, oils, and greases (FOG) co-processing (FOG Co-Processing)	5%	ASTM D1655, Annex A1 (2018)

Sources: National Renewable Energy Laboratory (NREL), *Sustainable Aviation Fuel (SAF) State-of-Industry Report: State of SAF Production Process*, NREL/TP-5100-87802, Table B-1, July 2024; U.S. Department of Energy, *SAF Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel*, September 2022; International Civil Aviation Organization, *Approved Conversion Processes*, December 2024.

Notes: The SAF production pathways listed in this table are some examples of the 11 ASTM-approved pathways. They were selected in no order of preference or priority. For a list of all 11 pathways, see NREL, *Sustainable Aviation Fuel (SAF) State-of-Industry Report: State of SAF Production Process*, NREL/TP-5100-87802, Table B-1, July 2024.

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