ADVANCING SUSTAINABLE AVIATION FUEL

Overcoming the challenges of reducing greenhouse gas emissions from air travel

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Increasing investments in renewable power production, energy efficiency measures, and transportation electrification are all building momentum in the shift to fossil-free fuel.

With electric and hydrogen aircraft technology, still in development for commercial flights, there is a golden opportunity to advance the use of sustainable aviation fuel (SAF) as a near-to-medium term solution to reduce greenhouse gas emissions, with longer term applications as part of a comprehensive solution to removing greenhouse gases. SAF is a clean source of fuel compared to conventional fossil-based fuel, holding promise to meaningfully reduce the sector's global greenhouse gas emissions as business and personal air travel recovers.

SAF is advancing beyond initial tests and demonstration flights, with smaller-scale production starting to be integrated with airport fuel supply, specifically in Los Angeles, San Francisco, Amsterdam, Helsinki, and Singapore. Worldwide capacity is anticipated to surpass 600 million gallons (2 million tonnes) per year by the end of 2022, expanding to 2.6 billion gallons (8.7 million tonnes) by 2026.

Some other notable steps are recent commitments by the International Air Transport Association (IATA) member airlines to achieve net-zero carbon emissions by 2050, supported by the International Civil Aviation Organization (ICAO). The European Union Green Deal includes a proposed new ReFuelEU Aviation initiative that mandates gradual increases in

SAF blending from five percent in 2030 to 63 percent by 2050. Furthermore, with increasing general transportation electrification the need for refineries to produce petroleum products is anticipated to decline, putting pressure on the production, supply and pricing of conventional jet fuel.

The primary constraint on initial growth in the SAF market has been the price differential relative to conventional fuels. A further challenge to increased SAF supply is market competition with sustainable diesel fuel; both are produced in the same facilities where limited production capacity currently exists. Financial incentives to meet advanced fuel blending requirements for sustainable diesel fuel have boosted demand, absorbing most of the existing and planned capacity for sustainable fuel production. Similar government mandates for SAF use, coupled with associated financial incentives, would support increased overall supply of sustainable fuels and encourage the production of both sustainable diesel and SAF.

New efforts toward this objective could emulate the stakeholder working group formed by San Francisco International Airport (SFO**),** a coalition of diverse partners, including airlines, airport authorities, energy companies/SAF producers, industry experts and non-profit organizations, convened to address the myriad of issues regarding SAF use and to strengthen advocacy efforts.

Building Momentum

Among the regulatory measures paving the way for the increasing use of SAF around the world is California's Low Carbon Fuel Standard (LCFS), which incorporates SAF into the provision of tax credits to reduce the carbon intensity of fuels within the state. Similar inclusion of SAF within the U.S. national renewable identification numbers credit system, and any subsequent systems, would help to reduce the price premium of SAF versus conventional jet fuel and place SAF on par with sustainable diesel.

In Europe, countries can opt-in to the Renewable Energy Directive, with updates covering SAF as part of the indirect land-use change (ILUC) amendment, allowing member states to meet their overall obligations through the use of SAF. The Netherlands was the first country to opt-in to the directive, resulting in the first dedicated facility in Europe; set to start production in 2022, the site is a joint effort between Shell Aviation and SkyNRG, providing capacity to produce 100,000 tonnes (730,000 barrels) of SAF per year. The ReFuelEU initiative, while helping to promote SAF use, does not include specific financial incentives for production and supply. Consortiums such as the ALIGHT partnership led by Copenhagen Airport are looking at opportunities to address the lack of direct financial incentives through innovative supply, production and pricing structures.

Commercial aviation has successfully used blends of SAF and conventional jet fuel in thousands of flights around the world. Norway initiated use of SAF in 2016. Rolls-Royce recently confirmed its Trent engines can use 100 percent SAF by 2023, with current commercial engines approved for 50-percent blends.

As of January 2022, Norway, Sweden and France require jet fuel suppliers to blend no less than one percent of sustainable aviation fuel in all of their aviation fuel, with near-term fuel supply to come from the Preem renewable fuels facility in Gothenburg, Sweden and Neste's production facilities in Rotterdam, Holland and Porvoo, Finland. Swedavia, the largest airport operator in Sweden, receives SAF at Stockholm Arlanda and other major airports from suppliers including Neste, SkyNRG and World Energy.

Almost all aircraft flying out of Los Angeles International Airport (LAX) currently use a small blend of SAF based on the United Airlines contract to supply SAF from World Energy's biorefinery—incorporating used cooking oil and tallow as feedstocks—to LAX using common storage and distribution infrastructure. SFO is poised to receive SAF, as Shell Aviation and World Energy announced plans in January 2020 to supply SAF for Lufthansa's flights.

Producing SAF

SAF is produced from renewable and sustainable feedstocks, including waste oils, forestry waste products, algae, and animal fats—as opposed to conventional fuel, which is mostly refined from petroleum. SAF is considered a next-generation biofuel, with the majority of current first-generation biofuels produced from agricultural feedstocks, including soy, corn, palm oil or sugar cane. Certification of bio-based sustainable sources, provided by organisations such as the Roundtable of Sustainable Biomaterials ensures compliance with greenhouse-gas emissions reduction goals.

SAF also meets stringent global fuel quality standards, including ASTM in the United States, CEN in Europe, and JIS in Japan[1] and can therefore be blended at various levels with conventional fuel for distribution to airport fueling facilities. As a drop-in fuel, SAF leverages existing infrastructure and engine technology to deliver a low-carbon alternative to conventional jet fuel.

Current and upcoming producers include the Amyris facility in Brazil using sugar cane; the Red Rock facility in Oregon using forestry residues; the Fulcrum facility in Reno, Nevada using municipal solid waste; and the Total facility in La Mède, France using vegetable oils and animal fats.

Planned facilities include Sinopec in Ningbo, China; LanzaTech in Georgia, United States; Shell Aviation and SkyNRG in Delfzijl, Netherlands; Gevo in Minnesota, United States; and FORGE Hydrocarbons and Shell Ventures in Ontario, Canada.

The total production capacity of sustainable fuels from the existing and upcoming facilities around the world is approximately 260 million gallons, with close to 36 million gallons already committed to SAF production. Sustainable diesel fuel, with similar characteristics to SAF, represents a majority of the volume being produced from current production capacity and will likely represent a large share of production in some of the near-term biorefinery startups.

Moving the Needle for Widespread Use

Investments in SAF production combined with purchase agreements with suppliers would make SAF an affordable long-term alternative to traditional fossil-based fuels. For SAF to be widely available, the aviation sector will need to leverage existing supply chain infrastructure in combination with increased production capabilities to deliver this low-carbon alternative to conventional jet fuel.

Production of SAF and other transportation fuels is largely dictated by the pricing environment, with producers prioritizing revenue generation as they ramp up production and benefit from economies of scale. With limited existing dedicated production of SAF and fewer financial incentives to produce SAF instead of alternatives to conventional diesel, SAF carries a price premium compared to conventional jet fuel.

In the United States, the national renewable identification numbers (RINs) credit system under the Environmental Protection Agency's Renewable Fuel Standard is available for sustainable diesel production to reduce the price premium versus conventional diesel. When incentives for SAF are introduced, such as California's expansion (2018) of the state's LCFS credits, they tend to encourage a more balanced production of sustainable diesel and SAF.

While programs such as California's LCFS provide a portion of the price premium for SAF, the remaining price differential may be offset by revisions to existing programs, co-funding opportunities and carbon offsets. For example, the proposed measure within the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) would price carbon offsets to reduce the differential in SAF prices compared to conventional jet fuel prices.

Cultivating a Viable Alternative Fuel

Steps to reduce carbon emissions, specifically the transition from fossil fuels to other propulsion methods such as electric, are increasing in the transportation market. In addition to personal

[1] ASTM – formerly known as American Society for Testing Materials; CEN – the European Committee for Standardization; JIS – Japanese Industrial Standards

vehicles, transit and trucking fleets are developing strategies to segue from fossil fuels and internal combustion engines to electric propulsion.

However, the aviation, rail and maritime sectors often require major technological advancements to address range and weight restrictions, with greater capital investment needed to support related infrastructure. Furthermore, assets tend to be utilized for longer durations, extending their lifecycle and reducing the opportunity for more frequent replacement. The challenges of reducing carbon emissions through electrification are therefore more difficult to overcome.

SAF helps to address this lag in technology development while addressing immediate emissions concerns. Depending on the production method and feedstock source, SAF has the potential to reduce emissions by 80 percent to more than 100 percent when accounting for carbon sequestration associated with some of the feedstock sources.

Meeting the Short-Term Challenge

The existing supply chain fueling infrastructure presents a short-term challenge in the transition to the widespread use of SAF. The majority of large airports are supplied with jet fuel through terminals and pipelines linked with large regional refining assets. Since current SAF production facilities are not always centered around existing petroleum refining assets, but rather the feedstock supply, there are incremental costs involved in supplying SAF to airports. In addition, many large pipeline operators require certification of any products entering their pipelines as well as volume commitments.

As demand and production increase, there will be greater opportunity to supply SAF either directly into a pipeline asset connected with large-scale production facilities and/or through an integrated approach, such as utilizing train or maritime supply to a terminal facility connected to a pipeline feeding a major airport. There will likely be a transition period where SAF is blended with conventional jet fuel at a variety of locations, including airport fuel farms, traditional fuel piping terminals and SAF production facilities. In order to accommodate blending, these sites will need to provide additional tanks or transition existing tanks to allow for adequate capacity for storage of neat SAF and blended SAF prior to being provided to the fuel farm hydrant systems.

Transitioning Away From Fossil Fuels

Future increases in SAF volumes will largely be dictated by pricing dynamics and consumer preferences. Pricing dynamics may start to favor SAF as conventional fuel production and refineries switch to biorefining in response to declining demand for conventional gasoline and diesel as the vehicle fleet transitions to electric motor options.

Elevated awareness of the benefits of SAF locally, regionally, nationally and internationally can quicken the pace of SAF development. The current environment offers a rare opportunity to advance efforts that support the production and use of SAF, and the logistics to supply SAF into more airports.

Taking key steps now will position commercial aviation for a cleaner and stronger path forward, toward net-zero emissions by 2050—supporting a healthier future for communities and the planet.

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