Airlines for America®

DEPLOYMENT OF SUSTAINABLE AVIATION FUEL IN THE UNITED STATES

A PRIMER

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EXECUTIVE SUMMARY

The U.S. aviation industry has taken a leadership role in the development and deployment of sustainable aviation fuel (SAF). We remain committed to advancing the commercialization and deployment of SAF to help the industry meet its emissions reduction goals, diversify fuel supply and enhance energy security. There are three core criteria that all types of SAF must meet for successful deployment by airlines. The fuel must be:

- Equally safe and effective as petroleum-based jet fuel
- Environmentally superior to petroleum-based jet fuel
- Commercially viable

While having the means to demonstrate that SAF is safe, effective and environmentally beneficial is critical, achieving commercial viability requires many more pieces to come together. Each of the following elements of the supply chain must be cost-effective and reliable: (1) commercial-scale quantities of sustainable feedstocks; (2) feedstock transportation and processing facilities; (3) facilities to convert feedstock into SAF; (4) facilities to blend "neat" SAF with petroleum-based jet fuel; (5) confirmation that fuel quality and environmental standards have been met; (6) transportation of the SAF purchased by the aircraft operator to an airport; and (7) receipt and deployment of blended SAF at airports.

While building or repurposing refineries to produce SAF – at a cost of hundreds of millions of dollars or more – is likely the most capital-intensive aspect of the supply chain, each aspect requires significant investment and logistics. Relatively little commercial supply of SAF has been produced and deployed to date, and SAF generally has been understood to be significantly more costly than petroleum-based aviation fuel. We have made progress but still need supportive government policies, ongoing commitment from an array of stakeholders and expanded public-private partnerships to push the industry over the cusp. There are five primary ways in which airports and other stakeholders can work with airlines to support SAF deployment:

- Promote collective understandings and collaboration
- Advocate maintaining and expanding positive incentives for SAF
- Collaborate with airlines on regional strategies and/or airport-specific opportunities
- Support airlines and their fuel producers during initial SAF deployment at an airport
- Celebrate volunteerism

Given the criticality of jet fuel to reliable flight operations and its prominence as a cost item, airlines must be the decision makers in fuel supply chain management. But airlines welcome support for efforts to make SAF fully commercially viable and deploy it where it makes sense as we scale up. We encourage airports and other stakeholders to work with us in cooperative ways to develop, evaluate and support policies that will, quite literally, get SAF off the ground.

INTRODUCTION

The U.S. aviation industry is committed to advancing the commercialization and deployment of sustainable aviation fuel (SAF) to help meet its emissions reduction goals, diversify fuel supply and enhance energy security. While significant progress has been made in advancing the SAF industry, substantial challenges remain in scaling up cost-effective supply. With very rare exceptions, in the United States airlines purchase their own fuel, which along with labor is consistently one of the top two expenses. Given the criticality of jet fuel to reliable flight operations and its prominence as a cost item, airlines must be the decision makers in fuel supply chain management. That said, airports and other stakeholders can support airline efforts to advance SAF deployment.

Sustainable aviation fuel (SAF) is one of the many terms describing liquid aviation fuel that emits less carbon on a lifecycle basis than traditional, petroleum-based aviation fuel, while satisfying other relevant sustainability criteria and still meeting the rigorous specifications required to ensure safety of flight.[1]

Means of producing SAF typically are described in terms of the feedstocks that are or may be coupled with particular fuel-processing technologies.

Feedstocks often are biomass-based (e.g., oil-seed crops, woody waste, municipal solid waste, inedible waste oils and fats), although capturing and recycling carbon dioxide (CO_2) from other industrial production processes and uses of renewable electricity for hydrogen production combined with recycled CO_2 also can be sources of renewable feedstocks.

This primer is intended to serve as a reference on the current state of SAF development and deployment in the United States, the challenges to making SAF more commercially viable, and ways that airlines, airports and other stakeholders can work together to overcome those challenges.[2] It identifies forums for information exchange, means for assessing potential supply-chain development, positive policy actions and best practices for supporting airline efforts to deploy SAF where such deployment is determined to be practicable and cost-effective. Most importantly, this primer is intended to promote common understandings to help those who are interested in SAF deployment to work together in constructive ways to enhance the role that SAF can play in ensuring the long-term sustainability of aviation.

AIRLINE INTEREST IN COMMERCIALLY VIABLE SAF

U.S. airlines are fostering the development and deployment of SAF for the following reasons:

ENVIRONMENTAL BENEFITS

The U.S. airlines have a strong fuel efficiency and emissions reduction record, having improved their fuel efficiency by over 135 percent since 1978. If economically viable and available at a commercial scale, SAF could significantly reduce aviation-related lifecycle greenhouse gas (GHG) emissions, thus further advancing aviation's longstanding commitment to minimize environmental impact. Although representing only 2 percent of the nation's GHG emissions inventory while driving 5 percent of GDP, the U.S. airlines take our role in further controlling GHG emissions very seriously. Accordingly, the U.S. airlines are part of a global aviation coalition that has committed to ambitious CO_2 emission reduction goals including (1) an annual average fuel efficiency improvement of 1.5 percent from 2009 through 2020; (2) carbon-neutral growth in international aviation starting in 2020, subject to critical aviation infrastructure, technology, operations and SAF advances by governments and industry; and (3) an aspirational goal to achieve a 50 percent net reduction in CO_2 emissions in 2050, relative to 2005 levels. Coupled with an array of technology, operations and infrastructure measures and the International Civil Aviation Organization's (ICAO) carbon offsetting and reduction program,[3] SAF is expected to play an important role in meeting the latter two of these goals.

In addition, SAF can provide environmental "co-benefits" – benefits aside from GHG emissions reductions – by also lowering aircraft emissions of pollutants such as sulfur oxides (SOx), particulate matter (PM), carbon monoxide, unburned hydrocarbons and oxides of nitrogen (NOx).[4] For example, a 2017 National Aeronautics and Space Administration (NASA)-led study found that biomass-based SAF reduces jet engine PM emissions by as much as 50 to 70 percent,[5] while some types of SAF are virtually free of sulfur and aromatic hydrocarbon compounds. Delivering such environmental co-benefits is also important to meeting the expectations of airline customers and the general public with respect to sustainability and environmental stewardship.

SUPPLY DIVERSIFICATION AND OPERATIONAL RELIABILITY

The volatile price of petroleum-derived jet fuel poses key business challenges to airlines, especially because fuel is one of the industry's largest and most volatile operating costs. Once SAF supply reaches commercial scale, it may offer an opportunity to diversify available sources of jet fuel and reinvent aspects of the fuel supply chain.

Given current technology, there are no practical options to power commercial aircraft engines other than with liquid fuels. Commercial-scale production of SAF can bolster the supply of liquid fuel to the airline industry. Expanding the available jet fuel slate in this way may help enhance market stability. In addition, SAF could be essential to accommodate future demand growth for air transport services, both in terms of supply and sustainability. Furthermore, SAF production facilities need not be situated in the same locations as conventional refineries. This would allow the geographic diversification of production away from sites prone to natural disasters, such as the U.S. Gulf Coast or West Coast, though this siting flexibility may bring with it a potential disadvantage if sufficient product storage and transportation infrastructure is not located in these other areas.

CORE ENABLERS FOR AIRLINE DEPLOYMENT OF SUSTAINABLE AVIATION FUEL

1. Equally safe and effective as petroleum-based jet fuel, meeting criteria so it may be "dropped in" to existing aviation fueling infrastructure and aircraft. This is addressed through jet fuel specification ASTM D7566 and the application of procedures to assure fuel quality is maintained.
2. Environmentally superior to petroleum-based jet fuel based on the carbon emissions footprint, while meeting other relevant environmental sustainability criteria. This is addressed through lifecycle GHG assessment and sustainability review/certification.
3. Commercially viable, defined as cost-competitive, appropriately scaled and reliably supplied. Scale and cost-competitiveness remain the biggest challenges.

ENSURING SAFE AND EFFECTIVE SAF

Airlines never lose sight of their core mission: safety. Jet fuel must meet rigorous requirements that ensure safe operation, whether in the icy cold at 30,000 feet or while filling tanks on the ground at an airport. Accordingly, before a particular SAF can be approved for commercial use, it must meet stringent safety and performance standards set out in the applicable specification, which is controlled by ASTM International, an organization devoted to the development and management of standards for a wide range of industrial products and processes. This specification, in turn, is included in the U.S. Federal Aviation Administration's (FAA) product approvals and required air-carrier manuals.

The original jet fuel specification, ASTM D1655 ("Standard Specification for Aviation Turbine Fuels"), covered only jet fuel derived from specific fossil-fuel sources. The Commercial Aviation Alternative Fuels Initiative® (CAAFI) team[6] worked within ASTM to identify means for gaining approval of jet fuel derived from alternative feedstocks, provided that the fuel is equally safe and effective.[7] In August 2009, after completing detailed reviews, ASTM approved D7566, "Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons," which allows for alternatives that are safe and effective and otherwise meet the technical and fit-for-purpose requirements to be blended with petroleum-based jet fuel and deployed as blended under ASTM D1655. ASTM D7566 is structured, via annexes, to accommodate different classes of alternative fuels when they are shown to meet the relevant requirements. There are now seven approved "pathways" for SAF production, with still others pending.[8]

APPROVED SAF "PATHWAYS" UNDER ASTM D7566

Pathway	Acronym	Feedstock Examples	Year Approved	Blending Limit
Fischer-Tropsch Synthetic Paraffinic Kerosene	FT-SPK	Biomass (e.g., forestry residues, grasses, municipal solid waste)	2009	50%
Hydroprocessed Esters and Fatty Acids	HEFA-SPK	Oil-bearing biomass (e.g., algae, jatropha, camelina, carinata)	2011	50%
Hydroprocessed Fermented Sugars to Synthetic Isoparaffins	HFS-SIP	Microbial conversion of sugars to hydrocarbon	2014	10%
FT-SPK with Aromatics	FT-SPK/A	Renewable biomass (e.g., municipal solid waste, agricultural waste, forestry residues, wood, energy crops)	2015	50%
Alcohol-to-Jet Synthetic Paraffinic Kerosene	ATJ-SPK	Agricultural waste products (e.g., stover, grasses, forestry slash, crop straws)	2016	30%
Catalytic Hydrothermolysis Jet	CHJ	Plant and animal fats, oils and greases	2020	50%
Hydroprocessed Hydrocarbons, Esters and Fatty Acids	HC-HEFA-SPK	Oil from the *Botryococcus braunii* species of algae	2020	10%

By meeting the rigorous jet fuel specification and fit-for-purpose requirements, SAF, as blended with petroleum-based aviation fuel up to the limit, is demonstrated to be an ASTM D1655 "drop-in" fuel completely compatible with existing airport fuel storage and distribution methods and airplane fuel systems. Consequently, it does not carry added infrastructure costs for airlines, fuel distributors or airport authorities.

As more SAF pathways are approved, the opportunity for increased SAF volumes grows at airports worldwide. However, given the high level of safety demanded by aviation, satisfying all the steps in the ASTM qualification and approval process (ASTM D4054) can be slow and costly. In fact, it can take a producer as many as seven years and $15 million to secure approval for a new pathway. The time and investment involved can be a challenge for emerging alternative fuel companies. Further, aircraft engine manufacturers and other experts involved in the ASTM process incur significant costs in reviewing data, undertaking testing, generating reports and conducting other related activities.

To date, the FAA, aircraft engine manufacturers and several U.S. entities have undertaken the lion's share of work and assumed the bulk of the costs for SAF approvals. The FAA has established the ASTM D4054 Clearinghouse — currently managed by the University of Dayton Research Institute — to increase the efficiency of the ASTM process for alternative fuel producers and expert reviewers and, hopefully, to diversify funding. While the FAA provided funding to establish the Clearinghouse and support for a portion of the fuel testing and review, the Clearinghouse is set up to accept funding from an array of public and private entities. Such funding is needed to support the review and approval activities for additional SAF pathways that are critical to scale up SAF supply.

ENSURING LIFECYCLE GHG EMISSIONS BENEFITS AND CONFIRMING SUSTAINABILITY

The airline industry has recognized that in developing new types of lower-carbon fuels, the industry should seek to avoid creating other environmental and social problems, such as negative land use changes, impacts to water resources and increases in emissions with local air quality effects. Demonstrating the environmental benefits of SAF requires a GHG emissions lifecycle assessment (LCA), to define and calculate the reduction in GHG emissions associated with the production, transportation and use of the alternative fuel, and an evaluation of the alternative fuel under other relevant environmental and social "sustainability" criteria.

GHG LCA:

As carbon is fundamental to powering aircraft engines, the CO_2 generated upon combustion cannot be eliminated from drop-in SAF, but these emissions can be reduced by 1) avoiding or lowering GHG emissions somewhere else along the fuel's full "lifecycle" or 2) increasing the per-unit energy provided in the SAF, or some combination of the two. By examining the emissions generated at each point in the lifecycle, one can ensure that the emissions benefits that are sought are in fact real and do not create emissions "dis-benefits" along the way.

In the lifecycle of SAF, significant CO_2 emissions savings can come from the feedstock itself. Rather than releasing CO_2 from crude oil-derived petroleum jet fuel, where the crude oil has been buried in the earth for tens of millions of years or more, biomass-based SAF feedstocks serve a sort of recycling function, with plant-based feedstocks first having absorbed (through photosynthesis) during the growth of the biomass the very CO_2 that is released upon combustion. Similarly, the use of CO_2 captured from industrial processes to make SAF puts such CO_2 to productive use, eliminating its release into the atmosphere and, again, reducing the need to drill for crude oil to make petroleum-based jet fuel, which upon combustion would release previously sequestered CO_2. However, this process typically would not result in one-to-one savings of CO_2 since other emissions can occur all along the "life," or the entire supply chain, of the fuel. As depicted in the diagram below, growing, harvesting and then extracting the feedstock, transporting that raw material, refining the feedstock into SAF and transporting the finished fuel product so that it can be used in an aircraft can all have associated emissions. The key is to be sure that all of these emissions are included in the LCA such that SAF, from the cultivation or generation of the feedstock all the way through to the fuel's combustion, yields a net GHG emissions reduction.

SAF Lifecycle

Guidance for completing LCAs of different fuels has been developed under both regulatory programs and voluntary emissions reduction frameworks. While the LCA is not precisely the same under each of the different standards, the evaluation processes and tools are well-matured. For example, both the U.S. Environmental Protection Agency (EPA) under the Renewable Fuel Standard program and the states of California and Oregon use versions of the widely respected GREET® model in defining LCA of alternative aviation fuels.[9] At the international level, ICAO has adopted an agreed methodology for LCAs to be used under CORSIA in evaluating the carbon reduction benefits of different types of SAF.[10] It has also established default GHG LCA values for specific SAF fuel pathways.[11]

Sustainability Criteria and Confirmation:

Currently, there are various regulatory and voluntary frameworks with indicators and criteria to evaluate sustainability performance of SAF. Key examples include the Roundtable on Sustainable Biomaterials and the International Sustainability and Carbon Certification. ICAO has developed an internationally-agreed approach to evaluate sustainability of SAF for purposes of CORSIA, which includes sustainability criteria and certification provisions for demonstrating compliance with those criteria.[12] Aircraft operators purchasing SAF that meets the GHG emissions and other sustainability requirements under CORSIA can apply the emissions savings from the SAF qualifying as "CORSIA eligible fuel" to reduce their CORSIA carbon offsetting obligations.

While there has been progress in defining "sustainability" for SAF, demonstrating GHG emissions benefits under GHG LCA and compliance with sustainability standards can be time-consuming and expensive. Additional work will be critical to scaling up SAF supply, namely further aligning the criteria under different sustainability standards and creating a more efficient and cost-effective way for SAF to be evaluated.

MAKING SAF COMMERCIALLY VIABLE

While demonstrating that SAF is safe, effective and environmentally beneficial is critical, achieving commercial viability requires that every element of the supply chain be cost-effective and reliable:

1. **Commercial-scale quantities of feedstocks:**
   Sources of biomass or other feedstocks must be accessible, sustainable and reliably available to meet fuel production needs.

2. **Feedstock transportation and processing facilities:**
   Typically, the feedstock will need to be collected and sorted, often with initial processing to put it into a form that can be used by a production process.

3. **Facilities to convert feedstock into SAF:**
   Although there are many petroleum refining facilities in the U.S. as well as various facilities that produce alternative fuel for automobiles and trucks, only one U.S. refinery is regularly producing commercial quantities of SAF. While others are in the works, establishing more SAF production facilities – whether converting existing facilities or constructing new ones – will take time and significant investment. Among the challenges have been the market realities that SAF typically requires more intense processing than renewable diesel, and diesel fuel typically has commanded a higher price on the spot market; together, these market realities make renewable diesel a more lucrative product for producers to manufacture and then sell. Given that SAF is relatively new to the market, the aviation industry must continue to focus on ensuring that SAF can avail itself of the supportive policies that ground-based alternative fuels have long enjoyed.

4. **Facilities to blend "neat" SAF with petroleum-based jet fuel:**
   As noted, SAF under all of the pathways approved to date (i.e., those meeting ASTM D7566) must be blended with petroleum-based aviation fuel to satisfy the jet fuel specification (ASTM D1655) before use in aircraft. Whether undertaken at the original SAF production facility, a separate petroleum-based jet fuel production facility or elsewhere, this step requires tankage and personnel to undertake the blending and to certify the resulting product.

5. **Confirmation that fuel quality and environmental standards have been met:**
   Documentation must be produced to demonstrate that the ASTM, fuel handling and relevant environmental criteria have been met.

6. Transportation of the SAF purchased by the aircraft operator to an airport:

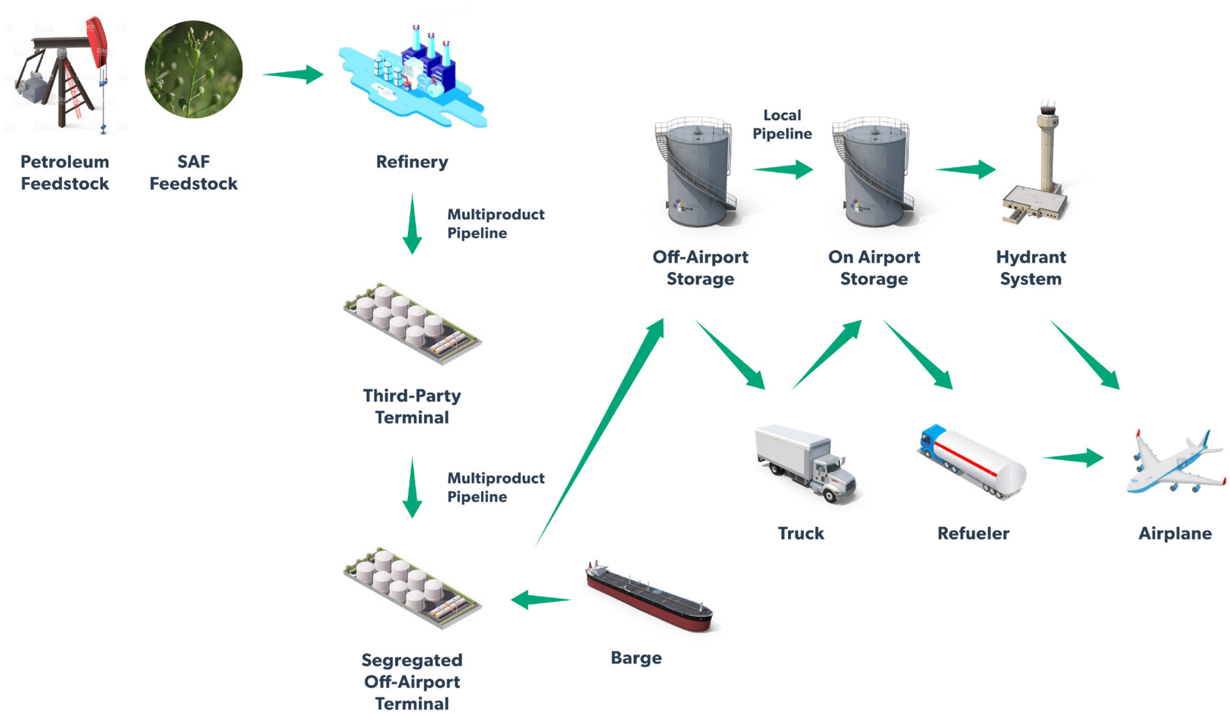
Long-standing U.S. refineries have well-established networks for transporting petroleum-based aviation fuel, typically including via pipelines, trucks and waterborne vessels. SAF production/blending facilities may not be near or otherwise initially have ready access to certain of these options. Hence, working through transportation logistics for delivering SAF from emerging production/blending facilities to airports is critical to ensuring commercial viability.

7. Receipt and deployment of blended SAF at airports:

Airlines purchase their own jet fuel and work with suppliers to secure on-time, on-specification delivery to airports.[13] SAF purchased by airlines and blended to meet ASTM D1655 can be "dropped in" airport fuel storage systems along with petroleum-based fuel. The logistics for receiving SAF-blended fuel may need to be developed if the transportation mode for delivering the SAF product to the airport differs from the mode otherwise used for on-airport fuel receipt.

While building or repurposing refineries to produce SAF — at a cost of hundreds of millions of dollars or more — is likely the most capital-intensive aspect of the SAF supply chain, each aspect requires significant investment and logistics. Accordingly, relatively little commercial supply of SAF has been deployed to date,[14] and SAF generally has been significantly more costly than petroleum-based aviation fuel. Even a one cent/gallon increase in the average annual price of jet fuel in 2019 would have cost U.S. airlines approximately $215 million, so SAF prices must be driven lower to achieve long-term commercial viability.[15]

JET FUEL SUPPLY CHAIN



POLICIES AND COLLABORATION TO FURTHER SUPPORT SAF SCALE-UP

U.S. airlines have worked hard to help establish the processes for developing and deploying SAF, both through individual efforts and collective efforts such as CAAFI, A4A's "Strategic Alliance for Alternative Aviation Fuels" with the U.S. Department of Defense's (DOD) Defense Logistics Agency-Energy (DLA Energy), the Farm-to-Fly and Farm-to-Fly 2.0 initiatives[16] and multiple advocacy efforts to make SAF eligible for the types of incentives and support programs available to ground-based alternative fuels.

Through CAAFI, we also published "Guidance for Selling Alternative Fuels to Airlines," which assists aspiring producers by defining various fuel readiness levels and recommending avenues for commercial engagement with carriers interested in purchasing SAF.[17]

We have made significant progress but still need supportive government policies, ongoing commitment from an array of stakeholders and expanded public-private partnerships to get the SAF industry over the cusp. Although the airlines that purchase SAF and integrate it into their businesses and airport fuel supply chains must remain in the lead for SAF deployment at any given location, collaborative efforts with airports and other stakeholders can be helpful.

THERE ARE FIVE PRIMARY WAYS IN WHICH AIRPORTS AND OTHER STAKEHOLDERS CAN SUPPORT SAF DEPLOYMENT:

1. **Promote collective understandings and collaboration**

2. **Advocate to maintain and expand positive incentives for SAF**

3. **Collaborate with airlines on regional SAF strategies and/or potential airport-specific opportunities**

4. **Support airlines and their fuel producers during initial SAF deployment at an airport**

5. **Celebrate volunteerism**

1. PROMOTE COLLECTIVE UNDERSTANDINGS AND COLLABORATION

Existing forums provide helpful resources to enhance understanding of SAF development and deployment opportunities and challenges and opportunities for sharing information and leveraging existing work.

In 2006, the FAA, airlines (via A4A), airports (via ACI-NA) and airframe and aircraft engine manufacturers (via AIA) jointly founded CAAFI to serve as the driving and coordinating force for the industry's efforts to develop and deploy SAF, a role that CAAFI continues to play today. While all of the CAAFI entities have worked on SAF since CAAFI's founding, much of the early development work on standards, processes, evaluation protocols and advocacy relied on the FAA, airframe and engine manufacturers and airlines, as those entities had the necessary tools (e.g., aircraft) and affiliations such as ASTM participation, public-private research and development engagements and alliances with the U.S. military.

As SAF deployment has become more possible, airports are increasingly expressing interest in deployment. Using existing forums such as CAAFI and the Center of Excellence for Alternative Jet Fuels and the Environment (ASCENT) to share information and collaborate can enhance common understanding, leverage existing work and create new synergies without reinventing the wheel.

CAAFI

Although U.S. aviation interests originally created CAAFI, its membership quickly expanded to include additional government agencies, researchers, academics, fuel providers, finance professionals and legal experts, among others, and extended beyond U.S. borders to include a broad swath of stakeholders across the world. CAAFI's work has focused on four areas, with virtual teams engaging in each of the following: (1) fuel certification and qualification; (2) research and development; (3) sustainability; and (4) business (including SAF supply chain development).

Short of getting directly involved in a CAAFI team, stakeholders can take advantage of CAAFI's resources at www.caafi.org, attend CAAFI's biennial meetings or connect with the CAAFI executive director or other members of the leadership team to learn and network.

ASCENT

Co-led by Washington State University and the Massachusetts Institute of Technology, ASCENT is a cooperative aviation research organization whose mission is to discover, analyze and develop science- and technology-based solutions to support the growth of the U.S. aviation industry by addressing the energy and environmental challenges the industry faces. ASCENT (https://ascent.aero/) is funded by the FAA, NASA, DOD, EPA and Transport Canada, coupled with a one-to-one match of private-to-federal funding.

ASCENT is doing essential work on the SAF supply chain, with researchers developing innovative and cost-effective production and distribution systems, evaluating how alternative fuels will affect emissions, air quality and engine performance, and creating more concrete standards for alternative fuel certification. The ASCENT Advisory Board includes ACI-NA and representative airports along with other aviation stakeholders.

2. ADVOCATE TO MAINTAIN AND EXPAND POSITIVE INCENTIVES FOR SAF

For several years, airlines and other stakeholders have worked to make SAF eligible for the types of supportive programs and incentives that are routinely available to ground-based alternative fuels. These programs and incentives must be maintained and expanded.

One of the most significant ways to support SAF commercialization is for airlines, airports and other stakeholders to partner in pursuing federal, state and/or local policies and incentives that will reduce the cost barriers for SAF production and purchase. This can include developing strategies and advocating policies across the nation and/or in a particular region to reduce the costs of feedstocks and/or production, provide financial support for necessary capital investment, or otherwise help narrow the price gap between SAF and petroleum-based fuel based on gallons produced or purchased.

While government policies and incentives have been crucial in facilitating the current level of SAF commercialization, such programs must be maintained and expanded to facilitate scale-up. Such policies play an important role in de-risking the investments needed throughout the entire SAF supply chain. There are various ways that airports can help support constructive public policies and incentives, including, for example: 1) advocating in collaboration with airline partners; 2) providing local and state knowledge and perspective to help identify ways to align SAF commercialization within state and local priorities and programs, along with identifying strategies and avenues to discuss and advocate for supportive policies; 3) using communications resources to raise the profile of SAF so policy leaders can understand more clearly how their engagement will lead to tangible results; and 4) growing the partnership network by identifying additional organizations and individuals who can provide support for government policies and incentives, thereby increasing the likelihood of success.

Following are some examples of supportive policies and programs that can benefit from collaborative advocacy:

FEDERAL PROGRAMS SUPPORTING SAF

Research, Development and Strategy

The federal government has played an important leadership role in organizations and programs facilitating SAF development, much of which has been coordinated through CAAFI. However, government funding for these efforts is always at risk and requires ongoing political support.

Two examples of programs that have provided federal funding for SAF research and development (R&D) are led by the FAA in coordination with other government, university and private entities. The first is the above-noted ASCENT program. The second is the Continuous Lower Energy, Emissions & Noise or "CLEEN" program, which is a public-private partnership focused on near-to-medium term aircraft engine and technology breakthroughs for lower emissions and noise, enhanced energy efficiency and aviation alternative fuels.

In another example, the U.S. Department of Agriculture (USDA) has invested hundreds of millions of dollars to accelerate research through its Biomass Research and Development Initiative (BRDI) on bioenergy feedstock crops and conversion processes to support various types of fuel, including SAF. USDA's involvement in SAF R&D work, a significant portion of which has been coordinated through the Farm-to-Fly initiatives and CAAFI, aims to boost feedstock availability to reduce carbon emissions from fuel while providing economic support to rural communities. BRDI is authorized in the Energy Title of the "Farm Bill," the most recent version of which is the Agriculture Improvement

Act of 2018. Unfortunately, however, funding is threatened for this and other Energy Title programs, necessitating ongoing advocacy in support of the program.

In addition, several federal agencies collaborated in creating the Federal Alternative Jet Fuels Research and Development Strategy (2016), which included significant input by stakeholders across the SAF value chain.[18] Ongoing work in support of the strategy is coordinated through the U.S. Department of Energy's (DOE) Bioenergy Technologies Office, whose mission is to support R&D of new technologies and processes for biofuels, including SAF.

Feedstock Assistance

USDA's Biomass Crop Assistance Program (BCAP) helps provide incentives to farmers and landowners in producing nonfood energy crops to support renewable fuels in rotation with or in addition to food crops. As with BRDI, the BCAP program is under threat and requires steadfast political support.

Grants and Loan Guarantees for Refineries

USDA, DOE and DOD have provided grants and loan guarantees to support renewable fuel facilities at the demonstration size, pilot size and initial commercial scale. The aviation industry and our partners have worked to create these programs, which help to de-risk investments from lenders and capital markets in order to support SAF facility construction. One of the most significant programs in this regard has been a partnership of these agencies under the Defense Production Act, leveraging the Farm-to-Fly initiative and the A4A-DLA Energy strategic alliance, to accelerate the development of domestic, competitively-priced drop-in renewable diesel and SAF through supply-chain support for commercial-scale facilities.

In July 2020, the House of Representatives passed a bill that would direct the U.S. Department of Transportation, of which the FAA is a part, to establish an alternative fuel and low-emission aviation technology grant program. The bill would authorize $200 million annually for the program over a 5-year period, with half of the program's funds dedicated to projects that produce, transport, blend or store SAF.[19] The bill also would provide a 5-year, $30 million per year authorization for the study and development of SAF.[20] Although the measure would only provide authorizations rather than actual funding for these SAF-related programs, on balance it would constitute a positive development for SAF if enacted into law.

Federal Renewable Fuel Standard (RFS) Financial "RIN" Incentive

Congress created the RFS via the Energy Policy Act of 2005 and revised it two years later in the Energy Independence and Security Act of 2007. (Regulations implementing the revised program are commonly referred to as "RFS2.") This program is focused on renewable fuel for ground transportation, requiring a minimum amount of renewable fuel to be used each year in the transportation sector, ramping up over time. Currently, only gasoline and diesel fuels are subject to the quota requirements. However, those who produce biomass-based jet fuel can qualify for credit under the program on a voluntary, opt-in basis if the fuel meets certain GHG emissions savings thresholds as confirmed through LCA and other specified criteria. This is significant, because the Renewable Identification Numbers or "RINs" that are issued for qualified fuels carry a monetary value that help make SAF more affordable.

Maintaining the voluntary, opt-in nature for SAF is critical given the nascent status of the SAF market, the "higher hurdle" of producing fuel to meet the rigorous jet fuel specification, and the inherent and extensive market advantages of producing ground-based alternative fuels, especially renewable diesel, compared to SAF. In addition to maintaining the opt-in credit under the RFS for SAF, action is needed to place SAF RIN crediting on par with that for renewable diesel. Currently, most renewable diesel generates 1.7 RINs per gallon, whereas SAF has been determined to generate

1.6 RINs per gallon.[21] Obtaining RIN parity or preferably a credit multiplier for SAF under the RFS2 program is particularly important given the market forces noted above that have favored and continue to favor renewable diesel production.

SAF Blender's Tax Credit

Congress established what is commonly referred to as the "biodiesel and renewable diesel tax credit," found in Section 40A of the Internal Revenue Code, to provide a $1.00/gallon tax credit to those who mix (i.e., blend) certain biofuels in the fuel supply chain. While referred to as the "biodiesel/renewable diesel" credit, Section 40A(f)(4) expressly provides that biomass-based jet fuel meeting the relevant ASTM standard qualifies as "renewable diesel" and thus is entitled to the credit. This tax credit is an essential tool to help bridge the price gap between SAF and petroleum-based jet fuel. Unfortunately, the credit is due to expire at the end of 2022, and at $1.00/gallon, it has not, to date, provided a sufficient incentive for the production of SAF.

A4A and other aviation industry stakeholders, together with SAF producers, have approached Congress about removing biomass-derived jet fuel from Section 40A and establishing instead a unique, stand-alone blender's tax credit for SAF at a level of $2.00/gallon. The proposed credit would encompass SAF derived from biomass as well as other feedstocks, and would remain in place for at least 10 years to provide SAF producers with much-needed stability and certainty. Airport support for this SAF-specific blender's tax credit would amplify the aviation (and SAF) industry's message.

STATE/LOCAL PROGRAMS SUPPORTING SAF

The availability of positive incentive programs within states and localities is one of the most critical factors in determining where SAF is produced and deployed. In addition to the following examples of financial support or incentives for SAF production and deployment, there are other opportunities at the state or local level to utilize existing financial tools and programs or to expand on these programs.

State Bonds

In certain cases, states have issued bonds to help build SAF facilities. Two examples are Nevada, which issued a bond of $150 million for Fulcrum BioEnergy, and Oregon, which issued a bond of $245 million for Red Rock Biofuels.

Financial Incentives for SAF Produced on a Voluntary Basis

California and Oregon both have adopted policies under their lower-carbon fuels initiatives that provide incentives for SAF on a "per gallon" basis. Similar to the federal RFS2 program, California, through its "Low Carbon Fuel Standard" (LCFS) program, and Oregon, through its "Clean Fuels Program," require the production of specified quantities of low-carbon fuel. Although jet fuel is not subject to the low carbon fuel production mandates in either state, both jurisdictions allow SAF meeting certain requirements to qualify, on a voluntary, opt-in basis, for credits under their respective programs.[22] A coalition of the aviation industry (including airports), SAF producers and potential SAF producers worked cooperatively to advocate for these supportive state policies, which, like the RFS2, help make SAF more affordable.

Stakeholders interested in SAF can work together to identify existing state and local incentive programs to support SAF deployment and advocate for new or additional programs to fill gaps.

3. COLLABORATE WITH AIRLINES ON REGIONAL SAF STRATEGIES AND/OR POTENTIAL AIRPORT-SPECIFIC OPPORTUNITIES

SAF provides the opportunity to diversify fuel supply based on regional feedstocks and opportunities. Assessing potential supply chain elements on a regional basis with particular airports in mind can help determine whether SAF production may be commercially viable in a region and help overcome obstacles.

Given that SAF supply chains are highly dependent on feedstock availability and cost, the siting of SAF refining facilities, and the transportation of feedstocks and resulting SAF, among other variables, regional characteristics and economic indicators can greatly affect whether SAF production in a particular region makes sense. Assessments of the potential for SAF production in an area can help address these issues and identify ways to overcome challenges to SAF production and delivery.

To date, there have been two comprehensive regional overview assessments, which benefited greatly from collaboration and funding provided by a combination of airlines, airports, fuel producers, airframe manufacturers and other stakeholders. The first of these, the Sustainable Aviation Fuels Northwest (SAFN) initiative, led in part by Alaska Airlines, together with the Port of Seattle, Port of Portland, Spokane International Airport, Boeing and Washington State University, found that an aviation biofuels industry can be commercially viable in the Pacific Northwest under certain conditions and identified four particularly promising feedstocks: oilseeds, forest residues, municipal solid wastes and algae.[23] The second, the Midwest Sustainable Aviation Biofuels Initiative (MASBI), led by United Airlines, Boeing, Honeywell's UOP, the Chicago Department of Aviation and the Clean Energy Trust, developed recommendations to help "achieve the potential economic, environmental, and energy security benefits that can be delivered from a robust sustainable aviation biofuels industry in the Midwest."[24]

Such regional work can be helpful in the growth of the SAF industry when there is demonstrated interest from airlines in potential supply and the work is targeted to identify specific ways to reduce costs. It is essential to ensure airlines and airline fuel consortia are fully engaged and supportive of the work.[25] Further, consideration should be made of which issues might warrant a regional/airport-specific effort or whether there are common issues that could be more effectively and efficiently discussed at a national level, such as through a collaboration among ACI-NA, the American Association of Airport Executives, A4A and others. Given that there are more than 500 airports in the U.S. with scheduled commercial service, splitting resources across many different airports may not be an effective way to increase volumes of SAF.

Because SAF is a drop-in fuel as blended with petroleum-based jet fuel, it can be stored and distributed in existing jet fuel infrastructure with the rest of the jet fuel supply at an airport without the need for modifications. Even so, some aviation industry participants have undertaken airport- or region-specific infrastructure assessments focused on potential means to transport neat SAF that might be produced in a region to another location for blending and/or for delivery of blended SAF to an airport through new transportation modes. For example, Alaska Airlines partnered with Boeing and the Port of Seattle on an infrastructure study for potential future deployment of SAF at Seattle-Tacoma International Airport.[26] Similarly, San Francisco International Airport collaborated with airlines, the local airline fuel consortium and consultants to explore SAF supply, blending, transportation and delivery options in the region.

4. SUPPORT AIRLINES AND THEIR FUEL PRODUCERS DURING INITIAL SAF DEPLOYMENT AT AN AIRPORT

When an airline seeks or identifies SAF supply to bring to an airport, the airline and airport can work together to facilitate initial start-up.

Airport engagement can be important in ensuring success of an airline's SAF deployment, particularly with respect to the first deliveries by a new SAF provider. Airlines, fuel consortia, airports and/or fuel facility operators can have specific rules for fuel deliveries, on-airport transfers and associated fuel quality confirmation testing and documentation. SAF providers may not have the same familiarity with airport operations that traditional fuel providers have, so support from the airport authority can be helpful for a smooth start-up.

Airports can play a role in welcoming new SAF providers and facilitating, in concert with the airline SAF purchasers and fuel consortia, communications with the broader airline community at the airport that SAF deliveries are being initiated.

5. CELEBRATE VOLUNTEERISM

Given the still-nascent state of the SAF industry, the high cost of SAF and federal limits on local regulation of aviation fuel, SAF quotas or mandates are not appropriate. But support for voluntary SAF deployment initiatives and incentives can make a real difference.

As noted, SAF must meet rigorous certification and environmental criteria. There are very few producers of SAF; costs of the fuel are very high; logistics for feedstocks, production, blending and delivery are still being established; and many of the policies that have long supported ground-based alternative fuels are not yet available for SAF. Although the U.S. airlines were instrumental in creating the pathways for SAF deployment and are committed to making SAF commercially viable to support our environmental and supply diversification goals, we still have work to do to scale up supply and make it cost competitive.

Accordingly, U.S. airlines welcome support for efforts to make SAF fully commercially viable and deploy SAF where it makes sense as we scale up. In looking for ways to demonstrate support for SAF, some airports have suggested setting targets for SAF use at their airports. In addition to legal and other constraints against state, local and airport SAF quotas and mandates, such an approach would be inconsistent with market realities both in terms of supply availability and airlines' ability to purchase non-cost-competitive fuels at scale. U.S. airlines are engaged with would-be SAF producers, CAAFI and others to assess and enhance opportunities for SAF deployment. We encourage airports and other stakeholders to work with us in cooperative ways to develop, evaluate and support policies that will, quite literally, get SAF off the ground.

ENDNOTES

[1]While "SAF" has become the preferred term to describe such fuel, other commonly used terms, typically intended to have the same meaning, include sustainable alternative jet fuel, renewable aviation fuel, alternative aviation fuel, renewable jet fuel, alternative jet fuel, aviation biofuel and biojet fuel.

[2]Although this primer focuses on SAF deployment by U.S. airlines at the U.S. airports they serve, many of the points apply more broadly to other airlines, other parts of the world and business aviation.

[3]The International Civil Aviation Organization (ICAO), the United Nations' standard-setting body for international aviation, established the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to help achieve carbon-neutral growth in international aviation from a 2020 baseline. See https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx.

[4]See Transportation Research Board, ACRP Project 02-80: "State of the Industry Report on Air Quality Emissions from Sustainable Alternative Jet Fuels" (April 2018), available at http://www.trb.org/Aviation1/Blurbs/177509.aspx.

[5]See NASA Release 17-027, "NASA Study Confirms Biofuels Reduce Jet Engine Pollution" (March 15, 2017), available at https://www.nasa.gov/press-release/nasa-study-confirms-biofuels-reduce-jet-engine-pollution.

[6]Co-founded in 2006 by the FAA, Airlines for America (A4A), Aerospace Industries Association (AIA) and Airports Council International-North America (ACI-NA), CAAFI (www.caafi.org) is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants and U.S. government agencies. CAAFI aims to promote the development of SAF options that offer equivalent safety and favorable costs compared with petroleum-based jet fuel, while offering environmental improvement and energy security for aviation.

[7]CAAFI worked within ASTM to facilitate the approval process for SAF, an effort that led to the issuance of ASTM D4054, "Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives."

[8]ASTM has also approved the co-processing of up to 5% by volume of fats and oils (free fatty acids and fatty acid esters found in oils derived from plants and animal fats), and up to 5% by volume of Fischer-Tropsch hydrocarbons, as feedstocks in petroleum refinery processes under ASTM D1655.

[9]The GREET® (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model was developed by Argonne National Laboratory with the support of the U.S. Department of Energy (DOE). GREET is an LCA tool, structured to systematically examine energy and environmental effects of a wide variety of transportation fuels and vehicle technologies in major transportation sectors (i.e., road, air, marine, rail). See https://greet.es.anl.gov.

[10]See https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_Supporting_Document_CORSIA%20Eligible%20Fuels_LCA_Methodology_V2.pdf.

[11]See https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO%20document%2006%20-%20Default%20Life%20Cycle%20Emissions.pdf.

[12]See https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx. In June 2019, ICAO approved the first edition of the "CORSIA Sustainability Criteria for CORSIA Eligible Fuels"; the document, which sets out the sustainability criteria applicable to such fuels during CORSIA's 2021-2023 "pilot phase," is available at https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO%20document%2005%20-%20Sustainability%20Criteria.pdf. Additional sustainability criteria will apply starting in 2024.

[13]Fuel storage and distribution systems at the nation's largest airports are typically leased and managed by airlines or airline fuel consortia. See https://airlines.org/media/management-of-airport-fuel-systems/.

[14]An average of approximately 1 million gallons of neat SAF per year was deployed by U.S. airlines in the years 2017 through 2019, the vast majority of which was deployed by United Airlines. By comparison, the industry's petroleum-based jet fuel consumption averaged 21 billion gallons per year in 2017-2019.

[15]According to the U.S. Department of Transportation's (DOT) Bureau of Transportation Statistics, U.S. airlines consumed approximately 21.4 billion gallons of jet fuel in 2019. See DOT Form 41 summary data, available at https://transtats.bts.gov.

[16]Originally launched by the U.S. Department of Agriculture, A4A and Boeing, the Farm-to-Fly initiative's mission was to accelerate the availability of a commercially viable SAF industry in the United States, increase domestic energy security, establish regional supply chains and support rural development. The expanded Farm-to-Fly 2.0 program continued this mission with a broader array of stakeholders.

[17]See http://www.caafi.org/files/CAAFI_Business_Team_Guidance_Paper.pdf (July 2018). This guidance document will be updated soon.

[18]Available at this website: http://www.caafi.org/files/Federal_Alternative_Jet_Fuels_Research_and_Development_Strategy.pdf.

[19]See § 10201 of H.R. 2, available at https://www.govinfo.gov/content/pkg/BILLS-116hr2eh/pdf/BILLS-116hr2eh.pdf.

[20]Id. § 10203.

[21]Under 40 CFR § 80.1415(b)(4), "[n]on-ester renewable diesel with a lower heating value of at least 123,500 Btu/gal shall have an equivalence value of 1.7." By comparison, SAF's RIN value, which is established under an "equivalence value" formula, has been set by EPA at 1.6, see, e.g., https://www.epa.gov/sites/production/files/2020-09/fuelproduction_aug2020_1.csv.

[22]Both States adopted their SAF opt-in provisions in 2018, with an effective date of January 1, 2019

[23]See SAFN, "Powering the Next Generation of Flight," available at https://www.climatesolutions.org/programs/saf/resources/safn.

[24]See MASBI, "Fueling a Sustainable Future for Aviation," available at http://www.masbi.org/content/assets/MASBI_Report.pdf.

[25]As noted, the A4A publication, "Management of Airport Fuel Systems," explains fuel consortia and is an important reference for questions regarding airline fuel management at U.S. airports.

[26]The infrastructure report is available at https://www.portseattle.org/sites/default/files/2018-03/Aviation_Biofuel_Infrastructure_Report_Condensed.pdf.

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