Farm-to-Fly 2.0 (F2F2) Fact Sheet

Summary of Activities and Outcomes from the
6 Year Period of Activity: April 2013 – April 2019[1]

Published September 2019

Foreword

This report summarizes the efforts and results of a public-private partnership (PPP) between select members of the jet-powered aviation industry and several federal agencies whose interests aligned with the desire to develop and commercialize a new industrial segment for the production of sustainable aviation fuel (SAF)[2]. This specific subset of activities (performed concurrent with a broader set of industry efforts focused on SAF development), was initiated from a 2013 agreement entitled the Farm-to-Fly 2.0 – Working Together Resolution (F2F2) between the U.S. Departments of Transportation and Agriculture and other aviation industry counterparts acting through the Commercial Aviation Alternative Fuels Initiative® (CAAFI®). In 2014 the U.S. Department of Energy also signed on as an F2F2 partner. The F2F2 agreement followed the original Farm-to-Fly (F2F) efforts, which occurred from 2010-2012 (discussed briefly below and documented in the Farm-to-Fly Report). CAAFI has supported all the signatories to the F2F and F2F2 agreements in carrying out their efforts to facilitate the development of SAF supply chains.

The F2F and F2F2 program names were selected as a reflection of the need to develop primarily biomass resources ("from the farm") whose compositional elements could be used to supplement petrochemical resources used to manufacture jet fuel ("used to power flight"). The continued use of petrochemical resources for fuel production results in taking sequestered carbon from the ground (in the form of oil, natural gas, and coal) and releasing it into the atmosphere in the form of carbon dioxide (CO_2) and other greenhouse gases, during both its conversion into fuel and subsequent combustion. In contrast, the use of biomass resources, which pull CO_2 from the atmosphere for their growth, decouples aviation's use of energy from the continued atmospheric buildup of CO_2. These biomass resources can be converted to jet fuel through a wide range of thermochemical or biochemical conversion processes, either as stand-alone refineries, or integrated with industrial processes or existing petroleum refining. Choice of the use of "farm" does not suggest all such biomass resources (generally referred to as feedstocks) would come from traditional farmed land and practices, but rather from many rural and other sources, including:

[1] The F2F2 agreement outlined a 5-year effort, commencing at its signing in April 2013, expecting the efforts to extend through the regime of the 2014 Farm Bill, and into the regime of the 2018 successor. The agreement committed to issue a final report at year-end 2018. Like many good initiatives, the F2F2 activity has efforts that continued past the original period of performance, into the present. As a compromise between the desire to communicate continuing progress while still meeting the final report mandate, CAAFI extended the timeframe of this report to April 2019, covering six years of actual effort.

[2] In 2018, the International Civil Aviation Organization (ICAO) adopted the simplified term Sustainable Aviation Fuels (SAF) to describe hydrocarbon jet fuel produced synthetically from biomass and waste sources rather than petrochemicals, and which also meet certain sustainability requirements. The industry is now consolidating on the use of the term SAF to replace several others the industry had been using (e.g. aviation biofuel, biojet, sustainable alternative jet fuel, and bio-synthetic-paraffinic-kerosene).

- Traditional agricultural resources (e.g. oilseeds/nuts, grains/starches/sugars, straws and stovers, animal wastes, culled agriculture products, agriculture residues, and energy grasses and canes);
- Forestry resources (e.g. sawdust, slash, trim, thinnings, and biomass from plantation and coppiced trees)
- Other byproduct streams originating from other human activities (e.g. municipal waste, construction waste, yard waste, food waste, food production wastes, animal fats, waste oils and greases, sewage); or
- Industrial activities (e.g. production of waste effluents rich in hydrogen and carbon that are the building blocks of fuels).

However, the participants in the F2F2 activities believe that to achieve a new, resilient, domestic energy future for the aviation sector, sustainable agriculture and silviculture practices are necessary to achieve scalable growth of SAF supply beyond what might be available from various "wastes and residues" streams whose volume and supply growth potential is likely limited. So, use of the term "farm" does not mean an exclusive focus on purpose grown feedstocks, but rather is a reflection of the interest of the partners in working with the aviation industry to understand how renewable resources, from the farm and forest primarily, might be able to be integrated into SAF production. The purpose of the F2F2 program was to enable the joint exploration of these concepts in a more structured manner, under a commitment to create a F2F2 Working Group, and to collaborate on SAF development activities amongst the signatories.

Lessons Learned

Several valuable best practices were identified from the F2F2 body of work to facilitate SAF supply chain development and production. These tenets will form the basis for any proposed follow-on activity, for which there is general support from the participants.

The successful development of SAF:

1. Must involve activities that span the purviews of multiple agencies.
    - The domain knowledge and expertise from existing resources within the signatory entities was formidable and extensive, although not always easy to find without having the networked discussions that such a partnership effort enabled.
    - Continued efforts to assist with the supply chain optimization will be necessary to unlock the production of SAF at the scale needed to achieve aviation goals.
    - SAF supply expansion will produce multiple benefits to the U.S. economy and society as a whole.
2. Requires focus on high potential development opportunities specific to aviation.
    - Multi-agency coordination on aviation concerns continues in the present by virtue of CAAFI's regular engagement, as well as the periodic coordination of the Federal Alternative Jet Fuel Strategy Interagency Working Group.
    - Additional coordination also occurs via the eight Interagency Work Groups (IWGs) that exist as part of the remit of the Biomass Research and Development Board (BRDB), though this group has a broader focus on all bio-products and not SAF specifically.
    - However, the current level of coordination may not be sufficient to address the size of the challenge to decarbonize this hard-to-abate industrial sector.
3. Needs leadership and focus from the heads of the participating organizations, and the effective engagement from a few key committed personnel, to drive successful action.

- Such leadership can make significant impacts, even operating under scenarios of limited resources.
- Coordinated efforts by leadership and key personnel results in impacts that are of greater value than the sum of individual parts.
- It is easier to modify the focus of existing efforts and working groups to achieve slightly altered goals than to start completely new programs.

4. Should be guided by lessons learned from F2F and F2F2, and similar public-private-partnership activities.
    - Nothing breeds success like learning from your efforts (both successes and failures), and F2F2 created templates and guidelines for how to continue such work in potential follow-on activity.
5. Can be significantly impacted by even modest amounts of funding.
    - Seed funding, which can come from diverse sources, was critical in F2F2 for the initiation of the collaboration and analytical activities necessary to perform this type of very early business development work. It is expected to be the same for the continuation of this type of collaboration.
6. In addition to seed funding, other types of financial support at all stages of development (research, pilot, and demonstration scale) are needed in order to ensure successful development and to achieve meaningful scale-up of new SAF production processes.

The final report that follow provides details on the history, efforts, and progress of the F2F2 program and closely related activities.

F2F2 Final Report

The Farm-to-Fly Initiatives

Farm-to-Fly entails two public-private initiatives that have functioned to facilitate the development and maturation of SAF supply chains in the United States. Over the last nine years of the F2F (2010-2013) and F2F2 (2013-2019) initiatives, government and industry along with academic and non-governmental institutions have demonstrated the value of public-private partnerships to advance the development of SAF supply chains. The F2F2 initiative has created templates for supply chain engagement and development that can be used to support implementation of SAF production going forward. The F2F2 signatories and their partners have built new tools that can support regional and national analyses of future energy scenarios. On-the-ground, tactical-deployment feasibility studies and assessments have laid the groundwork for effective and equitable supply chains. Now the opportunity awaits to leverage those investments to achieve maximum impact, developing new rural jobs and a new, innovative, and strategic industry.

Partners

The original Farm to Fly Initiative was signed in 2010 to formalize a joint commitment among the U.S. Department of Agriculture (USDA), Airlines for America, Inc. (A4A) (formerly the Air Transport Association) and the Boeing Company to work together to "accelerate the availability of a commercially viable and sustainable aviation biofuel industry in the United States, increase domestic energy security, establish regional supply chains, and support rural development." It resulted in a Farm-to-Fly Report that highlighted the significant opportunity presented by cooperation between aviation and agriculture sectors.

> **"… the USDA and the Aviation Enterprise acknowledge that their combined efforts have the potential to increase domestic energy security and improve sustainability for aviation, and are aligned with both USDA's goals to support rural economic development and Aviation's needs to establish robust regionalized biomass supply chains for the production of sustainable bio-Jet Fuel."**
> - Farm-to-Fly 2.0 Agreement, 2013

The Farm to Fly 2.0 (F2F2) Resolution, signed in April 2013, created an expanded effort to include additional government agencies and private sector partners. It joined together the U.S. Departments of Agriculture (USDA) and Transportation (DOT); the Commercial Aviation Alternative Fuels Initiative (CAAFI®); and private sector CAAFI coalition sponsors: Airlines for America (A4A), the industry trade association of major North American carriers; The Aerospace Industries Association (AIA), for expansion beyond Boeing's engagement; The Airports Council International - North America (ACI-NA). Elements of the business aviation community also joined through the General Aviation Manufacturers Association (GAMA) and the National Business Aviation Association (NBAA). This addition of the business aviation community was specifically targeted for the purpose of incorporating additional potential SAF users alongside commercial carriers. The U.S. Department of Energy (DOE) joined the F2F2 program as a signatory in 2014[3].

[3] https://www.energy.gov/eere/bioenergy/articles/farm-fly-20-energy-department-joins-initiative-bring-biofuels-skies

Together these parties committed to work together in an expanded collaboration to enable commercially viable, SAF supply chains in the U.S. that can support the goal of one billion gallons of SAF production capacity and use for the U.S. aviation industry. The group committed to 1) evaluate current and prospective feedstock types using the Feedstock Readiness Level (FSRL) tool and other resources; 2) develop teams at state and local level to develop multiple feedstock-to-fuel supply chains; and 3) communicate results and recommendations for future work. Much of this work was conducted through grants to academic institutions, as well as engagement with non-governmental organizations (NGOs) who provided input regarding community participation and impacts, and natural resources sustainability.

Since the F2F2 signing, the signatories have engaged in substantial collaborative efforts to honor this commitment to further the development and maturation of SAF supply chains in the United States. The F2F2 Working Group has acted as a coordinating body to ensure that activities among the signatories are aligned, complementary and non-duplicative, and to identify opportunities for further effort. Several individual efforts described below are expected to continue for at least another three years, and some will likely last longer, offering the promise of significant feedstock development. Other efforts currently seek to continue to expand their execution and impact through relevant funding opportunities.

Progress

The signatory organizations have individually and collectively undertaken efforts to facilitate the development of economically viable SAF pathways and supply chains. Activities addressing the specific commitments in the F2F2 agreement are summarized below.

F2F2 Commitment 1a: Assess and propose means for mutual goal: "systematic evaluation of current and prospective feedstock types and systems, and road-mapping of gaps and needs using the previously developed feedstock readiness level tools and other applicable resources."

Under the original Farm to Fly agreement, collaborators from USDA, DOT, and FAA developed the Feedstock Readiness Level tool, which applied the principles of gated risk-management (used heavily by the aviation sector) to the development and maturation of feedstocks for SAF production. The F2F2 feedstocks sub-team has developed a public repository of Feedstock Readiness Level (FSRL) evaluations that assess the maturity of various feedstocks by region and their linkages to SAF production. This repository is intended to enable stakeholders interested in developing SAF facilities, or acquiring SAF from a given facility, to understand what feedstocks may be available in the near term in a specific region. It also is intended to allow stakeholders to identify gaps where further research, development or investment may be needed to facilitate readiness of a feedstock for a given conversion process. The repository is located on USDA's National Agricultural Library Ag Data Commons and is updated quarterly when new evaluations are received. As part of the F2F2 effort, researchers from the USDA Regional Biomass Research Centers (RBRCs) contributed many of the FSRL evaluations on the repository based on their research and knowledge of diverse biofuel feedstocks. The FSRL and the associated repository can enable future decision-making regarding feedstock development investments.

The FSRL activity also served as a basis for work that is now being pursued by commercial entities to develop a set of standards for evaluating and scoring biomass supply chain risk such that a better understood level of risk might facilitate capital investment/financing with more favorable (risk reduced) rates.

USDA ARS continues to foster the development of new types of feedstocks, and due to the success of the F2F2 collaboration, they regularly reach out to CAAFI for coordination of such efforts with other academics, industry practitioners, and SAF developers.

F2F2 Commitment 1b: Assess and propose means for mutual goal: "systematic development of public/private teams at the state and local level, whose goals it will be to coordinate regional efforts to reach the Goal "

USDA has looked to its extramural R&D arm, the National Institute of Food and Agriculture (NIFA), for part of the implementation of the original F2F and F2F2 initiatives. SAF was highlighted early in the NIFA Regional Bioenergy Coordinated Agricultural Projects (CAP) Program, and the first cohort of CAPs included the following projects targeting or closely affiliated with SAF:

- Northwest Advanced Renewables Alliance (NARA) led by Washington State University working with industrial partners, including Gevo, Alaska Airlines, Boeing, Weyerhaeuser, Tribal Partners, Pacific Northwest university partners, and federal laboratories on SAF converted from alcohols derived from wood waste;
- Advanced Hardwood Biofuels (AHB) led by University of Washington working with ZeaChem, Greenwood Resources, Tesoro, and the waste-water treatment industry, looking at the use of purpose grown woody crops;
- Southeastern Partnership for Integrated Biomass Supply Systems (IBSS) led by University of Tennessee working with Rentech and other regional partners targeting lignocellulosic-based SAF, and;
- Sustainable Bioproducts Initiative (SUBI) led by Louisiana State University Ag Center working with Virent on SAF derived from catalytic conversion of sugars from energy cane and sweet sorghum.

Two subsequently awarded (2017) Sustainable Agricultural Systems CAP projects focus specifically on sustainable SAF supply chains:

- Southeast Partnership for Advanced Renewables from Carinata (SPARC) led by University of Florida with partners ARA and Agrisoma, focused on the use of a winter cash cover crop, carinata, to produce high protein animal meal and oils that can be converted to SAF;
- Sustainable Bioeconomy for Arid Regions (SBAR) project led by University of Arizona with partners Bridgestone America, Eastman Chemicals, and others.[4] SBAR is focused on the development of guar and guayule, the latter of which is grown for rubber production, the remnants of which might be valuable as a feedstock for conversion to SAF.

Three additional NIFA CAPs led by Penn State University (New-BIO: switchgrass, *Miscanthus*, shrub willow); Colorado State University (BANR: insect damaged trees); and Iowa State University (CenUSA: perennial grasses) whose potential commercial outcomes do not specifically target SAF also add to the wealth of knowledge about regional supply chains, sustainability, workforce development, and outreach/tech transfer.[5]

[4] These descriptions refer to initial partners in the grant application, but actual entities involved may have changed during execution.

[5] https://nifa.usda.gov/afri-regional-bioenergy-system-coordinated-agricultural-projects

The CAAFI State Initiatives program has established public-private teams at the regional, state, and local level that are working actively toward concrete supply chain development and SAF deployment projects. CAAFI's F2F2 State Initiatives have included feasibility studies in 1) southern Florida on the use of sugar beets for alcohol-to-jet supply chain establishment, as well as to offer new crops for blighted citrus grove land; 2) in South Carolina on the potential for woody biomass-based fuels and algae-based fuels; and 3) in Vermont on the integration of anaerobic digesters to process dairy farm waste to produce fuels as well as animal feed, fertilizer, potable water, and co-benefits of nutrient effluent reduction. These and other initiatives in Connecticut, Georgia, and Virginia all leveraged funding from USDA's Rural Development organization through the Rural Business Enterprise Grants (RBEG), Rural Business Opportunity Grants, Rural Business Development Grants (RBDG), Value Added Producer Grants (VAPG), Business and Industry (B&I) Loan Guarantee, and the Rural Development 9003, 9005, 9006, 9007, and 9008 programs. Beyond these projects, CAAFI has supported local stakeholder exploration of possible state initiatives in several other locations across the U.S., including the Chesapeake Region, Hawaii, Minnesota, Ohio, and Colorado.

> *"Nothing beats the efficiency of working simultaneously with multiple, engaged agencies through a dedicated initiative. This type of collaboration really helps foster success that likely cannot be matched otherwise. I look forward to a follow-up program."*
>
> - Steve Csonka, Executive Director, CAAFI

The FAA-funded Aviation Sustainability Center of Excellence[6] (ASCENT) Project 001 - Alternative Jet Fuel Supply Chain Analysis has developed, tested and refined a variety of tools, models and resources and will apply those tools to deployment projects in the inland Northwest (lipid-based SAF), Hawaii (lignocellulosic-based SAF), and the Southeastern U.S. (lipid and/or lignocellulosic-based SAF). The tools are intended to provide decision-support analysis to commercial entities. These various efforts are intended to bring about more rapid deployment of well-designed and implemented SAF supply chains.

F2F2 Commitment 2: ***"Work with associated teams, through USDA's range of applicable… programs, as well as all other available mechanisms, on the development of multiple feedstock supply chains that demonstrate promise" in five key areas: "feedstock development; feedstock logistics and transportation infrastructure; grower acceptance; education and extension; production risk mitigation; and sustainable production."***

In addition to the public-private initiatives above, which are assisting the formation of new supply chains, the signatories have also worked extensively to aid supply chain teams nearing commercialization. Agency programs such as the Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program, the USDA/DOE/DOD Defense Production Act (DPA) biorefinery assistance, as well as research grants for feedstock development and logistics, transportation infrastructure and flow analyses, and

> *"Having the bi-weekly rhythm of the F2F2 coordination meetings these last several years has clearly helped align thinking on timing and importance of various development and commercialization activities, and to discuss the viability of USDA resources which could assist in such efforts. The collegiality and energy of this team made it a joy to engage with them on matters of substance."*
>
> - Chris Cassidy, National Rural Energy Program Coordinator / Renewable Energy Advisor, USDA, Rural Business Cooperative Service

[6] https://ascent.aero/

sustainability, have provided important support for participants.

In the area of feedstock development, the USDA Agricultural Research Service (ARS) and US Forest Service (FS) jointly manage four regional Biomass Research and Development Centers (BRDCs). The BRDCs work on individual and system components of diverse regional biomass supply chains that have the potential to underpin extant or emerging commercial SAF feedstock supply chains and value propositions. Work from each of these centers has been linked to various CAAFI and Agency efforts targeting SAF.

CAAFI convened a pennycress (*Thlaspi arvense*) feedstock "summit" in the spring of 2015 to bring together researchers across disciplines to better understand that crop's feedstock readiness. Pennycress is a new winter cover cash crop potentially suitable for incorporation into the corn-soybean rotation in the U.S. heartland with potential for fuel production. CAAFI continues to work with USDA and multiple entities focused on the development of winter cover cash crops, positioning such development for continued expansion and commercialization.

Additionally, the release of 'Liberty' switchgrass by USDA-ARS as part of a USDA-NIFA CAP grant provided a perennial, dedicated biomass feedstock for the cellulosic biofuels pathways. Liberty is targeted for growing biomass on marginally-productive cropland in the central and eastern USA to enhance ecosystem services and promote rural development.

Feedstock logistics and transport infrastructure have been analyzed extensively as part of the public-private supply chain initiatives described under Commitment 1b. With U.S. DOE funding, Idaho National Laboratory has commissioned and is operating a feedstock Process Development Unit (PDU). The PDU can take diverse biomass resources and create pelletized uniform feedstocks that can be transported over long distances. Biorefineries can thus access larger quantities of feedstocks. In addition, FAA and DOT have undertaken modeling efforts to assess potential transportation flow patterns, costs, and emissions associated with scaled-up SAF scenarios using the Volpe Center's (DOT) Freight and Fuel Transportation Optimization Tool (FTOT). The National Renewable Energy Laboratory (NREL), funded by the DOE Bioenergy Technologies Office (BETO), and the Volpe National Transportation Systems Center and ASCENT, funded by FAA, collaborated using FTOT and the NREL Biomass Scenario Model (BSM) to assess potential SAF deployment trajectories and geospatial patterns that might arise from future waste-based SAF scenarios, including crop and forestry residues Lewis et al. 2018).

Grower acceptance, education, and extension are now better understood thanks to efforts by USDA- and FAA-funded researchers to assess the barriers to supply chain success. Grower acceptance has been evaluated through surveys of farmers (e.g., Bergtold et al. 2014) and modeling of the community features that can contribute to "willingness to engage" in new supply chains through the Washington State University and Pennsylvania State University work on the Community Attribute and Asset Model (CAAM). CAAM, which was developed through the NARA CAP program and has continued to be tested and refined under the ASCENT program, allows decision-makers to evaluate particular communities' likelihood of success in undertaking complex economic and environmental projects such as the development of an SAF supply chain. Each of the NIFA AFRI CAP activities also incorporate(d) significant bodies of work associated with education and extension.

Production risk mitigation is a critical enabler of supply chain success. The ASCENT team has established a project to develop tools to aid supply chain participants in understanding where supply chain risk

resides and how to manage that risk so that all components of the supply chain are stable and resilient. This work is led by Pennsylvania State University.

DOE is assisting the initiative by supporting activities such as technoeconomic and life cycle greenhouse gas (GHG) emissions analyses, development and support of pilot and demonstration-scale facilities, and assistance with fuel testing and approval. DOE is exploring new conversion technologies such as biochemically-derived alcohol-to-jet processes, pyrolysis, and conversion of waste-based materials into SAF blendstocks.

DOE also currently funds four Bioenergy Research Centers[7]—each led by a DOE National Laboratory or a top university. The Centers are designed to lay the scientific groundwork for a new bio-based economy that promises to yield a range of important new products and fuels derived directly from nonfood biomass. Such work includes development of the feedstocks as well as the conversion processes. CAAFI has direct linkage to the strategies being considered by two of the four centers, serving on an advisory basis, engagement of which was driven by F2F2 cross agency collaboration.

Other DOE activities in the specific area of SAF development include:

- A 2019 issued Funding Opportunity Announcement which includes 10 areas of focus, several of which are being pursued by SAF affiliated parties.
- Tri-Lateral Canada-Mexico-U.S. Biojet Workshop held in Richland, WA in May of 2018 to discuss progress and collaboration opportunities between the countries.
- Jet Workshop, held in Sept 21-22, 2017 at the NASA Glenn Research Center in Cleveland, OH focusing on aspects of how SAF might be able to deliver improved aircraft performance and lesser levels of emissions via fuel chemical composition manipulation.
- An Alternative Aviation Fuel Meeting held in Macon, GA, Sept 14-15, 2016, and the resulting Alternative Aviation Fuels: Overview of Challenges, Opportunities and Next Steps report.
- NREL techno-economic analyses on biochemical and catalytic processes (e.g., algal biofuels).
- Argonne National Laboratory AJF greenhouse gas LCAs and GREET development/updates, including a specific GREET-Jet version of the model
- Argonne modeling and analyses of water-use sustainability of fuels
- Oak Ridge National Laboratory (ORNL)'s Billion Ton Study update (2016) assessing future biomass-based feedstock availability for the bioeconomy, including alternative jet fuel
- Advancement of technologies – for example, collaboration between Pacific Northwest National Laboratory (PNNL) and LanzaTech, funded by BETO, to further develop a thermochemical process to convert ethanol to SAF.
- Sandia National Laboratory's research and development efforts to reduce the costs of lignocellulosic drop-in fuels and enhancing techniques for algal cultivation and biofuels.
- Support of Advanced Development and Optimization program to de-risk biofuel supply chains and enhance public-private partnerships to develop Integrated Biorefineries.

The FAA funded, ASCENT Center of Excellence has also executed complementary traditional and stochastic technoeconomic analyses and life cycle GHG emissions analyses for SAF processes and pathways. These include:

[7] https://www.energy.gov/articles/department-energy-provides-40-million-4-doe-bioenergy-research-centers

- Scenario-based life cycle analyses of GHG emissions from petroleum-derived transportation fuels (baseline GHG LCA)
- Technoeconomic assessments of alcohol-to-jet fuel production, corn stover-to-jet fuel, and municipal solid-waste to jet fuel, as well as other cellulosic biofuel pathways,
- Analyses of bioenergy uses in aviation and potential GHG emissions and benefits.

The F2F2 partners have also supported significant advances in our understanding of the sustainability of SAF production and supply chains. The ASCENT team has assessed sustainable future global SAF production and potential GHG emissions benefits, and ongoing efforts are focusing on the SAF value proposition, including the potential economic and rural development benefits of SAF supply chains, and a more detailed assessment for the U.S. potential for sustainable future feedstock and fuel production. The ASCENT team is also investigating how environmental benefits such as water quality protection/improvement, soil /nutrient retention, and other ecosystem services could provide both synergistic benefits to SAF production and possibly add to revenue streams for producers to enhance economic sustainability as well.

The F2F2 team contributed to the establishment of a suite of agreed upon objectives across the U.S. federal government toward facilitating SAF deployment and use in the U.S. as part of the development of a Federal Alternative Jet Fuel Research and Development Strategy (FAJFRDS). The FAJFRDS outlines specific goals for federal agencies in the areas of feedstock development, production and logistics, fuel conversion and scale-up, fuel testing and evaluation, and integrated challenges that cut across other categories. The FAJFRDS objectives were also brought to the Biomass Research and Development Board for their consideration in developing the Bioeconomy Initiative: Implementation Framework.

The business aviation community has developed and released a "Business Aviation Guide to the Use of Sustainable Alternative Jet Fuels." The guide was released at the European Business Aviation Convention & Exhibition (EBACE2018) and will facilitate the business aviation community's use of SAF to help meet the industry's environmental performance goals. This community has also executed an industry communication event, Business Jets Fuel Green, at Van Nuys, CA, and intends to do more in this regard to start showcasing the commercial engagement opportunities (offtake discussions) available for fuel suppliers, fixed-base-operators, pilots and flight departments. CAAFI has reinforced the concept with this segment that offtake agreements are necessary to allow potential producers to close their financing and initiate commercialization.

Taken together, these various efforts by the F2F2 signatories and partners have advanced the development of feedstock and SAF supply chains and have led to a better understanding of the risks, opportunities, and methods of de-risking SAF supply chains across the U.S. These efforts will bring about economic development opportunities and improve the environmental performance of SAF supply chains.

Outcomes

F2F2 Commitment 3: "communicate results and make recommendations for needed strategic public-private partnerships, regional pilot programs, implementation enhancement, and fast-track approvals. The Working Group shall issue periodic progress reports and a final report by year-end 2018."

Many of these activities have been highlighted and specific results disseminated at CAAFI Biennial General Meetings in 2014, 2016, and 2018. Other key venues for information dissemination have included DOE's Bioenergy meetings in 2013, 2014, 2015, and 2016, DOE's Bioeconomy meeting in 2017, and the 2017 Agricultural Outlook Forum.

Summarized key accomplishments related to F2F and F2F2 collaboration

- 6 NIFA CAPs addressing SAF supply chain evaluations, two of which are in year 2 of their 5-year remits. An additional project is likely to follow in 2019, but is as yet unannounced.
- 6 CAAFI F2F2 State Initiatives, plus multiple additional exploratory activities, several of which are still underway.
- First facility establishment underway for Red Rock Biofuels and Fulcrum Bioenergy funded under the DPA to build and commission bio-refineries.
- 28 Feedstock Readiness Level (FSRL) evaluations in the National Agricultural Library "Ag Data Commons".
- Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program (BAP), also known as the Section 9003 Program, has provided loan guarantees to assist in the development of advanced biofuels manufacturing facilities for SAF.
- 5 USDA Regional Biomass Research Centers coordinating intramural feedstock research activities.
- 3 CAAFI Biennial General Meetings (2014, 2016, 2018) convening hundreds of SAF sector stakeholders.
- 4 DOE Bioenergy Meetings, and 1 DOE Bioeconomy Meeting.
- 1 Federal Alternative Jet Fuel Research & Development Strategy.
- 1 National Academy of Sciences report on Commercial Aircraft Propulsion and Energy Systems Research: Reducing Global Carbon Emissions (2015).
- 4 chapters on SAF contributed to NASA Green Aviation book.
- 1 Business Aviation Guide for the Use of Sustainable Alternative Jet Fuel (SAJF) released by GAMA, NBAA, and partners European Business Aviation Association, International Business Aviation Council, Ltd., and the National Air Transport Association.

Alignment of Outcomes with USDA, DOT and DOE Strategic Priorities

USDA, DOT, and DOE have outlined key strategic goals for each agency under the Trump administration (see Box 1). The F2F2 activities align with these goals by promoting economic opportunities, particularly in rural areas, promoting a novel use of American agricultural products, and by enhancing sustainable agricultural practices in the production of feedstocks, feed, food and fuels (USDA goals 2-7, DOT goal 2, DOE goal 1-3). These new SAF supply chains offer an innovative approach to safely meeting transportation's energy needs (DOT goals 1, 3) while ensuring that current infrastructure investments are maximized through the use of drop-in fuels (DOT goals 2, 4).

Box 1: Select Agency Strategic Goals

USDA (2018-2022)

1. *Ensure USDA programs are delivered efficiently, effectively, and with integrity and a focus on customer service.*
2. *Maximize the ability of American agricultural producers to prosper by feeding and clothing the world.*
3. *Promote American agricultural products and exports.*
4. *Facilitate rural prosperity and economic development.*
5. *Strengthen the stewardship of private lands through technology and research.*
6. *Foster productive and sustainable use of our National Forest System Lands.*
7. *Provide all Americans access to a safe, nutritious and secure food supply.*

DOT

1. *Safety: Reduce Transportation-Related Fatalities and Serious Injuries Across the Transportation System.*
2. *Infrastructure: Invest in Infrastructure to Ensure Mobility and Accessibility and to Stimulate Economic Growth, Productivity and Competitiveness for American Workers and Businesses.*
3. *Innovation: Lead in the Development and Deployment of Innovative Practices and Technologies that Improve the Safety and Performance of the Nation's Transportation System.*
4. *Accountability: Serve the Nation with Reduced Regulatory Burden and Greater Efficiency, Effectiveness* and Accountability.

DOE/EERE/BETO

1. *Promoting national security by developing domestic sources of energy.*
2. *Growing a sustainable future with renewable biomass resources.*
3. *Generating green jobs by stimulating the U.S. bioenergy economy.*
4. *Leading global technology innovation*.

Industry Developments during the period of the F2F and F2F2 Efforts

CAAFI and the F2F2 signatories have been involved in facilitating many different elements of SAF industry development, alongside partners across the aviation and fuels industry. The joint efforts of the many industry partners inside and outside F2F2 have resulted in significant successes over the period of F2F2, including:

- Aviation industry approval for use of five SAF production pathways via ASTM International (listed in ASTM Specification D7566), evaluations continuing for additional pathways;
- Offtake agreements signed by airlines, accounting for >350M gallons per year of potential SAF production;
- World Energy Paramount (formerly AltAir Fuels) commenced production of SAF on an ongoing basis from March 2016 at their Paramount, CA refinery, for deliveries to United Airlines at Los Angeles, CA international airport (LAX) as well as to business aircraft manufacturer Gulfstream in Savannah, GA. World Energy have also announced intended investment to expand Paramount's renewable fuel production capacity by more than six times their current production levels;

- Neste has produced jet fuel on an intermittent batch basis previously, and recommenced continuous production in 4Q 2018 to supply fuel to European customers from their Porvoo, Finland refinery;
- Neste announced it plans to invest an additional $1.5 billion in expanding renewable product production capacity in Singapore, with an estimated 1 million metric tonnes of SAF capacity;
- Groundbreaking in 2018 on SAF refineries by Fulcrum Bioenergy in Nevada and Red Rock Biofuels in Oregon;
- Airbus and JetBlue announced a joint commitment to sustainable aviation fuel and commenced the first delivery flights of new aircraft from the Airbus Mobile, Alabama production facility;
- Airports engaged in evaluations of infrastructure to determine best approaches to facilitate accelerated uptake of SAF from their facilities (e.g., Seattle-Tacoma and San Francisco);
- The aviation industry worked with the California Air Resources Board to include SAF in the CA low carbon fuel standard (LCFS) beginning in January 2019;
- Multiple additional flight demonstration activities have been completed in the last few years with several airlines, business aviation participants, and armed services using fuel from World Energy, Neste, Gevo, LanzaTech, ARA and others.

Recommendations for Building a Diverse American Energy Future

The preceding sections highlight the success that the F2F2 initiative has had thus far in leveraging U.S. government resources to address inherently governmental roles in fostering innovation, infrastructure investment, economic development, information dissemination, and addressing gaps that private industry has not filled. Given the value of the efforts thus far, CAAFI will likely propose an additional, similar public-private-partnership effort going forward, in addition to, or in replacement of, the SAF Working Group mentioned above. CAAFI will take time in 2019/2020 to socialize the need and gauge interests, as well as to consider new approaches.

Whatever the resulting approach ends up being, CAAFI efforts will continue to engage the work teams and goals of the multiple federal agencies whose interests and focus overlap with the pursuits of aviation and SAF developers. CAAFI will continue to focus on supporting the deployment of commercial scale supply chains for SAF to create rural jobs, enhance energy security, and expand rural economic development with the following recommended activities:

- Strategic R&D Partnerships
    - Work through the CAAFI public-private partnership to identify gaps, coordinate efforts, and communicate across U.S. government agencies, academia, & industry.
    - Coordinate with ASCENT researchers on national level risk-reduction analyses as well as tactical regional projects.
    - Leverage the expertise of the DOE National Laboratories, DOE Regional BRCs and USDA BRDCs in energy & feedstock research to bring new, better technologies to the fore in the production of advanced SAF from a variety of agricultural feedstocks.
- Implementation enhancement and coordination

- Leverage USDA programs, including the CAP grants, Rural Development, Section 9000 funding, and intramural (ARS) and extramural (NIFA) research programs to facilitate real-world tactical deployment efforts.
- Hold important convening activities such as the upcoming CAAFI Biennial General Meeting (to be held in 2021 in Washington, DC), DOE Bioeconomy meetings, and other events. Continue collaborating with international partners on similar fora.
- Execute on the goals and objectives of the Federal Alternative Jet Fuel Research & Development Strategy (FAJFRDS), which provides a roadmap for distribution of SAF-related activities among federal agencies to avoid duplication and enhance efficiency and efficacy.
- Invest in R&D as well as support for transitioning to commercial production, dovetailing efforts with Farm Bill priorities and opportunities.
- Expand the use of feedstock readiness level tools and other communication tools to aid industry in better understanding the maturity of SAF feedstocks, economic operators, and technologies.

Closing Comments

F2F2 has created a template for supply chain engagement and development that can now be expanded to enhance implementation. The F2F2 signatories and their partners have built new tools, such as the Feedstock Readiness Level tool, the Freight and Fuel Transportation Optimization Tool, and the Biomass Scenario Model that can support regional and national analyses of future energy scenarios. On the ground tactical deployment feasibility studies and assessments have laid the foundation for effective and equitable supply chains. USDA NIFA CAP, ASCENT and DOE projects have created relevant regional supply chain techno-economic and life cycle assessments. Now, opportunities exist to leverage those investments to achieve the establishment of new rural jobs and develop a new, innovative, and strategic industry that holds the promise of a future of improved energy supply and resiliency for the U.S. and the world. This work will be continued by CAAFI, but we believe that the impact of the effort would be greater if continued under a public-private partnership approach similar to what was done in F2F2.

As a next step, CAAFI recommends the creation or reconstitution of a SAF focused, public-private Working Group with an express charter to work collaboratively to identify opportunities for further targeted engagement by the various federal agencies through existing or proposed agency efforts and programs. The Working Group should include a few key non-public members with clear linkages to efforts and interests of industry and academia. For example, this could include:

- an expansion of the currently operating Federal Alternative Jet Fuel Strategic Plan Implementation IWG (co-led by USDA, FAA, and NASA);
- a new or existing group that could be matrixed across the 8 BRDB IWGs to take advantage of this existing structure, creating linkage to the Bioeconomy Initiative: Implementation Framework.

If it proves untenable to add key non-public members to such groups, the Working Group could also liaise with industry stakeholders via CAAFI to establish a regular dialogue to maximize the effectiveness of federal efforts.

Finally, CAAFI offers its effusive thanks to the members of the F2F2 working group who made this work meaningful, uplifting and impactful. Since 2010, the Farm-to-Fly (F2F) and Farm-to-Fly 2.0 (F2F2) initiatives have built a solid foundation of trust and engagement across the agricultural, energy and aviation sectors upon which a new, resilient, domestic energy future can continue to be built. F2F and

F2F2 coordinated activities have furthered the development of supply chains to produce SAF. We hope to continue doing more along these lines with current and future federal administrations who are interested in improving the sustainability and resilience of the aviation sector in support of U.S. strategic, economic, environmental and social interests.

CAAFI is sponsored by the U.S. Federal Aviation Administration, Airlines for America (A4A), Aerospace Industries Association (AIA) and Airports Council International-North America (ACI-NA). Additional information is available at www.caafi.org.